Review of River Fisheries Valuation in Tropical Asia

by

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ABSTRACT

This study attempts to estimate the economic value of riverine fisheries in tropical Asia, as well as quantify the economic impacts of any changes to the environment which affect 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 fishery characteristic 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.

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.

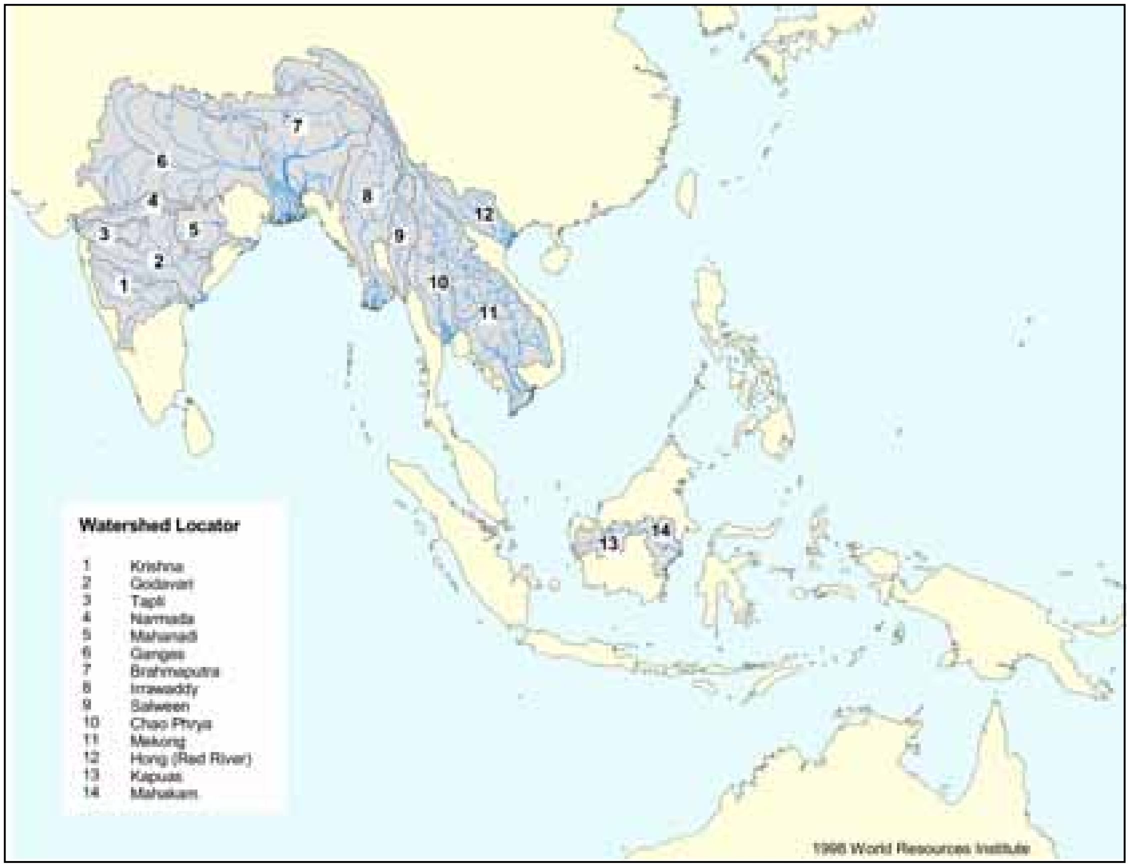
In tropical Asia a large part of the population is heavily dependent upon fishing within inland waters for their livelihoods. Catches in inland waters are profoundly influenced by monsoons and they have been observed to vary directly with water flow. In the dry season predictable periods of drought occur resulting in lower catches, to be 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 modelled 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 water level and the annual Dai catches. However, it is not only natural water flow which 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 not only competition for the usage of the river flow between countries but within different activities too, 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 to communities dependent upon fisheries.

For the purpose of this review, the geographical definition of tropical Asia will be defined as those watersheds that fall below or adjacent to the latitude denoted by the Tropic of Cancer (23^{o} 30’). Figure 1 illustrates the watersheds considered. This assessment includes the following countries: Bangladesh, Cambodia, India Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand and VietNam. China was omitted from this report due to the fact 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 data available.

The following paper is structured in seven sections following the abstract and introduction. Section two provides a description of the methodology used in this review. Section three briefly describes inland fisheries and riverine production in tropical Asia. Section four examines several economic valuation studies undertaken in tropical Asia. Section five highlights changes to the resource. Section six and seven present the discussion and conclusion. Finally, the references are presented in section eight.

Figure 1. The major river basins in tropical Asia



2. CONCEPTUAL AND MEASUREMENT ISSUES

2.1 Economic Value

In this section we describe recent developments of methodology in natural resource evaluation. As we shall see, 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) explain 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 piece of 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 individual 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

Placing monetary value on something as intangible as the environment is a controversial issue. Some of the points for and against this practice are worth consideration.

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 a certain tangibility to a resource's worth to society and as such any decisions regarding its 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 thus;

- 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 this data alongside other quantitative information. In these 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 judgement.
- 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' when describing 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. Accepting this, problems still arise in the way a 'value' is derived and is still the matter of some debate.

Reasoning 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 levelled against both the principle and practice of valuation. To start with, 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 degrade the debate. Secondly, the potential for manipulation is present. An accusation often levelled at *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). Thirdly, 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 of 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 both in respect of social attitudes towards the environment and the functioning of ecological systems. Barbier (1993) discusses the 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, 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 over-exploitation or excessive degradation of tropical wetlands.

Looking at 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 monetise only what can be monetised, 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* value. As Figure two demonstrates TEV is divided into *use-value* and *non-use* value. Use-values can be further divided into: Direct use-value, Indirect use-value and Option value. These terms are defined below.

Direct use-value, these are the most obvious benefits derived, where individuals exploit the resource for commercial, livelihood or recreational purposes;

Indirect use-value, where society does not profit immediately from the exploitation of the resource. An example is 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).

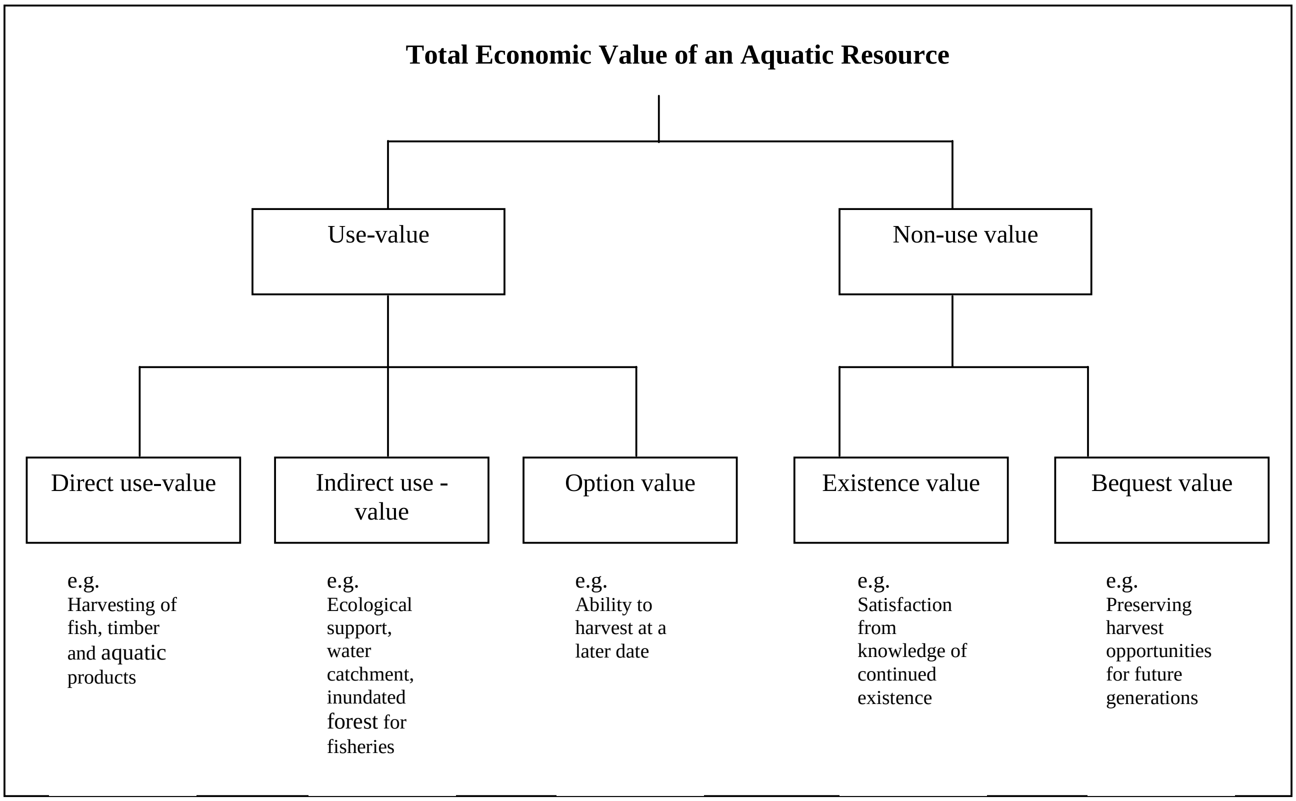
Option value, where individuals are prepared to maintain a resource for possible use at a later date.

Non use-values are broken down into: Existence value and Bequest value.

Existence value, where individuals are prepared to preserve something simply for the satisfaction of knowing its existence is assured.

Bequest value; where individuals derive value from maintaining something (e.g. a productive fishery) for the use of future generations.

Figure 2. Total economic value and its constituent parts



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 we move 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.

2.4 Applications of Resource Valuation

Economic efficiency analysis (EEA) is concerned with deriving the optimal allocation of resources in order to maximise 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 favourable (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 favoured.

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 that society is primarily concerned with. 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 & Soussan, 2003). This type of assessment is of use 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

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, via survey, what they would be willing to pay for the good or what they would be willing to accept in compensation were this good 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 modelling (Conjoint analysis (CA))

This is another direct technique. Data collection occurs via survey and is used to represent individual judgements of multi-attribute stimuli. Individual's 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.
Its four primary uses, 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 within limited resources.
- Produce overall benefit scores for alternative ways of providing a good/service; this allows the ranking of goods/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 overall benefit.
- Estimate whether an attribute is considered important.

Revealed preference methods – *estimation of people's preferences based on observed market behaviour.*

(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, a central assumption being 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 un-priced value of a location. The required data is commonly gathered by surveying site visitors.

(ii) Hedonic Pricing Method

Another indirect method, this assumes 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 seen much application 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.

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 very wide potential application to fisheries, because 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, of particular note being those by Hodgson and Dixon (1988) on coral reefs in the Philippines and by Barbier and Strand (1998) on mangroves and shrimp fisheries in Mexico. Despite its potential, the production function approach has a number of limitations. Firstly, 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* are unpriced. Secondly, 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).

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 centred approach, developed to help understand and analyse the livelihoods of the poor. The main aim of these techniques is usually to empower people and 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 modelling. 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. These objectives are as follows:

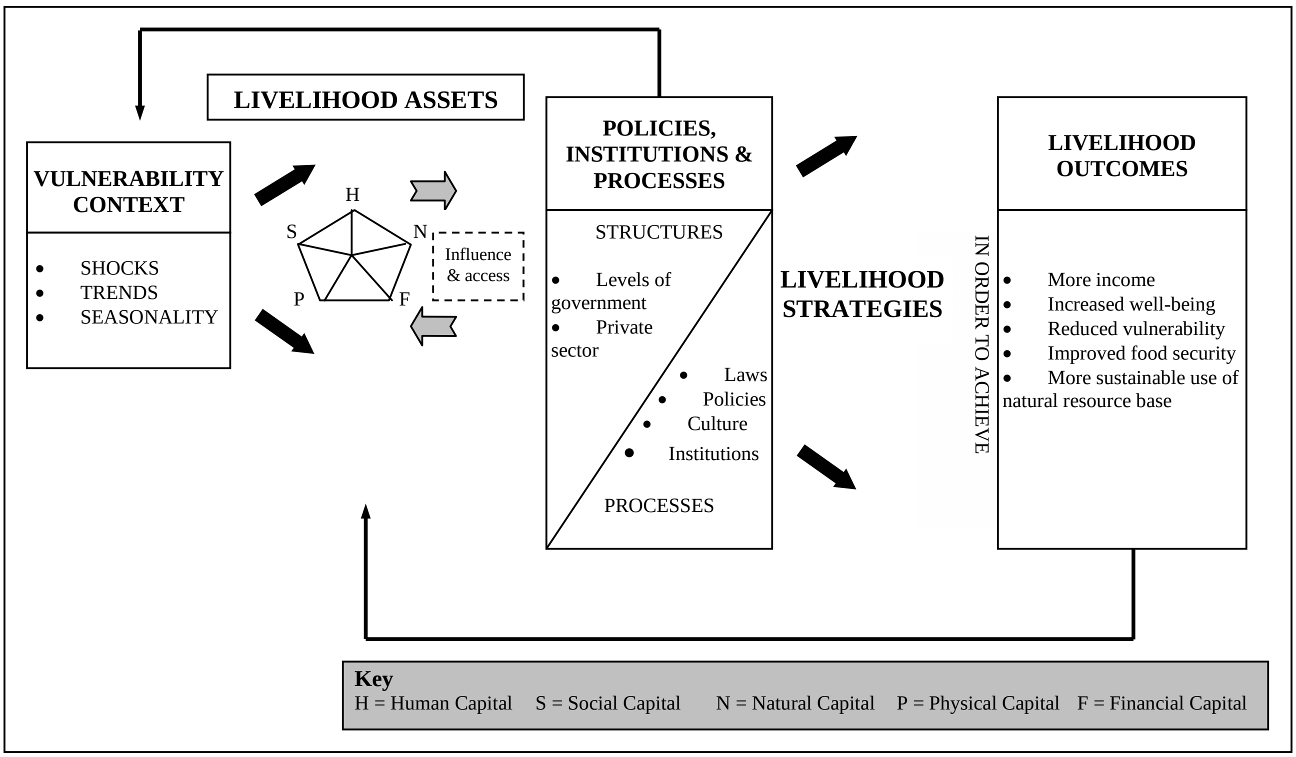
- improved access to high-quality education, information, technologies and training and better nutrition and health;
- a more supportive and cohesive social environment;
- more secure access to, and better management of, natural resources;
- better access to basic and facilitating infrastructure;
- more 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.

Figure 3 illustrates the framework of SLA, which 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, (5) the outcomes they achieve or aspire to. The framework summarises the main components of and 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 hard 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 understand quickly the area and the threats to the fishery and conflicts between different stakeholders. SLA can be very useful to provide an initial evaluation of the resource before other data collection techniques (e.g., socio-economic surveys) are used. As such the use of SLA is highly limited as a technique of valuing inland fisheries.

Figure 3. The Sustainable livelihoods framework



2.6 Data and sources of information

There are therefore a range of methods that can potentially be applied to value fisheries, the choice of which 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 we shall reveal shortly, the reason why the vast majority of empirical studies of Asian river fisheries have focussed 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 internet-based search of the peer reviewed, internationally recognised, literature and major databases. Due to nature of the subject there was also significant reliance on the so-called 'grey literature', such as reports produced by the OECD, DFID and the FAO. To contextualise these studies, Section 3 presents some basic factual data on the absolute and relative importance of Asian fisheries. In Section 4 we provide examples 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

Table 1 presents reported figures from FAO for inland capture, aquaculture and total production for the year 2002. This table also shows the percentage of inland capture fisheries to total production for each of the countries evaluated.

Table 1. Inland capture, aquaculture and total production in tropical Asia

2002	Inland capture (t)	Aquaculture (t)		Total production (t)	Marine production	% inland to total production
Country		Freshwater	Brackishwater			
Bangladesh	688435	696997	32026	1890459	473001	36.4
Bhutan	300	0	0	300	0	100
Cambodia	411150	14133	0	425283	0	96.9
India	425283	2076734	0	6061366	3559349	7
Indonesia	316030	429166	313531	5679391	4620664	5.6
Lao PDR	33440	59716	0	93156	0	35.9
Malaysia	3572	44370	310	1463625	1415373	0.2
Myanmar	304529	114716	0	1433908	1014663	21.2
Philippines	131111	147362	216686	3371874	2876715	3.9
Singapore	1058	616	0	7796	6122	13.6
Sri Lanka	28130	3670	0	306896	275096	9.2
Thailand	205500	327795	98	3566106	3032713	5.8
VietNam	149200	390000	28000	2042500	1475300	7.3

Source: FAO FISHSTAT PLUS

The values in table one indicate 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 effects of major loss of habitats caused by large scale water abstraction for irrigation, construction of embankments for flood controls, siltation and soil erosion due to deforestation in the catchments as well as effects of excessive fishing pressure and destructive fishing practices (FAO, 1994). When considering the proportion of inland capture fisheries to total production, Cambodia has the highest ratio (excluding Bhutan). Nevertheless, if we examine the Cambodian production, no marine fisheries are reported in FAO statistics. Cambodian marine production is very small in comparison to inland fisheries production but existent after all. 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 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 wide difference in the Cambodian fisheries statistics between different sources is not an isolated case. This issue is highlighted in Appendix one, which presents a compilation of the most recent estimates for riverine and floodplain fisheries production by country. This section provides an insight of the productivity of rivers and their floodplains within tropical Asia. However, this table also demonstrates the wide ranges 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 is a dominant hydrological structure in South-East Asia. It originates in China and flows through, Myanmar, Laos, Thailand, Cambodia and Viet Nam. Compared with other River systems globally, the Mekong ranks 8^{th} in terms of discharge (15,000 m^3/second). It is the 12^{th} largest River in the world (4,800 km) and it has the 21^{st} largest catchment area (795,000 km).

To the author's knowledge, no non-marketed valuation studies have been conducted to value environmental attributes of the Mekong River Basin. The need for such studies is increasing with rapid agricultural and economic developing in the Basin, resulting in increasing competition among the riparian countries for Mekong waters. Furthermore, there is not only competition for the usage of the river flow between countries but within different activities too, such as, captures fisheries, aquaculture, agriculture (irrigation), tourism, forestry and electricity generation. Several models have been produced in the literature in order to understand the interaction between different groups and different areas along the Mekong. However, 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.

Water use in the Mekong River Basin (Ringle and Cai , 2003)

The authors analyse alternative water using strategies and their implications on riparian countries and water uses. The Mekong Basin is divided into seven sites; One in China, one in Laos, two in Thailand, one in Cambodia, and two in Viet Nam. The baseline year is 1995. The data has 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).

Water supply is estimated through the hydrologic 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 maximising economic benefits to water use. The benefits from water use are presented in table two.

Table 2: Baseline Scenario, Profits from Water Use

Country/Region	**Irrigation**	**Domestic/ Industrial water use**	**Hydro-power**	**Capture Fisheries**	**Wetlands**	**Total**
(million US$)						
China/Yunnan	20	11	-	0.05	-	31
Lao	38	6	33	19	5	101
Viet Nam	513	81	-	188	44	825
Viet Nam/ Central Highlnd	29	6	-	-	-	35
Viet Nam/ 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

From table two, Cambodia is the only country obtaining its highest economic return from fisheries. The rest of the countries in the Mekong obtain their return from irrigation. This result agrees with those results from Seckler et al., (1998), who argue that irrigated agriculture is the largest user of the world's fresh water. Furthermore, the fisheries profits estimated by Ringle and Cai (2003) are similar to the direct use fisheries values estimated by Sverdrup-Jensen (2002). In table three, we present both results for comparison purposes.

Table 3. Fisheries production 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*
Sverdrup-Jensen (2002)	*Riverine capture*	*1,533,000*	*680*	*1,042*	-	
	Aquaculture	260,000	1050	*273*	-	-
	Reservoirs	240,000	680	*163*	-	-
	Total	*2,033,000*	-	*1,478*		

Ringle and Cai (2003) do not specify how they estimated the price and cost for riverine fisheries production. Sverdrup-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 680 US$/tonne is used, because although the fish are produced by both aquaculture and capture fisheries, the relative proportions cannot be estimated.

In the changes section, we present the results obtained by Ringle and Cai (2003) after they produce a sensitivity analysis in order to evaluate the variation in economic value for the different activities.

Economic valuation of mangroves in the Mekong Delta (Trong Nhuan et al. 2003)

The study concentrates on analysing the available data from previous research, and aims to provide the economic value (EV) of the main wetlands in Viet Nam. Two of the provinces analysed are Tra Vinh and Ben Tre (Tien River Estuary). The Mekong River ends in these two provinces. The following tables four and five present the EV estimated for the mangroves in both provinces. 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 recognised 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 it has been actually estimated.

Table 4. Ben Tre Province (Tien River Estuary)		
Direct Use Value	Low value (USD)	High value (USD)
Timber	9.52	10.34
Fuelwood	5.65	6.01
Coal	Not available	Not available
Aquaculture	1,401.96	1,469.28
Organised fishing	1,078.43	1,189.54
Unorganised capture fisheries (brackish/fresh)	316.99	409.80
Tourism	10.46	14.38
Indirect Use Value		
Stabilising micro-climate, improving air quality, water quality, preventing the site from water surge, etc	Not available	Not available
Economic Value / ha	***2,823.01***	***3,099.36***

Source: Adapted from a directory of Asian Wetland (2001) In *Trong Nhuan et al. 2003*

Table 5. Tra Vinh province		
Direct Value	Low value (USD)	High value (USD)
Timber	9.93	10.49
Fuelwood	4.90	5.39
Aquaculture	1,211.76	1,339.87
Unorganised capture fisheries (brackish/fresh)	947.71	1078.43
Tourism	166.01	186.27
Indirect value		
Stabilising micro-climate, improving air quality, water quality, preventing the site from water surge, etc	Not available	Not available
Economic Value / ha	***2,340***	***2,620***

Source: Adapted from Quynh, N.B., 2000 and Khuong, L.H., 2000 In: *Trong Nhuan et al. 2003*

Bangladesh

Net economic benefits from riverine fisheries in Bangladesh (Ahmed, M (1992); Ahmed, M (1996))

In these two studies, the author determines the total benefits obtainable from various riverine fisheries of Bangladesh (Ganges, Jamuna-Brahmaputra, Meghna and others) under an optimal management regime. This study uses a non-linear programming model. The use of a mathematical optimisation approach enables incorporation of non-linear catch-effort and cost functions as well as price-responsive demand functions in the model. 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 was the actual average annual catch during 1983-1984 to 1989-1990. Activity sets and constraints from 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 environment (different fishing grounds and/or rivers). The results presented in the following tables are for the whole fishery. Table six presents the actual and estimated catches and effort for the different river groups. Table seven presents a summary of results for the base model for all the riverine fisheries of Bangladesh.

Table 6. Distribution of catch (t) and level of effort (gear hr x 10^6) 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[a]	221,320	26,555	16,062	166,367	430,304
Total estimated effort[b]	93,793	7,637	6,684	88,940	197,054

[a] Approximate levels based on sample survey by the author, and survey of fishing units by DOF (unpublished data)

[b] Actual average annual catch during 1983-1984 to 1989-1990 (DOF unpublished data)

Source: Ahmed (1996)

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% higher than the estimated level of effort. In relation to individual rivers, the size of current effort is higher by 136% in Meghna River, 247% in Padma-Ganges River, 140% in Jamuna-Brahmaputra River and 87% for other rivers. This shows that the principal rivers, especially the Padma-Ganges River, have a relatively higher pressure of excess capacity as compared to small (other) rivers.

The author believes the reason for the high level of fishing effort in the Padma River is due to a 70% reduction in annual fishery harvest in the Padma River between 1983-1984 to 1989-1990. 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.

Table 7. Summary of results for the base model for riverine fisheries of Bangladesh

Benefit-cost (Bangladesh Taka x 10^6)	
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 10^6)	197,054
Catch per Unit of Effort (kg)	879

Source: *Ahmed, M (1996)*

Table seven presents the results of the base model. 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 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 total factor surplus.

The total cost of harvest and post-harvest activities is 4,251 million Bangladesh Taka, which is 77% of the gross revenue. Of the total cost, 57% represents cost of fishing or effort (2,435 million Bangladesh Taka). The remaining 43% (1,816 million Bangladesh Taka) represents market margin or the cost of post-harvest handling, processing, and transporting of fish and fish products, which is 33% of the aggregate gross revenue.

In the changes section, we will present the changes to the baseline model due to changes in fishing effort and demand.

Stocking seasonal floodplains in Bangladesh for Capture fisheries (Ali, 1997)

The contribution of inland open waters to the country's fish production has declined to about 50% at present. This has been due to the disturbance in natural reproduction of fish by overfishing and other causes. Under a project named Third Fisheries Project (TFP) carp fingerlings were directly stocked in mainly seasonal floodplains in western Bangladesh in 6 growing seasons (total cumulative area of 149,500 ha) 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 under-utilised 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 eight.

Table 8. Economic analysis of selected beels floodplain stocking (actuals 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
Costs (Tk'000)							
Stocking Cost	4,855	22,419	29,559	42,284	23,624	27,313	31,148
Fishermen Labour costs	634	5,696	8,645	10,991	9,922	11,591	11,591
Fisherm. 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
Benefits (Tk'000)							
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, 1997*

The analysis shows losses up to the third year, whereafter floodplain stocking will generate net economic benefit . From 1997 thereafter 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 fishermen fishing within the studied floodplains. The impact of floodplain stocking on local fishermen is summarised in table nine.

Table 9. Impact of floodplain stocking on local fishermen			
	Name of Floodplain		
Indicator	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)	20.3	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, 1997*

The socio-economic evaluation indicates a better status of local fishers resulting from the fingerling-stocking programme.

India

Social and Economic aspects of fisheries enhancement in Kerala reservoirs, India (Peters and Feustel, 1997)

Reservoir culture-based capture fisheries is relatively new in Kerala, India. Over-fishing 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 co-operatives and independent fishermen. The aims of the project are as follows:

- Involve fisherfolk in developing appropriate reservoir management strategies
- Provide fishery related income from the reservoir to the fisher folk
- Involve the community in planning and decision making
- Provide co-operative action planning and technical training to the target group

The authors undertook a socio-economic survey of five different reservoirs and used the recorded catches from the co-operative to estimate the returns from stocking the reservoirs. Recorded catches were believed to be greatly underestimated because the co-operative fishermen preferred to channel their catches to the market instead of selling them through the co-operative counter. This occurred because fishermen get a higher price for their catches in the market and also do not have to pay the royalty to the co-operative and the government. Below, we present the returns from stocking the

Malampuzha reservoir in order to show the decline in reported catches to the co-operative despite the increase in stocking (table 10). Also we present the difference in price obtained from the co-operative and the average market price near the reservoir of Malampuzha (table 11). Finally, the authors estimated the income of a co-operative fishermen income with a 5 kg average catch per day and average income from other professions per day (table 12). As it can be observed the income of a fisherman whose catch is less than 5 kg per day is far below the amount he can earn from daily wages in most other sectors.

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 fingerlings	0.30 Rs/individual	
Average Price for yield	25 Rs/kg	

Source: Peters and Feustel, 1997

Table 11. Comparison of market sales prices near Malampuzha reservoir & co-operative fishermen sales prices for fish

Co-operative Society Prices (in Rs)		Average Market Prices (in Rs)		
Species	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 co-operative fishermen income with a 5 kg average catch per day and average income from other professions per day

Catch (kg)	Fish Sales Price (Rs)	Total Value (Rs)	Co-op 25% Share	Govt. Share (Royalty) 25%	Daily Income (Rs)
5	20	100	25	25	50
Other Professions:		Agriculture Labour (Seasonal Men)			70-100
		Agriculture Labour (Seasonal Women)			45-70
		Firewood Collection (Women)			60
		Toddy Tapping (Men)			100
		Wood Cutting			125
		Minor Forest Produce Collection			50-60

Source: Peters and Feustel, 1997

Indonesia

Management options for the Inland Fisheries Resource in South Sumatra, Indonesia: Bioeconomic model (Koeshendrajana and Cacho, 2001)

Fishing is an important occupation for many 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 is undertaken, and an analytical model for identifying efficient levels of exploitation of the fishery is developed. The fishery is divided into two different types, the riverine and swamp fisheries. The swamp fishery refers to the sum of lake and swamp fishery data. Primary data are used to describe the current costs of fishing effort. Secondary data (catch data from

1979-1994), 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 Rp2,974 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 below:

Table 13. Calculated effort, catch, costs, revenues and profits of the inland fishery in South Sumatra Indonesia based on empirical model

Model/Resource	Harvest condition					
	MSY	MEY	MScY	BE	BESc	Actual (mean)
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 the inland capture fishery in South Sumatra has been over fished from both biological and economic perspectives during the period of the study, since actual effort is beyond both MEY and MSY levels. 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 which would be socially unacceptable if applied to the small-scale fisheries in Indonesia. Therefore, the author suggests policy action in the small-scale fishery, should instead be directed to maximising social yield

(MscY). Under social optimisation (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, 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% 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% 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 favoured.

Malaysia

Fisheries evaluation of the Chenderoh Reservoir using the rapid rural appraisal (RRA) technique (livelihood analysis) and fishermen survey (Ali and Lee, 1995)

A study on the artisanal fishery of Chenderoh Reservoir, Perak River, Malaysia was conducted using a fishermen and middlemen survey and RRA evaluation. The RRA provided the socio-economic background of the fishing community. Furthermore, the RRA indicated the number of landing sites, active fishermen 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 total daily landings. From this information, the author 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 effort (CPUE) to be calculated based on fisher day as a unit of effort. The following table summarises the monthly catch statistics of capture fisheries for the 1988-1989 season.

The study identified four commercial landing sites around the lake each controlled and operated by permanent middlemen. The total annual catch and income generated by the fishery was 25,713 kg and M$63,179.74 respectively.

Table 14. Monthly catch statistics of fisheries during 1988-1989 season

Catch Parameters	April	May	June	July	Aug.	Sept	Oct	Nov.	Dec	Jan.	Feb.	March	April	May
Total monthly catch (kg)	2542.1	1791.4	897.2	841.7	3328.6	803.4	704.5	5472.2	1928.6	1109.7	3376.3	1760.3	2815.9	3279.1
CPUE (kg/fisher-day)	6.5	7.3	8.4	2.7	9.5	3.3	2.8	12.8	7.1	3.0	10.4	8.6	7.2	6.5
Total daily catch (kg)	84.7	7.9	29.9	27.2	107.4	26.8	22.7	182.4	62.2	35.8	120.6	56.8	93.9	105.8
Total daily income (M$)	236.2	200.2	53.0	90.0	285.0	71.2	41.8	405.1	185.7	85.8	330.7	152.0	238.6	254.7
Total monthly income (M$)	7084.8	6006.2	1591.0	2699.6	8548.9	2135.9	1253.5	12152.2	5570.8	2575.0	9922.2	4561.1	7156.6	7639.7
Daily income/fisher (M$)	18.0	22.9	10.6	9.1	28.1	7.7	4.9	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

Sri Lanka

Valuing water in a multiple-use system (Renwick, M. E. 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), which 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-mater basis.

Initial failure of the KOSIP project to deliver an expected two crops a year on all 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% of household income in the KOISP. Paddy cultivation is the largest single source of agricultural income, averaging 30% for the area. However approximately half the households surveyed relied on fishing as the sole source of household income. Surveys were conducted with 12% (20) of the estimated 157 fisher boats operating in three reservoirs and obtained detailed information on: monthly catch, amount of catch sold and consumed at home, prices received in wholesale and retail markets, type of boat and nets, and detailed cost information. The economic contribution of inland fisheries in the KOISP area was calculated using the estimated economic returns to fishery operators and the value of water in fisheries. Data was collected for three of the five water bodies where commercial inland fisheries exist in the area; Lunugamwehera Reservoir, Wirawila Tank, and Yoda Wewa. In combination, these account for about 81% (4,100 ha) of the total reservoir surface area in the project area.

Table 15 presents catch, value of production, costs of production and economic returns for the three water bodies surveyed. Value of production was estimated based on actual monthly catch per unit of effort (CPUE) data, number of trips per month, home consumption, amount sold by each fisherman to wholesale and retail markets, and actual prices received. Average annual costs were calculated to average 23% of the total value of production in each reservoir. Economic returns per boat 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 and includes the costs of non-cash inputs such as labour and depreciation of fixed assets. This economic return per boat was estimated to be roughly US$ 2,789 and the average economic returns per fisher (usually 2 per vessel) to be approx US$ 1,395.

Annual returns to all five commercially important fisheries were estimated based on actual monthly returns to fishers by reservoir 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 in fisheries is roughly equivalent to 18% of the total economic returns in irrigated paddy production

Table 15. Catch, value of production, costs and economic returns (1999) for the three water bodies surveyed.

	Lunugamwehera	Wirawila	Yoda Wewa	Total
Catch per trip (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 m3 of water delivered (storage level)	0.16	0.46	2.38	0.23

Source: Taken from Renwick, M. E. (2001)

The use value of water in reservoirs was estimated based on reservoir storage levels (table 15). The per-unit value of delivered water in fisheries was determined to average 25% (0.0033 US$/$m^3$) of that for water delivered to irrigate paddy fields (0.0133 $/$m^3$). However, additional value was assumed as a large proportion of the water that supports fisheries ultimately ends up irrigating crops.

Fisheries are not currently recognised 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, that consider 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 seen 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%.

Assessment of the Economic Value of Muthurajawela Wetland. (Emerton & Kekulandala, 2003)

This report was based primarily on published literature and involved limited collection of original field data. The authors concede that few data exists on the economic value of the Muthurajawela wetlands and this study is a first attempt at estimating the economic value of conserving the region. The assessment of fisheries was limited to its direct use economic value, calculated using market prices of output. Data was insufficient to assess the value of fish breeding and nursery to downstream fisheries. Between 13-14% of the 1,200 local households are involved in fishing activities in the marsh area (this includes both fresh and brackish water parts). Fishing in the marsh is primarily for household consumption. The marshland also maintains and supports downstream fisheries production in the coastal Negombo Lagoon by trapping sediment, purifying wastewater, supplying freshwater and providing areas of habitat and fish breeding. The value of Negombo lagoon fishery was assumed to be Rs 200 million in 2002 (US$ 222,222)

Economic value;
Direct use

The marsh fishery was calculated to have a value of Rs 3,000/month.
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 only had a 10% impact on the fishery downstream).

The primary beneficiaries of the marshland fishery were deemed to be the 675 marsh-adjacent dwellers. Downstream 11,600 people depend on the fisheries in Negombo.

Table 16. Economic value of Muthurajawela

	Value ($/yr)	Value($/ha/yr)	Value as % of total
Flood attenuation	5,394,556	1,758	66.8
Industrial wastewater treatment	1,803,444	588	22.3
Agricultural production	336,556	110	4.2
Support to downstream fisheries	222,222	72	2.8
Firewood	88,444	29	1.1
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	2.8	0.11
TOTAL	8,072,111	2,631	100

(Source: adapted from IUCN, 2003)

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 will be examined from two perspectives – changes relating to fishery management factors (institutions and economic conditions) and changes relating to water management in river basins. A series of 6 case-studies are presented.

The Mekong River system

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 to 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 controlled by commercial fishermen for family 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 involves 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 was collected from a household survey questionnaire and the quantitative data for the commercial fishermen from a key informant interview with commercial fishermen. In relation to family fisheries, the Wilcoxon test showed with a 1% level of significance that capture fisheries for the 88 households interviewed (snails, whitefish, blackfish) and real prices of these products have changed significantly before (year 1998) and after (year 2003) the reform. The following table summarises these results:

Table 17. Family fishing capture fisheries 88 household surveyed

		Snails	Blackfish	Whitefish
Before reform (1998)	Quantity	2,645.35 kg	210.60	278.10 kg
	Real Price	188.75 Riel/kg	2085.63 Riel/kg	353.40 Riel/kg
After reform (2003)	Quantity	781.87 kg	80.96 kg	181.01 kg
	Real Price	481.58 Riel/kg	2940.83 Riel/kg	494.87 Riel/kg

Source: *Norman-Lopez, 2004*

Key interviews with lot operators and subleases 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).

Table 18 Cash flow for several commercial fishermen

LOT OPERATORS	CATCH & PRICE	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004
lot operator #1	catch blackfish	35,000 KGS	35,000 KGS	33,300 KGS	26,000 KGS	17,200 KGS	13,600 KGS
	real price blackfish	R2,759.25	R2,651.00	R2,670.75	R2,685.75	R3,960.36	R3,914.00
	catch whitefish	23,000 KGS	23,000 KGS	18,600 KGS	18,400 KGS	31,700 KGS	27,200 KGS
	real price whitefish	R772.59	R742.28	R747.81	R752.01	R1,250.64	R1,236.00
sub leaser 1 lot#1	catch blackfish	5,250 KGS	NOT SUB-LEASING		3,480 KGS	2,940 KGS	2,450 KGS
	real price blackfish	R2,759.25			R2,846.90	R3,699.81	R3,811.00
	catch whitefish	10,000 KGS			11,200 KGS	9,400 KGS	9,400 KGS
	real price whitefish	R596.00			R580.12	R896.29	R885.80
sub leaser 2 lot#1	catch blackfish	NOT SUB-LEASING					2,675 KGS
	real price blackfish						R6,180.00
	catch whitefish						1,300 KGS
	real price whitefish						R2,163.00
sub leaser from KREG	catch blackfish	NOT SUB-LEASING				2,810 KGS	2,810 KGS
	real price blackfish					R13,896.00	R13,733.33
	catch whitefish					3,100 KGS	3,100 KGS
	real price whitefish					R2,188.62	R2,163.00
lot operator #2	catch blackfish	9,300 KGS	NOT SUB-LEASING	LOT RELEASED TO COMMUNITY MANAGEMENT			
	real price blackfish	R1,655.55					
	catch whitefish	19,800 KGS					
	real price whitefish	R331.11					
lot operator #3	catch blackfish	12,000 KGS	LOT RELEASED TO COMMUNITY MANAGEMENT				
	real price blackfish	R2,759.25					
	catch whitefish	17,000 KGS					
	real price whitefish	R772.59					
lot operator #5	catch blackfish	77,400 KGS	77,400 KGS	77,400 KGS	73,700 KGS	58,200 KGS	45,000 KGS
	real price blackfish	R2,759.25	R2,651.00	R2,670.75	R2,685.75	R3,647.70	R3,914.00
	catch whitefish	32,600 KGS	32,600 KGS	32,600 KGS	21,400 KGS	25,000 KGS	23,000 KGS
	real price whitefish	R772.59	R742.28	R747.81	R752.01	R1,250.64	R1,236.00

Source: *Norman-Lopez, 2004*

Changes in water use value due to variation in water flow, wetland value and fisheries exploitation cost (Ringle and Cai , 2003)

In page 15, we present the hydrologic-economic model developed by (Ringle and Cai, 2003) in order to value water supply in the Mekong River system. In this section we present the changes in water use value due to changes in water inflow, wetland value and fisheries production cost. Sensitivity analysis estimates the variation in water use value in comparison to the base model. The authors estimate a reduction in water flow (50%, 60% and 80%) and increase in water flow (20%), a decline (US$16) and increase (US$ 50) in wetland value and finally a reduction (50%) and increase in fishing costs (200%) compared to the base model. Table 19 presents these results.

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$)							
	BASE MODEL	*917*	*170*	*43*	*546*	*134*	*1,809*
Inflow	50%	586.9 (64%)	161.5 (95%)	24.1 (56%)	174.7 (32%)	109.9 (82%)	1049,2 (58%)
	60%	632.7 (69%)	168.3 (99%)	28.0 (65%)	245.7 (45%)	116.6 (87%)	1193,9 (66%)
	80%	871.2 (95%)	168.3 (99%)	32.7 (76%)	447.7 (82%)	127.3 (95%)	1646,2 (91%)
	120%	944.5 (103%)	170 (100%)	43.9 102%)	726.2 (133%)	128.6 (96%)	2008.0 (111%)
Wetland value [a]	US$ 16	917 (100%)	170 (100%)	43 (100%)	546 (100%)	107.2 (80%)	1790.9 (99%)
	US$ 50	917 (100%)	170 (100%)	43 (100%)	546 (100%)	335 (250%)	2008.0 (111%)
Fisheries production cost [b]	50%	916.1 (99.9%)	170 (100%)	43.9 (102%)	726.2 (133%)	133.9 (99.9%)	1989.9 (110%)
	200%	917 (100%)	170 (100%)	43 (100%)	218.4 (40%)	134 (100%)	1483.4 (82%)
[a] Baseline value is US$ 20							
[b] Baseline value is US$ 280							
Source: *Ringle and Cai , 2003*							

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% reduction in water flow will reduce fisheries profits in comparison with the base model by 18%. On the other hand, a 20% increase in water flow will increase fisheries profits by 33% 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% of baseline profits, and overall basin profits to 110%. Increased fish production profits causes a slight reduction in net irrigation profits, and an improvement in hydropower profits to 102% of baseline values.

Bangladesh

Performance-response of the inland fishery under different simulated changes in cost of harvest and changes in aggregate demand for fish (Ahmed, M (1992); Ahmed, M (1996))

Changes in the cost of harvest

The model used in the analysis has been previously discussed in page 18**.** In the analysis, the author studies the case where effort is fishery specific but flexible to operate in different fishing grounds. Table 20 shows the aggregate results of variations of cost of harvesting in percentage terms of the Base model costs.

Table 20. Behaviour 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[a]						
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[b]	483,363	303,101	197,054	131,493	84,671	38,787
CPUE (kg)[c]	632	759	879	990	1,141	1,396

[a] In million Bangladesh Taka (US 1$ = BDT32)
[b] In gear hours x 10^6
[c] CPUE = catch per unit of effort

Source: *Ahmed, M (1996)*

Overall, table 20 shows that a decline in costs by 25% and 50% will increase fishing effort and catches. This result implies the potential catches of the fishery are much higher than the actual catches. If the fishery was being exploited at its full potential, a decline in fishing costs could increase fishing effort but catches would hardly change or even decline due to the excessive exploitation. On the other hand, a 25%, 50% and 100% increase in fishing costs would reduce fishing efforts and catches.

The shadow price of effort would be lower for cost increases and higher for a cost decrease at a given level of effort. This implies that an increase in the cost condition of harvest would shift the curve of 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.

Changes in Aggregate Demand

The change in aggregate demand imply changes such as population and real income. Changes in demand were shifted up and down by 10% and 20% from the Base model demand intercepts. The results are presented in table 21.

Table 21. Behaviour 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[a]					
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	4,51	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[b]	310,900	247,995	197,054	142,178	91,250
CPUE (kg)[c]	746	833	879	978	1,153

[a] In million Bangladesh Taka (US 1$ = BDT32)

[b] In gear hours x 10^6

[c] CPUE = catch per unit of effort (Ratio of total catch to total effort)

Source: *Ahmed, M (1996)*

As table 21 shows, 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 compared to the Base model. The results again imply the potential catches are higher than the actual catches. If the fishery was at its full potential, fishermen would increase fishing effort but catches would remain the same or even decline. The author also examines the shadow prices of effort under alternative demand conditions, and concludes that the optimal level of effort is higher for increases in aggregate demand while lower for decreases in the aggregate demand.

Sri Lanka

Valuing water in a multiple-use system (Renwick, M. E. 2001)

The study looks at the economic contributions of agriculture and reservoir fisheries within the Kirindi Oya irrigation and settlement project (KOISP) in southeastern Sri Lanka (p.26). Furthermore this study went on to model the potential outcomes of three alternative water management schemes. In KOISP the reservoirs provide storage for irrigation water and habitat for fisheries. Therefore allocation and management decisions for the purposes of irrigation directly affect reservoir fisheries by changing water levels.

Based on the assumption 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, on mean monthly storage levels for each reservoir, and on reservoir dummy variables for the different reservoirs to capture differences between them.

The model was deemed to perform well with an adjusted R^2 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% decrease in storage is associated with a 2.1% 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.

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, M. E. (2001)

Initially the proportional allocation of water between irrigation and reservoir fisheries was changed, increasing that allocated to irrigation and consequently reducing the volume available for fisheries (scenario 1). The affect of more efficient management of this increased volume, for the purposes of irrigation, was then looked at (scenarios 2 & 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, resulting in overall economic gains for the area.

Scenario one, which reduced reservoir levels by 14.47 MCM would lead to higher fishery yields and an economic gain of 42,000 kg of fish or approximately US$ 10,000 $year^{-1}$ over the status quo scenario. The optimal estimated economic gain to paddy farming of this increased allocation of water was US$ 613,000 $year^{-1}$ (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^3$) and that with more efficient management the value may be further increased (0.0148 US$/$m^3$). The average per-unit value for fisheries is significant (0.0033 US$/$m^3$) and would be higher if the gains can be made to both simultaneously.

Adaptive, Participatory and Integrated Assessment (APIA) of the Impacts of Irrigation on Fisheries – Evaluation of the Approach in Sri Lanka (Nguyen-Khoa, Smith & Lorenzen, 2005)

A later, ex-post, APIA study of the Sri Lankan KOISP project assessed the economic impacts of its implementation on the areas fisheries. 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 habitat
- excessive drawdown of water levels for reservoir fisheries
- impacts of drainage inflow to the lagoons
- conflicts 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 projects scope.

As table 23 demonstrates the KOISP project was shown to have a modest positive impact on pre-existing fisheries in terms of aggregate production and value.

Table 23. KOISP fisheries balance in terms of production and value

	Before KOISP			After KOISP		
Water body	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-Khoa, Smith & Lorenzen, 2005)

The reduction of river flow was thought to have had little impact, in terms of fisheries, as neither subsistence nor commercial fisheries had ever developed in the floodplain. Substantially increased aggregate fish production resulted through the creation of a large new reservoir compensating for any downstream losses. However negative impacts of scheme operation and water management on the actual production of the pre-existing reservoirs and lagoons was valued at Rs 225,000. This combined with 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. It was also recognised however, that not all the issues were related to the KOISP project. The aforementioned extreme drawdown in reservoirs resulted from lower than normal rainfall and increased demand for irrigation water from the pre-existing reservoirs.

The authors conclude stating that, if savings can 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 national fish output, employment and improved nutrition for poor households.

Impact of dams

According to Marmulla (2003) construction of dams and weirs for irrigation, hydropower generation or flow management has a long tradition in many parts of the world, and 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 contributes to a large degree, together with other factors, to the diminished abundance, disappearance and even extinction of species. Marmulla (2003) highlights that LARS2 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 an increasing feature of developing countries, compared to developed ones, and their number is expected to increase in developing countries at a faster pace 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 feature of many national development plans to control flooding, regulate and store water for agriculture and electricity generation. For example, there are 160 dams currently proposed for the River Mekong Basin alone.

While the impact of dams on river fisheries has been recognised, 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 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 45K ha 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 under 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, like 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, and 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 to distinguish the impacts attributable to the dam as opposed to other impacts such as over-fishing.

In India, there are two major dams on the tributaries of the Ganges at Hardwar and Farakka and both have produced major environmental changes, as well as causing political problems between the India and Bangladesh (Mukerjee, 1998). The dams have impacted negatively on fish migration and production, although associated reservoirs have given 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 the 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 provided fishery values in specific areas but also allowed us to put into perspective the value of riverine fisheries compared to other riverine resource uses such as, forestry, agriculture (irrigation), electricity generation etc. Table 24 provides a summary of the empirical studies that have been considered in this report. The table presents the country/region where the study was undertaken, author, 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 equally 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 CV technique to measure the conservation value of water, fish and mangrove of a wetland in Sri Lanka. This report highlighted 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 not included within 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), Ringle and Cai (2003)) provide not only the present value of the fishery but they 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 three). 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 under reported and studies usually differ in data collection methods as well as accuracy. This problem is highlighted in Appendix one. For those countries where several reports present fisheries production, high variations in values exist. This is for example the case with Lao PDR, in the year 2000, the reported capture production in the Mekong river system was 27,000 tonnes. Nevertheless, Van Zalinge *et al.*, (2003) estimated capture fisheries production in the Mekong from consumption values to be 182,700 tonnes in the year 2000. In relation to prices, a large variation in the quoted figures is apparant (see Appendix two). The main problem is due to unit values being derived from estimates based on different fresh water species in different areas of the country. Appendix three provides a range of values for the riverine fisheries of each country reviewed. This 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 realisation 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. Only when more rigorous investigations are conducted, that capture **all** the values derived from these resources, should we be confident enough to consider the figures 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 therefore 'valuable' on a number of different definitions and measures, but we need 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 over-exploited, 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 re-appropriated, should therefore be a priority. While this will require economic research, which can only be undertaken at a cost, policy makers will be rewarded with improved knowledge of how to manage these fisheries for the benefit of Asian communities.

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 & Cai (2003)	Production Function & Sensitivity Analysis	Value of the fishery US$ 546.3 million. Negative correlation between water flow & 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) & Tra Vinh province (US$ 2,340 – 2,620)
Bangladesh	Ahmed (1992); Ahmed (1996)	Supply-Demand model, Cost-Benefit & Sensitivity Analysis	Net benefit yielded from the various riverine fisheries (US$ 43 million). -VE correlation between costs of production & fishing effort. +VE correlation between aggregate demand & fishing effort.
	Ali & Islam (1997)	Cost-Benefit Analysis	Net benefit from stocking seasonal floodplains for capture fisheries (42,848,000Tk)
India	Peters & Feustel (1997)	Socio-Economic Survey	Failures of Co-op 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 & 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 & reservoir levels relationship & scenario analysis	Estimated total annual economic returns for five reservoirs in KOISP project region (US$ 544,000 – 566,000)
	Emerton & Kekulandala (2003)	Estimated economic value (EV) using secondary data	Estimated direct use value for Muthurajawela wetland marsh fishery ((US$ 69,556)
	Nguyen-Khoa et al, (2005)	Livelihood Analysis	Increase in aggregate economic value of fisheries after implementing the KOISP project (284,000 Rs)
Cambodia	Norman-Lopez (2004)	Livelihood Analysis & Socio Economic Survey	Overall decline in catches & increase in prices for commercial & subsistence fishers due to legislative reform

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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 & 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)	Nissanka *et al.*, 2000 average yield of 11 reservoirs in 1998 (118.59 kg/ha/yr); Average yield multiplied by the total surface area of major, medium and hydro-electric reservoirs (110,491 ha); subtracted from FAO FishStat Database inland capture fisheries production (1998) 29,900 tonnes; equals 16,796.57 tonnes (approximate River production)
Cambodia	1995	400,000	Jensen (2000b)	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 Water bodies	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 North-East 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 & 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 Center 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 Water bodies (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 & Cai (2003)	Production in the Mekong River system
	1995	> 1,200,000	Jensen (2000b)	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 0.68US$/kg This generates a value for the Mekong River system of 1,042,000 US$
	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 Water bodies	Production in rivers, lakes, floodplains, reservoirs and lagoons
	2002	530,000	ASEAN Database of Inland Water bodies	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.
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 Water bodies	Production includes lakes, reservoirs, rivers, floodplains and marshes

APPENDIX 2

Capture riverine (and floodplain) prices				
Country	**Year**	**Prices (US$/kg)**	**Author**	**Comments**
Bangladesh	1995	0.812	Ahmed (1996)	32.555 Bangladesh Taka/kg. Average exchange rate (1995): 40.100 Bangladesh Taka/US dollar. The price is derived from freshwater capture fisheries of several species caught in main rivers in Bangladesh (Jamuna-Brahmaputra, Meghna, Padma-Ganges and other rivers)
	1997	0.815	Ali and Islam (1997)	35 Bangladesh Taka/kg. Average exchange rate (1997): 42.930 Bangladesh Taka/US dollar. The price is derived from average freshwater capture fisheries of species caught in beels (deep floodplains) (stocked and non-stocked species)
	2002	1.098	Dey *et al.*, (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species
India	1991-96	0.796	Peters and Feustel (1997)	25 Indian rupee/kg. Average exchange rate (1995): 31.410 Indian rupee/US dollar. The price is derived from freshwater capture fisheries of major carp species stocked in reservoirs (*Catla catla, Labeo rohita, Cirrhinus mrigala, Labeo fimbriatus, Cyorubys carpio*)
	2000	0.717	Dey *et al.*, (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species
Sri Lanka	1999	0.239	Renwick (2001)	Average price, 16.76 Rs/kg, of freshwater capture fisheries from Lunugamwehera reservoir, Wirawila Tank, and Yoda Wewa reservoir. Approximate exchange rate: 70 Rs/US$
	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 (2000b)	The author averaged production in the Mekong River system to also be 0.75 US$/kg. [The author estimated production in Cambodia as 400,000. So estimated value of production is 300 US$ 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: 2317.66 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 [4454.75 Riel/kg(commercial fishermen); 2940.83 Riel/kg (local fishers)] Whitefish [1380.2 Riel/kg (commercial fishers) 494.87 Riel/kg (local fishers)]. Only 1 commercial fisher removed from

				estimation due to variability in estimate from other fishermen. Exchange rate (2003-4): 4016.25 Riel/US$
Lao PDR	2002	0.553	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	1.297	Dey *et al.*, (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species
Vietnam	2000	1.326	Dey *et al.*, (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species
	2000	0.357	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	0.750	Ringle and Cai (2003); Jensen (2000b)	Prices from freshwater capture fisheries. Value at retail market price. [Jensen (2000b) estimated production to be > 1.2 million tonnes. So production estimated 900 – 1000 US$ million]
	2000	0.680	Sverdrup-Jensen (2002)	Prices from freshwater capture fisheries. Average first hand sale price
Myanmar (Burma)	1999	0.148	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	1.413	Coates (2002)	Price derived by dividing value of tender ‘open’ 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$16) by quantity (10kg) of fish sold at market. Fish sold were mainly snakehead, relatively high value.
Indonesia	1994	0.563	Koeshendrajana and Cacho (2001)	Price obtained from Musi River. Average actual price of riverine freshwater fish at the producer level was 1,215 Rp/kg. Average exchange rate (1994): 2,160 Rp/ US$
	2000	0.514	Dey *et al.*, (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species
Philippines	2000	0.804	Dey *et al.*, (2004)	The price has been derived by dividing value and quantity from a range of capture and culture species
	2002	0.025	ASEAN Database of Inland Water bodies (2005)	Freshwater capture production from lakes, rivers, reservoirs and marshes. Exchange rate: 1 US$ = 1 PHP
Malaysia	1988-89	2.457	Ali and Lee (1995)	Capture fisheries production in Chenderoh Reservoir, Perak River, Malaysia. Exchange rate from author: 2.6 M$/US$
	2000	1.833	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 [1]	1098 [a]	616,883	Value derived from river and floodplains
	124,000 [2]	1098 [a]	136,152	Value derived from catches for all rivers
India	28,500 [3]	796 [b]	22,686	Production in rivers & canals
Sri Lanka	16,797 [4]	8015 [c]	13,462	Approx. river production value
Cambodia	289,000 [5]-682,150 [6]	544 [d]	157,216 – 371,090	Est. production from the Mekong river floodplins and Tonle Sap lake
	400,000 [7]	750 [e]	300,000	Est. from Jensen (2000b)
	284,000 [8]	510 [f]	145,000	Est. from Nam & Thuok (1999)
Lao PDR	17,790 [9] - 27,000 [10]	553 [g]	9,838 – 14,931	Reported production in Mekong river and tributaries
	182,700 [6]	553 [g]	101,033	Est. from Mekong river and floodplains
Thailand	200,000 [11] – 500,000 [11]	1,297 [a]	259,400 – 648,500	Est. national production from rivers, floodplains, canals, lakes, marshes. Excludes reservoirs.
Vietnam	136,000 [11] – 844,850 [6]	842 [h]	114,512 – 711,364	Est. production from rivers and floodplains
Mekong (Cambodia, Lao PDR, Thailand, Vietnam)	809,000 [5] – 2,642,000 [6]	680 [i]	550,120 – 179,656,0	Est. production from Mekong river and floodplains
	> 1,200,000[7]	750 [e]	900,000 – 1,000,000	Est. from Jensen (2000b)
	1,533,000 [12]	680 [i]	1,042,440	Est. from Sverdrup & Jensen (2002)
Myanmar	253,373 [13] – 2,900,000 [11]	781 [j]	197,884 – 702,900	Est. production in rivers, lakes, floodplains, reservoirs & lagoons
Indonesia	297,300 [14] – 900,000 [11]	514 [a]	152,812 – 462,600	Est. production in rivers, lakes, swamps, floodplains & reservoirs
	191,805 [11]	514 [a]	98,588	Est. river and swamp production for the main islands (Kalimantan, Java, Sumatra, Maluku, Irian Jaya, Bali & Nusa Tenggara) the only island not included is Sulawesi due to lack of

				data
Philippines	131,644 [15]	415 [a]	54,632	Est. production in lakes, reservoirs, rivers & marshes
Malaysia	3,369 [9] – 10,008 [11]	1,833 [a]	6,175 – 18,345	Lowest value represents reported production in lakes, reservoirs, rivers, floodplains and marshes. Highest value represents est. production for same areas.

Origin of data used	
Quantity (Appendix 1)	**Price (Appendix 2)**
[1] DoF (1998)	[a] Dey *et al.*, (2004)
[2] De Graaf & Chinh (2002)	[b] Peters and Feustel (1997)
[3] Sugunan (1997)	[c] Average from; Renwick (2001) & Dey *et al.*, (2004)
[4] Nissanka *et al.*, 2000; FISH-STAT FAO (2005) and De Silva (1988)	[d] Average from; Nam and Thuok (1999) & Norman-Lopez (2004)
[5] Baran (2005)	[e] Jensen (2000b)
[6] Van Zalinge *et al.*, (2003)	[f] Nam and Thuok (1999)
[7] Jensen (2000b)	[g] Singhanouvong and Phouthavong (2002)
[8] Nam and Thuok (1999)	[h] Average from; Dey *et al.*, (2004) & Mai *et al*, (2003)
[9] ASEAN (2005)	[i] Sverdrup-Jensen (2002)
[10] Van Zalinge *et al.*, (2000)	[j] Average from; Coates (2002)
[11] Coates (2002)	
[12] Sverdrup & Jensen (2002)	
[13] FAO (2003)	
[14] BPS Statistics Indonesia (2000)	
[15] Bureau of Fisheries and Aquatic Resources (2004)	