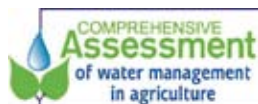


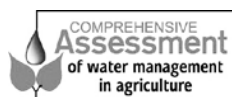
STUDIES & REVIEWS | 1836

# Tropical river fisheries valuation: background papers to a global synthesis





# Tropical River Fisheries Valuation: *background papers to a global synthesis*



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# Contents

Foreword	iv
Executive summary	v
Introduction	vi
Chapter	
1 Review of River Fisheries Valuation in Central and South America	1
2 Review of River Fisheries Valuation in West and Central Africa	47
3 The Valuation of Riparian Fisheries in Southern and Eastern Africa	107
4 Review of River Fisheries Valuation in Tropical Asia	147
5 Values of Inland Fisheries in the Mekong River Basin	227

# Foreword

**T**he Comprehensive Assessment of Water Management in Agriculture, started in 2003, has pioneered a global reexamination of how water contributes to the well-being and food security of the world's poor. While this program has involved looking again at how water productivity can be improved in irrigated and rain fed agriculture, its engagement with the wider role played by water in sustaining natural resource systems has brought a new dimension crucial to the management of water in agriculture. In doing so, the Comprehensive Assessment has moved beyond traditional concepts of water productivity and more "crop per drop" to embrace the importance of water in sustaining aquatic ecosystems, the resources they support, and the people that depend on these resources for food and income.

The present review is an important contribution to this reassessment of water productivity and the role that water in rivers and their associated ecosystems can play in supporting food security and livelihoods. By focusing on river fisheries, the review has concentrated not only on those inland fisheries that are most at risk from changes in water management at the basin scale, but also on a resource that has long been recognized as important but "too difficult" to be fully understood. Furthermore, by pulling together information from Africa, Asia and Latin America, the review shows that, while it may not be easy to obtain good assessments of the value of these resources, failure to grapple with this challenge will seriously constrain efforts to effectively manage water productivity at the basin level.

Because of their recognized importance and relative visibility, river fisheries may be viewed as the aquatic equivalent of the "canary in the coalmine". That is, they provide an indicator of ecosystem health and the ecological value of the water that remains in the world's river systems. As a result, fisheries can play a critical role in a world where policymakers require rapid information and indicators to guide their decisions. If the value of river fisheries and their role in supporting people's lives and livelihoods can be better understood and demonstrated, this can provide critical evidence for the policy and management changes required to regulate water flow in these systems and maintain the productivity of the aquatic ecosystems that sustain the fisheries. This review makes an important case for increasing investment in such valuation studies and in building up the capacity to pursue them. It is expected that this message will be heard and the investments required will be made.

**Patrick Dugan**  
Deputy Director General  
The WorldFish Center

# Executive Summary

**R**iver fisheries, and in general inland fisheries, in the tropical regions of the world provide a range of benefits including a means of livelihood and a source of food for millions of people. However, national policies relating to crucial issues, such as economic development, poverty alleviation, food security, conservation and sustainability, often fail to recognize these important attributes. This compilation of regional reviews documents the role of valuation and its contribution to policy-making and river fishery management. The document aims to provide a review of the global status of tropical river and inland fisheries valuation. It also considers the impact of changes in river basin management and compares valuation approaches used in different places. From this compilation, the main findings are as follows.

The best estimate of current tropical river and inland fisheries production is 5.46 million tonnes valued at US\$ 5.58 billion (gross market value), which is equivalent to 19 percent of the current value of annual fish exports from developing countries (US\$ 29 billion).

There is a general paucity of information globally. This is especially the case for information derived from conventional economic valuation (CEV) methods. Information derived from economic impact assessment methods (EcIA) and socio-economic and livelihood analysis (SE-LA) methods is more widely available. However, there are still serious gaps and deficiencies in these domains.

The status of knowledge on the impact of changes in river management on the value of tropical river fisheries is weak and patchy although there is widespread recognition of these issues. Impacts of large dams on the hydrology, ecology and livelihood support attributes of tropical rivers are well-recognized, but there have been only few valuation studies of these impacts. Among other reasons, the generation of information in this area is severely constrained in many countries and river systems by a lack of institutional capacity and skills to undertake valuation studies.

Finally, the document highlights the need for further valuation studies of tropical river fisheries and inland fisheries in developing countries. It is vital for policy-makers and other particular groups of stakeholders to understand the importance of these natural resources to society and to use this understanding as a basis for making appropriate decisions concerning the role of tropical river fisheries in development policy. The importance of matching valuation methodologies and their application to the needs of policy-makers and the policy process in each country is also critical. Capacity building in valuation should, therefore, become a major priority for agencies concerned with fisheries management and policy-making.

## INTRODUCTION

Freshwater resources underpin the livelihoods of millions of people in developing countries. As a form of natural capital and a source of wealth, these aquatic resources, particularly small-scale fisheries that depend on these resources, can be utilized both directly (e.g., through employment) and indirectly (e.g., wealth generated and extracted is reinvested in the economy) to contribute to economic development and poverty reduction. These resources and their associated fisheries can also provide a livelihood safety net and an element of food security for poor people in many situations where there are few other economic opportunities, and where the barriers of entry to these resources are minimal.

Despite the apparent importance of fisheries and other freshwater aquatic resources for large numbers of people in developing countries, national policies relating to such central issues as economic development, poverty alleviation, food security, conservation and sustainability often fail to recognize their role. This has contributed to a widespread failure to establish effective management systems. As a consequence, it seems likely that these resources and the benefits that they provide will become increasingly overexploited and degraded in the near future. This pattern of decline, which clearly has already started to take hold, will lead to severe competition and conflict between resource users, and may lead to a gradual lowering of socioeconomic conditions and increased poverty.

What can be done to address this serious and widespread problem? For a start, there is a chance that if the importance (or 'value') of these aquatic resources were given greater recognition and better integrated in national policy-making, then declines might be halted and even reversed. However, in order that national policy processes can be better informed about choices and decisions relating to the

management and sustainable development of these resources, policy-makers will need a wide range of appropriate information. For most developing countries, institutional and capacity constraints mean that information about common pool resources in general is very limited. This is particularly the case for information on the value of small-scale fisheries and freshwater resources, which has tended to be overshadowed by the technical and environmental information priorities of government agencies responsible for resource utilization, development and management.

In many countries, the need to incorporate fisheries valuation within the policy process has become increasingly recognized. At the same time, new valuation techniques are starting to emerge internationally. The big challenge now is to devise approaches by which developing countries can use these new valuation approaches to assist policy-making. Among the key questions to be addressed in order to develop an appropriate information-policy approach or strategy are: What information is needed by policy-makers? What methods can be used to generate this information? And what institutional capacities are needed to use valuation methods?

Valuation of river fisheries is particularly challenging for a number of reasons. First, river and inland fisheries are often well integrated into farming systems and associated agrarian livelihoods; this makes the valuation of fisheries using a strictly sectoral approach problematic. Second, river fisheries have been greatly impacted by new water management regimes, including dams and irrigation. This means that the nature of these changes must also be included within the valuation methodology. Third, there is a strong interaction between river fisheries and other users of water resources, including power generation, farming, navigation, industry and water supply for urban uses. This requires that the process of valuation should be treated with urgency to help deal with resource-use conflicts and interactions.



In order to consider how valuation might make an important contribution to future policy decisions on tropical river fisheries in developing countries, three important issues, framed as questions are considered in this document.

- What is the status of knowledge on the value of tropical river fisheries at present?
- What is known about the impact of changes in river or water management?
- What valuation techniques have been used to date and how do they compare in terms of their usefulness for future valuation assessments?

In the following chapters, the valuation of tropical river fisheries has been considered in relation to these questions through a series of review papers, commissioned to provide a global perspective covering Central and South America, West and Central Africa, Eastern and Southern Africa, and Asia<sup>1</sup>. In addition, a special review focusing on values of inland

fisheries in the Mekong River Basin – one of the most important inland fisheries in the world – is also included.

This study represents a first contribution in the field of tropical river fisheries valuation. The compilation has focused on rivers and river fisheries because it is considered that these features of inland aquatic systems throughout the tropical regions have been greatly impacted by changes in water management over the past 50 years. In turn, this has affected the value of the river fisheries and their role in the economies of the riparian countries concerned, most of which are developing countries. Inevitably, the chapters also cover other inland aquatic systems and fisheries, particularly large lakes and swamplands, and wherever possible this overlap has been identified in this report. In future, a more comprehensive survey and assessment of tropical inland fisheries will be required to take this initial study forward.

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<sup>1</sup> From these regional reviews a synthesis report was produced and published as a stand-alone document: Neiland, A. E. and C. Béné. 2006. Tropical river fisheries valuation: A global synthesis and critical review. Comprehensive Assessment of Water Management in Agriculture Research Report 15, Colombo, Sri Lanka: International Water Management Institute, 45 pp.



# CHAPTER 1

## **Review of River Fisheries Valuation in Central and South America**

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# Contents - Chapter 1

<b>1. Introduction</b>	3
1.1 Methodology	4
<b>2. The Rivers, Environment and Fishing Activity of Central and South America</b>	4
2.1 The Main River Basins in Central and South America	4
2.2 Other Water Resources: Lakes and Reservoirs	6
2.3 Main Species Caught in the Region	6
2.4 Central and South America River Fisheries in a Regional and Global Context	8
2.5 Freshwater Production Trends on the Continent	10
2.6 Aquaculture and Harvest of Aquarium Fish and Other Aquatic Species	10
2.7 Regional Importance of Fishing as a Livelihoods Option	10
<b>3. The Economic Value of River Fisheries</b>	12
3.1 Total Economic Value	14
3.2 Valuation Techniques (Applicable to River Fisheries).	15
3.3 Aggregating Use and Non-Use Values and Decision-Making	17
<b>4. TEV of the Region's Fisheries</b>	19
4.1 The Amazon Basin	19
4.2 Other Inland Waterbodies	24
<b>5. The Economic Impact on Fisheries of Dams and Water Management Schemes</b>	25
5.1 The Itaipu Dam	27
5.2 The Tucuruí Dam	27
5.3 The Yacyretá Dam	28
5.4 The Itá Dam	29
5.5 The Porto Primavera Dam	29
5.6 The URRÁ Dam	29
5.7 The Ralco Dam	29
5.8 Hidrovia Projects	30
5.9 Pollution Effects	31
<b>6. Conclusion</b>	31
<b>References</b>	32
Appendix 1: Major River Basins and Their Tributories in South America	37
Appendix 1a: Map of Latin American Rivers	39
Appendix 2: Crocodile Captures in Central and South America 1985-2001	40
Appendix 3: Freshwater Culture Production in Central and South America 1965-2000	41
Appendix 4: Freshwater Capture Production for Central and South America 1950-2000	44

## 1. INTRODUCTION

Central and South American (CSA) fisheries present some interesting paradoxes. Despite the wide biodiversity, its large share of the world's fish species<sup>1</sup> - up to 20 per cent of the planet's fresh water sources in the Amazon alone - Central and South Americans have never eaten large amounts of fish. Even though the continent is an important source of fish (Chile and Peru are among the top five marine fish producers in the world), the majority of their catch goes into fishmeal production rather than appear on the table as food. In fact, a recent study found that while Brazilians enjoy eating fish, only 2 per cent of the freshwater fish eaten in Brazil are native species caught in inland waters<sup>2</sup>. However, fishing for sport is the favorite pastime of an estimated 6 million Brazilians, and the continent is a popular destination for fishing tourists from Europe and North America (Worldpaper 1999).

The production potential in Central and South America is, theoretically, huge. While South America, in particular, contains two of the largest river basins in the world (the Amazon and the Plate), the largest freshwater wetland in the world (the Pantanal in Brazil), and the river with the largest volume in the world (the Amazon), Central and South America account for just 2 per cent of all the freshwater fish caught in the world.

Unlike Africa and Asia, where a large part of the population are heavily dependent upon fishing for their livelihoods, fishing for a living in the interior of CSA remains a marginal occupation for all but the most isolated of families. As such, the economics and management of

fisheries on the continent have received little attention from within the continent and the rest of the world. Nonetheless, the waters and fish of the region have been the focus of considerable attention by taxonomists, biologists and ecologists, and the region has been the center of debate regarding the role and importance of biodiversity and the significance of a stable ecosystem for the well being of the planet.

The following study shows that while a number of studies have been carried out on fishing in the region, they tend to be limited in their geographical focus and time scale. Although fishing of freshwater species may appear to be comparatively insignificant in the region, the rivers of CSA are very important. The continent contains a large number of dams, and hydropower accounts for 90 per cent of the total power consumption in Brazil (La Rovere and Mendes 2000:vii). Many of these dams, however, were built before the application of Environmental Impact Assessment became commonplace. As a result, it is often difficult to compare situations before and after this practice because before data simply do not exist.

This report, therefore, analyzes the literature available on CSA river fisheries and attempts to draw out an economic value of these fisheries. This has not been an easy task, not least because so few studies have been done on the topic. Furthermore, as dams can have such an important impact on the ecosystem in CSA, a literature survey has also been conducted on the impact of dams and related hydropower and irrigation projects on the aquatic environment in general and fisheries in particular.

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1 Eighty per cent of known freshwater fish species and three times the flora compared to similar areas in Africa and Asia (La Rovere and Mendes 2000:v).

2 The other 98 per cent are exotic species raised in tanks and ponds, most of it coming from Santa Catarina, the smallest state in the Federation (Worldpaper 1999).

## 1.1 Methodology

As noted above and expounded below, there is a paucity of information on freshwater fisheries in Central and South America compared to the same resources in other continents. The Internet provides a considerable amount of gray literature – particularly statistics from government web sites and information on locally managed projects dealing with fishery issues. Standard bibliographic databases reveal a considerable amount of literature published on biological matter in the region, but very little on the economics or the value of the fisheries in Central and South America. Unlike Africa and Asia, where English is often the academic lingua franca, Central and South America use Spanish and Portuguese as the main languages in all sectors. Consequently, it is possible that studies have been conducted on the economic valuation of river fisheries that have never been published in English-language journals.

A substantial part of the statistics used in section 2 is from the FAO FISHSTAT PLUS database. FAO statistics are, however, only as reliable as the underlying (national) sources and it is very possible that capture statistics for remote areas – particularly those fish destined for subsistence household consumption – do not appear in the figures presented here. Few studies on the region have specifically mentioned the problem with data collection, although the work of Dias-Neto and Dornelles (1996) and Paiva (1997) stand out in this regard. They point out the difficulty of establishing the veracity of statistics for the Amazon basin in particular. Common to all isolated fishing communities, collecting statistics for artisanal fisheries in the Amazon basin is complicated because fishers tend to catch a large variety of fish and the catches are distributed at a large

number of landing sites, many of which are only accessible by river.

This report is divided into a number of sections. First, the authors describe the major river basins on the continent, characterize their fisheries, and place freshwater fisheries in CSA into a global context. Second, the authors provide a review of valuation techniques for fisheries and use this analytical framework to review the principal literature on freshwater fisheries in the region. Then they turn their attention to the economic impact of dams and water abstraction schemes, reviewing the available literature to ascertain how/if economic values are computed for the impact on fisheries. Finally, they offer some conclusions and recommendations on the direction for future studies of freshwater fisheries in CSA.

## 2. THE RIVERS, ENVIRONMENT AND FISHING ACTIVITY OF CENTRAL AND SOUTH AMERICA

### 2.1 The Main River Basins in Central and South America

Because of their importance from a hydrological and ecological point of view, the rivers of Central and South America (those in Brazil in particular) have received a great deal of biological attention, but little work has been done on the economics of the fisheries operated there<sup>3</sup>.

All the major rivers of the continent are to be found in South America as opposed to Central America (see Appendix 1). The Brazilian Amazon covers an area of 5 million km<sup>2</sup>, nearly 60 per cent of the territory of Brazil<sup>4</sup>. The river

3 However, a £3 million project funded by CIDA started work in Brazilian inland waters in January 2003. This project (Brazil inland fisheries, sustainable livelihoods and conservation [http://www.worldfish.org/proj\\_sa\\_3.htm](http://www.worldfish.org/proj_sa_3.htm)) aims to focus on the social and economic side of fishing in the region.

runs 5,700 km from the Andes to the Atlantic Ocean; with all its entire system including about 1,100 rivers and lesser streams. The Amazon basin, which accounts for a fifth of the freshwater on the planet, includes the white water rivers such as the Amazon that are rich in minerals and suspended particles, the clear water rivers such as the Tapajos that also carry important quantities of suspended particles, and the black water rivers such as the Negro that are much poorer and owe their dark color to acids derived from decomposing organic materials in the flooded forests at their margins. The basin is also divided into the Lower and the Upper Amazon. The Lower Amazon has been analyzed by various authors (Bayley and Petrere 1989; Merona 1990; Santos and Ferreria 1999; Ceideira, Ruffino and Isaac 2000).

The Amazon River system drains the world's largest tropical rain forest as well as the Pantanal, the largest freshwater wetland in the world. The Amazon basin provides over 50 per cent of Brazil's freshwater supply, and substantial parts of that of Peru, Bolivia, Venezuela, Colombia and Ecuador (Map 1). Petrere et al. (1992, 2003) studied the West Amazon Basin and Almeida et al. (2003) studied the Amazon as a whole (See Section 4 for more details, and Appendix 1a for the map).

Brazil has the majority of the principal river basins of the continent: the Nordeste, Tocantins-Araguaia, Paraguay, Leste, Do Sul and Sao Francisco lie exclusively within Brazil although information on these other rivers and river basins is limited. Despite a large number of biological studies conducted in the region, basic information on its fish species is still patchy; taxonomic descriptions and life-cycle studies are only limited to species of greatest commercial importance (Petrere

1994) or to specific rivers, e.g., Tejerina-Garro et al. (1998) conducted a biological study of fish communities in the Araguaia river (part of the Amazon basin). A few studies have been conducted on fishers and their interactions with the environment: Cetra and Petrere (2001) on the middle Tocantins and the impact of the Tucuruí dam on the fisheries; Batista et al. (1998) on fishing gears used in the Lower Solimões river (the local name for the western part of the Amazon); and Agostinho and Gomes (nd) on the links between biodiversity and fisheries management in the Paraná basin. In addition, Silva (1986) documented the upper Paraguay basin, which is the habitat of many large migratory fishes and thus popular with recreational fishers.

Many of the rivers in the region are highly seasonal, resulting in the basins having a flooding and emptying cycle. The DFRP (2001) notes that a number of rivers in the Parnaíba basin (362,000 km<sup>2</sup>) dry up completely during the summer. However, the larger rivers have been dammed to generate hydropower (see Section 5) and have in turn created a large number of reservoirs: the São Francisco basin, for example, has 11 dams that account for 25 per cent of the reservoir area of the whole country (PLANSVAF 1989).

If information on rivers within Brazil is scarce, information on rivers in the rest of the continent is even more limited. Take, for example, the case of the Rio de la Plata basin, which is the second largest in the region and the fourth largest in the world. Covering Paraguay and large parts of Bolivia, Brazil and Uruguay, it forms the largest wetland corridor in the world, from the Pantanal in Mato Grosso to Rio de la Plata, which flows into Argentina. Surprisingly, there are no known studies on this basin, although a search on the Internet demonstrates that sport fisheries predominate

4 Usage of the word "Amazon-" is often very loose. Amazonas is the name of a State in Brazil, which stretches from the western-most border to just east of Manaus. About three-fourths of the Amazon river is in Amazonas State, and the other quarter is in Para State. The western-most stretch of the Amazon is also called the Solimões. Amazonia tends to be used to refer to the rainforest that covers the basin.

here. The Orinoco basin is shared by three countries: Brazil, the Guyanas and Venezuela, but the only reference encountered on this river system was from the 1970s when Auburn University (USA) conducted a survey on the Upper Meta River System. Ninety-two per cent of the Pilcomayo basin lies in Bolivia; the river then runs down into Paraguay, where it joins the Uruguay River, which flows into Argentina and empties into the Atlantic Ocean. There are currently around 30 small mining companies operating at Potosi on the Upper Pilcomayo; these contribute considerable waste to the river system. As a result, considerable attention has been focused on water quality in this basin. Various projects have been put forward to monitor water quality in the river and to control mining pollution, but few appear to have met with any degree of success (<http://www.gci.ch/GreenCrossPrograms/waterres/water/pilcomayo.html>).

The Bio-Bio River in Chile empties into the Pacific and is a significant source of hydroelectric power for the country as is the Colorado River in Argentina, which drains into the Atlantic. This river, the traditional and historic border between Spanish/Mapuche populations in Chile, is 380 km long, flows down the Andes into the Pacific, and has a number of dams constructed across it. It has a watershed surface area of 24,260 km<sup>2</sup>. Over a million inhabitants are estimated to rely upon its resources for drinking and irrigation water, recreation and fisheries.

Finally, Mérigoux et al. (1998) described freshwater fisheries in coastal streams in French Guiana; Mol et al. (2000) examined the effects of drought on freshwater fisheries in Suriname; and Beltran Zurriago and Villaneda Jiménez (2000) briefly mentioned inland artisanal fishing in Colombia.

Central America has many rivers (e.g., the Belize and Monkey rivers in Belize; the

Corobibi, Sarapiquí and Tabacón rivers in Costa Rica; and the Rio San Juan River in Nicaragua), but no evidence could be found of any studies on the economics or management of fisheries in those rivers. However, it appears that several of the rivers offer excellent opportunities for sport fishing and whitewater rafting ([www.uncommonadventure.com](http://www.uncommonadventure.com)); many offer ecologically unique habitats to fish species (See [www.si.edu/bermlab](http://www.si.edu/bermlab), for examples.) and quite a few are linked to important wetlands such as the Laguna del Tigre National Park in Guatemala ([www.worldbank.org](http://www.worldbank.org)) and a variety of Ramsar sites in Nicaragua ([www.ramsar.org/profiles\\_nicaragua.htm](http://www.ramsar.org/profiles_nicaragua.htm)).

## 2.2 Other Water Resources: Lakes and Reservoirs

With such a large quantity of water, hydroelectric power has always been important to the region. As a consequence of having a large number of dams built across the region (see section 5), numerous artificial lakes and reservoirs have been created (Paiva 1976; 1983). Lake Titicaca, however, is the largest natural lake in CSA and the only natural lake upon which any information could be found. The lake, which is shared by Peru and Bolivia, covers 8,372 km<sup>2</sup> and consists of two parts: Lago Mayor, the deep main basin and Lago Pequeño, the smaller, shallower one (Ghishan nd). Extensive anthropological work has been conducted on the fishers that work the lake (see Orlove 1986, 1989, 1990), but no economic assessment has been done.

## 2.3 Main Species Caught in the Region

Amazon fisheries, in common with other tropical freshwater fisheries, have a number of special characteristics. They are multi-species and fished with a wide range of gears. Temporal variation in capture is high because most fish are caught during the dry



season, the least during the wet season. In these circumstances, traditional fisheries population models are not able to predict the potential yield with any certainty, and it is also difficult to calculate marginal costs of production (Etchart 2000).

The Lower Amazon is characterized by great diversity and high production. Catch composition presents a significant spatial and temporal diversity, dominated by *Plagioscion squamosissimus* (Table 1). The only industrial freshwater fish in the Amazon is the Piramutaba

**Table 1: Principal fishes caught in South and Central American Rivers**

Local name	Latin name	Notes
Curvino	<i>Plagioscion squamosissimus</i>	Brazilian Amazon
Tucunaré	<i>Cichla monoculus</i>	
Jaraquis	<i>Semaprochilodus insignis</i> , <i>S. taeniatus</i>	
Curimatá	<i>Prochilodus nigricans</i> ,	
Anostomideos		
Hemiodontideos		
Tambaqui	<i>Colossoma macropomum</i>	
Cardinal tetra	<i>Paracheirodon axelrodi</i>	Ornamental fishery catch from Rio Negro
Piramutaba	<i>Brachyplatystoma vaillanti</i>	The only fish used in industrial fishery
Pescada	<i>Prochilodus lacustris</i> , <i>P. cearensis</i> , <i>P. argenteus</i>	Parnaíba
Piaus	<i>Plagioscion</i> sp	
Tilapia do Nilo	<i>Schizodon</i> sp, <i>Leporinus</i> sp	
Piaui	<i>Tilapia niloticus</i>	
Camaroes	<i>Plagioscion squamosissimus</i>	
Tucunare comum	<i>Macrobrachium</i> spp	
Curimatá comum	<i>Cichla ocellaris</i>	
Curimatá comum	<i>Prochilodus cearensis</i>	
Pintado	<i>Pseudoplatystoma corruscans</i>	Paraná
Dourado	<i>Salminus maxillosus</i>	
Barbado	<i>Pirinampu pirinampu</i>	
Piaporas	<i>Leporinus elongates</i> , <i>L. obtusidens</i>	
Mandi	<i>Pimelodus maculatus</i> , <i>Iheringichthyys laborosus</i>	
Armado	<i>Pterodora granulosus</i>	
Curimbas	<i>Prochilodus lineatus</i>	
Pequenos caracideos	<i>Astyanax</i> spp, <i>Moenkhausia intermedia</i>	
Traira	<i>Hoplias malabaricus</i>	
Pintado	<i>P. corruscans</i>	
Curimata	<i>Prochilodus marggravii</i>	São Francisco
Dourado	<i>Salminus brasiliensis</i>	
Traira	<i>Hoplias malabaricus</i>	
Bagres	<i>Pimelodidae</i>	
Cachara	<i>Pseudoplatystomas fasciatus</i>	
Pintado	<i>P. Corruscans</i>	Paraguay
Pacu	<i>Piaractus mesopotamicus</i>	
Curimba	<i>Prochilodus lineatus</i>	

Acarahuazu Boquichico Corvina Doncella Dorado Gamitana Llambina Maparate Paiche Palometa Ractacara Sardina Yahuarachi Yulilla Zungaro	Ray Ophidiidae Spanis aurata  Trachinotus	Peruvian Amazon (many of these terms are used by the locals in the region and scientific names are not known).
Camaron de Rio Carachi Pejerrey Trucha	Crayfish  Argentina elongata Salmo	Sierra waters

Source: DFRP 2001; Siamazonia 2002

(*Brachyplatystoma vaillant*, *Prochilodus lacustris*, *P. cearensis*, *P. argenteus*), found at the mouth of the river. Catches of these fish reached 28,829 tonnes in 1977, declined to 7,070 tonnes 1992, but had again risen to 22,087 tonnes by 1999 when the fish were considered to be recovering from overfishing (DFRP 2001). There is a significant fishery for ornamental fish in the lower Rio Negro, which is dominated by the Cardinal Tetra. In general, fisheries resources in Amazonia were considered underexploited by Petrere (1983) and Welcomme (1990), but with localized risk. Recent literature has reported declining catches close to large urban centers, and the decline in catches landed at Manaus was demonstrated by Bittencourt (1991), who suggested that fishing in this region was approaching the MSY level.

## 2.4 Central and South America River Fisheries in a Regional and Global Context

Since 1965, fisheries production from freshwater resources in Central and South America has never amounted to more than 4.2 per cent of fisheries production overall; it has normally been in the region of 1-3 per cent<sup>5</sup>. Over that same period, marine production has generally been above 10 million tonnes per year<sup>6</sup> (Table 2).

In a global perspective then, while a number of South American nations (notably Peru, Chile and Argentina) remain among the top marine capture producers in the world, the CSA share of global inland fish capture

5 Freshwater capture fisheries data do not include other aquatic animals (crocodiles, etc.) nor cultured fish production. A complete breakdown of capture production by species and country can be found in Appendix 2; figures for culture production can be found in Appendix 3; and those for crocodiles in Appendix 4.

6 Most of the marine production is destined for fish meal and the majority of this is caught by Peru and Chile, the second and fifth highest capture fisheries producers in the world (FAO 2000a).

**Table 2: Marine and freshwater production in Central and South America (tonnes)**

	Fresh (capture)	Marine	Total F + M	Freshwater capture as % of total
1965	150 200	8 645 065	8 795 265	1.7
1970	143 500	14 442 840	14 568 340	0.9
1975	251 138	5 409 696	5 660 834	4.4
1980	279 247	7 428 839	7 726 086	3.6
1985	319 136	11 440 871	11 760 007	2.7
1990	306 664	13 695 296	14 001 960	2.2
1995	376 166	18 837 534	19 213 700	1.9
2000	356 300	17 116 213	17 472 513	2.0
2001	351 735	13 962 671	14 314 406	2.4

Source: FAO FISHSTAT PLUS database

production has never exceeded 4 per cent in the period since 1965 (see Table 3).

This difference in production levels between the marine and freshwater sectors has occurred, in part, because a) the marine fisheries, particularly in the Eastern Pacific and Southern Atlantic are highly productive, and b) while there is an abundant amount of freshwater within continental Central and South American river basins, the population density in these areas is extremely low compared to the coast. Thus, production of the continent has always been far higher on the coast.

The disparity in production between the coast and the inland areas also helps explain the dearth of information on freshwater fisheries production: government support has traditionally been focused on the industrial marine sector, with the artisanal marine sector coming second. The inland sector only comes onto the agenda in countries that have a comparatively high freshwater production, such as Brazil. The paucity of economic or management literature on river fisheries in Central and South America is also attributable to the position of Central and South America in the global context. From an international aid perspective, little attention has been paid to freshwater fisheries production in Central and

**Table 3: Central and South American fresh and marine production (excluding aquaculture) as a percentage of world production**

	Fresh water (capture)			Marine		
	World	CSA	CSA% of total	World	CSA total	CSA% of total
1965	4 905 010	150 200	3.1	39 215 628	8 645 065	22.0
1970	5 754 441	143 500	2.5	52 820 006	14 424 840	27.3
1975	6 354 730	251 138	4.0	51 473 209	5 409 696	10.5
1980	6 995 335	279 247	4.0	55 449 299	7 428 839	13.4
1985	7 985 983	319 136	4.0	64 677 099	11 440 871	17.7
1990	8 787 867	306 664	3.5	69 099 914	13 695 296	19.8
1995	10 542 978	376 166	3.6	72 181 590	18 837 534	26.0
2000	11 938 651	356 300	3.0	72 816 750	17 116 213	23.5
2001	12 037 442	351 735	2.9	70 277 170	13 962 671	19.8

Source: FAO FISHSTAT PLUS database

South America simply because African and Asian fisheries offer more scope (production is much higher and is more significant in terms of livelihoods and poverty reduction).

However, while considerable attention has been paid to the biology of freshwater fish in Central and South America, in particular in the Amazon, little academic interest has been placed on fishing as an economic activity.

## 2.5 Freshwater Production Trends on the Continent

Overall capture production rose every year from the 71,600 tonnes recorded in 1950 to a peak of 376,166 tonnes in 1995<sup>7</sup>. Freshwater production since 1950 (the earliest available FAO data) shows that Brazil is by far the largest producer. Production from Brazilian freshwater resources rose from 30,600 tonnes in 1950 to 199,159 tonnes in 50 years, having peaked at 200,621 tonnes in 1985. For much of the same period, Colombia was the second most significant producer recording a growth of some 140 per cent, although production in 2000 stood at 24,854 tonnes, still significantly less than Brazil. Argentina's production has been erratic; although production in 1950 was recorded at 13,700 tonnes, it dipped to 5,400 tonnes by 1970, then climbing to 15,045 tonnes five years later before dipping again in 1980. Towards the end of the 1990s, however, Argentinian production experienced a sharp rise and, by 2000, it was the third largest producer on the continent. Peruvian production has also experienced a dramatic rise since the 1980s, making it the second largest producer in 2000. Other countries that have experienced a growth in their capture fisheries production include Venezuela and Paraguay, which saw production almost double between 1990 and 1995; and Guatemala, where production has increased from 4,500 tonnes in the 1970s to 7,301 tonnes in 2000 (Table 4).

## 2.6 Aquaculture and Harvest of Aquarium Fish and Other Aquatic Species

While the bulk of freshwater production comes from capture fisheries (85%), inland culture fisheries production rose 168 per cent in the five years between 1995 and 2000. Much of this rise is attributable to Brazil and Colombia. There is also a sizeable and growing fishery for other aquatic animals from the freshwaters of Central and South America. Most notable of these is the market for crocodiles, caimans and alligators (Appendix 2). While there are no readily available figures for the price of meat from these animals, caiman skins have a first sale value of US\$ 5-10, an export value of US\$ 50 each and up to US\$ 200 each on reexport from European tanneries. Crocodile skins retail at about five times the price of caiman skins, with a typical shipment of 2,000 skins for export selling for up to US\$ 200,000<sup>8</sup>. There is also evidence that the hunting of manatees (a protected species) provides livelihoods in certain parts of the Peruvian Amazon (Reeves et al. 1996). Manatees – large aquatic mammals that were recorded in Brazilian fisheries statistics during the 1950s – are no longer included. Also of note is the trade in tropical aquarium fish. Most of the fish destined for aquaria in Europe, North America and the Far East come from the Rio Negro. Fish caught in the wild from Brazil make up 5-10 per cent of the global ornamental fish market and cardinal tetra make up 85 per cent of the total catch in the Rio Negro basin (OFI Journal 2002; Chao and Prang 1997).

## 2.7 Regional Importance of Fishing as a Livelihoods Option

South America still has a low share of the total global fishers although after a marginal decrease in absolute numbers between 1970

7 A complete breakdown of production by species in all Central and South American countries is found in Appendix 4.  
8 [http://www.wcoomd.org/ie/En/Topics\\_Issues/Cross\\_borderCrime/Cites/broche/17.htm](http://www.wcoomd.org/ie/En/Topics_Issues/Cross_borderCrime/Cites/broche/17.htm)

**Table 4: Freshwater capture production in Central and South America (tonnes)**

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Argentina	13 700	7 900	14 700	12 900	5 400	15 045	8 327	9 715	10 281	17 111	30 298
Belize	.	.	.	.	<0.5	25	25	1	1	<0.5	<0.5
Bolivia	500	600	700	1 800	1 100	1 050	4 179	3 770	3 223	4 842	5 256
Brazil	30 600	41 200	54 000	94 000	93 300	173 327	184 273	200 621	191 111	193 042	199 159
Chile	.	.	.	.	.	.	.	1	32	.	.
Colombia	14 500	17 000	11 400	25 900	33 200	42 027	46 706	47 708	33 940	23 524	24 854
Costa Rica	<0.5	<0.5	<0.5	<0.5	<0.5	48	323	300	300	900	1 000
Ecuador	.	.	.	.	.	.	206	867	600	300	400
El Salvador	800	900	1 400	1 600	800	869	1 818	2 791	3 641	4 324	2 831
French Guiana	.	.	.	.	.	.	.	.	.	.	.
Guatemala	.	100	200	200	400	550	400	47	2 599	4 025	7 301
Guyana	.	.	.	.	.	.	681	800	800	700	800
Honduras	.	.	.	.	100	170	76	32	45	127	61
Nicaragua	100	200	600	1 100	1 300	359	79	84	150	538	1 076
Panama	.	.	.	.	.	.	.	50	15	130	20
Paraguay	400	500	600	700	1 800	2 800	3 300	7 500	12 490	21 000	25 000
Peru	.	1 000	1 000	3 000	2 000	6 671	12 538	27 791	28 321	50 789	32 297
Suriname	.	300	300	500	300	295	71	228	350	140	200
Uruguay	.	.	.	.	.	245	312	660	218	844	2 295
Venezuela	11 000	7 300	7 900	8 500	3 800	7 657	15 933	16 170	18 547	53 830	23 452
TOTALS	71 600	77 000	92 800	150 200	143 500	251 138	279 247	319 136	306 664	376 166	356 300

Source: From FAO FISHSTAT PLUS database

and 1980, the number of South American fishers and fish farmers grew by over 50% during the 1990s (FAO nd). However, throughout this period fishing has been a locally important livelihood option.

Artisanal fisheries in the Amazon basin are a very important source of employment and income (DFRP 2001). In inland areas, these fisheries often provide one source of employment for lowly or unqualified persons (in urban and rural areas), and they are generally conducted in conjunction with agriculture. The Solimões river at the western end of the Amazon accounts for around 45 per cent of all fishers in the Amazon River basin (Bayley and Petre 1989), yet as demonstrated in Table 5, accurate data on the number of fishers are hard to find, and the figures are often conflicting among reports. Part of the accounting problem arises because artisanal fishers often combine the fishing activity with farming or off-farm work and the

fishing portion of labor is aggregated into the agricultural statistics, or because many parts of the Amazon and other river basins are very remote and accurate counting of fishers is not possible. In the more remote parts of South America, where many fishers are subsistence fishers and do not join cooperatives or organizations to which commercial and many artisanal fishers belong, attempts at counting fishers through official organization membership can be misleading.

What is known is that in more remote parts of the interior, fishing is likely to make up a sizeable proportion of the animal protein intake and annual income, especially where alternative sources of employment or farming are not possible (Fernandez-Para 1998). Diegues (2002) has conducted extensive work on the artisanal fishers of Brazil where the form of fishing, the organization of fishing firms and the marketing relations are described. The DFRP (2001) highlights issues

with fishers in the Parnaíba basin (362,000 km<sup>2</sup>) where activity is highly seasonal as the Pindar, Grajua and Mearim rivers dry up completely during the summer. Almeida et al. (2003) provide the numbers of commercial and artisanal fishers on the Western Amazon (see Table 5).

**Table 5: Numbers of fishers on certain rivers/basins**

River/ Basin	No. of Fishers
Sao Francisco	26 000 (DFRP 1985)
Solimões	29 089 commercial (Almeida 2003) 77 485 artisanal (Almeida 2003) 102 870 commercial and artisanal on Floodplain (Bayley and Petrere 1989) 146 742 corrected for population growth which gives 117 653 subsistence (Almeida 2003)
Amazon	49 955 on the floodplain 228 600 subsistence and commercial (Bayley and Petrere 1989)

Finally, activity on other waterbodies is covered by Ghishan (nd), who estimates that 6,000 tonnes of fish are caught on the Titicaca by an estimated 800 fishers.

### 3. THE ECONOMIC VALUE OF RIVER FISHERIES

*“As is true of all natural resources, fishery resources constitute capital assets from the point of view of society. Similar to man-made capital assets, such as factories and machinery, fishery resources are capable of producing a stream of returns to society over time”* (Munro 1981:129). However, Central and South American fisheries are just one small piece of a complex regional environmental puzzle and, moreover, as they invariably only form

one element of a human livelihood strategy<sup>9</sup>, it would be remiss to analyze them in isolation from their immediate aquatic surroundings. Tropical and temperate river basins offer a wide spectrum of goods and services to society. These range from conventional and non-conventional extractive opportunities, such as biodiversity prospecting and the harvesting of timber, medicinal plants, rubber and wildlife as well as aquatic resources, to non-extractive options such as ecotourism, scientific research, and repositories for the unwanted carbon produced by local, national and global economic growth<sup>10</sup>. Equally, the institutional or public policy environment impacts to modify use patterns and the realization of value derived from a particular locale over time. In Chile, for example, the provision of public subsidies via the 1974 Forestry Law, covering 75 per cent of the costs of planting and tending trees, produced an internationally competitive lumber industry, albeit with suggestions of negative effects on both the rural population and native forest ecosystems (Clapp 1995a, 1995b; Lara and Veblen 1993).

Nevertheless, while economic valuations of such complex ecosystems and, indeed, the individual components thereof are a difficult task, there are strong grounds for undertaking such exercises as noted by Winpenny (1991:6):

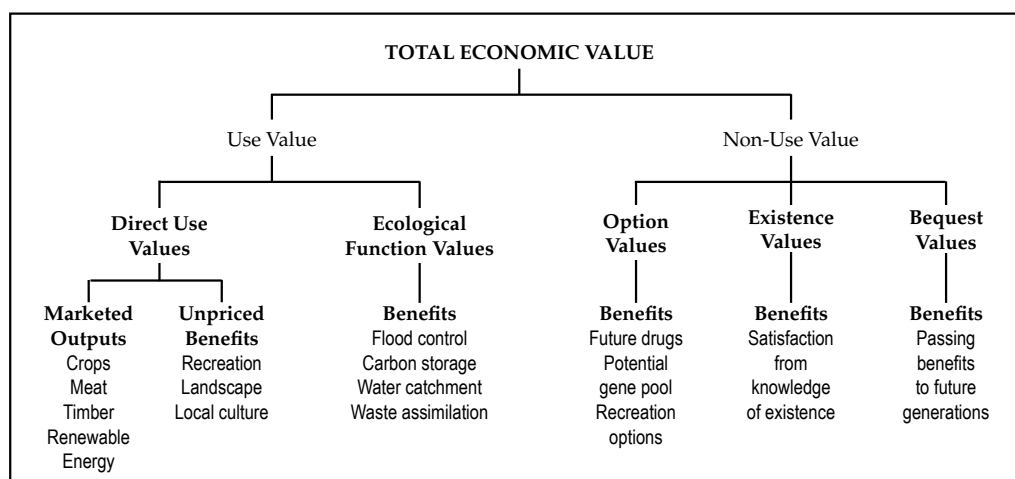
- Valuation highlights the rate at which resources are being depleted/harvested, serving as a reminder that environmental capital is not a *free* good. A 1989 World Bank study, for example, computed that the overexploitation of demersal fish stocks in the Philippines cost the country annually between US\$ 50-90 million.

9 See Scoones, Melnyk and Pretty (1992)

10 A number of studies have examined the role of tropical rainforests as carbon ‘sinks’, for example. Fankhauser (1993) calculates the carbon sequestration value of such forests at around US\$ 20 per tonne, while work reported by Van Kooten (1992) produces figures varying between US\$ 2 and US\$ 275 per tonne. Aylward et al. (1995:6), using Fankhauser’s figure, suggest that at this price preserving tropical rainforests as carbon sinks may well be the most beneficial option. Aylward (1993) has also calculated that the worth of extracted biodiversity as an input into the pharmaceutical research process may lie anywhere between US\$ 15 and US\$ 24 million per species.

- Valuation seeks to monetize unpriced benefits and costs so that they are not precluded from consideration in decision-making processes. Samples et al. (1986), for example, have calculated *preservation bids* that can be used in estimating the social value of species preservation (their research encountering an annual willingness to pay approx. US\$ 36-57 for the humpback whale within a group of 240 paid student subjects).
  - Valuation, by internalizing such benefits and costs, offers a more comprehensive frame-work for policymaking. The environmental and social impact report on the Cana Brava Hydroelectric power plant on the Toncantins river in the central and western parts of Brazil, for example, led to a figure of US\$ 25.5 million [6 per cent of the total project cost] being incorporated subsequently into the Management Plan to provide for the rehabilitation of degraded areas, to conserve the local fauna, to mitigate impacts on the wild fauna and ichthyofauna, and to rescue important archeological artifacts among other things (IADB 2000).
- Valuation is not an unchallenged panacea, however, and has its fair number of critics<sup>11</sup>. These challenges notwithstanding, accurate evaluation also remains critically dependent upon precise technical, scientific and economic data – data which may frequently be either unavailable, or costly to obtain. This is particularly true, as Section 4 of this paper shows, in the case of Central and South American river fisheries. Yet, in the absence of an accepted alternative technique that permits the aggregation of both monetary and non-monetary benefits and non-benefits within a standard evaluating framework, such methodological limitations are perhaps excusable. Consequently, this report elects to summarize the extant literature [published and gray] through recourse to the TEV (Total Economic Value) framework advanced by Hodge (1995:7), with the objective of assessing the direct economic and the wider

**Figure 1: Total economic value and its components**



Source: Hodge (1995:7)

11 Criticisms of economic valuation techniques generally divide into three categories. First, that it is impossible to assign a monetary value to intangibles like human life, the importance of species diversity, depletion of the ozone layer, preservation of pristine rainforests etc., and attempts to do so merely degrade the whole exercise. Second, that the valuation process is open to manipulation, whether consciously or unconsciously [given the set of values held by the evaluator], with the means – the valuation process – simply being used to justify the desired ends (Bowers 1990). Third, that valuation techniques derived in the developed world are rendered meaningless in the developing world – for example much of the work on fish population dynamics and eutrophication resulting from farm chemical runoff used to inform valuation methodologies has been done in temperate conditions, and similar causal relationships may not prevail in the tropics.

social values of Central and South America's river fisheries.

### 3.1 Total Economic Value

TEV can be disaggregated into two sub-components: use values and non-use values. Use values in turn can be further decomposed into direct use values [both marketed and non-marketed] and ecological, or indirect, use values, while non-use values can be split into option, existence and bequest values (See Figure 1).

In the case of Central and South American rivers, *marketed use values* would include the capture of food fish for local and/or external markets and ornamental fish for export (OFI 2002), while non-fishery marketed use values of the region's rivers might include (although would not be limited to) the hunting of crocodiles to satisfy international market demand for luxury leather goods (NRC 1983; Wallis 1980), the generation of hydro-electric power (Correa 1999), and the panning for gold from barges in the Peruvian Amazon ([www.panda.org](http://www.panda.org)). At a secondary level, it also includes forward and backward linkages in the fisheries, for instance, activities such as the construction of boats/gear (backward) and the subsequent processing and marketing of the harvested resource (forward), which constitute the wider social value in the terminology of the TOR. *Non-marketed use values* of the fishery would cover fish caught for the purposes of self-consumption (Diegues 2002), as baitfish, or for recreational and sport purposes ([www.thefishfinder.com/links/Destinations/Lodges\\_South\\_America/Ref](http://www.thefishfinder.com/links/Destinations/Lodges_South_America/Ref)), with the riverine environment permitting further non-marketed use values such as the abstraction of water for irrigation (FAO 2000b), washing clothes (Escobar et al. 2003) or recreational purposes. While the river basin affords a

number of *ecological, or indirect, use values* including benefits through flood control and the assimilation of mercury effluents resulting from the gold mining process ([www.unido.org](http://www.unido.org)), the fisheries-specific benefits principally relate to the relationship between species diversity and the underlying stability and resilience of the aquatic ecosystem (Peterson et al. 1998; Kublicki 2003). Overfishing may well change local fish population dynamics and have unintended impacts upon the wider ecosystem<sup>12</sup> although to date little work has been done globally to quantify these impacts in economic terms.

In contrast, *non-use values* refers to the value that *resides* in the particular ecosystem [in this case the riparian environment] and is presently unexploited - either because the individual or society chooses (or is coerced) to conserve the resource at the present point of time (option value) for the benefit of future generations (bequest value) or simply because the resource is seen as an asset (existence value).

The concept of *existence values* gained recognition following a 1967 paper by Krutilla that evaluated allocation decisions involving unique natural resources. The Southern Austral cone of Chile, for example, not only provides consumptive services to scattered local communities, but it also satisfies the *armchair environmentalist* who does not make use of the asset but derives pleasure from the preservation of such a complex pristine environment. Indeed, an American environmentalist Douglas Tomkins was so captivated by the beauty of the region that he was prepared to actually invest substantial funds to preserve the uniqueness of this environment by donating the land acquired for the Parque Pumalin Foundation, which now manages just under 300,000 hectares

12 Jackson and Marmulla (2001), for example, has documented how historical overfishing has led to the collapse of coastal ecosystems, while Pauly et al. (1998) document the very real dangers of fishing down 'marine food webs'. See too, the various papers emanating from the Ecopath with Ecosim project ([www.ecopath.org](http://www.ecopath.org)).



(Larrain and Stevens 2002; www.gochile.cl)<sup>13</sup>. Some organizations (Rainforest Alliance, Save the Whale, etc.) explicitly use existence values as a means of encouraging concerned individuals to donate to causes oriented towards protecting endangered species and/or ecosystems. Fish species and fisheries too may have existence values, and Samples et al. (1986) have analysed the preservation value of the humpback whale.

*Option values* refer to the returns that might be expected if the resource were to be subsequently exploited by the current generation. Peters et al. (1989), for example, suggest that the option value of a hectare of Amazonian rainforest could rise to as much as US\$ 9,000 once the commercial value of the standing forest has been factored in, while Myers (1988) suggests that a hectare of tropical forest could produce US\$ 200 of wildlife products annually<sup>14</sup>. The benefits are perhaps even greater once the potential of the resource as a gene pool is incorporated; the US pharmaceutical giant Merck, for example, paid US\$ 2 million for the right to evaluate the commercial prospects of a limited number of plant, insect and microbial samples collected from Costa Rica's conservation areas in 1991/2 (Eberlee 2000)<sup>15</sup>. While the aquatic gene pool is presently being tapped to support transgenic crop research (Thorpe and Robinson 2003), the more palpable (fisheries) option value is related to the failure to fully exploit fish stocks. As increased fishing effort would simply convert this option value into a direct, observable use value, there is a strong case for incorporating such option

values (where computation is possible) into any TEV evaluation.

Related to option values is the notion of *bequest values*, whereby the individual or society elects to conserve the resource for the benefit of descendants or future generations<sup>16</sup>. Generally unquantified, although frequently expressed, such motives are often encountered in field research.

Ideally then, a thorough assessment of the TEV of Central and South American river fisheries would aggregate both use and non-use values of the underlying resource. However, as many of these values [particularly non-use ones] remain unpriced, it is crucial to apply appropriate evaluation techniques to accurately capture their true value.

### 3.2 Valuation Techniques (Applicable to River Fisheries)

The *market analysis/value* approach is the most commonly used natural resource valuation method, largely due to its ease of application. It is relatively undemanding to count the ornamental fish and reptiles extracted from the Orinoco River and to obtain a figure for the value of the Negro's ornamental fish and reptile trade by weighing them in accord with their marketed price. Two caveats are in order. First, while there are well-established marketing channels for such products that aid information retrieval, not all trade may pass through such formal avenues, particularly if such a trade is prohibited due

13 Pumalin was one of the six protected areas included in a 1997 Chilean National Parks Service study on the total economic value (TEV) of such areas. Significantly, the study concluded that, thanks to non-use values, the estimated TEV was almost 40 times higher than the monetary incomes obtained by the residents of the areas (De la Maza 1997).

14 Both of these studies indicate the superiority of a managed approach to the forest resource, and the alternatives such as ranching in the Peters case and logging in the Myers study generate less income (US\$ 3,000 and US\$ 150, respectively).

15 Crook (cited in Eberlee 2000), however, is more downbeat about such bioprospecting, commenting: "compared to alternative values of the land, for example in timber values alone, *the earnings appear unlikely to increase the real value of natural ecosystems to any real extent.*" (The emphasis is the author's.)

16 If there is no expressed desire to either subsequently exploit the resource for one's own benefit, or to conserve it for the benefit of one's descendants, then bequest and option values become indistinguishable.

to the fish/reptile being placed on the CITES Appendix I list of most endangered species, as is the case with *Dermatemydidae*, the Central American river turtle. Second, there is a question of which price is the appropriate one, the final price paid by the British collector of tropical fish in Manchester, or the price paid to the Brazilian fisher who ensnares the fish.<sup>17</sup>

In relation to this, the *Effect on Production* (EOP) method is used to examine the change in direct use values resulting from a given environmental activity, such as identifying the physical effects associated with the change. Market values can be generated if these physical effects are then monetized through recourse to relevant market and/or shadow prices. The partial closing of the local river channel following construction of the Porto Primavera dam in Brazil, for example, sharply reduced fish migration and caused upstream fish catches to fall by around 80 per cent (Kudlavicz 1999), although no monetary value was imputed to such losses.

Alternative techniques are necessary to establish the economic value of sport fishing as the market value of the fish caught by recreational fishers invariably bears little relation to the value placed on the activity itself. For example, *The Travel Cost Method* (TCM), although originally developed to evaluate the worth of public recreation locations in the USA, could potentially be deployed to gauge the benefits of freshwater dorado (bream) fishing in the Plate and Parana rivers in Argentina ([www.jeep-ika.com.ar](http://www.jeep-ika.com.ar), [www.acuteangling.com](http://www.acuteangling.com)). In this case, aggregating the travel and opportunity costs incurred by surveyed individuals would produce an indirect measure of the unpriced benefits of recreational fishing on the river.

In some instances, direct markets (and prices) are absent and so *hedonic methods* are used by observing the prices of surrogate goods (generally property values and labor wage-rates) – that are affected by the environmentally based activity. Although the authors are not aware of any studies employing hedonic pricing methods to capture non-marketed use values within a fisheries context, riverine environments do offer some scope for the application of such techniques. For example, water abstraction for irrigation purposes could be valued by interrogating property registers to identify the price differential between irrigated and non-irrigated land that is identical in all other respects.

*Preventative Expenditures* (PE) and *Replacement/Relocation Cost* (RC) methods are more commonly used to track the amounts that people are prepared to spend to mitigate the degradation of the environment or ecosystem (PE) or alternatively, to either spend to restore the environment to its original state after it has been adversely affected (Replacement Cost), or to *replace* the environment by moving away from the degraded area (Relocation Cost). Although income constraints in the developing world are likely to bias both PE and RC valuations downwards, this can be offset by commissioning objective professional estimates of such costs, as is increasingly commonplace in Environmental Impact Assessments (EIA). In the case of the Porto Primavera dam alluded to above, the construction of fish ladders to minimize the impact of the dam on species migration would have been an example of PE, while the RC of fishing and other displaced households following construction of the Yacyretá dam was priced at US\$ 24,000 per household.<sup>18</sup>

17 Equally, the quantity of food fish harvested from, say, the Bio-Bio river can be multiplied by market prices to obtain the direct food fish value of the fishery. If levels of fish used for bait or subsistence can be ascertained, then appropriate shadow prices may be applied to generate the non-marketed use values of food fish. While there is a greater likelihood of food fish catches going unrecorded, the difference between the price paid to the fisher and the final market price is likely to be correspondingly lower than in the ornamental fish case.

18 This value was the cost of the homes built at the beginning of the relocation process, but cheaper constructions, known as *shellhouses* were later estimated to have cost just US\$ 4,000 by the residents. This discrepancy raised questions as to which figure (if either) represents the *true* relocation cost. Kudlavicz (1999) has also pointed out that the limited number of displaced Brazilian fishermen who were actually compensated following the early Brazilian dam projects were often rehoused in the city, forcing them to abandon their traditional activities.

Finally, *the Contingent Valuation Method* (CVM) surveys seek to elicit people's willingness to pay (WTP) to maintain/retain a specified environmental benefit such as the preservation of the Amazonian river dolphin (currently on the CITES Appendix II list of threatened species), or willingness to accept [WTA] compensation for a loss of environmental quality. Although widely applicable, and indeed indispensable if option and existence values are to be obtained, the technique has two principal weaknesses. First, unlike the TCM, it does not require survey participants to back up their response by parting with cash, and so a hypothetical bias is more likely<sup>19</sup>. Second, there are problems in identifying the relevant target group to survey, particularly in developing countries where information about environmental benefits is limited, and then *grossing-up* these values to get an aggregate WTP or WTA, particularly in those instances where non-use values are concerned (Winpenny 1991:60/1).

A variety of techniques are available to help determine the value of the distinctive components of riverine ecosystems and the fisheries found therein. While the methodology used for computing the value emanating from the direct use of fisheries resources is relatively straightforward, measurement of both indirect use values and non-use values is more problematic. The main difficulty in applying such techniques in the developing world is, however, the paucity of primary data that is presently available and the cost of augmenting such a limited knowledge base. Such shortcomings seriously hamper attempts to construct a robust picture of the TEV of any region's fisheries, including Central and South America.

### 3.3 Aggregating Use and Non-Use Values and Decision-Making

Barbier (1993) suggests that a comprehensive evaluation of the full potential TEV of any environmental resource or ecosystem can be obtained by adding the various components together. In other words,

$$\text{TEV} = (\text{Use} + \text{Non-Use}) \text{ Values}$$

or alternatively,

$$\text{TEV} = (\text{Marketed} + \text{Non-marketed} + \text{Ecological} + \text{Option} + \text{Bequest} + \text{Existence}) \text{ values}$$

A failure to either include, or correctly value, any of the component parts is likely to result in environmental degradation. For example, if both ecological and non-use (option, bequest and existence) values are excluded from the equation, then the misleading impression is given that TEV can be maximized by identifying marketed and non-marketed outputs. In the riverine fisheries case, a logical corollary of this is overfishing, although the private returns to increased fishing effort have a high opportunity cost at the margin (possible species extinction leading to an irreversible loss in option, bequest, existence and ecological values). It is equally crucial that decision-making that may affect the prevailing *status quo*, whether it be to authorize new nets or vessels in a fishery, to abstract or change the volume and flow of water, or to construct new settlements on the river banks, is subjected to scrutiny in terms of the impact such a policy/project will have on aggregate TEVs.

19 In the real world, actual bids have a resource cost. In the hypothetical CVM world, bids do not and so the respondent may be inclined to over- or underbid. Pearce and Turner (1990) further identify other factors, such as design (respondents may be swayed in their valuation decision by the information supplied to them), starting-point (responses are affected by the initial valuation price suggested by the researcher), strategy (respondents believe their response may, in fact, affect the course of events), or vehicle (payment method proposed), as potential obstacles to the effective application of CVM methodologies.

Historically, following the lead of Dupuit (1844), cost-benefit analyses (CBA) were deployed as a decision-making tool to quantify the costs and benefits accruing from major proposed projects. Project acceptance was conditional upon TEV being improved (i.e., net benefits exceeding net costs), with a positive net present value (NPV) the normal guiding criterion. However, the utilitarian and anthropocentric basis of CBAs (Turner 1991:213) and their depreciation of environmental values (Rees 1985:324) led some to place more emphasis on the generation of Environmental Impact Analyses (EIA). First advanced by the US environmental lobby during the 1960s, EIA purports to provide a more comprehensive appreciation of the environmental consequences of a proposed course of action<sup>20</sup> although the technique is open to similar criticisms to those leveled at CBA. The most common criticisms of such aggregating techniques include:

- *The Distribution of Costs and Benefits.* Although the net outcome may be favorable, not everyone benefits. For example, while the Tucuruí Hydropower Complex (THC) in Brazil raised the total commercial fish catch from 1,500 to 4,600 tonnes per year, catches downstream from the dam fell by 80 per cent (WCD 2000:61). Some projects make specific provision for the losers to be compensated, as in the case of the Yacyretá dam project where affected fishers were offered US\$8,000 to renounce any further claims for compensation.
- *Irreversibility.* Project acceptance sets in motion a chain of events that may well be irreversible. The decision to construct the THC, for example, is irreversible and had the consequence of causing the total

number of fish species to decline by over 28 per cent (50 species) in the reservoir area after damming (WCD 2000:60).

- *Discounting.* As individuals generally exhibit a positive time preference (preferring present to future satisfaction), it is incumbent to discount future benefits and costs so that they reflect such a preference. The problem arises in choosing the appropriate discount rate, particularly as Foy and Daly (1989), among others, have argued that environmentally sensitive benefit streams should be subject to a low(er) discount rate. In the case of the THC, for example, hydroelectric costs per MWh ranged from US\$ 40 to US\$ 58 depending on whether an 8 or 12 per cent discount rate was applied.
- *Immeasurable Items.* Despite the plethora of valuation techniques identified above, the worth of certain resources or ecosystems may still remain unquantifiable in monetary terms. Regional examples of this include, for example, Lake Titicaca (Peru and Bolivia), the El Tigre wetlands (Guatemala), Laguna Merim and Bañados del Este (Brazil and Uruguay), the Patagonian wetland lagoons (Argentina), the Llanos (Venezuela) and the Pantanal (Brazil, Bolivia and Paraguay), all of which have been identified for possible inclusion on the list of World Heritage sites ([www.unep-wcmc.org](http://www.unep-wcmc.org)).

These caveats notwithstanding, the objective of the next section of this report is to apply the methodological principles enunciated above in reviewing the extant literature (both published and gray) so as to provide some preliminary indications as to the true economic value of the region's fisheries.

20 Bisset (1978), however, has shown they are just as prone to manipulation and value judgments as CBAs.

## 4. TOTAL ECONOMIC VALUE OF THE REGION'S FISHERIES

### 4.1 The Amazon Basin

While Central and South America's principal river system, the Amazon, accounts for 20 per cent of the world's freshwater and is home to four-fifths of the 2,500 known species of freshwater fish, it is paradoxically the very size and associated diversity of its ecosystem that has precluded extensive study of the TEV of the system. Indeed, the most comprehensive work undertaken on this river basin, by the Amazon Rivers Program of the Rainforest Alliance under the direction of Michael Goulding between 1990 and 1999, focused on methods to protect and promote the conservation of Amazonian aquatic wildlife rather than place a tangible value on its economic or social worth<sup>21</sup>. Equally, even the economic research on specific riverine subsystems has generally not been formulated with the primary objective of assessing economic value, but rather to document information deficiencies (viewed from a management perspective) and alternative or improved management models, as will become clear in the ensuing review below (in which the studies are grouped together by region rather than by their relative merits in relation to the given TOR). Fortunately, information and data on economic values are a little more apparent in those instances where major ecosystem changes, such as the construction of dams or new industrial waterways, are proposed, as detailed in Section 5.

*A. The Commercial Fishing Sector in the Regional Economy of the Brazilian Amazon (Almeida et al. 2003).*

This study attempts to highlight the importance

of the Amazon-Solimões river to the regional economy by estimating employment within and the gross income and value added generated by the commercial fisheries sector in 2001. In their quest, the authors visited all three major cities with the population over 250,000 (Belém, Manaus and Santarém) and one quarter of the 48 smaller cities to interview Municipal Fishers' Union leaders, the Coastguard and all boatyards, fish processing plants, fishing gear stores, gas stations, ice factories and fish restaurants. In addition, a few fish vendors were interviewed in all public fish markets (with the exception of Belém and Manaus, where sample groups were chosen).

On the basis of the information collected, statistics were collected of the total fleet [5,457 vessels], number of commercial [29,089] and subsistence [49,955] fishers, and landings in urban markets [46,269 tonnes]. The total estimated sectoral income of R\$ 472 million (US\$ 160 million) is computed by aggregating the assumed income arising from four subactivities (input and input provision, fishing, processing and marketing, and services), although the major portion is derived from fishing, processing and marketing (89%). The authors then used these amounts to show both the lacunae in official survey methods and the real economic superiority of fishing over forestry in the region. For the former, the most recent agrarian census of 1997 estimated that just 17,742 persons were employed in the fisheries sector, resulting in the sector not receiving the attention and support it merits. For the latter, the authors pointed out that the NPV of the fisheries sector, at R\$ 93 million or R\$ 11,238 per hectare (US\$ 31.62 million or US\$ 3,821, respectively), is almost double that derived from forestry, at R\$ 50 million or R\$ 6,250 per hectare<sup>22</sup>.

21 See for example "The Catfish Connection: Ecology, Migration, and Conservation of Amazon Predators" (Barthem and Goulding 1997), "Floods of Fortune: Ecology and Economy along the Amazon" (Goulding et al. 1997), and "So Fruitful a Fish: Ecology, Conservation and Aquaculture of the Amazon's Tambaqui" (Araujo-Lima and Goulding 1997). In contrast, only a cursory three-page article "The Economic Value of the Amazonian Flooded Forest from a Fisheries Perspective" (Araujo-Lima et al. 1998) appears to have emanated from the project regarding valuation of the resource.

22 The R\$ was worth approximately US\$ 0.34 in September 2003.

While the contribution of Almeida et al. is welcomed, providing as it does a tangible figure for the primary and secondary marketed use values generated by fisheries in the region, the findings must be treated with some caution. Not only do the authors provide no details as to how they arrived at various figures, for example, the assumption of 1.14 fishers per household used in estimating the number of subsistence fishers, and the stated NPV quoted above, but there also appears to be a fundamental definition problem because the term *commercial* is used in two senses. On the one hand, it is used to identify those *employed* in the commercial fleet while, on the other hand, it is used to encompass the value of the landings of both the commercial and subsistence sectors, which are two rather different things<sup>23</sup>. Equally, MacFadyen's global findings (2002: Box 1) *that for every one fisher there are approximately ten employed in input or postharvest operations* stands in stark contrast to the study's findings, which suggest that there are nine fishers for every one person involved in other fish-related activities.

#### *B. Production Analysis of Commercial Fishing in the Lower Amazon (Almeida et al. 2000)*

In this paper, Almeida et al. use a Cobb-Douglas regression model to estimate the production function of commercial fishers in the Lower Amazon (defined as those fishers supplying the fourth largest fish market in the Amazon, at Santarém), with a view to contributing to the "formulation of policies in support of the region's small-scale floodplain lake fisheries" (p.1). While fishers operate in pairs from canoes using nets, long lines, harpoons and fishing poles, the catch is stored in a separate boat with a built-in storage compartment. Larger storage boats are often owned by non-fishers who supply

the boat and cover the expenses for every voyage, purchasing the daily catch at a price related to the prevailing market price for each species.

Standard economic assumptions were applied (boat owners are profit maximizing pricetakers who possess perfect market information, and input and output markets are perfectly competitive) although the paper made no subsequent attempt to either relax such assumptions or discuss the likely impact of relaxing them upon the regression findings. Catch size and composition were obtained for 2,992 landings in 1997 as part of an IARA/IBAMA project, and supplementary research established local values for gear, canoes, fuel and ice<sup>24</sup>.

The paper concluded that economies of scale were minimal in the Lower Amazonian commercial fishery, before suggesting that production could be increased through the provision of lower cost ice. While the paper did not go as far as computing the revenues generated by the fishery, and hence marketed use values, access to the raw data would permit such a calculation to be made. No consideration of non-marketed use values or non-use values was attempted beyond the recognition that four major species in the Lower Amazon (i.e., the tambaqui, surubim, piramutaba and pirarucu) are under excessive pressure, and the final rejoinder that the best policy is more cheap ice "combined with appropriate management measures to protect vulnerable species" (p.7).

#### *C. Amazonian Fisheries: Socioeconomic Issues and Management Implications (Fernandez-Boca 1998)*

Fernandez-Boca reviews the current state of inland fisheries in the Peruvian Amazon with a view to identifying key gaps in the economic,

23 Equally, using the term subsistence in this sense is incorrect as it fails to capture the values generated by the wholly subsistent fishers [non-market use values] whose landings do not enter the market. *Semi-commercial* fishers might be a better term.

24 Information on voyage duration and trip itinerary, ice and fuel consumption, number of fishers and canoes, and sale price of fish was obtained at the same time.

social and biological information needed to assist fishery decision-makers.

Noting the high levels of animal protein derived from fish products in parts of the Amazon (for example, 61 per cent in the Ucayali valley), the author proceeds to show how commercial fisheries have grown considerably in importance to service this demand, with commercial vessels from Manaus now undertaking round trips of up to 2,500 km in pursuit of fish. While official data are plotted to show a *modest* upward tendency in landings at both Iquitos and Pucallpa over the period 1980-92, this was accompanied by a sharp increase in effort (and a marked drop in cpue) that suggested some likelihood of overfishing. The failure to value these recorded landings, however, preclude us from identifying whether marketed use values have risen, declined or remained stable over time.

*D. The Experience of Community-based Management of Middle Amazonian Fisheries (Isaac et al. 1998)*

This paper by Isaac et al. seeks to propose a new management model for floodplain fisheries in the state of Pará in the Middle Amazon, where around 1.2 million people depend on fishing for their livelihood and 200,000 are active fishers. In order to emphasize the importance of developing an effective management model, the authors provide a fleeting idea of the marketed use value of the fishery by multiplying the 4,000 to 6,000 tonnes annually landed at the four principal towns in the Middle Amazon (Santarém, Alenquer, Monte Alegre and Óbidos) by average fish prices [US\$ 1 per kg] to produce a regional income figure of US\$ 4-6 million per year. Although the authors comment that the subsistence portion of the total catch is much larger, they fail to impute a value for this.

*E. Strategies for Managing Biodiversity in Amazonian Fisheries (Ruffino 2001)*

Ruffino's paper examines the experience of, and lessons learned from, the 1991-98 IARA project on participatory management in the Middle Amazon<sup>25</sup>. While chiefly concerned with documenting how biodiversity has been incorporated into fisheries management in the case of migratory *caracoideae*, sedentary species and large migratory catfish, the paper suggests that the Amazon fishery has a *use value* [marketed and non-marketed food fish] in the order of US\$ 100 million per year, based on a catch of 200,000 tonnes per year (as estimated by Bayley and Petrere 1989) and an average price of US\$ 0.50 per kg. Ancillary information culled from secondary historic sources is provided on the export fishery; prawn and piramutaba exports from Pará alone were worth around US\$ 35-45 million between the 1970s and 1990s (10 per cent of the state's total exports), and ornamental fish exports numbering around 17 million by the late 1980s were worth US\$ 2 million (employing 10,000 people, principally in the Rio Negro region of Amazonas State). An overview of stock exploitation levels for the major riverine species is also given, as shown in Table 6, although no price data are disclosed).

While the paper notes the recent emphasis given to sport fishing with the establishment of "The National Program for the Development of Amateur Fishing" [PNDPA], it also confirms the absence of reliable statistics to help gauge its economic worth or impact.

*F. The Floodplain Resources Management Project (FRMP- Provárzea)*

The FRMP has four components: strategic studies to support public policy formulation (notably in the areas of natural resource

<sup>25</sup> The findings from this project contributed to formulation of the Floodplain Resources Management Project (FRMP- Provárzea 2000) sponsored by IBAMA and the international community [See F.].

**Table 6: Landings in Amazonas State**

Species/Landing Point	Peak Landings – tonnes (Year)	Present Landings – tonnes	MSY?	Status of Stock
Piramutaba	32 000 (1977)	20 000	20-21 000	Overexploited
Tambaqui (Manaus)	15 000 (1972)	800		Overexploited
Surubim (Amazonas)		2 500		Overexploited

management, environmental legislation, and the economic and environmental use of the region's resources); promoting the development of innovatory systems of management that are economically, socially and environmentally sustainable; co-ordination of the project; and, most significantly in the context of this report, implementation of an integrated monitoring and control program, including the construction of a statistical data-bank on the riparian fishery. The program produces excellent monthly data on landings (by species, waterbody, vessel and gear type) and average prices for seventeen municipalities scattered along the river<sup>26</sup>. The results for 2001 were published in a 73-page document, *Estatística Pesqueira do Amazonas e Pará – 2001*, which details the methodology employed to collect and store the data, and an analytical summary for each municipality. The report is accompanied by one hundred tables, plus an annex containing the questionnaire applied in the study. On the basis of the data provided, it is a relatively simple matter to compute the marketed use value of the fishery in each municipality, while complementary tables can be constructed to show the economic value of individual species fisheries (such as the Apapá and the Mapará) for the surveyed municipalities. However, it is interesting to note that the project has not conducted this level of analysis so far with the large quantity of verifiable and good quality data available.

Two things emerged from this project. First, the wide variation in prices that prevail across regional Amazonian ports (in the case of

Apapá, average prices vary from R\$ 0.50 (US\$ 0.21) in Monte Alegre to R\$ 2.17 (US\$ 0.93) in Tabatinga, a difference of 334 per cent, the difference for Mapará is even greater – 592 per cent), variations that complicate further the task of placing an economic value on the Amazonian fishery (See Table 7).

Second, based on the figures available in the 2001 report, it is possible to calculate a crude figure for the first sale value of the fishery then and the quantity of landings (See Table 8.). However, it should be noted that for whatever reason, the project team has not done this and there may be a good reason why they feel that such a calculation would be misleading.

Thus, according to the Provarzea project, the current best estimate of the value of the fishery on the Amazon River is R\$ 49,622,541 or US\$ 21,337,692.

#### *G. The Sustainable Development Reserve of Mamirauá, Amazonas State (Begossi 2002).*

Begossi's paper provides an overview of Mamirauá, a 1.1 million-hectare reserve located entirely in the Amazonian flooded forest, between the Solimões, Japurá and Auati-Paraná rivers. Created in 1991, the reserve is home to 5,277 individuals. The annual mean earning of families in the reserve is US\$ 900, with 72 per cent of this income being generated through fisheries activity. While the author suggests that primary exploitation of the reserve [i.e., fishing, logging, caiman hunting and agriculture]

<sup>26</sup> The municipalities chosen extend from Tabatinga in the far western reaches of the Upper Amazon, to Belém in the lower eastern reaches. The locations can be seen, and the statistics also accessed, via the main web page [<http://www.ibama.gov.br/provarzea/varzea/menu.php?id=7>].



**Table 7: Landings and price data for Amazonas**

Municipal	Landings	Ave Price	VALUE R\$	Landings	Ave Price	Value
Abaetetuba	155 109	0.95	147 353.55	1 066 811	1.10	1 173 492.1
Alenquer	80	1.43	114.4	5 030	0.95	4 778.5
Alvarães	-	-	-	-	-	-
Belém	177 505	1.01	179 280.05	220 870	1.17	258 417.9
Coari	-	-	-	-	-	-
Fonte Boa	-	-	-	245	N/A	-
Itacoatiara	-	-	-	384 795	0.69	265 508.55
Manacapuru	-	-	-	226 104	0.51	115 313.04
Manaus	-	-	-	2 481	1.25	3 101.25
Monte Alegre	8 169	0.5	4 084.5	198 262	0.74	146 713.88
Óbidos	5 011	0.77	3 858.47	1 046 976	0.65	680 534.4
Oriximiná	1 144	1.02	1 166.88	19 683	0.94	18 502.02
Parintins	3 703	0.81	2 999.43	264 831	0.83	219 809.73
Prainha	-	-	-	111	0.70	77.7
Santarém	40 840	1.19	48 599.6	860 216	0.76	653 764.16
Tabatinga	983	2.17	2 133.11	18 375	2.56	47 040
Téfe	1 010	0.52	525.2	2 420	0.37	895.4
<b>Totals</b>	<b>393 554</b>		<b>390 115.19</b>	<b>4 317 210</b>		<b>3 587 948.3</b>

\* The first three columns relate to the Apapá fishery, the latter three to the Mapará fishery. Landings are in kilograms, and prices are average prices in R\$ per kilogram.

yields a marketed use value of US\$ 2.4 million annually between 1991 and 1995, this figure is significantly overstated due to summative errors in the accompanying table<sup>27</sup>.

#### *H. Projeto Piaba: Developing toward a Sustainable Natural Resource in Amazon Freshwater Fisheries*

Projeto Piaba is an ongoing community-based interdisciplinary project established in 1989 to understand the ecological and sociocultural systems of the middle Rio Negro basin, Amazonas, Brazil, in order to conserve and maintain the live ornamental fishery and other renewable resources at commercially feasible and ecologically sustainable levels.

Nevertheless, it does also provide some aggregated data on the ornamental fish for export market, suggesting export receipts totaled US\$ 2,216,620 in 1998 when 18.5 million fish were exported<sup>29</sup>.

#### *I. Siamazonía (Sistema de Información de la Diversidad Biológica y Ambiental de la Amazonía Peruana)*

Siamazonía is an offshoot of the National Environmental Council (CONAM), being entrusted with the management and exchange of information relating to the biodiversity and ecology of the Peruvian Amazon. As such, it does not purport to value the watershed, nor has it produced any

<sup>27</sup> Table 1 [p.17] effectively double-counts fishery resources. Removing the double-counting error produces a lower revenue stream [US\$ 1.5 million], of which fisheries accounts for about two-thirds.

<sup>28</sup> In mid-2001, the Real was worth US\$ 0.43.

<sup>29</sup> The project authors note that this is only the figure for ornamental fish exported officially from Manaus. If, as the authors suggest, between 30-40 million ornamental fish are caught annually, then this component of marketed use value may be substantially underestimated.

**Table 8: Landings and gross first-sale value on the Solimões and Amazon rivers, 2001<sup>28</sup>**

Municipality	Tonnes	Gross first-sale value in R\$
Abaetetuba	3 363	2 690 400*
Alenquer	247	254 381
Alvarães	73	nd
Belém	9 295	13 570 116*
Coari	577	766 373
Fonte Boa	337	nd
Itacoatiara	1 593	1 593 039
Manacapuru	2 544	2 174 551
Manaus	12 868	13 250 229
Monte Alegre	785	594 234
Óbidos	1 879	1 570 528
Oriximiná	269	290 548
Parintins	2 793	3 644 405
Prainha	104	80 000
Santarém	3 995	4 417 097
Tabatinga	1 197	3 394 015
Tefé	1 986	1 332 624.50
TOTAL	43 904	49 622 541

Source: ESTATÍSTICA PESQUEIRA DO AMAZONAS E PARÁ - 2001

\* The total value is not known; these figure are average values based on the average first-sale price in that municipality multiplied by total landings.

working papers. Its database, however, does offer a limited snapshot of the quantities of fish extracted and/or marketed in the municipality of Loreto that could be used to compute a use value [marketed and non-marketed food fish] for the vicinity.

## 4.2 Other Inland Waterbodies

If there are few sources offering any indication as to the economic value of Amazonian fisheries, there is a real paucity of information of any sort on the other river systems in the region. An extensive Internet search allied to a thorough search of the main economic and social science bibliographic databases disclosed no articles of any relevance to this report.

A number of other studies on river fisheries make only a cursory mention of documented landings in the study region. Such studies include the following:

*Coordenação-Geral de Capítulo 2: Tema: Recursos Pesqueiros: Pesca Extractiva e Aqüicultura (DFRP 2001)*

This review of catch statistics for Brazil notes that overall catches rose steadily during 1960-85 when around 78 per cent of catches came from marine waters and 22 per cent from inland waters. Since that time, there has been a decline to 744,600 tonnes/yr: 60% from marine sources and 40% from inland waters. But by 1990, the production had fallen to 640,300 tonnes. The rise in production, however, was largely attributable to inland (culture) production, given that marine production appears to be stagnating. Inland capture fisheries (of which 98 per cent were fish and 2 per cent crustacean, represented 25 per cent of the national production for that year) have declined since 1996 due to gold mining, domestic and industrial pollution, and agricultural inputs, the construction of barriers for hydroelectricity and the canalization of rivers (DFRP 2001). However, many of the instruments used to mitigate these problems cause new problems for the maintenance of fish stocks such as the restocking of exotic species. The study also notes that marketing of inland fisheries is dominated by a network of intermediaries, from the individual trader (generally someone from within the community) that specializes in buying and selling fish to the representatives of companies that buy and finance production. Because the extent of this marketing is small and irregular, it is difficult to generate internal capital. Producers are highly dependent on sources of finance, be it for the improvement of the species, and credit for hut supplies, ice, diesel oil, or fishing equipment.

## 5. THE ECONOMIC IMPACT ON FISHERIES OF DAMS AND WATER MANAGEMENT SCHEMES

According to the *Pilot Analysis of Global Ecosystems (PAGE): Freshwater Systems* report, much of the degradation of the world's freshwater systems is due to habitat destruction, construction of dams and canals, introduction of non-native species, pollution, and overexploitation. ([www.rivernet.org/general/WRI%20report.htm](http://www.rivernet.org/general/WRI%20report.htm)). With comparatively few non-renewable sources of power and so much water, it is not surprising that states in Central and South America have harnessed their water resources to generate energy, improve transportation across long distances, and for irrigation development. The continent provides many examples of large dams, hidrovias (large scale industrial canals), and at least one example of a large-scale irrigation development (Sistema Hidraulico Yacambú in the Llanos of Venezuela Nucete 2000).

An evaluation of the full impact of dams is an integral part of the EIAs and with increased public awareness of the potential negative side-effects of dam building, the costs of building dams is now expected to accommodate their impacts on the environment and populations from the local level up to the global level, as it is possible (See Section 3.) to place a value on the loss of biodiversity and cultural heritage among other things. The negative effects of dams are most observable in the short term, i.e., in the immediate aftermath of the construction. Such impacts include damage to the physical environment (first order impacts) as large areas of land (often forest in the case of Central and South America) are flooded; loss of aquatic and land-based species diversity as land disappears and the oxygen levels of

water change; downstream effects as natural changes in flooding cycles are disrupted; increased erosion of river banks as the flow of water rises in parts of the river; and increased anoxia in other parts of the river as the natural water flow is disrupted (second order impacts). Finally, there are third order impacts that follow from the first two and are characterized by lower fish catches; a rise in disease (malaria for example) as water levels and ecosystems change; changes in microclimate as valuable wetlands and watersheds are damaged; and social displacement that has direct costs (of moving peoples) and indirect costs (such as the fragmentation of vulnerable indigenous groups in parts of Brazil).

Some positive social benefits are also derived from dam construction. For example, Boa Nova and Goldemberg (1999 cited in WCD 2000) note that demographers attribute the reduction of the birth rate in Brazil to the increased availability of cheap hydroelectricity that the authorities in Sao Paulo (among others) provide to 2 million slum residents. With access to electricity, residents are able to watch television (a prime source of information on family planning). Other benefits that accrue from dam construction include increased employment opportunities in the construction phase and later in (expanding) industry as a result of increased power production. It is worth noting, however, that the WCD 2000 review of large dam projects came to the conclusions that while there are benefits accruing from their construction, these are not likely to trickle down to those who have borne the brunt of the costs of the construction.

Creating a legislative framework that would allow adequate consideration of the economic and social impacts of large dams would be a step forward in minimizing (if not eliminating) the negative impacts of dams. The WCD notes that the Rio Grande Hydroelectric

Project in Colombia incorporated a royalty payment scheme whereby those benefiting from the production of electricity contributed to a fund that was used to compensate those who had lost out through the building of the dam. The same principle was also applied in the Tucurui dam case. (See below.)

Evaluating the impacts of dams, canalization and water abstraction is a complex task because the effects can spread much further than the immediate physical area. The WCD report (2000) notes that while a cost-benefit spreadsheet analysis may be useful for some projects to evaluate impacts, in the case of most large dams they are often too complex for such an exercise to have any meaning; for example, livelihood, environmental and economic impacts do not allow for easy currency or metric comparisons. Furthermore, the report notes that poor accounting of the true costs and benefits of large dams in economic terms may mean that the efficiency and profitability of such schemes remains occluded (WCD 2000).

The available literature on dams (examined below) offers little in the way of economic evaluation of the impacts on fisheries. Dams certainly hinder the migratory routes of fish even though there are means of mitigating this (see below). Goulding et al. (1997) noted that no studies on the impact of fish had been conducted on the five large dams built in the Amazon River basin by 1996. The impact on fishing is often contradictory: while the type of fish caught and the level of catch in specific areas may fall, catch levels overall can rise. However, Jackson and Marmulla (2001) urged caution in this regard, noting that the further downstream the dam, the less likely the fishery in the newly flooded reservoir can compensate for lost catches on the other side of the dam wall. Yet, in many

cases, the change in fish catches is rarely mentioned (i.e., little data available on values of the catch before and after construction) although relocation and compensation costs are provided. Relocation costs (in so far as these can act as proxy values for the livelihoods of fishers) can be problematic because resettlement is frequently to areas that are wholly unsuitable (for example, fishers/farmers offered apartments in the city; occupants of wetlands moved to dry savannah areas) or at best less productive.

*The Influence of Dams on River Fisheries (Jackson and Marmulla 2001)*

The authors assess the status of catches from reservoirs in South America (principally Brazil) and find that more than half the catch from northeastern Brazil is made up of tilapia. They also state that, compared to other regions, the productivity of reservoirs is very low (from 2.1 kg/ha/year in the Uatum river up to 11.5 kg/ha/year in the Itaipu dam); they conclude that this is due to the length of time the water stays in the reservoir, affecting its quality and its suitability as a habitat for many species. The authors also assess dams in Central America (the only article that does so). Because rivers in Central America are generally much shorter and less important from a livelihoods point of view, reservoirs created by damming have served to provide extra fisheries opportunities. The authors cite the case of Panama where peacock bass, an exotic species (which had previously decimated native stocks) rapidly became an important commercial species providing a good source of income for local small fishers. Unfortunately, with no price or systematic landings data, it is not possible to derive any use value of peacock bass from the information given by the authors.

## 5.1 The Itaipu Dam

*Biodiversity and Fisheries Management in the Paraná River Basin: Successes and Failures (Agostinho and Gomes 2003)*

The Upper Paraná river is defined as the upper third of the Paraná river basin, stretching down to the Itaipu dam. Agostinho and Gomes analyze how biodiversity in this river has been affected by past fisheries management decisions, focusing in particular on adverse impacts of the construction of dams on fisheries. As reported, 130 of the dams are greater than 10 meters in height, and 26 of them cover an area larger than 100 square kilometers. Besides, it was not until relatively late in the day (1981) that it became mandatory for hydroelectric companies to produce EIAs ex-ante. While the article notes the failure of management programs designed to facilitate fish migration (1920-50s), and to increase yield by stocking exotic and/or native species (1950-90s), it merely alludes to the virtual absence of large fish species in the Upper Paraná and the low yields of artisanal fisheries in the south-southeastern reservoirs as evidence of the impact of dam construction. No corroborative figures are cited to support the authors' assertions.

## 5.2 The Tucuruí Dam

*Tucuruí Hydropower Complex Brazil (La Rovere and Mendes 2000)*

This study was conducted as part of a global report entitled "Dams and Development – a new framework for decision making" for the World Commission on Dams. The Tucuruí Hydropower Complex (THC) is located in the Tocantins River on the Tocantins-Araguaia River Basin. Construction was started in 1975 and completed in 1984. Phase II began in 1998

with the turbine starting in 2002. Although primarily built for hydropower production, it has a secondary goal of providing a navigable water route.

The river is estimated to contain some 300 species of fish and the ecosystem is reportedly one of the richest in the world. Prior to the construction of the dam, there were two distinct groups in the region: (three) indigenous peoples and the colonists<sup>30</sup> who survived mostly on fishing, gold and diamond mining, and subsistence agriculture. Fishing was estimated to produce 1,534 tonnes per year, 900 of which came from downstream of the dam. The dam was started under the Military Junta and the process was largely driven by the industrial sector, with concern at the time more on the impact of the ecosystem on the dam than vice versa. An attempt at an EIA was made in 1977, two years after construction began, but it was too late to have had any influence. The regularization of water flow affected natural flooding cycles that were responsible for natural fertilization processes; a large amount of nutrient-rich organic matter was now trapped behind the dam wall with lower agricultural yields downstream as a result. Although the 1977 assessment predicted that fish populations would be affected, there was insufficient information available on pre-dam populations to allow any realistic predictions. However, with reduced water quality downstream of the dam, observations suggested that *large-scale fish deaths* were occurring and the diversity of species was estimated to have been reduced by 19 per cent. In particular, the ubarana, a commercially significant fish species, came close to extinction as a marked decline in downstream *catch rates* was reported by fishing populations. But no bequest value for the ubarana was identified. Fish populations also suffered, with a reported 29 per cent

<sup>30</sup> A term used to describe non-indigenous Brazilians encouraged to migrate to the remote interior mainly during a period of border securing in the 1970s.

drop in reservoir species diversity and 25 per cent drop of species upstream of the reservoir. By the mid-1990s, scientists were able to demonstrate that fish productivity overall had risen by 200 per cent and reservoir catch had increased by 900 per cent, while the downstream catch had dropped by 45 per cent. No attempt is made, however, to ascribe a monetary value to the lost catches.

While the report does not put a monetary figure on the TEV of the dam, it does provide a breakdown of financial compensation paid to the various municipal districts [based on flooded area affected and ranging in price from R\$ 30,000 for Itupiranga to R\$ 287,900 for N. Repartimento (p. 89)]. This could be seen as providing an indication of the perceived value of the resource in terms of its foregone *option* and *bequest* values. However, the authors also note that while some indigenous groups (eventually) received sizeable compensation (replacement/relocation costs) for loss of land and livelihoods and a fund of US\$ 740,000 was made available to assimilate one group into modern society, other non-indigenous small holders did not. This information suggests that using such figures as proxies for the economic impact of the dam would be incomplete. The authors also provide a rudimentary cost/benefit analysis of the various components of the dam project (p. 132).

*Cana Brava Hydroelectric Power Plant: Environmental and Social Impact Report (IADB 2000)*

As this power plant on the Tocantins River was still under construction at the time of writing, this report only offers an examination of the potential impacts of the dam. Implications of the construction are identified, namely, environmental implication (the loss of land through flooding, increase of soil erosion, and decrease in fish populations); mineral implication (the loss of potentially valuable

alluvial deposits under the reservoir); and socioeconomic implication (258 families to be relocated with \$ 4 million allocated to cover resettlement costs). The US\$ 15,503 value attached to each family relocation appears to be much lower than other values given in reports on other dam resettlement calculations. The project has, however, a very sophisticated program in place to evaluate environmental changes following flooding.

### 5.3 The Yacyretá Dam

*Report of Social Impacts of Dams; Distributional and Equity Issues – Latin American Region (Ferradas 2000)*

This author notes that most studies focus on the upstream impacts of dams. Also, because many of the large dams from the 1970s were built as much for power as for political reasons, studies and information on the possible effects of impacts of the dams were negligible at the time. Besides, these dams were often built before EIA evaluation methods were commonly applied, and so there was little necessity to collect data before and after the construction. Largely based on her experience with the Yacyretá dam on the Paraná river, the author describes the political and economic contexts of the building of many large dams on the continent and outlines some of their biggest problems (lack of public consultation, relocation and requisition of indigenous lands, destruction of habitat and fishing livelihoods, etc). She notes that only when the democratization process began in the region did the issue of the social impacts of dams find a way onto the agenda.

Ferradas notes that fishers who were affected by the Yacyretá dam were offered US\$ 8,000 each as compensation for loss of earnings (i.e., low catches, harder access to the river) provided they agreed to make no further claims. However, according to Ferradas,

fishing activities were not identified as a possible source of conflict in the original plans for the dam possibly because many fishers were reluctant to identify themselves as such because it was an admission of poverty. The paper highlights a number of important issues. First, it assumes that decisions to accept the offer on the table were taken on the basis of *perfect information*. Given the isolated nature of the communities, their lack of access to public information services, the high levels of functional illiteracy and an inability to foresee the consequences, it is likely that the compensation accepted placed a far lower value on the resource and the livelihoods affected than was appropriate.

Brazil employs a system of royalties as a means of redistributing the benefits from dams. Ferradas mentions the distribution of some US\$ 989 million from the Itaipú dam (Brazil, Argentina, Paraguay border) although states have no control over how monies received are allocated. While ideally this amount should go towards compensating the losers from the project, it is not guaranteed nor protected by law. Again, the royalties could be viewed as an indication of the *lost* use values of the resource (in terms of foregone earnings from fishing, for example) and the non-use values of the environment as a whole (in terms of the loss of natural habitat, for example).

## 5.4 The Itá Dam

*Large Dams and Their Alternatives: Social and Resettlement Issues (World Commission on Dams)*

Bermann (1999) reports on the Itá dam, built on the Uruguaya River. The figure given in compensation (the relocation value) to each of the displaced 4,000 families was US\$ 93,750 per family under the conventional resettlement plan, but this amount fell to only US\$ 47,920 per family under the community-managed resettlement plan that was introduced

following the privatization of the company building the dam. Although the reduction in the cost of relocation is cited in the report as a benefit, this is only obviously so from a corporate perspective, and it is unclear which of the two figures is the more realistic forgone use value of the resettled inhabitants.

## 5.5 The Porto Primavera Dam

Kudlavicz (1999) reports that the building of the Porto Primavera dam on the Parana River (that began in the 1970s and is still uncompleted) has had a dramatic effect on fish stocks: there are no mechanisms in place to mitigate upstream migration problems; the flooding of natural upstream lakes has impacted upon breeding cycles with the result that downstream catches have fallen by 80 per cent and some 700 fishers have been affected by the dam. Kudlavicz does not, however, attempt to place a monetary value on the use values foregone through the decreased catches.

## 5.6 The URRRA Dam

Fishing production dropped from 6,000 to 1,700 tonnes per year (Correa 1999) in the lower Sinu Basin following the construction of the URRRA dam in Colombia in the early 1990s. This has had a particularly devastating effect on the people who depended upon fish as their main source of animal protein even though the study failed to quantify this consumption shortfall.

## 5.7 The Ralco Dam

*The Ralco Dam and the Pehuenche People in Chile: lessons from an ethno-environmental conflict (Aylwin 2002)*

As with many dams built in Central and South America, the issue of indigenous peoples is prominent in the discussion. The standoff between the Pehuenches and the Chilean

government over the imminent flooding of the Bio-Bio river, downstream of the Ralco dam, is analyzed by Aylwin. In common with all the available literature on the dam, the indigenous rights aspect of the project has overshadowed the environmental aspects; indeed, there is evidence that environmental assessments ordered by the World Bank on the Pangué dam further upstream were suppressed by the government. However, Aylwin does describe the impact of the dam on the fisheries, noting that six species endemic to the Bio-Bio River are likely to be lost when the valley is flooded, resulting in some loss of existence values. Moreover, he points out that the Pehuenche people who have traditionally relied upon the river for their livelihoods will suffer a potential loss in income as the river changes in nature (from a fast-flowing, steep river to a sluggish river) and the fisheries are consequently affected. No values are ascribed to the fisheries or their potential loss or change. In terms of relocation values, the figures quoted by the Miami Herald (6 November 2002) show that 84 of the 92 families who were affected by the dam have already moved out while 7 remained (the core of the indigenous protest), and that US\$ 20 million was allocated for the relocation (which amounts to US\$ 217,391 per family). This comparatively high figure perhaps reflects the bequest value assigned to the unique Pehuenche culture as much as the costs of moving and rebuilding. Evidence available on various environmental lists on the Internet also suggests that the marketed non-use value of tourism on the Bio-Bio (renowned as a white-water rafting destination) will be adversely affected by the flooding of the valley, although, once again, no supporting figures are given.

## 5.8 Hidrovia projects

*Critical environmental costs of the Paraná-Paraguay waterway project in South America (Bucher and Huszar nd)*

The Hidrovia project aims to create a navigable waterway 3,442 km long between

Caceres in Brazil and the harbor at Nueva Palmira in Uruguay. This will involve drastically altering the course of the river and would affect the Pantanal, the largest wetland in the world. Bucher and Huszar argue that if the critical value of the environmental costs of the project (i.e., the existence and bequest values) were included in the evaluation, they would tip the balance towards preserving the Pantanal rather than building the Hidrovia. Although no figures are presented to back up their assertions, the authors indicate that the implications of disturbing the water flow through the Pantanal would be complex and critical; water flow in rivers would increase, causing increased erosion and flooding during the rainy season. They also cite the potential loss of fish biodiversity as particularly important, but again no figures are given. Finally, the authors argue that while the current economic evaluation of the project shows a net positive return, the underlying assumptions are very sensitive and the environmental costs have not been internalized.

*Analysis of the EIA for the Araguaia-Tocantins Hidrovia Project (CEBRAC 2000)*

The Hidrovia is set to be an industrial waterway designed to transport grain from the interior of Brazil to the coast for onward export. The system will link to the Tucuruí hidrovia through a system of locks. CEBRAC evaluated the resubmitted EIA for the Hidrovia project because the first EIA for the project was rejected wholesale by the Federal Chamber of Deputies of Brazil on the grounds that it was full of errors. They list a catalogue of potential ecological, social and economic disasters should the plan be carried out. Many indigenous groups dependent on fish for their livelihoods will be directly affected; changes in fish populations will also have knock-on effects on other species in the food web. The analysis is scathing of the impact of this vast hydrological project; the authors find no justification at all for it. They argue that the economic cost of the project



is seriously underestimated as the feasibility of the project is simply based on comparing the savings in transportation costs with the costs of building the hidrovía. Unfortunately, the authors provide no data to support their claims.

## 5.9 Pollution Effects

Mining has been present on many rivers in CSA since the time of the Spanish occupation in the 16<sup>th</sup> century; as a result, the rivers have often acted as sinks for mining debris and the inputs used in the mining process (notably mercury). Research on the Internet also reveals that mining is currently the most commonly mentioned factor in river pollution in CSA. Many cases are cited on the Internet about the pollution of rivers in the region (See <http://www.globalminingcampaign.org/theminingnews/case.html>), but many of them are anecdotal, and there are few academic texts that quantify the level of pollution and its impact on fish resources. A recent cyanide spill on the Omai River (in the Essequibo River basin in Guyana), for example, caused the death of thousands of fish, and the Pan-American Health Organization, responding to the call for assistance by the government of Guyana, concluded that the Omai River was a dead river, devoid of any life. The fact that no baseline data exist for the many aquatic species of the river means that the impact will never be fully known.

## 6. CONCLUSION

In order to calculate a TEV for the river fisheries of Central and South America, a considerable amount of data is required on both direct and indirect use values. Thus, data are needed not only on the value of the fishery (marketed and non-marketed values) but also on the value of the underlying biodiversity of the system, the *existence* of the fishery, the livelihoods of the fishers, the existence (now and in the future) of the environment in a pristine or altered state,

the continued existence of certain indigenous groups, the aesthetic value of the resource (the river, the falls, the lake), and so on.

Yet, the importance of the inclusion of non-use values is highlighted in the study carried out in the Chilean National Parks (see section 3), where the TEV for the parks exceeded by forty times the non-use values calculated. In other words, a failure to account for both the value of the fishery and the surrounding ecosystem is likely to seriously undervalue the real value of the resource. However, with much of the necessary data on non-use values absent and very little data on the value of the fishery itself, computing a TEV for the freshwater river fisheries of CSA is impossible at present.

This report also looked at the impact of altered water courses on fisheries, particularly the impact of dams and water abstraction schemes. The report found that, again, there was a paucity of information on this topic. While many dam evaluations have cited a change in catches from rivers, or a change in the diversity of fish stocks, few attach numbers to such assertions and not one report attempts to quantify the level of impact in an economic/market sense. The only indication the reports give of the *value* ascribed to the area is in the size of the relocation grants given to affected households. These relocation monies represent the cost of rebuilding a house, and some also represent the potential lost earnings as a result of being shifted to less productive land or to an entirely different environment. There is an additional problem, however, of using relocation prices as a proxy for the impact of dams on fisheries. The bargaining power of the fishers is very weak and their acceptance of the relocation package may be wrongly interpreted as a *willing-to-accept* payment for their lost/changed livelihood rather than as a *having-to-accept* payment. Many of the fishers are functionally illiterate and are certainly not

able to negotiate relocation costs either on the basis of a good understanding of the implications of these decisions, or on the basis of complete information. Conversely, of course, in some cases the sums offered (and accepted) for relocation may stand for a fair representation of the impact of the dam on livelihoods; for example, some fishers may be more than happy to accept an apartment in the city in exchange for a precarious livelihood based on an unstable resource in the rural areas.

However, despite the less than positive summary above, some studies conducted on discrete parts of the continent have provided us with examples of the sorts of values we might hope to obtain. The authors suggest that attempts to value CSA river fisheries could be developed in two directions. First, the Provarzea project run by IBAMA (see section 3) has offered detailed catch and price data for selected parts of the Amazon basin and could provide a useful starting point for computing a more all-embracing value of the TEC of local fisheries. However, it will not be easy to extend such analyses to encompass the entire river basin, let alone the continent's other inland fisheries.

Second, the value of sport fishing in CSA (like in most parts of tropical Africa and Asia) remains an unknown quantity. A cursory glance on the Internet shows that the Amazon and Plate river basins offer numerous opportunities for sport fishing ventures (both for locals and foreign tourists), yet sport fishing as a contributor to the local economy is rarely taken seriously. Likewise, the role of white-water rafting and other riverine-based tourist activities could (and probably do) contribute significant amounts of foreign exchange to Peru, Bolivia, Chile, and many countries in Central America; yet there are no studies known that attempt to establish an economic value of these activities. The authors thus propose that a series of CVM

studies be conducted on the principal sport fishing venues in Brazil, Uruguay, Argentina and Chile as a first step in generating a value for recreational fishing in the region.

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## APPENDIX 1: MAJOR RIVER BASINS AND THEIR TRIBUTARIES IN SOUTH AMERICA

River Basin	Characteristics
Amazon Brazil	<b>Amazon:</b> Has up to 1,000 tributaries, including 7 more than 1,000 miles long Total length: 6,516 km 7,180,000 km sq drainage Western-most reaches referred as the Solimões <b>Negro:</b> Venezuela and Brazil <b>Tocatins:</b> Brazil, flows into Para Length: 2,699 km <b>Para:</b> <b>Madeira:</b> Confluence of Beni and Maumore rivers, forms Bolivia-Brazil boundary Length: 3,238 km <b>Purus:</b> Length: 3,590 km
Nordeste Basin Brazil 362 000 km sq drainage	<b>Parnaiba</b> Total length: 1,485 km <b>Mearim</b> <b>Das Balsas</b> <b>Pindare</b>
Tocantins-Araguaia Brazil	<b>Tocantins</b> (See Amazon Basin) <b>Araguaia</b> <b>Das mortes</b>
Paraguay Brazil	<b>Paraguay:</b> Brazil-Paraguay, Argentina, flowing into Parana River Total length: 2,549 km <b>Parana:</b> Confluence of Paranaiba and Grande, flowing into Plate River Total length: 4,498 km Parana-Paraguay system flows through Brazil, Bolivia, Paraguay, Argentina and Uruguay
Leste Brazil	<b>Paraiba do Sul</b>
Tiete-Parana Brazil	<b>Grande</b> <b>Parana</b> (See Paraguay Basin) <b>Paranapanema</b> <b>Ivai</b> <b>Paranaiba</b> <b>Tiete</b>
Do Sul Brazil	<b>Ibicui</b> <b>Canal de Sao Goncalo</b> <b>Jacui</b> <b>Lagoa Mirim</b> <b>Lagoa dos Patos</b> <b>Taquari</b> <b>Uruguai</b>
Rio de la Plata Brazil	<b>Pilcomayo:</b> Headwaters in Bolivian Andes, flowing into Paraguay River Total length: 1,999 km Flows into Atlantic 4,700 km long 2,650,000 km sq drainage
Sao Francisco Brazil	<b>Sao Francisco:</b> Headwaters in southwest Minas Gerais, Brazil, flowing into Atlantic Total Length: 3,198 km <b>Corrente</b> <b>Grande</b>

Orinoco Brazil	Headwaters in Serra Parima Moutains, VZLA, flowing into the Atlantic Total length: 2,062 km 1,086,000 km sq drainage
Pilcomayo Argentina Bolivia Paraguay	Headwaters in Bolivia Flows into Atlantic in Argentina Total Length: 2,500 272,000 km sq drainage, 92% in Bolivia
Bio-Bio Chile	Headwaters on Chile/ Argentina border Flows into Pacific Total Length: 380 km 24,260 km sq drainage
Colorado Argentina	Headwaters in Chilean/ Argentinean Cordillera, flowing into Atlantic

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## APPENDIX 1a: MAP OF LATIN AMERICAN RIVERS



## APPENDIX 2: CROCODILE CAPTURES IN CENTRAL AND SOUTH AMERICA 1985-2001

		1985	1990	1995	2000	2001
Bolivia	Spectacled caiman	.	300	.	.	28 170
	Nile crocodile	.	.	.	1 477	50
	Spectacled caiman	.	.	369	8 286	1 253
Colombia	American crocodile	.	.	.	.	100
	Spectacled caiman	.	119 612	828 533	832 203	704 313
Guyana	Cuvier's Dwarf caiman	.	.	.	409	476
	Smooth-fronted caiman	.	.	.	270	423
	Spectacled caiman	158 190	12 633	1 556	9 880	5 917
Honduras	Spectacled caiman	.	5 000	2 000	.	.
Mexico	Morelet's crocodile	.	.	2	1 228	3 643
Nicaragua	Spectacled caiman	.	.	4 238	6 440	.
Panama	Spectacled caiman	.	.	2 005	10 250	9 926
Paraguay	Spectacled caiman	.	.	19 793	9 750	3 792
Venezuela	Spectacled caiman	.	91 861	55 195	23 655	14 978
	TOTAL PIECES	158 190	229 406	913 691	903 848	773 041

### APPENDIX 3: FRESHWATER CULTURE PRODUCTION IN CENTRAL AND SOUTH AMERICA 1965-2000

		1965	1970	1975	1980	1985	1990	1995	2000
Argentina	Giant river prawn	.	.	.	.	.	.	12	.
	Pacu	.	.	.	.	.	.	.	700
	Rainbow trout	5	19	42	90	250	300	1 412	952
	Red claw crayfish	.	.	.	.	.	.	.	32
	Tilapias nei	.	.	.	.	.	.	.	10
Bolivia	Argentinian silverside	.	.	.	.	.	290	.	.
	Common carp	.	.	.	.	.	30	26	40
	Freshwater fishes nei	.	.	.	.	.	51	.	.
	Nile tilapia	.	.	.	.	.	.	70	30
Brazil	Rainbow trout	.	.	.	.	.	144	520	335
	Cachama	.	.	.	.	.	.	2 330	9 776
	Characins nei	.	.	.	.	.	.	4 070	5 081
	Common carp	.	.	.	.	.	.	16	54
	Freshwater fishes nei	.	.	100	3	10	18	1 644	25
				291	000	000	000		788
	Freshwater siluroids nei	.	.	.	.	.	.	2 452	2 475
	Giant river prawn	.	.	112	273	400	600	341	4 531
	Prochilods nei	.	.	.	.	.	.	.	1 363
	Rainbow trout	.	.	.	.	.	.	762	1 447
	Tilapias nei	.	.	.	.	.	.	12	32
								014	459
Chile	Atlantic salmon	.	.	.	.	.	.	.	.
	Coho(=Silver)salmon	.	.	.	.	.	.	.	.
	Rainbow trout	.	<0.5	<0.5	92	619	3 628	2 630	655
	Sea trout	.	.	.	.	.	.	.	.
Colombia	Barred sorubim	.	.	.	.	.	.	.	20
	Cachama	.	.	.	.	.	.	.	510
	Common carp	.	.	.	.	5	50	4	1 000
	Dorada	.	.	.	.	.	<0.5	<0.5	30
	Duckbill catfish	.	.	.	.	.	.	.	10
	Freshwater fishes nei	.	.	.	.	10	5	.	450
	Giant river prawn	.	.	.	.	1	60	.	.
	Netted prochilod	.	.	.	.	.	<0.5	<0.5	.
	Nile tilapia	.	.	19	93	300	2 040	3 747	3 720
	Pirapatinga	.	.	.	6	50	1 100	3 181	14
									980
	Prochilods nei	.	.	.	.	.	.	.	1 510
	Rainbow trout	.	.	29	98	400	1 200	9 297	9 016
	Redbreast tilapia	.	.	.	.	2	<0.5	<0.5	.
Tilapias nei	.	.	.	.	.	.	12	19	
							310	150	
Ecuador	Cichlasoma nei	.	.	.	.	.	.	.	.
	Giant river prawn	.	.	41	385	671	849	800	800
	Green terror	.	.	.	.	.	3	<0.5	.



		1965	1970	1975	1980	1985	1990	1995	2000
Panama	Bighead carp	.	.	.	.	1	1	1	.
	Blue tilapia	.	.	.	.	4	<0.5	<0.5	<0.5
	Cachama	.	.	.	.	53	56	7	<0.5
	Common carp	.	.	.	.	26	29	25	2
	Cyprinids nei	.	.	.	.	<0.5	<0.5	<0.5	<0.5
	Freshwater fishes nei	.	.	.	.	.	.	.	.
	Giant river prawn	.	.	.	.	5	6	3	<0.5
	Grass carp (=White amur)	.	.	.	.	20	29	57	.
	Jaguar guapote	.	.	.	.	<0.5	<0.5	<0.5	.
	Nile tilapia	.	.	.	.	69	8	.	900
	Silver carp	.	.	.	.	69	138	40	.
	Tilapias nei	.	.	.	.	.	41	186	.
Paraguay	Channel catfish	.	.	.	.	.	.	.	7
	Characins nei	.	.	.	.	.	10	30	20
	Common carp	.	.	.	.	.	25	80	20
	Grass carp (=White amur)	.	.	.	.	.	.	.	10
	Prochilods nei	.	.	.	.	.	.	.	6
	Tilapias nei	.	.	.	.	<0.5	26	80	40
Peru	Arapaima	.	.	.	.	.	20	<0.5	.
	Argentinian silverside	.	.	.	.	.	.	2	.
	Cachama	.	.	.	.	.	85	7	73
	Characins nei	.	.	.	.	.	<0.5	<0.5	.
	Common carp	.	.	.	.	.	35	.	.
	Dorada	.	.	.	.	.	<0.5	2	.
	Freshwater fishes nei	.	.	.	.	.	60	2	.
	Giant river prawn	.	.	.	.	.	5	100	13
	Netted prochilod	.	.	30	120	160	20	3	810
	Nile tilapia	.	.	.	10	52	186	.	8
	Pirapatinga	.	.	.	.	.	77	2	17
	Rainbow trout	.	40	269	350	607	1 608	635	3 075
Velvety cichlids	.	.	.	.	.	<0.5	<0.5	.	
Suriname	Freshwater fishes nei	.	.	.	.	.	.	<0.5	<0.5
	Giant river prawn	.	.	.	.	<0.5	<0.5	<0.5	<0.5
Uruguay	Common carp	.	.	.	.	.	.	2	1
	Red claw crayfish	.	.	.	.	.	.	.	.
	Siberian sturgeon	.	.	.	.	.	.	.	5
	South American catfish	.	.	.	.	.	3	4	3
	Sterlet sturgeon	.	.	.	.	.	.	.	70
Venezuela	Barred sorubim	.	.	.	.	.	.	.	180
	Cachama	.	.	4	32	160	49	680	3 000
	Prochilods nei	.	.	.	.	.	.	.	250
	Rainbow trout	.	20	130	240	345	212	230	500
	Tilapias nei	.	.	.	.	.	4	1 650	970

"nei" is the FAO term for "not elsewhere included"

## APPENDIX 4: FRESHWATER CAPTURE PRODUCTION FOR CENTRAL AND SOUTH AMERICA 1950-2000

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Argentina											
Characins nei	9 300	4 700	7 700	9 100	1 700	10 551	4 685	6 937	6 734	11 700	3 000
Freshwater fishes nei	3 600	2 300	6 000	1 500	1 700	2 125	886	344	308	2 908	6 098
Freshwater siluroids nei	800	900	1 000	2 300	2 000	2 369	2 756	2 284	3 089	2 500	3 500
Prochilods nei	.	.	.	.	.	.	.	.	.	.	17 700
Rainbow trout	.	.	.	.	.	.	.	150	150	3	.
Freshwater fishes nei	.	.	.	.	<0.5	25	25	1	1	<0.5	<0.5
Common carp	.	.	.	.	.	.	.	.	.	.	.
Bolivia											
Freshwater fishes nei	500	600	700	1 600	1 000	1 000	4 129	3 720	2 987	4 726	4 911
Rainbow trout	.	.	.	200	100	50	50	50	236	116	345
Cachama	.	.	.	.	.	.	.	.	.	11 379	4 965
Brazil											
Characins nei	12 600	16 800	21 800	40 000	38 500	80 726	72 155	97 787	95 400	81 433	67 297
Cichlids nei	1 200	1 600	2 100	2 800	4 200	8 359	7 784	11 233	14 700	12 045	8 145
Cyprinids nei	.	.	.	<0.5	<0.5	10	65	214	100	119	355
Freshwater crustaceans nei	500	1 000	1 800	700	1 100	2 385	.	.	9	<0.5	<0.5
Freshwater fishes nei	7 200	9 600	12 400	22 200	5 600	20 473	33 659	21 505	20 397	40 372	49 593
Freshwater siluroids nei	9 000	12 000	15 500	25 500	35 400	52 630	51 314	50 165	42 800	40 048	58 474
Rainbow trout	.	.	.	.	.	.	.	91	5	<0.5	<0.5
River prawns nei	100	200	400	2 800	8 400	6 719	9 854	9 751	6 600	1 412	2 437
Tilapias nei	.	.	.	.	100	2 025	9 442	9 875	11 100	6 234	7 893
Common carp	.	.	.	.	.	.	.	.	.	.	.
Chile											
Freshwater prawns, shrimps nei	.	.	.	.	.	.	.	1	32	.	.
Colombia											
Characins nei	9 500	11 000	7 000	17 700	18 200	26 158	28 630	24 978	19 507	5 698	6 600
Freshwater fishes nei	1 000	1 500	3 000	4 900	7 600	8 751	10 473	16 300	10 202	9 108	7 800

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Freshwater siluroids nei	4 000	4 500	1 400	3 300	7 400	7 118	7 603	6 430	4 231	8 718	10 454
Giant river prawn	.	.	.	.	.	.	.	.	.	.	.
Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	48	323	300	300	900	1 000
Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	206	867	600	300	400
Catfishes nei	.	.	.	.	.	.	.	.	.	250	142
Freshwater crustaceans nei	.	.	.	.	.	.	.	<0.5	4	5	9
Freshwater fishes nei	800	900	1 400	1 600	800	869	1 818	1 232	865	967	1 177
Freshwater molluscs nei	.	.	.	.	.	.	.	.	.	.	8
Jaguar guapote	.	.	.	.	.	.	.	.	.	608	324
Nile tilapia	.	.	.	.	.	.	.	1 559	2 772	2 494	1 171
Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cichlids nei	.	.	.	.	.	.	.	.	.	5	192
Freshwater fishes nei	<0.5	100	200	200	400	550	400	47	2 599	4 020	7 109
Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	681	800	800	700	800
Freshwater fishes nei	.	.	.	<0.5	100	170	41	.	45	127	61
Giant river prawn	.	.	.	.	.	.	35	32	.	.	.
Freshwater fishes nei	100	200	600	1 100	1 300	359	79	84	150	538	396
River prawns nei	.	.	.	.	.	.	.	.	.	.	<0.5
Tilapias nei	.	.	.	.	.	.	.	.	.	.	680
Peacock cichlid	.	.	.	.	.	.	.	.	15	120	4
Tilapias nei	<0.5	<0.5	<0.5	<0.5	.	.	.	50	.	10	16
Characins nei	.	.	.	.	.	.	.	2 000	3 990	7 700	9 000
Freshwater fishes nei	400	500	600	700	1 800	2 800	3 300	2 500	2 500	3 800	4 000
Freshwater siluroids nei	.	.	.	.	.	.	.	3 000	6 000	9 500	12 000





## CHAPTER 2

# Review of River Fisheries Valuation in West and Central Africa

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## Contents - Chapter 2

<b>Abstract</b>	49
<b>1. Introduction</b>	50
<b>2. Methodology</b>	51
2.1 Geographical Focus	51
2.2 Economic Valuation Study Approaches in Fisheries	52
2.2.1 Conventional Economic Valuation	52
2.2.2 Economic Impact Analysis (EclA)	54
2.2.3 Socioeconomic Analysis	54
2.2.4 Livelihood Analysis	54
2.3 Information Sources, Collation and Synthesis	56
<b>3. The Economic Value of River Fisheries in West and Central Africa</b>	57
3.1 Overview	57
3.2 Conventional Economic Valuation	57
3.3 Economic Impact Analysis	60
3.4 Socioeconomic and Livelihood Analysis Information	62
3.4.1 The Experience of the Traditional Management of Artisanal Fisheries Project (TMAF)	62
3.4.2 Lake Chad Basin Fishery Project	63
3.4.3 The Sustainable Fisheries Livelihood Program	64
<b>4. Economic Impact on Fisheries of Changes in River Basin Management</b>	65
4.1 Conventional Economic Valuation (CEV)	65
4.1.1 Economic valuation of the wetlands benefits: The Hadejia-Jam'are Floodplain, Nigeria; and the impact of the Kano River Project (Barbier et al. 1991; 1993)	65
4.1.2 Economic Impact of Changes in River Basin Management on Fisheries in NE Nigeria	66
4.2 Economic Impact Assessment (EcIA)	69
4.2.1. The Maga Reservoir and the Yaere Floodplain (Cameroon)	69
4.2.2. The Niger River Mali	70
4.3 Socioeconomic and Livelihood Analysis (SE-LA)	70
<b>5. Assessment of Valuation Methodologies</b>	70
<b>6. Conclusions and Recommendations</b>	72
<b>References</b>	73
Appendix 1: Major River Basins of West and Central Africa	76
Appendix 2: Potential Economic Value of Western and Central African Basins	80
Appendix 3: Country Fisheries Profiles	82

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## **ABSTRACT**

This paper provides a review of the valuation of river fisheries in West and Central Africa. It is the general perception that, compared to the biological and ecological aspects of river fisheries, this particular subject area has received relatively little attention. Economic valuation is concerned with finding expression for what is important in life for human society. It should, therefore, be a central and integral part of government decision-making and policy. The review started with concepts and methods for valuation. Three main types of valuation techniques were identified: conventional economic valuations, economic impact assessments and socioeconomic investigations, and livelihood analysis. On the basis of a literature review, valuation information was then synthesized for the major regional river basins and large lakes, and also used to develop a series of national fisheries profiles. To supplement this broad perspective, a series of case studies are also presented, which focus in particular on the impact of changes in water management regime. Finally, the paper presents an assessment of the three main types of valuation methodology and a set of conclusions and recommendations for future valuation studies.

### **Keywords:**

River fisheries review; Valuation; Economic valuation; West Africa; Central Africa; Future research

## 1. INTRODUCTION

The role of inland fisheries in providing a wide range of economic and social benefits for developing countries throughout the world is increasingly recognized by governments and international development agencies. In particular, river and floodplain fisheries have been observed to underpin the livelihoods of many millions of people in major river basins such as the Amazon, Congo, Ganges, Mekong, Niger and others.

However, it is also widely acknowledged that, apart from fisheries, there is increasing demand on the use of inland water resources for a wide range of other activities including hydroelectric power, irrigation, navigation and industrial uses. The problems for fisheries management, which this multi-sectoral context creates, are often very serious and difficult to resolve. The UN FAO Technical Guidelines for Responsible Fisheries (Inland Fisheries) (1997; p.3) provides some guidance for the development of an appropriate response, stating that,

**“Management should be conducted in a climate of compromise with other users and depends as much on regulations governing their activities as those governing the fishery itself. In other words, inland fishery managers are rarely in control of the resource they manage. Because of this the code (Code of Conduct for Responsible Fisheries) must be interpreted to inform and involve sectors other than fisheries.”**

The development of policies for the world's river basins requires decisions to be taken concerning the alternative usage of water resources. For example, should a river system and associated floodplains be conserved for wildlife and tourism uses, or should they be managed and drained for industrial and urban

uses? Under ideal circumstances, these types of decisions should be based on a sound methodological approach that incorporates the views and desires of all stakeholders involved, and should also be underpinned by a wide range of information (hydrological, biological, ecological, economic, social and institutional dimensions).

Unfortunately, in most developing countries, the circumstances for decision-making are far from the ideal described above. The basis for sound decision-making is constrained by a range of factors, particularly the nature of weak state and weak governance (that limits stakeholder participation and cooperation) and limited institutional capacity (that limits information flows).

In the following review, we will examine one important dimension of the information base required for effective decision-making in inland fisheries – economic value. It is the general perception that this particular subject area has received relatively little attention, compared with the biological and ecological aspects of river fisheries. A review of the status of knowledge is an important starting point to address this deficiency. The paper will focus exclusively on West and Central Africa, with the primary objective of producing a review of river fisheries valuation in the region.

The paper is arranged into six sections starting with this Introduction. Section 2 provides a description of the methodology used for the review. Section 3 identifies and examines the economic value of river fisheries in West and Central Africa. Section 4 identifies and describes the economic impact on fisheries of changes in river basin management. Section 5 provides an assessment of the methodologies used for economic valuation in West and Central Africa. Section 6 presents a series of conclusions and recommendations for future valuation studies.

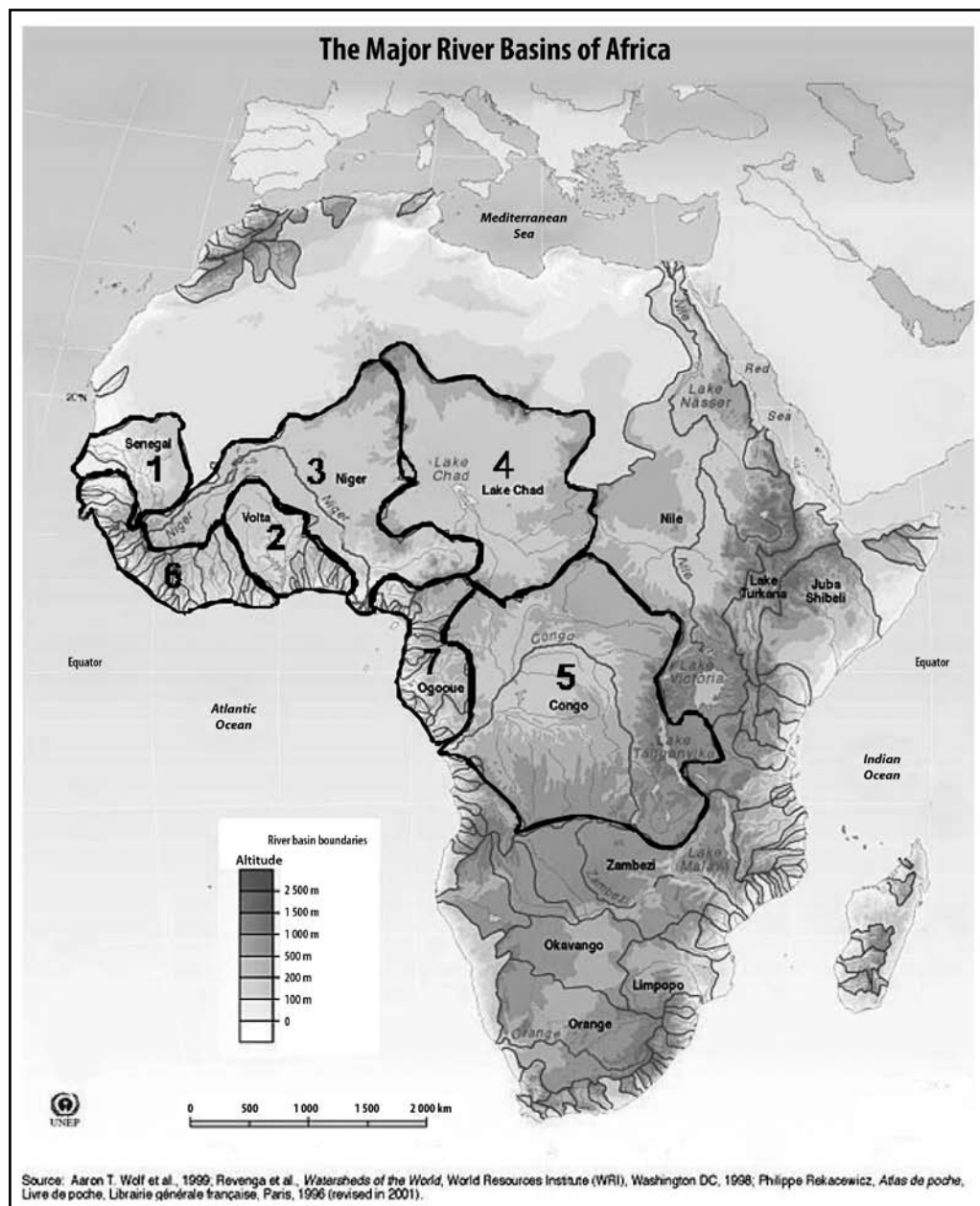
## 2. METHODOLOGY

### 2.1 Geographical Focus

For the purposes of this review, West and Central Africa is assumed to include the entire Sub-Saharan region stretching from Senegal in the West to Congo and Gabon in the East. This region covers seven major river basins (Figure 1), namely:

1. Senegal-Gambia river basin
2. Volta river basin
3. Niger-Benue river basin
4. Lake Chad basin
5. Congo-Zaire river basin
6. Atlantic coastal basin (I)
7. Atlantic coastal basin (II)

**Figure 1: The major river basins in Africa (The numbers indicate the seven basins included in this review)**



## 2.2 Economic Valuation Study Approaches in Fisheries

It is important to recognize that economic valuation in fisheries can be approached in a number of different and yet complementary ways.

In general terms, values can be defined as “beliefs, either individual or social, about what is important in life and thus about the ends or objectives which should govern or shape public policies” (Royal Commission on Environmental Pollution 1998).

Economic valuation tends to have a particular meaning to economists, as explained below, but it is appropriate to consider how this also relates to other approaches. Three broad categories of economic valuation study approaches can be identified as follows: (1) Conventional Economic Valuation, (2) Economic Impact Analysis, and (3) Socioeconomic Analysis.

### 2.2.1 Conventional Economic Valuation

In economics, the conventional approach to environmental valuation is to look for some way of measuring human preferences for or against changes in the state of the environment (improvement or deterioration). Where such preferences are expressed as willingness to pay (for example, to raise water quality on a certain stretch of river), value will be expressed in monetary terms. This can then provide a rational basis for policy decision-making over the use or management of environmental assets.

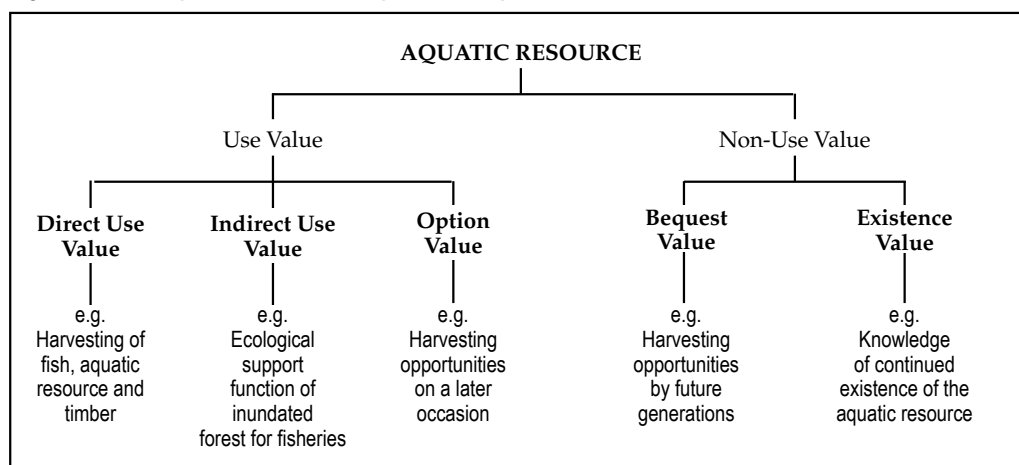
#### 2.2.1.1 Economic values as social values.

It can also be argued that economic values are social values, because the concept of

value is anthropocentric: it is the people who value the environment, and, accordingly, the estimated value resides in the individuals themselves rather than in the objects of their assessment. The arithmetic of conventional economic valuation is underpinned by *economic efficiency analysis* (EEA, which has the maximization of social welfare (defined in terms of the optimal allocation of resources) as its goal. There are two ways in which EEA is commonly applied, that is cost-effectiveness analysis and cost benefit analysis. With cost-effectiveness analysis, there is a presumption in favor of the least-cost option for achieving a given objective; with cost-benefit analysis, the presumption is in favor of the option which produces the highest ratio of monetary benefits to costs. In short, there is an implicit value judgment underlying efficiency analysis (i.e., that improvements in economic efficiency are desirable). In a policy-planning context, this presumption in favor of efficiency is the basis of a number of decision criteria that can be used to select and prioritize project options (or other interventions) in terms of their economic value to society (Whitmarsh and Premachandra pers. comm., Oct. 2003).

#### 2.2.1.2 Total economic value

It is nowadays recognized that a natural resource may provide a range of benefits according to the particular use or function it fulfills, and this forms the basis of the concept of total economic value (TEV). The components of TEV in respect of an aquatic resource, such as a river system and its adjacent floodplains, are shown in Figure 2. The obvious and tangible benefits would be those derived from *direct use* of the resource, and these may materialize in the form of commodities (e.g., fish, aquatic plants, fuel wood) or services (e.g., recreation and amenity). The aquatic resource may also have additional indirect benefits, such as providing coastal protection and serving as habitat for juvenile fish. Individuals may also

**Figure 2: The components of TEV in respect of an aquatic resource**

derive a benefit from being able to postpone their personal use of the resource to a later date; they attach an option value to using the resource. There is also another distinct type of benefit, called *non-use* value or *passive* value. This might include the value associated with the desire to maintain a river fishery intact for future descendents (bequest value) or simply the satisfaction from knowing that a particular aquatic habitat has been preserved in perpetuity (existence value).

### 2.2.1.3 Valuation in practice

Valuation is always a comparative exercise, and it is appropriate to consider how such comparisons might be undertaken. At its crudest, this might involve comparing the economic benefits provided by a natural resource in its current state with the absence of benefits if the resource were to be removed or completely destroyed. However, in reality, policy decisions tend to involve incremental (or marginal) changes from current conditions. For example, in the case of fisheries policy, we might wish to know how economic benefit might change if harvesting activity on a certain river were regulated using a different set of management measures; the comparison would thus be between the existing policy (i.e., the base case) and proposed regime. Within the framework of cost-benefit analysis, the comparative estimates of economic value

could then be used to decide whether the proposed policy change was worthwhile or whether it would be preferable to keep the status quo. Another way in which economic values may be compared is over time, an exercise that may prove necessary in situations where, in particular, there is concern about environmental degradation and the aim is to measure the social cost of this change. An especially important application of this type of retrospective comparison is natural resource damage assessment, an ex-post form of cost-benefit analysis used to assess the social cost of particular incidents (e.g., oil spills) or interventions (e.g., major infrastructure projects).

### 2.2.1.4 Valuation techniques

There are two broad classes of valuation techniques, direct and indirect. Direct techniques involve descriptions of situations to individuals and assessment of their valuations through direct questions. Contingent valuation method (CVM) and stated preference are examples of direct techniques. CVM has the advantage of being able to measure use and non-use (passive) values. Stated preference analysis, or the experimental analysis of choice, has its roots in conjoint analysis (CA). CA is a form of analysis used to represent individual judgments of multi-attribute stimuli. Indirect techniques (also known as revealed

preference techniques) use information on actual behavior to build economic models of choice. These models are then used to determine the value of environmental change. Indirect techniques are based on traditional economic theory, which provides several decades of experience in empirical modeling. Examples of revealed preference techniques include travel cost models and hedonic price models.

### 2.2.2 Economic Impact Analysis (EclA)

In contrast to the EEA described above, economic impact analysis (EclA) does not set out to determine whether a particular policy intervention or project is either beneficial or detrimental in terms of economic worth to society. While EclA will consider the level of benefits generated by an intervention, it does not consider costs of implementation (i.e., there is no benefit-cost framework). Instead, EclA aims to establish what effect a particular policy intervention or project has on specific variables. This might involve using revenue analysis to see whether a new fisheries management system is likely to raise fishers' gross earnings or revenue. The analysis would typically require the estimation of a demand function for the harvested product in order to determine the impact of changes in supply on market price (and hence total sales revenue). More ambitiously, EclA might involve the application of *multiplier analysis* to measure the total economic activity generated by a new fisheries management system (e.g., on output, income or employment) as a consequence of the interdependence between fishing and other sectors comprising the regional economy. The total economic impact will be made up of direct and secondary (i.e., indirect and induced) effects.

### 2.2.3 Socioeconomic Analysis

Finally, it is important to reiterate the point made above that conventional economic valuation is concerned with the analysis of

whether a particular intervention or project improves the net wealth of society. It might be the case that this outcome also involves the creation of *winners* and *losers* in society. For example, the building of a dam across a river for hydroelectric power involves a wide diversity of effects including major changes in environmental quality and aquatic resource use. Conventional cost-benefit analysis sidesteps the issue by invoking the principle of *potential compensation* (i.e., that the intervention represents a net gain to society if the winners could compensate the losers and still be better off), but because this principle does not insist that compensation actually be paid, it starts to become rather unsatisfactory where the losers also happen to be the poorest of the society/community.

In summary, the arithmetic of economic valuation may well adjudge a project such as dam construction to be worth undertaking insofar as it improves the net wealth of society, but it is unclear whether the social impact of the project is unlikely to be neutral. In such situations (especially where there is poor governance within the weak state context), something more than economic valuation is warranted, specifically a *distributional analysis* to examine how the net costs and benefits are apportioned across different groups affected by the change. Socioeconomic analyses that uses participatory rural appraisal techniques (PRA) such as group discussions and wealth-ranking can often provide an important starting point in identifying and characterizing the socioeconomic strata in a community or region. Once the social strata are known, further in-depth economic studies (e.g., income-expenditure surveys) can provide a better understanding of benefit flows (or the lack of them) in relation to specific policy interventions.

### 2.2.4 Livelihood Analysis

In recent years, socioeconomic analysis has been further extended with the development of techniques for livelihood analysis (LA).



When underpinned by frameworks such as the sustainable livelihoods approach (SLA) (After Scoones 1995), they can help to provide a better understanding of the relationship between human society and natural resources. In this respect, LA can be used to complement economic valuation and socioeconomic analysis.

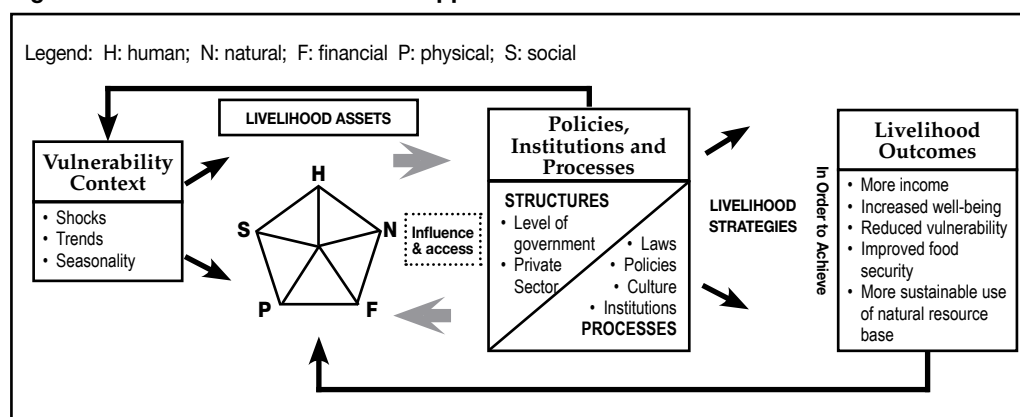
But why do we need to employ an additional set of LA techniques? Well, it can be argued that the objective of the economic valuation of the natural environment is to attach economic values to environmental resources or natural assets, and that by definition these economic valuations represent *resource-centered approaches*. It can also be argued that adequate policies and effective management of natural resources require information about the people involved, and the ways in which people use natural resources to sustain livelihoods. In other words, to make an appropriate decision regarding the management of a natural resource, one not only needs the economic value (albeit through the most comprehensive evaluation framework possible, such as the TEV), one also needs to know the contribution that this resource makes to livelihoods: Who uses the resources? When? How?

More fundamentally, economic valuation techniques do not permit the identification of the factors that influence or affect people's access to these resources. However, very

often the key issue is not the availability of the resource (or symmetrically its scarcity to which its economic or even social value is related) but the access to this resource. In extending Sen's main conclusion initially framed in the specific context of famine (Sen 1981) to the wider domain of natural resources, it should be recalled that poor people are usually those who lack access to these resources. In this context, determining the value of the resource is irrelevant if people cannot access it. Therefore, a key question is: what are the factors that influence people's access to, and control over, natural resources?

The Sustainable Livelihoods Approach (SLA) is a holistic and people-centred approach that attempts to capture and provide a means of understanding people's livelihoods, and in particular the factors and processes that affect these livelihoods. The framework (Figure 3) consists of five components: (1) the vulnerability context of the environment in which the communities under consideration operate; (2) the livelihood assets of these communities; (3) the policies, institutions and processes (PIPs) which affect their lives and in particular their access to livelihood assets; (4) the livelihood strategies which the communities adopt; and (5) the outcomes they achieve or aspire to. An important aspect of the SLA is its use in helping to understand the role of institutions (e.g., rules that affect resource access).

**Figure 3: The Sustainable Livelihood Approach SLA framework**



When combined with more conventional economic and socioeconomic techniques (e.g., economic valuation and household income-expenditure surveys), LA is a powerful tool that can provide the following benefits:

- an analysis of the causes of vulnerability – shocks and stresses in the economic, social and political context, trends, seasonality, fragility of natural resources, etc. – which affect the communities;
- an assessment of the assets, at the individual, household or community levels, comprising human, social, economic, physical and natural resource assets;
- a description of the context within which livelihoods evolve – policies at both micro- and macro-levels; civil, economic and cultural institutions, both formal and informal; the nature of governance and its processes at all levels in society;
- an identification of people's livelihood strategies, including, but not restricted to, consumption, production and exchange activities; and
- an evaluation of the resulting livelihood outcome, assessed multi-dimensionally in terms of food and other basic needs – security, greater sustainability of the natural resource base, reduced vulnerability and increased income.

The value of such a framework is to encourage analysts to take a broader and systematic view of the factors that affect people's livelihoods – whether these are shocks and adverse trends, poorly functioning institutions and policies, or a lack of assets – and to investigate the relations between them. It does not take a sectoral view, but tries to recognize the contribution made by all the sectors to building up the stocks of assets upon which people draw to sustain their livelihoods.

## 2.3 Information Sources, Collation and Synthesis

In order to establish an appropriate basis for the Review of River Fisheries Valuation in West and Central Africa, an extensive literature search was undertaken, mainly through on-line searches of the international literature and information databases. Other gray literature was provided by current regional programs (e.g., DFID/FAO Sustainable Fisheries Livelihoods Programme [SFLP]) or in the case of past regional programs or projects, literature was accessed through various libraries and collections (e.g., CEMARE Library, University of Portsmouth).

The review process consisted of four steps:

Step 1: the literature search aimed to undertake an inventory of all the valuation studies that had been undertaken in West Africa in recent times (since 1980). Initially, the outputs were collated according to the three broad methodological approaches:

- Conventional economic valuations (CEV)
- Economic Impact Assessments (EclA)
- Socioeconomic investigations and livelihood analysis (SE-LA)

Step 2: the resultant information was also synthesized (Appendix 1 and Appendix 2) according to the seven major regional river basins and the three largest lakes/reservoirs (Lake Volta, Lake Chad, and Lake Kainji) to highlight the following characteristics:

- Identification of all riparian countries
- Identification of major rivers and floodplains
- Length of river and floodplain area
- Number of fishers by river/floodplain

- Total annual catch by river/floodplain/river basin
- Identification of economic impact or value of fisheries

Step 3: a number of important and well-studied case studies of economic valuation in West and Central Africa were identified (including the Chad Basin, the Hadejia-Nguru-Gashua Wetlands and the Central Delta of the River Niger in Mali). The important elements that were highlighted for each included:

- Key methodologies employed and resultant values
- Impact of changes in water management regime (where available)
- Contribution to understanding the role of fisheries in livelihoods

Step 4: Finally, a series of National Fisheries Profiles for countries in West/Central Africa were developed, based on the following criteria for inclusion: (a) the share of inland fisheries production is >10 per cent of the total domestic catch and (b) the potential annual catch is estimated in the literature to be >5000 tonnes (Appendix 3).

### **3. THE ECONOMIC VALUE OF RIVER FISHERIES IN WEST AND CENTRAL AFRICA**

#### **3.1. Overview**

The results of the literature review have confirmed that information and statistics on the economic value of river fisheries in West and Central Africa are very sparse and limited, compared to information on other subjects (e.g., fisheries biology and ecology). This will not come as a major revelation for most fisheries administrators and scientists

connected with African inland fisheries. It is well known that the majority of countries concerned do not have effective statistical collection or reporting systems, mainly due to a lack of institutional capacity. While most countries provide an annual estimation of fisheries production to the UN FAO Statistical System, economic data on fisheries are not regularly reported. Despite all of this, however, it may come as a surprise to many that there is sufficient contemporary information and data to say something interesting and significant about the value of river fisheries in the region. Furthermore, the limited amount of economic valuation work that has so far been carried out successfully points the way to the potential for more work of this kind in the future. Using the three broad methodological approaches (above), the following results can be reported.

#### **3.2. Conventional Economic Valuation**

There have been very few studies of West and Central African fisheries that have attempted to apply a conventional economic valuation approach. Only two sets of studies appear in the formal literature. These are summarized below.

(a) *Economic valuation of the wetland benefits: The Hadejia-Jam'are Floodplain, Nigeria (Barbier et al. 1991; 1993)*

This study assessed the economic importance of the Hadejia-Jam'are wetlands, and thus the opportunity cost to Nigeria of its loss, by estimating some of the key economic benefits it provides to local populations (over 2 million people) through crop production, fuel wood and fishing. However, the wetlands are threatened by drought and upstream water developments that are taking place without consideration of their impacts downstream.

Based on a series of field surveys, the net benefits from the direct use of the floodplain for agriculture, fuel wood and fishing were calculated by Barbier and his co-authors, as shown in Table 1. Where appropriate, actual prices were adjusted to economic values using shadow prices. The terms “financial” and “economic” were used to express the values of commodities based on actual or market prices, and the values of commodities based on adjusted or shadow prices, respectively.

Fishing was shown to yield the annual net economic benefits of N18 million (US\$ 9 million) or N179 (US\$ 90) per hectare in the Hadejia-Jam'are wetlands. This exceeded the economic contribution from fuelwood, but was less than the contribution from agriculture.

comparing the returns to development projects that might have threatened the floodplain system. The results of this analysis will be examined in Section 4 when we examine the economic impact of changes in river basin management.

(b) *Fishing Income, Poverty and Fisheries Management in N.E. Nigeria (Neiland et al. 1998)*

As part of a DFID-funded research project “Traditional Management of Artisanal Fisheries in N.E. Nigeria”, Neiland et al. (1998) undertook an investigation of the profitability of fishing operations in three major fisheries: the Upper River Benue, the western shores of the Lake Chad, and the Nguru-Gashua Wetlands. The objective was to evaluate whether the fisheries were

**Table 1: Hadejia-Jam'are Wetlands, Nigeria: Summary of annual net economic benefits/ha 1989-90 (Barbier et al. 1991)**

Sector	Total output (tonnes)	Net economic benefits (N'000)	Total area exploited (ha)	Net economic benefits/ha (N/ha)
Agriculture	281 955	54 970	230 000	239
Fishing	6 264	17 877	100 000	179
Fuelwood	115 100	8 265	400 000	21
Total	.	81 112	.	439

The analysis of the Hadejia-Jam'are wetlands was then extended using a cost-benefit analysis of the net economic benefits over time from agriculture, fishing and fuel wood. The analysis assumed that the benefits provided by the floodplain do not arise just in a single year but that the wetlands, if properly managed, are capable of yielding a continuous stream of such benefits over a number of years. The sum of the stream of benefits discounted into present values indicated the present value of the wetlands in terms of agriculture, fishing and fuel wood (Table 2). This represented the present worth of the wetlands and was the benchmark for

generating net economic benefits, or, in other words, to see whether the resource exploitation and management systems were achieving a positive level of economic efficiency. It was assumed that economic efficiency and wealth generation from the fisheries were desirable from a societal point of view, and that this could have a positive effect on fisheries incomes and poverty alleviation (assuming that fishing communities could access the benefits). Clearly, if the fisheries were efficient and generating net economic benefits, society would probably chose to maintain their operation as a valuable contribution to the economy. If not, then steps would

**Table 2: Hadejia-Jam'are Wetlands: Present value of net economic benefits (i) per hectare, (ii) per river inflow, (iii) per controlled water release**

(i) Present value of net economic benefits per hectare (N/ha) a/

Base case	(8%, 50 years)	(8%, 30 years)	(12%, 50 years)	(12%, 30 years)
Agriculture	921	848	625	607
Fishing	300	276	203	197
Fuelwood	139	127	94	91
Total	1 359	1 251	923	895
Adjusted agriculture b/	838	773	574	558
Adjusted total	1 276	1 176	872	846

Notes: a/ economic benefits averaged over the total production area of 730,000 ha (400,000 ha for fuel wood, 230,000 ha for cropland and 100,000 ha for fishing); b/ NPV of agriculture adjusted for unsustainability of wheat production, with approx. 56% of wheat hectareage assumed unsustainable

(ii) Present value of net economic benefits per river inflow (N/'000 m<sup>3</sup>) c/

Agriculture	264	243	179	174
Fishing	86	79	58	57
Fuelwood	40	37	27	26
Total	389	358	264	256
Adjusted agriculture d/	240	221	164	160
Adjusted total	366	337	250	242

Notes: c/ based on the average annual river flow into Hadejia-Jam'are floodplain of 2,549 m<sup>3</sup> over 1985-87; d/ NPV of agriculture adjusted for unsustainability of wheat production, with approx. 56% of current wheat hectareage assumed unsustainable

(iii) Present value of net economic benefits per controlled water release (N/'000 m<sup>3</sup>) e/

Agriculture	408	375	277	269
Fishing	133	122	90	87
Fuelwood	61	56	42	40
Total	602	554	409	396
Adjusted agriculture f/	371	342	254	247
Adjusted total	565	521	386	375

Notes: e/ assumes a total controlled water release of 1,648 m<sup>3</sup> per annum from upstream water development projects on the Hadejia and Jam'are rivers; f/ NPV of agriculture adjusted for unsustainability of wheat production, with approx. 56% of current wheat hectareage assumed unsustainable

Exchange rate: N7.5 = US\$ 1 in 1989/90

Source: Barbier et al. 1991

have to be taken to improve economic performance (e.g., through better fisheries management), or to switch the inputs (labour, capital, technology) to other more productive uses.

Data for the study were obtained by a large-scale stratified sample survey of over 700 fishing households in the region,

in order to obtain information on the costs and returns of fishing operations (both financial and economic values). An earlier survey (Neiland et al. 1998) provided additional essential socio-economic information on the fishing households themselves. The results of the surveys are summarized in Table 3.

**Table 3: Fisheries of NE Nigeria: Net economic benefits, 1993-96 (Neiland et al. 1998)**

Fishery	Total no. of households	Annual catch/ household (kg)	Net economic profit/ household (N)	Total net economic profit (N'000)
Upper River Benue	5 660	877	917	5 190
Lake Chad	9 850	5 339	27 009	266 039
Nguru-Gashua Wetlands	6 026	3 077	24 002	144 636
Total	21 536	.	.	415 865

The results indicated that all three fisheries were yielding substantial net economic benefits (N415 million or US\$ 6 million), albeit at varying levels. Therefore, the contribution of fisheries to the local economy of NE Nigeria, and especially in the Chad Basin, is important and needs to be taken into account in decisions that might affect the benefit stream. In the worse-case scenario, whereby the fisheries were mismanaged or impacted by environmental changes (either natural or man-made), the opportunity cost to Nigeria would be N 415 million (US\$ 6 million). Interestingly, the majority of the fisheries within NE Nigeria are operated under traditional management systems.

### 3.3. Economic Impact Analysis

Economic impact analysis can be disaggregated into two categories:

- (a) *The seven major river basins in West and Central Africa (Table 4 and Appendix 2) provide economic indicators for employment (number of fishers), total annual fisheries production (tonnes), potential annual fisheries production (tonnes), financial value of total annual fisheries production, and financial value of potential total annual fisheries production.*

The fisheries of the river basins in West and Central Africa provide employment

**Table 4: Fisheries of the major river basins and lakes in West Africa: economic indicators**

	Employment (fishers)	Fisheries production (t/yr)	Value of production (million \$/yr)	Potential fisheries production (t/yr)	Value of potential production (million \$/yr)
River basins					
Senegal-Gambia	25 500	30 500	16.78	112 000	61.60
Volta (rivers)	7 000	13 700	7.12	16 000	8.32
Niger-Benue	64 700	236 500	94.60	205 610	82.24
Chad (rivers)	6 800	32 200	17.71	130 250	71.64
Congo-Zaire	62 000	119 500	47.80	520 000	208.00
Atlantic coastal	6 000	30 700	46.66	118 000	179.30
Major lakes					
Volta	20 000	40 000	28.40	62 000	44.02
Chad	15 000	60 000	33.00	165 000	90.75
Kainji	20 000	6 000	3.30	6 000	3.30
TOTAL	227 000	569 100	295.17	1 334 860	749.17

for a great number of households, with the largest numbers found in the Niger-Benue system (64,700) and the Congo-Zaire (62,000).

The total annual fisheries production for all the river basins in this region was 569,100 tonnes valued at US\$ 295 million (gross financial value). The highest production level for any single basin was found in the Niger-Benue River Basin (236,500 tonnes) valued at US\$ 95 million (gross financial value).

The total potential annual fisheries production for all the river basins in West and Central Africa is 1.34 million tonnes, with a potential annual value of US\$ 749 million (gross financial value).

(b) *The twelve major countries with significant inland fisheries in West and Central Africa (Table 5 and Appendix 3) also provide economic indicators on total annual catch (tonnes), financial value of total annual catch (US\$), fish consumption per capita (kg/capita), fisheries employment and percentage of fisheries contribution to GDP.*

The total annual fisheries production for the twelve countries with major inland fisheries in West and Central Africa is 597,500 tonnes. Nigeria (130,000 t/year), Chad (100,000t/year) and Mali (100,000t/year) have the largest annual fisheries production.

The total value (gross financial) of the annual inland fisheries production in the region is US\$ 1,416 millions. The countries with the largest values for national production are Mali, Chad, Senegal and Nigeria.

The average annual fish supply per capita in West and Central Africa is 11.10 kg/capita/year. The highest national averages are for Senegal (29.9 kg/capita/yr), Ghana (26.1 kg/capita/yr) and Gambia (23.7 kg/capita/yr). The lowest national averages for fish supply are for Burkina Faso (1.4 kg/capita/yr) and Nigeria (5.8 kg/capita/yr).

The total employment provided by fisheries in the twelve leading fisheries nations in West and Central Africa is 667,560, and Chad has the largest number of people working in the fisheries sector (170,000).

**Table 5: West African countries with major inland fisheries: economic indicators**

	Fisheries production (t/yr)	Value fish production (US\$million /yr)	Fish supply (kg/capita)	Employment (fishers & on-shore)	Fisheries % Agricultural GDP
Benin	34 000	29.30	9.1	75 000	Low
Burkina Faso	5 000	5.80	1.4	7 000	Low
Cameroon	50 000	36.40	9.3	65 000	Low
Chad	100 000	n.a.	6.5	170 000	High
Gambia	3 500	4.40	23.7	5 000	Medium
Ghana	53 000	380	26.1	110 000	5%
Ivory Coast	36 000	50	11.1	30 000	Medium
Mali	100 000	350	8.5	73 000	0.94
Niger	16 000	n.a.	0.47	2 000	1%
Nigeria	130 000	180	5.8	70 000	<2%
Senegal	60 000	350	29.9	60 400	5% ?
Sierra Leone	10 000	30	12.3	16 000	1%?
TOTAL	597 500	1 415.9	11.09	667 560	.

The contribution of fisheries to Agricultural GDP is generally low for the leading fishing nations in West and Central Africa. Even fisheries in Chad, which makes the largest contribution to the national economy of all nations in the region, add only five per cent to agricultural GDP.

### 3.4. Socioeconomic and Livelihood Analysis Information

The objective of this section is to *broaden* the perspective of the term “valuation assessment”, in contrast to the narrow economic sense with which it has been used so far. If we recognize that the value of an activity/resource may go beyond the purely quantitative economic estimation of the wealth generated by that activity or resource, then the term “value” should be considered and dealt with in a much broader way, in the sense of “contribution”, and the underlying question becomes: What is (are) the *contribution(s)* (i.e., no longer simply, *values*) of the activity/resource for the households, community, or society?

In the rest of this section, a series of projects or programs are reviewed that have espoused this broader definition of the concepts of “value” and “valuation process”. The review of some of the research carried out within these projects reveals that this broadening uncovers a whole set of new issues, questions and mechanisms that had been totally missed out or neglected by the economic approaches presented above.

#### 3.4.1 The Experience of the Traditional Management of Artisanal Fisheries Project (TMAF)

In this first example, the researchers again use some of the researches undertaken as part of the DFID-funded “Traditional Management of Artisanal Fisheries (TMAF)”

Project. One major element of this research was the implementation of a poverty analysis of the fishing communities living in the three regions included in the project (Upper River Benue, western shores of the lake Chad, Nguru Gashua wetland). Because of the methodological challenge presented by poverty assessment in an African rural environment (due, e.g., to the partially non-commercialized economy and the multiple activity portfolios adopted by the households) a series of interrelated methods were used to provide as wide a range of perspectives on this issue as possible, including: estimation of annual income by household (quantitative method) and participative wealth-ranking exercises within fishing communities (qualitative).

Interestingly, the wealth-ranking results showed that the fishing communities were highly heterogeneous in terms of income and wealth, ranging from “very rich” to “very poor”. It was also shown that 40 per cent or more of households in 12 case-study villages were impoverished. This state of “impoverishment” was defined by the communities themselves as having insufficient food for the year, low cash income and a reliance on other members of the community for help in time of need. They also tended to have no access to the inputs or resources (good land and fishing areas) to allow them to undertake the most valuable occupations, defined by the communities as farming and fishing.

A second important element of the project was an in-depth analysis of the local institutional arrangements (also called traditional management systems or TMS) and their potential role in the control of access to the resources and redistribution of the wealth generated by the fishing activity.

The analysis of the TMS reveals interesting results (Neiland 2000). Although TMS are widespread in the fisheries of NE Nigeria and appear to provide a basis for the sustainable



livelihoods of the fishers' families, there is also evidence that many TMS simply reinforce the exploitative positions of the local elites (and prevent some groups from achieving sustainable livelihoods). The analysis, therefore, suggests that it is important to distinguish between the two outcomes and the type of TMS that produce them. For instance, in the case of the *Bade* system (an example where the village-level traditional management system still persists), it seems that there is still a high level of equitability, with the profits of the fishery flowing back to the community. In contrast, in the *Dumba* system (an example of a neo-traditional management system associated with Islamic traditions), the results suggest that the local elites are enriching themselves at the expense of the local fishers (a form of rent-seeking activity).

In other words, a major paradox seems to exist with regards to the (potential) role of TMS in promoting sustainable livelihoods and poverty alleviation. On the one hand, TMS can be seen as the only socially and environmentally sound response by people in order to adapt to the risks and threats that this severe and unpredictable arid zone region have always produced. In that sense, and in absence of any tangible support by the authorities of the state, it can be seen as a central element that ensures the sustainability of the livelihoods of these rural populations. On the other hand, it is also possible to make a case that TMS encourage impoverishment of certain vulnerable members of fishing communities by denying access to resources and promoting exploitative social relationships.

Within the framework of the present section, this conclusion illustrates the extent to which a *pure* economic approach would have *missed the point*. None of these issues, mechanisms and dynamics relating to power relationships, distribution, socioeconomic stratification, etc. would have appeared by using a conventional economic approach.

### 3.4.2 Lake Chad Basin Fishery Project

The research undertaken under the EU-INCO project "Sustainable development of African continental fisheries: a regional study of policy options and policy formation mechanisms for the Lake Chad Basin (1998-2001)" is another illustration of what the term "valuation assessment" might mean when used in a broad, multi-sectoral and multi-dimensional sense.

The main objective of this 3-year European Commission-funded project was to carry out a multidisciplinary research program to address some of the major fisheries planning and policy constraints faced in this part of Sub-Saharan Africa, in particular (1) poorly established policy-formation mechanisms, (2) lack of relevant data and information, and (3) limited institutional capacity (Neiland and Béné 2002). As part of this project, a livelihood analysis was carried out throughout the Lake Chad Basin region. The main objective was to expand the knowledge of the so far very poorly understood livelihoods of the rural communities living in the region and, in particular, to assess the exact contribution of the fishing activities to their livelihoods.

For this purpose, a combination of participatory activity and wealth ranking exercises were carried out in 64 villages across the three main fishing areas of the Basin (Western shores of the Lake, Chari delta, and Yaere floodplain). These ranking exercises were complemented by a series of comparative analyses of the ethnic composition, level of food security, and accessibility to fishing grounds across the different socioeconomic strata (wealth groups) of the populations.

The livelihood strategy analysis, as it was designed, did not permit a quantification (in terms of overall household income) of the contribution of the different activities

undertaken by the households. But it offered an in-depth qualitative analysis of household livelihood strategies and in particular permitted a significant improvement in the understanding of the specific role of the fisheries in the multiple activity portfolios of the households. It showed in particular that for the entire area, households, irrespective of their wealth levels, still rely to a very large extent on a subsistence-based economy where the three major activities (fishing, farming and herding) are closely integrated. With respect to fishing activity, the survey demonstrates the central role of this activity (in terms of income, labor and food supply) for all wealth groups.

More importantly, however, the analysis revealed that there is not a one-to-one relationship between the contribution of fishing activity and the wealth (or poverty) level of the households. In the Yaere, the role of fishing activities increases with poverty: the poorer the people, the more they rely on fishing. In the Yaere, therefore, the fisheries seem to be the "activity of last resort". In the Chari delta and along the Western shores of the Lake, however, the situation is totally different. It is the richest who derive most of their income from the commercialization of their catches, while the poorest are only marginally involved in the fishing activities and must rely on alternative activities (such as wood cutting or daily wage labor) to sustain their livelihoods.

One of the most interesting results derived from this livelihood analysis is that the conclusions revealed through the activity ranking exercise were corroborated by the comparative analysis of accessibility to the fishing grounds. More specifically, it is the issue of access to the resource that is the key element conditioning the degree to which a fishery can (or cannot) fully play its role of a safety-net activity and act as potential entry

point for poverty reduction. This conclusion is in line with the recent progress made in the understanding of the complex relation between poverty and natural resources (Leach et al. 1999). It could not have been achieved if conventional economic evaluation techniques (which do not contain any analysis of (re-) distribution) had been used.

### **3.4.3. The Sustainable Fisheries Livelihood Programme**

In 1999, the Sustainable Fisheries Livelihoods Programme (SFLP) financed by the UK Department for International Development (DFID) and implemented by FAO was launched in 25 West African countries with the explicit objective of eliminating poverty in fishing communities. Within this program, research was carried out on how the Sustainable Livelihood Approach (SLA) developed, especially by Scoones (1998) at the Institute of Development Studies (University of Sussex); this was later adopted by DFID and may be used as a tool for assessing and addressing poverty in the specific context of fisheries.

#### *(a) The Sustainable Livelihood Approach*

The holistic principle of the SLA shows that the vital policies, institutions and processes are not only based on fisheries but are also linked to education, health, and administrative reforms, such as decentralization, environment, etc., all of which exert an impact on the livelihoods of artisanal fisheries communities.

However, the Sustainable Livelihood framework itself does not define what poverty is and cannot identify all the elements that would need to be taken into account to eliminate poverty or reduce vulnerability to poverty. Other tools such as poverty profiling are, therefore, needed to operationalize the approach.

*(b) Poverty Profiling*

Poverty profiles are analytical instruments directly linked to action, and are designed to provide information that may help in the formulation of actions to reduce poverty.

The basic structure of information contained in a poverty profile reflects the factors that influence livelihoods and the poverty situation of those being profiled. Such factors include:

- the variety of assets controlled by the household or to which the household has access;
- mediating factors such as laws, policies, and regulations directly affecting the household, development programs and projects operating in the area, and local attitudes and beliefs;
- external factors, such as demographic trends, the conditions of the natural resource base, and macroeconomic data; and
- the probability of shocks such as falling commodity prices, drought, conflict, or large-scale illnesses.

By looking at the synergies between these factors and at the processes in which the communities are embedded, a poverty profile allows us to understand the poverty context at large, describe the specific traits that characterize poor artisanal fishers' households, and identify the major factors generating or aggravating their poverty. By using census data and other sources of quantitative or qualitative data, it also provides information on the distribution of poor artisanal fishers across a given space (community, water body, or country).

Poverty profiles are currently being tested within the Sustainable Fisheries Livelihoods

Programme (SFLP) in West and Central Africa (Pittaluga et al. forthcoming).

## **4. ECONOMIC IMPACT ON FISHERIES OF CHANGES IN RIVER BASIN MANAGEMENT**

In this section, we will consider the economic impact on fisheries of changes in river basin management from the perspective provided by each type of valuation technique. From the start, it must be recognized that there have been relatively few studies of such impacts undertaken in West and Central Africa. However, those that have been completed, particularly when viewed together, provide a range of interesting and often complementary findings.

### **4.1 Conventional Economic Valuation (CEV)**

#### **4.1.1 Economic Valuation of the Wetlands Benefits: The Hadejia-Jam'are Floodplain, Nigeria; and the Impact of the Kano River Project (Barbier et al. 1991; 1993)**

The Kano River Project lies to the south of Kano city and along the Hadejia River. It was begun in 1976 with the building of Tiga Dam to store water for irrigated small-scale (1-2 ha) farming, which was commenced in 1981. By 1985/86, the Project was fully operational with over 7,000 hectares of dry season crops (wheat and tomatoes) and 12,000 hectares of wet season crops (rice, maize, cow peas and millet). Water use is high, estimated at 15,000 m<sup>3</sup> per hectare annually.

Although a complete cost-benefit analysis of the project has not been conducted, some information does exist on the costs and value of production when the project became fully

operational in 1985/86. Calculations of the current net economic benefits of the project are shown in Table 6.

The net economic crop benefits per hectare of the Kano River Project appear extremely high (N 865/ha). They easily exceed the net economic benefit per hectare of floodplain agriculture (N 239/ha, Table 1 above), and are virtually double the total net benefits from floodplain agriculture, fishing and fuel wood (N 439/ha, Table 1). However, as in the case of most irrigation projects, the Kano River Project also had high net operating costs. During 1984-86, these ranged from a low of 7.7 per cent to as much as 37 per cent of the total value of crop production. As shown in Table 6, when the net operating costs are deducted from the net economic crop benefits, the resulting net economic project benefits are reduced to just N 19/ha. Thus, the current returns per hectare to the fully operational Kano River Project do not compare favorably with those of the floodplain agriculture, fishing and fuel wood. It was also shown that the returns per water input were also higher economically for the floodplain agriculture system compared to the Kano River Project.

Based on the current net crop and project benefits in Table 6, a cost-benefit analysis was conducted for the Kano River Project (Phase I).

Adjustments to the time horizon and discount rate were included in a sensitivity analysis, as shown in Table 7 below. In comparison with the present value net benefits of the Hadejia-Jam'are Floodplain (Table 2), it is clear that the present worth of the Kano River Project is much lower. Only the present value of net crop benefits per hectare is substantially higher for the Project when compared to the floodplain. However, to exclude current operating costs would give a misleading indication of the net economic returns of the Project. In addition, the present value of net crop benefits per 1,000m<sup>3</sup> of water used for the Project is substantially lower than for floodplain recession agriculture, let alone for total net floodplain benefits.

#### 4.1.2 Economic Impact of Changes in River Basin Management on Fisheries in NE Nigeria

The findings of the DFID-funded "Traditional Management of Artisanal Fisheries in NE Nigeria Project" (Neiland et al. 1998) allow some conclusions to be drawn about the impact of changing hydrological patterns on river basin fisheries. It should be pointed out, however, that the research involved here was not originally aimed at producing a CEV analysis. In addition, there is the difficulty of trying to separate out the impacts of man-made changes (e.g., river basin modifications

**Table 6: Net economic benefits, Kano River Project Phase 1, northern Nigeria (N7.5=US\$ 1)**

	Net economic benefits (N'000)
Tradeable Crops	4 714
Non-Tradeable Crops	11 839
Total	16 533
Net economic crop benefits per ha (N/ha)	865
Less net operating costs (N/ha)	846
Net economic project benefits per ha (N/ha)	19
Net economic crop benefits per water input (N/'000m <sup>3</sup> )	1.10
Net economic project benefits per water input (N/'000m <sup>3</sup> )	0.02

Source: Barbier et al. 1991, 1993

**Table 7: Present value net economic benefits, Kano River Project Phase I, Nigeria (N 7.5=US\$ 1 in 1989/90)**

Per hectare	(8%, 50 years)	(8%, 30 years)	(12%, 50 years)	(12%, 30 years)
Crop (N/ha)	10 586	9 741	7 186	6 970
Project (N/ha)	233	214	158	153
Per water Use				
Crop (N/103/m <sup>3</sup> )	13	12	9	9
Project (N/103m <sup>3</sup> )	0.3	0.3	0.2	0.2

Source : Barbier et al. 1991, 1993

through dam construction and irrigation), as opposed to natural environmental fluctuations (a characteristic of African arid zone fisheries).

Two facts are known for certain about the fisheries of NE Nigeria – first, the fisheries currently yield a significant economic profit of at least N 415 million/year (US\$ 6 million/year); and second, they have been impacted by environmental change, mainly as a result of natural (e.g., Sahel drought) and man-made (e.g., dam construction) phenomena. The impact of change has in all cases led to a reduction in the aquatic environment. For instance, rivers and floodplains have been reduced in size; Lake Chad has shrunk and been replaced by a large swamp; and by and large, as a consequence, fish stocks have been reduced in size, diversity and distribution.

The question is, therefore, whether it is possible to estimate the change in value of the fisheries in NE Nigeria as a result of these environmental changes. A simple methodology has been used to produce some indicative figures, as shown in Table 8. The difficulty in estimating these values lies in making appropriate assumptions about the dynamics of the overall fishery system (e.g., biological, economic, and social parameters, and how they interact).

It has been assumed that, in a well-functioning arid-zone African floodplain fishery (Lake Chad fishery is assumed to have these

characteristics, with high stock level, good catch returns, economically efficient), small-scale fishers are able to catch about 5 tonnes of fish per year and produce a net economic yield of at least US\$ 1/day (or N 27,000/year). Using this baseline, the potential total net economic profit was calculated for each of the other fisheries. These values were then compared to the actual values at present.

The results show that the Lake Chad fishery has not experienced a change in terms of economic returns (zero change, which is the major assumption of the analysis). The fishery of the Nguru-Gashua Wetlands has experienced a decline of 11 per cent in economic returns. The Upper River Benue has experienced a massive 96 per cent decline in economic returns.

The changes in economic value for each fishery are purely indicative and should be treated with caution. However, it is possible to consider whether the changes could be explained using knowledge derived from recent research (e.g. other elements of the TMAF Project; Neiland et al. 1998). In the case of the Lake Chad Basin fishery, which has been taken as the baseline, the impact of environmental change has been widely characterized in the literature as a drastic decline of the fishery. However, an alternative narrative might view the situation as an evolution of the fishery from a lacustrine/riverine fishery into a swampland fishery. It may be the case, as suggested here, that while the nature of the fishery has changed,

**Table 8: Economic impact on fisheries of hydrological changes in the river basins of NE Nigeria (Neiland et al. 1998)**

River basin fishery	Major hydrological modifications over past 30 years	Impacts on fishery	Current economic value of fishery landings (Total net economic profit, N'000s) <sup>(a)</sup>	Estimated change in value of fishery (+/- total net economic profit, N'000s or % change) <sup>(b)</sup>
Upper River Benue	(i) Construction of Lagdo dam; (ii) Construction of Gongola River dam; (iii) Sahel drought (70s/80s)	Reduction of riverine discharge, size of annual flood, less inundation of floodplains, reduction of fish biodiversity and stock size; falling catch rates; prices stable; stable local demand	5 190	- 146 010 (-96%)
Lake Chad Basin	(i) Construction of dams in northern Cameroon; (ii) Sahel drought (70s/80s);	Reduction of riverine discharge and floodplain; major reduction in size of Lake Chad, but creation of fringing floodplain; change in species diversity; change in fish migrations and distribution; catch rates stable; increased demand/ prices from non-local markets	266 039	266 039 (0%)
Nguru-Gashua Wetlands	(i) Construction of dams on headwaters; (ii) Smaller irrigation dams elsewhere; (iii) Sahel drought (70s/80s)	Reduction of riverine discharge and floodplain; reduction of fish stock in size, abundance and diversity; falling catch rates; increased regional demand and prices	144 636	-18 066 (-11%)
<b>TOTAL</b>			<b>415 865</b>	<b>364 076</b>

Notes: a) As shown in Table 3 above, based on research findings of TMAF project (Neiland et al. 1998); (b) It is assumed that in a well-functioning fishery such as the Lake Chad fishery (above), households will achieve a net economic profit of N 27,009/year (or US\$ 1 per day); based on the number of fishing households per fishery the potential total net economic profit was calculated for Upper River Benue and Nguru-Gashua Wetlands; the current total was deducted from this value to give an indication of the change in the value of the fishery.

the total economic value has remained relatively stable. Of course, this would need to be tested, but it is not necessarily the case that a larger Lake Chad would produce higher economic returns (compared to a more inaccessible swamp system). Three factors that have facilitated the operation and resilience of the fishery are the existence of alternative livelihood options (farming), protected remote fishing areas (that act as fish refuges), and the well-developed fish marketing system.

In the case of the Nguru-Gashua Wetlands fishery, it can be hypothesized that the

relatively low reduction in economic value of the fishery (11%), in the face of drastic reduction in the aquatic environment, is only a temporary phase. The relatively high household catches and economic profit are probably due to an increased level of fishing effort (with few income alternatives), and a high demand for fish products (and prices) from nearby Kano and other urban areas (supported by a good marketing network). It is anticipated that the fishery in the Nguru-Gashua Wetlands will not be able to sustain the present level of activity, and that it will become overexploited (biologically and economically) in the near future. The situation

will be exacerbated by the inability of local authorities to manage water releases from the major headwater dams.

In the case of the Upper Benue River, the impact of the reduction of the aquatic environment on the local fisheries and their economic value has been devastating. The current economic value is a meager N 5 million/year (or US\$ 71,428) compared to the Lake Chad and Nguru-Gashua Wetlands fisheries. The reduction in the size of the Benue River and its floodplain over 20 years since the construction of the Lagdo Dam upstream in Cameroon, coupled with low and only local demand for the available fish, has produced a fishery of low value to the local economy overall.

## 4.2 Economic Impact Assessment (EclA)

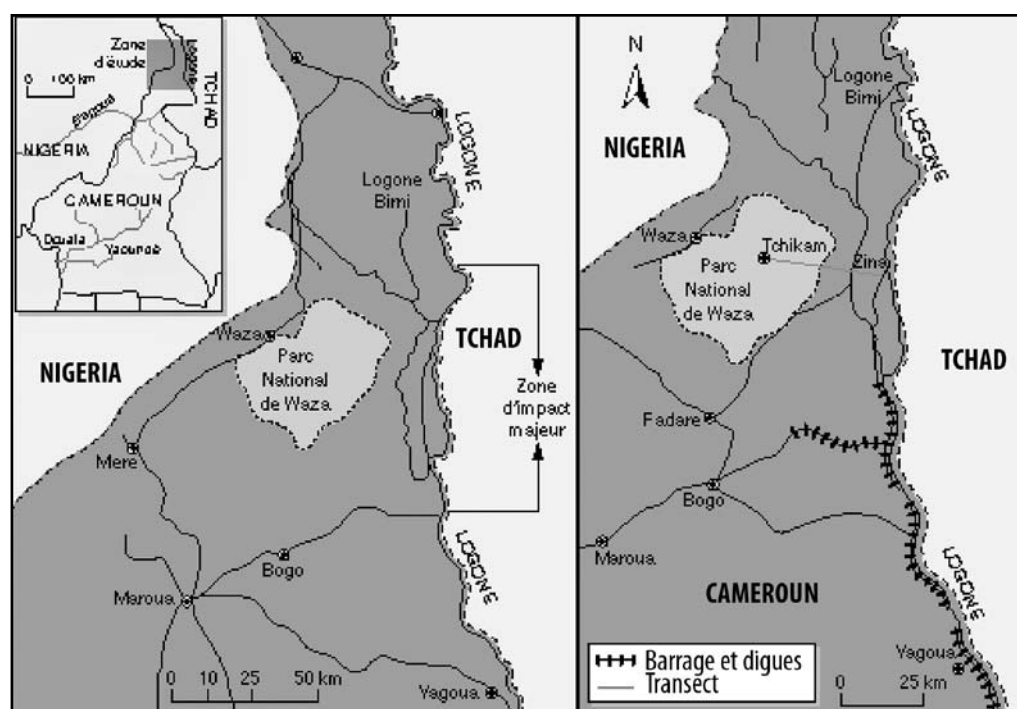
### 4.2.1 The Maga Reservoir and the Yaere Floodplain (Cameroon)

There are many examples of economic impact assessments available in the literature,

most of which concentrate on the impacts of dams on the river flood. One relatively well-documented (and classical) case is the Maga dam on the Logone River, located in the Far-North Province of Cameroon at the border with Chad. In the pre-dam situation, the Logone River used to flood the fringing plain (called the Yaere floodplain). However, in 1979, a national irrigated rice-growing project was carried out under the management of the state-controlled company SEMRY (Rice Culture Expansion and Modernization Authority). The hydrological component of the project consisted of 28 km of embankments that created the Maga reservoir, plus some 80 km of dykes along the Logone River to control the flooding of adjoining floodplains (See Figure 4) and to allow the cultivation of irrigated rice.

The SEMRY project has, however, never attained its expected production level. But more importantly, these schemes seriously modified the floodplain regime, leading to an acceleration of the degradation of the environment caused by drought (including the disappearance of many plant species).

**Figure 4: The 28 km dam and 80 km dykes along the River Logone SEMRY project**



These modifications are also thought to have eliminated the flooding of some 59,000 ha of floodplain and seriously reduced another 150,000 hectares that were important breeding and nursery areas for fish. As a consequence, IUCN had worked with local partners to start a rehabilitation project in 1993. The main objective was the restoration of the flooded area back to a level close to the pre-dam conditions. This was to be achieved by the opening of the dyke at two different locations close to the Maga reservoir.

Although a more comprehensive estimate (valuation) of the total economic benefits and costs of the SEMRY scheme is now possible – especially based on the various detailed economic, social and ecological studies carried out by IUCN during the early phases of the rehabilitation project (1993-97) – the only type of evaluation of the economic impacts of the SEMRY scheme on the fishery that was possible prior to the IUCN studies consisted of evaluating the loss of direct catches induced by the reduction of the floodplain area. Taking into consideration the catch losses induced by the 590 km<sup>2</sup> flood reduction and assuming a 50 per cent reduction of productivity for the other 1,500 km<sup>2</sup> affected by the flood disruption (i.e., assuming a productivity of 2.5 t/km<sup>2</sup>/yr instead of the *normal* 5 t/km<sup>2</sup>/yr), the total catch reduction would be an estimated 6,700 t/yr. At the current average local price of US\$ 0.85/kg (Jolley et al. 2002), this represents a total direct lost of 120 US\$ million (first sale value) over the 21 years during which the flooding pattern was significantly affected (1979-2000).

#### 4.2.2 The Niger River, Mali

The production of the Central Delta was estimated to be around 100,000 tonnes in the 1960s (Daget 1973). However, in 1973, severe drought conditions in the entire Sahelian region substantially affected the flooding of the Niger River and impacted on the fisheries

activities. By 1990-91, the production of the fisheries operating in the Central Delta had decreased to 50,000 tonnes, a 50 per cent decline with respect to the pre-drought period. Adopting a similar approach to the one above, the economic impact induced by the drought on the Niger River can be estimated to be US\$ 20 million (first sale value) per year.

### 4.3 Socioeconomic and Livelihood Analysis (SE-LA)

The literature review has not revealed any specific SE-LA studies that have investigated the impact of changes in river basin management on fisheries. The detailed research findings of many of the projects mentioned above certainly provide some evidence that impacts have been felt by fishing communities. In the case of NE Nigeria, a survey of village heads revealed the major changes that had affected the fisheries over the past 30 years, as shown in Table 9. These included deterioration of the aquatic environment, which was undoubtedly linked to the impact of dams, irrigation schemes, and a series of Sahel droughts.

There is a need for both cross-sectoral and time-series studies of this kind to examine the changes that are taking place in the fisheries of West and Central Africa. The newly emerging LA approaches offer considerable potential for further work in this area throughout the region.

## 5. ASSESSMENT OF VALUATION METHODOLOGIES

The range of valuation methodologies that have been applied to the river fisheries of West and Central Africa, as revealed by the literature review in this paper, have been grouped into three categories: conventional economic valuation (e.g., household



**Table 9: Major changes detected in the fisheries of NE Nigeria over the last 30-50 years by village heads (Neiland et al. 1998)**

Major changes	Total responses from village heads (%)		
	Upper River Benue	Lake Chad	Nguru-Gashua Wetlands
Catching less/smaller fish	18	17	3
Smaller catch, higher unit value	14	0	8
Deterioration in fishing environment	4	22	18
Deterioration in aquatic environment	4	22	23
Traditional gears now ineffective	0	0	3
New gears introduced	36	17	10
Decline of fisheries management	0	0	3
More fishers now	7	11	0
Less fishers now	7	6	5
Increased fishing costs	4	6	23
No changes	7	0	0
Village does not fish	0	0	5
Total	100	100	100

surveys as a basis for undertaken economic cost benefit analysis), economic impact assessment (e.g., monitoring of fish markets to estimate output volume and value based on financial prices), and socioeconomic and livelihood analysis (e.g., participatory rural appraisal techniques such as wealth-ranking of fishing households).

In this brief section, the three types of methods are compared to answer three simple questions within the context of undertaking valuation studies in West and Central Africa:

- Which methods are most easily used and applied?
- Which methods produce information outputs with the greatest utility?
- Which methods are most cost-effective?

In order to make the comparison and answer the key questions, twelve assessment criteria were used and each type of method was scored for each criterion (1 = low or unfavorable, up to 3 = high or favorable). The results are shown in Table 10 below.

As seen in Table 10, Economic Impact Assessment methods produced the highest score (32), followed by socioeconomic and livelihood analysis (25) and conventional economic methods (18). In other words, in terms of a global assessment of the ease of usage, utility and cost, methods such as market monitoring are better than methods such as PRA wealth-ranking or cost-benefit analysis using household surveys.

This comparative analysis was undertaken using relatively few (12) assessment criteria and directed specifically to take account of conditions on the ground in West and Central Africa based on personal experience. In other words, based on the researchers' experience, valuation techniques, such as market monitoring, are most likely to be successful.

A brief examination of the criteria scored for each of the three methods reveals why this is the case overall. Economic impact assessment methods do not need a large quantity of data and formal sampling is not a requirement. At the same time, there is good potential for scaling-up and generating representative statistics or indicators. The methods have high potential for time-series

**Table 10: Comparison of valuation methods using criteria scoring**

Criteria	CEV methods e.g., CBA using household surveys	EcIA methods e.g., monitoring of fish markets for volume and value	SE-LA e.g., PRA wealth- ranking of fishing households
Quantity of data required	1	3	2
Formal sampling required	1	3	3
Representativeness/scaling-up potential	3	2	1
Time-series capacity	1	3	3
Replicability of methods	3	2	2
Potential for errors	1	3	2
Data processing difficulty and time needed	1	2	2
Potential for causality analysis	3	2	2
Capacity needed	1	3	2
Ease of local training in short-term	1	3	2
Cost	1	3	2
Potential for local sustainability	1	3	2
Total	18	32	25

data collection, replicability of operation and low potential for errors (compared to more complex approaches). The time required for data processing and information outputs is comparatively low, and the results may be used in the analysis of causality between a limited number of parameters. The methods may be implemented even in cases of low local capacity, and this expertise may be increased quickly through relatively simple training courses. The overall cost of the methods is low and the sustainability of the methods by local staff over time is high.

From the researchers' personal experience of implementing a range of valuation methodology in West and Central Africa, the most successful one, in terms of the assessment criteria used here (ease, utility, cost), is the fish market monitoring system in the Lake Chad Basin (Neiland et al. 2003), compared to the socioeconomic and livelihood analysis approaches (Béné et al. 2001) and the very detailed economic analysis conducted in NE Nigeria (Neiland et al. 1998). For more information on each of the approaches, please refer to the references cited.

## 6. CONCLUSIONS AND RECOMMENDATIONS

Three main conclusions and matching recommendations can be made from the Review of River Fisheries Valuation in West and Central Africa.

### Valuation information and the policy process

First, there is relatively little information on the value of river (or inland) fisheries in West and Central Africa. For most river basins and countries, it is possible to derive some estimates of gross financial values of fisheries production based on landings data and local prices. For the major river basins of West and Central Africa, the total potential value of fisheries production is US\$ 749 million/year, and the value of current production is US\$ 295 million. For the countries with major inland fisheries, the actual value of all inland fisheries is US\$ 1,415 million (cf. Table 5). In addition, a number of case studies have revealed that inland fisheries make a positive economic contribution to regional economies, and also provide important livelihood benefits

including employment. At the same time, other studies have shown that changes in river management regimes can deleteriously impact on this flow of benefits. As a result of these findings, it is *recommended* that valuation studies need to be undertaken more widely in the region, in order to avoid the situation whereby the role of river fisheries is overlooked or underestimated within the policy process.

### **Toolbox of valuation methods and opportunities for application**

Second, there are a wide variety of valuation methods that produce a range of information types. There is important scope to combine different methods in different situations to provide a powerful mechanism for information generation and analysis. In the context provided by many countries of West and Central Africa, the application of valuation techniques is constrained by a variety of factors (e.g., weak institutional capacity). At the same time, there are also opportunities to utilize valuation methods to develop sustainable and robust information systems. On the basis of past experience revealed by this literature review, it is *recommended* that investigations should be undertaken to understand how valuation techniques be developed and applied under particular conditions within West and Central Africa. It would be useful to develop "A manual for valuing river fisheries in Africa" on this basis. One central element to be considered very seriously is the relationship between policymakers (information users) and the information generation process (involving a range of stakeholders); the sustainability of the system will depend upon this.

### **Increased capacity for valuation studies**

Third, one of the major constraints to the development of information systems and

policy processes that incorporate valuation information in West and Central Africa is limited capacity at all levels of government fisheries and development organizations. There are many possibilities for increased capacity through in-country training courses, particularly short courses. Once again, it is important to match the demand for such capacity building with the need for valuation information within the policy process of a particular country. It is *recommended*, therefore, that a generic approach to capacity building in fisheries valuation should be developed for West and Central Africa, taking into account the needs of the policy process, and the full range of opportunities and constraints.

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## APPENDIX 1: MAJOR RIVER BASINS OF WEST AND CENTRAL AFRICA

The major river basins considered in this study are: (1) the Senegal-Gambia rivers basin, (2) the Volta river basin, (3) the Niger-Benue rivers basin, (4) the Lake Chad river system, (5) the Congo-Zaire river basin, and (6-7) the Atlantic coastal basins. Also included in the table are three largest lakes/reservoirs of West and Central Africa: (8) the Volta Lake (man-made), (9) the Lake Chad (open waters) and (10) the Kandji Lake (man-made).

River Basins	Characteristics
1. Senegal-Gambia rivers basin	<p>Countries: Senegal, South Mauritania, South-West Mali, North-East Guinea, Gambia</p> <p>Gambia river            Total length: 1120 km            Gambia: +480 km            Annual catches: 1 500-3 500 t (1977-82)            Potential yield: 2 000 – 8 000 t (Welcomme 1979)            Guinea: 200 km            Annual catches: 1 000-2 000 t (1987)            Potential yield: 5 000 t (Welcomme 1979)</p> <p>Senegal river            Total length: 1 640 km            Length (in Senegal): 1 400 km            No. fishers (Senegal): 14 000 (1977)            Fringing floodplain: + 5 000 km<sup>2</sup>            River delta: 7 000 km<sup>2</sup></p> <p>Main tributaries (Mali)            Faleme river: 300 km            Bakoye river: 300 km            Baoule river: 350 km            Total annual catches: 2 000 t</p> <p>Other rivers            Sine-Saloum river (Senegal)            Length: 100 km            No. fishers: 4 000 – 6 000 (1988)            Total annual catches: 6 000 – 8 000 t (1988)            Casamance river (Senegal)            Length: 325 km            No. fishers: 5 500 (Frenoux 1988)            Total annual catches: 12 000 – 15 000 t (1987)</p>
2. Volta river basin	<p>Countries: Burkina Faso, Ghana, Togo, Benin</p> <p>Volta river (cum. Red, White, Black Volta)            Total length:            Benin: 380 km            Burkina Faso: 1 250 km            Ghana: 650 km            No. fishers: (Burkina Faso): 7 000 (1995)            Total annual catches (Burkina Faso): 8 000 t (including reservoirs and lake) (1997)            Estimated annual productivity: 50-100 kg/ha</p> <p>Oueme river and floodplain            Length: 700 km (Benin)            Floodplain: 2 000 km<sup>2</sup> (Benin)            Annual catches: 5 700 t (1976) (Welcomme 1979)</p> <p>Volta tributaries            Oti, Koumongou, Kara, Mono rivers            Togo: Length: 700 km            Potential annual yield: 2 000 – 6 000 t (Patasse 1982)            Benin: 360 km            Potential annual yield: 500 t</p>

3. Niger-Benue river basin	<p>Countries: Guinea, Mali, Niger, Nigeria, Benin, Cameroon</p> <p>Floodplain:  Central delta (Mali):  Surface: 16 123 km<sup>2</sup></p> <p>Annual catches  Nigeria: 19 000 t (1980)  Benin: 1 000 t (1971)  Mali: 90 000 t</p> <p>Fringing plains:  Niger: 637 km<sup>2</sup>  Benin: 242 km<sup>2</sup>  Nigeria: 3 000 km<sup>2</sup></p> <p>Niger river  Total length: 4 183 km  Nigeria: 1 300 km  Benin: 120 km  Niger: 600 km  Mali: 3 000 km  Guinea: 580 km (3 400 km with tributaries)</p> <p>Total annual catches (excluding Niger delta): 114 000 t (1966)  Niger: 4 000 – 7 000 t (Welcomme 1972)  Benin: 1 000 t  Mali: 90 000 t  Nigeria: 13 000 t</p> <p>No. fishers:  Benin (Niger river): 3 000  Mali (Niger delta and river): 40 000 – 54 000 (1975)  Niger (Niger river): 2 600 (1981)</p> <p>Benue river  Nigeria: 1 440 km  Cameroon: 550 km (including Mayo Kebi)</p> <p>Annual catch:  Cameroon: 3 000 t (estimation 1966)  Nigeria: 6 500 t (Barbier et al. 1991)  No. fishers: 5 100 (Nigeria) (Welcomme 1985)</p>
4. Lake Chad river system	<p>Countries: Niger, Chad, Central African Republic, Nigeria, North Cameroon</p> <p>Main rivers  Logone (Cameroon): 280 km  Chari (Chad): 1 300 km</p> <p>Potential productivity  Logone-Chari: 20 000 – 30 000 t/yr</p> <p>Floodplains  Yaéré (Cameroon-Chad)  Surface: 4 600 km<sup>2</sup>  Potential annual yield: 20 000-30 000 t/yr  Annual catches: 2 272 t (Logone river only) (Bobo and Boukar 1997)  No. fishers: 6 800 (1997)</p> <p>Salamat river and floodplain (Chad)  Salamat river: 950 km  Fringing floodplain: 4 000 km<sup>2</sup>  Total annual catches: 22 000 t (Deceuninck 1985)</p> <p>Bahr Aouk river and floodplain (CAR)  Bahr Aouk river: 620 km  Fringing floodplain: 8 000 km<sup>2</sup>  Total annual catches: 6 000 t (Deceuninck 1985)</p>

5. Congo-Zaire river basin      Countries: Congo-Brazzaville, Democratic Republic of Congo (DRC), Central African Republic (CAR), Rwanda, Burundi, Uganda
- Main rivers:  
 Lualaba river becoming Congo-Zaire River:  
 Total length: 4 140 km  
 Tributaries' floodplains: 17 000 km<sup>2</sup>  
 No. fishers: 40 000 – 50 000 (Corsi, 1984)  
 Total annual catches: 70 000 – 75 000 t  
 Potential annual yield: 150 000 t (including tributaries)  
 Luapula River (DRC):  
 Total length: 560 km  
 Floodplains: 1 500 km<sup>2</sup>  
 No. fishers: 2 850 (Konare 1984)  
 Total annual catches: 8 800 t (1983)  
 Ubangui and Uele (Congo, DRC, CAR):  
 Total length: 2 270 km  
 Total annual catches: 7 520 t (1984)  
 Floodplains: 1 300 km<sup>2</sup>  
 Sangha (Congo): 1 000 km  
 Floodplains (including Likouala river floodplain): 35 000 km<sup>2</sup>  
 No. fishers: 7 000 – 10 000 (river and floodplain)  
 Total annual catches: 10 000 – 15 000 t (1980)  
 Potential annual yield: 60 000 – 100 000 t  
 Tributaries and floodplains  
 Cameroon: 1 400 km  
 DRC: 10 000 km of tributaries  
 17 000 km<sup>2</sup> of floodplain (not including Congo-Zaire floodplains)  
 CAR floodplains: 15 000 km<sup>2</sup>  
 Congo: Annual catches: 10 000 – 15 000 t (floodplains and tributaries)
6. Atlantic coastal basin I      Countries: Gambia, Guinea Bissau, Sierra Leone, Liberia, Ivory Coast
- Ivory Coast rivers:  
 Length (cum.): 1 700 km  
 Potential annual yield: 20 000 t  
 Total annual catches: 18 500 (1997)  
 No. fishers: 6 000 (FAO 2002)  
 Sierra Leone rivers:  
 Length (cum.): 1 280 km  
 Total annual catches (1998): 10 000 t  
 Potential annual yield: 11 000 – 14 000 t  
 Fringing floodplains: 10 000 km<sup>2</sup>
7. Atlantic coastal basins II      Countries: South Cameroon, Equatorial Guinea, Gabon  
 Gabon:  
 Ogooué river: 820 km  
 No. fishers: 1 485 (1977)  
 Total annual catches: 1 800 t  
 Equatorial Guinea:  
 Rio Benito: 230 km  
 No. fishers: 400 (Matthes 1980)  
 Annual catches: 400 t  
 Potential annual yield: 1 000 t (Matthes 1980)  
 Other rivers and tributaries:  
 Cameroon: +500 km  
 Productivity: 210 – 940 kg/km
8. Volta Lake      Country: Ghana
- Surface: 8 270 km<sup>2</sup>  
 Total annual catches: 40 000 t (1979)  
 No. fishers: 20 000 (1975)  
 Potential annual yield: 40 000 – 50 000 t (Welcomme 1972)



9. Lake Chad (Open-watersandsurrounding floodplains/swamps)	Countries: Nigeria, Cameroon, Chad, Niger Total surface (for "normal Chad"): 22 000 km <sup>2</sup> Nigeria: 5 500 km <sup>2</sup> (25%) Niger: 4 000 km <sup>2</sup> (17%) Cameroon: 1 800 km <sup>2</sup> (8%) Chad: 11 000 km <sup>2</sup> (50%) Total surface ("Little Chad"): 2 000 km <sup>2</sup> Chad: 1 200 km <sup>2</sup> (60%) Cameroon: 800 km <sup>2</sup> (40%)  Total annual catches: 60 000 t (1997) (Neiland et al. 1998) Potential annual yield: 160 000 – 200 000 t (Lévêque 1987) No. fishers: 10 000 – 15 000 (during "normal phase" Welcomme 1972)
10. Lake Kaindji	Country: Nigeria  Surface: 1 270 km <sup>2</sup> Total annual catches: 4 000 – 6 000 t (1980s) No. fishers: 20 000 (1975) Potential annual yield: 6 000 t (Ita et al. 1984) Other smaller reservoirs in Nigeria Surface (cum.): 2 750 km <sup>2</sup> Total annual catches: 20000 t (estimates)

Source: Compiled from Welcomme 1972, 1979, and Van den Bossche and Bernacsek (1990), unless indicated otherwise

### Synthesis of continental fisheries catches in West and Central Africa

Country	Inland catches (t)	% of total catches	No. fishers
Benin	32 000	76	3 000
Burkina Faso	7 000	100	
Cameroon	20 000	24	
Central African Republic	9 000	100	
Chad	110 000	100	10 000 – 15 000 (LC)
Ivory Coast	27 500	27	6 000 <sup>a</sup>
Gambia	2 700	19	
Ghana	53 000	14	20 000
Mali	55 500	100	40 000 – 54 000
Niger	2 500	100	2 600
Nigeria	103 000	44	5 100 + 20 000 (LK)
Senegal	15 000	5	4 000 + 4 000 – 6 000 + 5 500
Sierra Leone	16 000	30	

Source: Synthesized from the Table above, except when mentioned otherwise

<sup>a</sup> FAO. World fisheries statistics (2002)

## APPENDIX 2: POTENTIAL ECONOMIC VALUE OF WESTERN AND CENTRAL AFRICAN BASINS

Potential economic value of Western and Central African basins are estimated through the first sale values (US\$/yr) of river and floodplain fisheries potential catches<sup>a</sup>. The number of fishers and total annual catches actually recorded in the literature for these basins<sup>b</sup> is also indicated in this table. These records can be considered as very conservative estimates of the real figures. (See footnotes below.)

River basins <sup>b</sup>	Coefficients used for the calculation	Potential economic value
<b>1. Senegal-Gambia rivers basin</b>		
Recorded No. fishers: = 23 500 – 25 500 <sup>c</sup> [1977-1988] <sup>d</sup>	Potential river yield: 15 t/km/yr	
Recorded total annual catches: 22 500 – 30 500 <sup>e</sup> t/yr [1977-1988]	Potential floodplain yield: 5 t/km <sup>2</sup> /yr	
Potential annual yield: Rivers: 52 000 t/yr Floodplains: 60 000 t/yr	Unit price (first sale value): US\$ 0.55/kg (estimate)	US\$ 61.6 million/yr
Total potential: 112 000 t/yr		
<b>2. Volta river basin</b>		
Recorded No. fishers: 7 000 <sup>f</sup> [1995]	Potential river yield: 15 t/km/yr	
Recorded total annual catches: 13 700 <sup>g</sup> t/yr [1976 -1997]	Potential floodplain yield: 5 t/km <sup>2</sup> /yr	
Potential annual yield: Rivers: 6 000 t/yr Floodplains: 10 000 t/yr	Unit price (first sale value): US\$ 0.52/kg (FAO 2002)	US\$ 8.32 million / yr
Total potential: 16 000 t/yr		
<b>3. Niger-Benue river basin</b>		
Recorded No. fishers: 50 700 – 64 700 <sup>h</sup> [1975 – 1985]	Potential river yield: 15 t/km/yr	
Recorded total annual catches: 236 500 t/yr [1971-1991]	Potential floodplain yield: 5 t/km <sup>2</sup> /yr	
Potential annual yield: Rivers: 105 600 t/yr Floodplains: 100 010 t/yr	Unit price (first sale value): US\$ 0.4/kg <sup>n</sup>	US\$ 82.244 millions/yr
Total potential: 205 610 t/yr		
<b>4. Lake Chad river system</b>		
Recorded No. fishers: 6 800 <sup>i</sup> [1997]	Potential river yield: 15 t/km/yr	
Recorded total annual catches: 32 200 t/yr [1985-1997]	Potential floodplain yield: 5 t/km <sup>2</sup> /yr	
Potential annual yield: Rivers: 47 250 t/yr Floodplains: 83 000 t/yr	Unit price (first sale value): US\$ 0.55/kg <sup>o</sup>	US\$ 71.637 million/yr
Total potential: 130 250 t/yr		

<sup>a</sup> Lagoons, lakes and reservoirs are not included in this estimation.

<sup>b</sup> Note that the recorded total annual catches may differ from the potential annual yield. The closer the former is to the latter, the more likely the fisheries are at their maximal exploitation level.

<sup>c</sup> Not recorded: number of fishers on the Gambia river.

<sup>d</sup> The periods between [ ] indicate the first and last year of estimation.

<sup>e</sup> Not recorded: total annual catches of the Senegal river.

<sup>f</sup> Only recorded fishermen in Burkina Faso operating on the Volta river; not recorded fishers in Ghana, Togo, and Benin.

<sup>g</sup> Not recorded: total annual catches in Ghana, Togo, and Benin of the fishermen operating on the Volta river.

River basins <sup>b</sup>	Coefficients used for the calculation	Potential economic value
5. Congo-Zaire river basin		
Recorded No. fishers: 50 000 – 62 000 <sup>i</sup> [1984 – 1989]	Potential river yield: (“black” acid, low productivity water)	
Recorded total annual catches: 104 500 – 119 500 <sup>k</sup> [1980-1984]	10 t/km <sup>2</sup> /yr	
Potential annual yield: Rivers: 290 500 t /yr Floodplains: 229 500 t/yr	Potential floodplain yield (“black” acid, low productivity water): 2.5 t/km <sup>2</sup> /yr	
Total potential: 520 000 t/yr	Unit price (first sale value): US\$ 0.40/kg (estimate)	US\$ 208 million/yr
6 – 7. Atlantic coastal basins (I and II)		
Recorded No. fishers: 6 000 <sup>l</sup> [2002]	Potential river yield:	
Recorded total annual catches: 30 700 t <sup>m</sup> [1997-1998]	15 t/km <sup>2</sup> /yr	
Potential annual yield: Rivers: 68 000 t/yr Floodplains: 50 000t/yr	Potential floodplain yield: 5 t/km <sup>2</sup> /yr	
Total potential: 118 000 t/yr	Unit price (first sale value): US\$ 1.52 / kg <sup>p</sup> (Vallet 1993)	US\$ 179.3 million/yr
8. Volta Lake		
Recorded No. fishers: 20 000 [1975]	Potential river lake:	
Recorded total annual catches: 40 000 t/yr [1979]	5.5 t/km <sup>2</sup> /yr	
Potential annual yield: 62 000 t/yr	Unit price (first sale value): US\$ 0.71/kg (1992) (Braumah 1995)	US\$ 44.02 million/yr
9. Lake Chad (Open-waters and surrounding floodplains/swamps)		
Recorded No. fishers: 10 000 – 15 000 [1972]	Potential lake yield:	
Recorded total annual catches: 60 000 (1997 = during “little Chad” period)	7.5 t/km <sup>2</sup> /yr	
Potential annual yield: 165 000 t/yr (“normal Chad”)	Unit price (first sale value): US\$ 0.55/kg <sup>o</sup>	US\$ 90.75 million/yr
10. Lake Kaindji		
Recorded No. fishers: 20 000 [1975]	Potential river lake:	
Recorded annual catches: 4 000 – 6 000 t [1980-1989]	7.5 t/km <sup>2</sup> /yr	
Potential annual yield: 6 000 t	Unit price (first sale value): US\$ 0.55/kg (estimate)	US\$ 3.3 million/yr

<sup>h</sup> Not recorded: number of fishers operating on the Niger river in Nigeria.

<sup>i</sup> Not recorded: number of fishers operating in the Logone-Chari system and in Chad.

<sup>j</sup> Not recorded: Ubangui fishers.

<sup>k</sup> Not recorded: Total annual catches in Congo of the Ubangui river.

<sup>l</sup> Only recorded fishers in Ivory Coast; not recorded fishers in Gambia, Guinea Bissau, Sierra Leone, Liberia.

<sup>m</sup> Not recorded: annual inland catches in Gambia, Guinea Bissau and Liberia.

<sup>n</sup> Rough estimates from: Niger first sale value: US\$ 0.15 – 0.50/kg (Mamane 2002); Benue (Nigeria) first sale value: US\$ 0.35 – 0.64/kg (Ovie et al. 2001); and Niger central delta (Mali) first sale value: US\$ 0.15 – 0.50/kg (Weigel and Stomal 1994).

<sup>o</sup> Estimated for Nigeria, Cameroon, Chad first sale value, Table 1 in Jolley et al. (2002).

<sup>p</sup> This first sale value seems to be significantly higher than the values observed in other places. It needs to be crosschecked and should therefore be considered with caution.

### APPENDIX 3: COUNTRY FISHERIES PROFILES

In this appendix, the fishery profiles of the West and Central African countries for which the share of inland fisheries exceeds 10 per cent of the total catches and with a potential annual catch exceeding 5 000 tonnes are presented. This includes:

Benin, Burkina Faso, Cameroon, Chad, Ivory Coast, The Gambia, Ghana, Mali, Niger, Nigeria, Senegal, and Sierra Leone. Cape Verde, Equatorial Guinea, Gabon, Guinea, and Liberia are not included in this list.

## BENIN

### General information <sup>▲</sup>

Surface area:	112 622 km <sup>2</sup>
Populations (1997):	5 720 million
GNB (1995):	EURO 2.33 billion
GNB per capita (1995):	EURO 430
Gross Value of Agricultural Output (estimation 1995):	36%

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers and floodplains

Niger Basin (Niger river and main tributaries):

Surface area: 758 000 km<sup>2</sup>

Length (cum.): 1 118 km

Floodplains: 275 km<sup>2</sup>

Volta

Length: 380 km

### Inland fisheries <sup>\*</sup>

Inland catches as percentage of total catches:

76% (1987); 69% (1999)<sup>▼</sup>

Degree of exploitation (1987):

inland catch range (t): 20 000 – 34 000<sup>a</sup>

inland potential catch range: 28 000 – 33 000<sup>a</sup>

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Supply per capita
	'000 t (fresh weight)				kg/yr
Fish for direct human consumption	43.771	8.5	0.321	51.95	9.1
Fish for animal consumption and other uses	-	-	-	-	-

Employment (1996):

(i) full-time fishers (professional):

53 000

(ii) part-time and seasonal fishers:

22 000

Fisheries first sale value (1995):

EURO 29.3 million

Trade (1997 estimates):

Import values:

EURO 6.7 million

Export values:

EURO 1.4 million

<sup>\*</sup> Van den Boosche and Bernacsek (1990, Vol. 2, Table 2, p. xii)

<sup>▼</sup> FAO. World fisheries statistics (2002)

<sup>a</sup> Including lakes, rivers, floodplain and lagoons

<sup>♦</sup> FAO. World fisheries statistics (2002)

## Inland fisheries ♦

### General overview

Two socioeconomic categories are involved in continental fisheries activities (50,000 fishermen and 19,000 fishmongers). In addition, the sector provides employment to about 300,000 people in various related fields, such as vessel and fishing gears reparations, fish distribution and marketing.

The majority of the fishers (approx. 75%) are full-time professionals. They use different types of fishing techniques and gears. The remaining 25% include:

- Farmer-fishers for whom fishing is a complementary or seasonal activity;
- The seasonal fishers who fish only during specific period of the year;
- The occasional fishers who fish only as a complementary subsistence activity;
- Households involved in traditional extensive aquaculture activities to complement their income derived from fisheries or farming activities.

Of the 33,000 tonnes of fish caught annually (1977) inland, 92.3 per cent (i.e., 30,000 tonnes) come from lagoons and coastal lakes. Generally lagoon activity is performed on individual basis, from a non-motorised monoxyle pirogue. Fishing techniques and gears are diverse: driftnets, castnets, traps (for fish or shrimp), and hooklines.

### Fish demand and catch uses

Fish constitutes the main source of animal protein for the population in particular in southern (coastal) regions. In 1995, fish represented 5.5 per cent of the total protein source and 31.9 per cent of the total consumption in animal protein. About three-fourths of the catches are consumed fresh; the rest (about 120,000 t) is smoked, salt or dried before it is sold on the inland markets. In various fishing camps outside the fishing port, about 2,800 women are involved in processing and trading activities. The national production is not sufficient to cover the demand. Frozen and canned fish are therefore imported. In 1995, 14,200 tonnes of frozen fish were imported.

♦ FAO. World fisheries statistics (2002)

## BURKINA FASO

### General information <sup>▲</sup>

Surface area:	274 200 km <sup>2</sup>
Inland water surface:	Approx. 122 000 ha (flooding season)
Population (1997):	10.5 millions
Gross Domestic Product (1996):	EURO 1 726 million
GDP per caput (1996):	EURO 165
Gross Value of Agricultural Output (estimate 1995):	EURO 800 million

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers

Volta Basin (Black Volta, White Volta, and Red Volta):

Black Volta

Length: 650 km

Floodplain area: 570 km<sup>2</sup>

Estimated annual productivity: 50-100 kg/ha

White Volta

Length: 255 km

Estimated annual productivity: 100 kg/ha

Red Volta

Length: 350 km

Estimated annual productivity: 100 kg/ha

### Inland fisheries <sup>\*</sup>

Inland catches as percentage of total catches: 100

Degree of exploitation (1987):

inland catch range (t): 2 500 – 5 000

inland potential catch range: 15 000

<sup>\*</sup> Van den Boosche and Bernacsek (1990, Vol. 2 Table 2, p. xii)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Supply per capita
	'000 t (fresh weight)				kg/yr
Fish for direct human consumption	8	6.2	3	14.2	1.4
Fish for animal feed and other purposes	-	-	-	-	-

Estimated employment (1996):

Primary sector: Approx. 7 000 people

Secondary sector: Approx. 3 000 people

Gross value of fishery (1992) (first sale value): EURO 5.8 million

Trade (1995):

Value of imports: EURO 3.5 million

Value of exports (estimation): EURO 2.0 millions

## Inland fisheries †

### General overview

Inland fisheries have been producing annually between 6,000 and 80,000 tonnes over the last few years in Burkina Faso. Despite Sahelian conditions, Burkina Faso enjoys a relatively important hydrological network including three major basins: Comoé river basin in the western part of the country, the Volta river basin in the central part, and the Niger river basin in the eastern region. During the flooding period, the whole network extends over 122,000 hectares, while during the receding season, it reduces to approximately 50,000 hectares. This includes lakes and reservoirs for about 75 per cent of the total surface, while the remaining 25 per cent is made of rivers and associated floodplains. Fisheries activities take place mainly on the large permanent lakes and reservoirs.

About 7,000 people are directly involved in fisheries activities. Several socioeconomic groups can be distinguished: the full-time professional fishermen (about 10 per cent of the total number), who are mainly migrant fishermen from Mali (Bozo) or from Nigeria (Haoussa); the national "semi-professional" fishers who are also farmers (Mossi, Bobo, Marka); and the large number of occasional fishers. During the 1980s, the semi-professional fishermen were generally organized in corporative groups in order to favor their *professionalization*. The boats are usually 6-m long, non-motorized Malian pirogues. Fishing gears are not highly diversified but they are used specifically at different period in the season: gillnets are used all year rounds, hooklines are used more

specifically during the flooding season, while cast nets are preferred during the dry season.

### Catch commercialization and trade

The majority of the catch is sold fresh, while the rest is dried or smoked using traditional techniques. The post-harvest losses are relatively low and rarely exceed five per cent. Transport and commercialization of fresh fish caught from remote small and medium-sized reservoirs is made by a large number of traders who do not use ice. For waterbodies closer to the urban centers, however, ice or even isothermal storage boxes are used to transport the fish. Most of the fresh fish is sent to the large cities such as Ouagadougou and Bobo Dioulasso. The largest commercial networks are organized by a fish-trader organization located in Ouagadougou. Less organized exports networks are also taking place from fishing camps located at the Malian border.

Approximately 6,000 tonnes are imported every year (2/3 of frozen marine fish and 1/3 of dried or smoked product) for a total value of EURO 3.5-4 million. Since 1989, however, the volume of import is constantly decreasing due to the increase in inland production and the decrease in meat price, which allow low-income households to substitute meat for fish.

### State of the fisheries sector

Monitoring of fish landings is inefficient. It is based on voluntarily declaration by the fishers. The official records do not exceed 1,500 tones while the total annual



catch is thought to vary between 7,000-8,000 tonnes. Most of these catches are made by migrant fishers. The fishing performances of the national *semi-professional* fishers largely depend on their access to fishing gears and the degree of professionalization.

#### **Economic role of fisheries sector**

Fisheries activities are not playing a central role in the economy of Burkina Faso. However, despite a relatively marginal contribution to the GNP and a decrease in the fish per capita consumption (1.4 kg/yr in 1995) fisheries appear to play a more important role in the rural economy. The sector employs about 10,000 people (full-time, part-time or seasonal fishers and jobs in related activities). It also constitutes a complementary activity to

agriculture, especially in areas close to small or medium-sized reservoirs.

#### **Fisheries development**

The annual potential yield is estimated around 10,000 tonnes, which suggests some perspectives for development. Field reports and observations seem to indicate, however, that the fisheries, especially those of large waterbodies, are already close to their maximum potential yield. The construction of the Bagre dam (20,000 ha) may however provide an additional development opportunity for the sector. Moreover, it is thought that the domestic supply could further increase if the fish exported informally toward neighboring countries was sold on domestic markets.

♦ FAO. World fisheries statistics (2002)

## CAMEROON

### General information <sup>^</sup>

Surface area:	475 000 km <sup>2</sup>
Population (1996) :	13 560 000
GNP (1995):	US\$ 8.840 million
GNP per capita (1995):	US\$ 680
Gross Value of Agricultural Output (estimate 1995):	US\$ 2.213 million
Gross Value of Agricultural Output (estimate 1995):	EURO 800 million

<sup>^</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers and floodplains <sup>~</sup>

Lake Chad Basin rivers and floodplains (Logone, Chari and main tributaries):

Length (Logone): 280 km  
Floodplains (Yaéré): 250 – 7 000 km<sup>2</sup>  
Potential productivity (rivers): 30 000 t/yr

Congo-Zaire tributaries

Length (cum.): 1 390 km  
Potential productivity: 350 t/yr

Atlantic coastal basin tributaries

Length (cum.): >3 800 km  
Potential productivity: 2 173 t/yr

Niger-Benue

Length Benue and tributaries (cum.): +550 km  
Potential productivity: 2 125 t /yr

<sup>~</sup> Compiled from Van den Boosche and Bernacsek (1990)

### Inland fisheries <sup>\*</sup>

Inland catches as percentage of total catches: 24% (1987); 38% (1999)<sup>♦</sup>

Degree of exploitation (1987):

inland catch range (t): 20 000 – 50 000  
inland potential catch range : 45 000 – 80 000

<sup>\*</sup> FAO. World fisheries statistics (2002)

<sup>♦</sup> Van den Boosche and Bernacsek (1990, Vol. 2, Table 2, p xii)

### Fisheries data (1997)<sup>♦</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)			kg/year	
Fish for direct human consumption	93	43	2	126	9.3
Fish for animal feed and other purposes	-	3.7	-	3.7	-

Estimated employment (1996):

Primary sector:	65 000
Secondary sector:	180 000
Gross Value of Fisheries Output (at ex-vessel prices 1996):	US\$ 36.4 million
Trade (1998 estimated):	
Value of imports:	US\$ 14.6 million
Value of exports (shrimp):	US\$ 1.4 million

<sup>♦</sup> FAO. World fisheries statistics (2002)

## Inland fisheries ♦

### General overview

Cameroon has a dense drainage network comprising rivers, floodplains, natural lakes and reservoirs, which covers approximately 4 million hectares. The main traditional zones of continental fishing activities are the Lake Chad and the other waterbodies of the northern part of the country. However, since the 1980s, the production of these regions has decreased dramatically due to recurrent rainfall deficit. This decline is partially compensated by the catches from the reservoirs Bamendjin (25,000 ha), Lagdo (60,000 ha), Maga (24,000 ha), Mbakaou (50,000 ha), and Mayo-Oulo (80,000 ha).

### Catch commercialization

In general the exact volumes or values of the catches are poorly estimated. The majority of the inland fisheries catches is commercialized as dried or smoked fish.

A large part of this production is exported, notably to Nigeria. The post-harvest losses are relatively important due to the lack of proper commercialization and trade infrastructures. To satisfy the increasing demand (mainly in the southern urban centers), Cameroon now imports about 43,000 t/yr of frozen fish.

### State of the fisheries sector

For the past two decades, the development of the fisheries sector has been impacted negatively by various factors: (i) the drought which affects the inland fisheries; (ii) the overexploitation of marine resources; (iii) high input costs and trade taxes induced by the CFA devaluation imposed in 1994 as part of the structural adjustment program; (iv) the sector does not benefit from any government subsidies notably those which used to be available for fuel or fishing gear imports.

♦ FAO. World fisheries statistics (2002)

## CHAD

### General information <sup>▲</sup>

Surface area:	1 284 000 km <sup>2</sup>
Population (1995):	6 515 000
GDP (1995):	US\$ 1.185 million
GDP per capita (1995):	US\$ 187
Gross Value of Agricultural Output (estimated 1995):	US\$ 577 million
Gross Value of Agricultural Output (estimate 1995):	EURO 800 million

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers and floodplains

Lake Chad Basin rivers and floodplains

Chari-Logone system:

Length (cum.): 1 300 km

Floodplains (Yaéré): 4 000 km<sup>2</sup>

Salamat river and floodplain (Chad)

Salamat river: 950 km

Fringing floodplain: 4 000 km<sup>2</sup>

Total annual catches: 22 000 t

### Inland fisheries <sup>★</sup>

Inland catches as percentage of total catches: 100

Degree of exploitation (1987):

inland catch range (t): 50 000 – 100 000

inland potential catch range : n.a.

<sup>★</sup> Source: Van den Boosche and Bernacsek (1990, Vol. 3, Table 2, p. xii)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Supply per capita
	'000 tonnes (fresh weight)				kg/yr
Fish for direct human consumption	90	0.7	n.a.	.	6.5
Fish for animal feed and other uses	.	.	.	.	.

Employment (1996):

Fulltime professional fishers: 20 000

Seasonal fishers: 150 000

Gross Value of Fisheries Output (first sale value): n.a.

Trade (1995):

Value of imports: US\$ 0.9 million (estimation)

Value of exports (estimation): n.a.

## Inland fisheries <sup>♦</sup>

### General overview

Until recently, fisheries were ranked third in the national economy of Chad, after agriculture and livestock. Chad was then one of the five largest producers of inland fish in Sub-Saharan Africa with an annual production above 100,000 tonnes. However, severe drought and political instability have caused a relative decline in the production. It is estimated that the production in 1996 was probably close to 90,000 tonnes, with 30,000 tonnes from the Lake Chad and the remaining 60,000 tonnes from the Chari-Logone River system.

### Economic contribution of fisheries activities

Nowadays the fisheries sector contributes approximately 10 per cent of the GNP. A large number of farmers and herders are now involved in fisheries activities and numerous migrant (foreign) fishers are operating from the Lake Chad and other waterbodies. The exact number of fishers, however, is unknown. Three categories of fishers can be distinguished:

- full-time professional fishers;
- seasonal fishers; and
- occasional fishers.

The first category consists mainly of

foreign (from Mali, Nigeria, Ghana, Benin), well-equipped professional fishers that operate from the Lake and the rivers. The second category of fishers is mainly from Chadian households; they fish on a seasonal basis essentially during the receding season (Nov. - June). These are essentially farmers and herders who have been affected by the drought. Occasional fishers adopt fishing as a complementary activity for subsistence.

### Trade and commercialization

Globally men are involved in the fishing activities while women are involved in fish processing and trading. Although the commercialization is still relatively poorly organized, it is recognized that fishing can generate significant revenues and it is often observed that fishers are better off than farmers.

There are numerous local (rural and urban) markets where catches are commercialized. Demand is globally higher than supply. The quality of the products sold in these markets is, however, particularly low, especially in comparison to the products exported to the foreign markets in Nigeria, CAR, and Cameroon. Domestic consumers prefer fresh product. Unfortunately, expansion of commercialization is largely constrained by the scarcity of processing and transport infrastructure. The consumption per capita is still relatively low, at 6.5 kg/yr.

<sup>♦</sup> FAO. World fisheries statistics (2002)

## THE GAMBIA

### General information <sup>▲</sup>

Surface area:	10 600 km <sup>2</sup>
Population (1997):	1.189 million
GDP at purchaser's value (1998):	US\$ 348 million
Gross Value of Agricultural Output (1998):	US\$ 73 million
PCE per head (1998):	US\$ 252
Water area (inland):	2 100 km <sup>2</sup>

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main river

The Gambia River  
 Length: +480 km  
 Annual catches: 1 400 – 3 500 t (1977-82)  
 Potential yield: 2 000 – 8 000 t (Welcome 1979)

### Inland fisheries<sup>\*</sup>

Inland catches as percentage of total catches: 19% (1987); 11% (1999)<sup>▼</sup>  
 Degree of exploitation (1987):  
     inland catch range (t): 1 400 – 3 500  
     inland potential catch range: 2 000 – 8 000

<sup>\*</sup> FAO. World fisheries statistics (2002)

<sup>▼</sup> Van den Boosche and Bernacsek (1990, Vol. 2, Table 2, p. xii)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	32.258	1.28	5.408	28.135	23.7
Fish for animal feed and other purposes	.	.	.	.	.
Estimated employment (1998):					
Primary sector:		5 000			
Secondary sector:		25 000			
Gross value of fisheries output (at ex-vessel prices):		US\$ 4.4 million			
Trade (1998):					
Value of imports:		US\$ 135 000			
Value of exports:		US\$ 2.72 million			

### River fisheries <sup>♦</sup>

Gambia has considerable quantities of brackishwater and freshwater fish. Some of the most abundant species are tilapia (*Oreochromis niloticus*), African bonytongue (*Heterotis niloticus*), upsidedown catfish (*Synodontis gambensis*), catfish (*Clarias lazera*), bagrid catfish (*Auchenoglanis occidentalis*), *Labeo senegalensis* and *Chrysichthys furcayus*. Artisanal fishing activities fall into three categories: marine, lower river and upper river. The lower portion of the River Gambia has a brackishwater regime and marine fish are caught in this area, particularly bonga, catfish, threadfins, barracuda, sole and shrimps. The shrimp (*Penaeus duorarum*) and tonguesole (*Cynoglossus senegalensis*) caught along the river are purchased by industrial fishing companies for processing and export to Europe.

<sup>♦</sup> FAO. World fisheries statistics (2002)

## GHANA

### General information <sup>▲</sup>

Area:	238 539 km <sup>2</sup>
Population (1997):	17 832 million
Gross Domestic Product (1996):	US\$ 5.42 billion
GDP per caput (1996):	US\$ 307

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers and floodplains <sup>☞</sup>

Volta river:

Length (Black Volta): 650 km  
Annual catches (1960): 4 000 t <sup>a</sup>

Oti river: Length: 900 km

Tano river: Length: 625 km

Pra river: Length: 445 km

<sup>☞</sup> Compiled from Nerguaye-Tetteh et al. (1984) and Van den Boosche and Bernacsek (1990)

<sup>a</sup> total catch of the river clam *Egeria radiata*

### Inland fisheries <sup>☞</sup>

Inland catches as percentage of total catches:

14% (1987); 16% (1999) <sup>\*</sup>

Degree of exploitation (1987):

inland catch range (t): 40 000 – 53 000<sup>b</sup>

inland potential catch range : 40 000 – 65 000<sup>b</sup>

<sup>b</sup> including lakes, reservoirs, floodplain and rivers

<sup>\*</sup> FAO. World fisheries statistics (2002)

<sup>☞</sup> Van den Boosche and Bernacsek (1990, Vol. 2, Table 2, p. xii)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (fresh weight)				kg/yr
Fish for direct human consumption	477.2	14.6	32.2	465.6	26.1
Fish for animal feed and other purposes	.	9.0	.	9.0	.

Estimated employment (1996):

Primary sector: 110 000

Secondary sector: 290 000

Gross value of fishery (1996): US\$ 380 million

Trade (1996):

Value of imports: US\$ 19.5 million

Value of exports: US\$ 56 million

## Inland fisheries ♦

### General overview

The inland sources of fish comprise 50 lagoons with a total area of 40,000 hectares, rivers of about 6,000 km in length and lakes covering about one million hectares. The Volta Lake is the largest; it covers about 900,000 hectares with a shoreline of 8,400 km. Fishing on the Volta Lake is done by about 15,000 small (3-7 m) planked canoes, mostly non-motorized, although outboard engines are becoming more common. The sector is wholly artisanal and employs about 85,000 fishers and traders. The annual production is about 74,000 tonnes, accounting for 16 per cent of the annual total national production. The most common fishing gears are handlines and gillnets for tilapia, lates and alestes.

### Economic role of the fishing industry

The Ghanaian fisheries sub-sector accounts for about five per cent of the agricultural GDP. Fish is the major source of animal protein for Ghanaians. Per caput consumption of fish is about 26 kg, representing 60 per cent of all animal protein. In 1996, fish and fish products, including shrimps, tuna loins and canned tuna contributed US\$ 56 million or about 21 per cent of the total non-traditional exports of Ghana. In total, the industry supports up to 1.5 million people, about 10 per cent of the total population.

♦ FAO. World fisheries statistics (2002)



## IVORY COAST

### General information <sup>▲</sup>

Surface area:	322 455 km <sup>2</sup>
Population (1996) :	14.8 million
GNP (1996):	US\$ 10.753 billion
GNP per capita (1996):	US\$ 727.1
Gross Value of Agricultural Output (1996 estimates):	US\$ 3.086 billion

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers

(as part of the Atlantic coastal basin)

Sassandra River:	Length: 650 km
Bandama River	Length: 1 050 km

### Inland fisheries\*

Inland catches as percentage of total catches:	27% (1987); 20% (1999) <sup>a</sup>
Degree of exploitation (1987):	inland catch range (t): 36 000
	inland potential catch range (t): 62 000

\* Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

<sup>a</sup> Van den Boosche and Bernacsek (1990, Vol. 2, Table 2, p. xii)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	67.6	213.1	104.1	156.6	11.1
Fish for animal feed and other purposes	20.0	.	1.0	.	.

Estimated employment (1997):

Primary sector:	30 000
Secondary sector:	Approx. 80 000
Gross Value of Fisheries Output (1995) (first sale value):	US\$ 50 million
Trade (1997 estimated):	
Import values:	US\$ 167.7 million
Export values:	US\$ 200.4 million

### Inland fisheries <sup>♦</sup>

The exact inland fisheries production remains unknown. It is thought to be around 18,500 tonnes per year, essentially constituted by *Tilapia nilotica* (50-70%). Fishers (estimated to be around 6,000) employ small, usually non-motorized boats. Fishing techniques and gears are diverse, including driftnets, castnets, traps and hooklines.

<sup>♦</sup> FAO. World fisheries statistics (2002)

## NIGER

### General information <sup>▲</sup>

Surface area:	1 287 000 km <sup>2</sup>
Population (1996):	9 286 860
GDP at purchaser's value (1996):	US\$ 1.533 billion
PCE per head (1996):	US\$ 216
Gross Value of Agricultural Output (1997):	US\$ 600.6 million

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main river and floodplain

Niger river

Length: 600 km (including 140 km of border shared with Benin)  
Annual catches: 5 000 – 7 000 t

Niger floodplain:

Surface: 90 000 ha (of which 27 000 ha are permanent)

### Inland fisheries <sup>▲</sup>

Inland catches as percentage of total catches: 100

Degree of exploitation (1987):

inland catch range (t): 2 500 – 16 000

inland potential catch range: 4 000 – 16 000

<sup>▲</sup> Source: Van den Boosche and Bernacsek 1990, Vol. 3, Table 2, p. xii)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	4 156	175.1	6.3	4 337.4	0.47
Fish for animal feed and other purposes	.	35	.	.	.

Estimated employment in fisheries (1996): 2 000 households (approx.)

Primary sector: 73 000

Gross Value of Fisheries Output: n.a.

Trade (1999):

Value of imports: US\$ 168 427

Value of exports: -

### Inland fisheries <sup>♦</sup>

#### Fisheries overview

Niger is a landlocked country. Its fish production comes from its inland waterbodies i.e. rivers (e.g., Niger and Komadougou Yobé rivers), lakes (Lake Chad and Lake Madarounfa), permanent and seasonal ponds, and artificial reservoirs. The total area is about 70,000

hectares (1993) while it was probably around 400,000 hectares before 1974. This reduction is mainly due to the effects of the drought, which has even in some cases caused the complete disappearance of waterbodies, as is the case with the Niger part of the Lake Chad. This degradation, combined with the construction of dikes (for irrigation purposes) and the absence of

coherent policies and regulations of water resources uses and fisheries management at the national level has resulted in the constant decline of fish production since 1981 (16,400 t in 1972; 8,000 t in 1980; 6,000 t in 1982; and between 2,000 and 4,100 t/yr since 1990).

### **The fishers**

The professional fishers who exploit the various waterbodies come from 2,000 households. They use gillnets, hooklines, harpoons, castnets, traps, clapnets and seines. The low catches and the necessity to recover the high costs of the fishing gear force them to use prohibited gears and to fish during closed season with obvious negative effects on the resources. Some other fishers practice farming and herding activities. They fish (for subsistence) mainly during the period of low activity on farms. Most of the boats are non-motorized pirogues (the few motorized boats being used for transportation).

### **Trade and commercialization**

Per capita fish consumption is extremely low. In 1996 the average consumption of fish was 0.47 kg/person/yr while that for meat was 14 kg/person/yr. In urban centres, fish consumption can be slightly higher (0.8 to 1.2 kg/person/yr). This low consumption results from a combination of different cultural and socioeconomic factors: the lack of infrastructure for the transport, commercialization and distribution of fish, diet habits, scarcity and high price of fish products. Imports from Mali, Burkina Faso and Nigeria and exports of dried fish to Nigeria or Benin have been both modest and stable over the last few years. Imports of marine fish stopped just after the CFA devaluation in 1994 and have not yet resumed.

### **State of the sector**

Since 1994, the total annual production has not exceeded 4,500 tonnes. The annual variation simply reflects the flood volumes, the local rainfall levels, and the water level of Lake Chad. Some ponds do present significant potentials but are usually underexploited. Most of them have no management plan, the activity being simply limited by the remoteness of the waterbody and the distance from market or urban centers.

### **Economic role of the fisheries**

The fishery sector contributes about one per cent to the GNP (in *good* years). However, it plays an important role in terms of food security for the fishers' households (self-consumption estimated to be about 20 per cent) and the consumers. Fishing activities allow the generation of constant revenue for both fishers and traders.

### **Market dynamics**

The (small) Niamey market is the main commercial center for fish products in Niger. Niger consumers prefer fresh fish rather than dried or smoked fish. Imports (175 tonnes in 1996) are essentially for foreign consumers. The supply of fresh fish varies depending on the fishing season. The flood recession season (February-July) is the period of greatest abundance (and low price). In contrast, during the flood season (December-February) the supply is lower and prices higher. The prices are determined by market mechanisms despite an official price regulation by the Ministry of Commerce. Globally the supply is insufficient (less than 0.5 kg/person/yr), but the demand is also low due to the low purchasing power of the consumers.

## NIGERIA

### General information <sup>▲</sup>

Population (1997):	103.9 million
GDP at 1984 factor cost (1997):	US\$ 1.36 billion
PCE per head (1997):	US\$ 248
Gross Value of Agricultural Output (1997):	US\$ 526 million

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main river and floodplains <sup>≈</sup>

Niger River:

Length (in Nigeria):	1 300 km
Floodplains:	3 000 km <sup>2</sup>
Annual catches:	13 450 t (1966)
Niger outer delta	
Annual catches:	19 000 t (1980)

Benue River

Length:	1 440 km
Floodplains:	1 810 km <sup>2</sup>
Annual catches	10 000 (1966)

Cross River

Annual catches	4 000 – 8 000 (1975)
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Other rivers and mangroves

Annual catches:	13 000 t (1980)
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Other floodplains: 300 km<sup>2</sup>

Oueme river floodplain (deltaic): 100 km<sup>2</sup>

Annual catches: 5 700 t (1976)

<sup>≈</sup> Compiled from Ita et al. (1985) and Van den Boosche and Bernacsek (1990)

### Inland fisheries <sup>▲</sup>

Inland catches as percentage of total catches:

44% (1987); 41% (1999)\*

Degree of exploitation (1987):

inland catch range (t): 110 000 – 130 000<sup>a</sup>

inland potential catch range : 200 000 – 250 000<sup>a</sup>

<sup>a</sup> including lakes, reservoirs, floodplain and rivers

\* FAO. World fisheries statistics (2002)

<sup>▲</sup> Van den Boosche and Bernacsek 1990, Vol. 2, Table 2, p. xii)

### Fisheries data <sup>▲</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	383.4	227.14	9.14	602.41	5.8
Fish for animal feed and other purposes	.	.	.	.	.

Estimated employment (1997):

Primary sector: 70 000

Secondary sector: n.a.

Gross Value of Fisheries Output (at ex-vessel prices): US\$ 180 million (estimated)

Trade (1997):

Import values: US\$ 159 million

Export values: US\$ 8.4 million

## Inland fisheries \*

### General overview

The inland capture fishery is basically artisanal, exploiting the major rivers, their tributaries, natural lakes and various reservoirs. The catch is dominated by *Lates* spp., *Gymnarchus* spp., *Synodontis* spp., *Clarias* spp. and *Chrysichthys* spp. The total surface area of freshwater bodies in Nigeria has been estimated at almost 15 million hectare. This includes rivers, flood plains, wetlands and lakes (natural and artificial).

### Utilization of the catch

There is a huge supply-demand gap for fish and fishery products in Nigeria: 400,000 tonnes of supply against 800,000 tonnes of demand (1997). This is in spite of its significance in the local diet and its favorable price compared to its substitutes. Fish alone contributes on average 20 - 25 per cent of per caput animal protein intake, and could be as high as 80 per cent in coastal and riverine communities. The total supply from all sources – artisanal coastal, brackishwater, inland waters, aquaculture, industrial coastal, and imports – is, therefore, consumed locally, with the exception of high quality shrimps graded for export.

The predominant species in the landings of the coastal artisanal fishery – the pelagic – are preferred smoked. There is, therefore, a huge processing industry – dominated by women – along the entire coast. It is characterized by individual, small-scale enterprises, mostly home-based, but the products are aggregated in markets by wholesalers, also women, who take over the distribution to inland markets, up to the northern fringes of the country. There is an equally important and

similar trade in the opposite direction, for processed fish from Lake Chad and some important rivers in the north. *Clarias* spp. from Lake Chad is also preferred smoked. The processing and packaging has been improved over the years, such that it has the highest shelf life among the local products and is available in the markets of the very densely populated cities of the southern region.

The major freshwater species – tilapia, *Chrysichthys*, *Gymnarchus*, *Lates*, *Heterotis* – are preferred fresh, but they are available fresh only at high cost. For reservoirs and lakes that are within or close to major human settlements, markets develop around the landing sites and the product is usually disposed of within hours of landing, partly to direct consumers and partly to marketers who may retain the fish for a few days. Most other landing sites in the inland water system are remote and facilities for preservation other than smoking are non-existent. The smoked product ends up in roadside markets where patronage is anything but guaranteed. The value of such smoked products vis-à-vis the fresh equivalent depends on the species and the quality of processing.

### State of the inland fisheries resources

The inland fisheries resources are also highly depleted, especially the rivers where illicit fishing practices are rife, and erosion and siltation recur annually. The reservoirs and lakes are in a better state, with various management measures being applied. Natural productivity is being enhanced by restocking with high quality, hatchery-produced fingerlings, and fishing effort is under some sort of control. An example

here is the Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project, which has put in place a management plan for the sustainable exploitation of the fisheries resources of the lake.

### **Economic role of the fishing industry**

For the entire artisanal coastal and inland sectors, fishing is the major source of livelihood. A total of 500,000 coastal and 200,000 inland fishers are recorded as primary producers. For such a well-

integrated industry, the total employment could well be five-fold. The industrial sector provides employment for about 100,000 Nigerians in various fields such as management, engineering, vessel operation, distribution and marketing.

Output of the fishing industry is very important economically. Although less than 50 per cent of the total supply is produced locally, it accounted for 1.71 per cent of the 38.7 per cent contributed by agriculture to GDP in 1997.

♦ FAO. World fisheries statistics (2002)

## MALI

### General information <sup>▲</sup>

Surface area:	1 240 278 km <sup>2</sup>
Population (1999):	11 039 000
GDP at purchaser's value (1999):	US\$ 2.568 billion
Fisheries GDP (1999):	US\$ 24.14 million
Fisheries GDP / GDP (1996):	0.94%
Surface of waterbodies	20 000 km <sup>2</sup>

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main river and floodplains <sup>≈</sup>

#### Niger river

Length: 3 000 km  
Annual catches: 5 000 – 7 000 t

#### Central delta of Niger River

Surface area: Annual permanent equivalent: 16,000 km<sup>2</sup>  
Annual catches: 55 000 – 75 000 t (1980s)  
Potential yield: 75 000 – 150 000 t/yr

#### Senegal River

Length: 1 400 km  
Annual catches: 2 000 t (1980s)

#### Main tributaries

Faleme River: 300 km  
Bakoye River: 300 km  
Baoule River: 350 km

<sup>≈</sup> Compiled from Van den Boosche and Bernacsek (1990)

### Inland fisheries <sup>\*</sup>

Inland catches as percentage of total catches: 100

Degree of exploitation (1987):

inland catch range(t): 55 000 – 100 000  
inland potential catch range: 100 000 – 200 000

Number of fishers: 55 000 (in 1975); 73 000 (in 1997) <sup>§</sup>

<sup>\*</sup> Van den Boosche and Bernacsek (1990, Vol. 2, Table 2, p. xii)

<sup>▼</sup> FAO. World fisheries statistics (2002)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	93 056	900	661	93 294	8.5
Fish for animal feed and other purposes	5 710	.	.	1 143	.
Estimated employment (1998):					
Primary sector:	3 000				
Secondary sector:	260 000				
Gross value of fisheries output (1999):	US\$ 350 million				
Trade (1999):					
Value of imports:	US\$ 566 million				
Value of exports:	US\$ 535 million				

## Inland fisheries <sup>♦</sup>

### Fisheries overview

In Mali, the annual production is greatly dependent on the flooding of the two main rivers: the Niger and the Senegal. For instance, in 1969-70, when these two rivers were strongly affected by the severe Sahelian drought, the production was only 87,000 tonnes; yet in the period 1984-85 that was characterized by a large flood, the production reached 350,000 tonnes.

The Niger River (1,700 km in Mali) constitutes the main fishing zone, thanks to the central delta and the numerous lakes and ponds that are inundated during the flooding season. In good flooding years, the total flooded area may reach 30,000 km<sup>2</sup>. Three main fishing grounds can be distinguished:

- The Niger River (and its main tributary: The Bani river) characterized by important variations in their volume of discharge between the receding and flooding periods
- The delta floodplains that are inundated during the flooding seasons and dry out after the receding season
- The seasonal ponds connected to the river during the flooding period.

### The fishers

The total number of fishers is probably around 73,000 (1997). Three main categories of fishers can be distinguished:

- The fishers-farmers (They allocate a large part of their labor and income to agricultural activities and use fishing products to complement their subsistence economy.)
- The non-migrant professional fishers (Bozo, Somono) (Fisheries activities

represent an important element of their income, but they are also involved in agricultural activities.)

- The migrant professional fishers who depend exclusively on fishing activities for their livelihoods.

### Catches commercialization and trade

Due to the lack of infrastructure, a large part (75%) of the catches is commercialized as smoked, burned or dried fish. The production is then transported to Mopti. In 1999, the average price in Mopti was 1,250 FCFA/kg (US\$ 1.9/kg). The production was used as follows:

- 3,760 tonnes for domestic markets;
- 927 tonnes for export to Ivory Coast (808 tonnes) and Burkina Faso (119 tonnes) for the total commercial value of 1,161,278,850 FCFA (US\$ 1,772,945), with the added value of about CFA 30 billion; and
- 1.143 tonnes for animal consumption.

At the same time, 1.891 tonnes of fresh fish were traded locally. In addition, 2.6 tonnes were exported to other destinations at the average price of 676 FCFA/kg (US\$1/kg). The per capita consumption is still relatively low at 8.5 kg/yr.

### Economic role of fisheries activities

Fishing is a very important economic activity in Mali, especially in rural areas. It directly concerns 260,000 persons, or 3.6 per cent of the rural population, and it is estimated that overall more than 500,000 people are directly or indirectly dependent on this activity (including fishing gear repairers or sellers, fish traders, and fish processors).

<sup>♦</sup> FAO. World fisheries statistics (2002)



## SENEGAL

### General information <sup>▲</sup>

Surface area:	196 722 km <sup>2</sup>
Population (1996):	8 530 000
GDP at purchaser's value (1996):	US\$ 4.795 billion
Gross Value of Agricultural Output (estimated 1996):	US\$ 482 million
PCE per head (1996):	US\$ 290

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers

#### Senegal River

Total length: 1 640 km  
Length (in Senegal): 1 400 km

#### Sine-Saloum River

Length: 100 km  
Total annual catches: 6 000 – 8 000 t

#### Casamance River

Length: 325 km  
Total annual catches: 12 000 – 15 000 t (1987)

### Inland fisheries <sup>▲</sup>

Inland catches as percentage of total catches: 5% (1987); 23% (1999)<sup>▼</sup>

Degree of exploitation (1987):

inland catch range (t): 13 000 – 60 000  
inland potential catch range (t): 100 000

<sup>▲</sup> FAO. World fisheries statistics (2002)

<sup>▼</sup> Van den Boosche and Bernacsek (1990, Vol. 2, Table 2, p. xii)

### Fisheries data <sup>▲</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	383.2	17.0	145.0	252.0	29.9
Fish for animal feed and other purposes	53.0	.	53.0	.	.

Estimated employment (1998):

Primary sector: 60 400 amongst whom 3,350 industrial fishers

Secondary sector: n.a.

Gross value of fisheries output (at ex-vessel prices): US\$ 350 million

Trade (1996):

Value of imports: US\$ 11.3 million

Value of exports: US\$ 310.5 million

## Inland fisheries ♦

In the 1950s, rainfall in Senegal was abundant and river floods regular. At that time, inland fisheries provided more than 80 per cent of animal protein intake in the regions where fishery activities were taking place. During the 1970s and 1980s, however, the drought and various dams built for purposes of flood control have dramatically affected the inland fisheries production. In 1996, inland fishery catches were 47,500 tonnes.

In the inland regions far from the coast, most fish is consumed in dried and smoked form. Recently, however, Dakar has become the first region for consumption of Kethiakh (smoked fish) distributed through the two main retailer markets of Thiaroye and Castor.

♦ FAO. World fisheries statistics (2002)

## SIERRA LEONE

### General information<sup>▲</sup>

Surface area:	72 326 km <sup>2</sup>
Population (1998):	4.568 million
GDP at purchasers' value (1998):	US\$ 699 million
GDP per caput (1998):	US\$ 155

<sup>▲</sup> Economic and demographic data from UN and World Bank sources; fisheries data from FAO. World fisheries statistics (2002)

### Main rivers and floodplains<sup>\*</sup>

Rivers (Sewa, Jong, Little Scarcies, Rokel, and Moa rivers)

Total length (cum.): 1,280 km

River floodplains

Surface area (cum.): 10,000 km<sup>2</sup>

### Inland fisheries<sup>\*</sup>

Inland catches as percentage of total catches: 30 (1987); 30 (1999)<sup>⊗</sup>

Degree of exploitation:

inland catch range (t): 16,000 (1987) – 10,000 (current)<sup>a</sup>

inland potential catch range (t): 11,000 – 14,000 <sup>a</sup>

<sup>a</sup> including lakes, reservoirs, floodplain and rivers

<sup>⊗</sup> FAO. World fisheries statistics (2002)

<sup>\*</sup> Compiled from Balarin 1985 and Van den Boosche and Bernacsek (1990)

### Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Per caput supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	59 437	2 282	9 120	52 599	12.3
Fish for animal feed and other purposes	.	.	.	.	.

Estimated employment (1994):

Primary sector: About 80,000 - 100,000 full-time, plus additional 60,000 part-time, middlemen and processors

Secondary sector: n.a.

Gross Value of Fisheries Output (at ex-vessel prices 1998): US\$ 30 million

Trade (1998 estimated):

Value of imports: US\$ 3.2 million

Value of exports: US\$ 13.6 million

## Inland fisheries ♦

### General overview

Sierra Leone has a dense drainage network comprising the main river systems, which empty into the Atlantic Ocean. Inland lakes also include Lake Sonfon, Lake Mape and Lake Mabesi. Species caught include mullets, catfish (*Clarias* spp.) tilapia, oysters and clams. None of these have been commercialized as the fishing methods have to be substantially improved. Everything is done at the subsistence level. Production estimates have not been worked out although a conservative estimate can be put at about 10,000 tonnes. This sector has been severely disrupted as a result of the civil war in the country with many areas not under government control for the past five years. With the return of peace, it can be considered a priority for development.

### Utilization of the catch

In the industrial sector, the catch landed in Freetown is sold frozen, and it is also distributed frozen to consumers by traders. Some of the frozen fish is later thawed, smoked and sold in local markets for immediate consumption, or is hard-smoked and packed into baskets

for transportation to the hinterland. The previous, well-organized trade in frozen fish by insulated trucks appears to be suspended for the time being. At the same time, the massive displacement of inhabitants has resulted in a big drop in the inland market for fish. The bulk of the catch is, therefore, utilized within the capital city Freetown and its environs. It is hoped that, with the signing of the Lome peace accord and eventually the maintenance of stability and security, the inland market will reappear and kick-start fish trade once again.

### State of the industry

The artisanal or small-scale fisheries sector, notwithstanding the various constraints, continues to contribute significantly to the protein intake of the population. From the limited figures available, there seems to have been a continuous drop in the gross value of the industrial fishery (export and locally-landed fish) from 1991 to 1996. Much as the artisanal fishery contributes significantly to feeding the people, the industrial fishery could contribute significantly to foreign exchange earnings.

♦ FAO. World fisheries statistics (2002)

## **CHAPTER 3**

# **The Valuation of Riparian Fisheries in Southern and Eastern Africa**

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## Contents - Chapter 3

<b>Summary</b>	109
<b>1. Introduction</b>	110
<b>2. Riparian Fisheries in Southern and Eastern Africa: Context for Valuation</b>	111
2.1 The Scale and Importance of Freshwater and Riparian Fisheries	111
2.2 Contribution to Livelihoods	112
2.3 The Dynamic Nature of Fisheries	112
2.4 Control and Sustainability of Fishery Values	113
<b>3. Riparian Fisheries Valuation Studies</b>	113
3.1 Rufiji Floodplain and Delta	114
3.2 Kilombero Floodplain	117
3.3 Lower Shire River	117
3.4 Zambezi-Barotse Floodplain	119
3.5 Zambezi-Chobe Floodplain System	120
3.6 Chobe-Lake Liambezi System	121
3.7 Okavango River, Namibia	122
3.8 Zambezi Delta	123
3.9 Mutshindudi River	124
3.10 Crocodile River	124
<b>4. Valuation of Potential Changes Due to Water Development Projects</b>	125
4.1 Tana River	126
4.2 The Lesotho Highlands	127
<b>5. Discussion: Methods for Valuation of Riparian Fisheries</b>	129
5.1 An Appraisal Framework for Valuation	129
5.2 Economic Valuation Techniques	130
5.3 The Market Value Approach	130
5.3.1 The Quantification of Catch	131
5.3.2 Measurement of Price	131
5.3.3 Measurement of Production Costs	132
5.4 Survey Methods	132
5.4.1 Focus Group Discussions and Key Informant Interviews	132
5.4.2 Household Surveys	134
5.5 Analysing and Interpreting Values	136
5.5.1 Issues of Time, Scale and Sustainability in Value Calculation	137
5.5.2 Considering Potential Value	139
5.6 Estimating Impacts on Value Due to Environmental Change	139
5.7 Should Valuation Be Carried out More Efficiently or Rapidly?	140
<b>References</b>	143

## SUMMARY

This paper was commissioned by the WorldFish Center as part of a global survey. It reviews the published and gray literature concerning economic valuations of river fisheries in eastern and southern Africa, extracting the best available information on their direct economic values and on the impacts of changes in water management on this value. It then assesses the methods used and makes recommendations regarding approaches to be used in future. The review concentrates on rivers with their associated floodplains and major deltas. The values and issues associated with estuaries and lakes are not considered.

Riparian fisheries in eastern and southern Africa tend to be small-scale, labor intensive, artisanal fisheries. They have received relatively little attention because they have limited commercial value compared to marine and lacustrine fisheries. However, they make an important contribution to subsistence income. Because they are highly seasonal, they tend to form part of a risk-spreading strategy, as one of several activities that households engage in. Fishing can provide a fallback source of food and income in years when local rainfall events lead to crop failure.

There is a concern that the capacity for fisheries, which forms part of a risk-spreading strategy, is being adversely affected by development processes, which will lead to overexploitation. Fisheries in the region consist of three types: primarily subsistence fisheries; semi-commercialized fisheries; and primarily commercial fisheries in which, if controls are weak, can become overexploited with a predominance of outsiders. This tendency is exacerbated by a general trend in weakening of traditional leadership and control of natural resources. The stage of development and status of a fishery should be taken into consideration in the execution and interpretation of valuation studies.

There have been relatively few attempts at the comprehensive valuation of riparian fisheries in the region, and almost none of these studies are published. Fisheries have been valued in about 15 large river, floodplain or delta systems: the Tana River, Rufiji floodplain and delta, Kilombero floodplain, Lower Shire wetlands, Barotse floodplain, Okavango River, Zambezi-Chobe floodplain system, Lake Liambezi, Zambezi delta, Orange River, Komati River, Muthsindudi River, Lesotho Highlands rivers and Crocodile River, and results are summarized.

The valuation methods employed have all involved fairly straightforward conventional economic valuation based on market-based methods. Many also included a degree of livelihood analysis in which the contribution of the fisheries to household livelihoods was examined. Only two included economic impact assessments.

Valuation of natural resource impacts has not been a common practice in EIAs. However, two of the above studies, the Lesotho Highlands and Tana River studies, addressed losses in downstream fishery values as a result of proposed dam construction. Both studies relied on the estimated changes in fish supply made by biologists, before converting these changes in supply into changes in value. Although the Lesotho Highlands study was based on relatively crude estimates of the expected changes in fishery production, it included sensitivity analysis relating to demand elasticity, and risk assessment.

In market valuation, the quantification of catches poses the largest challenge because reliable statistics are often not available. This requires comprehensive household surveys, repeated at appropriate intervals. Most of the studies reviewed had a similar approach to data gathering in that they used a combination of complementary methods, including focus group discussions, key informant interviews and household surveys. Subtle aspects of

the design of these instruments were crucial to their success.

Values are calculated and presented in a number of ways, and it is important to consider the values in context. This requires a much broader study than of fisheries alone. A major problem with the existing studies is the fact that they are based on a maximum of one year's data without taking interannual variability into account, and so none of them accurately assess the status of the fishery in terms of its sustainability. Values could thus be overestimated or underestimated when considered over a longer term. The relationship between catches and flows is very poorly understood, and this hampers the estimation of economic impact assessments.

Most of the studies reviewed were fairly substantial undertakings. It has been proposed that future studies ought to be more rapid if more systems are to be understood and valued. Various short-cut methods have been attempted, but these invariably compromise the quality of results, as none of the studies was considered to yield highly reliable results. In fact, baseline studies in future should be more comprehensive attempting to better understand the dynamics of these fisheries, and rapid evaluations should be designed for monitoring purposes.

## 1. INTRODUCTION

Fisheries represent one of the most important benefits to society that aquatic systems provide, often sustaining the livelihoods of poor rural communities. There is a growing concern that the manipulation of aquatic systems to provide water for external uses, such as urban consumption and irrigated agriculture, threatens the production of fishery resources, and thus the livelihoods of many users. However, decisions about water allocation need to be well informed if the right tradeoffs are to be made. It is thus

important to understand the contribution that aquatic ecosystem goods and services make to food security, local livelihoods and local and national economies, if these are to be taken into account in water allocation, policies, institutions and governance, and also in schemes to maximize such values. It is also important in other cases where compensation for a loss of fishery production is required.

However, valuation of natural resources has only taken off relatively recently, and there are still vast gaps in our knowledge as to how freshwater fisheries contribute to local livelihoods and economies. This is especially true in eastern and southern Africa, where the lack of knowledge can be largely ascribed to a general lack of capacity not only in terms of trained professionals but also in terms of appropriate tools and methodologies for developing world situations. Several studies have taken place within the last decade, however, which have started to explore different approaches and adapt various methods to the problem of valuing fisheries, and these have yielded a number of estimates of varying quality. Enough work has now been generated to get an idea of the types of values involved, to evaluate the methodologies used, to address the way in which future valuation studies should be carried out, and particularly, to consider how valuation can best be applied in project analyses. This study was thus undertaken, with the following purposes:

- To review published and gray literature concerning economic valuations of river fisheries in southern and eastern Africa.
- To extract the best available information on the direct economic value of these fisheries, as well as information on the wider social value accrued through processing and marketing activities.



- To extract the best available information on the economic impact of any decreases in fisheries catches due to dam construction, water abstraction, or other changes in water management.
- To assess the methodologies used in these studies and provide recommendations on the most suitable for future use, with modifications as appropriate for different sites and circumstances.

Not only does the review concentrate on rivers, but it also covers their floodplains, floodplain lakes and major deltas, all of which are integral parts of the flowing system and affected by water allocation decisions. These will be collectively referred to as riparian fisheries. Estuaries should also fall into this grouping, but they have not been included here because they introduce another level of complexity (See, for example, Lamberth and Turpie 2003). The fisheries associated with large lakes (e.g., Lake Victoria, Lake Malawi) and reservoirs or dams (e.g., Lake Kariba) are not considered here. The review begins by giving a brief background to southern and eastern African river fisheries, and their socioeconomic context. It then describes existing case studies on the value of fisheries and the impact of dams on fishery values, before discussing methodological issues and making recommendations for future studies.

## **2. RIPARIAN FISHERIES IN SOUTHERN AND EASTERN AFRICA: CONTEXT FOR VALUATION**

### **2.1 The Scale and Importance of Freshwater and Riparian Fisheries**

With the exception of semi-industrial fisheries in the great lakes, most freshwater fisheries

in Africa are small-scale and labor-intensive artisanal fisheries. An estimated 2 million fishers are believed to be active in the artisanal sector, of which about 840,000 are in inland fisheries. For each inland fisher, five people are believed to be active in support functions such as processing, transport, marketing and production and maintenance of boats and gear. Thus, about 2.5 million people derive subsistence income from inland fisheries (Tvedten et al. 1994). In addition to this is the recreational fishing sector, which is especially of growing importance in South Africa, where it creates substantial economic activity in areas that offer trout and bass fishing.

Despite the huge numbers of people that depend on them, freshwater fisheries have received little attention from governments and international aid organizations, perhaps because their commercial importance is normally less than marine fisheries (Tvedten et al. 1994). In most cases, much of the value of freshwater fisheries is subsistence value that has not been quantified because it does not contribute to national income statistics. For Africa as a whole, the estimated value of inland fisheries is only 22 per cent that of marine fisheries (Bonzon 1993). This discrepancy is much larger in South Africa, Angola and Namibia, which have highly productive marine fisheries and lack any major inland waters. Indeed, inland fisheries are given very little attention in Namibia's Ministry of Fisheries, and in Botswana and Angola all fisheries are relegated to the Ministry of Agriculture (Tvedten et al. 1994). In eastern Africa, riparian fisheries are small in terms of their total output when compared to lake fisheries. Another factor that seems to discourage attention is the fact that riparian fisheries tend to be more complex than other fisheries because of their integral connection to rainfall, catchment functioning and other economic sectors (Tvedten et al. 1994).

## 2.2 Contribution to Livelihoods

Inland fisheries are considered important mainly as a source of subsistence income and employment, rather than because they provide a significant contribution to the national economy. They are labor intensive, and involve women and children (generally to a greater extent than marine or lake fisheries). Women are often involved in processing and trade, though men are reputed to get more involved with increasing commercialization (Tvedten et al. 1994).

Riverine fisheries are usually seasonally variable; this affects the way in which people fish. Usually, people fish opportunistically, and there are few full-time fishers in the community. Indeed, fishing is usually part of a risk-spreading strategy. This means that rather than aiming to maximize income by specializing in one activity at the risk of starvation in bad years, households aim to minimize risk, which means maintaining a relatively steady (but possibly lower) income or level of subsistence in spite of environmental variability. Risk spreading is common in poor households that lack the buffer of sufficient cash in the bank or its equivalent, cattle. Thus, most households involved in freshwater fishing in the region engage in numerous other activities, many of which may usually take precedence, such as farming, livestock and salt production. Fishing is particularly important to poor households in that it provides a food supply that is not entirely dependent on local rainfall events (LaFranchi 1996).

As long as fisheries form part of a risk spreading strategy, they are likely to have positive implications for management and conservation of fish resources (Tvedten et al. 1994). However, as fisheries in the region become more developed, as described below, their capacity to be utilized in this way is diminishing.

## 2.3 The Dynamic Nature of Fisheries

Freshwater fisheries in the region can be classified into different stages of development. Scudder and Conelly (1985) described the evolution of fisheries from a traditional to a commercial state as follows:

- Stage 1: Primarily subsistence. There are no significant markets, and the fishery is geared towards consumption or local exchange. These are typical in isolated areas with low population density. They employ simple fishing techniques (handlines, traps, baskets, small weirs, cast or dip nets), are seasonal, and usually involve men, women and children.
- Stage 2: Semi-commercialization. As populations increase, expanded marketing leads to intensification, new gear, and a higher catch per unit effort (CPUE). Gill and seine nets are commonly adopted in addition to traditional methods. Trade starts to take place via middlemen, and women tend to be excluded from commercialized fishing, remaining mostly in the subsistence fishery.
- Stage 3: Primarily commercialization. Further development leads to intensive exploitation for local and regional markets. Outsiders move into the fishery seeking profits, and the fishery becomes dominated by gill and seine nets, such that traditional methods are rare. Total catch increases, but CPUE drops as more people enter the fishery. Marketing is dominated by middlemen.
- Stage 4: Overexploitation. In situations of weak or inappropriate management, the traditional fishery becomes totally marginalized and the fishery

becomes overexploited, such that there are low returns to all and the resource declines. There is also a widening socioeconomic gap between a large number of small-scale fishers and a few successful entrepreneurial fishers. Women become excluded from the sector. The last situation arises due to a complex set of factors such as water tenure, credit policies and management strategies (Scudder and Connelly 1985).

In the interpretation of valuation results, it is critical to recognize the fact that fisheries are, more often than not, undergoing dynamic change. This means that total values and their distribution do not remain constant over time.

## 2.4 Control and Sustainability of Fishery Values

Management has a strong influence on value and the distribution of income. Due to a range of social and political pressures, there is a tendency in eastern and southern Africa for a weakening or breakdown in traditional leadership and control, and hence in the effective control of natural resource use on communal lands. Even where there is relatively good control over the use of other natural resources, access to fisheries is often much less controlled, resulting in a tendency toward overexploitation. Thus, it is not surprising that most fisheries, which are often the most difficult to control due to spatial and temporal variability, have become open access. It is, therefore, important to be aware of both the state of management and the stage of exploitation of a fishery in any valuation assessment, as measurement of current values yielded by fisheries would be overestimates if the current levels of harvesting were not sustainable.

## 3. RIPARIAN FISHERIES VALUATION STUDIES

Many of the riparian fisheries of eastern and southern Africa, especially in the larger floodplain systems, have been described in some way, and several are well studied. However, very few of these have involved valuation of these fisheries, and almost none have been published. For example, extensive work has been carried out on the Phongolo floodplain (See reports edited by Walmsley and Roberts 1989 and Merron and Weldrick 1995) and much of which was done in response to impending development, but no valuation study was carried out. In another case, Tvedten et al. 1994 produced a comprehensive overview of Namibian freshwater fisheries, but although various prices were reported, they did not attempt valuation, and this was at least partly due to their philosophy on its usefulness.

Valuation studies that were identified in this review are listed in Table 1. However, it must be emphasized that the search was not exhaustive due to time constraints, and it may not have unearthed all existing *gray literature* reports.

These studies were carried out for a variety of purposes – for the development of natural resource management plans, environmental impact assessments, policy formulation, development programs and the determination of instream flow requirements. They serve to articulate the local value of fishery resources to managers, traditional leaders, local government officials, decision makers and policy makers. The methods and findings of these studies are summarized below.

**Table 1: Summary of fishery assessments involving some level of valuation in southern and eastern Africa (Note: this list may not be exhaustive.)**

System	Location	Authors
Tana River	Kenya	Emerton 1994
Rufiji floodplain and delta	Rufiji district, Tanzania	Turpie 2000
Kilombero floodplain	Morogoro, Tanzania	Mapunda 1981
Lower Shire	Southern Malawi	Turpie et al. 1999
Zambezi & Barotse Floodplain	Western Zambia	Turpie et al. 1999
Okavango River	Namibia	LaFranchi 1996, based on Tvedten et al. 1994
Zambezi-Chobe floodplain system	Eastern Caprivi, Namibia	Van der Waal 1991; LaFranchi 1996, based on Tvedten et al. 1994; Turpie et al. 1999
Chobe R & Lake Liambezi	Southeastern Caprivi, Namibia	Turpie and Egoh 2002
Zambezi Delta	Mozambique	Turpie et al. 1999
Orange River	Namibia/South Africa	Tvedten et al. 1994
Komati River	Swaziland	Turpie 1998
Mutshindudi River	Northern Province, South Africa	Van der Waal 2000
Lesotho Highlands (several rivers)	Lesotho highlands	Majoro 2000
Crocodile River	South Africa	Cox et al. 2001
South African estuaries (all)	South Africa	Lamberth and Turpie 2003

### 3.1 Rufiji Floodplain and Delta

Turpie (2000) conducted a study on the use and value of natural resources of the lower Rufiji River floodplain and delta as an input into the development of a management plan for the area. The 720,000-hectare study area encompassed the lower stretch of the Rufiji River from the boundary of the Selous Game Reserve to the coast. The area was divided into three ecoregions for the study: the floodplain area (containing 8,700 households), the delta area (with 5,093 households), and a *transition area* between the two, in which 2,300 households had close access to both floodplain and delta resources.

A survey was carried out in nine villages across the three ecoregions in order to estimate the direct consumptive use value of all natural resources exploited by the households, including woodland resources,

and the production value of agricultural and other activities. General information (e.g. on prices, seasonality, equipment durability) was collected in focus groups and key informant interviews for each resource type in each of the nine villages, and quantitative data on rates of resource use, sales etc. were collected at a household level ( $n = 128$ ). Estimates were made of the numbers of users and quantities of different resources used, input costs and gross and net income. Income was estimated at the household level and for the study area as a whole, and values were assigned to habitats using GIS data.

Nearly all households in the area consider farming as their primary economic activity. At least 24 types of crops are grown in the area, with rice, maize, sweet potatoes, millet, vegetables and fruit being the principal subsistence crops. Additional crops such as cashew nuts are grown for cash income. Little livestock is kept in this area. In addition,

numerous types of natural resources are harvested by households in the area, including salt, grass, reeds, palm leaves, firewood, timber, mammals, birds and honey. Nevertheless, fishing is considered to be one of the most important activities, and is carried out by 57 per cent of the households (Turpie 2000). This proportion is relatively constant throughout the floodplain and delta areas, and is far more than the 19 per cent of the households estimated twenty years ago (FAO 1979).

Most freshwater fishing takes place in the numerous permanent lakes of the floodplain, which provide breeding habitat for fish and are replenished in most years by floods. In the delta, fishing is in the estuarine and shallow inshore coastal waters. The majority of fishers use nets, although traditional traps and hooks are still commonly used. Gill nets were introduced in the 1960s and only became common in the 1990s (Sorensen 1998). Seine nets are also used. Women in the delta use mosquito nets suspended between poles for catching shrimp. About half of the fishing households own canoes (Table 2).

The freshwater fishery is very unselective in terms of both species composition and size: over 40 freshwater fishes occur in the floodplain system (Hobson 1979), of which more than 30 were named by fishers as being part of their catch. The fishery is, however, dominated by the most common species,

notably the cichlid fish *Oreochromis urolepsis*, commonly referred to as tilapia, and also catfishes (*Clarias*, *Schilbe* and *Bagras*) and *Alestes*. At least 30 species are caught in the delta. The most important fish reported in catches was *dagaa*, a general term for small fishes such as mullet, and *mbarata*, a term for clupeid fish such as *Hilsa kelee*. Prawns (mainly *Peneaus indicus*, *Metapenaeus monocerus* and *Penaeus monodon*) are the most valuable fishery production in the delta, where they form a large proportion of catches (Turpie 2000).

On the river and floodplain, fishing is year round, with strong seasonal change in effort corresponding to periods of flooding. Fishing in the delta is also year round, but with less of a marked seasonal change in catches, as fishers tend to track the changes in availability of prawns by moving up and down the coast. Fishers from the transition area have access to the river, floodplain lakes and the delta, but they tend to concentrate either on freshwater or marine and estuarine fishing. Among the fishing households, annual effort is 86 days per year in the floodplain, 56 days in the transition area, and 123 days in the delta area (Turpie 2000).

In all cases, fishing areas are close to villages, but seasonality in fish availability necessitates migrations of fishers. Focus group data on seasonality revealed a clear trend for peak catches to be later and later as one moves downriver (April to October), while prawn

**Table 2: Average numbers of different types of fishing equipment owned by fishing households in three areas of the Rufiji floodplain and delta, based on household survey data (Turpie 2000)**

Type of equipment	Floodplain	Transition	Delta
Canoes	0.5	0.5	0.7
Hooks	16.5	16.7	3.9
Nets (50 yard pieces)	4.1	3.9	1.8
<i>Nyando/Wando</i> (V-shaped trap from reeds or sticks)	0.4	0.1	0.7
<i>Kifaba/Vifaba</i> (cones)	0.4	0.1	0.0
<i>Kutanda</i> (shrimp net with poles)	0.0	0.0	0.4

fishing is said to vary up and down the coast in response to seasonal wind shifts. The extent to which fishers track these patterns is evident from the numerous fishing camps along the lake shores, river and delta. There is thus extensive overlapping in the use of fishing areas by people from different villages, and outsiders are common in the coastal fishing camps in the delta. Although there are government regulations requiring licences, the fisheries are effectively open access resources.

The total finfish catch was estimated to be about 9,000 tonnes per year, with freshwater fish making up about 5,500 tonnes (Turpie 2000). This is within the estimated sustainable yield of the floodplain area of about 7,500 tonnes, based on Welcomme's (1974) relationship between floodplain area and catch (38 kg/ha). It is also higher than a previous estimate of 3,841 tonnes for freshwater fish, when a much smaller proportion of households were engaged in fishing (Hobson 1979). The artisanal prawn fishery production is in the order of 2,200 tonnes per year, and additionally 113 tonnes of shrimps and 34 tonnes of crabs are also caught (Turpie 2000). The prawn catch estimated by Turpie (2000) was higher than the official statistics of 360-1,583 tonnes in 1987-1992. Turpie's (2000) estimates were, however, lower than that made by a parallel sociological study at 1,700 kg per user household, which would lead to double the total catch estimate by an ongoing survey of landing sites, which, according to government statistics, was purportedly yielding estimates in the order of 10,000 tonnes.

The gross values of the fish and prawn catches (excluding minor coastal crustacean fisheries) were estimated to be US\$ 3.76 and US\$ 4 million, respectively (Tables 3 and 4). These figures include the value of household consumption. In order to calculate net value,

input costs were quantified based on the cost and durability of fishing equipment (including canoes) and the number per household, and variable costs, such as firewood for smoking.

Most fish in the study are sold dried or smoked, except for a small proportion sold fresh on the local market. Prawns are always sold fresh except for the leftovers (small or damaged prawns) that are dried. Prawn dealers supply nets and ice boxes, and are nearly always on hand to ensure the swift export of prawns from the delta. Thus, input costs in the fishery were not high for local fishers, but their bargaining power might have been reduced by these arrangements. A high proportion of catches were sold, and much of the gross income generated was realised in the form of cash income (Tables 3 and 4). Fishing households generate cash incomes of \$213-476 per year, which is substantial in this area.

Further value is added in the community through fish trading, but Turpie (2000) did not investigate this in any detail. However, the prawns caught in the study area are marketed outside it at double the price, and about 90 per cent of the catch is exported (Mwalyosi 1993), bringing much needed foreign income into Tanzania.

Based on estimates of the income from all household activities, fisheries were estimated to constitute 22-48 per cent of the net income per household (including subsistence value), and 38-54 per cent of household cash income (Table 5). Thus, fishing is extremely important to these households. Based on the overall estimates of the total net value, the direct use values of mangrove estuaries and inshore waters were estimated to be about \$ 192/ha/yr, while freshwater systems were estimated to be worth \$ 42/ha/yr.

**Table 3: Estimated total catch of finfish by residents of the Rufiji floodplain and delta, based on household survey data (Turpie 2000)**

FISH	Catch (kg)	Sold (kg)	Price	Gross financial value	Net financial value	Cash income	Net economic value
<b>Flood-plain</b>							
Per user hh	1 078	925	412	444 136	285 355	381 100	292 283
Total	5 214 502	4 474 410		2 148 374 659	1 380 321 141	1 843 456 920	1 413 829 393
<b>Transition</b>							
Per user hh	1 049	772	221	231 829	89 469	170 612	108 535
Total	969 905	713 791		214 349 093	82 723 037	157 747 855	100 351 276
<b>Delta</b>							
Per user hh	1 502	943	227	340 954	278 924	214 061	312 335
Total	2 830 384	1 776 999		642 497 127	525 607 175	403 378 689	588 566 820
TOTAL	9 014 791	6 965 200		3 005 220 880	1 988 651 353	2 404 583 464	2 102 747 489
TOTAL (US\$)				3 756 526	2 485 814	3 005 729	2 628 434

Note: Values in Tanzanian Shillings (TSh 800 = US\$ 1 at time of study); hh: household

**Table 4: Estimated total catch of prawns by residents of the Rufiji floodplain and delta, based on household survey data (Turpie 2000)**

PRAWNS	Harvested (kg)	Sold (kg)	Price	Gross financial value	Net financial value	Cash income	Net economic value
<b>Transition</b>							
Per user hh	780	595	975	760 500	760 500	580 125	912 600
Total	206 310	157 378		201 152 250	201 152 250	153 443 063	241 382 700
<b>Delta</b>							
Per user hh	751	741	1 498	1 124 998	1 124 998	1 110 018	1 344 365
Total	1 996 568	1 969 983		2 990 858 933	2 990 858 933	2951 033 914	3 574 056 459
TOTAL	2 202 878	2 127 360		3 192 011 183	3 192 011 183	3 104 476 976	3 815 439 159
TOTAL (US\$)				3 990 014	3 990 014	3 880 596	4 769 299

Note: Values in Tanzanian Shillings (TSh 800 = US\$1 at time of study); hh: household

### 3.2 Kilombero Floodplain

The Kilombero floodplain fisheries are considered to be one of the greatest fishery resources in Tanzania (Mapunda 1981). The author reported on government catch records and estimated value of the subsistence fishery (Table 6), but no additional information was given on how the data were obtained.

### 3.3 Lower Shire River

The Lower Shire River and its associated floodplain wetlands (Elephant Marsh and Ndinge Marsh) cover about 162,000 hectares and are surrounded by a relatively dense population of about 395,000. The area has better access to markets and far more commercial activity than many of the

**Table 5: Estimated annual total net income (including subsistence value) and cash income per household in the Rufiji floodplain and delta (Turpie 2000)**

INCOME PER HH	Floodplain		Transition		Delta	
	Total net income	Cash income	Total net income	Cash income	Total net income	Cash income
Crops	231.81	77.61	249.99	117.03	211.99	54.82
Livestock	51.72	14.48	30.80	14.10	51.24	19.30
Salt	.	.	.	.	18.47	26.01
Clay	0.11	0.08	0.05	.	1.50	1.86
Plants	54.34	7.01	46.05	18.01	42.68	15.38
Wood products	102.85	44.55	89.34	23.31	135.63	86.56
Fishing	198.32	264.86	154.28	169.13	868.90	825.20
Hunting	0.19	0.14	9.58	3.43	1.19	0.85
Honey	1.47	0.67	1.20	0.52	1.82	1.16
Other	280.50	280.50	326.30	326.30	485.30	485.30
TOTAL	921.32	689.91	907.59	671.83	1 818.73	1 516.44
% Fishing	22%	38%	17%	25%	48%	54%

Note: Values in US\$

**Table 6: Fish production and values for the Kilombero floodplain (Mapunda 1981)**

Year	Fishers	Catch (tonnes)	Value of catch (US\$)	Value per canoe (US\$)	Value per fisher (US\$)
1977	350	7 031	43 572	150.20	124.50
1978	332	2 042	13 911	55.60	41.90

other major floodplain wetland systems in the region. Both subsistence fishing and commercial fishing are carried out. Fish and fisheries play a major role in the economy of the area and provide dietary protein for many rural households and for urban dwellers as far as Blantyre. According to Turpie et al. (1999), who conducted a valuation study of the natural resources including fisheries, some 53 per cent of households in the area are involved in fishing. This study entailed initial village meetings, focus groups (for general information) and a household survey to quantify resource use.

The Lower Shire fisheries had been well studied in the past (Timberlake 1997). Even though the last studies were conducted in the 1970s, comprehensive fish checklists are available, with recent research interests renewed in the area. About 12 species are

exploited commercially, and three species make up 90 per cent of the catch – *Clarias gariepinus*, *C. ngamensis* and *Sarotherodon mossambicus*. Gill nets are the most common modern gear, and cast and seine nets are also used. Many fishers use traditional gear, and wall traps constructed from reeds are used by 27 per cent of fishing households. The mean reported fishing household catch was 317 kg per year, yielding an estimated total catch of 9,750 tonnes. This is similar to the potential catch of 9,000 tonnes calculated by Welcomme (1975). About 40 per cent of the fishing households sell an average of two-thirds of their catch for cash income. Much of this is sold to middlemen who transport the fish to surrounding towns.

Catches are highly dependent on floodwater levels, with poor floods resulting in a low annual catch. At the time of study, there had



been a good flood, and thus good catches for the first time in several years. Indeed, fishery department statistics indicate major declines in recent years, from the estimates of 11,000 tonnes in 1989 to 1,800 tonnes in 1996. The fishery is by nature an open access fishery with no licensing and poor extension services. Outsiders are common and policing non-existent. Fishing with mosquito nets is common, and even members of the fisheries department are using shade netting. Thus, a combination of factors makes the current value of the fishery lower than it could be if well managed and sustainable.

### 3.4 Zambezi-Barotse Floodplain

The area associated with the Barotse floodplain wetlands on the upper Zambezi is approximately 1.2 million hectares in extent, with the main wetland area extending over about 550,000 hectares. Its approximate 224,000 inhabitants fall under the dual administration of the Barotse Royal Establishment and the Central Government. The Lozi culture and traditions are closely linked with the seasonal flooding of the plain, with people moving between the uplands and wetlands. As with many of the other systems mentioned here, people derive their livelihoods from a number of sources, with agriculture being the most important activity and livestock being of great importance as a source of wealth. Fishing provides the traditional staple relish of the floodplain people (99.3 per cent of households consume fish) and is an important source of income (Turpie et al. 1999). Many other natural resources are also harvested for subsistence use and cash income. Less than five per cent of the people are in formal employment (Simwinji 1997). The

fishery is one of the most important sectors in the Western Province (Van Gils 1988), with most production being consumed locally. However, there has been very little research on the Barotse land fishery apart from earlier descriptive work (e.g., Kelly 1968; Bell-Cross 1971, 1974) and government catch statistics from landing sites. Using these data, Van Gils (1988) correlated fish catch to the length of the flooding season.

Based on household survey data, some 54 per cent of the households engage in fishing, reporting an effort of around 327 person-days per year (Turpie et al. 1999). A mixture of modern and traditional gear is used, with 75 per cent of the catch being caught in gill nets. Traditional methods are used when the floodplain is inundated. Women make up a significant proportion (24%) of fishers. The mean reported household catch was 712 kg, leading to an estimated total catch of 10,500 tonnes. This is slightly below the estimated production potential of 12,000 – 15,000 tonnes (Van Gils 1988), and higher than government catch estimates of around 5,000 – 6,000 tonnes (Chitembure 1995, 1996). The fishery has a gross value of approximately US\$5 million, a large proportion of which is subsistence value (Turpie et al. 1999).

Catches are highly variable from year to year, but villagers agreed that their catches had declined markedly over the past four decades. This is blamed on the introduction of modern gear and population increases (Turpie et al. 1999). The fishery is regulated by government and traditional laws, and has the advantage of a fairly strong traditional structure controlling access. However, rules such as mesh size are flouted (many fishers use mosquito nets),

**Table 7: Annual values (US\$) of the Lower Shire fishery, southern Malawi (Turpie et al. 1999)**

	Gross income	Net value	Cash income	Net economic value
Per user household	106	56	28	33
Total study area	4 956 000	4 803 000	1 452 000	4 587 000

because the penalties have not been revised since 1974 despite rampant inflation (Turpie et al. 1999). A closed season was imposed in 1986 by government, but was ineffective because traditional authorities were not consulted.

### 3.5 Zambezi-Chobe Floodplain System

Several studies have been carried out on the fisheries of the eastern Caprivi. The fishery was described by Van der Waal (1990), and a comprehensive survey was also carried out by Tvedten et al. 1994, as a background study for the development of a national policy on freshwater fish resources. Their data were then used by LaFranchi (1996) to estimate fishery values at a regional scale (Caprivi and Okavango), in a study that aimed to assess the value of natural resources to livelihoods and household incomes, intended to support the governments' Community-Based Natural Resource Management (CBNRM) program. This was followed by another study by Turpie et al. (1999) in which fishery values in eastern Caprivi were calculated at the household and aggregate level and set in the context of other livelihood values.

The fish of the Zambezi-Chobe region of eastern Caprivi are highly diverse, with up to 74 species having been recorded, and are a major resource in Caprivi (Van der Waal and Skelton 1984; Bethune and Roberts

1991; Holtzhausen 1991; Timberlake 1997; Mendelsohn and Roberts 1997). Indeed, according to a common saying, "if you don't fish, you are not a Caprivian" (Tvedten et al. 1994), although this particularly applies to the traditionally floodplain living and fishing Subia tribe. According to Turpie et al. (1999), some 75 per cent of the households in the eastern Caprivi/Zambian floodplain area (population about 30,000) are engaged in subsistence fishing, they eat fish almost daily, and fish is rated as the most important source of protein.

Fishing takes place in the main river channels during low water periods and on the floodplain during the flood months. Gill nets are the most common gear, with 98 per cent of fishing households reportedly using an average of four nets at any one time (Turpie et al. 1999). Seine nets, hooks and traditional gear are also used. The traditional methods such as fence traps, spears and baskets, catch a broader suite of species (van der Waal 1990). About 87 per cent of fishers use dug-out canoes, with 67 per cent owning them (Tvedten et al. 1994).

Catches include a large variety of species, with *Oreochromis*, *Serranochromis* and *Clarias* dominating by weight. Household survey data suggested that fishing households spent an average of 760 hours per year on fishing and caught 370 kg, yielding a total estimated catch of 1,279 tonnes. Some 64 per cent sell an

**Table 8: Annual values (US\$) of the Barotseland fishery on the Upper Zambezi, Western Zambia (Turpie et al. 1999)**

	Gross income	Net value	Cash income	Net economic value
Per user household	335	325	98	310
Total study area	4 956 000	4 803 000	1 452 000	4 587 000

**Table 9: Annual values of the Zambezi-Chobe fishery in Kabe district, eastern Caprivi (Turpie et al. 1999)**

	Gross income	Net value	Cash income	Net economic value
Per user household	432	299	32	201
Total study area	1 492 000	1 034 000	108 000	694 000

average of 10 per cent of their catch. Prices fluctuated seasonally and varied among species, as well as between dried and fresh fish. The gross value of the fishery is estimated to be almost \$1.5 million, yielding substantial subsistence value to households. The cash income was small, however, and this can be at least partly attributed to the lack of access to markets. These values do not include the recreational fishing, which also takes place in the area but does not compete much with the artisanal fishery.

At a broader level, the total catch of the Caprivi region, which includes the rest of the Chobe and the Kwando-Linyanti systems, has been estimated at 1,500 tonnes (Tvedten et al. 1994). This was valued by multiplying the weight by a price range to obtain an estimated total value of N\$6.75 – 9.75 million (LaFranchi 1996), or roughly US\$1.35-1.95 million. Thus, the two studies generated fairly similar estimates of gross income. LaFranchi (1996) emphasized the importance of recognizing the subsistence value of the catch.

There is some doubt that the current catch is sustainable. The estimated catch is above the government estimates of MSY (400 tonnes for the eastern floodplains and 300 tonnes for the Zambezi), but below the estimate of 1,800 tonnes one would obtain using Welcomme's figure (1974) of roughly 40 kg per hectare of floodplain area. However, much of this floodplain is inundated only very rarely. Van der Waal (1990) showed a decreasing trend in CPUE between 1975 and 1980, and villagers described decreasing availability of fish over the past four decades (Turpie et al. 1999). This is in spite of the fact that villagers do perceive a greater level of access control in the fishery than in other areas (Tvedten et al. 1994; Turpie et al. 1999).

### **3.6 Chobe-Lake Liambezi System**

Lake Liambezi is particularly interesting from a

fishery valuation perspective. The lake, which falls within the Chobe floodplain and is also fed by the Zambezi via the Bhukalo channel, is a large floodplain wetland of some 10,000 hectares that may be alternatively dry or inundated for periods of several years. It is inundated during high flooding events, and once full, the lake may remain inundated for several years. Several long dry periods have been recorded, the most recent of which was from 1985/6 to 2001, when the lake started to fill up again. When the lake is inundated, it becomes a highly utilized fishing area by the surrounding inhabitants. When dry, a few fishing households continue to fish by traveling to the Zambezi and Chobe rivers, but there is a significant decrease in fishing activity by households in the area. Studies were carried out on the Lake Liambezi fisheries during the 1970s and 80s, and it is estimated that catches amounted to about 600-800 tonnes per year (Van der Waal 1990). The fishery was not given a value at the time. While dry or partially filled, most of the Liambezi flood area is vegetated with floodplain grassland, and much of this is cultivated. This was the situation when Turpie and Egoh (2002) carried out a valuation study as part of an impact assessment for a proposed sugar estate within the Liambezi floodplain area. The situation at the time is described below.

Households in the study area were divided into two groups: those living within easy reach of both the Chobe River and Lake Liambezi (Zone CL), and those within reach of Lake Liambezi only (Zone L). Focus groups were used to collect general information, and an extensive survey was carried out of over 80 per cent of the households to collect quantitative information. According to the household survey data, 22 per cent of CL households and seven per cent of L households had been fishing in the past year (Turpie and Egoh 2002), which is a much lower proportion than one would expect when the lake is inundated. Fishing households were well equipped, with 86 per cent in Zone CL and 59 per cent in

Zone L having canoes, and an average of 5.5 and 1.5 nets per household in the two zones, respectively (Table 10). Traditional fishing methods are considered old fashioned and mainly used by old people (Turpie and Egoh 2002).

Interestingly, some 14 per cent of non-fishing households in Zone CL and 6 per cent in Zone L also owned fishing gear, and 11 per cent and 20 per cent of them, respectively, had canoes. This gives some idea of the latent fishing effort that might come into play when the lake is fully inundated.

Fishing households reported high catches, with an average of 1,740 and 740 kg per household in the two zones, respectively. This adds up to a total estimated catch of some 154 tonnes, which is far less than the full potential of the lake. About 73 per cent of the catch is sold, most being transported to the town of Katima Mulilo or other small towns in the area. Fish is sold fresh as far as possible, transported in wet sacks or cool boxes, and the remainder is dried and transported in boxes. The fishery generates healthy incomes to fishing households (Table 11).

### 3.7 Okavango River, Namibia

The fishery of the Okavango River is among the most traditional fisheries in Namibia (Tvedten et al. 1994). It is interesting to compare this fishery with the Caprivi fisheries. There is greater use of traditional gear in the former case than in the latter one (100% versus 82% of fishing households), and on the contrary much lower use of modern gear (43% versus 98%). Indeed, fishers there claim to prefer traditional gear. Along with this are a much larger number of women fishers in the former than in the latter (55% versus 15%), and even less marketing of fish in the former (Tvedten et al. 1994). According to the authors, most fishers describe the resource as open access. Richness of high-valued species is recorded, and cichlids dominate catches. Estimates of catches vary, though. Van der Waal (1991) estimated that 35,000 residents fished 40 days per year and caught 840 tonnes, while Tvedten et al. (1994) estimated that 56,000 residents fished 60 days per year, yielding 1,045 tonnes. Estimates of the MSY range from 840 to 3,000 tonnes. Van der Waal (1981) estimated the total economic value of the Okavango fishery to be R1.8 million annually. The fishery

**Table 10: Fishing gear owned by households around Lake Liambezi (Turpie and Egoh 2002)**

Average number per fishing household:	Zone CL	Zone L
Canoes	1.05	0.78
Gillnets	5.50	1.52
Seine nets	0.14	0.04
Lines with hooks	1.14	0.70
Fish funnels & fences	0.23	0.26

**Table 11: Annual values of the Liambezi-Chobe fishery in eastern Caprivi (Turpie and Egoh 2002)\***

	Gross income	Net value	Cash income	Net economic value
Per user household in zone CL	440	139	322	36
Per user household in zone L	187	50	137	15
Total study area	38 924	11 687	28 442	2 880

\* Values have been recalculated at N\$ 8.70 to the US\$ as the original estimates were made during a temporary sharp drop in the exchange rate.

makes an important contribution to household food security, both as a food source and as cash income. The protein and micronutrients are also especially important as a contribution to household nutrition and health. The fishery also reportedly helps sustain the social and cultural fabric of communities along the river. Most fishing is for home consumption, and agricultural food production rarely fulfils household food requirements. Agricultural productivity is also declining, so fish is becoming relatively more important (Tvedten et al. 1994). Residents recalled that people relied on fish during the 1978 drought to see them through. Fishing is also important during the famine season, before crops are harvested.

Cash earned from the sale of fish is usually small – about N\$ 45/month on average. However, it needs to be stressed that “this income is integrated into a risk-averse strategy of diverse income source, contributing to household income security and indirectly to the village economy” (Tvedten et al. 1994). Agriculture is the mainstay of daily subsistence, but household security depends on availability of cash income for food, household goods, clothing and school fees, etc. Selling fish is seen as a quick, low-risk source of cash (Tvedten et al. 1994). Even wealthier households with wage earners participate in fishing to diversify their income sources. Sometimes fish is bartered directly for maize meal.

Using the catches reported in Tvedten et al. (1994), LaFranchi (1996) estimated the total value of the catches to be N\$ 2.6-5.2 million, or roughly US\$ 0.5-1 million (LaFranchi 1996). Household-level income was not estimated.

### 3.8 Zambezi Delta

The Zambezi Delta in Mozambique extends in a large triangle from Mopeia to the coast, some 120 km downstream. It covers an area

of 1.4 million hectares and has a population of about 250,000, after having been somewhat depopulated during the civil war. The area is extremely isolated, with very poor road access from centers such as Beira and Quelimane. Most households are involved in subsistence activities, with 95 per cent depending on agriculture (Turpie et al. 1999). The fish and fisheries of the lower Zambezi have been described (Jubb 1967; Willoughby and Tweddle 1977; Sweco 1982; DNFFB 1998) but had not been valued prior to Turpie et al. (1999). Turpie and colleagues used focus groups to obtain general information and conducted a household study in three parts of the delta to obtain quantitative information.

According to Turpie et al. (1999), artisanal fishers use canoes (67%), gill nets (44%), seine nets (2%), hooks (35%), and circle and basket traps (6%). At the coast, seine nets are also used for prawn fishing. Fishers concentrate in small fishing camps along the river banks and coast. Because of the scale of the delta and the variety of habitats involved, the fishery is quite diverse. In the outer delta (towards the coast), about 37 per cent of the catch comes from the marine environment (Turpie et al. 1999). This figure was not included in the valuation.

About 78 per cent of the inner delta households and 66 per cent of the outer delta households were engaged in finfish fishing, and an additional 27 per cent of the latter households were prawn fishers. Catches of freshwater and estuarine fishes were 267 kg and 450 kg in the inner and outer delta, respectively, yielding an overall estimated catch of 15,610 tonnes. With a flooded area of about 500,000 hectares, the delta could yield about 19,000 tonnes per year (Welcomme 1978). Based on the fact that much of the delta is inaccessible, Sweco estimated that the catch would be about 10,000 tonnes (Sweco 1982). Government

**Table 12: Annual values (US\$) of the Zambezi Delta fishery in Mozambique, excluding marine catches (Turpie et al. 1999)\***

	Gross income	Net value	Cash income	Net economic value
Per user household – finfish	115	110	60	120
Per user household – prawns	131	125	21	143
Total – finfish	4 995 000	4 792 000	2 603 000	5 226 000
Total – prawns	129 000	124 000	20 000	141 000

statistics, compiled just from the 15 registered fishing camps, give the estimated catch as 645 tonnes (DNFFB 1998). In addition, prawn-fishing households in the outer delta caught an average of 328 kg per year, excluding the marine portion of their catch, and about 70 per cent of the catch is sold.

Catches, however, are dependent on flood levels, and are much lower in poor flood years. This study was conducted during a period of good floods (Turpie et al. 1999). Nevertheless, fishers complain that catches on average are much lower than in the 1960s before the construction of Cahora Bassa, which has radically reduced freshwater inflows into the system.

Fisheries in the delta are regulated in theory by means of a licencing system. However, fishers maintain that monitoring is scarce, and some were unaware that there were any regulations at all (Turpie et al. 1999). However, it appears that the negative impact of freshwater flows might be greater than that of overfishing, especially considering the relatively low population density in the delta.

### 3.9 Mutshindudi River

Recognizing the need to understand the value of goods and services provided by instream flows for water allocation in South Africa, Van der Waal (2000) studied fish utilization by a rural population around the Mutshindudi River, a part of the Limpopo system in Northern Province. According to the author, little attention has been devoted to the use of fish in smaller rivers such as this, and these fisheries are generally not considered to be

important, with the result that their benefits are ignored in planning and management. The study involved an attitude survey and a survey of fishing activities. In the latter, fishers were approached while fishing and asked a number of open-ended questions while their catch was recorded. The status of the fish resource was also assessed. Many types of gear were identified, such as modern gill nets or modernized traditional gear (traditional traps constructed with shade netting). Catches were dominated by small tilapias, small barb species and catfish. They were quantified in terms of average catch per fishing trip (162 g); from this figure, the annual catch per fisher of 16 kg per year was estimated from approximately 100 fishing trips. At an estimated value per kilogram, this represented a rather small annual income of R130 (compared with the relatively small cash income of about R 2,400 – 6,000 per household). Even though the investment in fishing gear was very low, this still meant a low return on investment. Van der Waal (2000) then estimated the total value of the fishery to be about R 20,000 – 40,000, based on the assumed total length of the river section that is fishable (75 km), and an estimated number of active fishers (125-250 per day). Thus, the total value of the fishery was essentially estimated on the basis of average catches in a sample of fishers (162 g per day – a surprisingly low figure), with all other values based on professional judgment.

### 3.10 Crocodile River

One of the first attempts to value a river fishery in South Africa was a brief study on

the Crocodile River in Mpumalanga Province (Cox et al. 2001), which aimed to demonstrate the way in which valuation might be carried out in the determination of the environmental reserve for a river system. The river flows through private lands of a fairly affluent region for most of its course, but also borders part of a former homeland area in which tenure is communal and inhabitants have a largely subsistence economy. There are thus both recreational fisheries (for exotic trout and indigenous yellow fish) and subsistence fisheries on the river. Cox and colleagues surveyed 10 known fishing households in the communal area on the use of a variety of river resources. No background information on the fishery was obtained, e.g., from focus groups. Respondents were asked about the number of each type of fish caught per day and the number of days and months fished. These data were used to estimate average quantity of fish caught per household per year. Fishing was reported mainly in summer. The data for the six types of fish named were eventually lumped in the analysis, and valued according to size alone. An average price was assigned to all fish, and a gross value per fishing household was calculated as average catch per month x 3 months x average price. In a rather back-of-the-envelope estimation, it was assumed (without any basis) that 15 per cent of the 11,000 households in the communal area were close to the river and that 30 per cent, or 3,400, of these would be fishing households. These figures led to a gross value estimate of about US\$ 1.17 million per year (Cox et al. 2001). The estimate is not reliable, however, due to the sample size and survey design; it was apparently intended only to demonstrate the possible order of magnitude of the value.

Cox et al. (2001) also tackled the recreational fishery. A questionnaire was distributed to all fly fishing clubs, generating 28 acceptable responses from the estimated total of 1,600 fishers (1.75%). The questionnaire aimed to

establish the value of equipment used, its durability, number of fishing expeditions per year, costs per trip, time spent fishing, and fees paid. From the information obtained, it was estimated that fishers spent a total of about US\$ 2.5 million per year on this activity (Cox et al. 2001). Again, the estimate cannot be considered reliable because of the small sample size, questionnaire design and probably avidity bias. The questionnaire, which lacked an explanation of purpose and whose questions had no time frame, was difficult to follow and generated data that made results hard to defend statistically. Thus, it is not surprising that the responses it generated required several follow-up calls (Cox et al. 2001).

#### **4. VALUATION OF POTENTIAL CHANGES DUE TO WATER DEVELOPMENT PROJECTS**

Losses in downstream fishery production as a result of dam construction are a well-known phenomenon around the world (WCD 2002; Jackson and Marmulla 2001). Major losses have been reported for downstream communities in Africa due to dam construction, some of the most well-known examples being on the Senegal and Niger rivers in West Africa. Examples from southern Africa include the Phongolo floodplain and the Zambezi River. Very few estimates of the economic impact of these losses can be found, however. For example, while much work has been carried out on the Phongolo fishery (e.g., Buchan et al. 1988; Coke and Pott 1970; Heeg and Breen 1982, Merron et al. 1993), there is very little done in the way of quantification and no apparent attempts are made at valuation of these impacts. Several studies have been carried out on the fisheries of the Kafue floodplain, including estimated impacts of the dam on catches (Chipungu 1981), but these impacts were not valued.

The creation of Lake Kariba on the Zambezi River is also known to have had major ecological impacts downstream (Masundire 1996), but no studies could be located that have attempted to quantify these impacts. Yet, further downstream, the impact of altered river flow by the Cahorra Bassa on the prawn fishery of the Sofala Bank, offshore from the Zambezi delta, has been quantified. Prawns are dependent on freshwater flows for nutrient supply and sediments. Gammelsrod (1996) obtained catch data from one of the fishing fleets for the period 1974 to 1988, which coincided with the first 15 years of operation of the Cahorra Bassa dam, and showed a clear relationship between river runoff in October to March, and catch per unit effort. His straightforward model was then applied to simulated natural runoff conditions, and it showed that catch rates were some 1,500 tonnes lower than they could be. A simple calculation of the gross value of this loss was US\$ 10 million, based on an assumed price of US\$ 7 per kg. An interesting deduction was that, given the small proportion of the dam capacity actually being used, it would be possible to increase wet season flows to restore shrimp production levels without interfering with the economic outputs of the hydropower plant (Gammelsrod 1996). This information has never been acted upon, however.

In general, the environmental impact assessments for dam construction have not included the valuation of environmental impacts until relatively recently. Thus, the impact assessment for major developments such as the proposed Stieglers Gorge HEP dam on the Rufiji River led to estimations of total catches and the impact on them (Hobson 1979), but the value was not considered. While the notion of valuing environmental impacts has been promoted for several years now, it has not yet been successfully integrated into the EIA procedure. Even in South Africa, which is certainly the leader in

the region in terms of the application of EIA, and which has guidelines for the incorporation of environmental values, valuation has not yet been incorporated into the legal requirements of EIA. Thus, such valuations have rarely been applied at all (Crookes and de Wit 2002). One of the first such valuation studies in the region was by Emerton (1994, 1996) for the Tana River in Kenya. Afridev was one of the first groups to attempt this in southern Africa, with the impact assessment for the Maguga dam on the Komati River in Swaziland. However, the study was only allowed to assess the impacts within the inundation area, and not downstream, although a much bigger impact would be expected to occur downstream. This was followed by a far more comprehensive study by Southern Waters for the Lesotho Highlands Development Project (LHDP). The Tana River and LHDP studies are described in more detail below.

#### 4.1 Tana River

The Tana River is the only permanent river in an extremely arid region of Kenya. Emerton (1994, 1996) provided estimates of the economic impact of changes in some of the production systems relying on the river that would occur as a result of further dam construction. Estimates had to be extrapolated from existing data that had been generated before the construction of any dams (i.e. outdated, as there were five reservoirs on the river at time of study), to a future set of scenarios. The estimation involved a number of assumptions and the figures were largely conjectural (Emerton 1994). Dam construction had already had a major impact on downstream populations through reduction in the biannual flooding of the floodplain and delta area. The proposed additional dams would further reduce flow by up to 70 per cent, effectively cutting the water supply to the floodplain. An estimated 54,400 people of the overall 180,000 living adjacent to the river and delta are dependent on the fisheries, with 50,000



of them on subsistence basis (Emerton 1994). Subsistence fishing is carried out using traps, lines and fish drives, catching mainly tilapia *Sarotherodon mossambicus*, catfish *Clarias mossambicus* and lungfish *Protopterus amphibus*. Fisheries in the delta also target prawns as well as other crustaceans and marine species at the coast. The commercial freshwater catches had been monitored for six years (1985-90) and catches were valued at average prices per kilogram. The total catch for the river was estimated at 500 tonnes, based on Welcomme's (1974) relationship. Ecologists working on the project estimated that the fisheries had already diminished by about 10 per cent, and over the next 50 years wetland fisheries would further decline to a quarter of their original levels, and river and marine fisheries to half their present levels. This loss was valued at KSh 67 million. With additional dams, the situation was predicted to worsen more rapidly; in the worst scenario (High Grand Falls Dam), the same reductions were expected to occur within ten years. This was estimated to represent a cost of KSh 144 million compared to the past situation and KSh 77 million compared to the present (Emerton 1994). These figures represent a stream of values over 50 years, discounted at 10 per cent as the then prevailing opportunity cost of capital in Kenya.

## 4.2 The Lesotho Highlands

An environmental impact study conducted for the Lesotho Highlands Development Project included an assessment of the value of fisheries in the Matsoku, Malibamatšo,

Senqu and Senqunyane rivers. Fishing is one of many subsistence activities of the inhabitants of the highlands, who rely principally on agriculture and livestock. The fishing season in this area lasts roughly six months, and catches are dominated by rock catfish, small mouth yellow fish, and rainbow trout (an exotic species). The study included separate specialist reports on fish (Arthington et al. 1999), sociology (Boehm and Hall 1999) and economics (Majoro 2000). Resource levels were determined in the ichthyological study, use levels in the sociological study, and values in the economics study. The economics report thus relied heavily on the output of the other two, and had to interpolate data when necessary. For example, the ichthyological surveys did not always record the presence of species that local communities reported catching. This can occur when an IFR site is not suitable for the species in question, whereas the fishers catch it elsewhere in the same reach.

The total affected population was calculated to be 155,000 (33,000 households), of which about 1,680 households were surveyed in eight reaches. Households were asked how much fish had been caught per month during summer and winter over the past year, with amounts being separated for small, medium and large fish for each of the three species. Small, medium and large fish were then converted to average weights of 200 g, 500 g and 1,500 g, respectively. Prices were also obtained from the household survey. Results suggested that fish is caught by 15.6 per cent of the households, with mean

**Table 13: Example of the estimated value of fishery in the Katse River reach, and the predicted change in value with the proposed reduction in flow associated with the 'Treaty' scenario of the Lesotho Highlands Development Project (adapted from Majoro 2000)**

Species	Current catch (kg)	Price per kg (Maloti)	Current value (Maloti)	% remaining under Treaty scenario	Predicted future value (Maloti)
Rock catfish	1 332	5-15	13 319	80-100 (90)	11 987
Small mouth yellowfish	5 771	5-20	72 144	80-100 (90)	64 929
Rainbow trout	1 085	5-25	16 279	100	16 279

catches of 17.5 kg of small-mouth yellow fish, 2.2 kg of rock catfish and 3 kg of rainbow trout (Boehm and Hall 1999). Data were provided separately for each reach. Of those who sold fish, 71.5 per cent did so in their own villages, the remainder going further afield (Boehm and Hall 1999).

Resource values were derived by multiplying resource use by prices, and monetary impacts were then isolated by weighting resource value using the magnitude and direction of the predicted biophysical change. Prices for fish of different sizes (given in lengths) were obtained in the sociological study and these were transformed into their weight equivalent to arrive at the data used in the economic study (Majoro 2000). Prices per kilogram varied four- or fivefold.

It was assumed that the supply of resources was limited, and more would be used if available. This assumption was necessary to translate changes in resource supply into losses at the household level (Majoro 2000), and it was supported by the sociological study (Boehm and Hall 1999). It was also assumed that the percentage loss in fish supply as estimated by the ichthyological study translated directly into a similar percentage loss to the households. Although fish is not considered abundant in the system, this is one of the few resources whose use is not controlled by local authorities. Of the biophysical components of the entire study, only vegetation and fish were used in the estimation of costs for flow-related changes (Majoro 2000). Estimated percentage changes were given for each reach in the study, and each reach (or riparian area) was assumed to be accessed by a defined set of households living within 5 km on either side of the river.

Average catch rates were computed from a total of 1,600 households (200 per reach) in the sociological study, and were extrapolated

to the total population. Potential problems of recollection identified during the pilot survey led to the use of different recall periods in the main survey. Respondents were asked to give their mean monthly catch in kilograms over the 6 months of the past fishing season.

If fish resources were to be seriously depleted, then use should stop before the resource was completely extirpated, because the cost of fishing effort would rise to the point where the benefits no longer justified the cost (Conrad and Clark 1987; Majoro 2000). Indeed, fishers in reach 2 indicated that since the construction of Katse Dam it was already barely worth their while fishing (Boehm and Hall 1999). Thus, if fish abundance was predicted to decline by more than 50 per cent, then the economic study treated it as if the fishery had ceased altogether.

The analysis carried out like the one above assumes that a drop in the supply of resources has no effect on price. However, scarcity affects value, and actual market prices would be expected to increase, especially in the absence of substitute resources. Majoro (2000) carried out sensitivity analyses on the basis of three levels of price elasticity (responsiveness of price to a change in quantity supplied). In a situation where prices are highly elastic (prices rise steeply), the loss of value is greater than the straight one-for-one percentage reduction shown in Table 13 above. A further element of the sensitivity analysis assumed that the fish lost is valued at the substitute price of US\$ 2 per kg for hake available in Maseru shops (Majoro 2000).

It is important to emphasize, however, that the estimates of change in value are based on rather uncertain, educated *guesstimates* of the ichthyologists, and somewhat uncertain findings of the sociological study. Thus, Majoro (2000) also incorporated the full range of estimates of change given by the biologists, and the range of prices for

fish, into risk analysis software (@RISK for Excel Version 3.5.1) to calculate a probability distribution for the total change in value. From this information, a mean, minimum, maximum and standard deviation of the expected losses are generated for each reach and for each water development scenario (Majoro 2000). Coefficients of variation were relatively low, probably because of the relatively small range of possible change predicted in the case of fish.

## 5. DISCUSSION: METHODS FOR VALUATION OF RIPARIAN FISHERIES

### 5.1 An Appraisal Framework for Valuation

Barbier (1994) introduced a useful framework to valuation studies as follows:

1. Choose an appropriate general assessment approach within which to apply valuation methods.
2. Define the scope and limits of the valuation and information needs:

- indicate geographic and analytical boundaries;
- draw time frame;
- identify the basic characteristics of the area in terms of structural components and functions, and also attributes, e.g., biodiversity, cultural uniqueness;
- determine the type of value associated with each, e.g., direct consumptive use value;
- rank the major characteristics and values, e.g., in terms of relevance to the study, or contribution to overall value; and
- tackle the most important values first, and the least important only if it becomes necessary.

3. Define data collection methods and valuation techniques.

In the case of riparian fisheries, it is important to recognize that the value is determined via the user population, a portion of which often resides away from the resource for at least part of the year. Thus, the definition of geographic

**Table 14: Commonly-used natural resource valuation methods and the types of value that they are generally used to measure**

	Direct use values		Indirect use values	Option and non-use value
	Consumptive	Non-consumptive		
<b>Market Value Approaches</b>				
Simple Valuation $P \times Q$	33	3		
Production Function	33	3		
Replacement Costs, etc.	3	3	33	
<b>Surrogate Market Approaches</b>				
Travel Cost Method	3	33		
Hedonic Pricing	3	33	33	
<b>Simulated Market Approaches</b>				
Contingent Valuation Methods	33	33	3	33
Conjoint Valuation	3	3	3	3

scope is important when estimating total value and investigating its distribution and contribution to livelihoods. Furthermore, an area may be heterogeneous in ecological or socioeconomic characteristics. Valuation studies should take this into account. For example, Turpie (2000) divided the study area into *ecoregions* on the basis of access to different fish communities.

It is also important to make an upfront decision as to whether the valuation study needs to generate an overall value in terms of gross contribution to the national economy, for example, or the contribution that the resource makes to individual households, and the extent of its influence. Other boundaries that need to be identified up front include the level at which knock-on effects, such as value added by processing and trade, are taken into account.

Valuation techniques and data collection methods are discussed in more detail below.

## 5.2 Economic Valuation Techniques

A variety of methods is used to value economic goods and services provided by natural systems, each being variously suited to different types of values that are being measured (Table 14). This discussion is primarily concerned with the direct use values of fisheries, as opposed to other types of value that ecosystems generate, such as indirect use value and existence value. Direct use value is the value that is most obvious at the local level and often of less concern at the global level. Other values, such as existence and option values, are usually relatively irrelevant at the local level, but they may be significant at the global level. The number of possible methods that can be used to measure the different types of values also decreases from left to right along the columns in Table 14. Option value is seldom measured

explicitly and is also fairly difficult to separate in practice from existence value.

In the case of fisheries, valuation usually involves market value and surrogate market approaches. Market value approaches are appropriate for subsistence and commercial fisheries, whereas the value of recreational fisheries is better estimated using the travel cost approach.

## 5.3 The Market Value Approach

In the case of most fisheries, even remote ones, there are usually market prices for fish even if very few are traded. Thus, market prices can be used as a proxy for the total value of fish production even if much of it is consumed by the fishing households or bartered or shared. In well-functioning, competitive markets, consumers express values through their willingness to pay (WTP) the prices asked for in markets. In such markets, WTP is thus an indicator of positive value attached to any item, and prices function as expressions of value for units of goods and services. Total economic value can simply be calculated by price times quantity. Difficulties arise where markets are not functioning well. Where market prices are distorted (e.g., by subsidization of inputs), adjustments are usually made to correct for these distortions, and the corrected prices are referred to as shadow prices.

Before temporal and other dynamic effects are taken into account, the current annual use value of a river reach in terms of harvested fish can simply be calculated as follows:

$$\text{Annual use value} = Q \times (P - C),$$

where Q is the total catch, P is the market price and C is the cost of harvesting the resource. This measure of value is equivalent to consumer expenditure, and may not

include consumer surplus. This method relies on the measurements of price, harvest costs (which include the cost of capital) and the quantities harvested annually. However, the measurement of Q, P and C is not always straightforward, as discussed below.

### 5.3.1 The Quantification of Catch

Output levels, i.e., catch, or fishing days in the case of a recreational fishery, can be estimated in a number of ways depending on the accuracy required. Although much attention is given in the literature to the measurement of value in valuation studies, comparatively little is said about the measurement of quantity. In fact, as is clear from the results summarized in the previous section, the estimation of catches is the most difficult part of a fishery valuation study, and it is unlikely that any two studies will yield the same estimate for the same fishery.

Quantities of outputs can be measured by direct observation, such as the monitoring of fish landings. Such data are often available although it sometimes requires searching through piles of paper in government offices. However, these statistics often pertain to only a portion of the fishery, such as the commercial fishers, or catches from selected landing sites. Nevertheless, this is useful for measuring trends. Such data, while useful for calibrating trends and estimates of total catch, do not provide much information about the value of fisheries at the household level.

The valuation of artisanal fisheries usually requires an understanding of fishing activities at the household level, as well as the context of the household economy. To obtain this level of information, primary data gathering has usually been in the form of surveys of households in the area, in order to obtain the proportion of households fishing, and then effort and catches of fishing households. This is further discussed below under survey methods.

### 5.3.2 Measurement of Price

Where market prices for harvested resources are available, these should serve adequately as measures of value (Barbier et al. 1997), unless price distortions are expected. The type of price used should be stated explicitly in valuation studies. Prices used are usually those accepted by the harvester before any value is added to the resource by marketing or processing. However, it may be more appropriate to consider the full value generated by a fishery, right up to the final consumer or export. Thus, the value of a commercial fishery should also include the value added by processing and export, and that of a recreational fishery should consider knock-on effects. Market prices do usually exist for most fisheries in southern and eastern Africa. Indeed, many studies that describe fisheries report a few market prices although they do not go as far as using these to compute values for the fishery.

Under certain conditions, market prices may not reflect the true value of a resource. Prices may be distorted by conditions of imperfect competition, for example when local markets are relatively isolated, or through government intervention. If distortions are suspected, the use of shadow prices is usually advocated (Barbier et al. 1997), but only if they can be adequately estimated (James 1991). Shadow prices are corrected prices that account for the distortions and aim to reflect the full value of a commodity to society. They thus reflect economic value rather than financial value. However, the proper correction of distorted prices relies on accurate diagnosis of the direction and magnitude of the distortion, which is often difficult.

If no market prices are available for a resource, as is sometimes the case in subsistence economies, then surrogate prices can be used. There are several possible ways of doing this (Barbier et al. 1997):

- (a) *Barter or trade value*: If the resource is bartered or traded, e.g. fish for rice, then it may be possible to estimate its value based on the market value of a commodity for which it is traded. This method requires information about the rate of exchange between two goods. If such trade is not observed, the information can be obtained using properly designed survey instruments, e.g., ranking techniques in a focus-group discussion.
- (b) *Substitute price*: If a close substitute that can be identified has a market value, then it is possible to assign the value as the price of the substitute. This requires information about the degree of substitution between different goods. For example, Majoro (2000) used the market price of hake as a substitute price for freshwater fish caught in the Lesotho Highlands.
- (c) *Opportunity cost*: Alternatively, it is possible to derive a minimum value for a commodity by estimating the opportunity cost of inputs required for its harvest or production.
- (d) *Indirect substitute price*: In the absence of all the above possibilities, and when the substitute is also unpriced, then it may be necessary to use the opportunity cost of the substitute as a proxy for the value of the commodity in question.

### 5.3.3 Measurement of Production Costs

The costs of inputs such as fishing nets can be estimated directly using market prices. The costs of labor time are usually taken as some proportion of the wage rate, or the shadow price of labor. Where opportunities for formal and informal employment are very low, the shadow price of labour time to collect natural resources approaches zero. This is a complex issue, however, as all time could be said to have an opportunity cost in terms of

other tasks or recreational activities that could be carried out.

## 5.4 Survey Methods

Data are invariably scarce when it comes to conducting valuation studies of artisanal fisheries in eastern and southern Africa. Most of the fisheries valuation studies described in this review thus had a similar approach to data gathering in that they entailed fairly labor intensive household surveys for the collection of primary data. In addition, focus group discussions and key informant interviews are also frequently employed, in which complementary data and sometimes supplementary data are obtained by means of Rapid Rural Appraisal (RRA) techniques (commonly misstated as Participatory Rural Appraisal methods) borrowed from sociology methods. Although questionnaire surveys theoretically provide the most statistically rigorous quantitative data, there are many problems with such surveys that are better addressed by the various RRA techniques available. Turpie (1998); Turpie et al. (1999); Boehm and Hall (1999); Turpie (2000) and Turpie and Egoh (2002) used a combination of household surveys, focus groups and key informant interviews in their studies. In addition, all of these studies were preceded with a reconnaissance visit to the study area to observe circumstances and meet with villagers and leaders, after which survey instruments were designed. The initial reconnaissance-stage meetings are always vital to obtain the cooperation of the community being surveyed, as well as to provide enough information for the appropriate design of survey instruments.

### 5.4.1 Focus Group Discussions and Key Informant Interviews

These techniques are common in social studies, and are useful in fisheries valuation studies for the provision of general data that do not need to be quantified at the

household level. Focus group discussions are usually held with groups of 5-10 people, and while following a semi-structured line of questioning, the discussions are allowed to deviate from the questionnaire, or to concentrate on a particular aspect when appropriate. These discussions are used to collect information of a generally applicable nature, for example on seasonality of catches and effort, descriptions of fishing methods

and their inputs, on markets and prices, processing methods and transport. They are also useful for obtaining information on the control of the fishery and on perceptions of its status or sustainability.

A typical focus group discussion is outlined in Box 1. In the case of some resources such as salt and palm leaves, enough information can be obtained from focus groups to make

### **Box 1 General structure of focus group discussions (Turpie 2000)**

#### **FOCUS GROUP DISCUSSIONS**

##### **A. Introductions**

The purpose of the discussion was explained, and members of the group were encouraged to be as open as possible about the issues to be discussed.

##### **B. Resource description**

All species of natural resources were named and described in detail, indicating where they occur or are grown. Their treatment and uses were also described.

##### **C. Rules of access**

The group was asked to describe how households gain access to resources, and what limitations exist on use.

##### **D. Individuals involved**

People were asked about the role of men, women and children in the production or harvesting of the resource.

##### **E. Equipment**

The group was asked about the type of equipment used, its price, durability, and whether it is shared among households.

##### **F. Seasonality**

The group was usually asked to describe seasonality in the availability and harvesting of certain resources. Some groups were also asked about seasonality of different agricultural activities (e.g., cultivating, harvesting).

##### **G. Returns to effort**

The group was asked how much could be harvested in a day or week during different times of year.

##### **H. Prices and inputs**

Selling prices were obtained for each resource and for products made from these resources. Natural resource inputs into crafts and other products were also quantified.

##### **I. Changes in availability**

Members of the group were asked to describe and explain changes in availability over time.

estimates of total production and value that are comparable to those obtained by using more detailed survey data (Turpie 2000), but this method has not been successful for fisheries because of their relative complexity.

In addition to, and sometimes instead of, formal focus group discussions, informal discussions can be held with members of the fishing community. This is often particularly useful, especially when the interviewee has recently returned from fishing, as it allows the researcher to observe fishing equipment and catches, and to adapt questioning in a more natural manner. This makes respondents far more relaxed than in the rather formal setting of the focus group. It allows gathering information that cannot be anticipated in the formal surveys, and is better for obtaining information on things that people are fairly reluctant to disclose when in groups. Women tend to be particularly responsive to this type of *walking and talking* tactic. Furthermore, in all cases where such an informal discussion was initiated by Turpie (2000), the initial one-on-one interaction ended up with other people voluntarily joining in to provide more information, which was a better way of assembling a group than the more formal nature of the focus group method. The use of a female interviewer and interpreter is essential for interviewing women.

Seasonality can be described qualitatively, but patterns produced cannot be translated to real variation. In other words, it is not possible to take catch in the current month and extrapolate it to the rest of the year based on these data, no matter how appealing. Prices are problematic too. Fish prices are highly variable and do not go according to weight. The researcher is left with the problem of converting prices per fish (measured relative to the size of a hand), often of dried fish, into price per kilogram. Using an average price per fish (Cox et al. 2001) does not produce a reliable valuation of catches.

#### 5.4.2 Household Surveys

Most fishery valuation studies have relied on household survey data to provide quantitative data on fish catches. These are then used to estimate total annual catches at the household level and for the area as a whole. Although catches can be estimated in other ways, household surveys are usually the only reliable way of estimating the number or proportion of fishing households in a study area.

The structure of household questionnaire surveys varies between studies, but it may typically follow the basic structure outlined in Box 2. A fisheries valuation study may or may not include other natural resources, depending on the purpose and context of the study (see discussion below). In the example given, the questionnaire includes questions about the harvesting of all major categories of natural resources, as well as value added through processing and income generated; and it also investigates agricultural production. The most difficult questions are posed early in the questionnaire, with agricultural production at the end to counter the effects of survey fatigue. Questions on fishing would thus be close to the beginning of the questionnaire. A questionnaire such as this takes about an hour to complete when questioning is about all resources.

Most of the studies described above involved a single household survey in which households were questioned just once about their harvesting of resources. In a couple of cases, the surveys were repeated during the dry season and wet season. Where there is significant temporal variation in any of the resource use activities in the study, or where the use of resources is irregular or erratic, it is preferable to survey households more than once, or as often as possible. This is especially important for fishery resources. Most fishers cannot reasonably be expected to recall their catches with accuracy over a



**Box 2 General structure of household surveys used in Turpie et al. (1999), Turpie (2000) and Turpie and Egoh (2002)**

**HOUSEHOLD SURVEYS**

**A. Household information**

Household size and composition

**B. Relative value of household production**

Respondents are asked to apportion a pile of beans among eight different sources of income (crops, fishing, hunting, wood products, plant products, salt making, livestock, and other cash income from trade etc.) to indicate their relative contribution to household income in an average year.

**C. Natural resources**

Respondents are asked about fishing, wood products (forest or mangrove), honey, hunting, reeds, papyrus, grasses, palms, food and medicinal plants, clay and salt production. For each resource, they are asked about the following topics, as applicable:

- whether they harvest the resource, and in the case of fishing, household fishing effort and equipment
- amount harvested over a specified period
- amount sold and price per unit
- amount of products produced from natural resources
- amount sold and prices obtained

**D. Livestock**

Questions are asked on the following topics:

- numbers of small and large stock
- production and sales over a specified period, and prices obtained
- livestock losses to wild animals

**E. Crops**

Questions are asked on the following topics:

- total area cultivated, and crops grown
- amount produced over a specified period for each crop
- amount sold or exchanged, and price obtained
- crop losses to wild animals
- household reaction to poor crop years

**F. Cash income**

Respondents are asked about cash income from wages, pensions, and absent family members.

period longer than a few days or a couple of weeks. Yet, fishers are often asked to recall catches over periods of months, or to integrate their remembered catches into an average per month. Nearly all of the studies reviewed here can be heavily criticized in this respect. Either fishers were expected to recall

catches over too long a period, or surveys were not repeated enough times to yield reliable variation in catches over the year.

Another particularly difficult issue is the choice of units for quantification. Again, while this is an issue for most resources, it is a particularly

problematic issue in the case of fisheries. Fishers transport and sell their catches in a variety of ways, such as in baskets of different sizes, tied bundles, buckets etc. This makes the enumeration of catches and sales extremely difficult to reduce to a total catch weight, unless thorough research is done beforehand to assess the capacity of these different units and the weights of the typical species and sizes caught. Thus, focus group discussions, key informant interviews and direct observation are very important as precursors to survey design. Furthermore, since fish are sold in different forms, such as fresh, dried or smoked, the enumeration of selling quantities has to be equally meticulous.

No matter how carefully designed surveys are for the quantification of household catches, the presence of outsiders in the fishery will always confound estimates of total catch, and thus total value, made in this way. Yet, extending the survey to the temporary *households* in fishing camps may not be helpful in this regard because of the statistical difficulties involved. None of the surveys reviewed here have attempted to carry out quantitative interviews of fishers in fishing camps, although focus group discussions are routinely held in such camps.

As important as the design of the questionnaire is the way in which it is worded and administered. The potential for communication errors is great, and may occur in translation or due to the use of inappropriate terminology. It is thus very important that, after translation into the local vernacular, the final wording is checked by someone who has an understanding of the purpose of the questionnaire as well as the local terms. Wording should not be so formal as to intimidate simple households. There are many other subtleties about survey design that are discussed in the literature but will not be delved into here. It is important to

note, however, that these aspects are seldom given much attention in the write-up of valuation studies. In particular, details of pre-testing and the way in which survey designs were changed after such testing are never given, which means that new researchers do not benefit from the lessons learned before by others. Even the final questionnaires developed for studies are seldom published with the studies. There is a danger in copying questionnaires from other studies, though, as their shortcomings may not be apparent to new users, and not all aspects are necessarily appropriate to the next situation. On the whole, however, basic design is transferable to a large variety of fisheries as long as the habitat and way of life are relatively similar.

## 5.5 Analyzing and Interpreting Values

Value can be expressed in a number of ways, with different values being appropriate in different contexts. In the studies reviewed above, values were expressed as both financial and economic values. The financial values include gross income (the total market value of production), net income (the total subsistence plus cash value to households net of input costs but not labor costs), and cash income. Economic values are calculated as gross and net values, on the basis of financial values, but using shadow prices. Turpie et al. 1999 expressed net income after labor costs, but there has been some debate suggesting that the latter calculation should also exclude labor costs (K. Goran-Maler, pers. comm.). While economic values are used to articulate the contribution of fisheries to the national economy, in most cases the financial values are the most useful ones as they reflect the direct values of fisheries to users and surrounding communities. Gross values are the most commonly reported, but it is important to recognize that these values are generated at a cost to the household, apart from the labor inputs involved. There has

been insufficient emphasis on the opportunity cost of labor and returns to fisheries as part of a mixed household strategy. The value of fisheries in terms of cash income is also an important consideration, because even households that can meet all of their own subsistence needs have to generate cash income for goods and services such as health and schooling.

Calculation of net incomes or returns to capital or labor requires far more data than simple estimates of gross value. It requires identification of capital inputs, estimates of depreciation, of variable costs, and of labor costs. These are not always easy to estimate since equipment is often shared and fishing equipment such as fence traps is sometimes difficult to value. Nevertheless, the collection of such data is not particularly difficult.

Turpie et al. 1999, Turpie 2000 and Turpie and Egoh 2002 developed a spreadsheet model to calculate the various types of value outlined above; this was based on the model developed by the Namibian Directorate of Environment Affairs (e.g., Ashley et al. 1994; Barnes and de Jager 1995, 1996; Ashley and Barnes 1996; Barnes 1996). The multi-page spreadsheet includes a page for each resource as well as the front page for entering general data, such as the characteristics of each ecoregions of the study area, equipment used in each enterprise, and the price and durability of equipment. The development of the model was particularly useful in identifying exact data needs in survey design.

The values generated in valuation studies can be fairly meaningless to decision-makers and policymakers if they are not given a context. Thus, it is vital to show what fisheries values mean to households in terms of their contribution to households' total annual income, to a study area in terms of their contribution to the total economic activity, or to the national economy in

terms of their contribution to the regional or national income. Many valuation studies fall short of doing this. The most common way of expressing value in the studies reviewed here was in the context of total household income. This is the most costly in that it involves the valuation of all resources in the study, not just fisheries. However, the value of fisheries is much clearer when seen in the context of agricultural incomes, for example, which is traditionally of great concern to policymakers.

Nevertheless, it is important to bear in mind that percentage contribution to household income is not the only facet to fishery values that should be considered. The value of fisheries in terms of risk spreading needs to be evaluated. Even if households only rely on fish once in six or seven years, during drought, for example, the fishery can still be of critical importance to the population. None of the studies have articulated this in a quantitative way.

### **5.5.1 Issues of Time, Scale and Sustainability in Value Calculation**

There are no limits to the spatial extent to which some costs and benefits associated with fishing areas could be felt, and it is thus important to be explicit about the scale at which benefits and costs are being considered and compared in order to answer the question: *value to whom?* Costs and benefits can be considered at a local, national, regional and global scale. Local-scale benefits may incur regional-scale costs, and vice versa. *Local communities* have to be defined on the basis of explicitly stated criteria.

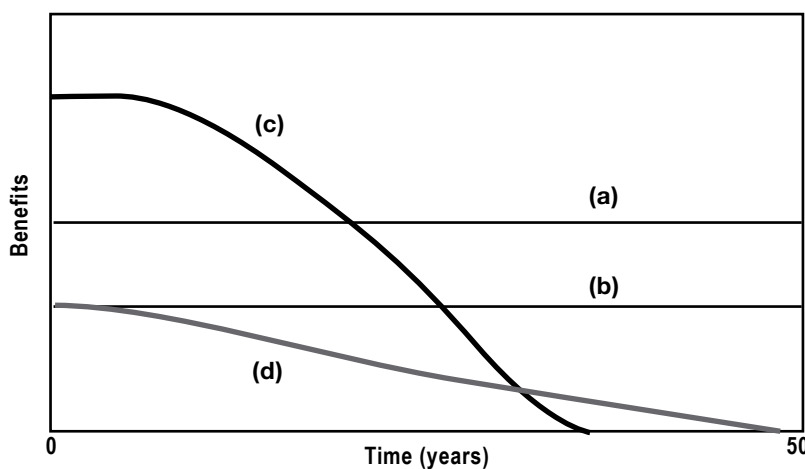
In most cases, the valuation studies concentrate on estimating the annual values of fisheries. However, the value of a fishery should strictly include some consideration

of future values. The net present value of a fishery would be the present value of the flow of income from the present until some specified time in the future. The calculation involves setting a time frame for the analysis and the relative weighting of future and present values, through the choice of discount rate. Economic analyses are usually conducted using a time frame of 10 to 50 years. While longer time frames are of more interest to ecologists, shorter time frames are more commonly used because the lifespan of policy is usually relatively short, and because of the effect of discounting on future values. Under most circumstances, values accruing beyond 20 years into the future are rendered negligible in present terms by discounting, and so 20 or 30 years is a common time frame for analysis. The discount rate can be based on the prevailing opportunity cost of capital, but it should be lower if long-term social and environmental benefits are considered paramount.

Without mentioning future values, most valuation studies implicitly assume that the resources are used both sustainably and optimally. Both the current value and its expected path over time affect the net present value of a fishery (Figure 1). With a zero discount rate, the present values of the

benefit streams in Figure 1 would be ranked as follows:  $NPV(a) > NPV(b) > NPV(c) > NPV(d)$ . In other words, the most optimal and sustainable use path (a) yields the highest value. If resources are underutilized (path b) or have been mined to low output levels by past overutilization (path d), then the valuation exercise is in danger of underestimating the value of the area. If on the other hand, resource use is assessed at a time when fisheries are being overutilized at levels above the maximum sustainable yield (path c), then the exercise will result in an overestimation of the value. To some extent, the effects of over- or underutilization may also be reflected in relatively high and low prices and input costs respectively. It is interesting to note that, even if the future path of the net benefits of resource use were known, a high discount rate would tend to favor the overutilization of resources. Thus, beyond a certain discount rate, the present value of path (c) will be higher than the present value of the sustainable path (a), because future benefits in path (a) will be worth very little to the present generation.

Thus, in fisheries valuation studies, it is imperative that the level of use in relation to optimal sustainable yields is investigated in order to produce a valid interpretation of the results of the valuation methods applied,



**Figure 1: Hypothetical, undiscounted benefit stream from a flow of consumptive use of natural resources under base-year conditions of (a) optimal sustainable use, (b) sustained underutilization, (c) early-stage overexploitation and (d) long-term overexploitation**

and a realistic estimate of net present value. The determination of optimal yields requires detailed biological information on the dynamics of resource availability as well as use. None of the studies reviewed here has had sufficient biological data to estimate the sustainability of the fisheries involved.

Ideally, such studies should be preceded by a biological understanding of the fishery resource and its status. These elements are important in order to put current values into a longer time frame. However, fisheries biologists are often reticent to estimate how sustainable a fishery is due to the need to gather large quantities of data to perform such an assessment properly. The use of techniques such as *Rapfish*, which is essentially an assessment of characteristics such as the above, might provide a short cut to assessing the sustainability of catches.

### 5.5.2 Considering Potential Value

Interesting situations also arise where fisheries potential exists but is not exploited. For example, capture and consumption of freshwater fish has never been part of the traditional culture of the Xhosa people, who reside in the Eastern Cape, South Africa. The government, however, recognizes that the existing resources have the potential to be exploited as small-scale fisheries for the relief of poverty in the region. This has led to a brief investigation of the potential value that they could generate (Andrew et al. 2000), but the study only went as far as estimating what a small group of fishers could earn, and not what the resource could support in total.

## 5.6 Estimating Impacts on Value Due to Environmental Change

Estimation of a change in value due to a proposed environmental change, such as alteration of river hydrology by dam

construction, is carried out using the Change in Production approach (e.g., Ellis and Fisher 1987; Barbier 1994). This approach is relatively straightforward in theory, but it can be more complicated in practice because it would involve the estimation of a production function.

Riparian fisheries production is dependent on the qualities of the area, such as river flow and water quality, as well as the inputs, such as labor involved, as displayed in the following production function:

$$Q = f(S, X_1 \dots X_n)$$

where Q is the catch produced for a given set of inputs, including flow S, and other inputs  $X_1 \dots X_n$  (after Barbier 1994). The quality of the result is largely dependent on the amount and quality of data that is entered into the model, as well as the quality of the model itself. The production function approach is considered to be a particularly promising approach to valuing certain environmental functions (Barbier 1994). However, it is important that the relationship between the environmental attributes and the economic activity they contribute to is well understood. Ideally, this approach demands an understanding of the relationship between the output and the state of the environment, or the physical effects on production of changes in a resource, and should be modeled by taking dynamic functions into account. This is usually achieved through time series or cross-sectional analysis, and thus usually requires data spanning a number of years or comparable data from a number of areas. The production function approach makes it possible to examine the effects of marginal changes in the environment such as incremental changes in water allocation to other uses.

Estimation in reality is done over a relatively short time period, thus requiring some level of innovation in shortcutting the theoretical

methods outlined above. The main problem lies in predicting future supplies of fish (a biological problem), although predicting future prices is also problematic. In the Lesotho Highlands Development Project, biologists were required to estimate the percentage change in fish resulting from a change in flow. Thus, in essence they applied a “gut-feel” production function but did not attempt to describe it explicitly. Majoro (2000) provides an exemplary valuation of these impacts, taking price elasticity and uncertainty into account. Emerton (1994) was more fortunate in that she was able to consider the predicted gradual change in fishery production over time as a result in changed hydrology, and used this to compute a present value. The value was crudely and rapidly estimated, but it was based on an apparently detailed ecological assessment (Emerton 1994). In comparison, Majoro (2000) produced a comparatively sophisticated analysis of impacts complete with risk and sensitivity analyses, but these were based on a fairly crude assessment of change, treated as an instantaneous change from one level of production to another.

### 5.7 Should Valuation Be Carried Out More Efficiently or Rapidly?

The way in which valuation studies are currently carried out is considered to be quite intensive (Dugan 2002). Indeed, most of the studies cited above were fairly substantial undertakings, with each one taking at least two months (not necessarily contiguous), or usually much longer, to complete. Studies involve a reconnaissance visit by the lead researchers, in which time is taken to understand the fishery, its heterogeneity, and the fishers, as well as to hold essential meetings with the local community and representatives. This is followed by a series of focus groups and key informant interviews, and then a survey design phase. Enumerators are then selected and trained, questionnaires

and enumerators are tested in the field and the necessary refinements are made before the proper survey is carried out. The actual household survey can be carried out relatively quickly, especially if several enumerators are used, but this also depends on the difficulty of traveling around the study area. Most of the study areas described above do not have conventional road access to villages and fishing areas, and boats other than local canoes are sometimes hard to come by or to launch. Following field surveys, data have to be entered, checked, and finally analyzed for report writing. The final phases can be immensely time consuming if surveys were badly designed, such as when fish catches are enumerated in a variety of ways that need conversion to common units, or if questions have obviously been badly designed and good answers have to be sorted from possible misunderstandings. How well a valuation study is designed has a tremendous impact on the efficiency with which it can be carried out, as well as on the reliability of the estimates produced. This obviously has important implications for research costs.

Valuation estimates can be made more roughly and for lower budgets, but there are probably some tradeoffs involved, particularly in the certainty of such estimates. Several means of rapid assessment exist, including the following:

- (a) Simple estimates of aggregate value based on existing catch statistics;
- (b) Reduced sample sizes for household surveys;
- (c) “Benefits transfer”;
- (d) Using data from focus group discussions and key informant interviews; and
- (e) “Bean games”.

The aggregate gross annual value of a fishery is simply the catch multiplied by average price. Thus the most rapid valuation of a fishery can be obtained using government statistics on catches, and current price data that are fairly easily obtained. Two main problems with this method, as alluded to above, are that catch data are often unreliable, and that a single aggregate value does not give sufficient information on which to make either management or development decisions. In particular, there is a danger of underestimation of the size of the fishery and very little indication of its importance to the local population.

Recognizing the heterogeneity of fisheries along river systems is a very important part of determining their value, both at the aggregate and the household levels. This division of an overall area into *ecoregions* or river reaches (see Majoro 2000; Turpie 2000; Turpie and Egoh 2002), allowing some form of stratified random sampling, provides a better description of the way in which resources are used in conditions of differing fish availability and population characteristics. In this way, the values are better understood and impacts of environmental change are not incorrectly generalized across all households and areas. In general, within areas that are relatively homogenous, e.g., within an ecoregion, sample sizes can be relatively small. However, as the variability in fisheries data supplied by households is generally greater than for other resources, larger sample sizes are needed for fisheries valuation than for valuing woodland resources, for example. With the exception of the study by Turpie and Egoh (2002) in which nearly all households were surveyed, none of the studies reviewed here had involved particularly large sample sizes, and in most cases decreasing costs by decreasing households sampled would not have been justifiable.

Interestingly, at a broader scale, there appears to be remarkably little variation in the

household livelihood strategies and fishery values among communities surrounding different floodplain wetland systems in southern and eastern Africa. This suggests that *benefits transfer* could be applied to some extent. Benefits transfer is the ultimate in rapid valuation, being application of results of other studies to similar areas under consideration (Georgiou et al. 1997; Barbier et al. 1997). However, its use implies a number of inherent assumptions about the preferences and socio-economic characteristics of the study area (OECD 1994) and is not something that should be done lightly. As an example at the other end of the extreme, no generalizations or benefits transfer could be validly applied across different estuaries in South Africa because each estuary is unique in terms of its size and biophysical characteristics, population density, accessibility, and uses (e.g., recreational, commercial and subsistence fisheries).

Turpie (2000) used two methods for valuing several different resources in the Rufiji floodplain area in order to double check estimates. For example, focus groups gave information on the proportion of households engaged in an activity, seasonal patterns in harvesting, average harvests per time period in high and low seasons, proportions sold, selling prices and input prices. Similar data are yielded from household surveys. Turpie found that the results generated from the two sources of data were remarkably similar in many cases (e.g., salt production, timber harvesting), but she did not attempt this for fisheries as the data yielded in discussions were often highly variable. Furthermore, the estimates obtained from household survey data are regarded as statistically valid, whereas the former are not.

In order to assess the importance of fisheries to local livelihoods, Turpie et al. 1999, Turpie 2000, and Turpie and Egoh 2002 asked households to describe the contribution that fisheries and other sources of income made

to household income (including subsistence value). This was done by apportioning a pile of beans or stones among six or so categories of income (fish, agriculture, livestock, pensions, woodland resources, etc.). The purpose was to check household perceptions against actual incomes estimated on the basis of quantitative data, as well as to evaluate this as a potential future *short cut* to estimating values. Used in the latter sense, it was suggested that overall values could be calculated for all different sources of income on the basis of the relative values given if the value of just one or two of these was known. The anchor values would be chosen on the basis of the component that was easiest to value. The results of using these *bean games*, which have been applied both in focus groups and in household surveys, have been variable (Turpie et al. 1999; Turpie 2000). In most cases, household perception of the relative value of resources is remarkably close to that estimated on the basis of quantitative survey data. However, when there is a discrepancy it is difficult to say whether villagers' perceptions or household calculations are more accurate.

Dugan (2002) suggests that simpler methodologies need to be developed which can provide information more directly to communities and to other key stakeholders on an ongoing basis. The latter would of course require ongoing monitoring of key parameters, and possibly also the establishment of research networks. In addition, they suggest that existing valuation techniques could be made more readily applicable in developing countries with limited institutional research capacity. In other words, it is necessary to determine what critical information is required in order to manage riparian fisheries optimally, and how this information can be generated on a regular basis (Dugan 2002).

Such a program could easily be developed, but it should not replace the detailed study of riparian fisheries. First, much of the

work that has been carried out so far has concentrated on obtaining average values, and more, not less, detailed research is needed to understand production functions and the marginal values in the fisheries and household coping systems. This would require large-scale surveys and econometric modeling to produce dynamic ecological economic models. It is only when this level of understanding is achieved that impact studies can hope to improve their (currently rather low) confidence in the prediction of impacts of changes in flow on fishery values. Second, detailed studies provide the important baseline against which to monitor fisheries, and form the basis for choosing the key parameters that need to be monitored over time. Thus, it is recommended that detailed studies of systems continue, and that monitoring programs be set up in areas in which fisheries and their values are well described. Such monitoring programs should aim to track changes in demand and supply and should collect data on prices for standard units (species, size), household and aggregate fishing effort, catches and management. Although monitoring programs involving local fishers have been implemented successfully (Ticheler et al. 1998), these programs are sometimes set back by poor data collection performed by local field enumerators (pers. obs.; REMP, pers. comm.), possibly due to lack of direct and regular supervision by those with an interest in the outcome.

As a result, baseline fishery valuation studies should probably become more intensive in future, and rapid evaluations should only be carried out after these studies for monitoring purposes. It is probably true to say that the use of more rapid techniques in fishery valuation studies would be accompanied by a loss of accuracy and resolution, and increasing uncertainty. Ultimately, the rapidity with which a study is carried out should be determined on the basis of its purpose, and with its potential future application in mind.



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## CHAPTER 4

# Review of River Fisheries Valuation in Tropical Asia

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## Contents - Chapter 4

<b>Abstract</b>	150
<b>Acknowledgements</b>	150
<b>1. Introduction</b>	151
<b>2. Conceptual and Measurement Issues</b>	151
2.1 Economic Value	151
2.2 Economic Valuation of the Natural Environment	152
2.2.1 Reasons for the Economic Valuation of Natural Resources	152
2.2.2 Reasoning against the Economic Valuation of Natural Resources	153
2.3 Total Economic Value (TEV)	154
2.4 Applications of Resource Valuation	155
2.5 Methods of Economic Evaluation	155
2.5.1 Stated Preference Methods – estimation of people’s preferences based on direct questioning	155
(i) Contingent Valuation Methodology (CVM)	155
(ii) Discrete Choice Modeling (Conjoint Analysis (CA))	156
2.5.2 Revealed Preference Methods – estimation of people’s preferences based on observed market behaviour	156
(i) Travel Cost Method (TCM)	156
(ii) Hedonic Pricing Method	156
(iii) Production Function Analysis	156
(iv) Sustainable Livelihood Analysis (SLA)	157
2.6 Data and Sources of Information	158
<b>3. Inland Fisheries Production</b>	159
<b>4. Economic Valuation Case Studies</b>	160
4.1 The Mekong River system	160
4.1.1 Water Use in the Mekong River Basin	160
4.1.2 Economic Valuation of Mangroves in the Mekong Delta	162
4.2 Bangladesh	163
4.2.1 Net Economic Benefits from Riverine Fisheries in Bangladesh	163
4.2.2 Stocking Seasonal Floodplains in Bangladesh for Capture Fisheries	164
4.3 India	165
Social and Economic Aspects of Fisheries Enhancement in Kerala Reservoirs, India	
4.4 Indonesia	167
Management Options for the Inland Fisheries Resource in South Sumatra, Indonesia: Bioeconomic Model	
4.5 Malaysia	169
Fisheries Evaluation of the Chenderoh Reservoir Using the Rapid Rural Appraisal (RRA) Technique (Livelihood Analysis) and Fishers Survey	
4.6 Sri Lanka	170
4.6.1 Valuing Water in a Multiple-use System	170
4.6.2 Assessment of the Economic Value of Muthurajawela Wetlands	171

<b>5. The Impact of Changing River Fishery Management and Water Management</b>	172
5.1 The Mekong River System	172
5.1.1 Changes in Fisheries Production and Prices before and after a Change in Fisheries Legislation	172
5.1.2 Changes in Water Use Value Due to Variation in Water Flow, Wetland Value and Fisheries Exploitation Cost	173
5.2 Bangladesh	174
Performance-response of the Inland Fishery under Different Simulated Changes in Cost of Harvest and Changes in Aggregate Demand for Fish	
5.2.1 Changes in the Cost of Harvest	174
5.2.2 Changes in Aggregate Demand	176
5.3 Sri Lanka	176
5.3.1 Valuing Water in a Multiple-use System	176
5.3.2 Adaptive, Participatory and Integrated Assessment(APIA) of the Impact of Irrigation on Fisheries	178
5.3.3 Impact of Dams	179
<b>6. Discussion</b>	180
<b>7. Conclusion</b>	182
<b>References</b>	183
Appendix 1: Capture Riverine (and Floodplain) Production	187
Appendix 2: Capture Riverine (and Floodplain) Prices	190
Appendix 3: Capture Riverine (and Floodplain) Values	192
Appendix 4: Country Data	194

## **ABSTRACT**

This study attempts to estimate the economic value of riverine fisheries in tropical Asia and quantify the economic impacts of any changes to the environment that affects rivers and hence fisheries. The value of riverine fisheries has been considered in the following two ways: firstly, through a compilation and summary of the results of existing studies on this topic; secondly, by estimating the direct use value of riverine and floodplain fishing by country using quantities and freshwater fish prices derived from various sources. Furthermore, a review of the characteristics of the fisheries is presented. These fisheries have been shown to be valuable (i.e., economically or socially important) in at least two specific ways: as a generator of commercially marketable output, and as a source of income and employment in relatively impoverished communities.

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## 1. INTRODUCTION

The aim of this report is to provide a review of the best available information on the direct value of tropical river fisheries in Asia as well as a valuation of environmental impacts, which affect rivers and hence fisheries.

In tropical Asia, a large part of the population is heavily dependent upon fishing within inland waters for their livelihoods. Catches in inland waters are profoundly affected by monsoons and have been observed to vary directly with water flow. In the dry season, predictable periods of drought occur resulting in lower catches, this is followed by increased water discharge during the wet season when the floodplains are inundated resulting in higher catches. One example is given in the study by Baran et al. (2001) who modeled the flow-catch relationship for the Dai (commercial fishery in Cambodia) in the Tonle Sap lake/floodplain system of the Mekong. The study identified a positive correlation between the water level and the annual Dai catches. However, it is not only natural water flow that affects catches. Increasing competition for water resources and high population growth in riparian countries of major river basins, such as the Mekong, Ganges and Irrawaddy systems have elevated pressures on the distribution of water flow and depleted fisheries stocks as a result. Furthermore, there is competition for the usage of the river flow not only between countries but also for different activities, such as captures fisheries, aquaculture, agriculture (irrigation), tourism, forestry, and electricity generation.

Estimating the value of these fisheries is essential if the livelihoods of the communities dependent on them are to be protected. If the true value of the resource is not established, the resulting costs or benefits of any alteration to its present state cannot be quantified. As such, governments and international agencies that develop policies regarding the use, preservation, or degradation of natural resources will be unequipped to

fully appreciate the impact on communities dependent upon fisheries.

For the purpose of this review, the geographical areas of tropical Asia will be defined as those watersheds that fall below or adjacent to the latitude denoted by the Tropic of Cancer ( $23^{\circ} 30'$ ). Figure 1 illustrates the watersheds considered. This assessment includes the following countries: Bangladesh, Cambodia, India, Indonesia, the Lao PDR, Malaysia, Myanmar, the Philippines, Sri Lanka, Thailand and Vietnam. China was omitted from this report because the majority of the country falls within the temperate region. Bhutan and Singapore were also excluded due to their low inland fisheries production and lack of available data.

The paper is broken down into seven sections. Following the abstract is Section 1: introduction. Section 2 then provides a description of the methodology used in this review. Section 3 briefly describes inland fisheries and riverine production in tropical Asia. Section 4 examines several economic valuation studies undertaken in tropical Asia. Section 5 highlights changes to the resource. Section 6 and 7 present the discussion and conclusion. Following the references are four useful appendices with statistical data.

## 2. CONCEPTUAL AND MEASUREMENT ISSUES

### 2.1 Economic Value

In this section, recent developments of methodology in natural resource evaluation are described. As shall be seen, the absence of market prices for most environmental assets (especially those with *public goods* characteristics) makes it particularly difficult to measure economic value in straightforward monetary terms.

The OECD (Winpenny 1995) explains the concept of economic value thus:

**“To the economist, scarcity is what imparts value to a good or service. Something that is abundantly available to all who wish to consume it has no economic value, however much it may be desirable on moral, aesthetic, or other grounds. A beautiful sunset, or clean air, has no economic value so long as it is freely available to all. The moment it ceases to be freely available, it has potential economic value.”**

Economic value with regard to the environment is typically measured by attempting to elicit preferences for or against an improvement (or a reduction) in its current state. This often results in the generation of a monetary value. A commonly applied method is that of *willingness to pay* (WTP) where people indicate the value they are prepared to give up in order to see, for example, a specified level of improvement in or the preservation of a particular aspect of the environment. It is also possible to consider economic values as social values, as the concept of value is

anthropocentric, i.e., the derived value of the resource under consideration is nothing more than that attached by the individuals themselves, the value actually residing within them rather than the objects of their assessment (Bene et al. 2002).

## 2.2 Economic Valuation of the Natural Environment

It is a controversial issue to place monetary value on something as intangible as the environment. Some of the points for and against this practice are worth consideration.

### 2.2.1 Reasons for the Economic Valuation of Natural Resources

The significance of overlooking the economic valuation of natural resources must not be underestimated. If the value of what we have in our midst is not known, informed decisions as to its use or management cannot be accurately or justifiably made. It gives certain tangibility to a resource’s worth to society and, as such, any decisions regarding its

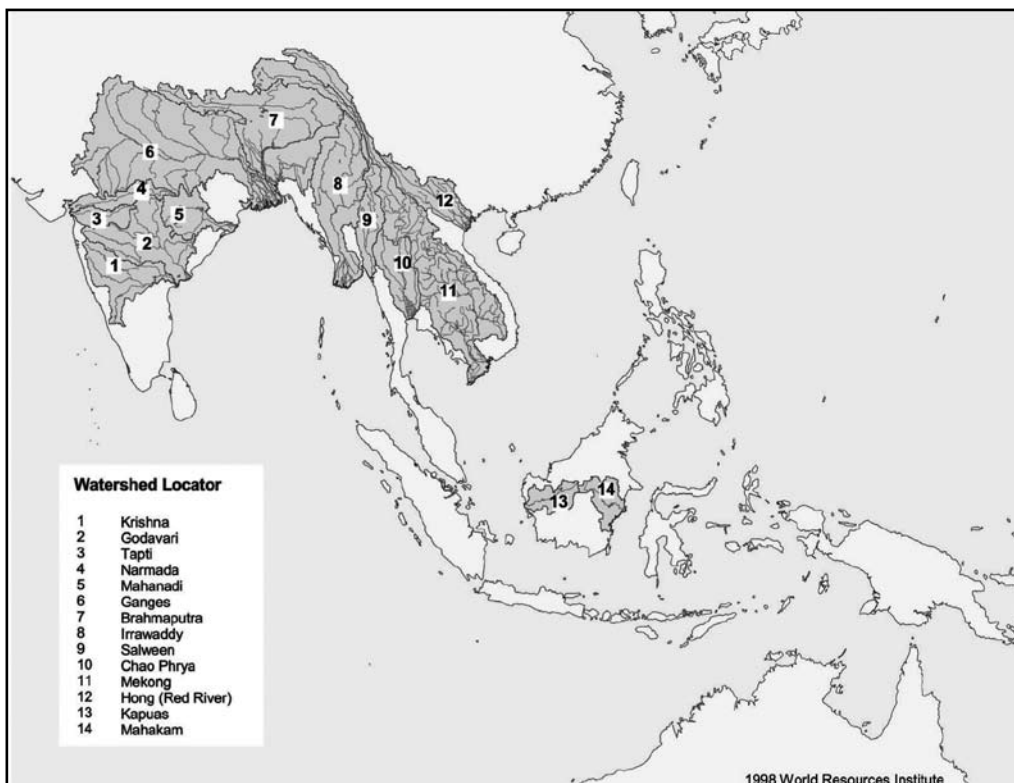


Figure 1: The major river basins in tropical Asia

preservation, use or degradation can be more easily made. If the initial value of a resource cannot be determined, the resulting costs or benefits of any alteration to its present state cannot be quantified.

Winpenny (1991) explains the importance of assigning economic value to environmental assets as follows:

- It allows measurement of the rate at which environmental resources are being consumed.
- Where environmental impacts can be quantified in monetary terms (i.e., valued) they will carry more weight with decision-makers, who can then set these data alongside other quantitative information. In such circumstances, better decisions will be made.
- By assigning a tangible, comparable, value to a resource, it reduces the number of occasions where decisions have to be made, based solely on the decision-maker's judgment.
- It can provide the basis for appropriate management or policy development, assuming the derived economic value is correct.

The use of expressions such as “*invaluable*” to describe anything must be considered dubious in nature. As Whitmarsh (1993) points out, the claim that a particular site or resource is “*priceless*”, in the sense that we cannot possibly attach a monetary value to it, is simply not acceptable if it implies that it must be preserved at all costs. It is a fact that in a world of finite resources, nothing is of infinite value. However, accepting this still raises problems regarding the way a “*value*” is derived and is the matter of some debate.

## 2.2.2 Reasons against the Economic Valuation of Natural Resources

Although there have been substantial improvements in the techniques used to value the environment over the last two decades, a number of criticisms can be leveled against both the principle and the practice of valuation. First, it has been argued that placing a monetary value on things as intangible as the importance of species diversity or the value of life ultimately degrades the debate. Second, the potential for manipulation is present. An accusation often raised against *Cost Benefit Analysis* (CBA) is that if the requirements of objectivity are not met, the valuation process can simply end up being used to justify the desired outcome (Bowers 1990). Third, the accurate derivation of economic value requires precise economic, scientific and technical data. All of these can be notoriously scarce or costly and time consuming to obtain in developing countries.

Last of all, and with particular relevance in the present context, valuation techniques derived in the developed world are not always directly applicable to the developing world. For a start, there are likely to be important differences in respect to both social attitudes towards the environment and the functioning of ecological systems. Barbier (1993) discusses this issue from the social perspective, raising the point that the use and non-use values of areas such as wetlands tend to differ significantly between tropical and temperate areas. As a general rule, tropical wetlands occur in the developing world, whereas temperate ones exist more in the developed. The direct result of this is that many tropical wetlands are directly exploited, through *informal*, non-market economic activity to support human livelihoods, e.g., fishing, hunting, and fire wood collection. Formal economic activity, such as tourism or recreational use,

is often absent or relatively insignificant. In contrast, temperate wetlands will, with the occasional exception of commercial fisheries or forestry, be exploited more for recreation or tourism, the significance of direct exploitation being much reduced. As a result rigorous valuation and inclusion of informal, non-market, economic activity is essential if an accurate value of tropical wetlands is to be derived. Failure to do this is cited as a significant factor in policy decisions that result in the overexploitation or excessive degradation of tropical wetlands.

From the pros and cons of economic evaluation, it can be concluded that capturing the full monetary value of natural resources is a difficult task. One view is that:

**“economic appraisal should attempt to monetize only what can be monetized, making it clear what environmental impacts have been excluded from the arithmetic and providing as much quantitative detail (even in non-monetary units) about these effects as possible.” (Whitmarsh 1999)**

### 2.3 Total Economic Value (TEV)

The value of a resource can be defined as its total economic value. The concept of TEV is based on the recognition that natural resources are multifaceted and their absolute value is derived from the sum of both their *use* and *non-use* values. As demonstrated in Figure 2, TEV is divided into *use* and *non-use* values. Use values can be further divided into: *direct use value*, *indirect use value* and *option value*. These terms are defined below.

*Direct use value* is the most obvious benefit derived where individuals exploit the resource

for commercial, livelihood or recreational purposes.

*Indirect use value* refers to a scenario where society does not profit directly or immediately from the exploitation of the resource. An example can be seen in the case where inundated forests provide habitat for the juveniles of fish stocks located elsewhere (indirect value), implying that changes to the forest (e.g., through logging) would destroy the breeding/nursery grounds and reduce catches in the future (direct value).

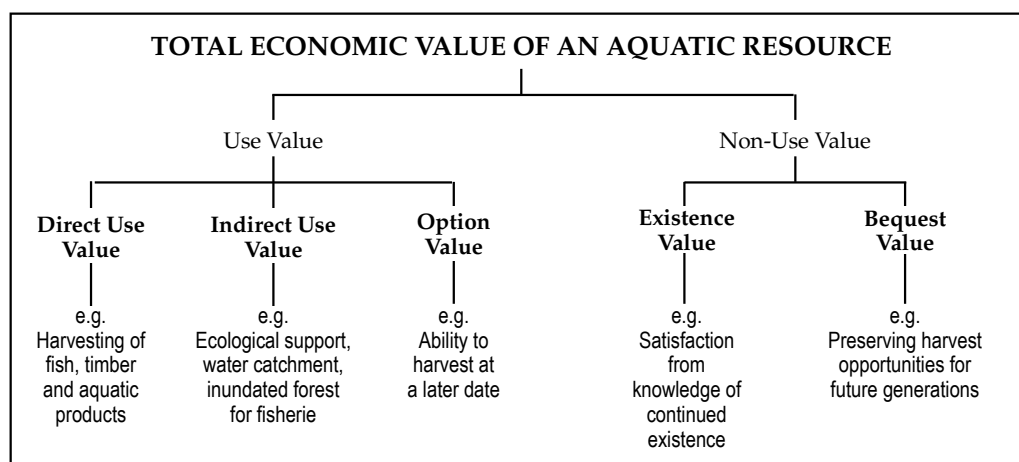
*Option value* refers to a situation where individuals are prepared to maintain a resource for possible use at a later date.

*Non-use values* are broken down into: *existence value* and *bequest value*.

*Existence value* exists where individuals are prepared to preserve something simply for the satisfaction of knowing that its existence is assured.

*Bequest value* exists where individuals derive value by maintaining something (e.g., a productive fishery) for the use of future generations.

The informational requirements and methodologies applied in order to derive the above values become more demanding as one moves from left to right across the bottom of Figure 2 (Laplante 2005). Direct use values are relatively straightforward to obtain; where a market exists for the derived good (e.g., fish) or service (e.g., recreation), a price is often available. As soon as one moves to the right of the direct use value box, quantification in monetary terms becomes more problematic and controversial. As such, a number of differing valuation methodologies have arisen in an attempt to tackle the issue.

**Figure 2: Total economic value and its constituent parts**

## 2.4 Applications of Resource Valuation

Economic efficiency analysis (EEA) is concerned with deriving the optimal allocation of resources in order to maximize social welfare. Two of the methods applied to measure this are: *Cost-effectiveness analysis*, where it is presumed that the least costly option is the most favorable (underpinned by the assumption that any gain in efficiency is desirable); and *Cost-benefit analysis* (CBA), where the option producing the highest benefits in relation to costs is favored.

With respect to fisheries, which are based on renewable resources and which have the potential to generate an indefinite benefit stream, it is often the quantification of *changes* to the value of output with which society is primarily concerned. It is, therefore, useful to be able to make *ex ante* assessments of interventions that may impinge on values, such as policy measures (e.g., effort controls) or public projects (e.g., stock enhancement). The potential change in benefit is commonly quantified through the application of CBA. Comparing the economic values of the current situation (the base case) with those of the one proposed gives decision-makers an indication of the economically optimal choice. However, it has been suggested that it is perhaps more appropriate to compare what the situation (and therefore the value) is expected to become under the new

scenario relative to what the situation would be expected to become without the change. This is due to the fact that in many instances the two are not the same (Laplante 2005).

The value of a resource may also be assessed through the application of an *ex-post* CBA (Wattage and Soussan 2003). This type of assessment is useful when comparing the economic value of a resource over time and can be employed in instances where environmental degradation is suspected. Natural resource damage assessment is an application of this type and can be used to determine the social cost of incidents, such as an oil spill, or interventions, such as the construction of a dam.

## 2.5 Methods of Economic Evaluation

### 2.5.1. Stated Preference Methods – estimation of people's preferences based on direct questioning

#### (i) *Contingent Valuation Methodology (CVM)*

This is a direct technique where the value for a non-market good, such as clean air or water, can be estimated. CVM relies on the simulation of a market for the specified good, e.g., clean water, where individuals are then

asked, through survey, what they would be willing to pay for the good or what they would be willing to accept in compensation if this good were to become unavailable or to be lost. An advantage of this technique is that it can be used to estimate both use and non-use benefits. It can also be used to directly elicit payments (open-ended forms) or to obtain yes/no answers to a predetermined WTP value (closed-ended).

**(ii) Discrete Choice Modeling (Conjoint Analysis (CA))**

This is another direct technique. Data collection occurs via survey and is used to represent individual judgments of multi-attribute stimuli. Individuals' preferences are estimated by determining the relative importance of attributes for goods, services, objectives and/or alternatives. The technique is based on the assumption that any good or service can be described by its attributes and that the extent to which an individual values a good or service depends on the levels of these attributes.

The four primary uses of discrete choice modelling, as indicated by Ryan and Farrar (2000), are to:

- Show how people are willing to trade between characteristics; this is useful when deciding on the optimal way to undertake a project with limited resources.
- Produce overall benefit scores for alternative ways of providing a good or service; this allows the ranking of goods or services against one another when setting priorities.
- Estimate the relative importance of different characteristics of a good objective; this allows the policymaker to observe the individual impact of each characteristic on the overall benefit.

- Estimate whether an attribute is considered important.

**2.5.2. Revealed Preference Methods – estimation of people's preferences based on observed market behavior**

**(i) Travel Cost Method (TCM)**

This indirect method is essentially based on an extension of the theory of consumer demand and considers the value of time. It originated from the desire to value areas used for public recreation, with a central assumption that the time (opportunity cost) and monetary costs individuals are prepared to incur in order to visit a specific location can be used to derive the unpriced value of a location. The required data are commonly gathered by surveying site visitors.

**(ii) Hedonic Pricing Method**

This is another indirect method; it assumes that the price of a commodity and its characteristics are related. Where one of these characteristics relates to the condition of the environment, e.g., water quality, the relationship between price and the characteristic can be used to derive a monetary value for clean water. This technique has often been applied in the housing market. Price differences that reflect the value of local environmental attributes are used to estimate the values (positive or negative) associated with changes in environmental quality (e.g., water/air quality) or amenities (e.g., aesthetic views). This methodology relies on the availability of data pertaining to house prices, quality of the environmental factor under scrutiny, and a set of attributes that influence property prices.

**(iii) Production Function Analysis**

This methodology is predicated on the idea that there is a physical relationship between

the output of an economic activity (e.g., fishing) and the various factor inputs (human, man-made and natural) that are used in its production. Changes in any of the inputs will, therefore, be expected to have an affect on the level of output, the precise relationship between input and output being determined *inter alia* by the technological and biological characteristics of the system. The production function approach to economic valuation has a very wide potential application to fisheries. If outputs can be measured in monetary terms (using market or shadow prices) then it becomes possible to indirectly estimate a monetary value for the natural inputs (i.e., fish population and/or critical habitat) that generate it. Several studies into habitat-fishery linkages have adopted this analytical framework; those of particular note are by Hodgson and Dixon (1988) on coral reefs in the Philippines and Barbier and Strand (1998) on mangroves and shrimp fisheries in Mexico. Despite its potential, the production function approach has a number of limitations. First, it requires data on the prices of the outputs, which largely restricts its application to situations where a marketed commodity is being considered. For this reason, it is unable to account for the non-use value of fisheries resources, which *ipso facto* is unpriced. Second, it requires a relatively robust understanding of the physical (i.e., causal) relationships between input and output. Without such information, it is clearly not possible to make predictions about how the value of a fishery will alter as a result of environmental impacts brought about by policy intervention (e.g., vessel licensing) or anthropogenic disturbance (e.g., pollution).

**(iv) Sustainable Livelihood Analysis (SLA)**

Livelihood analysis is an attempt to go further than conventional economic analysis, such as CBA, where consideration is only given to whether there will be a net gain to society as a whole, neglecting the issue of how this gain is apportioned within society. The principal

of *potential compensation*, where there is a net gain to society if the winners can afford to compensate the losers and still be better off, is an acknowledgement of this issue. However, the fact that this compensation rarely makes the transition from *potential* to *actual* is where the problem lies.

In the developing world, the question of who gains and, often more importantly, who loses is something that should be given careful consideration, especially when the losers are often the poorest members of society. Participatory methodologies are a holistic, people-centered approach, developed to help understand and analyse the livelihoods of the poor. The main aim of these techniques is usually to empower people. As DFID (2000) describes “participatory methods are not a fixed set of methods but rather a way of thinking, behaving and acting”. Some of the techniques used in these studies are: semi-structured interviews, focus group discussion, preference ranking, mapping, and modeling. Outputs such as identification of the social hierarchy can then be followed up allowing the path of any potential benefit flows to be mapped.

DFID (2000) lists the six core objectives of SLA; they are as follows:

- Improved access to high-quality education, information, technologies and training and better nutrition and health;
- A more supportive and cohesive social environment;
- More secure access to, and better management of, natural resources;
- Better access to basic and facilitating infrastructure;
- More secure access to financial resources; and

- A policy and institutional environment that supports multiple livelihood strategies and promotes equitable access to competitive markets for all.

The framework of SLA is illustrated in Figure 3; it can be divided into five core components moving from left to right: (1) the vulnerability context under which the communities being considered operate; (2) the livelihood assets of these communities; (3) the policies, institutions and processes that affect their lives and their access to livelihoods assets; (4) the livelihood strategies adopted by the communities; and (5) the outcomes they achieve or aspire to. The framework’s main components emphasize their influences on livelihoods.

In focusing on these five components, the livelihoods approach aims to influence policy in a way that improves the well being of the communities under consideration. It addresses issues relating to reduced vulnerability and resource exploitation patterns in the pursuit of increased well-being. These values are difficult to assess but highly important when attempting to ensure basics such as food security.

SLA is a highly useful set of techniques when valuing inland fisheries in developing countries as the resource is usually under threat from a multitude of factors and the areas have

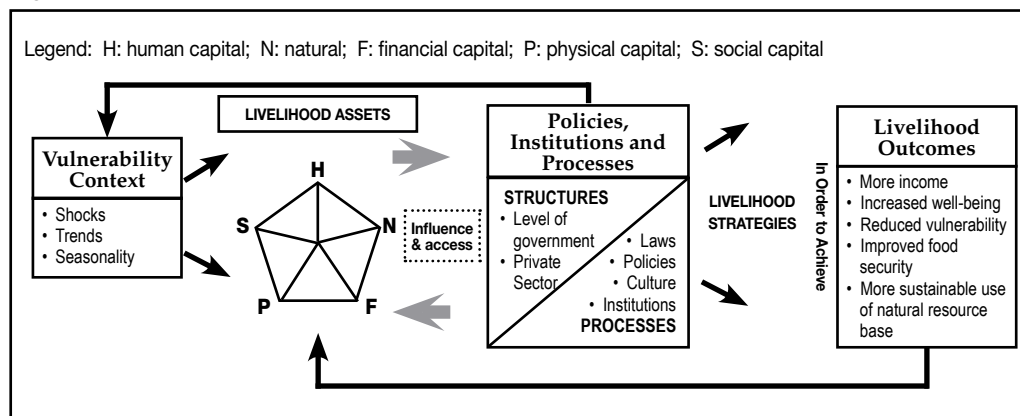
hardly or never been evaluated before. SLA allows researchers to quickly understand the area, the threats to the fishery, and conflicts among different stakeholders. SLA can be very useful in providing an initial evaluation of the resource before other data collection techniques (e.g., socioeconomic surveys) are used. As such, the use of SLA is limited as a technique of valuing inland fisheries.

### 2.6 Data and Sources of Information

As can be seen in section 2.5 there are, therefore, a range of methods that can potentially be applied to value fisheries. The choice of method will depend in the first instance on the question being addressed (e.g., economic efficiency in resource use, livelihoods of fishing communities, etc.). However, a serious practical constraint on the choice of valuation technique is the availability of data. As shall be revealed shortly, the reason why the vast majority of empirical studies on Asian river fisheries have focused on the direct use benefits of fishing is mainly due to the methodological challenge of obtaining reliable numerical estimates on the indirect and non-use benefits of aquatic resources.

In this report, information has been collated from an extensive search of the peer reviewed, internationally recognized, literature

**Figure 3: The Sustainable Livelihoods Framework**





and major databases. Owing to nature of the subject, there was also significant reliance on the so-called “gray literature”, such as reports produced by the OECD, DFID and the FAO. To put these studies in context, some basic factual data are presented in Section 3 on the absolute and relative importance of Asian fisheries. In Section 4, examples are provided of empirical investigations that attempt to value riverine and other connected inland capture fisheries. The studies have been chosen based on their economic methodology and ability to generate an overall value for the fishery under review. In particular, studies were selected so as to provide some comparison of values created by fisheries with those of other activities exploiting rivers. The ability to compare different activities in this way is especially useful since it provides a more complete picture of the issues affecting the livelihoods of people within the area.

### 3. INLAND FISHERIES PRODUCTION

FAO figures for inland capture fisheries, aquaculture and total fisheries production for

tropical Asia in the year 2002 are presented, by country, in Table 1. The percentage contribution of inland capture fisheries to total production for each of the countries evaluated is also shown.

The values in Table 1 indicate that Bangladesh is the country with the highest level of inland capture fisheries production. Floodplains followed by rivers and estuaries are the most productive fishing resources in Bangladesh (Liaquat and Zahirul 1997). Nevertheless, catches have declined over the years due to a major loss of habitats. This has been caused by: large-scale water abstraction for irrigation, construction of embankments for flood controls, siltation and soil erosion due to deforestation in the catchments. Excessive fishing pressure and destructive fishing practices have also contributed to declining catches (FAO 1994). When considering the contribution of inland capture fisheries to total production, Cambodia has the highest ratio (excluding Bhutan which only has inland fisheries production). Nevertheless, if we examine Cambodian production, no marine fisheries are reported in the FAO statistics.

**Table 1: Inland capture fisheries, aquaculture and total production in tropical Asia in the year 2002**

Country	Inland capture fisheries (t)	Aquaculture (t)		Total production (t)	Marine production	% inland to total production
		Freshwater	Brackishwater			
Bangladesh	688 435	696 997	32 026	1 890 459	473 001	36.4
Bhutan	300	0	0	300	0	100
Cambodia	411 150	14 133	0	425 283	0	96.9
India	425 283	2 076 734	0	6 061 366	3 559 349	7.0
Indonesia	316 030	429 166	313 531	5 679 391	4 620 664	5.6
Lao PDR	33 440	59 716	0	93 156	0	35.9
Malaysia	3 572	44 370	310	1 463 625	1 415 373	0.2
Myanmar	304 529	114 716	0	1 433 908	1 014 663	21.2
Philippines	131 111	147 362	216 686	3 371 874	2 876 715	3.9
Singapore	1 058	616	0	7 796	6 122	13.6
Sri Lanka	28 130	3 670	0	306 896	275 096	9.2
Thailand	205 500	327 795	98	3 566 106	3 032 713	5.8
Vietnam	149 200	390 000	28 000	2 042 500	1 475 300	7.3

Source: FAO FISHSTAT (2005)

Cambodian marine production is very small in comparison to inland fisheries production, but it does exist. The Cambodian government reported 36,000 tonnes of marine production in the year 2000 and 245,600 tonnes inland capture fisheries production for the same year (Planning and Accounting Office 2001). Nevertheless, the inland capture figure provided by the Cambodian government is very low compared to FAO's values and other expert values for this fishery. For example, Van Zalinge and Thuok (1999) estimated Cambodian inland capture fisheries to be in the range of 279,000 – 441,000 tonnes per year. The substantial discrepancies between sources for Cambodia is by no means an isolated case. This issue is highlighted in Appendix 1, which presents a compilation of the most recent estimates for riverine and floodplain fisheries production by country. This section provides some insight into the productivity of rivers and their floodplains within tropical Asia. However, this table also demonstrates the wide range in catch estimates derived from separate studies, demonstrating the need for more rigorous statistical evaluation of the resource.

## 4. ECONOMIC VALUATION CASE STUDIES

### 4.1 The Mekong River System

The Mekong River, now a dominant hydrological feature of Southeast Asia, originates in China and flows through Myanmar, Laos, Thailand, Cambodia and Vietnam. When compared with other river systems of the world, the Mekong ranks 8th in terms of discharge (15,000 m<sup>3</sup>/second). It is the 12th longest river in the world (4,800 km) and has the 21st largest catchment area (795,000 km<sup>2</sup>).

To the authors' knowledge, no non-market valuation studies have yet been conducted to value the environmental attributes of the Mekong River Basin. Rapid agricultural and economic development in the basin is resulting in increasing competition among the riparian countries for Mekong waters and means the need for such studies is increasing. Furthermore, there is competition for use of the river flow not only among countries but also within different activities, such as capture fisheries, aquaculture, agriculture (irrigation), tourism, forestry and electricity generation. Several models have been proposed in the literature in an effort to understand the interactions of different groups and different areas along the Mekong. The study by Ringle and Cai (2003) is especially noteworthy as it estimates the economic value of different activities along the entire Mekong River system. The results are reported below. Following this, we present the economic valuation of wetlands in the Mekong Delta.

#### 4.1.1 Water Use in the Mekong River Basin (Ringle and Cai 2003)

The authors analyze alternative water-use strategies and their implications on riparian countries. The Mekong Basin is divided into seven sites: one in China, one in Laos, two in Thailand, one in Cambodia, and two in Vietnam. The baseline year is 1995. The data have been collected from several national and international databases. The model contains three components:

- Hydrological components, including the water balance in reservoirs, river reaches and crop fields.
- Economic components, including the calculation of economic benefits from water use by sector (irrigated agriculture, domestic-industrial areas, wetlands, fisheries and hydropower).

- Institutional rules and economic incentives that impact upon the economic and hydrologic components.

Water supply is estimated through the hydrological water balance in the river system. Water demand is estimated endogenously through water use by sector. Afterwards, water supply and demand are balanced based on the objectives of maximizing economic benefits to water use. The benefits from water use are presented in Table 2.

As shown in Table 2, Cambodia is the only country obtaining its highest economic return from fisheries. The rest of the countries in the Mekong obtain their highest economic returns from irrigation. This result agrees

with the findings of Seckler et al., (1999), who argue that irrigated agriculture is the largest user of the world's fresh water. The direct use values of the fishery in the Mekong River Basin have been estimated by Ringle and Cai (2003) and Sverdrup-Jensen (2002). Both of these studies have obtained similar results and they are presented in Table 3.

Ringle and Cai (2003) do not specify how they estimated the price and cost for riverine fisheries production. Sverdrup and Jensen (2002) indicate prices from capture fisheries as the average first-hand sale price and for aquaculture as the average farm gate price. For the reservoir fisheries, a conservative value of US\$ 680/t is used, because although the fish are produced by both aquaculture

**Table 2: Baseline scenario, profits from water use in the year 1995**

Country/Region	Irrigation	Domestic/ Industrial water use	Hydropower	Capture Fisheries	Wetlands	Total
<i>(million US\$)</i>						
China (Yunnan)	20	11	.	0.05	.	31
Laos	38	6	33	19	5	101
Vietnam	513	81	.	188	44	825
Vietnam (Central Highland)	29	6	.	.	.	35
Vietnam/ Mekong Delta	484	75	.	188	44	790
Thailand	320	65	10	151	4	551
North Thailand	52	5	.	10	.	68
North-East Thailand	268	60	10	141	4	483
Cambodia	26	7	.	188	80	301
Total Basin	917	170	43	546	134	1 809

Source: Ringle and Cai 2003

**Table 3: Fisheries production of the Mekong River Basin**

Authors	Production	Quantity (tonnes)	Price (US\$/ tonne)	Value (US\$ millions)	Estimated cost (US\$/tonne)	Profit (US\$ millions)
Ringle & Cai (2003)	Riverine capture	1 162 400	750	871.8	280	546.3
	Riverine capture	1 533 000	680	1 042	.	.
Sverdrup- Jensen (2002)	Aquaculture	260 000	1 050	273	.	.
	Reservoirs	240 000	680	163	.	.
	Total	2 033 000	.	1 478	.	.

and capture fisheries, the relative proportions cannot be estimated.

The results obtained by Ringle and Cai (2003) are presented in Section 5. The authors performed sensitivity analysis in order to evaluate the variation in economic value for the different activities.

#### 4.1.2 Economic Valuation of Mangroves in the Mekong Delta (Trong Nhuan et al. 2003)

This study concentrates on analyzing the available data from previous research, and aims to provide the economic value (EV) of the main wetlands in Vietnam. Two of the provinces analyzed are Tra Vinh and Ben

Tre (on the Tien River estuary). The Mekong River empties into the ocean in these two provinces. The EV estimated for the mangroves in both provinces is presented in Table 4 and Table 5. The overall picture from the emerging economic data is that wetlands are economically important to the country. The difficulties of estimating the value of all the ecosystem effects of mangroves are recognized in this study, which focuses on the valuation of the direct use benefits of products. Also overlooked are various sources of *non-visible* value, such as the benefits to the poor derived from the collection of (freely available) natural products. Both these limitations mean that the value of mangroves in the Mekong Delta is probably much higher than actually estimated.

**Table 4: Ben Tre Province (on Tien River Estuary)**

Direct use value	Low value (US\$)	High value (US\$)
Timber	9.52	10.34
Fuel wood	5.65	6.01
Coal	Not available	Not available
Aquaculture	1 401.96	1 469.28
Organized fishing	1 078.43	1 189.54
Unorganized capture fisheries (brackish/fresh)	316.99	409.80
Tourism	10.46	14.38
Indirect Use Value		
Stabilizing micro-climate, improving air quality, water quality, protecting the site from water surge, etc.	Not available	Not available
Economic Value/ha	2 823	3 099

Source: Adapted from Trong Nhuan et al. 2003

**Table 5: Tra Vinh Province**

Direct value	Low value (US\$)	High value (US\$)
Timber	9.93	10.49
Fuel wood	4.90	5.39
Aquaculture	1 211.76	1 339.87
Unorganized capture fisheries (brackish/fresh)	947.71	1 078.43
Tourism	166.01	186.27
Indirect value		
Stabilizing micro-climate, improving air quality, water quality, protecting the site from water surge, etc.	Not available	Not available
Economic Value/ha	2 340	2 620

Source: Adapted from Trong Nhuan et al. 2003

**Table 6: Distribution of catch (t) and level of effort (gear hr x 10<sup>6</sup>) in the base model for riverine fisheries of Bangladesh by river group**

	Meghna	Padma-Ganges	Jamuna-Brahmaputra	Other Rivers	Total
Total actual catch	73 533	5 238	3 879	104 437	189 087
Total estimated catch	63 942	5 870	6 323	97 028	173 163
Estimated direct catch	56 950	4 630	5 021	73 256	139 857
Estimated bycatch	6 992	1 240	1 302	23 772	33 306
Total actual effort <sup>a</sup>	221 320	26 555	16 062	166 367	430 304
Total estimated effort <sup>b</sup>	93 793	7 637	6 684	88 940	197 054

<sup>a</sup> Approximate levels based on sample survey by the author, and survey of fishing units by DOF (unpublished data)

<sup>b</sup> Actual average annual catch from 1983-84 to 1989-90 (DOF unpublished data)

Source: Ahmed (1996)

## 4.2 Bangladesh

### 4.2.1 Net Economic Benefits from Riverine Fisheries in Bangladesh (Ahmed 1992, 1996)

In these two studies, the author determines the total benefits obtainable from various riverine fisheries in Bangladesh (Ganges, Jamuna-Brahmaputra, Meghna and others) under an optimal management regime. Both studies use a non-linear programming model. The use of a mathematical optimization approach enables incorporation into the model of non-linear catch-effort and cost functions, as well as price-responsive demand functions. This model allowed the author to estimate the performance-response of the fishery under different simulated changes in cost of harvest and changes in aggregate demand for fish. The data used in the analysis were the actual average annual catch from 1983-84 to 1989-90. Activity sets and constraints of the model were grouped into three blocks: harvesting, post-harvest handling (processing, transporting, storing, and marketing), and selling (retail demand). These blocks represented biological, technological, and market characteristics and interdependencies across species, space (region), time period of fishing (season), and the environment (different fishing grounds

and/or rivers). The results presented in Tables 6 and 7 are for the whole fishery. Table 6 presents the actual and estimated catches and effort for the different river groups. A summary of the results of the base model for all the riverine fisheries of Bangladesh is given in Table 7.

As presented above, the optimal level of harvest is 173,163 tonnes. Of the total harvest, a significant portion comes as bycatch. In relation to fishing effort, the current actual annual level of effort is roughly 430,304 million gear (square meters) hour, which is about 118 per cent higher than the estimated level of effort. In relation to individual rivers, the size of current effort is higher by 136 per cent in the Meghna River, 247 per cent in the Padma-

**Table 7: Summary of results of the base model for riverine fisheries of Bangladesh**

Benefit-cost (Bangladesh Taka x 10 <sup>6</sup> )	
Net benefit	1 383
Gross benefit	5 634
Producer surplus	1 289
Consumer surplus	94
Total revenue	5 540
Total cost	4 251
- Harvest cost	2 435
- Post-harvest cost	1 816
Total Effort (gear hour x 10 <sup>6</sup> )	197 054
Catch per Unit of Effort (kg)	879

Source: Ahmed (1996)

Ganges River, 140 per cent in the Jamuna-Brahmaputra River and 87 per cent for other rivers. This shows that the principal rivers, especially the Padma-Ganges River, have a relatively higher level of excess capacity as compared to (other) small rivers.

The author believes that the reason for the high level of fishing effort in the Padma River is due to a 70 per cent reduction in annual fishery harvest in the Padma River from 1983-84 to 1989-90. The decline in fish catches was due to severe environmental degradation, such as loss of water flows and siltation due to the effect of the dam constructed in the Indian territory. There was no commensurate reduction in fishing effort.

The results of the base model are presented in Table 7. The total net benefit yielded by the various riverine fisheries is 1,383 million Bangladesh Taka (US\$ 43 million) of which 1,289 million Bangladesh Taka (96%) constitutes the producer surplus and the remaining 94 million Bangladesh Taka constitutes the consumer surplus (4%). Because all costs are considered to be in terms of opportunity costs, the value for producer surplus can be treated as the total factor surplus.

The total cost of harvest and post-harvest activities is 4,251 million Bangladesh Taka, which is 77 per cent of the gross revenue. Of the total cost, 57 per cent represents the cost of fishing or effort (2,435 million Bangladesh Taka). The remaining 43 per cent (1,816 million Bangladesh Taka) represents the market margin or the cost of post-harvest handling, processing, and transporting of fish and fish products, equivalent to 33 per cent of the aggregate gross revenue.

The changes to the baseline model due to changes in fishing effort and demand will be presented in Section 5.

#### 4.2.2 Stocking Seasonal Floodplains in Bangladesh for Capture Fisheries (Ali and Islam 1997)

The contribution of inland open waters to the country's fish production has declined to about 50 per cent at present. This is due to the natural reproduction of fish being disturbed by Overfishing and other causes. Under a project named the Third Fisheries Project (TFP) carp fingerlings were directly stocked into mainly seasonal floodplains in western Bangladesh. Stockings took place in six growing seasons over a period of six years (1991-96).

Stocking of carp fingerlings in floodplains is done by the Department of Fisheries in order to:

- Increase fish production by making use of underutilized resources
- Enhance the income for fishers
- Create employment opportunity

The economic analysis was done for eight floodplains out of the 26 floodplains that have actually been stocked. The author used the statistical data in catches and costs collected to estimate the average net benefits of stocking beels (deep floodplains) over the six years of stocking and thereafter. The results are presented in Table 8.

The analysis shows losses up to the third year, after which floodplain stocking generates net economic benefit. From 1997 onward, the study estimates net benefits to be 52,848,000 Tk every year.

The author also carried out a socio-economic survey on the local fishers fishing within the studied floodplains. The impact of flood-plain

**Table 8: Economic analysis of selected beels floodplain stocking (actual to 1996; constant after)**

Parameter	1991	1992	1993	1994	1995	1996	1997
Stocking area (ha)	3 700	13 200	14 700	22 200	22 200	22 200	22 200
Stocking quantity (kg)	73 049	253 874	249 094	428 606	265 658	325 539	358 591
Stocking density (kg/ha)	20	19	17	19	19	15	16
Stocking price (Tk/kg)	66	88	119	99	89	84	87
Catch (kg)	0	694 716	511 271	2 180 637	4 372 701	3 338 782	3 707 679
Catch/ha (kg)		53	35	98	308	150	167
Mean catch price (Tk/kg)		26	30	34	34	32	35
<b>Costs (Tk'000)</b>							
Stocking cost	4 855	22 419	29 559	42 284	23 624	27 313	31 148
Fishers' labor costs	634	5 696	8 645	10 991	9 922	11 591	11 591
Fishers' equipment costs	912	8 731	13 458	18 167	14 688	20 026	20 026
DOF admin costs	2 065	9 165	13 987	17 735	7 998	10 195	10 195
NGO supervision	0	392	276	260	3 690	7 124	7 124
Other supervision	0	0	0	17	111	111	111
Total financial costs	8 666	46 403	65 927	89 466	59 936	76 360	80 195
Total econ. costs	7 366	39 442	56 036	76 046	50 947	64 906	68 166
<b>Benefits (Tk'000)</b>							
Incremental catch	0	18 086	15 576	73 659	150 338	107 970	128 931
Total financial benefit	0	18 086	15 576	73 659	150 338	107 970	128 931
Total econ. benefit	0	15 373	13 239	62 610	127 787	91 775	109 591
Net benefits (Tk'000)	(7 366)	(24 069)	(13 436)	76 840	26 868	41 426	52 848
Net econ. benefits		42 020					
NPV @ 12%		29.70%					

Source: Ali and Islam 1997

stocking on local fishers is summarized in Table 9.

The socioeconomic evaluation indicates a better status of local fishers resulting from the fingerling-stocking program.

### 4.3 India

#### **Social and Economic Aspects of Fisheries Enhancement in Kerala Reservoirs, India (Peters and Feustel 1997)**

Reservoir culture-based capture fisheries are relatively new in Kerala, India. Overfishing and pollution have deeply affected the lives of many people. From 1992, the Indo-German Reservoir Fisheries Development Project (IGFP) has stocked several reservoirs. In

1996, ten reservoirs were managed under a culture based fishery and harvested by members of fisheries cooperatives and independent fishers. The aims of the project are as follows:

- Involve fishers in developing appropriate reservoir management strategies
- Provide fishery related income from the reservoir to the fishers
- Involve the community in planning and decision making
- Provide cooperative action planning and technical training to the target group

The authors undertook a socioeconomic

**Table 9: Impact of floodplain stocking on local fishers**

Indicator	Name of Floodplain		
	CHANDA	BSKB	HALTI
Land assets			
Before (1991-92)	60 688	72 644	121 893
After (1993-94)	63 020	83 458	128 751
% Increase	4	14	5
Livestock assets			
Before (1991-92)	4 678	5 086	4 441
After (1993-94)	6 138	5 136	4 991
% Increase	31	100	12
Fishing income			
Before (1991-92)	1 126	2 822	2 763
After (1993-94)	7 324	5 810	6 843
% Increase	550	105	147
Per capita daily fish consumption (g)			
Before (1991-92)	20.30	5.62	8.71
After (1993-94)	48.79	18.11	24.76
% Increase	140	222	180
Housing assets			
Before (1991-92)	11 570	10 361	10 877
After (1993-94)	12 487	11 579	11 176
% Increase	7	11	2

Source: Ali and Islam 1997

survey of five different reservoirs and used the recorded catches from the cooperative to estimate the returns from stocking the reservoirs. It is believed that recorded catches were greatly underestimated because the cooperative fishers preferred to channel their catches to the market instead of selling them through the cooperative counter. This occurred because fishers get a higher price for their catches in the market and also do not have to

pay a share to the cooperative and the royalty to the government. The returns from stocking the Malampuzha reservoir presented below show the decline in reported catches to the co-operative despite the increase in stocking (Table 10). Also presented are the differences in prices obtained from the co-operative and the average prices in the markets near the reservoir of Malampuzha (Table 11). Finally, the authors compared the income of a co-

**Table 10: Quantity and price of fingerlings and harvest in Malampuzha reservoir**

Year	Stocking (individuals)	Harvest (kg)
1991-92	1 445 625	4 821
1992-93	3 446 370	4 306
1993-94	2 243 610	6 118
1994-95	3 185 746	1 518
1995-96	2 538 102	933
Average price of fingerlings	0.30 Rs/individual	
Average price for yield	25 Rs/kg	

Source: Peters and Feustel 1997



**Table 11: Comparison of fish prices in the market near the Malampuzha reservoir and cooperative society prices**

Species	Co-operative Society Prices (in Rs)		Average Market Prices (in Rs)		
	Co-op	Market I	Market II	Market III	
Stocked carps	25	35	35	30	
Other indigenous spp.	15	30	30	25	

Source: Peters and Feustel 1997

**Table 12: Calculation of cooperative fisher's income from a 5-kg average catch per day and average incomes per day in other professions**

Catch (kg)	Fish Sales Price (Rs)	Total Value (Rs)	Coop 25% Share	Govt. Share (Royalty) 25%	Daily Income (Rs)
5	20	100	25	25	50
		Agriculture Labor (Seasonal Men)			70-100
		Agriculture Labor (Seasonal Women)			45-70
Other Professions:		Firewood Collection (Women)			60
		Toddy Tapping (Men)			100
		Wood Cutting			125
		Minor Forest Produce Collection			50-60

Source: Peters and Feustel 1997

operative fisher from a 5 kg average catch per day with average incomes per day in other professions (Table 12). As can be observed, the income of a fisher whose catch is less than 5 kg per day is far below the amount that can be earned from daily wages in most other sectors.

#### 4.4 Indonesia

##### **Management Options for the Inland Fisheries Resource in South Sumatra, Indonesia: Bioeconomic Model (Koeshendrajana and Cacho 2001)**

Fishing is an important occupation for a large number of rural people living in the floodplains of the Musi River and its major tributaries in South Sumatra, Indonesia. In this study, an evaluation of the status of the existing fish stock was undertaken, and an analytical model for identifying efficient levels of exploitation of the fishery was developed. The fishery is divided into two different types: the riverine and swamp fisheries. The swamp fishery refers to the total of lake and swamp

fishery data. Primary data are used to describe the current costs of fishing effort. Secondary data (catch data from 1979-94), combined with results of analysis of primary data, are then used to derive a supply function of the fishery. Primary data was obtained through a cross-sectional survey in 1994 undertaken by the authors. Information was obtained about costs and landing prices in rivers and swamps. The total costs of fishing effort (TC) for the standard fishing unit in South Sumatra were Rp 2,974 and Rp 2,631 in river and swamp fisheries, respectively. The average actual prices of freshwater fish at the producer level were 1,215 Rp/kg (riverine) and 1,125 Rp/kg (swamp). The difference in prices between resources may indicate that the quality of harvested fish from the river is better than from the swamp. The authors chose two different models for identifying efficient levels of exploitation of the fishery: the Gordon-Fox model and the Gordon-Schaefer model. The various critical points for both models and the average actual capture during the period of study for both fisheries are presented in the Table 13.

**Table 13: Calculated effort, catch, costs, revenues and profits of the inland fishery in South Sumatra, Indonesia based on the empirical model**

Model/Resource	Harvest condition					Actual (mean)
	MSY	MEY	MScY	BE	BESc	
Schaefer/River						
Effort (1 000 trips)	6 711	4 696	5 374	10 748	9 392	7 217
Catch (tonnes)	27 350	24 884	26 264	17 458	22 986	22 833
Cost (M Rp)	19 957	13 964	15 979	21 459	27 928	21 459
Revenue (M Rp)	33 231	30 234	31 911	21 459	27 928	27 743
Profit (or resource rent) (M Rp)	13 274	16 270	15 931	0	0	6 283
Schaefer/Swamp						
Effort (1 000 trips)	4 407	4 281	4 329	7 246	6 285	5 415
Catch (tonnes)	17 960	17 945	17 955	10 508	14 701	14 830
Cost (M Rp)	11 597	11 265	11 391	11 822	16 538	14 249
Revenue (M Rp)	20 205	20 189	20 199	11 822	16 538	16 684
Profit (or resource rent) (M Rp)	8 608	8 924	8 808	0	0	2 435
Fox/River						
Effort (1 000 trips)	6 472	3 763	4 468	12 053	9 400	7 217
Catch (tonnes)	24 900	22 002	23 427	19 578	23 005	22 833
Cost (M Rp)	19 246	11 190	13 285	23 788	27 951	21 459
Revenue (M Rp)	30 253	26 733	28 464	23 788	27 951	27 743
Profit (or resource rent) (M Rp)	11 007	15 543	15 180	0	0	6 283
Fox/Swamp						
Effort (1 000 trips)	4 120	2 450	2 951	8 140	6 170	5 415
Catch (tonnes)	15 851	14 137	15 078	11 805	14 433	14 830
Cost (M Rp)	10 843	6 447	7 765	13 280	16 237	14 249
Revenue (M Rp)	17 832	15 904	16 963	13 280	13 237	16 684
Profit (or resource rent) (M Rp)	6 990	9 457	9 197	0	0	2 435

MSY=Max. Sustainable Yield; MEY=Max. Economic Yield; MScY=Max. Social Yield; BE=Bionomic Equilibrium; BESc=Bionomic Social Equilibrium;

Source: Koeshendrajana and Cacho 2001

Results indicate that, from both biological and economic perspectives, the inland capture fishery in South Sumatra has been over-fished during the period of the study because the actual effort is beyond both MEY and MSY levels. Even though MEY produces the highest resource rent, the required reduction in fishing effort implies that some fishers may be forced out of fishing, a result that would be socially unacceptable if applied to the small-scale fisheries in Indonesia. Therefore,

the authors suggest that policy actions in the small-scale fishery should be directed to maximizing social yield (MScY) instead. Under social optimization (MScY), the fishing effort would also have to decrease relative to the actual simulation, but not by as much as with MEY. The optimal solutions derived from the Schaefer and Fox models are similar. However, the fishing effort in the Schaefer model is higher than in the Fox model. In the riverine fishery, the Schaefer model yield

values of  $E_{MScY}$  (5.37 million trips) that are 20 per cent higher than in the Fox model. In the swamp fishery, the Schaefer model yields values of  $E_{MScY}$  (4.33 million trips) that are 46 per cent higher than in the Fox model. If a more conservative (i.e., lower) level of effort is desired on biological grounds, then the Fox model results would presumably be favored.

## 4.5 Malaysia

### Fisheries Evaluation of the Chenderoh Reservoir Using the Rapid Rural Appraisal (RRA) Technique (Livelihood Analysis) and Fishers Survey (Ali and Lee 1995)

A study considering the artisanal fishery of Chenderoh Reservoir, Perak River, Malaysia was conducted using a fishers and middlemen survey and RRA evaluation. The RRA provided the socioeconomic background of the fishing community. Furthermore, the RRA indicated the number of landing sites, active fishers and middlemen, and it provided information on the numbers, types of fishing

gear, and the sizes and mesh sizes of gill-nets used. The survey was conducted fortnightly from April 1988 to May 1989 at Kg. Pelagut, the main landing site of the reservoir, but the other three landing sites were determined through the RRA and it was estimated they were small and insignificant. Three types of data were obtained from the fishers, the number of active fishers per day, the amount landed, and the sizes and body weight of fish caught. The middlemen indicated the number of active fishers, the types of gear used, and the total daily landings. From this information, the authors estimated monthly and annual catches as well as catch per hectare of the reservoir's surface area. Furthermore, gear uniformity and single operator/ownership among fishers allowed catch per unit of effort (CPUE) to be calculated based on the fisher's day as a unit of effort. Table 14 gives a summary of the monthly catch statistics of capture fisheries for the 1988-89 season.

The study identified four commercial landing sites around the lake, each controlled and operated by permanent middlemen. The

**Table 14: Monthly catch statistics of fisheries during the 1988-89 season at Kg. Pelagut (Malaysia)**

Catch Parameters	April	May	June	July	Aug	Sept	Oct
Total monthly catch (kg)	2 542.1	1 791.4	8 97.2	841.7	3 328.6	803.4	704.5
CPUE (kg/fisher-day)	6.5	7.3	8.4	2.7	9.5	3.3	2.8
Total daily catch (kg)	84.7	7.9	29.9	27.2	107.4	26.8	22.7
Total daily income (M\$)	236.2	200.2	53.0	90.0	285.0	71.2	41.8
Total monthly income (M\$)	7084.8	6 006.2	1 591.0	2 699.6	8 548.9	2 135.9	1 253.5
Daily income/fisher (M\$)	18.0	22.9	10.6	9.1	28.1	7.7	4.9
	Nov	Dec	Jan	Feb	March	April	May
Total monthly catch (kg)	5 472.2	1 928.6	1 109.7	3 376.3	1 760.3	2 815.9	3 279.1
CPUE (kg/fisher-day)	12.8	7.1	3.0	10.4	8.6	7.2	6.5
Total daily catch (kg)	182.4	62.2	35.8	120.6	56.8	93.9	105.8
Total daily income (M\$)	405.1	185.7	85.8	330.7	152.0	238.6	254.7
Total monthly income (M\$)	12 152.2	5 570.8	2 575.0	9 922.2	4 561.1	7 156.6	7 639.7
Daily income/fisher (M\$)	32.0	24.3	9.3	32.4	21.3	19.5	15.9
Total annual catch (kg) landed by the fishing community 25 713 kg							
Total annual income (M\$) obtained by the fishing community \$63 179.74 (US\$ 1 = M\$ 2.60)							

Source: Ali and Lee, 1995

total annual catch and income generated by the fishery was 25,713 kg and M\$ 63,179.74, respectively.

## 4.6 Sri Lanka

### 4.6.1 Valuing Water in a Multiple-use System (Renwick 2001)

The inland capture fisheries of Sri Lanka are almost entirely restricted to its perennial reservoirs. It is reported that there is a lack of any riverine fishery worth mentioning and that the main share of inland production originates from the reservoirs (Sugunan 1997). This situation is reflected in the available literature. However, one noteworthy study is by Renwick (2001), who examines the economic contribution of multiple uses (agriculture, a consumptive use, and reservoir fisheries, a non-consumptive use) within the Kirindi Oya Irrigation and Settlement Project (KOISP) in southeastern Sri Lanka. The economic value of water in irrigated paddy and fisheries are estimated for the KOISP as a whole and on a per-cubic-meter basis.

Initial failure of the KOISP project to deliver an expected two crops a year on all the 9,600 hectares of land has led to alternative management strategies being considered. The derived values are used to examine the economic implications of alternative water management practices. It was assumed that improvements in allocative efficiency may be achieved if decision makers account for fishery requirements in management decisions. Agriculture plays a substantial role in the local economy of the Kirindi Oya area, accounting for about 55 per cent of the household income in the KOISP. Paddy cultivation is the largest single source of agricultural income, averaging 30 per cent for the area. However, approximately half the households surveyed relied on fishing as the sole source of household income. Surveys were conducted on 12 per cent (20 boats) of the estimated 157 fisher boats operating

in three reservoirs. Detailed information was obtained on: monthly catch, amount of catch sold and consumed at home, prices received in wholesale and retail markets, type of boat and nets, and specific costs. The economic contribution of inland fisheries in the KOISP area was calculated by using the estimated economic returns to fishery operators and the value of water in fisheries. Data were collected for three of the five waterbodies in the area where commercial inland fisheries exist, namely, Lunugamwehera Reservoir, Wirawila Tank, and Yoda Wewa. In combination, these account for about 81 per cent (4,100 ha) of the total reservoir surface area in the project.

See Table 15 for information on catch, value of production, costs of production and economic returns for the three waterbodies surveyed. The value of production was estimated based on the actual monthly catch per unit of effort (CPUE) data, number of trips per month, home consumption, amount sold by each fisher to wholesale and retail markets, and actual prices received. Average annual costs were estimated to be 23 per cent of the total value of production in each reservoir. Economic returns were also estimated in order to provide a measure of the economic value of water in the reservoir fisheries. This calculation included the value of both marketed fish and those consumed at home, as well as the costs of non-cash inputs such as labor and depreciation of fixed assets. The economic return per boat was estimated to be roughly US\$ 2,789 and the average economic return per fisher (usually two per vessel) to be approximately US\$ 1,395.

Annual returns for all five commercially important fisheries were estimated based on actual monthly returns to fishers for the surveyed reservoirs. The total annual economic returns to the five reservoirs from inland fishing were calculated to be about US\$ 544,000-566,000 per year. The value of water use in fisheries is roughly estimated

at 18 per cent of that required for irrigated paddy production.

The use value of water in reservoirs was estimated based on the reservoir storage levels (Table 15). The per-unit value of water use in fisheries was determined to average 25 per cent (0.0033 US\$/m<sup>3</sup>) of that for water delivered to irrigate paddy fields (0.0133 US\$/m<sup>3</sup>). Nevertheless it must be considered that as a large proportion of the water that supports fisheries ultimately ends up irrigating crops giving it extra value.

Fisheries are not currently recognized in management and water allocation plans for the KOISP region. This reflects the fact that the development of inland fisheries is a secondary use of most reservoirs. This study demonstrates the economic value of the fisheries and indicates that integrated water management plans, considering irrigation and non-irrigation uses, would be preferable.

A number of assumptions were made in the estimation of the value of water in paddy production and a full list can be found in Appendix B of the original report. One

assumption perhaps worthy of note is that yield figures used to estimate the value of water in paddy production were assumed to be upwardly biased and, as such, were reduced by a factor of 25 per cent.

#### 4.6.2 Assessment of the Economic Value of Muthurajawela Wetlands (Emerton and Kekulandala 2003)

This report was based primarily on published literature and involved a limited collection of original field data. The authors concede that few data exist on the economic value of the Muthurajawela wetlands and this study is a first attempt at estimating the economic value of these resources. The assessment of fisheries was limited to its direct use economic value by calculating the market prices of output. Data were insufficient to assess the value of fish breeding and nursery for downstream fisheries. About 13-14 per cent of the 1,200 local households are involved in fishing activities in the marsh area (including both freshwater and brackish-water parts). Fishing in the marsh is primarily for household consumption. The marshland also

**Table 15: Catch, value of production, costs and economic returns for the three waterbodies surveyed (1999)**

	Lunugamwehera	Wirawila	Yoda Wewa	Total
Catch per unit of effort (CPUE) (kg)	50.0	20.6	33.8	34.8
Annual yield (tonnes)	1 354.5	225.3	421.8	2 001.6
----- Rupees -----				
Per boat				
Value of production	370 164	207 900	293 220	290 424
Costs of production	124 116	62 148	99 240	95 148
Economic returns	246 048	145 752	193 980	16 632 132
Per reservoir				
Value of production	32 204 268	6 237 000	11 728 800	50 170 068
Costs of production	10 798 092	1 864 440	3 969 600	16 632 132
Economic returns				
Total by reservoir	21 406 176	4 372 560	7 759 200	33 537 936
	\$ 305 803	\$ 62 265	\$ 110 845	\$ 479 113
Per m <sup>3</sup> of water delivered (storage level)	0.16	0.46	2.38	0.23

Source: Taken from Renwick (2001)

maintains and supports downstream fisheries production in the coastal Negombo lagoon by trapping sediment, purifying wastewater, supplying freshwater and providing habitat and fish breeding areas. The value of the Negombo lagoon fishery was assumed to be Rs 200 million (US\$ 222,222) in 2002.

#### **Economic value:**

##### *Direct use*

The marsh fishery was calculated to have a value of Rs 3,000/month.

The total economic value for the surrounding households was estimated to be Rs 6.26 million/yr (US\$ 69,556), based on 175 households being involved in fishing.

##### *Indirect use*

This value is unknown. The authors suggest a conservative estimate of at least Rs 20 million (if removal of the ecological services provided by the marshlands had only a 10 per cent impact on the fishery downstream).

The primary beneficiaries of the marshland fishery were deemed to be the 675 people living next to the marsh. Downstream, 11,600 people depend on the fisheries in Negombo.

## **5. THE IMPACT OF CHANGING RIVER FISHERY MANAGEMENT AND WATER MANAGEMENT**

In this section, the impact of change on tropical river and inland fisheries in Asia is examined from two perspectives: changes relating to fishery management factors (institutions and economic conditions) and changes relating to water management in river basins. Six case studies are presented.

### **5.1 The Mekong River System**

#### **5.1.1 Changes in Fisheries Production and Prices before and after a Change in Fisheries Legislation (Norman-Lopez 2004)**

This study assessed the effect of the reform of fishing lots in the year 2000 on the commercial fisheries and family-scale fisheries in the province of Takeo, Cambodia. The area is situated at the Bassac River (Lower Mekong). The legislation released large areas formerly controlled by commercial fishers for family

**Table 16: Economic value of Muthurajawela**

	Value (US\$/yr)	Value (US\$/ha/yr)	Value as % of total
Flood attenuation	5 394 556	1 758	66.80
Industrial wastewater treatment	1 803 444	588	22.30
Agricultural production	336 556	110	4.20
Support to downstream fisheries	222 222	72	2.80
Firewood	88 444	29	1.10
Fishing	69 556	23	0.86
Leisure and recreation	58 667	19	0.73
Domestic sewage treatment	48 000	16	0.59
Freshwater supplies for local populations	42 000	14	0.52
Carbon sequestration	8 667	3	0.11
<b>TOTAL</b>	<b>8 072 111</b>	<b>2 632</b>	<b>100</b>

Source: adapted from IUCN 2003

fishing. The primary aim of the reform was to transfer responsibility of resource protection and management from the government to local resident communities.

The methodology uses a livelihood analysis in order to understand the way different stakeholders accessed the resource and how they were affected by the reform of fishing lots. The quantitative data for the analysis of the villagers' responses were collected through a household survey questionnaire and the quantitative data for the commercial fishers from key informant interviews with commercial fishers. In relation to family fisheries, 88 households were interviewed and the Wilcoxon test showed with a one per cent level of significance that capture fisheries (snails, whitefish, blackfish) and real prices of these products have changed significantly before (1998) and after (2003) the reform. A summary of the results may be seen in Table 17.

Key interviews with lot operators and subleasers in the area also showed a decline in fish catches over time. Nevertheless, real prices increased with the decline in catches so some of the operators increased their profits (Table 18).

### **5.1.2 Changes in Water Use Value Due to Variation in Water Flow, Wetland Value and Fisheries Exploitation Cost (Ringle and Cai 2003)**

In Section 4, the hydrologic-economic model developed by Ringle and Cai (2003) was introduced in order to value water supply in

the Mekong River system. In this section, the changes in water use value due to changes in water inflow, wetland value, and fisheries production cost are presented. Sensitivity analysis estimates the variation in water use value in comparison with the base model. The authors then estimate a reduction in water flow (by 50%, 60% and 80%), an increase in water flow (20%), a decline (US\$ 16) and an increase (US\$ 50) in wetland value, as well as a reduction (50%) and an increase in fishing costs (200%) for comparison with the base model. The results are given in Table 19.

From the sensitivity analysis, fisheries will be negatively affected by a decline in water flow and positively affected by an increase in water flow. A 20 per cent reduction in water flow is estimated to reduce fisheries profits by 18 per cent in comparison with the base model. On the other hand, a 20 per cent increase in water flow will increase fisheries profits by 33 per cent compared to the base model.

Interestingly, the output from the model suggests that a change in wetland value will have no direct impact on the values derived from any of the functional uses of the Mekong (irrigation, water extraction, hydropower or capture fisheries). This, of course, does not deny the indirect importance of wetlands in supporting fisheries by acting as a habitat for juveniles. Other results of the model are more clear-cut. For example, if fisheries production costs are reduced to half of baseline production costs, then profits from fish production increase to 133 per cent of baseline profits, and the overall basin profits to 110 per cent. Increased fish production profits cause a slight reduction in net irrigation

**Table 17: Results of family capture fisheries based on 88 households surveyed**

		Snails	Blackfish	Whitefish
Before reform (1998)	Quantity (kg)	2 645.35	210.60	278.10
	Real Price (Riel/kg)	188.75	2 085.63	353.40
After reform (2003)	Quantity (kg)	781.87	80.96	181.01
	Real Price (Riel/kg)	481.58	2 940.83	494.87

Source: Norman-Lopez 2004

**Table 18: Cash flow for several commercial fishers**

LOT OPERATORS	CATCH & PRICE	1998-99	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	
<b>Lot operator #1</b>	catch blackfish (kg)	35 000	35 000	33 300	26 000	17 200	13 600	
	real price blackfish (R)	2 759.25	2 651.00	2 670.75	2 685.75	3 960.36	3 914.00	
	catch whitefish (kg)	23 000	23 000	18 600	18 400	31 700	27 200	
	real price whitefish (R)	772.59	742.28	747.81	752.01	1 250.64	1 236.00	
<b>Subleaser 1 lot#1</b>	catch blackfish (kg)	5 250			3 480	2 940	2 450	
	real price blackfish (R)	2 759.25			2 846.90	3 699.81	3 811.00	
	catch whitefish (kg)	10 000			11 200	9 400	9 400	
	real price whitefish (R)	596.00			580.12	896.29	885.80	
<b>Subleaser 2 lot#1</b>	catch blackfish (kg)						2 675	
	real price blackfish (R)						6 180.00	
	catch whitefish (kg)			NOT SUBLEASING				1 300
	real price whitefish (R)						2 163.00	
<b>Subleaser from KREG</b>	catch blackfish (kg)					2 810	2 810	
	real price blackfish (R)					13 896.00	13 733.33	
	catch whitefish (kg)			NOT SUBLEASING		3 100	3 100	
	real price whitefish (R)					2 188.62	2 163.00	
<b>Lot operator #2</b>	catch blackfish (kg)	9 300						
	real price blackfish (R)	1 655.55						
	catch whitefish (kg)	19 800		NOT SUB-LEASING LOT RELEASED TO COMMUNITY MANAGEMENT				
	real price whitefish (R)	331.11						
<b>Lot operator #3</b>	catch blackfish (kg)	12 000						
	real price blackfish (R)	2 759.25						
	catch whitefish (kg)	17 000		LOT RELEASED TO COMMUNITY MANAGEMENT				
	real price whitefish (R)	772.59						
<b>Lot operator #5</b>	catch blackfish (kg)	77 400	77 400	77 400	73 700	58 200	45 000	
	real price blackfish (R)	2 759.25	2 651.00	2 670.75	2 685.75	3 647.70	3 914.00	
	catch whitefish (kg)	32 600	32 600	32 600	21 400	25 000	23 000	
	real price whitefish (R)	772.59	742.28	747.81	752.01	1 250.64	1 236.00	

Source: Norman-Lopez 2004

profits, and an improvement in hydropower profits to 102 per cent of the baseline values.

## 5.2 Bangladesh

### Performance-response of the Inland Fishery under Different Simulated Changes in the Cost of Harvest and Changes in Aggregate Demand for Fish (Ahmed1992, 1996)

#### 5.2.1 Changes in the Cost of Harvest

The model used in the analysis has been previously discussed in Section 4. In the

analysis, the author studied the case where effort is fishery specific but flexible to operate in different fishing grounds. Table 20 shows the aggregate results in percentage terms under several alternative cost conditions from the base model.

Overall, a decline in costs by 25 and 50 per cent will increase fishing effort and catches. This result implies that potential catches of the fishery could be much higher than actual catches. If the fishery were exploited at its full potential, a decline in fishing costs could increase fishing effort, however catches would hardly change or even decline due to the excessive exploitation. On the other



**Table 19: Sensitivity analysis: profits from water use (values and percentage)**

Parameters	Levels/ values	Irrigation	Domestic/ industrial water use	Hydro- power	Capture fisheries	Wetlands	Total
(million US\$)							
	<b>BASE MODEL</b>	<b>917</b>	<b>170</b>	<b>43</b>	<b>546</b>	<b>134</b>	<b>1,809</b>
Inflow	50%	586.9 (64%)	161.5 (95%)	24.1 (56%)	174.7 (32%)	109.9 (82%)	1 049.2 (58%)
	60%	632.7 (69%)	168.3 (99%)	28.0 (65%)	245.7 (45%)	116.6 (87%)	1 193.9 (66%)
	80%	871.2 (95%)	168.3 (99%)	32.7 (76%)	447.7 (82%)	127.3 (95%)	1 646.2 (91%)
	120%	944.5 (103%)	170 (100%)	43.9 (102%)	726.2 (133%)	128.6 (96%)	2 008.0 (111%)
Wetland value <sup>a</sup>	US\$ 16	917 (100%)	170 (100%)	43 (100%)	546 (100%)	107.2 (80%)	1 790.9 (99%)
	US\$ 50	917 (100%)	170 (100%)	43 (100%)	546 (100%)	335 (250%)	2 008.0 (111%)
Fisheries production cost <sup>b</sup>	50%	916.1 (99.9%)	170 (100%)	43.9 (102%)	726.2 (133%)	133.9 (99.9%)	1 989.9 (110%)
	200%	917 (100%)	170 (100%)	43 (100%)	218.4 (40%)	134 (100%)	1 483.4 (82%)

<sup>a</sup> Baseline value is US\$ 20

<sup>b</sup> Baseline value is US\$ 280

Source: Ringle and Cai 2003

**Table 20: Behavior of the riverine fisheries of Bangladesh under alternative cost conditions (changes in the cost of harvesting from the base model)**

Items	Condition of cost					
	50% decrease	25% decrease	Base Model	25% increase	50% increase	100% increase
Benefit-cost <sup>a</sup>						
Net benefit	2 808	2 258	1 383	929	642	330
Gross benefit	10 712	8 099	5 634	4 153	3 041	1 661
Producer surplus	2 163	1 653	1 289	873	616	321
Total revenue	10 066	7 494	5 540	4 097	3 016	1 652
Total cost	7 904	5 841	4 251	3 224	2 399	1,331
- harvest cost	3 186	2 918	2 435	1 929	1 456	819
- post-harvest cost	4 718	2 922	1 816	1 295	943	512
Catch-Effort						
Total catch (t)	305 650	230 060	173 160	130 230	96 580	54 130
- direct catch	245 870	184 260	139 860	104 670	77 360	44 300
- bycatch	59 770	45 800	33 310	25 560	19 220	9 830
Total effort <sup>b</sup>	483 363	303 101	197 054	131 493	84 671	38 787
CPUE (kg) <sup>c</sup>	632	759	879	990	1 141	1 396

<sup>a</sup> In million Bangladesh Taka (US\$1 = BDT32)

<sup>b</sup> In gear hours x 10<sup>6</sup>

<sup>c</sup> CPUE = catch per unit of effort

Source: Ahmed 1996

hand, a 25, 50 and 100 per cent increase in fishing costs would reduce fishing effort and catches.

The shadow price of effort would be lower for a cost increase and higher for a cost decrease at any given level of effort. This implies that an increase in harvest costs would shift the shadow price down and vice versa. The implication of such movements of shadow prices across different cost conditions are that each additional unit of effort would result in a larger contribution to the net benefit when applied to a cost situation that is lower than the one assumed in the base model and vice versa.

### 5.2.2 Changes in Aggregate Demand

Changes in population and real income will change aggregate demand. This in turn, will lead to changes in fishing effort and catches. Table 2 shows the changes in fishing effort and catches predicted to result from increases or decreases in demand of 10 and 20 per cent.

As shown in Table 21, a decrease in the aggregate demand would reduce the level of effort and catches while an increase in the aggregate demand would increase the level of effort and catches when compared with the base model. The results again imply that the potential catches are higher than the actual catches. If the fishery were exploited at its full potential, fishers would increase fishing effort and catches would remain the same or even decline. The author also examined the shadow prices of effort under alternative demand conditions, and concluded that the optimal level of effort would be higher if aggregate demand increased, and vice versa.

## 5.3 Sri Lanka

### 5.3.1 Valuing Water in a Multiple-use System (Renwick 2001)

As indicated in Section 4, this study looked at the economic contributions of agriculture and reservoir fisheries within the Kirindi Oya irrigation and settlement project (KOISP)

**Table 21: Behavior of different riverine fisheries of Bangladesh under alternative demand conditions (changes in the demand intercept from the base model)**

	20% increase	10% increase	Base model	10% decrease	20% decrease
Benefit-cost <sup>a</sup>					
Net benefit	2 619	2 099	1 383	935	561
Gross benefit	8 978	7 459	5 634	4 082	2 827
Producer surplus	2 443	1 973	1 289	878	529
Total revenue	176	126	94	58	32
Total cost	6 359	5 360	4 251	3 147	2 267
- harvest cost	3 811	3 185	2 435	1 742	1 184
- post-harvest cost	2 548	2 175	1 816	1 405	1 083
Catch-Effort					
Total catch (t)	232 045	206 610	173 163	139 072	105 254
- direct catch	186 050	164 847	139 857	110 071	83 498
- bycatch	45 995	41 763	33 306	29 001	21 758
Total effort <sup>b</sup>	310 900	247 995	197 054	142 178	91 250
CPUE (kg) <sup>c</sup>	746	833	879	978	1 153

<sup>a</sup> In million Bangladesh Taka (US\$1 = BDT32)

<sup>b</sup> In gear hours x 10<sup>6</sup>

<sup>c</sup> CPUE = catch per unit of effort (Ratio of total catch to total effort)

**Table 22: Economic value of water in irrigated paddy and reservoir fisheries under alternative water management schemes**

	Water management scheme			
	Status quo	Scenario 1	Scenario 2	Scenario 3
Irrigation conservation per hectare reductions	0	0	5%	10%
		----- 1 000s -----		
Paddy (16 730 Rs/ha)	251 352	264 878	278 816	294 303
	\$ 3 591	\$ 3 784	\$ 3 983	\$ 4 204
Fisheries (16.76 Rs/kg)	33 547	34 251	34 251	34 251
	\$ 479	\$ 489	\$ 489	\$ 489
Total	284 898	299 129	313 068	328 555
	\$ 4 070	\$ 4 273	\$ 4 472	\$ 4 694
Economic gain		14 231	28 169	43 656
		\$ 203	\$ 402	\$ 624

Source: Taken from Renwick 2001

in southeastern Sri Lanka. Following this, the study went on to model the potential outcomes of three alternative water management schemes. In KOISP, the reservoirs provide storage for irrigation water and habitats for fish. Therefore, allocation and management decisions for the purposes of irrigation directly affect reservoir fisheries by changing water levels.

Based on the assumption that there is an optimal range of water volume stored within a reservoir in terms of fishery productivity, a simplified econometric model of fishing yield was specified and estimated to better identify the relationship between CPUE and reservoir levels. The average monthly CPUE by reservoir was regressed on a constant, the mean monthly storage levels for each reservoir and reservoir dummy variables for each reservoir to determine capture differences among them.

The model was deemed to perform well with an adjusted R<sup>2</sup> of 0.62 indicating a good fit. A strong correlation was seen between declining water levels and CPUE for the observed range of levels in 1999. The estimated elasticity of CPUE with respect to water levels is -0.21 indicating that a 10 per

cent decrease in storage is associated with a 2.1 per cent increase in CPUE. However, this elasticity is only valid over the range of storage levels observed in 1999 and for marginal changes in storage levels. The result is important, as a substantial negative change in the volume of water would ultimately have a negative impact on the fisheries.

After estimating the main model, three scenarios were investigated. Scenario 1, evaluates the economic gain of proportionally allocating an increasing amount of water for irrigation and a decreasing amount for fishers. The effect of more efficient management of this increased volume, for the purposes of irrigation, was then looked at (Scenarios 2 and 3).

Primarily, the model indicated that marginal reductions in the amount of water allocated to fisheries reservoirs actually generated individual economic gains for both the fishery and farming activities, resulting in overall economic gains for the area.

Scenario 1, which reduced reservoir levels by 14.47 MCM (million cubic meters) would lead to higher fishery yields and an economic gain of 42,000 kg of fish or approximately

US\$ 10,000 per year over the status quo scenario. The optimal, estimated economic gain for paddy farming from this increased allocation of water was US\$ 613,000 per year (under Scenario 3).

The model demonstrated that the status quo per-unit value of water was, on average, higher for paddy irrigation (0.0133 US\$/m<sup>3</sup>), and that, with more efficient management, the value might be further increased (0.0148 US\$/m<sup>3</sup>). The average per-unit value for fisheries is significant (0.0033 US\$/m<sup>3</sup>) and would be higher if the gains could be made to both simultaneously.

### 5.3.2 Adaptive, Participatory and Integrated Assessment (APIA) of the Impacts of Irrigation on Fisheries – Evaluation of the Approach in Sri Lanka (Nguyen-Khoa, Smith and Lorenzen 2005)

A later, ex-post APIA study of the Sri Lankan KOISP project assessed the economic impacts of its implementation on fisheries in the areas previously evaluated. Impacts were assessed through a series of workshops, field studies, interviews with key informants and the compilation of a knowledge base from primary and secondary data sources and technical assessments.

Five critical issues were identified for investigation:

- Reduced river flow and floodplain habitats
- Excessive drawdown of water levels for reservoir fisheries
- Impacts of drainage inflow to the lagoons
- Conflict of interest between fishers and farmers
- A lack of institutional coordination between irrigation and fisheries agencies

The first three were considered as impacts of the project and/or management, and the last two as contributing factors. These issues were used to define the scope of the projects.

As shown in Table 23, the KOISP project had a modest positive impact on preexisting fisheries in terms of aggregate production and value.

The reduction of river flow downstream was thought to have had little impact, in terms of fisheries, as neither subsistence nor commercial fisheries had ever developed in the floodplain. On the other hand, the

**Table 23: KOISP fisheries balance in terms of production and value**

Water body	Before KOISP			After KOISP		
	Catchment area (ha)	Production t/year	Value Rs 1,000	Catchment area (ha)	Production t/year	Value Rs 1,000
Floodplain	6 200	124	50	0	0	0
Lagoons	15 000	150	225	1 500	150	60
Lunuganwehera	0	0	0	3 200	1 344	538
Tanks	1 608	1 013	405	1 608	1 013	405
Small Tanks	300	189	76	200	126	50
River*	-117 800	35	14		0	0
Total*	9 608	1 511	14	6 508	2 633	1 053
Change				-3 100	1 122	284

\* The river does not contribute to catchment area but it contributes to fisheries production and value.

Source: Taken from Nguyen-Kho et al. 2005

creation of a large reservoir upstream led to a substantial increase in aggregate fish production. This compensated for downstream losses. However, negative impacts of scheme operation and water management on the actual production of the preexisting reservoirs and lagoons were valued at Rs 225,000. Overall the combined effects of the KOISP project, overfishing and a recent drought were held responsible for degrading fish stocks and driving fishing towards being little more than a livelihood of last resort.

The authors conclude that if savings could be made in the water needs of farming and the minimum water levels needed to conserve fish stocks were better accounted for, gains could be made in the national fish output, employment, and improved nutrition for poor households.

### 5.3.3 Impact of Dams

According to Marmulla (2003), the construction of dams and weirs for irrigation, hydropower generation or flow management has a long tradition in many parts of the world; in the past 50 years, many thousands of dams of different sizes have been constructed. The construction of such barriers has a negative impact on natural fish populations and, together with other factors, greatly contributes to the reduction, disappearance and even extinction of some species. Marmulla (2003) highlights that LARS2 (The Second International Symposium on the Management of Large Rivers for Fisheries) identified dams and the disruption of ecological flows in rivers and floodplains as a major factor in the decline of inland fisheries. It should be noted that dams are a significant feature of developing countries, compared to developed ones, and their number is expected to increase at a much faster pace. This is because of demands for water (and electricity) from industry, agriculture and expanding populations of consumers.

In Asia, dam construction has had a major impact on many rivers and their fisheries. Dams remain a component of many national development plans to control flooding, regulate and store water for agriculture and electricity generation. For example, 160 dams are currently proposed for the Mekong River Basin alone.

While the impact of dams on river fisheries has been recognized, and assessed to some degree in terms of environmental, ecological and biological impacts, there have been relatively few valuation studies undertaken (or at least published in the literature). Some of the impacts and issues involved can be illustrated with reference to cases studies from the Lao PDR, Thailand and India/Bangladesh.

In the case of the Nam Theun 2 Hydroelectric Project in the Lao PDR, the environmental assessment plan showed that the dam would destroy 45,000 hectares of land, supporting 4,500 people and natural habitats (Wegner 1997). The social and environmental costs were estimated at US\$ 60-130 million, with half of this represented by the opportunity cost of the land. The mitigation budget for the project was set at US\$ 60-75 million, with a sum of up to US\$ 50 million for additional unforeseen costs. Wegner (1997) commented that, overall, the costs of the project had been underestimated and the benefits overestimated.

In Thailand, the World Bank (2000) highlighted to the World Commission on Dams (WCD) that the proposal for the Pak Mun Dam, similar to other such projects, did not include detailed baseline studies on fisheries. There were also additional problems in determining the appropriate level of compensation for the impact of the dam, as well as the application of the cost-benefit analysis with particular reference to the loss estimates. The issue of the impact on biodiversity was particularly difficult to assess, and it was as difficult to

**Table 24: Economic evaluation of Asian riverine fisheries: a summary of the evidence**

Country/Region	Author	Method	Key Results
Mekong river system (Lao PDR, Cambodia, Thailand, Vietnam)	Ringle and Cai (2003)	Production function and sensitivity analysis	Value of the fishery US\$ 546.3 million. Negative correlation between water flow and fishery value
Mekong delta (Vietnam)	Mai et al. (2003)	Estimated economic value (EV) using secondary data	Range value of the fishery in Ben Tre Province (US\$ 2 832 – 3 099) and Tra Vinh Province (US\$ 2 340 – 2 620)
Bangladesh	Ahmed (1992, 1996)	Supply-demand model; cost-benefit and sensitivity analysis	Net benefit yielded by the various riverine fisheries (US\$ 43 million)
	Ali and Islam (1997)	Cost-benefit analysis	Net benefit from stocking seasonal floodplains for capture fisheries (Tk 42 848 000)
India	Peters and Feustel (1997)	Socioeconomic survey	Failures of coop. system leading to undervaluation of fishery in official figures
Indonesia	Koeshendrajana and Cacho (2001)	Production function (bioeconomic analysis)	Estimation of various optimal management solutions for Musi River fishery
Malaysia	Ali and Lee (1995)	Livelihood analysis	Total annual income for fishing community in the Chenderoh Reservoir (US\$ 63 180)
Sri Lanka	Renwick (2001)	Cost-benefit analysis; Regression analysis to est. CPUE and reservoir levels relationship; and scenario analysis	Estimated total annual economic returns for five reservoirs in KOISP project region (US\$ 544 000 – 566 000)
	Emerton and Kekulandala (2003)	Estimated economic value (EV) using secondary data	Estimated direct use value for Muthurajawela wetland marsh fishery (US\$ 69 556)
Cambodia	Nguyen-Khoa et al. (2005)	Livelihood Analysis	Increase in aggregate economic value of fisheries after implementing the KOISP project (Rs 284 000)
	Norman-Lopez (2004)	Livelihood analysis and socioeconomic survey	Overall decline in catches and increase in prices for commercial and subsistence fishers due to legislative reform

distinguish the impacts attributable to the dam as opposed to other impacts such as overfishing.

In India, there are two major dams on the tributaries of the Ganges at Hardwar and Farakka; both have produced major environmental changes and caused political problems between India and Bangladesh (Mukerjee 1998). The dams have negatively impacted on fish migration and production although the associated reservoirs have yielded good production. There are no

valuation studies on the overall impact of the dams on the fisheries in the Ganges.

## 6. DISCUSSION

The aim of this study was to estimate the economic value of riverine fisheries in tropical Asia. It is widely accepted that this resource is significant in the maintenance of many people's livelihoods (Coates 2002); Van Zalinge et al. (2000). Nevertheless, examples of studies that have attempted to quantify this value are limited and often incomplete in

nature (evaluation of direct use value but not indirect use value). This report examines the value of Asian riverine fisheries in the following two ways: firstly, through a compilation and summary of the results of existing studies on this topic; secondly, through estimating the direct use value of riverine and floodplain fishing by country using quantities and freshwater fish prices derived from various sources.

The review of several case studies not only provided fishery values in specific areas but also allowed us to put into perspective the values of riverine fisheries, compared to other riverine resource uses such as forestry, agriculture (irrigation), electricity generation, etc. A summary of the empirical studies that have been considered in this report is provided in Table 24. Presented in the table are the country/region where the study was undertaken, the author(s), main economic methodology used, and key fishery results. The main point to be highlighted is that all the studies under review estimated direct use values but none obtained indirect use values. Non-use attributes are just as important as use values. Nevertheless, estimating non-use values is usually so complicated in developing countries that only a few of these studies exist for tropical Asia. One such study is by Wattage (2002), who used the contingent valuation (CV) technique to measure the conservation value of water, fish and mangrove of a wetland in Sri Lanka. This report pointed out that the conservation value of coastal wetlands in Muthurajawela Marsh and Negombo Lagoon (MMNL) area is equally important in developing countries in addition to the formal direct values. This study was, however, not included in this review for the simple reason that it does not separate the value of the fishery from the entire value of the resource. Finally, some of the studies reviewed, such as Ahmed (1996), and Ringle and Cai (2003), not only provide the present value of the fishery but also include the

change in value under different situations. This is absolutely necessary to understand the effect to the resource and society under different management regimes.

The estimation of a direct economic value by country provides a rough estimate of the importance of riverine and floodplain fisheries (Appendix 3). This value provides a first glimpse of the significance of these fisheries to the countries reviewed. The main problems encountered were accuracy and availability of data on quantity and price. It is generally accepted that quantities are often underreported and studies usually differ in data collection methods as well as accuracy. This problem is highlighted in Appendix 1. For those countries where several reports present fisheries production, high variations in values exist. This discrepancy can be seen, for example, in the case with the Lao PDR. In the year 2000, the capture production in the Mekong river system was reported at 27,000 tonnes; nevertheless, Van Zalinge et al. (2003) estimated from consumption values that the capture fisheries production in the Mekong for that year was 182,700 tonnes. In relation to prices, a large variation in the quoted figures is apparent (see Appendix 2). The main problem is due to unit values being derived from estimates based on different freshwater species in different areas of the country. A range of values for the riverine fisheries of each country reviewed is provided in Appendix 3. This not only provides an insight into how valuable the fishery is within the area but also emphasizes the problem of data availability.

A major outcome of this study is the realization that we still have some way to go before truly reliable estimates of the *total* economic value riverine fisheries provide to the countries and communities of tropical Asia are available. Only when more rigorous investigations are conducted that capture *all* the values derived from these resources, can we be confident

enough to consider the figures as actual representations of the fisheries value to society.

## 7. CONCLUSION

Studies have demonstrated the social and economic importance of Asian riverine fisheries using various different indicators, and in the broadest sense, this makes them valuable. These fisheries have been shown to be valuable (i.e., important) in at least two specific ways: as a generator of commercially marketable output, and as a source of income and employment in relatively impoverished communities. We could also make the obvious point that these fisheries are important to consumers, and indeed make a necessary contribution to nutrition and food security.

These fisheries in their present state are *valuable* on a number of different definitions and measures, but it is necessary to know how that value will change under different

circumstances. Some of the studies discussed in this report have addressed this issue, but there is a need for more research in this area. With a few exceptions, most of the valuation studies have undertaken *snapshot* reviews of fisheries in order to gauge their current actual value. What is important, however, is to be able to see how that value compares with the maximum value that could potentially be achieved under alternative fisheries management regimes. The fact that many Asian river fisheries are open-access and thus have a tendency to become overexploited suggests that economic surplus in the form of resource rent is being at least partially dissipated. Assessing the magnitude of this lost value and finding ways in which it can be reappropriated should, therefore, be a priority. While this will require economic research that can only be undertaken at a cost, policymakers will be rewarded with improved knowledge of how to manage these fisheries for the benefit of Asian communities.



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## APPENDIX 1: CAPTURE RIVERINE (AND FLOODPLAIN) PRODUCTION

Country	Year	Production (t)	Author	Comments
Bangladesh	1989/90	89 006	Bangladesh Bureau of Statistics (1994)	Annual total catch in principal rivers (Padma-Ganges; Jamuna-Brahmaputra; Meghna River systems)
	1990/91	561 824	DOF (1998)	Annual catches of rivers and floodplains
	1991	124 000	De Graaf and Chinh (2002)	Annual total catch for ALL rivers
India	1994/95	28 500	Sugunan (1997)	Production in rivers and canals
Sri Lanka	1998	16 796.57	Nissanka et al. 2000; Fish-Stat FAO (2005) and De Silva (1988)	Total inland capture fisheries production in 1998 (FAO Fish-Stat) was 29 900 tonnes. Capture riverine production is the remainder once reservoir production has been accounted for. Reservoir production is estimated as the product of the average yield of 11 reservoirs in 1998 (118.59 kg/ha/yr. Nissanka et al. 2000) and the total surface area of major, medium and hydro-electric reservoirs (110 491 ha)
Cambodia	1995	400 000	Jensen (2000)	Production in the Mekong River system
	2000	289 000 – 431 000	Baran (2005)	Production from Mekong River, floodplains and Tonle Sap lake
	2000	682 150	Van Zalinge et al. (2003)	Production estimated from consumption values. Catch from Mekong River, floodplains and Tonle Sap lake. Reservoir catch 22 750 t, aquaculture 14 100 t. Total production in Mekong River system 719 000 t
Lao PDR	2000	27 000	Van Zalinge et al. (2000)	Production in Mekong River
	2000	182 700	Van Zalinge et al. (2003)	Production estimated from consumption values. Catch from Mekong River and floodplains. Reservoir catch 16 700 t, aquaculture 5 400 t. Total production in the Mekong River system 204 800 t
	2002	17 790	ASEAN Database of Inland waters	Production in Mekong River and 14 tributaries (70 kg/ha/yr)
Thailand	2000	303 000	Van Zalinge et al. (2000)	Production in Mekong River and floodplains
	2000	875 000	Van Zalinge et al. (2003)	Production estimated from consumption values. Catch from Mekong River and floodplains in northeast of Thailand
	2001	200 000 – 500 000	Coates (2002)	Est. national production from rivers, floodplains, canals, lakes, marshes (reservoir production and aquaculture not included); Reservoirs provide the largest capture production.

Vietnam	1976	60 000 – 75 000	De Graaf and Chinh (2002)	Annual total catches for ALL rivers
	1980's	29 500	UNEP (1998)	Annual total catches for ALL rivers (20 000 t Mekong River; 6 000 t Red River; 3 000 t Central rivers; 500 t High land rivers)
	1998	136 000	Coates (2002)	Annual production in rivers and floodplain
	2000	190 000	Van Zalinge et al. (2000)	Annual production in rivers and floodplain
	2000	50 000 – 200 000	ASEAN Database of Inland eaters (2005)	Inland fish production in Mekong Delta (Mekong River, floodplains, canals)
	2000	844 850	Van Zalinge et al. (2003)	Production estimated from consumption values. Catch from Mekong River and floodplains
Mekong (Cambodia, Lao PDR, Thailand, Vietnam)	1995	1 162 400	Ringle and Cai (2003)	Production in the Mekong River system
	1995	> 1 200 000	Jensen (2000)	Production in the Mekong River system
	2000	809 000 – 951 000	Baran (2005)	Production in the Mekong River and floodplains
	2000	1 533 000	Sverdrup-Jensen (2002)	Production in the Mekong River and floodplains. Price US\$ 0.68/kg This generates a value for the Mekong River system of US\$ 1 042 000
	2000	2 642 000	Van Zalinge et al. (2003)	Production estimated from consumption values. Catch from Mekong River and floodplains
	2004	2 500 000	Baran (2005)	Production in the Mekong River and floodplains
Myanmar (Burma)	2000-01	253 373	FAO (2003)	Production in rivers, lakes, floodplain, reservoirs and lagoons
	2000-01	600 000 – 900 000	Coates (2002)	Estimated indicative figure for actual catches (rivers, lakes, swamps, floodplains and reservoirs)
	2000	360 000	ASEAN Database of Inland waters	Production in rivers, lakes, floodplains, reservoirs and lagoons
	2002	530 000	ASEAN Database of Inland waters	Production in rivers, lakes, floodplains, reservoirs and lagoons
Indonesia	1999	800 000 – 900 000	Coates (2002)	Estimated indicative figure for actual catches (rivers, lakes, swamps, floodplains and reservoirs)
	2000	297 300	BPS Statistics Indonesia (2000)	Production in rivers, lakes, swamps, floodplains and reservoirs
	2000	191 805	Coates (2002)	Estimated river and swamp production for the main islands (Kalimantan, Java, Sumatra, Maluku and Irian Jaya, Bali and Nusa Tenggara). The only large island not included in the estimate is Sulawesi due to lack of data. The author indicates catches are probably 2-3 times higher than the official figure.

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Philippines	2002	131 644	Bureau of Fisheries and Aquatic Resources (2004)	Production includes lakes, reservoirs, rivers, and marshes
Malaysia	1999	10 008	Coates (2002)	Estimated indicative figure for actual catches (rivers, lakes, swamps, floodplains and reservoirs)
	2001	3 368.51	ASEAN Database of Inland waters	Production includes lakes, reservoirs, rivers, floodplains and marshes

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## APPENDIX 2: CAPTURE RIVERINE (AND FLOODPLAIN) PRICES

Country	Year	Prices (US\$/kg)	Author	Comments
Bangladesh	1995	0.812	Ahmed (1996)	32.555 Bangladesh Taka/kg. Average exchange rate (1995): 40.100 Bangladesh Taka/US\$. The price is derived from freshwater capture fisheries of several species caught in main rivers in Bangladesh (Jamuna-Brahmaputra, Meghna, Padma-Ganges and other rivers).
	1997	0.815	Ali and Islam (1997)	35 Bangladesh Taka/kg. Average exchange rate (1997): 42.930 Bangladesh Taka/US\$. The price is derived from average freshwater capture fisheries of species caught in beels (deep floodplains) (stocked and non-stocked species)
	2002	1.098	Dey et al. (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species.
India	1991-96	0.796	Peters and Feustel (1997)	25 Indian rupee/kg. Average exchange rate (1995): 31.410 Indian rupee/US\$. The price is derived from freshwater capture fisheries of major carp species stocked in reservoirs ( <i>Catla catla</i> , <i>Labeo rohita</i> , <i>Cirrhinus mrigala</i> , <i>Labeo fimbriatus</i> , <i>Cyprubys carpio</i> ).
	2000	0.717	Dey et al. (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species.
Sri Lanka	1999	0.239	Renwick (2001)	Average price, 16.76 Rs/kg. of freshwater capture fisheries from Lunugamwehera reservoir, Wirawila Tank, and Yoda Wewa reservoir. Approximate exchange rate: 70 Rs/US\$
	2002	1.364	Dey et al. (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species.
Cambodia	1995	0.750	Jensen (2000)	The author averaged production in the Mekong River system to be 0.75 US\$/kg. [Jensen estimated production in Cambodia as 400 000. So estimated value of production is 300 US\$ million.]
	1998	0.510	Nam and Thuok (1999)	Average price of Mekong River fisheries. [The authors estimated production to be 284 000 t. So estimated value of production is 145 US\$ million.]
	2003-4	0.577	Norman-Lopez (2004)	Average price: 2 317.66 Riel/kg. Estimate obtained from freshwater capture fisheries in Bassac River, Takeo Province. Average value from commercial and local fishers for blackfish and whitefish species. Blackfish [4 454.75 Riel/kg (commercial fishers); 2 940.83 Riel/kg (local fishers)] Whitefish [1 380.2 Riel/kg (commercial fishers) 494.87 Riel/kg (local fishers)]. Only one commercial fisher removed from estimation due to variability in estimate from other fishers. Exchange rate (2003-4): 4 016.25 Riel/US\$



Lao PDR	2002	0.55	Singhanouvong and Phouthavong (2002)	Average price: 5 562.5 kip/kg. Estimate obtained from small and large catfish and scaled fish. Exchange rate (2002): 10 056.3 kip/US\$
Thailand	2000	1.30	Dey et al. (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species.
Vietnam	2000	1.33	Dey et al. (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species.
	2000	0.36	Mai et al. (2003)	Price obtained from inland fisheries in Mekong River estuary (Ben Tre Province). Exchange rate (2000): 14,020 VND/US\$
Mekong (Cambodia, Lao PDR, Thailand, Vietnam)	1995	0.75	Ringle and Cai (2003); Jensen (2000)	Prices from freshwater capture fisheries. Value at retail market price. [Jensen (2000) estimated production to be > 1.2 million tonnes. So production estimated 900 – 1 000 US\$ million]
	2000	0.68	Sverdrup-Jensen (2002)	Prices from freshwater capture fisheries. Average first-hand sale price
Myanmar (Burma)	1999	0.15	Coates (2002)	Price derived by dividing value of lease fishery (commercial fishery) (621.89 million Kyat) by estimated landings (70 000 tonnes). Exchange rate (1999): 6.286 Kyat/US\$
	1999	1.41	Coates (2002)	Price derived by dividing value of tender <i>open</i> fishery (83.519 million Kyat) by estimated landings (90 000 tonnes). Exchange rate (1999): 6.286 Kyat/US\$
	2003	1.6	FAO (2003)	Price derived by dividing value (US\$ 16) by quantity (10 kg) of fish sold at market. Fish sold were mainly snakehead, relatively high value.
Indonesia	1994	0.56	Koeshendrajana and Cacho (2001)	Price obtained from Musi River. Average actual price of riverine freshwater fish at the producer level was 1 215 Rp/kg. Average exchange rate (1994): 2 160 Rp/US\$
	2000	0.51	Dey et al. (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species
Philippines	2000	0.80	Dey et al. (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species.
	2002	0.03	ASEAN Database of Inland waters (2005)	Freshwater capture production from lakes, rivers, reservoirs and marshes. Exchange rate: 1 PHP/US\$
Malaysia	1988-89	2.46	Ali and Lee (1995)	Capture fisheries production in Chenderoh Reservoir, Perak River, Malaysia. Exchange rate from authors: 2.6 M\$/US\$
	2000	1.83	Dey et al. (2003)	The price has been derived by dividing value and quantity from a range of capture and culture species

## APPENDIX 3: CAPTURE RIVERINE (AND FLOODPLAIN) VALUES

Country	Quantity (tonnes)	Price (US\$/tonne)	Value (US\$ '000)	Comments
Bangladesh	561 824 <sup>1</sup>	1 098 <sup>a</sup>	616 883	Value derived from river and floodplains
	124 000 <sup>2</sup>	1 098 <sup>a</sup>	136 152	Value derived from catches for all rivers
India	28 500 <sup>3</sup>	796 <sup>b</sup>	22 686	Production in rivers and canals
Sri Lanka	16 797 <sup>4</sup>	8 015 <sup>c</sup>	13 462	Approx. river production value
Cambodia	289 000 <sup>5</sup> –682 150 <sup>6</sup>	544 <sup>d</sup>	157 216 – 371 090	Est. production from the Mekong river floodplains and Tonle Sap lake
	400 000 <sup>7</sup>	750 <sup>e</sup>	300 000	Est. from Jensen (2000)
	284 000 <sup>8</sup>	510 <sup>f</sup>	145 000	Est. from Nam and Thuok (1999)
Lao PDR	17 790 <sup>9</sup> – 27 000 <sup>10</sup>	553 <sup>g</sup>	9 838 – 14 931	Reported production in Mekong river and tributaries
	182 700 <sup>6</sup>	553 <sup>g</sup>	101 033	Est. from Mekong river and floodplains
Thailand	200 000 <sup>11</sup> – 500 000 <sup>11</sup>	1 297 <sup>a</sup>	259 400 – 648 500	Est. national production from rivers, floodplains, canals, lakes, marshes Excludes reservoirs
Vietnam	136 000 <sup>11</sup> – 844 850 <sup>6</sup>	842 <sup>h</sup>	114 512 – 711 364	Est. production from rivers and floodplains
Mekong (Cambodia, Lao PDR, Thailand, Vietnam)	809 000 <sup>5</sup> – 2 642 000 <sup>6</sup>	680 <sup>i</sup>	550 120 – 179 656 0	Est. production from Mekong river and floodplains
	> 1 200 000 <sup>7</sup>	750 <sup>e</sup>	900 000 – 1 000 000	Est. from Jensen (2000)
	1 533 000 <sup>12</sup>	680 <sup>i</sup>	1 042 440	Est. from Sverdrup-Jensen (2002)
Myanmar	253 373 <sup>13</sup> – 2 900 000 <sup>11</sup>	781 <sup>j</sup>	197 884 – 702 900	Est. production in rivers, lakes, floodplains, reservoirs and lagoons
Indonesia	297 300 <sup>14</sup> – 900 000 <sup>11</sup>	514 <sup>a</sup>	152 812 – 462 600	Est. production in rivers, lakes, swamps, floodplains and reservoirs
	191 805 <sup>11</sup>	514 <sup>a</sup>	98 588	Est. river and swamp production for the main islands (Kalimantan, Java, Sumatra, Maluku, Irian Jaya, Bali and Nusa Tenggara); the only island not included is Sulawesi due to lack of data
Philippines	131 644 <sup>15</sup>	415 <sup>a</sup>	54 632	Est. production in lakes, reservoirs, rivers and marshes
Malaysia	3 369 <sup>9</sup> – 10 008 <sup>11</sup>	1 833 <sup>a</sup>	6 175 – 18 345	Lowest value represents reported production in lakes, reservoirs, rivers, floodplains and marshes. Highest value represents est. production for same areas.

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**Origin of data used**


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Quantity (Appendix 1)	Price (Appendix 2)
<sup>1</sup> DOF (1998)	<sup>a</sup> Dey et al. (2004)
<sup>2</sup> De Graaf and Chinh (2002)	<sup>b</sup> Peters and Feustel (1997)
<sup>3</sup> Sugunan (1997)	<sup>c</sup> Average from Renwick (2001) and Dey et al. (2004)
<sup>4</sup> Nissanka et al. 2000; FAO Fish-Stat FAO (2005) and De Silva (1988)	<sup>d</sup> Average from Nam and Thuok (1999) and Norman-Lopez (2004)
<sup>5</sup> Baran (2005)	<sup>e</sup> Jensen (2000)
<sup>6</sup> Van Zalinge et al. (2003)	<sup>f</sup> Nam and Thuok (1999)
<sup>7</sup> Jensen (2000)	<sup>g</sup> Singhanouvong and Phouthavong (2002)
<sup>8</sup> Nam and Thuok (1999)	<sup>h</sup> Average from Dey et al. (2004) and Mai et al (2003)
<sup>9</sup> ASEAN (2005)	<sup>i</sup> Sverdrup-Jensen (2002)
<sup>10</sup> Van Zalinge et al. (2000)	<sup>j</sup> Average from Coates (2002)
<sup>11</sup> Coates (2002)	
<sup>12</sup> Sverdrup-Jensen (2002)	
<sup>13</sup> FAO (2003)	
<sup>14</sup> BPS Statistics Indonesia (2000)	
<sup>15</sup> Bureau of Fisheries and Aquatic Resources (2004)	

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## APPENDIX 4

## BANGLADESH

### General information<sup>▲</sup>

Surface area:	143 998 km <sup>2</sup>
Population (1995):	118 000 000
GDP (1996/97):	US\$ 14 000 million
Agricultural GDP (1996/97):	US\$ 4 508 million
Capture fisheries as percentage of GDP <sup>1</sup> :	1.88%
Aquaculture as percentage of GDP <sup>1</sup> :	2.69%
Indicative exchange rate (1999) US\$ 1 = Tk 48.5	

<sup>▲</sup> FAO. World fisheries statistics (1999)

<sup>1</sup> Asia-Pacific Fishery Commission (2005)

### Main rivers<sup>∞</sup>

Total area rivers and estuaries:	4 047 316 ha
Total length of 700 rivers:	22 155 km

### The Padma-Ganges and its distribution system

Annual catch <sup>3</sup> :	6 489 tonnes (1996-97) (capture)
i) Ganges, Padma:	305 km
Surface area <sup>2</sup> :	69 481 ha
Annual catch <sup>2</sup> :	1 641 tonnes (1991-92)
	50.6 kg/ha (1991-92)
	0.34% contribution to production (1991-92)
ii) Mathabhanga:	128 km
iii) Ichhamati:	285 km
iv) Bhairab:	559 km
v) Kumar:	443 km
vi) Kobadak:	280 km
vii) Chitra:	188 km
viii) Nabaganga:	210 km
ix) Garai, Madhumati:	314 km
x) Arial Khan:	266 km

### The Meghna and Surma system

Surface area <sup>2</sup> :	73 999 ha
Annual catch <sup>2</sup> :	84 737 tonnes (1989-90)
	54 244 tonnes (1991-92)
	1 369.60 kg/ ha (1991-92)
	11.3% contribution to production (1991-92)
i) Surma:	350 km
ii) Kushiya:	110 km

### The Jamuna-Brahmaputra system

Surface area <sup>2</sup> :	73 666 ha
Annual catch:	2 280 tonnes (1989-90)
i) Brahmaputra:	350 km
Annual catch:	505 tonnes (1989-90)
	391 tonnes <sup>2</sup> (1991-92)
	0.081% contribution to production <sup>2</sup> (1991-92)
ii) Jamuna:	531 km
Annual catch:	1 775 tonnes (1989-90)
	2 253 tonnes <sup>2</sup> (1991-92)
	30.58 kg/ ha <sup>2</sup> (1991-92)
	0.46% contribution to production <sup>2</sup> (1991-92)

### Other rivers in Western region

i)	Nagar:	238 km
ii)	Tangan:	119 km
iii)	Purnabhaha:	133 km
iv)	Mahananda:	90 km
v)	Baral:	20 km
vi)	Karatoya Atrai, Hurasagar Gum, Gumani:	841 km
vii)	Dharla:	62 km

### Rivers in Chittagong region

i)	Karnaphuli:	180 km
ii)	Sangu:	287 km
iii)	Matamuhari:	161 km

<sup>1</sup> Bangladesh Bureau of Statistics (1994)

<sup>2</sup> FAO (1994) 2: Productivity and Exploitation of Inland Open Water Fisheries

<sup>3</sup> Payne et al. (2003) A Review of the Ganges Basin: Its Fish and Fisheries

### Inland fisheries \*

Inland fisheries surface area <sup>1</sup> :	4 047 316 ha
Inland fishers <sup>2</sup> :	768 632 fishermen (1988-89)
Inland catches as percentage of total catches:	90% (1960s)
	77.9 % (1995-96)
	total production 1 264 435 t
	total inland production 985 265 t

Year 1995-96	Inland open water (capture) <sup>2</sup>					Inland close water (culture)		
Inland water	River and estuaries	Sundarban	Depression (beels & haors)	Kaptai Lake	Flood Land	Ponds	Oxbow lake (baors)	Shrimp farms
<b>Production (tonnes)</b>	146 744	7 857	63 014	7 449	370 105	310 130	3 018	76 948

\* Liaquat and Zahirul (1997) An Assessment of the Economic Benefits from Stocking Seasonal Floodplains in Bangladesh.

<sup>1</sup> FAO (1994) Productivity, Exploitation and Fishing Technology of Inland Open-Water Fisheries, Bangladesh

<sup>2</sup> Bangladesh Bureau of Statistics (1994)

### Fisheries data \*

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				Kg/year
Fish for direct human consumption	1 170	0.3	38	1 128	9.5
Fish for animal feed & other purposes	5	-	-	-	

### Estimated employment (2002)

(i) Primary sector (including aquaculture):

Full-time fishers: 570 000

Part-time: 1 196 000

(ii) Secondary sector: NA

Gross value of fisheries output (1997):  
(at ex-vessel prices, estimate) US\$ 1 000 million (=3.12% of GDP)

Trade (1994-95)

Value of fisheries imports (estimate): US\$ 590 000 (Average 1994-95)

Value of fisheries exports: US\$ 325.11 million (9.38% of total export)

## Inland fisheries ♦

Development and the growing population in Bangladesh have had a strong impact on its inland fisheries. The development of flood control schemes and changes in patterns of land use have often led to siltation. This has caused a reduction in water flows and fish being cut off from vital access routes to feeding and reproduction grounds. Another factor contributing to the deterioration of the aquatic environment is the accumulation of industrial pollution resulting from the increased use of pesticides and fertilizers in agriculture. Furthermore, the growing population has increased fishing pressure. This is seriously affecting the abundance of some species such as valuable migratory carps and may also be impacting the availability of more resilient floodplain fish.

Increasing fishing pressure has led to greater competition for access to inland fisheries resources, frequently resulting in confrontation and violence. This illustrates the importance of the resource and the pressure to which it is subjected.

Furthermore, leases to formally harvest the resource have increased in value following the rise in demand. The increased value of access arrangements has contributed to government revenue but at the same time encouraged leaseholders to further exhaust the resource. This situation has had greatest impact on those fishers that traditionally used to harvest the resource for subsistence.

The Government of Bangladesh is addressing these issues through a strategy that includes: (i) protecting aquatic resources; (ii) shifting priority to sustainable production rather than revenue generation; (iii) involving resource users in the management of the resource; (iv) rehabilitation of degraded habitats through a program of floodplain stocking and fish pass construction. Also, the introduction of gear-based licensing schemes has been seen to facilitate a more equitable distribution of benefits between users in some fisheries.

♦ FAO. World fisheries statistics (2005)

## CAMBODIA

### General Information <sup>▲</sup>

Surface area:	181 040 km <sup>2</sup>
Water area:	4 520 km <sup>2</sup>
Population (2004):	Est. 13 363 421
Population growth (2004):	1.8%
GDP at purchaser's value (2003):	US\$ 25.02 billion
Agricultural, fisheries and forestry percentage of GDP (2002):	8.6%
Fisheries GDP (2003):	US\$ 442 million (12%)
Capture fisheries as % of GDP <sup>1</sup> :	10.03%
Aquaculture as % of GDP <sup>1</sup> :	0.89%

<sup>▲</sup> FAO. World fisheries statistics (2005)

<sup>1</sup> Asia-Pacific Fishery Commission (2005)

### Main rivers

Mekong River (originates in China and passes through Myanmar, Laos, Thailand, Cambodia and Vietnam)

Total length:	4 225 km
Length (in Cambodia):	500 km
Total annual catch <sup>1</sup> :	279 000-441 000 tonnes (1999) (excludes aquaculture)

The Mekong River in Cambodia flows into 4 main branches:

- Great Lake	
Surface area:	
Dry season:	2 000-3 000 km <sup>2</sup>
Wet season:	10 000-12 000 km <sup>2</sup>
Annual catch <sup>2</sup> :	235 000 tonnes (1995-96)
- Tonle Sap River	
- Lower Cambodian Mekong River	
Length:	90 km
- Bassac River	
Length:	100 km

<sup>1</sup> Van Zalinge and Thuok (1999) Summary of Project Findings: Present Status of Cambodia's Freshwater Capture Fisheries and Management Implications

<sup>2</sup> Sverdrup-Jensen (2002). Fisheries in the Lower Mekong Basin: Status and Perspectives

### Inland fisheries <sup>\*</sup>

Inland fisheries include rivers, lakes, ponds, floodplains, ricefields and swamps. The types of land and water resources in Cambodia are presented below.

#### Areas of various types of land and water resources that support Cambodia's freshwater capture fisheries <sup>1</sup>

Types of land and water resources in Cambodia	Areas (ha) 1992-93
Permanent water (river, lake, ponds, etc.)	411 100
Flooded forests	370 700
Flooded secondary forests	259 800
Flooded grassland	84 900
Receding and floating ricefields	29 300
Seasonally flooded crop fields	529 900
Swamp	1 400
Total	1 687 000

Inland catches as % of total catches: 89.6% (1999)

Inland fisheries production by different scale of fisheries

Rice-field production:	45 000-110 000 tonnes
Small-scale fisheries:	115 000-140 000 tonnes
Middle-scale fisheries:	85 000-100 000 tonnes
Large-scale fisheries:	34,000-91 000 tonnes
Total	279 000-441 000 tonnes

\* Van Zalinge and Thuok (1999) Summary of Project Findings: Present Status of Cambodia's Freshwater Capture Fisheries and Management Implications

<sup>1</sup> Ahmed et al. (1996) Sustaining the gift of the Mekong: the future of the freshwater capture fisheries of Cambodia

## Fisheries data <sup>†</sup>

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				Kg/year
Fish for direct human consumption	412.7	1.6	31.6	382.7	28.4
Fish for animal feed & other purposes	-	-	-	-	-

Estimated employment (2002)

(i) Primary sector (including aquaculture):

812 500

(ii) Secondary sector:

> 2 000 000

Trade (2003)

Value of fisheries imports:

US\$ 5.4 million

Value of fisheries exports:

US\$ 34.5 million

## Inland fisheries <sup>†</sup>

Cambodia's inland fisheries are some of the richest in the Mekong, and the world. This is due to the Mekong's natural flood regime and its ecological diversity. The Cambodian section of the Mekong River flows into four main branches, the Great Lake, the Tonle Sap River, the Lower Cambodian Mekong River and the Bassac River. The direction of flow in the Tonle Sap River changes twice a year. In the rainy season, water flows back towards the Great Lake and vice versa during the dry season. This allows the annual inundation of large floodplains around the Great Lake and northeast and south of Phnom Penh, where important fish habitats such as flooded forests are found leading to rich fish productivity.

According to the fisheries Fiat Law from 1987; the inland capture fishery is divided

into three categories: small-scale fisheries, medium-scale fisheries and large-scale fisheries or fishing lots.

Small-scale fisheries are open-access non-licensed with certain restrictions on gear size and use. These fishers are allowed to fish anywhere at anytime, except within fishing lots during open seasons and in protected areas. This scale of fisheries is intended for "subsistence" but this term is open to interpretation as to whether it refers only to fishing for food or fishing to derive a small income from the sale of the catch.

Some of the gears used in small-scale fisheries include, short gillnets, cast nets, scoop nets, shrimp scoop nets, hand-push nets, small bamboo traps, short hook lines, single hook lines, spears





## INDIA

### General information <sup>▲</sup>

Surface area:	3.3 million km <sup>2</sup>
Population (1999):	approximately 1 000 million
Population growth (2004):	1.8%
GDP (1997-98):	US\$ 319 733 million
Agricultural GDP (1997-98):	US\$ 89 479 million
Currency: rupee. Indicative exchange rate (1999) US\$ 1 = Rs 43.3	

<sup>▲</sup> FAO. World fisheries statistics (2000)

### Main rivers <sup>~</sup>

The catch from rivers does not contribute significantly to the total inland fish production in terms of volume. On the other hand, reservoirs are considered the prime resource as regards capture fisheries and extensive aquaculture.

Total riverine fisheries production	
Number of fishers:	190 000
Riverine production:	150 kg/fisher/year

### Flowing into the Bay of Bengal

#### Indus

Total length:	1 114 km
Catchment area:	312 289 km <sup>2</sup>

#### Ganges River (Starts in the Himalayas and passes through China, India, Nepal & Bangladesh)

Total length:	2 525 km.
Length (India):	2 071 km
Number riverine fishers <sup>1</sup> :	7.8 fishers/km
Potential river production <sup>2</sup> :	198.3 kg/ha/year
Actual river production <sup>2</sup> :	30 kg/ha/year
River production (1993-94) <sup>1</sup> :	49.4 mt/year (from Patna Market Centre)
Ganges River basin (Catchments area):	India 80.1%, Nepal 19.3%, and Bangladesh 0.6%)
Surface area:	1 060 000 km <sup>2</sup>
Main tributary:	Yamuna River (main tributary from the Ganges)
Tributaries:	Ramgange Gomati Ghagra Gandak Saptkosi Mahananda
Length:	1 300 km
River production:	128 – 174 tonnes/year (from Allahabad Market Centre) <sup>1</sup> (1979-80)

Brahmaputra River	
Total length:	2 580 km
Length (India):	885 km
River production:	No data available

#### Brahmaputra River Basin

Surface area:	1 000 km <sup>2</sup>
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#### Mahanadi River

Length:	857 km
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#### Sabarmati River

Length:	371 km
Catchment area:	21 674 km <sup>2</sup>

#### Mahi River

Length:	583 km
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Godavari River	Catchment area:	34 842 km <sup>2</sup>
	Length:	1 465 km
Krishna River	Catchment area:	312 812 km <sup>2</sup>
	Length:	1 401 km
Pennar	Catchment area:	258 948 km <sup>2</sup>
	Length:	597 km
Cauvery	Catchment area:	55 213 km <sup>2</sup>
	Length:	800 km
Brahmani	Catchment area:	81 155 km <sup>2</sup>
	Length:	799 km
Mahanadi	Catchment area:	39 033 km <sup>2</sup>
	Length:	851 km
	Catchment area:	141 589 km <sup>2</sup>

### Flowing into the Arabian Sea

Narmada River	Length:	1 312 km
	Catchment area:	98 796 km <sup>2</sup>
Tapti River	Length:	724 km
	Catchment area:	65 145 km <sup>2</sup>

<sup>2</sup> Sugunan (1997) India. In: Fisheries management of small water bodies in seven countries in Africa, Asian and Latin America

<sup>1</sup> Payne et al. (2003) A Review of the Ganges Basin: Its Fish and Fisheries

<sup>2</sup> Das (2002) Social and economic impacts of disease in inland open-water and culture-based fisheries in India

### Inland fisheries\*

Inland fisheries include rivers, floodplains, estuaries, mangroves, estuarine impoundments, lagoons, upland lakes, reservoirs and ponds.

#### Inland Fisheries resources of India

Resource	Size
Rivers and canals	173 287 km
Swamps and other wetlands	1 097 787 ha
Floodplain lakes	202 213 ha
Upland lakes	72 000 ha
Mangroves	356 500 ha
Estuaries	285 000 ha
Lagoons	190 500 ha
Reservoirs	3 153 366 ha
Freshwater ponds	2 254 000 ha
Brackishwater ponds	1 235 000 ha

Inland catches as percentage of total catches:

43.03% (1994-95)

52.10% (1998-1999)

total production: 4 950 000 t

total production: 6 158 000 t

Inland catches: description year 1994-95; total inland catches: 2 130 000 t

Capture fisheries	Production
Rivers & canals	28 500 t
Reservoirs	93 650 t
Other capture fisheries	507 850 t
Freshwater aquaculture	1 500 000 t

\* Sugunan (1997). India. In: Fisheries management of small water bodies in seven countries in Africa, Asia and Latin America

## Fisheries data <sup>†</sup>

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				Kg/year
Fish for direct human consumption	5 378	Nil	385	4 670	4.8
Fish for animal feed & other purposes	780	-	-	-	

Estimated employment (1997)

(i) Primary sector:

Full-time fishers: 2.40 million

Part-time: 1.45 million

Occasional: 2.11 million

**TOTAL 5.96 million**

(ii) Secondary sector: NA

Gross value of fisheries output (1997-98)  
(at ex-vessel prices, estimate): US\$ 4 845 million (=1.47% GDP)

Trade (1998-99):

Value of fisheries imports: Nil

Value of fisheries exports: US\$ 1 107 million

## Inland fisheries <sup>\*</sup>

Over the ten-year period covering 1987-1997 inland fisheries production steadily increased by 45.4%. Inland production includes catches from rivers, upland lakes, peninsular tanks, reservoirs and oxbow lakes. The major states contributing are: West Bengal (33%), Andhra Pradesh (9.09%), Bihar (8.71%), Assam (6.92%) Uttar Pradesh (6.49%), Orissa (6.01%), Tamil Nadu (4.82%), Madhya Pradesh (4.07%), Karnataka (3.89%) and Maharashtra (3.4%).

\* FAO. World fisheries statistics (2000)

## INDONESIA

### General information<sup>▲</sup>

Surface area:	1 900 000 km <sup>2</sup>
Population (2003):	214 500 000
Population growth (1998-2003):	1.3 %
GDP (2003):	US\$ 208.3 billion
Agricultural GDP (2003):	US\$ 34.6 billion (16.6 %)
Capture fisheries as % of GDP <sup>1</sup> :	2.35 %
Aquaculture as a % of GDP <sup>1</sup> :	1.66 %

<sup>▲</sup> World Bank (2003) Indonesia at a Glance

<sup>1</sup> Asia-Pacific Fishery Commission (2005)

### Main rivers

#### Five main islands

Kalimantan Island (539 460 km<sup>2</sup>)

Sungai Kapuas River (longest river in Indonesia)

Length: 1 400 km

Makakam River

Length: 920 km

Catchment area: 77 700 km<sup>2</sup>

Barito River (largest river in Indonesia, 3 km wide and 10-30 m deep in places)

Tributaries

Martapura River

Length: 600 km

Kupas River

Sumatra (473 606 km<sup>2</sup>)

Lempuing River (one of the most productive inland fisheries in Indonesia)<sup>1</sup>

Fishermen density: 3-4/km<sup>2</sup> (1997)

Fishing activity: 4 hours/day (1997)

Catch/fisherman: 2.2 – 3.3 tonnes/year (1997)

Catch/area: 72 – 118 kg/ha/yr (1997)

Siak River

Asahan River

Hari River

Musi River

Length: 2 000 km

Catchment area: 60 000 km<sup>2</sup>

Annual catches<sup>1</sup>: 22 833 kg (average river catches 1979-94)

Indragiri River

Batanghari River

Kampar River

Sulawesi (189 216 km<sup>2</sup>)

Jeneberang River

Length: 75 km

Surface area: 760 km<sup>2</sup>

Walanae River (feeds Lake Tempe)

Irian Jaya (Papua) (421 981 km<sup>2</sup>)

Mamberamo River system (largest river on the island)

Length: 1 300 km

Baliem River

Length: 400 km

Java (132 187 km<sup>2</sup>)

Bengawan Solo River basin (largest river on the island)

Length: 600 km+

Surface area: 16 100 km<sup>2</sup>

Brantas River (second largest river on the island)

Tributaries

Konto River

Widas River

Ngrowo River

Length:	320 km
Catchment area:	11 800 km <sup>2</sup>
Wawar River	
Catchment area:	780 km <sup>2</sup>
Flooded area (annual):	15 000 hectares
Tarum River	
Manuk River	
Serang River	
Catchment area:	281 km <sup>2</sup>
Serayu River	

### Main lakes

#### Kalimantan

Jempang	
Surface area:	10 875 ha
Melintang	
Surface area:	7 062.5 ha
Potential fish production:	55 kg/ha/yr
Semayang	
Surface area:	8 937 ha
Potential fish production:	54 kg/ha/yr
Luar	
Sentarum	
Siawan	

#### Sumatra

Toba (largest lake of Indonesia and largest lake in Southeast Asia)	
Surface area:	1 145 km <sup>2</sup>
Tempe (important for fisheries)	
Maninjau	
Kerinci	
Singkarak	

#### Sulawesi

Towuti	
Sidenreng	
Poso	
Tondano	
Matan	

#### Irian Jaya

Pania	
Sentani	

<sup>1</sup> Koeshendrajana and Cacho (2001) Management Options for the Inland Fisheries Resource in South Sumatra, Indonesia: I Bioeconomic Model

### Inland fisheries\*

Indonesia has a huge area of inland open water covering 55 million hectares; – natural lakes, man-made lakes, rivers and swamps.

In 1991, it was estimated that Kalimantan

and Sumatra produced 50 per cent and 30 per cent of all the open, freshwater fish production in Indonesia, respectively. It was also estimated that at this time 43 per cent of Indonesian freshwater ponds were located in Western Java.

Inland catches as a % of total catch (2000) <sup>1</sup> :	5.8 %
Brackish/freshwater aquaculture as a % of total catch (2000) <sup>1</sup> :	14.54 %
Inland fisheries production (2000):	297 300 tonnes
Brackishwater pond cultured (2000):	360 800 tonnes
Freshwater pond cultured (2000):	185 200 tonnes
Cage cultured (2000):	97 300 tonnes
Paddy field cultured (2000):	100 800 tonnes

Inland fisheries potential and actual (1998) yield per island<sup>2</sup>:

#### Potential capture inland fisheries yield per island<sup>1</sup>

Island	Area (ha)	Potential yield (T)	Actual yield (T) (1998) <sup>a</sup>
Java	96 400 ha	30 000 – 35 000	?
Sumatra	4 053 850	300 000 – 330 000	86 365
Kalimantan	9 029 000	400 000 – 450 000	118 227
Sulawesi	492 200	50 000 – 55 000	34 438
Maluku & Irian Jaya	63 300	13 000 – 20 000	2 582
Bali & Nusa Tenggara	17 500	7 000 – 10 000	?

<sup>a</sup> The author estimated the actual catches were two to three times the official figure.

\* BPS Statistics Indonesia (2000)

<sup>1</sup> Inland/aquaculture catch percentage generated using year 2000 figures from BPS Statistics Indonesia

<sup>2</sup> Coates (2002) Inland capture fishery statistics of South-East Asia: C current status and information needs

#### Fisheries data \*

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	4 066 630	19 169	715 498	3 370 301	16.3
Fish for animal feed & other purposes	329 100	197 935	95 029	432 006	

Estimate employment (1997)

(i) Primary sector: 4 600 000

(ii) Secondary sector: NA

Trade (1999)

Value of fisheries imports: US\$ 49 million

Value of fisheries exports: US\$ 1 640 million

#### Inland fisheries and aquaculture \*

In 1997 the open water fisheries are thought to have employed 154,302 vessels. The majority (approximately 93 per cent) were engineless with outboard engines being used on 85 per cent of the remaining vessels. Fish were primarily landed fresh with some being salted/dried, frozen or smoked. The fishery employed 508,626 primarily part-time (64 per cent)

fishers, 35 per cent from Sumatra, 29 per cent from Kalimantan, 25 per cent from Java and 5 per cent from Sulawesi.

Multiple gears were exploited in the open water capture fisheries and included, in order of importance; set gillnets (21 per cent), traps (16 per cent), handlines (11 per cent), guiding barriers (10 per cent) and

long lines (5 per cent). River fisheries were most important contributing slightly less than 62 per cent of open water landings. Swamps (21 per cent), lakes (12 per cent) and reservoirs (5 per cent) accounted for the remaining 38 per cent. Just under 95 per cent of the open water capture landings were finfish and originated from Kalimantan (55 per cent), Sumatra (19 per cent), Java (13 per cent) and Sulawesi (11 per cent).

Aquaculture was growing in 1997, at which point there was thought to be 2,052,725 fish farmers, primarily in Java (68 per cent). Freshwater pond aquaculture was the predominant form of culture (68 per cent) followed by paddy-field, brackishwater and then cage aquaculture.

However, brackishwater aquaculture produced the highest volumes of fish generating 307,259 tonnes and occupying 306,740.9 ha of land. The majority of brackishwater finfish production was milkfish (73 per cent), Mozambique tilapia (12 per cent) and mullets (6 per cent). The main areas of brackishwater aquaculture were Java (36 per cent), Sulawesi (31 per cent), and Sumatra (26 per cent). Pond aquaculture occupied 60,647.8 ha and generated 171,768 tonnes of fish. It primarily produced common carp (31 per cent), catfish (14 per cent), Nile tilapia (10 per cent), Mozambique tilapia (10 per cent), Java carp (9 per cent) and more. This form of culture was most prevalent in Sumatra (48 per cent), then Java (37 per cent) and Sulawesi (9 per cent).



## LAO PDR

### General information <sup>▲</sup>

Surface area:	236 725 km <sup>2</sup>
Population (1995):	5 032 000
GDP at purchaser's price (1995):	US\$ 1 500 million
Agricultural GDP (1995):	US\$ 362
Fisheries GDP (1995):	US\$ 900 million
Capture fisheries as % of GDP <sup>1</sup> :	1.43%
Aquaculture as % of GDP <sup>1</sup> :	5.78%

<sup>▲</sup> FAO. World fisheries statistics (1999)

<sup>1</sup> Asia-Pacific Fishery Commission (2005)

### Main rivers <sup>⌘</sup>

Mekong River (originates in China and passes through Myanmar, Laos, Thailand, Cambodia and Vietnam.)

Total length:	4 220 km
Length (Laos):	886 km
Surface area:	202 000 km <sup>2</sup> (97% of total country area)
Annual catch:	182 700 tonnes (2000) (capture fisheries)
(The capture fisheries figure is five times the officially reported figure.)	
	16 700 tonnes (2000) (reservoir)
	5 400 tonnes (2000) (aquaculture)

<sup>⌘</sup> Sverdrup-Jensen (2002). Fisheries in the Lower Mekong Basin: Status and Perspectives

### Inland fisheries

Inland catches as percentage of total catches: 100%

### Fisheries data <sup>▲</sup>

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				Kg/year
Fish for direct human consumption	40.0	3	0.01	42.99	8.54

Estimated employment (2002)

(i) Primary sector (including aquaculture):	200 000
(ii) Secondary sector:	25 000
Gross value of fisheries output (ex-vessel prices):	US\$ 48 million
Trade (2003)	
Value of fisheries imports:	US\$ 4 million
Value of fisheries exports:	NA

## Inland fisheries\*

Inland fisheries represent its entire fisheries production as Lao PDR is landlocked. The majority of landings come from the Mekong River and its tributaries (60%). Rice fields are another important source followed by catches from hydropower reservoirs; although productivity from the latter is usually low.

In the Mekong River and tributaries, the main fishing gears are beach seines and drifting gillnets. Other gears include long-lines and traps. Fishers commonly use flat-bottom boats similar to riverine canoes, although boats equipped with long-tail engines are becoming very popular. Most

of the catches from the Mekong River and tributaries are thought to be landed in Thailand due to higher market prices.

Rice fields mostly provide a variety of small species with a short life span and rapid growth. Some of the species include crabs, shrimps, fish, snails, frogs, and insects. All these aquatic species are consumed entirely within Lao PDR. It is thought the fisheries statistics data could be under accounting for total household consumption of aquatic species as the data collection may be concentrating on fish.

\* FAO. World fisheries statistics (2002)

## MALAYSIA

### General information<sup>▲</sup>

Surface area:	329 758 km <sup>2</sup>
Population (2003):	24 800 000
Population growth (1998-2003):	2.2 %
GDP (2003):	US\$ 103.7 billion
Agricultural GDP (2003):	US\$ 10.0 billion (9.7 %)
Capture fisheries as % of GDP <sup>1</sup> :	1.13 %
Aquaculture as a % of GDP <sup>1</sup> :	0.37 %

<sup>▲</sup> World Bank (2003): Malaysia at a Glance

<sup>1</sup> Asia-Pacific Fishery Commission (2005)

Malaysia consists of the Malay Peninsular, West Malaysia, (154,680 km<sup>2</sup>) and the northwestern part of Borneo Island, East Malaysia, (202,020 km<sup>2</sup>)

### Main rivers<sup>≈</sup>

#### East Malaysia

Rajang River	
Length:	565 km
Est. productivity:	100 kg/ha/yr
Kinabatangan River	
Length:	565 km
Catchment:	+17 000 km <sup>2</sup>
Batak Lupar	
Length:	228 km
Baram River	
Length:	402 km
Est. productivity:	142-169 kg/ha/yr
Limbang River	
Length:	196 km
Sarawak	
Length:	115 km

#### West Malaysia

Pahang River system	
Length:	459 km
Annual catch (2000-02 average) <sup>2</sup> :	131 tonnes
Kelantan River	
Length:	400 km
Perak River	
Length:	522 km
Est. productivity:	11.64 kg/ha/yr
Gombak River	
Length:	
Est. productivity:	180 kg/ha/yr
Klang River	
Length:	120 km
Catchment:	1 200 km <sup>2</sup>
Langat River	
Length:	160 km
Catchment:	1 240 km <sup>2</sup>

## Main lakes

### West Malaysia

Lake Kenyir (largest reservoir in Malaysia and sustaining a small-scale commercial fishery)

Area:	360 km <sup>2</sup>
Mean depth:	37 m
Annual catch <sup>1</sup> :	720 tonnes

Lake Temengor

Area:	152 km <sup>2</sup>
Est. annual catch <sup>2</sup> :	100 tonnes

Lake Bera (largest natural lake)

Area:	61.5 km <sup>2</sup>
Annual catch:	No data available

Bukit Merah

Storage:	75 million m <sup>3</sup>
Annual catch:	100 tonnes

Chenderoh (oldest reservoir in Malaysia)

Annual catch (late 80s):	2.57 tonnes
Value of landings:	63 179 RM (US\$ 24 300)

<sup>2</sup> Jackson & Marmulla (2001)

<sup>1</sup> This figure has been synthesized and is based on a yield figure of 20 kg/ha/year derived by Yusoff et al. (1995)

<sup>2</sup> Khoo et al. (2003)

### Inland fisheries\*

Freshwater fish catch (2000):	22 636 tonnes
Freshwater aquaculture production (1997):	20 303 tonnes

\* Earthtrends Water Resources and Freshwater Ecosystems (2003) Malaysia

### Fisheries data ♦

	Production	Imports	Exports	Total supply	Per capita supply
	'000 (tonnes (live weight))				kg/yr
Fish for direct human consumption	1 252	343	94	1 003	45.9
Fish for animal feed & other purposes	210	47	58	221	-

♦ FAO. World fisheries statistics (2000)

Estimate employment (1997)

(i) Primary sector (excluding FW fisheries sector): 79 000

(ii) Secondary sector: NA

Trade (1999)

Value of fisheries imports: US\$ 258.7 million

Value of fisheries exports: US\$ 181.2 million

## Inland fisheries <sup>♦</sup>

Cyprinids and silurids are the species dominating the inland capture fisheries within Malaysia's major rivers (Khoo et al. 1987). Nevertheless, Malaysia has no large river systems compared to other countries. Man-made lakes dominate the Malaysian lentic environment. The estimated surface area of these lakes is 1 000 km<sup>2</sup>. Furthermore, there are several large reservoirs that have been developed for inland fisheries. In particular, the Perak and Terengganu dams located in Peninsular Malaysia have been successfully converted for recreational fisheries.

<sup>♦</sup> FAO. World fisheries statistics (2003b)  
<sup>1</sup> Khoo et al. (1987)

## MYANMAR (BURMA)

### General information <sup>▲</sup>

Surface area:	676 577 km <sup>2</sup>
Population (2001-02):	47 114 million
GDP at purchaser's price (1999-2000):	2 190 301 million kyat
Agricultural GDP:	29 151 million kyat
Aquaculture as % of GDP <sup>1</sup> :	0.17%

- <sup>▲</sup> FAO. World fisheries statistics (2001)  
<sup>1</sup> Asia-Pacific Fishery commission (2005)

### Main rivers<sup>⊕</sup>

The Mekong River system and the Irrawaddy system have great similarities in terms of their fisheries. Therefore, the fisheries of Myanmar and Cambodia are usually compared. Even though the Mekong River runs along Myanmar, it only covers a very small area of the country.

Total aquatic resource area of the river systems<sup>1</sup>: 8.2 million ha

### Irrawaddy system

Ayeyarwaddy River (or Irrawaddy River)

Length:	2 150 km
Catchment:	424 000 km <sup>2</sup>
Annual catch <sup>2</sup> :	No data available

Chindwin River (tributary of the Ayeyarwaddy River)

Length:	844 km
Annual catch <sup>2</sup> :	No data available

Sittaung River

Length:	563 km
Annual catch <sup>2</sup> :	No data available

Salween (Thanlwin) River

Length:	2 400 km
Annual catch <sup>2</sup> :	No data available

- \*\* FAO (2003) Myanmar Aquaculture and Inland Fisheries  
<sup>1</sup> Coates (2002) Inland capture fishery statistics of Southeast Asia: Current status and information needs  
<sup>2</sup> No data available for specific permanent water bodies and seasonal floodplains

### Inland fisheries<sup>★</sup>

Inland fisheries production comes mainly from floodplains, the water surface of which covers six million hectares during 4-5 months of the year<sup>1</sup>.

Inland catches as percentage of total catches: 25%  
 (Total fisheries production 1 300 648 tonnes (2000-01))

Degree of exploitation:

Inland freshwater fishers <sup>2</sup> :	1 398 410 fishers
Inland capture fishery potential <sup>3</sup> :	600 000-900 000 tonnes
Inland capture fisheries (2000-01) <sup>4</sup> :	253 373 tonnes
Inland culture fisheries (2000-01) <sup>4</sup> :	109 188 tonnes
Inland prawn farming (2000-01) <sup>4</sup> :	6 603 tonnes

- <sup>★</sup> FAO (2003) Myanmar Aquaculture and Inland Fisheries  
<sup>1</sup> Moo (2002) Inland Fisheries of the Union of Myanmar  
<sup>2</sup> Coates (2002) Inland capture fishery statistics of Southeast Asia: Current status and information needs  
<sup>3</sup> Estimate based on revised valuation of the Mekong River system capture fishery potential  
<sup>4</sup> Including lakes, rivers, floodplains, reservoirs and lagoons

## Fisheries data ♦

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				Kg/year
Fish for direct human consumption	793.9	1	97.2	723.2	15.4
Fish for animal feed & other purposes	151.9	0.565	-	-	

Estimated employment (2002)

(i) Primary sector (including aquaculture): 540 845 persons employed (full-time)

(ii) Secondary sector: 3 082 persons

Gross value of fisheries output (at ex-vessel prices 1999-2000): 106 763 million kyats

Trade (2003)

Value of fisheries imports: -

Value of fisheries exports: US\$ 158.56 million

♦ FAO. World fisheries statistics (2001) locally

## Inland fisheries ♦

Permanent freshwater bodies include rivers and estuaries as well as two major lakes (the Inlay and Inndawgyi), which cover about 1.3 million hectares; and over one hundred major man-made reservoirs covering approximately 1.2 per cent of Myanmar's total annual water resources. There are three types of capture inland fishery: floodplain, leasable and open water.

The floodplain fishery is a seasonal fishery that takes place at the end of the monsoon when the waters recede from the Delta. During this time, fish either become trapped within water pockets of small lakes and ponds or they follow the receding floodwaters into rivers and their tributaries. To follow fish species following the decreasing waters, fishers use bamboo screens and fixed traps at suitable points. This type of fishing method is known as the Myanmar Inn and it is very profitable. As a result, it is considered to

be the most important (inland) fishing method. In 2000-01, the production using this technique was 90,948.44 tonnes.

The leasable fishery is also seasonal. It is practiced in streams and various forms of water catchment areas. Fishing operators obtain temporary lease agreements to operate within these areas. In 2000-01, 3,481 leases were given out of the 3,721 designated leasable areas.

The open water fishery occurs in permanent freshwater bodies such as streams, rivers and lakes. The species caught are highly demanded fish including air-breathers, snakeheads, climbing perches, and feather backs. Private fishers and cooperatives require licenses to operate this fishery. Of the total inland catches within this fishery, 96 per cent are accounted by private fishers. The rest is accounted by the cooperative sector.

♦ FAO. World fisheries statistics (2000)

## PHILIPPINES

### General information<sup>▲</sup>

Surface area:	300 000 km <sup>2</sup>
Total number of islands:	7 107 islands
Population (1998):	73 130 000
GDP (1998) current prices:	US\$ 65 100 million
Agricultural GVA (1998) (current prices):	US\$ 11 000 million
Based on an exchange rate of:	US\$ 1 = peso 40.89 (1998)

<sup>▲</sup> FAO. World fisheries statistics (2000)

### Main rivers, lakes and swamps/marshes<sup>≈</sup>

Total number of islands:	7 107 islands
Largest island:	Luzon
Surface area:	104 688 km <sup>2</sup>

#### Main rivers

Abra River basin (Northwestern Luzon)	
Surface area:	5 125 ha
Cagayan River basin (Northern Luzon)	
Length:	190 km
Surface area:	25 649 ha
Agno River basin (West Central Luzon)	
Surface area:	13 800 ha
Pampanga River basin (Central Luzon)	
Surface area:	9 759 ha
Pasig-Laguna River (Southern Luzon)	
Length:	25 km
Surface area:	4 678 ha

#### Main lakes

Laguna de Bay O	
Surface area:	90 000 ha
Annual catch <sup>1</sup> :	20 400 tonnes (1979-80)
Taal O	
Surface area:	24 356.40 ha
Annual catch <sup>1</sup> :	11 800 tonnes (1984)

#### Main swamps/marshes

Candaba Swamp, Bulacan and Pampanga provinces	
Surface area:	32 000 ha
Second largest island:	Mindanao
Surface area:	94 630 km <sup>2</sup>

#### Main rivers

Mindanao River (Central Mindanao)	
Length:	320 km
Surface area:	23 169 ha
Agusan River (East Mindanao)	
Length:	390 km
Surface area:	10 921 ha

#### Main Lakes

Mainit O	
Surface area:	17 430.20 ha
Annual catch <sup>1</sup> :	13 000 tonnes (1980-84)
Lanao O	
Surface area:	34 700 ha
Annual catch <sup>1</sup> :	10 000 tonnes (1984)



## Main swamps/marshes

Agusan Marsh (in Agusan River basin)	
Surface area:	90 000 ha
Liguasan Marsh (in Mindanao River basin)	
Surface area:	220 000 ha

- <sup>2</sup> Bureau of Fisheries and Aquatic Resources (2004). Current information on inland capture fisheries in the Philippines
- <sup>1</sup> De la Cruz (1997). Social, Economic and Cultural Aspects in Implementing Inland Fishery Enhancements in the Philippines

## Inland fisheries\*

The Philippine inland resources consist of lakes, rivers, reservoirs, swamps, marshes, and small water impoundments. Lakes and reservoirs are the most important environments for inland fisheries with the total surface area of 219,000 hectares<sup>1</sup>.

Inland catches as percentage of total catches<sup>2</sup>:

Year 1992: 8.75% (inland fisheries: 229 673 t; total: 2 625 607 t)

Year 2002: 3.95% (inland fisheries 131,644 t; total: 3 329 118 t)

(indicating decline in inland fisheries production over time)

## Inland fishery resource area in the Philippines<sup>1</sup>

Environment	Surface area (ha)
<i>Swamplands</i>	246 063
Freshwater	106 328
Brackishwater	139 735
<i>Existing fishponds</i>	253 854
Freshwater	14 531
Brackishwater	239 323
<i>Other inland resources</i>	250 000
Lakes	200 000
Rivers	31 000
Reservoirs	19 000

- \* Bureau of Fisheries and Aquatic Resources (2004). Current information on inland capture fisheries in the Philippines

<sup>1</sup> Coates (2002). Inland capture fishery statistics of Southeast Asia: Current status and information needs

<sup>2</sup> Inland production includes lakes, rivers, reservoirs and marshes

## Fisheries Data \*

	Production <sup>1</sup>	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				Kg/year
Fish for direct human consumption	1 950.8	121.7	180.5	1 92.0	25.9
Fish for animal feed & other purposes	193.7	87.8 <sup>b</sup>	43.2	238.3	-

Notes: <sup>1</sup> Excluding 642 319 t of seaweed (wet weight)

<sup>2</sup> Including 42 989 t of fish meal (>> 85 978 t live weight)

## Estimated employment (2002)

(i) Primary sector (including aquaculture):	Approximately 1 million persons of which 57,000 were employed on large vessels, 259,000 in fish culture activities, and the remainder in municipal fisheries
(ii) Secondary sector:	Approximately 35,000 persons operating shore facilities and involved in fish drying and other post-harvest activities
Gross value of fisheries output: (at ex-vessel prices, 1998)	US\$ 1.8 billion
Trade (1998)	
Value of fisheries imports:	US\$ 83.3 million
Value of fisheries exports:	US\$ 530 million

**Inland fisheries** ♦

Total inland water production has declined steadily over time, from 237,000 tonnes in 1990 to 146,471 tonnes in 1998. The decline is attributed to widespread overfishing; pollution and siltation from the discharge of urban and industrial effluents; as well as the use of the resource for activities conflicting with inland fisheries (e.g., the extensive development of fish pens).

♦ FAO. World fisheries statistics (2004)

## SRI LANKA

### General information <sup>▲</sup>

Surface area:	65 610 km <sup>2</sup>
Population (2004):	19 400 000
Population growth (1998-04):	1.3%
GDP (2004):	US\$ 18.2 billion
Agricultural GDP (2004):	US\$ 3.24 billion (17.8%)
Capture fisheries as % of GDP <sup>1</sup> :	1.428 %
Aquaculture as a % of GDP <sup>1</sup> :	0.468 %

<sup>▲</sup> World Bank (2004). Sri Lanka at a Glance

<sup>1</sup> Asia-Pacific Commission (2005)

### Main rivers <sup>≈</sup>

There are 103 distinct river basins covering over 4,500 km in length. The four main rivers all originate in the central hills and pass through the lower plains to the sea; they include the following:

Mahaweli		
	Length:	335 km
	Catchment area:	2 442 km <sup>2</sup>
Kelani		
	Length:	145 km
	Catchment area:	2 292 km <sup>2</sup>
Kalu		
	Length:	129 km
	Catchment area:	2 719 km <sup>2</sup>
Walawe		
	Length:	138 km
	Catchment area:	2 471 km <sup>2</sup>

<sup>≈</sup> Ministry of Irrigation and Water Management of Sri Lanka (2002)

### Perennial reservoirs<sup>\*</sup>

The inland capture fishery of Sri Lanka is confined to its perennial reservoirs (1,550 km<sup>2</sup> in total)<sup>1</sup>.

The culture fishery tends to be confined to the seasonal tanks (1,000 km<sup>2</sup>)<sup>1</sup>.

### Main reservoirs:

Senanayake Samudra (largest reservoir)		
	Area:	76.8 km <sup>2</sup>
	Catchment area:	983 km <sup>2</sup>
Maduru Oya		
	Area:	63.9 km <sup>2</sup>
	Catchment area:	433 km <sup>2</sup>
Moragahakanda		
	Area:	40.5 km <sup>2</sup>
	Catchment area:	782 km <sup>2</sup>
Udawalawe Reservoir		
	Area:	34.2 km <sup>2</sup>
Lunugamwehera		
	Area:	30.2 km <sup>2</sup>
	Catchment area:	904 km <sup>2</sup>
Randenigala		
	Area:	23.5 km <sup>2</sup>
	Catchment area:	2 333 km <sup>2</sup>

The overwhelming majority of the reservoirs in the country can be classified as small waterbodies<sup>2</sup>.

### Estimated surface area of inland lentic waterbodies in Sri Lanka including the recently constructed Manhaweli reservoirs<sup>2</sup>

Type	Number	Area (ha)
Major irrigation reservoirs (ancient)	73	70 850
Medium scale reservoirs (ancient)	160	17 004
Minor irrigation reservoirs (ancient)	10 000	39 271
Floodplain lakes	-	4 049
Upland hydroelectric reservoirs (recent)	7	8 097
Mahaweli reservoirs	5	22 000
Maduru Oya	-	6 280
Victoria	-	2 270
Kotmale	-	970
Randengala	-	2 750
Ulhiyia-Ratkinda	-	2 270
Total	10 245	175 811

\* Individual reservoir details from De Silva (1988)

<sup>1</sup> Ministry of Fisheries and Aquatic Resources (2005)

<sup>2</sup> Sugunan (1997). Fisheries management of small water bodies in seven countries in Africa, Asia and Latin America

### Inland fisheries\*

It is reported that while the floodplains are a productive ecosystem in Sri Lanka, there is no riverine fishery worth mentioning. The main share of inland production is from the reservoirs<sup>1</sup>. Most of the large reservoirs are constructed storages for hydroelectric power generation, and the medium ones are ancient (for capture fisheries). Small reservoirs and seasonal tanks are for culture fisheries.

Inland catches as a percentage of total catch (2003) <sup>2</sup> :	10.6 %
Freshwater aquaculture as a percentage of total catch <sup>3</sup> :	3 %
Inland fisheries production, including aquaculture (2003) <sup>4</sup> :	30 280 tonnes

\* Individual reservoir details from De Silva (1988)

<sup>1</sup> Sugunan (1997). Fisheries management of small water bodies in seven countries in Africa, Asia and Latin America

<sup>2</sup> Inland catch percentage generated from 2003 figures obtained from the Ministry of Fisheries and Aquatic Resources

<sup>3</sup> Freshwater aquaculture percentage from ICLARM The WorldFish Center (2002)

<sup>4</sup> Catch figures from Ministry of Fisheries and Aquatic Resources (2005)

### Fisheries data \*

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	286 370	67 284	13 680	339 974	17.4
Fish for animal feed & other purposes	-	N/A	-	-	-

\* FAO. World fisheries statistics (2000)

Estimate employment (2004)	
(i) Primary sector:	250 000
(ii) Secondary sector:	100 000
Trade (2004)	
Value of fisheries imports:	US\$ 59 million
Value of fisheries exports:	US\$ 94 million

### **Inland fisheries and aquaculture ♦**

Inland fisheries experienced steady growth, from 23,000 tonnes in 1995 to 30,280 tonnes in 2003 (including aquaculture). This growth is attributed to a development program that has stocked waterbodies with fingerlings; raised fish in ponds, cages and pens; and provided subsidies to fishers to purchase canoes and fishing gear. Furthermore,

the Aquaculture Development Division of the Ministry of Fisheries and Aquatic Resources Development are providing support to rehabilitate two fish breeding stations at Dambulla and Udawalave. These institutions are also encouraging farmers, fishers and NGOs to increase fish feed production.

♦ FAO. World fisheries statistics (2004)

## THAILAND

### General information <sup>▲</sup>

Surface area:	514 000 km <sup>2</sup>
Population (2004):	62 400 000
Population growth (1998-2004):	0.7%
GDP (2004):	US\$ 163.5 billion
Agricultural GDP (1996):	US\$ 12 695.8 million
Capture fisheries as % of GDP <sup>1</sup> :	2.04%
Aquaculture as % of GDP <sup>1</sup> :	2.07%

<sup>▲</sup> FAO. World fisheries statistics (2000)

<sup>1</sup> Asia-Pacific Fishery Commission (2005)

### Main rivers

Thailand has 47 major rivers

Estimated total riverine production<sup>1</sup>: 200 000 – 500 000 tonnes/year

Mekong River (originating in China and passing through Myanmar, Laos, Thailand, Cambodia and Vietnam)

Total length:	4 225 km
Length along the Thai-Laos border:	850 km (approx.)
Total annual catches <sup>2</sup> :	875 000 tonnes (2000) (capture fisheries)
	68 100 tonnes (2000) (aquaculture)
	187 500 tonnes (2000) (reservoirs)

#### Tributary

Mun River	
Length:	673 km
Pak River	
Songkhram River (the only river without a main stream dam)	

Salween (Originating in the Tibetan plateau, it flows southward through China, down through the East of Myanmar along the Thai-Myanmar border, before continuing through Myanmar and emptying into the Andaman Sea. It is the last free-flowing international river in Asia)

Total length:	2 800 km
Total length along the Thai- Myanmar border:	120 km
Total floodplain:	320 000 km <sup>2</sup>
Floodplain within Thailand:	16 000 km <sup>2</sup> (5%)

Chao Phraya (Forming in Pak Nam Pho from four upstream tributaries, the river connects with three tributaries, Sakaekrung and Tachin from the southwest and Pasak from the northeastern Petchabun Range, before running off into the Gulf of Thailand.)

Length:	230 km
Floodplain:	21 521 km <sup>2</sup>
	(overall Chao Phraya system: 160 000 km <sup>2</sup> )

#### Tributaries

Ping (major tributary)	
Length:	480 km
Catchment area:	35 535 km <sup>2</sup>
Yom	
Catchment area:	19 516 km <sup>2</sup>
Nan	
Length:	800 km
Catchment area:	32 854 km <sup>2</sup>
Wang	
Floodplain:	11 084 km <sup>2</sup>

Tapi River (longest river of southern Thailand)		
Length:		230 km
Catchment:		5 460 km <sup>2</sup>
Kwai Noi River		
Mae Klong River		
Kwae Yai River		
Songkhram River		
Production:		91 kg/ha
Pa Sak River		
Length:		513 km
Catchment area:		18 000 km <sup>2</sup>

Sources:

<sup>1</sup> Coates (2002) Inland capture fishery statistics of Southeast Asia: Current status and information needs

<sup>2</sup> Sverdrup-Jensen (2002). Fisheries in the Lower Mekong Basin: Status and Perspectives

## Inland fisheries

The inland fishery in Thailand is primarily provided for inland capture fisheries concerned with reservoir fisheries represents mainly reservoir fisheries production. Therefore, the national figure production<sup>1</sup>.

### Inland fishery resources of Thailand

Inland fishery resources of Thailand <sup>2</sup>		
Resource	Number	Area (ha)
		(ha)
Rivers and canals	47	120 000
Natural lakes and swamps	8 000	300 000
Large reservoirs	21	292 590
Medium and small reservoirs	1 745	425 500
Village ponds	4 947	25 676
Brackishwater lakes	1	96 000
Other public waters	10 859	143 000
<b>Total</b>		<b>1 285 420</b>

## Inland catches

Inland capture fisheries as a percentage of the total catch<sup>3</sup>:

48.2%(2000)<sup>3</sup>

Total production: 477 552 tonnes

Inland capture: 205 500 tonnes

Reservoir (estimate): 122 314 – 318 909 tonnes<sup>1</sup>

38.5% (2002)

Total production: 533 393 tonnes

Inland capture: 206 350 tonnes

<sup>1</sup> Coates (2002). Inland capture fishery statistics of Southeast Asia: Current status and information needs

<sup>2</sup> Sugunan (1997). Fisheries management of small water bodies in seven countries in Africa, Asian and Latin America

<sup>3</sup> FAO – Fish-Stat Plus Database (2005)

## Fisheries data <sup>♦</sup>

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				kg/yr
Fish for direct human consumption	2 420	735	1 732	1 423	23.6
Fish for animal feed & other purposes	1 050	59	126	983	-

Estimate employment (1997)

(i) Primary sector: 530 401

(ii) Secondary sector: 196 105

Trade (1999)

Value of fisheries imports: US\$ 840.7 million

Value of fisheries exports: US\$ 4.1 billion

## Inland fisheries <sup>♦</sup>

Inland fisheries are harvested as an open access resource. Production has decreased slowly in the last few years due to habitat degradation and increased pollution from industrial wastes.

Nevertheless, rehabilitation efforts and fish re-stocking programs are aiming to increase freshwater fish resources in public waters.

The most commonly used fishing gears are gill nets, long lines, hook-and-lines, scoop nets, cast nets and lift nets. Inland catches include local carp, catfish, gourami, shrimp and snakehead fish. The catch is used entirely for human

consumption. Of which, 80 per cent is consumed fresh, 9 per cent is processed into salted and dried fish, and 5 per cent is fermented.

In the future Thailand plans to focus on intensifying fish stocks in public waters. In order to do this, the Department of Fisheries is releasing fish fry into these areas. For example, in 1999, 720 million fish fry were released countrywide. If three to ten per cent of these fry are estimated to survive to adulthood, then, the stocking of public waters should allow the number of food-fish available to increase between 2,160,000 and 7,200,000.

<sup>♦</sup> FAO. World fisheries statistics (2000)



## VIETNAM

### General information <sup>^</sup>

Water area (inland):	329 560 km <sup>2</sup>
Population (2004):	Est. 82 689 518
Population growth (2004):	1.3%
GDP at purchaser's value (2003):	US\$ 203.7 billion
Agricultural percentage of GDP (2003):	21%
Fisheries GDP (2003):	4%
Capture fisheries as percentage of GDP <sup>1</sup> :	3.7%
Aquaculture as percentage of GDP <sup>1</sup> :	3.5%

<sup>^</sup> FAO. World fisheries statistics (2005)

<sup>1</sup> Asia-Pacific Fishery Commission (2005)

### Main rivers <sup>^</sup>

Total number of rivers	2 500 rivers
Red River system	
Annual catches:	6 000 tonnes (1980's) (Capture fisheries)
Thao	
Length:	902 km
Catchment area:	51 750 km <sup>2</sup>
Da	
Length:	1 013 km
Catchment area:	52 610 km <sup>2</sup>
Lo	
Length:	469 km
Catchment area:	38 970 km <sup>2</sup>
Hong	
Length:	1 126 km
Catchment area:	154 720 km <sup>2</sup>
Red River delta	
Surface area:	19 000 km <sup>2</sup>
Annual catches:	136 000 tonnes (Capture fisheries)
Thai Binh system	
Cau	
Length:	288 km
Catchment area:	6 064 km <sup>2</sup>
Thuong	
Length:	164 km
Catchment area:	3 580 km <sup>2</sup>
Luc Nam	
Length:	175 km
Catchment area:	3 066 km <sup>2</sup>
Thai Binh	
Length:	385 km
Catchment area:	15 520 km <sup>2</sup>
Kyung-BacGiang system	
Bang Giang	
Length:	108 km
Catchment area:	4 565 km <sup>2</sup>
Kycung	
Length:	243 km
Catchment area:	6 663 km <sup>2</sup>
Ma system	
Ma	
Length:	538 km
Catchment area:	28 370 km <sup>2</sup>
Chu	
Length:	325 km
Catchment area:	7 552 km <sup>2</sup>

Ca system		
	Ngan Sau	Length: 135 km Catchment area: 3 813 km <sup>2</sup>
	Hieu	Length: 228 km Catchment area: 5 330 km <sup>2</sup>
	Ca	Length: 531 km Catchment area: 27 224 km <sup>2</sup>
Gianh		Length: 158 km Catchment area: 4 676 km <sup>2</sup>
Quang Tri		Length: 156 km Catchment area: 2 500 km <sup>2</sup>
Thu Bon		Length: 205 km Catchment area: 10 590 km <sup>2</sup>
Ba system		Length: 13 814 km Catchment area: 13 814 km <sup>2</sup>
DongNai-SaiGon system		
	Dong Nai	Length: 586 km Catchment area: 29 520 km <sup>2</sup>
	La Nga	Length: 272 km Catchment area: 4 000 km <sup>2</sup>
	Be	Length: 344 km Catchment area: 8 200 km <sup>2</sup>
	Sai Gon	Length: 256 km Catchment area: 5 560 km <sup>2</sup>
Mekong system		
	Bassac River	Total length: 420 km (Cambodia and Viet Nam) Length (Vietnam): 320 km Annual capture: 119 kg/ha/year <sup>1</sup>
	Cuu Long (Mekong River, originating in China and passing through Myanmar, Laos, Thailand, Cambodia and Vietnam)	Total length: 4 225 km Length (Vietnam): 350 km Catchment area: 795 000 km <sup>2</sup> Annual capture: >30 000 tonnes (63 kg/ha/year <sup>1</sup> ) 20 000 tonnes (1980s)
Mekong delta		
	Surface area in Viet Nam:	39 500 km <sup>2</sup> (16 000 km <sup>2</sup> in Cambodia)
	Annual capture <sup>3</sup> :	190 000 tonnes (2000) for capture fisheries
	Total production <sup>2</sup> :	438 000 tonnes (2000)

<sup>1</sup> UNEP (1998). National Report of Vietnam

<sup>2</sup> De Graaf and Chinh (2002). Floodplain fisheries in the southern provinces of Vietnam

<sup>3</sup> Van Zalinge et al. (2000). Where there is water there is fish? Cambodian fisheries issues in a Mekong River Basin perspective

<sup>4</sup> Baran (2005). Cambodia inland fisheries: facts, figures and context

## Inland fisheries\*

Inland catches as a percentage of total catches:	43.8%
Total catch (2003):	2 536 361 tonnes
Degree of exploitation (2003)	
Inland catches:	1 110 926.12 tonnes

### Estimated amount of captured freshwater fish in different types of waterbodies and socioeconomic regions in Vietnam in the 1980s (tonnes)

	Aquaculture	Lakes Reservoirs	Rice fields	Rivers	Total
North	120 000	5 000	5 000	6 000	136 000
South	90 000	4 000	30 000	20 000	144 000
Center	5 000	3 000	900	3 000	11 900
High lands	5 000	1 000	100	500	6 600
Total	220 000	13 000	36 000	29 500	298 500

\* UNEP (1998). National Report of Vietnam

### Fisheries data \*

	Production	Imports	Exports	Total supply	Per capita supply
	'000 tonnes (live weight)				kg/year
Fish for direct human consumption	1 434 (2002)	21	482	973	19.4 (2001)
Fish for animal feed & other purposes	990 (MOFI, 25% of total = 634)	54	8	1 036	

#### Estimated employment (2002)

(i) Primary sector (including aquaculture):	553 900
(ii) Secondary sector:	3.4 million
Gross value of fisheries output (2003):	US\$ 1.7 billion
Trade (2003)	
Value of fisheries imports:	US\$ 52.1 million
Value of fisheries exports:	US\$ 2.24 billion (2.35 billion in 2004, estimated in January 2005)

### Inland fisheries \*

#### Fishing production means

In recent years, the number of fishing boats has increased considerably in Vietnam. The Vietnamese capture fishing industry had a total of 81,000 motorized fishing vessels with a total capacity of 4,038,000 hp (2003).

#### Inshore fisheries

The continuing construction of dams and reservoirs means the total size of its water bodies is still increasing. However, in 2005 natural lakes and rivers were thought to occupy approximately 4,200 km<sup>2</sup> with ponds and seasonal flood plains adding a further 6,000 km<sup>2</sup>.

Freshwater capture fisheries, once of economic importance in certain regions,

have been in decline. Overexploitation has resulted in diminished productivity and led to many fishers pursuing alternative activities and cooperatives ceasing to operate. Furthermore, management policies relating to flood control have led to once highly productive rivers such as the Red River Delta becoming significantly less so.

The inland fisheries that occur in rivers, lakes, dams and rice fields remain important to people living in rural areas. These fisheries are thought to have peaked in 2001 at 244,00 tonnes before falling to 209,000 tonnes in 2003. The figures include culture-based capture of species such as carp and tilapia but are still believed to underestimate true production (a common problem of fisheries statistics in the Mekong region). The Mekong itself is thought to support 48,000 Vietnamese fishers in 250 communities and produce 30,000 tonnes of fish each year.

- ♦ FAO. World fisheries statistics (2005)

## CHAPTER 5

# Values of Inland Fisheries in the Mekong River Basin

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## Contents - Chapter 5

<b>Acknowledgements</b>	230
<b>Acronyms</b>	230
<b>1. Introduction</b>	231
<b>2. Basinwide Analyses</b>	231
2.1 Basin Overview	231
2.2 Economic Valuation Analyses	234
2.2.1 Direct Use Values	234
2.2.1.1 Catch values	234
2.2.1.2 Market values	235
2.2.1.3 Consumption values	236
2.2.2 Indirect Use Values	237
2.2.2.1 Biodiversity values	237
2.2.2.2 Cultural values	238
2.3 Economic Impact Analyses	241
2.4 Livelihood Analyses	242
2.5 Impact of Changes on Fisheries Basinwide	244
2.5.1 Changes in Flow Regime	244
2.5.2 Changes in Fishing Patterns	246
2.5.3 Changes in Political Agendas	247
<b>3. Yunnan Province, People's Republic of China</b>	247
<b>4. Lao People's Democratic Republic</b>	249
4.1 Country Overview	249
4.2 Economic Valuation Analyses	250
4.2.1 Direct Use Values	250
4.2.1.1 Catch values	250
4.2.1.2 Market values	251
4.2.1.3 Consumption values	252
4.3 Socioeconomic Analyses	254
4.4 Livelihood Analyses	255
4.5 Impact of Changes on Fisheries in Laos	256
4.5.1 Example of Nam Ngum Dam	256
4.5.2 Example of Nam Theun 2 Dam	256
<b>5. Kingdom of Thailand</b>	257
5.1 Country Overview	257
5.2 Economic Valuation Analyses	258
5.2.1 Direct Use Values	258
5.2.1.1 Catch values	258
5.2.1.2 Market values	258
5.2.1.3 Consumption values	260
5.3 Socioeconomic Analyses	260
5.4 Impact of Changes on Fisheries in Thailand	260
5.4.1 Example of Pak Mun Dam	260

<b>6. Kingdom of Cambodia</b>	261
6.1 Country Overview	261
6.2 Economic Valuation Analyses	262
6.2.1 Direct Use Values	262
6.2.1.1 Catch values	262
6.2.1.2 Market values	263
6.2.1.3 Consumption values	266
6.3 Socioeconomic Analyses	268
6.4 Livelihood Analyses	269
6.5 Impact of Changes on Fisheries in Cambodia	270
6.5.1 Changes in Flow Regime	270
6.5.2 Habitat Quality Loss	271
6.5.3 Changes in Fishing Patterns	271
<b>7. Socialist Republic of Vietnam</b>	272
7.1 Country Overview	272
7.2 Economic Valuation Analyses	273
7.2.1 Direct Use Value	273
7.2.1.1 Catch values	273
7.2.1.2 Consumption values	274
7.3 Socioeconomic Analyses	274
7.4 Livelihood Analyses	275
7.5 Impact of Changes on Fisheries in Vietnam	276
<b>8. Conclusions</b>	276
<b>References</b>	278

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## 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



## 1. INTRODUCTION

Asia has the most productive inland fisheries in the world. The fishery sector contributes significantly to the national economies of the region (Revenega 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 put mounted 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 gray 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 localized studies leading to generic conclusions.

The report addresses the basinwide issues and studies. It is then organized 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 a theoretical framework synthesized from Emerton and Bos (2004) and Neiland and Béné (2006):

- a) resource-centered approaches, including
  - i) conventional economic analyses, with 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

The valuation studies at the regional level as well as in each riparian country did not always match or fill in this framework. For this analysis, the Emerton and Bos framework was modified as follows:

### Economic valuation analyses

#### Direct use values

Catch values

Consumption values

Market values

#### Indirect use values

Economic impact analyses

Socioeconomic analyses (whenever existing)

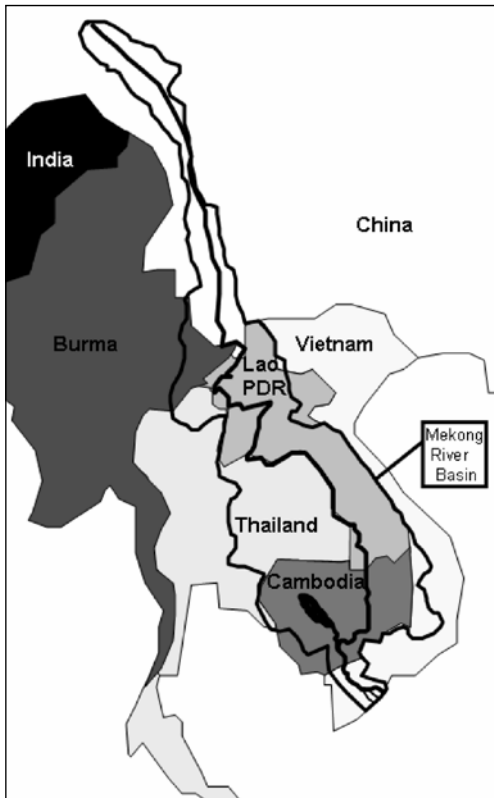
Livelihood analyses

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 12<sup>th</sup> longest river in the world (MRCS 1992) and the lifeline of Southeast Asia. The river flows through the riparian states of China, Myanmar, Laos, Thailand, Cambodia and Vietnam (see Figures 1 and 2).



**Figure 1: Map of the Mekong River Basin, from Tibet to the South China Sea**

In 2003, the population in the Lower Mekong Basin amounted to 53 million (MRC 2003a). Fifty per cent of this population was 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 km<sup>2</sup>, giving a population density of 92 person/km<sup>2</sup>. 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 per cent of Vietnam's agricultural production comes from the Mekong Delta (Jones 1997) and 60 per cent of Cambodia's fish catch comes from the Tonle Sap Lake (Ojendal and Torell 1998).

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 the Amazon and the Brahmaputra, and can reach 54 times the minimum mean discharge (Welcomme 1985). The floods annually inundate some 84,000 km<sup>2</sup> of floodplains (Scott 1989), which creates huge breeding and spawning grounds for fish. Many Mekong fish species are migratory, crossing national boundaries during their lifecycle 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.

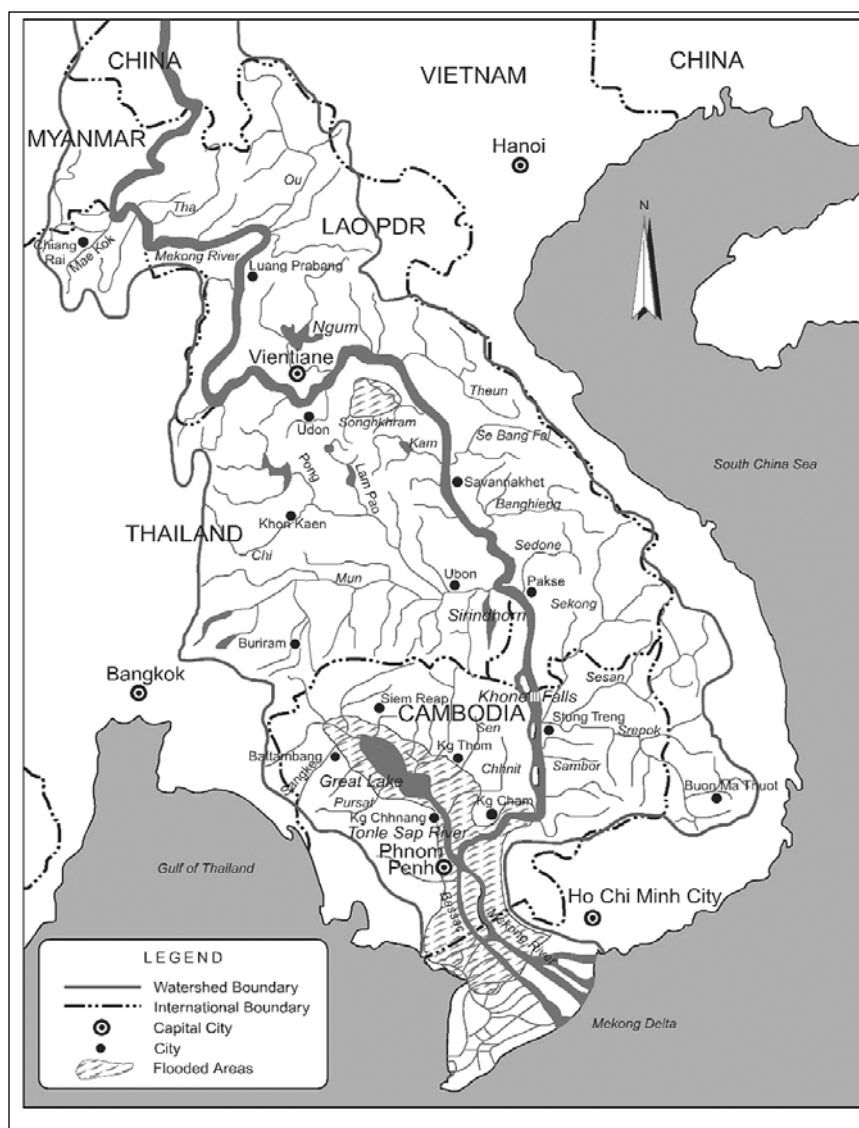
Compared to most international river basins, the Mekong River has a unique cooperation organization: the Mekong River Commission (MRC). The MRC is a successor of the Mekong Committee and the Interim Mekong Committee, which were in operation during the periods 1957-75 and 1978-95, respectively. The UN 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, the 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 modeling 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 relies heavily 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).

Marine fisheries and the aquaculture sector have been generally regarded in the Mekong Basin as important for revenue generation,



**Figure 2: Map of the Lower Mekong Basin showing major tributaries, large reservoirs and flooded areas (after Van Zalinge and Thouk 1999)**

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

#### 2.2.1.1 Catch values

Estimates of the 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 1940s and the 1990s.

Another recurrent issue has been the discrepancy between official statistics and those based on scientific surveys, as illustrated in Table 1, 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.

Starting in 1991-92, reports estimated the catch at 357,000 tonnes, including aquaculture. This figure was increased a few years later to 620,000 tonnes (Jensen 1996), then close to one million tonnes (Jensen 2000), then to 1.53 million tonnes (Sverdrup-Jensen 2002). At that time, Jensen (2001a) noticed that the floodplains of the Lower Mekong Basin (LMB) were producing some four times as much fish per square kilometer as the North Sea in Europe. In 2004, the estimates for the LMB rose to 2.64 million tonnes from capture fisheries in rivers alone, with an

**Table 1: Estimated inland capture fisheries production in the Mekong Basin in 2000, in tonnes**

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

<sup>1</sup> Van Zalinge et al. 2000; <sup>2</sup> FAO data

additional 250,000 tonnes from reservoir fisheries and another 250,000 tonnes 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 periodic 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.

Statistics on Myanmar's inland capture fisheries are not available. Although these fisheries are very developed (FAO 2003), only 2 per cent of the Mekong River 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 tonnes of inland fish caught per year worldwide, including 563,000 tonnes 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 tonnes from Mekong capture fisheries (Van Zalinge et al. 2004), then the total catch from inland fisheries worldwide amounts to about 10 million tonnes. The Mekong River Basin would then contribute one fourth of the world freshwater fish catches even though this relative share might be somewhat of an overestimate owing to underreporting of catches in other countries, particularly in Africa.

### 2.2.1.2 Market values

A detailed estimate of the value of Mekong inland fisheries, reproduced in Table 3, has been proposed by Barlow (2002).

**Table 2: Different estimates of LMB fish production from river capture fisheries**

Year of publication Country	1999 <sup>1</sup>	2002 <sup>2</sup>	2004 <sup>3</sup>
Cambodia	290 000 - 430 000	508 000	682 150
Lao PDR	27 000	133 000	182 700
Thailand	303 000	795 000	932 300
Vietnam	190 000	597 000	844 850
China		25 000 <sup>4</sup>	
Total LMB	810 000 - 950 000	2050 000	2 642 000

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

**Table 3: Fish production and value in the LMB (Barlow 2002)**

Fish and aquatic product source	Quantity (tonnes)	Price (US\$ per kg)	Value (US\$ 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

In 2004, Van Zalinge et al., citing Jensen (1996), Sjorslev (2001a), Sverdrup-Jensen (2002) and Hortle and Bush (2003), valued the total inland Mekong fish production at more than US\$ 1,700 million<sup>1</sup>, and the MRC (2005) valued it at about US\$ 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 the 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 tonnes in 1990 to around 260,000 tonnes in 1999-2000, which is equal to 12-13 per cent 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 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 tonnes of aquaculture fishes whose cycle has been mastered, or just 4 per cent 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

Sverdrup-Jensen (2002) estimated the total fish consumption in the LMB at 2.03 million tonnes 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 world<sup>2</sup>. Hortle and Bush (2003) estimated the fish consumption at over 3 million tonnes 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 al. (2004), compiling fish consumption figures from different sources, estimate it at 2.6 million tons annually for the Lower Mekong Basin (Table 4). However, conservative estimates still put the consumption of basin dwellers at just *“over one and a half million tonnes of fish per year”* (MRC 2004b).

It is impossible to overemphasize 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 Western countries, because rice does not contain calcium and milk is not part of the traditional

1 However, the authors do not detail the estimate of the average price per kilogram 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).

**Table 4: 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)**

Country	Population (million)	Average fish consumption (kg/person/year)	Total fish consumption (tonnes)	Capture fisheries catch (tonnes)	Reservoirs fish catch (tonnes)
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 <sup>a</sup>	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

diet in Southeast Asia. Small dried fish eaten whole (as most calcium lies in the bones) give more than 1,000 mg of calcium per 100 g, i.e., more than 150 per cent 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. Even though the bulk of the protein (76%) is derived from rice, 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 therefore 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 per cent of all pregnant women and children below five years of age suffer from anemia. 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 a matter related not only to quantity but also to quality.

The role of other living aquatic resources (prawns/shrimps, snails, frogs, shellfish as well as algae, 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 2002; Halwart et al. 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.

## 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 markets<sup>3</sup>, 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 of inland fish biodiversity (Baran 2005) range from 758 freshwater species according to FishBase 2004<sup>4</sup> (Froese and Pauly 2000) to 1,500 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 2003). This aquatic biodiversity includes particular endemic and iconic 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*), with *O. brevirostris* being a significant tourist attraction in southern Laos and northern

Cambodia, although its number has drastically declined to about 40 individuals (Baird and Beasley 2005).

The fish biodiversity is presented in the table below.

Dudgeon (2003) showed that the Mekong freshwater biodiversity is scientifically undervalued, with less than 0.1 per cent 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; Mollot et al. 2003) while a joint IUCN/MRC/UNDP project focusing on wetlands management puts the local cultural dimension of aquatic resources at the heart of conservation efforts<sup>5</sup>. In Vietnam, Hashimoto (2001) also detailed in an extensive review the multiple ecosystem values of flooding.

### 2.2.2.2 Cultural values

The cultural value of fish in Southeast Asia was comprehensively analyzed in Ivanoff (2003). Southeast Asia in particular is symbolized by the nutritional trilogy of rice, fish and salt (the latter two being united through brine, i.e., fish

**Table 5 Freshwater fish species richness in the Mekong riparian countries**

Location	Number of freshwater fish species	Source	Comment
Yunnan province, China	130 species	Yang 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 et al. 2003	Freshwater areas of the Mekong Delta. Also 14 shrimp taxa

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](http://www.fishbase.org)

5 See [www.mekongwetlands.org](http://www.mekongwetlands.org)



sauce). The importance and omnipresence of fish is illustrated by a number of proverbs known by all: for instance, “In water there is fish; in rice fields there is rice” in Thai; “Where there is water, there is fish” in Khmer, and “Nothing is better than rice eaten with fish; nothing is better than the love of a mother” in Vietnamese. 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 the everyday nature of fish, men have not developed a strong emotional, 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)<sup>6</sup>. 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 as 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 who master irrigation have regarded the sea as being wild, unmanageable, unpredictable 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 rice fields and ponds to somehow less valuable long-distance migrants from the Mekong (“*cá dong*” in Vietnamese) and then to marine species, can be seen as 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 even though it is 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 traveler Chou Ta Kuan noted in the 13<sup>th</sup> century the exceptional importance of fish in the life of the Angkor people, as depicted in multiple bas-reliefs particularly in Angkor Wat and Bayon temples (Voëun 2004). More recently, the notion of indirect use values underlies the 1997 declaration of the Tonle Sap area as a UNESCO biosphere reserve. These values, detailed by Bonheur (2001), and Bonheur and Lane (2002), include Khmer cultural identity and the values of biodiversity conservation.

<sup>6</sup> 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.

Touch and Todd (2003), and Torell et al. (2004) have also highlighted the non-use values of aquatic and wetland resources. Even among Cambodians who have immigrated to Brittany (France) and been exposed to abundant marine fish, freshwater fish remain much preferred, although they are in short supply



**Figure 3: Mekong catfish monument, Chau Doc, Vietnam.**

and more expensive (Simon-Barouh 1993). These immigrants even continue fishing for wild fish stranded in drying peri-urban wetlands in summer, just like in Cambodia in the dry season, as detailed by Khin (1993).

Southern Laos provides another example of how aquatic biodiversity and livelihoods 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, this would go beyond the scope of this review. Nevertheless, it can be noted that the stronger the consumer's feeling about these foods, the closer he/she is to his/her countryside roots. (Conversely, fish sauce is not favored among those preferring a modern lifestyle.) 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 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 further 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 only two per cent of questionnaires at most. They also show that, unlike men, women often catch and collect fish and other aquatic animals all year round owing 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; for instance, with "*Trey kolriang*", the giant barb, (*Catlocarpio siamensis*) honored 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 stainless steel and granite monument erected in Chau Doc (Vietnam Delta), which displays eleven catfishes (two large "*Ca basa*", *Pangasius bocourti*), and nine "*Ca tra*" *Pangasius*

*spp.*), which serves as a symbol of the nine branches of the Mekong Delta. This monument represents “the creativity and prosperity of the 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 raised in the region and exported worldwide<sup>7</sup>.

### 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 River 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 were assessed through the integration of utility functions for all economic activities related to the river. Ringler found that artificial diversions of water from the Mekong could readily 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 the irrigated agriculture sector; b) the Mekong Delta uses the largest amount of water and obtains the highest economic benefits from the river, making it very vulnerable to water management options taken in upstream countries.

As shown in Table 6, total profits from optimal water allocation and use were estimated at US\$ 1.8 billion in 1990, with irrigated agriculture ranking first at US\$ 917 million and fisheries second at US\$ 546 million. Vietnam obtains the greatest benefits from Basin’s water uses, consisting chiefly of 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 tonnes as per recent estimates.

To our knowledge, no socioeconomic analysis has been done for the whole Mekong Basin. At the moment, the Mekong River Commission is developing a simple resource allocation and

**Table 6 Baseline scenario profits from water use in million US\$ (Ringler 2001)**

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 Highlands	29	6				35
- VN, Mekong Delta	484	75		188	44	790
<b>Total Basin</b>	<b>917</b>	<b>170</b>	<b>43</b>	<b>546</b>	<b>134</b>	<b>1 809</b>

<sup>7</sup> In particular, in the USA prior to 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 raised 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.

optimization model (RAOM) similar to Ringler's model, but is 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 socioeconomic 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 socioeconomic 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 socioeconomic assessments"* (Halcrow 2004b and c).

In terms of policy, Feng et al. (2004) analyzed the conflicting needs of the riparian countries and the current problems hampering the development of a basinwide water allocation model that would include China. Fox (2004) highlighted the fact that the terms of the 1995 Mekong Agreement<sup>8</sup>, 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 focusing efforts on controlling and redirecting 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. (2005), who found that the diversity of fisheries-related livelihood strategies is poorly represented in practice by socioeconomic analyses and policies, and called for a more diverse and flexible range of measures that secure 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 the values 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 to socioeconomic analysis, with a focus on people-centered, dynamic and adaptive approaches, with particular attention 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

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

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. (2005) think that in developing countries, fishing can either be (i) a primary livelihood of last resort, (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 view themselves as very poor and highly dependent on others for financing. However, they are considered relatively less vulnerable than the agriculture-based poor who are more subject to seasonal scarcity periods. The majority of part-time fishers also consider themselves poor or very poor. The third group of subsistence fishers includes landless laborers, women, children and small farmers. They include both the very poor and the 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 regarded as an activity for the more wealthy was noted by Béné and Neiland (2003); this 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 (including deforestation and agro-chemical pollution), and ii) modification of river flows by flood control, drainage and irrigation structures or hydropower schemes. Among ongoing conflicts mentioned are 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, 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 1) integrate aquatic resource 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 is not a problem; only exceptional floods are.

## 2.5 Impact of Changes on Fisheries Basinwide

Several factors make the future of Mekong fisheries uncertain. These include preliminary calculations suggesting a 20 per cent increase in demand for fish in the LMB over the next 10 years (Sverdrup-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. Detailed below are 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 per cent 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 per cent lower than during 1924-56, while the interannual variations have become more extreme (Nam 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 impacts. 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.

According to the MRC (2003b), in the Mekong Basin, thirteen hydropower dams of a capacity higher than 10 megawatts existed in 2003: two in China on the mainstream, five in Laos, four in Thailand and two in Vietnam, the latter being on tributaries, for a total production of 4,400 megawatts (15% of the Basin's 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 stations<sup>9</sup>. 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 that do not

9 Vietnam Economic Times, 4 August 2005

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 northeastern 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 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 is 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 per cent. 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 loss to the HAI ranges from 1 to 13 per cent 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 tonnes (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 tonnes with a monetary value of US\$ 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 tonnes of fish caught per hour in the Tonle Sap River during the migration peak) makes fish ways unrealistic in most main channels (Jensen 2001c).

One of the issues that has recently surfaced is the trapping of sediments and the reduced flow speed that results from dams, particularly those across the mainstream (Sarkkula et al. 2003; Kummur et al. 2005). Analyses detailed in Plinston and He (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 as follows:

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

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 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 socioeconomic implications remain to be assessed (Baran et al. 2006).

The impact of Chinese dams is also feared in the Mekong Delta; yet, according to Nguyen (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 overfishing 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 more sensitive to environmental change than to overfishing. In Cambodia, however, the dominance of these low-value opportunists is thought to be increasing as a result of overexploitation (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 into valuation studies (Van Zalinge and Nao 1999). Year after year, total catches seem to contain a higher proportion of less valuable small fish and a lower proportion of medium- and large-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, which 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 et al. 2003)

### 2.5.3 Changes in Political Agendas

Inland capture fisheries are characterized by diversity not only 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 analyzed in view of management.

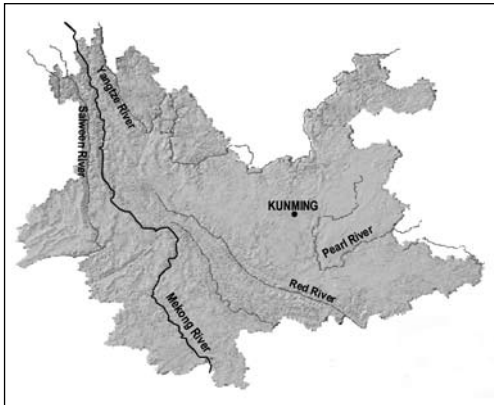
According to Coates (2002, 2003), most published figures for inland capture fisheries in Southeast Asia do not actually qualify as *statistics* because they are not based upon data. Inland capture fisheries are clearly seriously underreported by 250 to 360 per cent in all countries in the Mekong Basin. 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, the 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 organizations 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 km<sup>2</sup> and a population of about 42 million, 81.7 per cent of it being rural (population density: 107 persons/km<sup>2</sup>). The

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



**Figure 4: Map of the Yunnan province, in China**

province remains poorly developed, with a per capita GDP of US\$ 565 in 2000 (but only US\$ 180/year for rural dwellers). The population growth reaches 1.2 per cent per year (2000 data in ADB/UNEP 2004<sup>10</sup>). With 10 per cent 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 seven prefectures of Yunnan along the Mekong River are below the provincial average, itself below the national average (Makkonen 2005).

This mountainous province (from 6,740 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), extensive forest cover (32.4% of the land area) and a large number 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 areas<sup>11</sup>.

Statistics and figures for Yunnan and the Upper Mekong are difficult to find (NSF 1998; Chapman and He 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 languages, and apart from a number of articles originating from conservation NGOs, very few scientific documents could be found<sup>12</sup>.

Twenty-one per cent of the Mekong Basin area lies in China (Feng et al. 2004), and the Chinese section of the Mekong River contributes 45 per cent of the dry season flow in Cambodia (Goh 2004). But for Yunnan alone, the Mekong Basin covers 165,000 km<sup>2</sup> or 38 per cent of the province, and this section of the river contributes 16 per cent of the average annual flow of the whole Mekong volume (MRC 2003b).

He and Hsiang (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 tonnes (Xie and Li 2003) and capture fishery labor in this province involves about 15,000 persons (ibid.).

Four hundred and thirty-two fish species are recorded in Yunnan, and 130 species are found in the Chinese section of the Mekong River (Yang 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; 280 species have become rare or

11 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 eco-network, Kunming, China (2001).

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

have not been found in the past five years (ibid.). This region is also characterized by massive introduction programs, of 34 species overall, that have 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 totaling 15,550 megawatts (dam characteristics in Plinston and He 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 and Chen (2002), and Osborne (2004). However, it is also argued that the development of 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 and Hsiang 1997; He and Chen 2002).

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-tonne ships, and 90 to 100 additional reefs and rapids to be blasted in phase 2 for 300-tonne 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 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, and have reportedly reduced the fish catch in the area by 50 per cent (Sretthachau and Deetes 2004).

## 4. LAO PEOPLE'S DEMOCRATIC REPUBLIC

### 4.1 Country Overview

The Lao PDR has a population of about 5.1 million. Approximately 77 per cent of this population lives in rural areas, and 40 per cent lives below the World Bank poverty line. Annual per capita GDP was estimated at US\$ 280 in 1999. The main economic sector in the Lao PDR is agriculture, accounting for 52.6 per cent of the national GDP. However, the overall importance of agriculture is declining as industry and services increase. Selected economic indicators for the Lao PDR are summarized in Table 7.

Wood products contributed 34 per cent and manufactures 23 per cent to the total exports of US\$ 337 million in 1998. By contrast, the agricultural sector contributed only 2.4 per cent

**Table 7: Selected economic indicators for the Lao PDR from 2000 to 2003 (World Bank web site)**

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	5.00	5.00
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	5.40	5.53	5.66



**Figure 5: Map of the Lao PDR (cities and provinces mentioned in the text are highlighted)**

or US\$ 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 per cent of the country (202,000 km<sup>2</sup>) and Laos contributes

35 per cent of the average annual flow of the Mekong. Therefore, it has a major role to play in basinwide water resource management, especially as the country is now keenly developing hydropower.

## 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 recent years. Interestingly, fish production is not even mentioned in the 2001 statistical yearbook (NSC 2002), and nor is 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 the Lao PDR. In 1997, national fisheries catches amounted to 37,825 tonnes (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 tonnes. In 2002, capture fisheries production alone was estimated at 29,250 tonnes (Table 8).

**Table 8: Lao PDR inland fisheries production and productivity in 2000 (Souvannaphanh et al. 2003). The totals have been recalculated.**

Type of water resources	Area in (ha)	Productivity (kg/ha/year)	Total production (tonnes/year)	% of total fisheries production
Mekong and tributaries	254 150	70	17 790	
Reservoirs (stocked)	57 025	60	3 421	
Irrigation and small reservoirs (natural and stocked)	34 460	150	5 169	40.4
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	100.0

**Table 9: Estimates of capture fisheries and aquaculture production in the Lao PDR (Lorenzen et al. 2003b)**

Type of water resources	Area in (ha)	Productivity (kg/ha/year)	Total production (tonnes/year)	% of total fisheries production
Mekong and tributaries	254 150	70	17 790	
Reservoirs (stocked)	57 025	60	3 421	
Irrigation and small reservoir (natural and stocked)	34 460	150	5 169	78
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

The latest estimates, integrating rice paddies, amount to 82,500 tonnes, including 64,600 tonnes from capture fisheries (Lorenzen et al. 2003b), which accounts for 78 per cent of the country's fish production (Table 9). The authors believe the share of aquaculture remains grossly overestimated<sup>13</sup>.

The highest estimate of fish production is given by Sjorslev (2001a), who concluded that fish consumption alone (excluding trade with neighboring countries) amounts to 204,800 tonnes annually. This figure, based on raw consumption studies, is much higher than that of other authors.

#### 4.2.1.2 Market values

The gross value of fisheries output is estimated at around US\$ 48 million, commercial capture fisheries contributing approximately four per cent of GDP and subsistence fisheries another two per cent (Lorenzen et al. 2003a and 2003b). Souvannaphanh et al. (2003) consider that fisheries account for about eight per cent of national GDP. According to Emerton and Bos (2004) quoting STEA (2003), fish and other aquatic animals are

worth US\$ 100 million a year. The LARReC Medium Term Plan 2000-2005 estimates the value of total annual aquatic production to be approximately US\$ 66 million, excluding aquatic plants.

This estimate is based on the average market value of fish/frog/turtle (wet weight) at US\$ 0.66 per kg. According to Lorenzen et al. (2000), fish in local markets costs between US\$ 0.5 per kg for small *trash* fish and US\$ 1.5-2.5 per kg for larger fish. As household catches consist of about one third *small* and two-thirds of *large* fish, the average value reaches US\$ 1.5 per kg. More recently, Bush (2003b) gave a value for the overall average price of capture species in three lowland districts at US\$ 1.14 per kg, which was superior to the average value of aquaculture species (US\$ 0.98 per kg).

An alternative value of the fish consumed in Laos is detailed in Table 10.

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

13 The 1998/99 Lao Agricultural Census estimated that 8.3 per cent 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 2,400 ha that, with a realistic average production estimate of 650 kg/ha/year, gives a total production of no more than 1,560 tonnes."

**Table 10: Value of the fish consumed in Laos (1997-98), cited in Souvannaphanh et al. 2003) (The figures have been recalculated because currently US\$ 1 is worth approximately 10,000 kip, but early in 1998 US\$ 1 was worth approximately 1,300 kip.)**

	Consumption value, in million kip	Consumption value, in US\$ (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
<b>Total (rounded up)</b>	<b>46 000</b>	<b>4 600 000</b>

(Champassak), northern Cambodia and Thailand. Baird estimated the value of fish traded in the district at US\$1 million per year. However, Phonvisay and Bush (2001) deepened the study and concluded that 435 tonnes of fish are traded annually from Siphandone district to the main markets in Pakse and Thailand. At an average value of 9,500 kip/kg, they valued this trade at around US\$ 440,000. The study also led to the conclusion that about 87 tonnes 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 tonnes of fresh fish are traded daily. Out of this, nearly 1.8 tonnes come from Thailand, for a value of up to 5.188 billion kip or US\$ 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 US\$ 1.1 million a year (more than half of 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 labor requirements.

The consumption of aquatic products in Laos has been addressed in a number of studies. Available figures are summarized in the following Table 11.

A quick analysis of the data in Table 11 shows that i) figures related to 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 studies<sup>14</sup>; and iii) that fish consumption seems to be highest in Champassak Province, characterized by extensive wetlands, although other central and northern provinces also exhibit relatively high consumption figures.

In Khong District (Champasack Province), Baird et al. (1998) estimated the average

14 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.

**Table 11: Per capita consumption of fish and other aquatic resources**

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 (1992-93 and 1997) National Statistics Center 1998; cited in Souvannaphanh et al. 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; and 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		
24.2 kg of aquatic products/person/year	FAO PADP 1998 cited in Guttman and Funge-Smith 2000	Oudomxay Province (northern hilly province bordering the Mekong)
15.1 kg of aquatic products/person/year		Savannakhet Province (southern province bordering the Mekong)
21.2 kg of aquatic products/person/year		Sayaboury Province (central province bordering the Mekong)
25.6 kg of aquatic products/person/year		Sekong Province (southern province away from the Mekong mainstream)
		Xieng Khouang Province (central hilly province away from the Mekong mainstream)
42 kg of fish/person/year	Baird et al. 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 et al. 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 per cent of these aquatic resources, other aquatic organisms 23 per cent and processed fish 2 per cent.
11.8 kg of fish/person/year	Calculated from Garaway 2005	Based on a one-year survey (103 households) in Savannakhet province in 1997-98

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 per year in Attapeu and Savannakhet Provinces.

The role of fish and other aquatic resources in the diet of the Lao rural population was detailed in Guttman and Funge-Smith (2000) and Meusch et al. (2003) also highlighted the deplorable nutritional status of the people in Attapeu Province, as well as the importance

of aquatic resources in supplementing a nutrient-poor diet. A table summarizing available studies is provided in Table 12.

### 4.3 Socioeconomic Analyses

In Laos, 2.7 million people live along a river (MRC 2003b). The Agricultural Census indicated that more than half the population of the Lao PDR was engaged in capture fisheries in one way or another<sup>15</sup>. 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 was predominant in rural households, with more than 80 per cent of the households in southern Lao PDR being involved (Lorenzen et al. 2003). The same author (2000) showed that in an average household, the use of aquatic resources (with an estimated value of US\$ 90) accounted for about 20 per cent of gross income (Lorenzen et al. 2003). On average, 70 per cent of household fish supply is caught by households themselves; less than 20 per cent is purchased; and 10 per cent is received as gifts, reciprocal exchange,

**Table 12: Contribution of fish and aquatic resources to diet in the Lao PDR**

Percentage in the diet	Source	Note
Fish accounts for approximately 78 per cent of the animal protein consumed.	Baird et al. 1998	Khong District, Champassak Province
Fish contributes 42.5 per cent of the 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 per cent among hill tribes and 90 per cent among the Lower Lao population.
Fish contributes 17 per cent 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 per cent of the total protein.	Guttman and Funge Smith 2000	Range over 6 rural provinces; average: 40.6 per cent
Fish and other aquatic animals account for 43 per cent of the total animal product consumption.	Sjorslev 2000	The study specifies that aquatic resources actually account for 55-59 per cent of the total animal intake if differences in the protein contents of various foods are integrated.
Fish is present in 52-95 per cent of all meals.	Baird 2001; Baird and Flaherty 2000	In Khong District, Champassak Province. Fish is also the largest source of cash income.
Fresh and processed fish contribute 56.3 per cent of the total animal protein intake.	Mattson et al. 2001	Around the Nam Ngum reservoir
Fish and other aquatic animals are present in 85 per cent 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 the total protein consumption at the national level.	Emerton and Bos (2004), quoting STEA (2003)	
Fish contributes 18 per cent of food supply.	Mollot et al. 2003	Attapeu and Savannakhet Provinces

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



or payment in kind for labor (Lorenzen et al. 2003b; Garaway 2005).

Nguyen Khoa et al. (2003) showed that the average household fishing effort was consistent at about five hours per 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 the 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, until recently practiced by remote, isolated and subsistence-oriented people, 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).

#### 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 site<sup>16</sup>). Shoemaker et al. (2001) showed how important the contribution of the river to livelihoods was, thanks to fishing, 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 to buy rice seeds at the end of a long dry season, for instance (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 socioeconomic 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 a very poor country, as illustrated by the fact that agriculture accounts for more than half of the GDP, while only around three per cent 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 per cent 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

16 See [www.mekong.es.usyd.edu.au/case\\_studies/fisheries/index.html](http://www.mekong.es.usyd.edu.au/case_studies/fisheries/index.html)

a common characteristic of 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 per cent of the time spent on income generating activities in rural areas that are 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.

##### **4.5.1 Example of Nam Ngum Dam**

The Nam Ngum reservoir, covering an area of 477 km<sup>2</sup>, was created by a 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 tonnes while another study found it to be 6,833 tonnes (Mattson et al. 2001). According to Mattson et al. (2001), the increase could be the result of 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 of four between 1982 and 1998 (cited in Mattson et al. 2002a), in correlation with an increase in fishing effort, particularly gillnets. The total estimated landings (6,833 tonnes) correspond to a 143kg/ha/year yield. Annual registered yield amounted to US\$ 800,000 in 1997 (Ringler 2000). However, Roberts (2004) pointed out that during 1971-79 the reservoir was largely anoxic with very low fish catch, and after a peak in fisheries production in 1985-90, the 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 per cent in fishing effort and catch for rural households. However, no literature was found 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 unfavorable 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 the Lao PDR (IRN 1999). The

project, planned for central Laos, consists of a 50-meter-high dam on the Theun River, the fourth largest tributary of the Mekong. The river provides habitat for 85 species of fish 16 of which are endemic (Roberts 2004), and 33-55 per cent of these species are strongly migratory. Out of the 85 species, only 27 are likely to become established in the reservoir, and 14 of these 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 US\$ 7,400 per inhabitant for a population of 64.8 million. About 10 per cent of the population lives below the poverty line. However, there is a great disparity between

regions, and the northeastern provinces bordering the Mekong River are among the driest and poorest in the country.

Agriculture contributes less than 10 per cent to the national economy while industry and services contribute 40 and 50 per cent, respectively (Table 13). Out of all the LMB countries, Thailand is least economically dependent on the Mekong River. However, fisheries have huge importance for rural food security and employment in the northeastern provinces. The population growth of the country is low compared to its neighbors and very similar to that of developed countries.

Water resources are managed intensely in Thailand for hydropower, irrigation, industrial and domestic uses. However, problems of availability and adequacy of water resources are created by inefficient use of water in various sectors, deteriorating water quality due to urban sewage and industrial waste, and excessive use of fertilizers and pesticides. 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, or 43 per cent of the total annual runoff. Within Thailand, 1,872 reservoirs are located in the Mekong River Basin, with a total surface area of 2,120 km<sup>2</sup> and an estimated total fish catch of 25,428 tonnes per year (Virapat and Mattson 2001).

**Table 13: Selected economic indicators for Thailand from 2000 to 2003 (World Bank web site)**

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\$)	11.50	4.59	4.80	
Population growth (%)	0.80	0.75	0.70	0.65
Population total (millions)	60.70	61.20	61.60	62.00

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 of 4.9 million hectares for inland fish habitat. 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 freshwater and brackishwater ponds and tanks constitute 320,000 hectares of production area in the country. However, most of the freshwater ponds 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 iii) the relatively low level of research done in Thailand by the MRC. Therefore, some gaps in the economic valuation of river fisheries in Thailand remain in this section.

### 5.2.1 Direct Use Values

#### 5.2.1.1 Catch values

Inland fisheries contribute approximately six per cent (about 200,000 tonnes) to the total fisheries production in Thailand (Pawaputanon 2003). Indeed, in 1996, the Department of Fisheries reported this contribution at 5.8 per cent, with the northeastern region that lies in the Mekong Basin contributing 122,000 tonnes (cited in Prapertchob 1999). Marine and aquaculture production seem to outweigh inland fisheries production considerably (Table 14), with marine production of over 3 million tonnes dominating the fisheries sector.

This assessment of freshwater fish catches for the 1997-99 period is 2.6 times higher than that available for the year 1996 (Table 15).

#### 5.2.1.2 Market values

Surprisingly, it was possible to find only one study in English that details the value of inland capture fisheries production in Thailand, as shown in Table 16.

Should the 1996-price-per-kilogram figure (US\$ 0.77/kg) be applied to the 1997-99 assessment detailed in Table 14, it would result in a total value of US\$ 157.5 million for Thailand's inland fisheries production. As a comparison, the value of all fish and fish

**Table 14: Capture fisheries production in 1997-99 in Thailand (tonnes; adjusted from Pawaputanon 2003)**

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

products in Thailand is estimated at 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 figure for open waters 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. Virapat et al. (1999) supported the view that statistics reported by the DOF referred almost exclusively to reservoirs and noted, *“... this confirms that the perception of inland capture fisheries in Thailand is one*

**Table 15: Inland fish production per water-body type in Thailand in 1996 (cited in Virapat and Mattson 2001)**

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
Total	63 ,866		78 711

**Table 16: Inland fish value per water-body type in Thailand in 1996 (cited in Virapat and Mattson 2001).**

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
Total	78 711	60 364 000

*of reservoirs. Whilst reservoirs are obviously important ... Thailand in fact does still have considerable river and swamp fisheries, plus*



**Figure 6: Map of northeast part of Thailand, bordered by the Mekong**

*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 by Prapertchob (1999). According to this review, based on a 500-household survey by Prapertchob et al. (1989), the author cited the amount of freshwater fish consumption in northeastern Thailand as 21.3 kg/person/year on average, with a variability 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 northeastern Thailand was subsequently estimated at 395,000 tonnes (i.e., almost twice the 207,000 tonnes estimated in Table 14). Fish was by far the dominant food item in the diet of the people surveyed, followed by chicken and pork (half and one-third of the consumption of fish, respectively). 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 rely more 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, with the central and northern regions importing fish from other provinces due to insufficient local supply.

## 5.3 Socioeconomic 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 Virapat and Mattson (2001), about 825,000 labor 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 per cent 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 aquatic resources and the people who depend on them; however, there are few scientific studies to back up these journalistic articles. Presented below is an example of the famous and controversial Pak Mun dam, which 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 northeastern Thailand. The dam has a maximum height of 17 m, and 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 program. However, in Thailand, even storage reservoirs that perform better under fish-stocking programs have a fish yield of only about 19 to 38 kg/ha/year. There has been no evidence that the fish productivity of the 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 (US\$ 69,000).

Regarding biodiversity, Roberts (1993) reported that the number of fish species in the Mun River declined from 121 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 US\$ 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 US\$ 212,000 per annum (at a rate of 38 Baht per US\$ 1), and the reservoir fisheries created did not match the losses generated by the dam construction.

In the post Pak Mun dam period, fishing communities located upstream and downstream of the dam reported a 50-100 per cent decline in fish catch and the disappearance of many fish species. The number of households that were dependent on fisheries in the upstream region declined from 95.6 per cent to 66.7 per cent, and the villagers who were dependent on fisheries for income found no viable, alternative 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 (US\$ 19.5 million) had been paid to 6,202 households as compensation by the Thai government for the loss of fisheries and livelihoods.

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 per cent 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 built on Pak Mun to mitigate the impact of the dam 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 a year.

## **6. KINGDOM OF CAMBODIA**

### **6.1 Country Overview**

Cambodia is the poorest country in Southeast Asia with a GDP per capita of US\$ 297 (UNDP 2004). The population of Cambodia

has tripled over the past couple of 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 per cent, about 300,000 jobs need to be created each year (Degen et al. 2000) in the future, considerably straining the country's already weak economy (see Table 17 for details).

The rural population comprises about 90 per cent of the nation's poor, 43 per cent of whom live below the poverty line (cited in Zurbrugg 2004). According to Keskinen (2003), while the role of agriculture has great significance to employment because it provides jobs for almost 80 per cent of the population, the economic importance of the whole agricultural sector is decreasing, accounting for only 34 per cent of the national economy in 2000, compared with more than 50 per cent in 1990. However, the author noted that the proportion of the agricultural and fishery sectors' contribution to GDP might be considerably underestimated, partly because of their subsistence nature (Keskinen 2003).

## 6.2 Economic Valuation Analyses

### 6.2.1 Direct Use Values

On his way to Angkor Wat in 1858, Henri Mouhot noted, "*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 per cent of Cambodia's total fish catch (Sam et al. 2003) of which the Tonle Sap Lake provides about 60 per cent, or 179,500-246,000 tonnes annual harvest over the 1995-2000 period (Ahmed et al. 1998; Lieng and Van Zalinge 2001). In 1998, according to the DOF (2001a), 35 per cent of the Cambodian population was living in fishing dependent communities.

#### 6.2.1.1 Catch values

Similar to fish consumption figures in the 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 1995-96. Both official and 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 Table 18.

**Table 17: Selected economic indicators for Cambodia from 2000 to 2003 (World Bank web site)**

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)	12.70	12.90	13.20	13.40



In fact, these figures result from an aggregation of various localized 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 gear 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)<sup>17</sup>.

Assuming an annual production of 300,000-400,000 tonnes, Cambodia's freshwater capture fisheries rank fourth worldwide after China, India and Bangladesh. Furthermore, as shown by Baran (2005), when the catch is divided by the population (i.e., the number of people who can realize the harvest), Cambodia's inland fishery is the most intense in the world, with 20 kg of fish caught per inhabitant per year (Figure 7).

Baran et al. (2001b), and Lieng and Van Zalinge (2001) provide estimates of the fish yield of the Cambodian floodplains, which amount to between 139 and 230 kg/ha/year. This is the highest amount when compared with figures from the other tropical floodplains (i.e., Thailand, Laos, Indonesia, Bangladesh, Amazon), which range from 24 to 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/fisher/day (Ouch 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

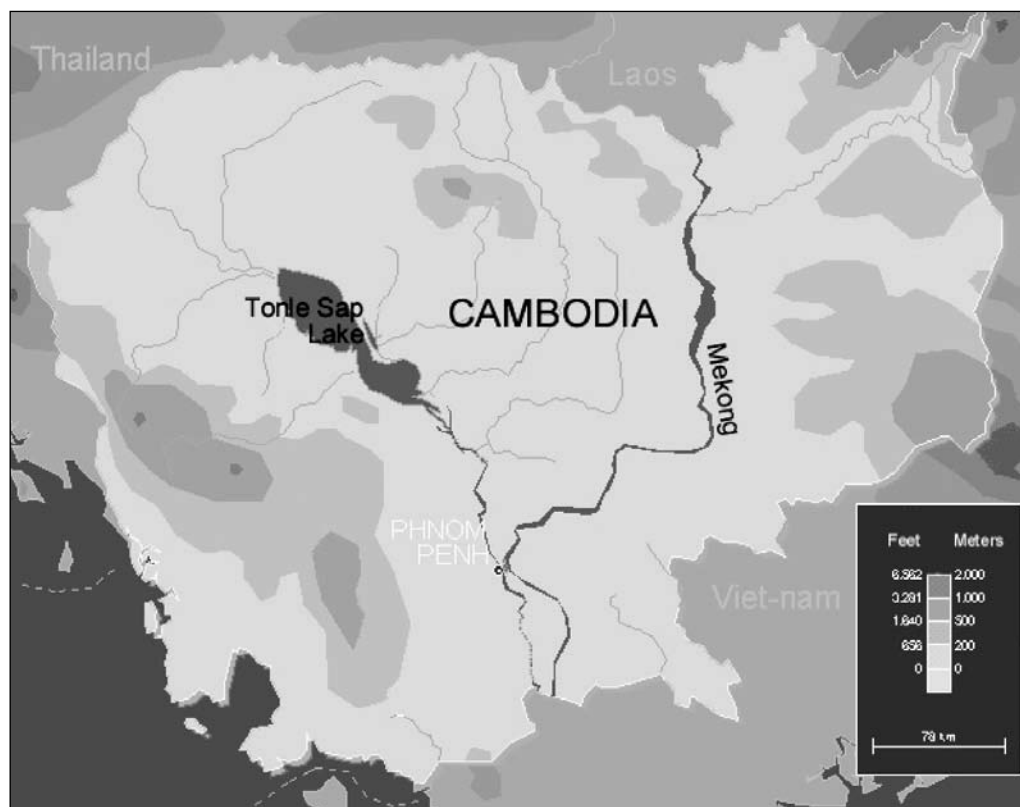
In a recent large-scale study conducted on 540 households in three provinces (Stung Treng, Siem Reap and Takeo), Israel et al. (2005) calculated that the annual net economic value (NEV) of aquatic resource-based activities is US\$ 190,000 for an average village community, less the cost of labor that is generally not accounted for. This NEV, however, varies from US\$ 6,106 to 440,895 per village per year depending upon the degree of dependence on aquatic resources and market access. The annual return to labor (i.e., the amount the communities earn from aquatic activities) reaches US\$ 108,614 per village per year on 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 US\$ 2.4 million per 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 US\$ 100 to 200 million, and to increase in the marketing chain up to US\$ 250 to 500 million. Nowadays, official statements estimate the fishery at 300,000-450,000 tonnes per year, with a value of US\$ 150-225 million<sup>18</sup>. Hurtle et al. (2004a) valued the total catch at US\$ 300 million. Nao and Ly (1998) estimated that the value of fisheries in 1995 made up 3.2 to 7.4 per cent of GDP. However, the contribution of fisheries to the GDP has recently been estimated at 11.7 per cent (Starr 2003) and 16 per cent (Van Zalinge et al. 2004). This represents more than half the

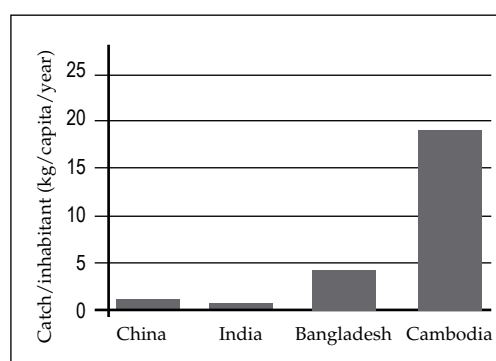
<sup>17</sup> The only fishery scientifically monitored in the basin is the bagnet ("dai") fishery, which accounts for 15,000 tonnes/year, or approximately 4% of the total catch in Cambodia and 0.6% of the catch basinwide.

**Table 18: Cambodian inland fisheries catches, according to various authors**

Figure (tonnes of inland fish per year)	Source	Note
130 000 tonnes	Chevey and Le Poulain 1939	Earliest scientific assessment, preceded by a rough estimate of 200 000 tonnes by Chevey (1938)
Catch varying between 50 500 and 75 700 tonnes 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 tonnes	Van Zalinge et al. 1998a	First post-war assessment partly based on a scientific monitoring
289 000-431 000 tonnes	Van Zalinge and Nao Tuok 1999; Van Zalinge et al. 2000; Hortle et al. 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 tonnes between 1999 and 2002	Department of Fisheries data	Upgraded national statistics (still not based on extensive monitoring) integrating catches of subsistence fisheries
500 000 tonnes	Van Zalinge 2002	Upgrading by 20% of the previous figure to integrate the population growth in order to reflect today's situation
600 000 tonnes	Hortle et al. 2004a	
682 000 tonnes	Van Zalinge et al. 2004	Most recent estimates, integrating the results of fish consumption studies



**Figure 7: Map of Cambodia**



**Figure 8: Fish catch per inhabitant in the four countries having the biggest inland fish catch (Baran 2005)**

share of the whole country's industry (21.9% in 2001).

Inferring value from catch is highly dependent upon the average price-per-kg factor used, and very few studies detail this factor. Rab et al. (2004a) detailed the evolution of the price along the trade chain (Table 19) and showed that the price at the landing site can be five times that received by the fisher.

**Table 19: Average price of a kilo of fish at each level of the trade chain (Rab et al. 2004a)**

	US\$/kg
Price received by fishers	0.39
Price paid by the households	0.60
Retail market price	1.84
Landing site price	2.16
Export house price	4.26
Border price	5.28

**Table 20: Average price per kilogram of fish (US\$) per quality ("grade") at various retail markets during the closed season (Rab et al. 2005)**

Average price (US\$/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

In a similar study, Yim and McKenny (2003a) found that the marketing margin (profit share in the retail price) varies from 65 to 75 per cent (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, 2005; table 20), while Ker et al. (2001) outlined their temporal variability (fish prices being generally highest from June to August and lowest from December to February).

Ker et al. (2001) also showed that the mean price of other animal protein is generally higher than that of cultured and wild fish, making the latter a more affordable staple for the poor. Touch and Todd (2003) estimated the total value of processed and exported inland fish commodities, such as fish sauce, dried fish, smoked fish, etc. at US\$ 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 tonnes of exports in 1998 at a value of US\$ 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 tonnes of exports of fishery products in that year, which seems more realistic*". Officially, Cambodia exported 23,700 tonnes of inland fish in 2001 (Nao et al. 2001, cited in Hurtle et al. 2004a)<sup>19</sup>. By comparison, in the 1940s, under a strong colonial administration backed by extensive studies of the fisheries sector, the fish export was estimated at 28,000 tonnes per year (Le Poulain 1942), for a total population three times smaller than nowadays (Baran et al. 2001a).

Yim and McKenny (2003a, 2003b and 2003c) found that fish exports registered by

<sup>18</sup> Minister of Agriculture, Forestry and Fisheries, National Fish Day 2004.

<sup>19</sup> Out of a total of 38,100 tonnes of fish exported for a total value of US\$ 31.14 million, according to DOF statistics.

the Department of Fisheries were often one third or even one tenth of their real weight. Yim and McKenney (2003b) also showed that official and above all informal fees add more than 50 per cent to the cost of exporting a tonne 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 per cent 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 US\$ 3 million (FACT 2001). Thus, the official revenue collection from an estimated US\$ 300 million worth resources amounts to taxation of only one per cent. This can be compared to the taxation rate under the French Protectorate, which ranged from 1 to 10 per cent depending on the gear (average: 5.6% among 6 gears, calculated from Chevey and 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 licenses has been estimated at US\$ 3-4 million (Touch and Todd 2003).

### 6.2.1.3 Consumption values

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 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 consumed, on average, 95 kg/household (15.7 kg/person). The cost of *prahoc* was US\$ 0.09 per kg, whereas low quality pork cost US\$ 1-2 per kg. The cost of *prahoc* rose by 60 per cent between 2001 and 2003 due to low fish catch. If similar rises follow, food security for many Cambodians could be severely threatened as no substitute for *prahoc* exists.

Rab et al. (2004a, 2006), 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 caught was sold for cash, while a quarter was used locally for consumption or aquaculture (Table 22). This is to be related to the per capita consumption in Table 21: can 75 kg/person/year really represent only one fourth of the overall catch?

The consumption of fisheries products is extremely high in Cambodia, as illustrated in Table 21.

Hap et al. (2006) have dedicated a specific study to the values of Tonle Sap fisheries. In 2003, there were approximately 1.25 million people living by the Tonle Sap Lake. The majority of these people were involved in small-scale, non-commercial fishing. Although fishing is central to the lives of Tonle Sap people, it is important to recognise that their livelihood strategies are pluralistic in nature, and that the whole aquatic ecosystem and its

**Table 21: Fish consumption and contribution of aquatic resources to diet in Cambodia**

Figure	Source	Comment
13.5-40 kg of fish are consumed per person per year	Kim and Hav 2004	Consumption estimated before the study by Ahmed et al. (1998)
75.6 kg of fish are consumed per person per year	Ahmed et al. 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 65-75% of the animal protein requirements of households.	Ahmed et al. 1998	
79% of the animal protein consumed originates from fish.	Israel et al. 2005	Large-scale study (540 households in a northern, a western and a southern province)
On average, 53% of the vegetables consumed are sourced from aquatic plants; the figure reaches 61% among the lower wealth groups.	Israel et al. 2005	
5.2 kg of other aquatic organisms (non-fish) are consumed per person per year.	Hortle et al. 2004a	Other aquatic animals include shrimps, crabs, mollusks, frogs, etc.
4.5 kg of other aquatic organisms (non fish) are consumed per person and per year.	Mogensen 2001	

diversity of resources contribute to them. The gross annual income for these communities is estimated at US\$ 233 million. Of this, home consumption of fisheries products is worth US\$ 13 million and the collection of aquatic plants and animals is worth US\$ 5 million. Yet, there is a stark contrast in income levels among households around the lake. The poorest households, with an annual income of less than US\$ 1,000 make up 72 per cent of all households but capture only about one-third of this total wealth. These households are

engaged mainly in small-scale, subsistence fishing, and they are particularly dependent on the Tonle Sap Lake for their livelihoods. Also, it must be remembered that estimates of direct "consumption" use value focus exclusively on the economic value of the system and ignore the ecological and social values of these resources, as well as the total wetlands ecosystem of the area, which is comprised of lakes, rivers, streams, rice fields, and inundated areas.

**Table 22: Average catch and utilization of fish in Tonle Sap villages (Rab et al. 2006)**

	Average among all villages	
	Open season 2002	Closed season 2003
Total catch (kg)	3 501.0	488.0
Consumption (%)	5.0	12.5
Sold (%)	74.9	73.9
Processed (%)	9.3	1.2
Fish feed (%)	10.8	12.3

### 6.3 Socioeconomic Analyses

The first socioeconomic study of Cambodian fisheries after those of Le Poulain in the forties (Chevey and Le Poulain 1939, 1940; Le Poulain 1942) is that of Ahmed et al. (1998), which surveyed 83 fishing dependent communes in eight provinces of Cambodia and provided a detailed assessment of the socioeconomic 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 per cent of the households while another 34.1 per cent 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), which also focused 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 per cent 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 per cent of the households had access to common property resources, and nearly 80 per cent used big rivers and lakes for fishing and irrigation. Households primarily involved in fishing amounted to 39 per cent, compared to 77 per cent in farming.

In official statistics, however, the 1998 Population Census pretends that only 5.7 per cent of the people living in the Tonle Sap floodplain are involved in fishing. According to Keskinen (2003), this gross underestimation of the importance of fishing is due 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 23:

**Table 23: Proportions of primary and secondary occupations around the Tonle Sap Lake (Keskinen 2003, after Ahmed et al. 1998)**

	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%

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); this might help explain a negative migration rate in four of the five provinces surrounding the Lake (Haapala 2003).

Rab et al. (2004a, 2006) showed that fish-related activities make up to two-thirds of income in the villages of the Tonle Sap system (Table 24). They also highlighted the fact that households collect on average 2,355 kg of common pool resources per year (mainly aquatic plants and firewood) that have a value of US\$ 132.

The socioeconomic 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, and conservation. This preliminary approach, which 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; and
- 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 cited 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 to employ 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 per cent of the households harvested aquatic resources for consumption, 76 per cent sold fish and 61 per cent processed it. According to this study, aquatic resources also played a medicinal role for 10 per cent of the respondents (who do not have access to health services), and a

**Table 24: Average annual household income by source type (Rab et al. 2006)**

	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	1 158.5
Percentage	40.30	16.90	1.60	2.00	18.80	2.00	2.70	4.20	11.50	
	Two-thirds				One-fifth		One-fifth			

social and recreational role for 74 per cent of the households (festivals, ceremonies, etc.).

Another project focusing on fisheries-dependent livelihoods (Kaing et al. 2003) demonstrated that Cambodia's fishing-dependent population falls into 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 system<sup>20</sup>. In a detailed study focusing on policy options for the Tonle Sap communities (Agrisystems/CamConsult/MRAG 2004), ADB consultants demonstrated that priorities were different among communities, with those of the flooded areas being most concerned with renewable natural assets, while those in the transition zone focus 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 villagers desire 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.

## 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 per cent and caused 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; Hortle et al. 2004b), which is dominated by about 40 per cent 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 in 1999 resulted in over US\$ 2.5 million in lost income for 3,434 households. On average, livelihood income per household decreased from about US\$ 109 to US\$ 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

20 See [http://www.adb.org/Projects/Tonle\\_Sap/](http://www.adb.org/Projects/Tonle_Sap/)



(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 overexploited, a degree of protection is provided by keeping poachers out and preventing large-scale destruction of the flooded 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 suboptimal. 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 that are thought to be of marginal value for agriculture and crucially important for fish production (Van Zalinge 1998a).

Among the threats to fisheries are chemicals that are widely used in and around the Tonle Sap Lake. Sixty-seven per cent 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 liters of pesticides were used in the Tonle Sap catchment area (Yang et al. 2001). Many of them are highly hazardous chemicals (including DDT and methyl-parathion) imported from neighboring countries and used indiscriminately, for instance, to harvest fish or to preserve dry fish (FACT 2001; Touch and Todd 2003). Although one study of organochlorine residue levels based on 48 freshwater fishes concluded that Cambodian fishes are among the less contaminated in the region (In 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 (2002). Considering the ongoing 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; Kummu et al. 2005). This often-neglected fact 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 2000; FACT 2001). But there is also strong evidence that fish stocks have not declined; on the contrary, the overall catches at the moment are higher than any time in the past (Baran et al. 2001a; Van Zalinge et al. 2001). According to these researchers, 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 rare while small opportunistic species (of low market price but high nutritional value) are becoming more abundant.

The causes of the perceived decline are believed to be widespread illegal fishing and overfishing caused by an increasing number of fishers, together with ineffective fishing management by the government. Fishers themselves also state that illegal fishing and overexploitation are the main reasons for the decrease (e.g., Keskinen et al. 2002).

Fishing lots provide an example of changes in fishing patterns and conflicting interests. Fishing lots that are auctioned for exclusive exploitation of fish resources (Van Zalinge et al. 1998b) represent large-scale commercial fishing. In 1996, these fishing lots covered 80 per cent of the Tonle Sap's shoreline (Gum 2000). Following social pressure, 56 per cent 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 regarded by biologists as a good way to combine exploitation, environmental protection (Chheng 1999), and even biodiversity conservation (Coates et al. 2003). Hence, there is a dilemma between a "socially unjust" management system (as the fruits of the resource are captured by a few operators) that somehow contributes to conservation and a "socially fairer" open access system that is likely to result in unrestricted exploitation levels and thus jeopardize 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 per cent of the whole country.

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

Agriculture contributed 23.6 per cent to Vietnam's GDP (US\$ 32.7 billion) in 2001. From 1994 to 1997, the fisheries sector contributed about three per cent to the national GDP (Vo et al. 2003). However, Thai (2003) commented that the fisheries sector has developed rapidly and now contributes seven per cent to 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 cent per year, i.e., faster than in the rest of the country and four times faster than the population growth (Table 26).

**Table 25: Selected economic indicators for Vietnam from 2000 to 2003 (World Bank web site)**

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\$)	31.20	32.70	35.10	39.20
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	1.10
Population total (millions)	78.5	79.50	80.40	81.30

**Table 26: Number of fishers in Vietnam and in the Mekong Delta in 1990 and 1998 (after Vo et al. 2003)**

Region/ Year	Number of Fishers		% increment per year over 8 years
	1990	1998	
Mekong Delta	314 802	448 564	5.3
Whole Country	1 171 130	1 557 921	4.1

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 per cent 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.

## 7.2 Economic Valuation Analyses

### 7.2.1 Direct Use Value

#### 7.2.1.1 Catch values

National statistics for the inland provinces of the Mekong Delta, where fisheries are exclusively freshwater and brackishwater, detail the catch and the labor force as shown in Table 27.

However, scientific estimates once again 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 tonnes/year, of which 22,971 tonnes/year was from aquaculture and 64,587 tonnes/year from capture fisheries (AMFC 2002). In An Giang, near the Cambodian border, a study in 1999 estimated the annual production at 194,678 tonnes and consumption at 92,202 tonnes/year (Sjorslev 2001b). Jensen (2000) set An Giang total annual production at 180,000 tonnes, 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 and Pham (1999) put the catch in An Giang Province at 190.7 kg/person/year (40 per cent of the catch

**Table 27: Inland fish catch and labor force in two provinces of the freshwater area of the delta (General Statistical Office 1999)**

Year	Catch Dong Thap (tonnes)	Catch An Giang (tonnes)	Effort Dong Thap (number of fishers)	Effort An Giang (number of fishers)	Tonnes/man Dong Thap	Tonnes/man An Giang
1995	16 194	68 047	4 853	8 518	3.34	7.99
1996	28 292	72 004	5 109	8 967	5.58	8.03
1997	26 705	74 300	5 989	9 023	4.46	8.23
1998	27 118	76 577	7 092	8 899	3.82	8.61

coming from rice fields and 53 per cent from rivers and canals, with high variability depending upon profession and distance from waterways).

The productivity of Vietnamese inland waters is supplemented by that of reservoirs, acknowledging that most species originate from wild stocks. According to a study done in 1995 and cited in Vo 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 reservoirs (about 10,000 to 1,000 ha) and the highest yield (83.0 kg/ha) from small reservoirs (Ngo and Le 2001). Inland freshwater and brackishwater aquaculture ponds and tanks have 392,000 hectares of production area in Vietnam. However, most of the area is in the form of brackishwater ponds. Van Zalinge et al. (2004) estimated the total production of Mekong Delta aquaculture at 171,600 tonnes in 1999.

### 7.2.1.2 Consumption values

On the official side, wild and cultured fish account for about 40 per cent of the total

**Table 28: Consumption of rice, fish and meat in the Mekong Delta in 2000 (after Vo Tong Anh et al. 2003)**

	<b>Mekong Delta</b>
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

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 1994-97, the contribution of the fisheries sector to national GDP was about three per cent (Vo et al. 2003)

As mentioned above, scientific assessments at a more local level contradict the estimate of the overall fish consumption in the Vietnamese part of the Lower Mekong Basin, cited at 1,021,700 tonnes annually (Sjorslev 2001a). The average annual consumption of fish in Tra Vinh Province is 58.35 kg/person/year, of which fresh fish accounts for 41.86 kg/person, and fisheries products such as fish paste, dried fish and fermented fish account for 16.49 kg/person. An Giang Province has a very similar consumption figure, 58 kg/person/year, and Long An Province shows a slightly higher figure, 64 kg/person/year. In comparison, the average consumption of other animal products, such as pork, chicken and wildlife, is 35.58 kg/person/year in Tra Vinh.

## 7.3 Socioeconomic Analyses

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

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 et al. 2003). However, fish production in this region has fallen by 10-15 per cent compared to 20 years ago (Sinh 1995, cited in Vo et al. 2003). 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 in Vietnam, with 407,000 tonnes 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 both poor and rich rural people in the Mekong Delta, and not only for full-time fishers but also for households in which fishing is a component of wider livelihood strategies. More specifically, Phan and Pham (1999) found that while only three per cent of the 1,002 persons interviewed in An Giang Province were professional fishers, 37 per cent of the people were involved in fish-related activities. According to Sjorslev (2001b), however, in the same province, 7 per cent of the households were involved in professional fishing, 66 per cent in part-time fishing, and a further 5.7 per cent 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 aquacultural activities. At the national level, Vo et al. (2003) concluded that capture fisheries form an important livelihood strategy for both poor and rich rural people in many parts of Vietnam.

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 per cent of *low-income* households and 88 per cent of *very low-income* households were involved in fishing, as compared with only 58 and 44 per cent of *medium-income* and *high-income* households, respectively. 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 overfishing and use of damaging fishing methods; natural fish habitats and niches in the area have been reduced 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.

## 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 brackishwater inland, the saline intrusion being incompatible with intensive rice production. However, the complex and much documented saline intrusion issue is not the subject of this review focusing on fisheries.

The changes in river basin management have similar impacts on fisheries 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 (overfishing). Hashimoto (2001) extensively reviewed the consequences of infrastructure development on the environment of the Mekong Delta. The main negative elements, analyzed 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 aluminum in the area, and by washing away pesticides and pollution accumulated in waterways during the dry season. However, the significant increase in suspended sediment during the flood is detrimental to fish aquaculture production, and sometimes the sudden and large fluctuation in physico-chemical parameters also 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 it has never been studied in the case of the Mekong River and is surprisingly absent from discussions about the impact of reduced flows, although its importance has been highlighted several

times in the scientific literature focusing 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 being the most intensive worldwide in terms of catch per person. These aquatic resources are crucial to the income, livelihoods, and subsistence of the population; they not only 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 River 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 hasty development process carried out 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.

Although the value of inland capture fisheries is probably much better documented in the Mekong Basin than in Africa or South America, the accuracy of the data and lack of up-to-date data remain a major gap that must be addressed in order to provide more reliable information and contribute to policymaking 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 to i) accurately value the fisheries and ii) better communicate 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 opportunity does aquaculture present to improve security of fish supply? As aquaculture fish represents only 12 per cent of the fish resources basinwide

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 an aquaculture sector dependent on capture fisheries. In Cambodia, for instance, without the supply of wild fish, aquaculture would produce only 15,000 tonnes – just four percent of the fish that 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 four-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.

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This report is a compilation of five regional reviews that document the global status of tropical rivers and inland fisheries in three continents: Latin America, Africa and Asia. It explores the role of 'valuation' methods and their contribution to policy-making and river fishery management. From the compilation, the best estimate of the global value of inland fisheries for those three continents is US\$ 5.58 billion (gross market value), which is equivalent to 19 percent of the current value of annual fish exports from developing countries (US\$ 29 billion) for 2004.

The compilation shows that there is a general shortage of information on inland fisheries, especially derived from conventional economic valuation methods, though information from economic impact assessment methods and socio-economic and livelihood analysis methods is more widely available.

The status of knowledge about the impact of changes in river management on the value of tropical river fisheries is weak and patchy. Although the impacts of large dams on the hydrology, ecology and livelihood support attributes of tropical rivers are well-recognized, there have been only few valuation studies of these issues.

The document highlights the need for further valuation studies of tropical river and inland fisheries in developing countries. It underlines how vital it is for policy-makers and other stakeholders to understand the importance of these natural resources in order to make appropriate decisions concerning their role in development policy and illustrates why capacity building in valuation should become a major priority for agencies concerned with fisheries management and policy-making.



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