The Valuation of Riparian Fisheries in Southern and Eastern Africa

By

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SUMMARY

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

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

There is concern that the capacity for fisheries to form part of a risk-spreading strategy is being diminished by development processes which lead to overexploitation. Fisheries in the region range from those that are primarily subsistence fisheries, through semi-commercialisation to primarily commercial fisheries, and where controls are weak can become overexploited with a predominance of outsiders in the fishery. This tendency is exacerbated by a general trend of weakening of traditional leadership and control of natural resources. The stage of development and status of a fishery should be taken into consideration in the execution and interpretation of valuation studies.

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

The valuation methods used have all involved fairly straightforward conventional economic valuation based on market-based methods. Many also included a degree of livelihood analysis, in that the role of the fisheries in their contribution to household livelihoods was examined. Only two included economic impact assessment.

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

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

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

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

1. INTRODUCTION

Fisheries are one of the most important of the wide range of benefits to society that aquatic systems provide, often sustaining the livelihoods of poor rural communities. There is growing concern that the manipulation of aquatic systems to provide water for external uses such as urban consumption and irrigated agriculture, threatens the production of fishery resources, and thus also the livelihoods of many users. However, decisions about water allocation need to be well informed if the right tradeoffs are to be made. It is thus important to understand the contribution that aquatic ecosystem goods and services make to food security, local livelihoods and local and national economies, if these are to be taken into account in water allocation, policies, institutions and governance, and also in schemes to maximise such values. It is also important in other cases where compensation for a loss of fishery production is required.

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

- Review published and grey literature concerning economic valuations of river fisheries in southern and eastern Africa.
- Extract the best available information on the direct economic value of these fisheries, as well as information on the wider social value accrued through processing and marketing activities.
- Extract the best available information on the economic impact of any decreases in fisheries catches due to dam construction, water abstraction, or other changes in water management.
- Assess the methodologies used in these studies and provide recommendations on the most suitable for future use, with modifications as appropriate for different sites and circumstances.

The review concentrates on rivers, but also covers their floodplains, floodplain lakes and major deltas, all of which are integrally part of the flowing system and affected by water allocation decisions. These will be collectively referred to as riparian fisheries. Estuaries should also fall into this grouping, but have not been included here because they introduce another level of complexity (see Lamberth & Turpie 2002, for example). The fisheries associated with large lakes (e.g. Lake Victoria, Lake Malawi) and reservoirs or dams (e.g. Lake Kariba) are not considered here. The review begins by giving a brief background to southern and east African river fisheries, and their socio-economic context. It then describes existing case studies on the value of fisheries and the impact of dams on fishery values, before discussing methodological issues and making recommendations for future studies.

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

2.1 The scale and importance of freshwater and riparian fisheries

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

Fish contributes a substantial amount to the diet and protein intake in many countries in the region (Table 1). It is particularly important to the poor because it is often cheaper than meat.

Table 1. Fisheries statistics for countries in eastern and southern Africa (1990).

	Fisheries production (capture only) (t/yr)[a]	**Value fish production: ex-vessel prices (US$million/yr)**[b]	**Apparent Cons-umption (kg/capita)**[c]	**Fisheries exports % Agricul-tural GDP**[d]	**Employment (primary + secondary)**[e]
Angola	238 351	83 500 000 (1996)	10.2	3.9	85 000 + 8000 (1996)
Botswana	166	N/a	5.2	1.4	2720 + n/a (1989)
Burundi	10 000 F	8 000 000 (1997)	2.3	0.4	3-4000 + 9-10 000 (1997)
Djibouti	350 F	N/a	2.2	0.6	N/a
Eritrea	12 612	5 500 000 (2002)	0.9	58.2	3500 + 10 000 P (2002)
Ethiopia	15 681	1 500 000 (1994)	0.2	N/a	37 270 + n/a (1994)
Kenya	215 106	264 500 000 (1997)	5.4	3.7	35-40 000 + 140-150 000 (late 90’s)
Lesotho	32	40 000 (2000)	N/a	N/a	100 + n/a (1998)
Malawi	45 000 F	49 500 000 (1995)	4.5	0.9	40 000 + n/a (1995)
Mozambique	39 065	25 000 000 (1997)	2.6	64.1	7000 + 73 000 (1997)
Namibia	282 965	356 500 000 (2000)	11.6	60.7	7530 + 6470 (2000)
Rwanda	6 726	6 173 913 (2001)	1.0	0.1	30 000 + 5 500 (2001)
Somalia	20 200 F	N/a	2.4	3.3	N/a
South Africa	643 812 F	N/a	6.7	10.9	27 000 A + 100 000 (1998/9?)
Swaziland	70 F	100 000 (1997)	10.2	3.9	200 + n/a (mid 90’s)

Tanzania	332 779	580 000 000 (1997)	8.8	16.7	
Uganda	355 831	361 000 000 (1997)	8.9	10.0	100 000 + 400 000 (late 90's)
Zambia	66 671	44 400 000 (1998)	7.3	1.4	40 000 + 300 000 (mid 90's)
Zimbabwe	13 114	N/a	2.5	5.3	N/a

[a]World fisheries production by capture (2000): Source: FAO Summary Tables. FAO estimates are marked by "F".
[b]Gross value of landed catch from various years (in brackets). Source: FAO Country profiles. Note: For many of these, export and import figures are higher, suggesting that this may not be the best indicator of fishery value.
[c]Relative importance of trade in fishery products in 2000: Source: FAO Summary Tables

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

2.2 Contribution to livelihoods

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

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

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

2.3 The dynamic nature of fisheries

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

Stage 1. Primarily subsistence. There are no significant markets, and the fishery is geared towards consumption or local exchange. These are typical in isolated areas with low population density. They employ simple fishing techniques (handlines, traps, baskets, small weirs, cast or dip nets), are seasonal, and usually involve men, women and children.

Stage 2. Semi commercial. As populations increase, increased marketing leads to intensification, new gear, and a higher catch per unit effort (CPUE). Gill and seine nets commonly adopted, in addition to traditional methods. Trade starts to take place via middlemen, and women tend to be excluded from commercialised fishing, remaining in the subsistence fishery.

Stage 3. Primarily commercial. Further development leads to intensive exploitation for local and regional markets. Outsiders move into the fishery seeking profits, and the fishery becomes dominated by gill and seine nets, such that traditional methods are rare. Total catch increases, but CPUE drops as more people enter the fishery. Marketing is dominated by middlemen.

Stage 4. In situations of weak or inappropriate management, the traditional fishery becomes totally marginalized and the fishery becomes overexploited, such that there area low returns to all and the resource declines. There is also a widening socio-economic gap between a majority of small-scale fishermen and a minority of successful entrepreneurial fishermen. Women become excluded from the sector. The last situation arises due to a complex set of factors such as water tenure, credit policies and management strategies (Scudder & Conelly 1985).

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

2.4 Control and sustainability of fishery values

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

3. RIPARIAN FISHERIES VALUATION STUDIES

Many of the riparian fisheries of eastern and southern Africa, especially the larger floodplain systems, have been described in some way, and several are well studied. However, very few of these have involved the valuation of these fisheries, and almost none have been published. For example, extensive work has been carried out on the Phongolo floodplain (see reports edited by Walmsley & Roberts 1988 and Merron & Weldrick 1995), much of which was done in response to impending development, but no valuation study was carried out. In another case, Tvedten *et al.* 1994 produced a comprehensive overview of Namibian freshwater fisheries, but although various prices were reported, they did not attempt valuation, and this was at least partly due to their philosophy on its usefulness.

Valuation studies that were identified in this review are listed in Table 2. However, it must be emphasised that the search was not exhaustive due to time constraints, and may not have unearthed all existing 'grey literature' reports.

Table 2. Summary of fishery assessments involving some level of valuation in southern and eastern Africa. (Note: this list may not be exhaustive).

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

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

3.1 Rufiji Floodplain & Delta

Turpie (2000) conducted a study on the use and value of natural resources of the lower Rufiji River floodplain and delta as an input into the development of a management plan for the area. The 720 000 ha study area encompassed the lower stretch of the Rufiji River from the boundary of the Selous Game Reserve to the coast.

The area was divided into three ecoregions for the study – the floodplain area (containing 8700 households), delta area (5093 households) and a 'transition area' between the two, in which 2300 households had close access to both floodplain and delta resources.

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

Nearly all households in the area consider farming as their primary economic activity. At least 24 types of crops are grown in the area, with rice, maize, sweet potatoes, millet, vegetables and fruit being the principal subsistence crops. Additional crops such as cashew nuts are grown for cash income. Very few livestock are kept in this area. In addition, numerous types of natural resources are harvested by households in the area, including salt, grass, reeds, palm leaves, firewood, timber, mammals, birds and honey. Nevertheless, fishing is considered to be one of the most important activities, and is carried out by 57% of households (Turpie 2000). This proportion is relatively constant throughout the floodplain and delta areas, and is far more than the 19% of households estimated twenty years ago (FAO 1979).

Most freshwater fishing takes place in the numerous permanent lakes of the floodplain, which provide breeding habitat for fish and are replenished in most years by floods. In the delta, fishing is in the estuarine and shallow inshore coastal waters. The majority of fishes use nets, although traditional traps and hooks are also still commonly used. Gill nets were introduced in the 1960s and only became common in the 1990s (Sorensen 1998). Seine nets are also used. Women in the delta use mosquito nets suspended between poles for catching shrimp. About half of fishing households own canoes (Table 3).

Table 3. Average numbers of different types of fishing equipment owned by fishing households in three areas of the Rufiji floodplain and delta, based on household survey data. (Turpie 2000)

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

The freshwater fishery is very unselective in terms of both species composition and size: over 40 freshwater fishes occur in the floodplain system (Hobson 1979), of which more than 30 were named by fishers as being part of their catch. The fishery is, however, dominated by the most common species, notably the cichlid fish *Oreochromis urolepsis*, commonly referred to as tilapia, and also catfishes (*Clarias, Schilbe* and *Bagras*) and *Alestes*. At least 30 species are caught in the delta. The most important fish reported in catches was *dagaa*, a general term for small fishes such as mullet, and *mbarata*, a term for clupeid fish such as *Hilsa kelee*. Prawns (mainly *Peneaus indicus*, *Metapenaeous monocerus* and *Penaeus monodon*) are the most valuable fishery in the delta, where they form a large proportion of catches (Turpie 2000).

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

In all cases, fishing areas are close to villages, but seasonality in fish availability necessitates migrations of fishers. Focus group data on seasonality revealed a clear trend for peak catches to be later and later as one moves downriver (April to October), while prawn fishing is said to vary up and down the coast in response to seasonal wind shifts. The extent to which fishers track these patterns is evident from the numerous fishing camps along the lake shores, river and delta. There is thus extensive overlap in the use of fishing areas by people from different villages, and outsiders are common in the coastal fishing camps in the delta. Although there are government regulations requiring licences, the fisheries are effectively open access resources.

The total finfish catch was estimated to be about 9000 tons per year, with freshwater fish making up about 5500 tons (Turpie 2000). This is within the estimated sustainable yield of the floodplain area of about 7500 tons, based on Welcomme's (1974) relationship between floodplain area and catch (38kg/ha). It is also higher than a previous estimate of 3 841 tons for freshwater fish, when a much smaller proportion of households were engaged in fishing (Hobson 1979). Finfish catches from the delta have also been estimated to be smaller in the past, amounting to 1835 tons (Euroconsult 1980). The artisanal prawn fishery catches in the order of 2200 tons per year, and an additional 113 tons of shrimps and 34 tons of crabs are also caught (Turpie 2000). The prawn catch estimated by Turpie (2000) was higher than official statistics of 360 – 1583 tons in 1987-1992 and the 1620 tons estimated by Euroconsult (1980). Turpie's (2000) estimates were, however, lower than those made by a parallel sociological study of 1700kg per user household, which would lead to double the total catch estimate, and an ongoing survey of landing sites, which were purportedly yielding estimates in the order of 10 000 tons (E. Chirwa, *in litt*).

The gross value of the fish and prawn catches (excluding minor coastal crustacean fisheries) were estimated to be US$3.76 and US$4 million, respectively (Tables 4 and 5). This value includes the value of household consumption. In order to calculate net value, input costs were quantified based on the cost and durability of fishing equipment (including canoes) and the number per household, and variable costs, such as firewood for smoking.

Most fish in the study are sold dried or smoked, except for a small proportion sold fresh on the local market. Prawns are always sold fresh except for the leftovers (small or damaged prawns) which are dried. Prawn dealers supply nets and ice boxes, and are nearly always on hand to ensure the swift export of prawns from the delta. Thus, input costs in the fishery were not high for local fishers, but their bargaining power might have been reduced by these arrangements. A high proportion of catches were sold, and much of the gross income generated was realised in the form of cash income (Tables 4 and 5). Fishing households generate cash incomes of $213-476 per year, which is substantial in this area.

Table 4. Estimated total catch of finfish by residents of the Rufiji floodplain and delta, based on household survey data. Values in Tanzanian Shillings (TSh 800 = US$1 at time of study) Source: Turpie 2000.

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

Table 5. Estimated total catch of prawns by residents of the Rufiji floodplain and delta, based on household survey data. Values in Tanzanian Shillings (TSh 800 = US$1 at time of study) Source: Turpie 2000.

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

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

Based on estimates of the income from all household activities, fisheries were estimated to contribute 22-48% of the net income to households (including subsistence value), and 38-54% of household cash income (Table 6). Thus fishing is extremely important to these households. Based on the overall estimates of total net value, the direct use values of mangrove estuaries and inshore waters were estimated to be about $192/ha/y, while freshwater systems were estimated to be worth $42/ha/y.

Table 6. Estimated annual total net income (including subsistence value) and cash income per household in the Rufiji floodplain and delta. Values in US$. Source: Turpie (2000)

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

3.2 Kilombero floodplain

The Kilombero floodplain fisheries are considered to be one of the greatest fishery resources in Tanzania (Mapunda 1981). Mapunda (1981) reported on government catch records and estimated value of the subsistence fishery (Table 7), but no additional information was given on how the data were obtained.

Table 7. Fish production and values for the Kilombero floodplain (Mapunda 1981)

Year	Fishermen	Catch (tons)	Value of catch (US$)	Value per canoe (US$)	Value per fisherman (US$)
1977	350	7031	43 572	150.20	124.50
1978	332	2042	13 911	55.60	41.90

3.3 Lower Shire River

The Lower Shire River, and associated floodplain wetlands (Elephant Marsh and Ndinde Marsh) cover about 162 000 ha and are surrounded by a relatively dense population of about 395 000. The area has better access to markets and far more commercial activity than many of the other major floodplain wetland systems in the region. Both subsistence and commercial fishing is carried out. Fish and fisheries play a major role in the economy of the area and provide dietary protein for many rural households and for urban dwellers as far as Blantyre. Some 53% of households in the area are involved in fishing (Turpie *et al.* 1999). Turpie *et al.* (1999) conducted a valuation study of the natural resources including fisheries. This entailed initial village meetings, then focus groups (for general information) and a household survey to quantify resource use.

The lower Shire fisheries have been well studied in the past, and comprehensive fish checklists are available (Timberlake 1997). However, until recently renewed research interests in the area, the last studies were conducted in the 1970s. About 12 species are exploited commercially, and three species make up 90% of the catch – *Clarias gariepinus*, *C. ngamensis* and *Sarotherodon mossambicus*. Gill nets are the most common modern gear, and cast and seine nets are also used. Many fishers use traditional gear, and wall traps constructed from reeds are used by 27% of fishing households. Mean reported fishing household catch was 317kg per year, yielding an estimated total catch of 9 750 tons. This is similar to the potential catch of 9000 tons calculated from Welcomme (1975). About 40% of fishing households sell an average of two thirds of their catch for cash income. Much of this is sold to middlemen who transport the fish to surrounding towns.

Table 8. Annual values (US$) of the Lower Shire fishery, southern Malawi (Turpie *et al.* 1999).

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

Catches are highly dependent on floodwater levels, with poor floods resulting in a low annual catch. At the time of study, there had been a good flood, and good catches for the first time in several years. Indeed, fishery department statistics indicate major declines in recent years. Their estimates declined from 11 000 tons in 1989 to 1800 tons in 1996. The fishery is an open access fishery with no licensing and poor extension services. Outsiders are common. Policing is non-existent, mosquito nets are common, and even members of the fisheries department were using shade-netting. Thus a combination of factors makes the current value of the fishery lower than it could be if well managed and sustainable.

3.4 Zambezi – Barotse floodplain

The area associated with the Barotse floodplain wetlands on the upper Zambezi is approximately 1.2 million ha in extent, with the main wetland area extending over about 550 000 ha. Its approximately 224 000 inhabitants fall under the dual administration of the Barotse Royal Establishment and the Central Government. The Lozi culture and traditions are closely linked with the seasonal flooding of the plain, with people moving between the uplands and wetlands. As with many of the other systems mentioned here, people derive their livelihoods from a number of sources, with agriculture being the most important activity and livestock being of great importance as a source of wealth. Fishing provides the traditional staple relish of the floodplain people (99.3% of households consume fish) and is an important source of income (Turpie *et al.* 1999). Many other natural resources are also harvested for subsistence use and cash income. Less than 5% are in formal employment (Simwinji 1997). The fishery is one of the most important sectors in the Western Province (van Gils 1988), with most production being consumed locally. However, there has been very little research on the Barotseland fishery apart from earlier descriptive work (e.g. Kelly 1968, Bell-Cross 1971, 1974) and government catch statistics from landing sites. Using these, van Gils (1988) correlated fish catch to the length of the flood season.

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

Table 9. Annual values (US$) of the Barotseland fishery on the Upper Zambezi, Western Zambia (Turpie *et al.* 1999).

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

Catches are highly variable from year to year, but villagers agreed that their catches had declined markedly over the past four decades. This is blamed on the introduction of modern gear and population increases (Turpie *et al.* 1999). The fishery is regulated by government and traditional laws, and has the advantage of a fairly strong traditional structure controlling access. However, rules such as mesh size are flouted (many fishers use mosquito nets), since the penalty had not been revised since 1974 despite rampant inflation (Turpie *et al.* 1999). A closed season was imposed in 1986 by government, but was ineffective because traditional authorities were not consulted.

3.5 Zambezi - Chobe floodplain system

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

The fish of the Zambezi-Chobe region of eastern Caprivi are highly diverse, with up to 74 species having been recorded, and are a major resource in Caprivi (Van der Waal & Skelton 1984, Bethune & Roberts 1991, Holtzhausen 1991, Timberlake 1998, Mendelsohn & Roberts 1997). Indeed, according to a common saying, "if you don't fish you are not a Caprivian" (Tvedten *et al.* 1994), although this particularly applies to the traditionally floodplain living and fishing Subia tribe. Some 75% of households in the eastern Caprivi/Zambian floodplain area (population about 30 000) are engaged in subsistence fishing (Turpie *et al.* 1999). Households in the area eat fish almost daily, and fish is rated as the most important source of protein (Turpie *et al.* 1999).

Fishing is in the main river channels during low water periods and on the floodplain during the flood months. Gill nets are the most common gear, with 98% of fishing households reportedly using an average of 4 nets at any one time (Turpie *et al.* 1999). Seine nets, hooks and traditional gear are also used. The traditional methods such as fence traps, spears and baskets, catch a broader suite of species (van der Waal 1990). About 87% of fishermen use dug-out canoes, with 67% owning them (Tvedten *et al.* 1994).

Catches include a large variety of species, with *Oreochromis*, *Serranochromis* and *Clarias* dominating by weight. Household survey data suggested that fishing households fished on average 760 hours per year and caught 370 kg, yielding a total estimated catch of 1279 tons. Some 64% sell an average of 10% of their catch. Prices fluctuated seasonally and between species, and for dried vs fresh fish. The gross value of the fishery is estimated to be almost $1.5 million, yielding substantial subsistence value to households. The cash income was small, however, and this can be at least partly attributed to the lack of access to markets. These values exclude the recreational fishing which also takes place in the area, but which does not compete much with the artisanal fishery.

Table 10. Annual values of the Zambezi-Chobe fishery in Kabe district, eastern Caprivi (Turpie *et al.* 1999).

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

At a broader level, the total catch of the Caprivi region, which includes the rest of the Chobe and the Kwando-Linyanti systems, has been estimated at 1500 tons (Tvedten *et al.* 1994). This was valued by multiplying the weight by a price range to obtain an estimated total value of N$6.75 – 9.75 million (LaFranchi 1996), or roughly US$1.35-1.95 million. Thus the two studies generated fairly similar estimates of gross income. LaFranchi (1996) emphasised the importance of recognising the subsistence value of the catch.

There is some doubt that the current catch is sustainable. The estimated catch is above the government estimates of MSY (400 tons for the eastern floodplains and 300 tons for the Zambezi), but below the estimate of 1800 tons one would obtain using Welcomme's (1974) roughly 40 kg per ha of floodplain area. However, much of this floodplain is inundated only very rarely. Van der Waal (1990) showed a decreasing trend in CPUE between 1975 and 1980, and villagers described decreasing availability of fish over the past four decades (Turpie *et al.* 1999). This is in spite of the fact that villagers do perceive a greater level of access control in the fishery than in other areas (Tvedten *et al.* 1994, Turpie *et al.* 1999).

3.6 Chobe - Lake Liambezi system

Lake Liambezi is particularly interesting from a fishery valuation perspective. The lake, which falls within the Chobe floodplain, but which is also fed from the Zambezi via the Bhukalo channel, is a large floodplain wetland of some 10 000 ha which may be alternatively dry or inundated for periods of several years. It is inundated during high flooding events, and once full, the lake may remain inundated for several years. Several long dry periods have been recorded, the most recent of which was from

1985-6 to 2001, when the lake started to fill up. When the lake is inundated, it becomes a highly utilised fishing area by the surrounding inhabitants. When dry, a few fishing households continue to fish by travelling to the Zambezi and Chobe Rivers, but there is a significant decrease in fishing activity by households in the area. Studies were carried out on the Lake Liambezi fisheries during the 1970s and 80s, and it is estimated that catches amounted to about 600-800 tons per year (van der Waal 1990). The fishery was not given a value at the time. While dry or partially filled, most of the Liambezi flood area is vegetated with floodplain grassland, and much of this is cultivated. This was the situation when Turpie & Egoh (2002) carried out a valuation study as part of an impact assessment for a proposed sugar estate within the Liambezi floodplain area. The situation at the time is described below.

Households in the study area were be divided into those living within easy reach of both the Chobe River and Lake Liambezi (Zone CL), and those within reach of Lake Liambezi only (Zone L). Focus groups were used to collect general information, and an extensive survey was carried out of over 80% of households to collect quantitative information. According to household survey data, 22% of CL households and 7% of L households had been fishing in the past year (Turpie & Egoh 2002), which is a very much lower proportion than one would expect when the lake is inundated. Fishing households were well equipped, with 86% and 59% having canoes, and an average of 5.5 and 1.5 nets per household in zones CL and L, respectively (Table 11). Traditional fishing methods are considered old fashioned and mainly used by old people (Turpie & Egoh 2002).

Table 11. Fishing gear owned by households around Lake Liambezi (Turpie & Egoh 2002)

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

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

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

Table 12. Annual values of the Liambezi-Chobe fishery in eastern Caprivi (Turpie & Egoh 2002)*.

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

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

3.7 Okavango River, Namibia

The fishery of the Okavango river is amongst the most traditional fisheries in Namibia (Tvedten *et al.* 1994). It is interesting to compare this fishery with the Caprivi fisheries. There is much greater use of traditional gear (100% of fishing households vs 82% in Caprivi), and lower use of modern gear (43% vs 98% in Caprivi). Indeed fishers claim to prefer traditional gear. Along with this is a much greater proportion of women fishers (55% vs 15%), and even less marketing of fish (Tvedten *et al.* 1994). Most fishers describe the resource as open access (Tvedten *et al.* 1994). High species richness is recorded, and cichlids dominate catches. Estimates of catches vary. Van der Waal (1991) estimated that 35 000 residents fished 40 days per year and caught 840 tons, while Tvedten *et al.* (1994) estimated that 56 000 residents fished 60 days, yielding 1 045 tons. Estimates of the MSY range from 840 – 3000 tons. Van der Waal (1981) estimated the total economic value of the Okavango fishery to be R1.8 million annually. The fishery makes an important contribution to household food security, as a food source, and as cash income. The protein and micronutrients are also especially important as a contribution to household nutrition and health. The fishery also reportedly helps sustain the social and cultural fabric of communities along the river. Most fishing is for home consumption, and agricultural food production rarely fulfils household food requirements. Agricultural productivity is also declining, so fish is becoming relatively more important (Tvedten *et al.* 1994). Residents recalled that people relied on fish during the 1978 drought to see them through. Fishing is also important during the famine season, before crops are harvested.

Cash earned from the sale of fish is usually small – about N$45/month on average. However it needs to be stressed that "this income is integrated into a risk-averse strategy of diverse income source, contributing to household income security and indirectly to the village economy" (Tvedten *et al.* 1994). Agriculture is the mainstay of daily subsistence, but household security depends on availability of cash income for food, household goods, clothing and school fees, etc. Selling fish is seen as a quick , low risk source of cash (Tvedten *et al.* 1994). Even wealthier households with wage earners participate in fishing to diversify their income sources. Sometimes fish is bartered directly for maize meal.

Using the catches reported in Tvedten *et al.* (19994), LaFranchi (1996) estimated the total value of the catches to be N$2.6-5.2 million, or roughly US$0.5 – 1 million (LaFranchi 1996). Household level income was not estimated.

3.8 Zambezi Delta

The Zambezi Delta in Mozambique extends in a large triangle from Mopeia to the coast, some 120km downstream. It covers an area of 1.4 million ha, and has a population of about 250 000, having been somewhat depopulated during the civil war. The area is extremely isolated, with very poor road access from centres such as Beira and Quelimane. Most households are involved in subsistence activities, with 95% depending on agriculture (Turpie *et al.* 1999). The fish and fisheries of the lower Zambezi have been described (Jubb 1967, Willoughby & Tweddle 1978, Sweco 1982, DNFFB 1998), but had not been valued prior to Turpie *et al.* (1999). Turpie *et al.* (1999) used focus groups to obtain general information and conducted a household study in three parts of the delta to obtain quantitative information.

Artisanal fishers use canoes (67%), gill nets (44%), seine nets (2%), hooks (35%), and circle and basket traps (6%) (Turpie *et al.* 1999). At the coast, seine nets are also used for prawn fishing. Fishers concentrate in small fishing camps along the river banks and coast. Because of the scale of the delta and the variety of habitats involved, the fishery is quite diverse. In the outer delta (towards the coast), about 37% of the catch comes from the marine environment (Turpie *et al.* 1999). This was excluded in the valuation.

About 78% of inner and 66% of outer delta households were engaged in finfish fishing, and an additional 27% of households in the outer delta were prawn fishers. Catches of freshwater and estuarine fishes were 267kg and 450kg in the inner and outer delta, respectively, yielding an overall estimated catch of 15 610 tons. With a flooded area of about 500 000 ha, the delta could yield about 19 000 tons per year (Welcomme 1978). Based on the fact that much of the delta is inaccessible, Sweco estimated that the catch would be about 10 000 tons (Sweco 1982). Government statistics, which are just from the 15 registered fishing camps, give the estimated catch as 645 tons (DNFFB 1998). In addition, prawn fishing households in the outer delta caught an average of 328kg per year, not including the marine portion of their catch, and about 70% of the catch is sold.

Table 13. Annual values (US$) of the Zambezi Delta fishery in Mozambique, excluding marine catches (Turpie *et al.* 1999)*.

	Gross income	Net value	Cash income	Net economic value
Per user household - finfish	115	110	60	120
Per user household – prawns	131	125	21	143
Total– finfish	4 995 000	4 792 000	2 603 000	5 226 000
Total - prawns	129 000	124 000	20 000	141 000

Catches, however, are dependent on flood levels, and are much lower in poor flood years. This study was conducted during a period of good floods (Turpie *et al.* 1999). Nevertheless, fishers complain that catches on average are much lower than in the 1960s before the construction of Cahora Bassa, which has radically reduced freshwater inflows into the system.

Fisheries in the delta are regulated in theory by means of a licencing system. However, fishers maintain that monitoring is scarce, and some were unaware that there were any regulations at all (Turpie *et al.* 1999). However, it appears that the impact of freshwater flows might be greater than that of overfishing, especially considering the relatively low population density in the delta.

3.9 Mutshindudi River

Recognising the need to understand the value of goods and services provided by instream flows for water allocation in South Africa, Van der Waal (2000) studied fish utilisation by a rural population around the Mutshindudi River, part of the Limpopo system in Northern Province. Little attention has been devoted to the use of fish in smaller rivers such as this, and these fisheries are generally not considered to be important, with the result that their benefits are ignored in planning and management (van der Waal 2000). The study involved an attitude survey and a survey of fishing activities. In the latter, fishers were approached while fishing, an asked a number of open-ended questions while their catch was recorded. The status of the fish resource was also assessed. Many types of gear were identified, mostly modern gear such as gill nets or modernised traditional gear (traditional traps constructed with shade netting). Catches were dominated by small tilapias, small barb species and catfish. Catches were quantified in terms of average catch per fishing trip (162g), and from this the annual catch per fisher of 16kg per year was estimated from an estimated 100 fishing trips. At an estimated value per kg, this represented a rather small annual income of R130 (compared with the relatively small cash income of about R2400 – 6000 per household). Even though the investment in fishing gear was very low, this still meant a low return on investment. Van der Waal (2000) then estimated the total value of the fishery to be about R20 – 40 000, based on assumed total length of fishable river (75km), and estimated number of fishers (125-250 active per day). Thus total value of the fishery was essentially estimated on the basis of average catches in a sample of fishers (162g per day), with all other values based on professional judgement.

3.10 Crocodile River

One of the first attempts to value a river fishery in South Africa was a brief study on the Crocodile River in Mpumalanga Province (Cox *et al.* 2001), which aimed to demonstrate the way in which valuation might be carried out in the determination of the environmental reserve for a river system. The river flows through private lands of a fairly affluent region for most of its course, but also borders part of a former homeland area in which tenure is communal and inhabitants have a largely subsistence economy. There are thus both recreational fisheries (for exotic trout and indigenous yellowfish) and subsistence fisheries on the river. Cox *et al.* (2001) surveyed 10 known fishing households in the communal area on the use of a variety of river resources. No background information on the fishery was obtained, e.g. from focus groups. Respondents were asked about numbers of each type of fish caught per day and the number of days and months fished. These data were used to estimate average numbers of fish caught per household per year. Fishing was reportedly mainly in summer. The data for the six types of fish named were eventually lumped in the analysis, and valued according to size alone. An average price was assigned to all fish, and a gross value per fishing household was calculated as average catch per month x 3 months x average price. In rather a back-of-the-envelope estimation, it was assumed (without any basis) that 15% of households (~11 000) in the communal area were close to the river and that 30% of these (~ 3400) would be fishing households. These sums led to a gross value estimate of about $1.17 million per year (Cox *et al.* 2001). The estimate is not reliable, however, due to the sample size and survey design, even though it was apparently only intended to demonstrate the possible order of magnitude of the value.

Cox *et al.* (2001) also tackled the recreational fishery. A survey was distributed to all flyfishing clubs, generating 28 useable responses from the estimated total 1600 fishers (1.75%). The questionnaire aimed to establish the value of equipment used, its durability, numbers of fishing expeditions per year and costs per trip, time spent fishing, and fees paid. From this it was estimated that fishers spent a total of about $2.5 million per year on this activity (Cox *et al.* 2001). Again the estimate cannot be considered reliable because of small sample size, a badly designed questionnaire and probably avidity bias. The questionnaire lacked explanation of purpose, was difficult to follow, questions had no time frame and it generated data that would make results challenging to defend statistically. Thus it is not surprising that the responses generated required several follow-up calls (Cox *et al.* 2001).

4. VALUATION OF POTENTIAL CHANGES DUE TO WATER DEVELOPMENT PROJECTS

Losses in downstream fishery production as a result of dam construction is a well known phenomenon around the world (WCD 2000, Jackson & Marmulla 2001), and major losses have been reported for downstream communities in Africa due to dam construction, some of the most well-known examples being on the Senegal and Niger Rivers in West Africa. Examples from southern Africa include the Phongolo floodplain and the Zambezi River. Very few estimates of the economic impact of these losses can be found, however. For example, while much work has been carried out on the Phongolo fishery (Buchan *et al.* 1988, Junod 1912, Tinley 1964, Da Costa 1968, Felgate 1968, Coke & Pott 1970, Torres 1978, Poultney 1982), there is very little in the way of quantification and no apparent attempts at valuation of these impacts. Several studies have been carried out on the fisheries of the Kafue floodplain, including estimated impacts of the dam on catches (Chipungu 1981), but these impacts were not valued.

The creation of Lake Kariba on the Zambezi River is also known to have had major ecological impacts downstream (Masundire 1996), but we could locate no studies that have attempted to quantify these. Further downstream, the impact of altered river flow by the Cahorra Bassa on the prawn fishery of the Sofala Bank, offshore from the Zambezi delta, has been quantified. Prawns are dependent on freshwater flows for nutrient supply and sediments. Gammelsrod (1992) obtained catch data from one of the fishing fleets for the period 1974 to 1988, which coincided with the first 15 years of operation of the Cahora Bassa dam, and showed a clear relationship between river runoff in October to March, and catch per unit effort. His straightforward model was then applied to simulated natural runoff conditions, and it showed that catch rates were some 1500 tons lower than they could be. A simple calculation of the gross value of this loss was US$10 million, based on an assumed price of $7 per kg (Gammelsrod 1996). An interesting deduction was that, given the small proportion of the dam capacity actually being used, it would be possible to increase wet season flows to restore shrimp production levels without interfering with the economic outputs of the hydro-electric power plant (Gammelsrod 1996). This information has never been acted upon, however.

In general, the environmental impact assessments for dam construction have not required the valuation of environmental impacts until relatively recently. Thus the impact assessment for major developments such as the proposed Stieglers Gorge HEP dam on the Rufiji River led to estimations of total catch and the impact on this (Hobson 1979), but the value was not considered. The notion of valuing environmental impacts has been promoted for several years now, but has not yet been successfully integrated into EIA procedure. In South Africa, which is certainly the leader in the region in terms of the application of EIA, and which has guidelines for the incorporation of environmental values, has not yet incorporated valuation into the legal requirements of EIA. Thus such valuations have rarely been applied at all (Crookes & de Wit 2002). One of the first such valuation studies in the region was by Emerton (1994, 1996) for the Tana River in Kenya. Afridev was one of the first groups to attempt this in southern Africa, with the impact assessment for the Maguga Dam on the Komati River in Swaziland. However, the study was only allowed to assess the impacts within the inundation area, and not downstream although a much bigger impact would be expected to occur downstream. This was followed by a far more comprehensive study by Southern Waters for the Lesotho Highlands Development Project. The Tana River and LHDA studies are described in more detail below.

4.1 Tana River

The Tana River is the only permanent river in an extremely arid region of Kenya. Emerton (1994, 1996) provided estimates of the economic impact of changes in some of the production systems relying on the river that would occur as a result of further dam construction. Estimates had to be extrapolated from existing data that had been generated before the construction of any dams (i.e. outdated, as there were five reservoirs on the river at time of study), to a future set of scenarios. The estimation involved a number of assumptions and the figures were largely conjectural (Emerton 1994). Dam construction had already had a major impact on downstream populations through reduction in the biannual flooding of the floodplain and delta area. The proposed additional dams would further reduce flow by up to 70%, effectively cutting the water supply to the floodplain. An estimated 54 400 people of the 180 000 living adjacent to the river and delta are dependent on the fisheries, 50 000 of these for subsistence (Emerton 1994). Subsistence fishing is carried out using traps, lines and fish drives, catching mainly tilapia *Sarotherodon mossambicus*, catfish *Clarias mossambicus* and lungfish *Protopterus amphibus*. Fisheries in the delta also target prawns and other crustaceans and marine species at the coast. The commercial freshwater catches had been monitored for six years (1985-90) and catches were valued at average prices per kg. Nippon Koei's (1989) socio-economic survey provided data on subsistence catches in the delta (10 000 households made an average of 3 trips a week, catching 7 fish per trip). Emerton estimated the annual catch to be 1000 tons based on an assumed average fish mass of 100g, and applied an average price per kg (source not given). Total catch for the river was estimated as 500 tons, based on Welcomme's (1985) relationship. Ecologists working on the project estimated that the fisheries had already diminished by about 10%, and wetland fisheries would further decline to a quarter of their original levels, and river and marine fisheries to half their present levels, over the next 50 years (Mavuti 1994). This loss was valued at KSh 67 million. With additional dams, the situation was predicted to worsen more rapidly, with, in the worst scenario (High Grand Falls Dam), the same reductions expected to occur within ten years (Mavuti 1994). This was estimated to represent a cost of KSh144 million compared to the past situation and KSh77 million compared to the present (Emerton 1994). These values are present values of a stream of values over 50 years, discounted at 10%, the then prevailing opportunity cost of capital in Kenya.

4.2 The Lesotho Highlands

An environmental impact study conducted for the Lesotho Highlands Development Project included an assessment of the value of fisheries in the Matsoku, Malibamatšo, Senqu and Senqunyane Rivers. Fishing is one of many subsistence activities of the inhabitants of the highlands, who rely principally on agriculture and livestock. The fishing season in this area is roughly six months, and catches are dominated by rock catfish, small mouth yellowfish and rainbow trout (an exotic species). The study included separate specialist reports on fish (Arthington *et al.* 1999), sociology (Boehm & Hall 1999) and economics (Majoro 2000). Resource levels were determined in the ichthyological study, use levels in the sociological study, and values in the economics study. The economics report thus relied heavily on the output of the other two, and had to interpolate data when necessary. For example, the ichthyological surveys did not always record the presence of species that local communities reported catching. This can occur when an IFR site is not suitable for the species in question, whereas the fishers catch it elsewhere in the same reach.

The total affected population was calculated to be 155 000 (33 000 households), of which about 1680 households were surveyed in eight reaches. Households were asked how much fish had been caught per month during summer and winter over the last year, with amounts being separated for small, medium and large fish for each of the three species. Small, medium and large fish were then transformed to weights at 200g, 500g and 1500g, respectively. Prices were also obtained from in the household survey. Results suggested that fish is caught by 15.6% of households, with mean catches of 17.5kg of smallmouth yellowfish, 2.2kg of rock catfish and 3.0kg of rainbow trout (Boehm & Hall 1999). Data were provided separately for each reach. 71.5% of those who sold fish, sold in their own villages, the remainder going further afield (Boehm & Hall 1999).

Resource values were derived by multiplying resource use by prices, and monetary impacts were then isolated by weighting resource value using the magnitude and direction of the predicted biophysical change. Prices for different sized fish (given in lengths) were obtained in the sociological study and these were transformed into their weight equivalent to arrive at the data used in the economics study (Majoro 2000). Prices per kilogram varied 4 or 5-fold.

It was assumed that the supply of resources was limiting, and more would be used if available. This assumption was necessary to translate changes in resource supply into losses at the household level (Majoro 2000), and was supported by the sociological study (Boehm & Hall 1999). It was also assumed that the percentage loss in fish supply as estimated by the ichthyological study translated directly into a similar percentage loss to the households. Although fish are not considered abundant in the system, this is one of the few resources whose use is not controlled by local authorities. Of the biophysical components of the entire study, only vegetation and fish were used in the estimation of costs for flow-related changes (Majoro 2000). Estimated percentage changes were given for each reach in the study, and each reach (or riparian area) was assumed to be accessed by a defined set of households living within 5km of the river on either side.

Average catch rates were computed from a total of 1600 households (200 per reach) in the sociological study, and were extrapolated to the total population. Potential problems of recollection identified during the pilot survey led to the use of different recall periods in the main survey. Respondents were asked to give their mean monthly catch in kilograms over the 6 months of the past fishing season.

Table 14. Example of the estimated value of fishery in the Katse river reach, and the predicted change in value with the proposed reduction in flow associated with the 'Treaty' scenario of the Lesotho Highlands Development Project (adapted from Majoro 2000).

Species	Current catch (kg)	Price per kg (Maloti)	Current value (Maloti)	% remaining under Treaty scenario	Predicted future value (Maloti)
Rock catfish	1 332	5-15	13 319	80-100 (90)	11 987
Small mouth yellowfish	5 771	5-20	72 144	80-100 (90)	64 929
Rainbow trout	1 085	5-25	16 279	100	16 279

If fish resources were to be seriously depleted, then use may stop before the resource is completed extirpated, since the cost of fishing effort rises to the point where the benefits no longer justify the costs (Conrad & Clark 1987, Majoro 2000). Indeed, fishermen in reach 2 indicated that it was already barely worth their while fishing since the construction of Katse Dam (Boehm & Hall 1999). Thus if fish abundance was predicted to decline by more than 50%, then the economic study treated it as if the fishery had ceased altogether.

The analysis carried out as above assumes that a drop in the supply of resources has no effect on price. However, scarcity imparts value, and actual market prices would be expected to increase, especially in the absence of substitute resources. Majoro (2000) carried out sensitivity analyses on the basis of three levels of price elasticity (responsiveness of price to a change in quantity supplied). In a situation where prices are highly elastic (prices rise steeply), the loss of value is greater than the straight one-for-one percentage reduction shown in Table 14 above. A further element of the sensitivity analysis assumed that the fish lost is valued at the substitute price of M14 for hake available in Maseru shops (Majoro 2000).

It is important to emphasise however that the estimates of change in value are based on rather uncertain, educated 'guestimates' of the ichthyologists, and somewhat uncertain findings of the sociological study. Thus Majoro (2000) also incorporated the full range of estimates of change given by the biologists, and the range of prices for fish, into risk analysis software (@RISK for Excel Version 3.5.1) to calculate a probability distribution for the total change in value. From this, a mean, minimum, maximum and standard deviation of the expected losses is generated for each reach and for each water development scenario (Majoro 2000). Co-effecients of variation were relatively low, probably because of the relatively small range of possible change predicted in the case of fish.

5. DISCUSSION: METHODS FOR VALUATION OF RIPARIAN FISHERIES

5.1 An appraisal framework for valuation

Barbier (1994) introduced a useful framework to valuation studies as follows:

1. Choose appropriate general assessment approach within which to apply valuation methods.
2. Define the scope and limits of the valuation and information needs:
   - geographic and analytical boundaries,
   - time frame,
   - identify the basic characteristics of the area in terms of structural components and functions, and also attributes, e.g. biodiversity, cultural uniqueness,
   - determine the type of value associated with each, e.g. direct consumptive use value
   - rank the major characteristics and values, e.g. in terms of relevance to the study, or contribution to overall value, and
   - tackle the most important values first, and the least important only if it becomes necessary.
3. Define data collection methods and valuation techniques.

In the case of riparian fisheries, it is important to recognise that the value is determined via the user population, part of which often resides away from the resource for at least part of the year. Thus the definition of geographic scope is important when estimating total value and in investigating its distribution and contribution to livelihoods. Furthermore, an area may be heterogenous in ecological or socio-economic characteristics. Valuation studies should take this into account. For example, Turpie (2000) divided the study area into 'ecoregions' on the basis of access to different fish communities.

It is also important to make an upfront decision as to whether the valuation study needs to generate an overall value in terms of gross contribution to the national economy, for example, or the contribution that the resource makes to individual households, and the extent of its influence. Other boundaries that need to be identified up front include the level to which knock-on effects, such as value added by processing and trade, are taken into account.

Valuation techniques and data collection methods are discussed in more detail below.

5.2 Economic valuation techniques

A variety of methods is used to value economic goods and services provided by natural systems, each being variously suited to different types of values that are being measured (Table 15). This discussion is primarily concerned with the direct use values of fisheries, as opposed to other types of value that ecosystems generate, such as indirect use value and existence value. Direct use value is the value that is most obvious at the local level and often of less concern at the global level. Other values, such as existence and option value are usually relatively irrelevant at the local level, but may be significant at the global level. The number of possible methods that can be used to measure the different types of values also decreases from left to right along the columns in Table 15. Option value is seldom measured explicitly and is also fairly difficult to separate in practice from existence value.

In the case of fisheries, valuation usually involves market value and surrogate market approaches. Market value approaches are appropriate for subsistence and commercial fisheries, whereas the value of recreational fisheries is better estimated using the travel cost approach.

Table 15. Commonly-used natural resource valuation methods, and the types of value which they are generally used to measure.

	Direct use values		Indirect use values	Option and non-use value
	Consumptive	Non-consumptive		
Market value approaches				
Simple valuation P x Q	33	3		
Production Function	33	3		
Replacement Costs etc	3	3	33	
Surrogate market approaches				
Travel Cost Method	3	33		
Hedonic Pricing	3	33	33	
Simulated market approaches				
Contingent Valuation Methods	33	33	3	33
Conjoint Valuation	3	3	3	3

5.3 The market value approach

Where markets do not exist, such as in the case of certain recreational fisheries, valuation is conducted by the various non-market valuation methods available. In the case of most other fisheries, even remote ones, there are usually market prices for fish, even if very few are traded, and thus market prices can be used as a proxy for the total value of fish production, even if much of it is consumed by the fishing households or bartered or shared. In well-functioning, competitive markets, consumers express values through their willingness to pay (WTP) the prices asked for in markets. In such markets, WTP is thus an indicator of positive value attached to any item, and prices function as expressions of value for units of goods and services. Total economic value can simply be calculated as price times quantity. Difficulties arise where markets are not well-functioning. Where market prices are distorted (e.g. by subsidisation of inputs), adjustments are usually made to correct for these distortions, and the corrected prices are referred to as shadow prices.

Before temporal and other dynamic effects are taken into account, the current annual use value of a river reach in terms of harvested fish can simply be calculated as follows:

$$\text{Annual use value} = Q \times (P-C),$$

where Q is the total catch, P is the market price and C is the cost of harvesting the resource. This measure of value is equivalent to consumer expenditure, and may not include consumer surplus. This method relies on the measurements of price, harvest costs (which include the cost of capital) and the quantities harvested annually. However, the measurement of Q, P and C is not always straightforward, as discussed below.

5.3.1 The quantification of catch

Output levels, i.e. catch, or in the case of a recreational fishery, fishing days, can be estimated in a number of ways depending on the accuracy required. Although much attention is given in the literature to the measurement of value in valuation studies, comparatively little is said about the measurement of quantity. In fact, as is clear from the results summarised in the previous section, the estimation of catches is the most difficult part of a fishery valuation study, and it is unlikely that any two studies will yield the same estimate for the same fishery.

Quantities of outputs can be measured by direct observation, such as the monitoring of fish landings. Such data are often available, though sometimes require searching through piles of paper in government offices. However, these statistics often only pertain to a portion of the fishery, such as the commercial fishers, or catches from selected landing sites. Nevertheless, this is useful for measuring trends. Such data, while useful for calibrating trends and estimates of total catch, do not provide much information about the value of fisheries at the household level.

The valuation of artisanal fisheries usually requires an understanding of fishing activities at the household level, as well as the context of the household economy. To obtain this level of information, primary data gathering has usually been in the form of surveys of households in the area, in order to obtain the proportion of households fishing, and then effort and catches of fishing households. This is discussed further under survey methods, below.

5.3.2 Measurement of Price

Where market prices for harvested resources are available, these should serve adequately as measures of value (Barbier *et al*. 1997), unless price distortions are expected. The type of price used should be stated explicitly in valuation studies. Prices used are usually those accepted by the harvester, before any value is added to the resource by marketing or processing. However, it may be more appropriate to consider the full value generated by a fishery, right up to the final consumer or export. Thus the value of a commercial fishery should also include the value added by processing and export, and that of a recreational fishery should consider knock-on effects. Market prices do usually exist for most fisheries in southern and eastern Africa. Indeed, many studies which describe fisheries report a few market prices, though not going as far as using these to compute values for the fishery.

Under certain conditions, market prices may not reflect the true value of a resource. Prices may be distorted by conditions of imperfect competition, for example when local markets are relatively isolated, or through government intervention. If distortions are suspected, the use of shadow prices is usually advocated (Barbier *et al*. 1997), but only if they can be adequately estimated (James 1991). Shadow prices are corrected prices, to account for the distortions, and aim to reflect the full value of a commodity to society. They thus reflect economic value rather than financial value. However, the proper correction of distorted prices relies on accurate diagnosis of the direction and magnitude of the distortion, which is often difficult.

If no market prices are available for a resource, as is sometimes the case in subsistence economies, then surrogate prices can be used. There are several possible ways of doing this (Barbier *et al*. 1997):

(a) *Barter or trade value*: If the resource is bartered or traded, e.g. fish for rice, then it may be possible to estimate its value based on the market value of a commodity for which it is traded. This method requires information about the rate of exchange between two goods. If such trade is not observed the information can be obtained using properly-designed survey instruments, e.g. ranking techniques in a focus-group discussion.

(b) *Substitute price*: If a close substitute can be identified which has a market value, then it is possible to assign the value as the price of the substitute. This requires information about the degree of substitution between different goods. For example, Majoro (2000) used the market price of hake as a substitute price for freshwater fish caught in the Lesotho Highlands.

(c) *Opportunity cost*: Alternatively, it is possible to derive a minimum value for a good by estimating the opportunity cost of inputs required for its harvest or production.

(d) *Indirect substitute prices*: In the absence of all the above possibilities, and when the substitute is also unpriced, then it may be necessary to use the opportunity cost of the substitute as a proxy for the value of the commodity in question.

5.3.3 Measurement of production costs

The costs of inputs such as fishing nets can be estimated directly using market prices. The costs of labour time is usually taken as some proportion of the wage rate, or the shadow price of labour. Where opportunities for formal and informal employment are very low, the shadow price of labour time to collect natural resources approaches zero. This is a complex issue, however, as all time could be said to have an opportunity cost in terms of other tasks or recreational activities that could be being carried out.

5.4 Survey methods

Data are invariably scarce when it comes to conducting valuation studies of artisanal fisheries in eastern and southern Africa. Most of the fisheries valuation studies described in this review thus had a similar approach to data gathering in that they entailed fairly labour intensive household surveys for the collection of primary data. In addition, focus group discussions and key informant interviews are often also employed, in which complementary data and sometimes also supplementary data are obtained by means of Rapid Rural Appraisal (RRA) techniques (commonly mis-stated as Participatory Rural Appraisal methods) borrowed from sociology methods. Although questionnaire surveys theoretically provide the most statistically rigorous quantitative data, there are many problems with such surveys that are better addressed by the various RRA techniques available. Turpie (1998), Turpie *et al.* (1999), Boehm & Hall (1999), Turpie (2000) and Turpie & Egoh (2002) used a combination of household surveys, focus groups and key informant interviews in their studies. In addition, all of these studies were preceded with a reconnaissance visit to the study area to observe circumstances and meet with villagers and leaders, after which survey instruments were designed. The initial reconnaissance-stage meetings are always vital to obtain the co-operation of the community being surveyed, as well as to provide enough information for the appropriate design of survey instruments.

5.4.1 Focus group discussions and key informant interviews

These techniques are common in social studies, and are useful in fisheries valuation studies for the provision of general data that do not need to be quantified at the household level. Focus group discussion s are usually held with groups of 5 – 10 people, and while following a semi-structured line of questioning, the discussions are allowed to deviate from the questionnaire, or to concentrate on a particular aspect, as appropriate. These discussions are used to collect information of a generally applicable nature, for example on seasonality of catches and effort, descriptions of fishing methods and their inputs, on markets and prices, processing methods and transport. They are also useful for obtaining information on the control of the fishery and on perceptions of its status or sustainability.

Box 1. General structure of Focus Group discussions (Turpie 2000)

FOCUS GROUP DISCUSSIONS

A. Introductions
The purpose of the discussion was explained, and members of the group were encouraged to be as open as possible about the issues to be discussed.

B. Resource description
All species of natural resources were named and described in detail, giving where they occur or are grown. Their treatment and uses were also described.

C. Rules of access
The group was asked to describe how households gain access to resources, and any limitations on use.

D. Who is involved
People were asked about the role of men, women and children in the production or harvest of the resource.

E. Equipment
The group was asked about the type of equipment used, its price, durability, and whether it is shared among households.

F. Seasonality
The group was usually first asked to describe seasonality in the availability and harvesting of certain resources. Some groups were also asked about seasonality of different agricultural activities (e.g. cultivating, harvesting).

G. Returns to effort
The group was asked how much could be harvested in a day or week during different times of year.

H. Prices and inputs
Selling prices were obtained for each resource and for products made from these resources. Natural resource inputs into crafts and other products were also quantified.

I. Changes in availability

Members of the group were asked to describe and explain changes in availability over time.

A typical focus group discussion is outlined in Box 1. In the case of some resources such as salt and palm leaves, enough information can be obtained from focus groups to make estimates of total production and value which are comparable to that obtained using more detailed survey data (Turpie 2000), but this has not been successful for fisheries because of their relative complexity.

In addition to, and sometimes instead of, formal focus group discussions, informal discussions can be held with members of the fishing community. This is often particularly useful, especially when the interviewee is recently returned from fishing, as it allows the researcher to observe fishing equipment and catches, and to adapt questioning in a more natural manner. This makes respondents far more relaxed than in the rather formal setting of the focus group. It allows information gathering which had not been anticipated in the formal surveys, and is better for obtaining information on things which people are fairly reluctant to disclose when in groups. Women tend to be particularly responsive to this type of "walking and talking". Furthermore, in all cases where such an informal discussion was initiated by Turpie (2000), the initial one-on-one interaction ended up with other people voluntarily joining in to provide more information, which was a better way of assembling a group than the more forced nature of the focus group method. The use of a female interviewer and interpreter is essential for interviewing women.

Seasonality can be described qualitatively, but patterns produced cannot be translated to real variation. In other words it is not possible to take catch in the current month and extrapolate it to the rest of the year based on this data, no matter how appealing. Prices are problematic too. Fish prices are highly variable and do not go according to weight. The researcher is left with the problem of converting prices per fish (measured relative to the size of a hand), often of dried fish, into price per kg. Using average price per fish (Cox *et al.* 2001) does not produce a reliable valuation of catches.

5.4.2 Household surveys

Most fishery valuation studies have relied on household survey data to provide quantitative data on fish catches. These are then used to estimate total annual catches at the household level and for the area as a whole. Although catches can be estimated in other ways, household surveys are usually the only reliable way of estimating the number or proportion of fishing households in a study area.

The structure of household questionnaire surveys varies between studies, but might typically follow the basic structure outlined in Box 2. A fisheries valuation study may or may not include other natural resources, depending on the purpose and context of the study (see discussion below). In the example given, the questionnaire includes questions about the harvesting of all major categories of natural resources, as well as value added through processing, and income generated, and also investigates agricultural production. The most difficult questions are posed early in the questionnaire, with agricultural production at the end, to counter the effects of survey fatigue. Questions on fishing would thus be close to the beginning of the questionnaire. A questionnaire such as this takes about an hour to complete when questioning is about all resources.

Most of the studies described above involved a single household survey in which households were questioned just once about their harvesting of resources. In a couple of cases, the surveys were repeated during the dry season and wet season. Where there is significant temporal variation in any of the resource use activities in the study, or where the use of resources is irregular or erratic, it is preferable to survey households more than once, or as often as possible. This is especially important for fishery resources. Most fishers cannot reasonably be expected to recall their catches with any accuracy over a period longer than a few days or a couple of weeks. Yet fishers are often asked to recall catches over periods of months, or to integrate their remembered catches into an average per month. Nearly all of the studies reviewed here can be heavily criticised in this respect. Either fishers were expected to recall catches over too long a period, or surveys were not repeated enough times to yield reliable variation in catches over the year.

Box 2. General structure of household surveys used in Turpie *et al.* (1999), Turpie (2000) and Turpie & Egoh (2002).

HOUSEHOLD SURVEYS

A. Household information.
Household size and composition

B. Relative value of household production
Respondents are asked to apportion a pile of beans among eight different sources of income (crops, fishing, hunting, wood products, plant products, salt making, livestock, and other cash income from trade etc.) to indicate their relative contribution to household income in an average year.

C. Natural resources
Respondents are asked about fishing, wood products (forest or mangrove), honey, hunting, reeds, papyrus, grasses, palms, food and medicinal plants, clay and salt production. For each resource they are asked about the following, as applicable:

- whether they harvest the resource, and in the case of fishing, household fishing effort and equipment
- amount harvested over a specified period,
- amount sold and price per unit
- amount of products produced from natural resources
- amount sold and prices obtained,

D. Livestock
Questions are asked on the following:

- numbers of small and large stock
- production and sales over a specified period, and prices obtained
- livestock losses to wild animals

E. Crops

Questions are asked on the following:

- total area cultivated, and which crops grown
- amount produced over a specified period for each crop
- amount sold or exchanged, and price obtained
- crop losses to wild animals
- household reaction to poor crop years

F. Cash income

Respondents are asked about cash income from wages, pensions, and absent family members.

Another particularly difficult issue is the choice of units for quantification. Again, while this is an issue for most resources, it is a particularly problematic issue in the case of fisheries. Fishers transport and sell their catches in a variety of ways, such as in baskets of different sizes, tied bundles, buckets etc. This makes the enumeration of catches and sales extremely difficult to reduce to a total catch weight, unless thorough research is done beforehand to assess the capacity of these different units and the weights of the typical species and sizes caught. Thus, focus group discussions, key informant interviews and direct observation are very important as precursors to survey design. Furthermore, since fish are sold in different forms, such as fresh, dried or smoked, the enumeration of selling quantities has to be equally meticulous.

No matter how carefully designed surveys are for the quantification of household catches, the presence of outsiders in the fishery will always confound estimates of total catch, and thus total value, made in this way. Yet extending the survey to the temporary 'households' in fishing camps may not be helpful in this regard because of the statistical difficulties involved. None of the surveys reviewed here have attempted to carry out quantitative interviews of fishers in fishing camps, though focus group discussions are routinely held in such camps.

As important as the design of the questionnaire is the way in which it is worded and administered. The potential for communication errors is great, and may occur in translation or due to the use of inappropriate terminology. It is thus very important that the final wording, after translation into the local vernacular, is checked by someone who has an understanding of the purpose of the questionnaire as well as the local terms. Wording should not be so formal as to intimidate simple households. There are many other subtleties about survey design which are discussed in the literature, and which will not be delved into here. It is important to note, however, that these aspects are seldom given much attention in the write-up of valuation studies. In particular, details of pre-testing and the way in which survey designs were changed after such testing is never given, which means that new researchers do not benefit from the lessons learned by others. Even the final questionnaires developed for studies are seldom published with the studies. There is a danger in copying questionnaires from other studies, though, as their shortcomings may not be apparent to new users, and not all aspects are necessarily appropriate to the next situation. On the whole though, basic design is transferable to a large variety of fisheries as long as the habitat and way of life is relatively similar.

5.5 Analysing and interpreting values

Value can be expressed in a number of ways, with different values being appropriate in different contexts. In the studies reviewed above, values were expressed as both financial and economic values. The financial values include gross income (the total market value of production), net income (the total subsistence plus cash value to households net of input costs but not labour costs), and cash income. Economic values are calculated as gross and net values, on the basis of financial values, but using shadow prices. Turpie *et al.* 1999 expressed net income after labour costs, but there has been some debate suggesting the latter calculation should also exclude labour costs (K. Goran-Maler, pers. comm.). While economic values are used to articulate the contribution of fisheries to the national economy, in most cases the financial values are the most useful as they reflect the direct values of fisheries to users and surrounding communities. Gross values are the most common reported, but it is important to recognise that these values are generated at a cost to the household, apart from the labour inputs involved. There has been insufficient emphasis on the opportunity cost of labour and returns to fisheries as part of a mixed household strategy. The value of fisheries in terms of cash income is also an important consideration, since even households that can meet all their own subsistence needs have to generate cash income for goods and services such as health and schooling.

Calculation of net incomes or returns to capital or labour requires far more data than simple estimates of gross value. It requires identification of capital inputs and estimates of depreciation, and estimates of variable costs, as well as of labour costs. These are not always easy to estimate since equipment is often shared and fishing equipment such as fence traps is sometimes difficult to value. Nevertheless, the collection of such data is not particularly difficult.

Turpie *et al.* 1999, Turpie 2000 and Turpie & Egoh 2002 developed a spreadsheet model to calculate the various types of value outlined above, which was based on model developed by the Namibian Directorate of Environment Affairs (e.g. Ashley *et al.* 1994, Barnes & de Jager 1995, 1996, Ashley & Barnes 1996, Barnes 1996). The multi-page spreadsheet includes a page for each resource as well as front page for entering general data, such as the characteristics of each ecoregions of the study area, equipment used in each enterprise, and the price and durability of equipment. The development of the model was particularly useful in identifying exact data needs in survey design.

The values generated in valuation studies can be fairly meaningless to decision-makers and policy-makers if they are not given a context. Thus it is vital to show what fisheries values mean to households, in terms of their total annual income, to a study area in terms of contribution to total economic activity, or to a the national economy, in terms of contribution to regional or national income. Many valuation studies fall short of doing this. The most common way of expressing value in the studies reviewed here was in the context of total household income. This is the most costly, in that it involves the valuation of all resources, not just fisheries, in the study. However, the value of fisheries is much clearer when seen in the context of agricultural incomes, for example, which are traditionally of much concern to policy makers.

Nevertheless, it is important to bear in mind that percentage contribution to household income is not the only facet to fishery values that should be considered. The value of fisheries in terms of risk spreading needs to be evaluated. Even if households only rely on fish once in 6 or 7 years, during drought, for example, the fishery can still be of critical importance to the population. None of the studies have articulated this in quantitative way.

5.5.1 Issues of time, scale and sustainability in value calculation

There are no limits to the spatial extent to which some costs and benefits associated with fishing areas could be felt and it is thus important to be explicit about the scale at which benefits and costs are being considered and compared in order to answer the question: "value to whom?". Costs and benefits can be considered at a local, national, regional and global scale. Local-scale benefits may incur regional-scale costs, and vice versa. ‘Local communities’ have to be defined on the basis of explicitly stated criteria.

In most cases the valuation studies concentrate on estimating the annual values of fisheries. However, the value of a fishery should strictly include some consideration of future values. The net present value of a fishery would be the present value of the flow of income from the present until some specified time in the future. The calculation involves setting a time frame for the analysis and the relative weighting of future and present values, through the choice of discount rate. Economic analyses are usually conducted using a time frame of 10 to 50 years. While longer time frames are of more interest to ecologists, shorter time frames are more commonly used because the lifespan of policy is usually relatively short, and because of the effect of discounting on future values. Under most circumstances, values accruing beyond 20 years into the future are rendered negligible in present terms by discounting, and so 20 or 30 years is a common time frame for analysis. The discount rate can be based on the prevailing opportunity cost of capital, but should be lower if long-term social and environmental benefits are considered paramount.

In failing to mention future values, most valuation studies implicitly assume that the resources are used both sustainably and optimally. Both the current value and its expected path over time affect the net present value of a fishery (Figure 1). With a zero discount rate, the present values of the benefit streams in Figure 1 would be ranked as follows: NPV (a) > NPV (b) > NPV (c) > NPV (d). In other words, the most optimal and sustainable use path (a) yields the highest value. If resources are under-utilised (path b) or have been mined to low output levels by past overutilisation (path d), then the valuation exercise is in danger of underestimating the value of the area. If on the other hand, resource use is assessed at a time when fisheries are being over-utilised at levels above the maximum sustainable yield (path c), then the exercise will result in an overestimation of the value. To some extent, the effects of over- or under-utilisation may also be reflected in relatively high and low prices and input costs respectively. It is interesting to note that, even if the future path of the net benefits of resource use were known, a high discount rate would tend to favour the over-utilisation of resources. Thus, beyond a certain discount rate, the present value of path (c) will be higher than the present value of the sustainable path (a), because future benefits in path (a) will be worth very little to the present generation.

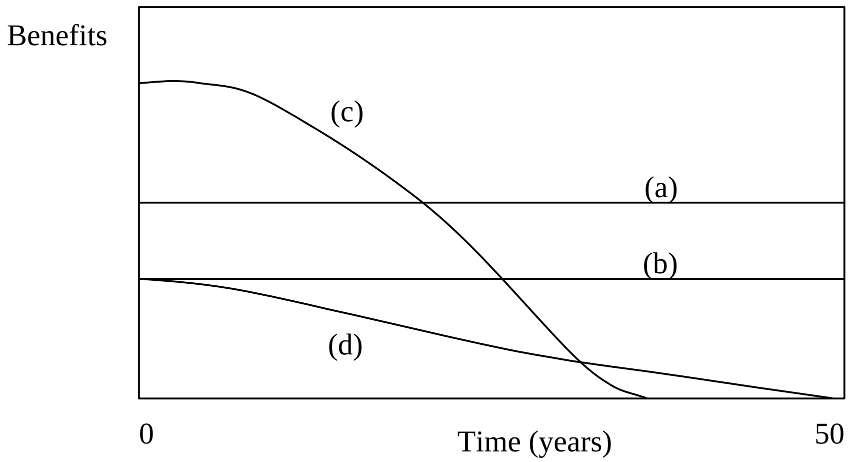

Figure 1. Hypothetical, undiscounted benefit stream from a flow of consumptive use of natural resources under base-year conditions of (a) optimal sustainable use, (b) sustained underutilization, (c) early-stage overexploitation and (d) long-term overexploitation.

Thus, in fisheries valuation studies it is imperative that the level of use in relation to optimal sustainable yields is investigated in order to produce a valid interpretation of the results of the valuation methods applied, and a realistic estimate of net present value. The determination of optimal yields requires detailed biological information on the dynamics of resource availability as well as use. None of the studies reviewed here has had sufficient biological data to estimate the sustainability of the fisheries involved.

Ideally, such studies should be preceded by a biological understanding of the fishery resource and its status. These elements are important in order to put current values into a longer time frame. Fisheries biologists are very often reticent to estimate how sustainable a fishery is, however, due to the need to gather large quantities of data to perform such an assessment properly. The use of techniques such as *Rapfish*, which is essentially an assessment of characteristics such as the above, might provide a short cut to assessing the sustainability of catches.

5.5.2 Considering potential value

Interesting situations also arise where fisheries potential exists but is not exploited. For example, capture and consumption of freshwater fish has never been part of the traditional culture of the Xhosa people, who reside in the Eastern Cape, South Africa. Government however, recognises that the existing resources have the potential to be exploited as small-scale fisheries for the relief of poverty in the region. This has led to a brief investigation of the potential value that they could generate (Andrew *et al.* 2000), but the study only went as far as estimating what a small group of fishers could earn, and not what the resource could support in total.

5.6 Estimating impacts on value due to environmental change

Estimation of a change in value due to a proposed environmental change, such as alteration of river hydrology by dam construction, is carried out using the Change in

Production approach (e.g. Ellis & Fisher 1987, Barbier 1994). This is a relatively straightforward approach in theory, but can be more complicated in practise, as it should involve the estimation of a production function.

Riparian fisheries production is dependent on the qualities of the area, such as river flow and water quality, as well as the inputs, such as labour, involved, as in the following production function:

$$Q = f(S, X_i \ldots X_n)$$

where Q is the catch produced for a given set of inputs, including flow, S, and other inputs, X (after Barbier 1994). The quality of the result is largely dependent on the amount and quality of data that is entered into the model, as well as the quality of the model itself. The production function approach is considered to be a particularly promising approach to valuing certain environmental functions (Barbier 1994). However, it is important that the relationship between the environmental attributes and the economic activity they contribute to is well understood. Ideally, this approach demands an understanding of the relationship between the output and the state of the environment, or the physical effects on production of changes in a resource, and should be modelled taking dynamic functions into account. This is usually achieved through time-series or cross-sectional analysis, and thus usually requires data spanning a number of years or comparable data from a number of areas. The production function approach makes it possible to examine the effects of marginal changes in the environment such as incremental changes in water allocation to other uses.

Estimation in reality is done over a relatively short time period, thus requiring some level of innovation in shortcutting the theoretical methods outlined above. The main problem lies in predicting future supplies of fish (a biological problem), though predicting future prices is also problematic. In the Lesotho Highlands Development Project, biologists were required to estimate the percentage change in fish resulting from a change in flow. Thus in essence they applied a 'gut-feel' production function, but did not attempt to describe it explicitly. Majoro (2000) provides an exemplary valuation of these impacts, in that it takes price elasticity and uncertainty into account. Emerton (1994) was more fortunate in that she was able to consider the predicted gradual change in fishery production over time as a result in changed hydrology, and used this to compute a present value. The value was crudely and rapidly estimated, but was based on an apparently detailed ecological assessment (Emerton 1994). In comparison, Majoro (2000) produced a comparatively sophisticated analysis of impacts complete with risk and sensitivity analyses, but these were based on a fairly crude assessment of change, treated as an instantaneous change from one level of production to another.

5.7 Should valuation be carried out more efficiently or rapidly?

The way in which valuation studies are currently carried out is considered to be quite intensive (Dugan et al., 2002). Indeed, most of the studies cited above were fairly major undertakings, with each one taking at least two months (not necessarily contiguous), and usually much longer, to complete. Studies involve a reconnaissance visit by the lead researchers, in which time is taken to understand the fishery, its heterogeneity, and the fishers, as well as make essential meetings with the local community and representatives. This is followed by a series of focus groups and key informant interviews, then a survey design phase. Enumerators are then selected and trained, questionnaires and enumerators are tested in the field and the necessary refinements are made before the proper survey is carried out. The actual household survey can be carried out relatively quickly, especially if several enumerators are used, but this also depends on the difficulty of travelling around the study area. Most of the study areas described above do not have conventional road access to villages and fishing areas, and boats other than local canoes are sometimes hard to come by or to launch. Following field surveys, data have to be entered and checked, and finally analysed for write-up. The final phases can be immensely time consuming if surveys were badly designed, for example, if fish catches are enumerated in a variety of ways which need conversion to common units. Or, for example, if questions have obviously been badly designed and good answers have to be sorted from possible misunderstandings. How well a valuation study is designed has a tremendous impact on the efficiency with which it can be carried out, as well as the reliability of the estimates produced. This obviously has important implications for research costs.

Valuation estimates can be produced more roughly and for lower budgets, but there are probably some tradeoffs involved, particularly in the certainty of such estimates. There are several means of rapid assessment, including

(a) Simple estimates of aggregate value based on existing catch statistics
(b) Reduced sample sizes for household surveys
(c) 'Benefits transfer'
(d) Using data from focus group discussions and key informant interviews, and
(e) 'Bean games'

The aggregate gross annual value of a fishery is simply the catch multiplied by average price. Thus the most rapid valuation of a fishery can be obtained using government statistics on catches, and current price data, which are fairly easily obtained. Two main problems with this method, as alluded to above, are that catch data are often unreliable, and that a single aggregate value does not give sufficient information on which to make either management or development decisions. In particular there is a danger of underestimation of the size of the fishery, and very little indication of its importance to the local population.

Recognising the heterogeneity of fisheries along river systems is a very important part of determining their value, both at the aggregate and the household level. This division of an overall area into 'ecoregions' or river reaches (see Majoro 2000, Turpie 2000, Turpie & Egoh 2002), allowing some form of stratified random sampling, provides a better description of the way in which resources are used in conditions of differing fish availability and population characteristics. In this way the values are better understood and impacts of environmental change are not incorrectly generalised across all households and areas. In general, within areas that are relatively homogenous, e.g. within an ecoregion, sample sizes can be relatively small. However, since the variability in fisheries data supplied by households is generally greater than for other resources, larger sample sizes are needed for fisheries valuation than for valuing woodland resources, for example. With the exception of Turpie & Egoh (2002) in which nearly all households were surveyed, none of the studies reviewed here has involved particularly large sample sizes, and in most cases decreasing costs by decreasing households sampled would not have been justifiable.

Interestingly, at a broader scale, there appears to be remarkably little variation in the household livelihood strategies and fishery values among communities surrounding different floodplain wetland systems in southern and eastern Africa. This suggests that 'benefits transfer' could be applied to some extent. Benefits transfer is the ultimate in rapid valuation, being application of results of other studies to similar areas under consideration (Georgiou *et al.* 1997, Barbier *et al.* 1997). However, its use implies a number of inherent assumptions about the preferences and socio-economic characteristics of the study area (OECD 1994) and is not something that should be done lightly. As an example at the other end of the extreme, no generalisations or benefits transfer could be validly applied across different estuaries in South Africa, since each estuary is unique in terms of its size and biophysical characteristics, population density, accessibility, and uses (e.g. recreational, commercial and subsistence fisheries).

Turpie (2000) used two methods for valuing several different resources in the Rufiji floodplain area in order to double check estimates. For example, focus groups gave information on the proportion of households engaged in an activity, seasonal patterns in harvesting, average harvests per time period in high and low seasons, proportions sold, selling prices and input prices. Similar data are yielded from household surveys. Turpie (2000) found that the results generated from the two sources of data were remarkably similar in many cases (e.g. salt production, timber harvesting), but interestingly did not attempt this for fisheries, as the data yielded in discussions were often highly variable. Furthermore, the estimates yielded from household survey data are regarded as statistically valid, whereas the former are not.

In order to assess the importance of fisheries to local livelihoods Turpie *et al.* 1999, Turpie 2000 and Turpie & Egoh 2002 asked households to describe the contribution that fisheries and other sources of income made to household income (including subsistence value). This was done by apportioning a pile of beans or stones among six or so categories of income (fish, agriculture, livestock, pensions, woodland resources, etc). The purpose of this was to check household perceptions against actual incomes estimated on the basis of quantitative data, as well as to evaluate this as a potential future 'short-cut' to estimating values. Used in the latter sense, it was suggested that overall values could be calculated for all different sources of income on the basis of the relative values given if the value of just one or two of these was known. The anchor values would be chosen on the basis of that component that was easiest to value. The results of using these 'bean games', which have been applied both in focus groups and in household surveys, have been variable (Turpie *et al.* 1999, Turpie 2000). In most cases household perception of the relative value of resources is remarkably close to that estimated on the basis of quantitative survey data. However, when there is a discrepancy it is difficult to say whether villagers' perceptions or household calculations are more accurate.

Dugan et al (2002) suggests that simpler methodologies need to be developed which can provide information more directly to communities and to other key stakeholders on an ongoing basis. The latter would of course require ongoing monitoring of key parameters, and possibly also the establishment of research networks. In addition, they suggest that existing valuation techniques could be made more readily applicable in developing countries with limited institutional research capacity. In other words, it is necessary to establish what critical information is required in order to manage riparian fisheries optimally, and how this information can be generated on a regular basis (Dugan et al., 2002).

Such a programme could easily be developed, but should not replace the detailed study of riparian fisheries. Firstly, much of the work that has been carried out so far has concentrated on obtaining average values, and more, not less, detailed research is needed to understand production functions and the marginal values in the fisheries and household coping systems. This would require large-scale surveys and econometric modelling, to produce dynamic ecological economic models. It is only when this level of understanding is achieved that impact studies can hope to improve their (currently rather low) confidence in the prediction of impacts of changes in flow on fishery values. Secondly, detailed studies provide the important baseline against which to monitor fisheries, and provide the basis for choosing the key parameters that need to be monitored over time. Thus it is recommended that detailed studies of systems continue, and that monitoring programmes be set up in areas in which fisheries and their values are well described. Such monitoring programmes should aim to track changes in demand and supply and should collect data on prices for standard units (species, size), household and aggregate fishing effort, catches and management. Although monitoring programmes involving local fishers have been implemented successfully (Ticheler *et al.* 1998), monitoring programmes are sometimes set back by bad data collection by local field enumerators (pers. obs.; REMP, pers. comm.), possibly due to lack of direct and regular supervision by those with an interest in the outcome.

Thus baseline fishery valuation studies should probably become more intensive in future, and rapid evaluations should only be carried out after these, for monitoring purposes. It is probably true to say that the use of more rapid techniques in fishery valuation studies would be accompanied by a loss of accuracy and resolution, and increasing uncertainty. Ultimately, the rapidity with which a study is carried out should be determined on the basis of its purpose, and with its potential future application in mind.

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