Environmental Management and Biodiversity Conservation of Forests, Woodlands, and Wetlands of the Rufiji Delta and Floodplain

The Use and Value of Natural Resources of the Rufiji Floodplain and Delta, Tanzania

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[1] The Rufiji District Council implements Rufiji Environment Management Project with technical assistance from IUCN – The World Conservation Union, and funding from the Royal Netherlands Embassy.

Rufiji Environment Management Project - REMP

Project Goal: To promote the long-term conservation through 'wise use' of the lower Rufiji forests, woodlands and wetlands, such that biodiversity is conserved, critical ecological functions are maintained, renewable natural resources are used sustainably and the livelihoods of the area's inhabitants are secured and enhanced**.**

Objectives

- To promote the integration of environmental conservation and sustainable development through environmental planning within the Rufiji Delta and Floodplain.

- To promote the sustainable use of natural resources and enhance the livelihoods of local communities by implementing sustainable pilot development activities based on wise use principles.

- To promote awareness of the values of forests, woodlands and wetlands and the importance of wise use at village, district, regional and central government levels, and to influence national policies on natural resource management.

Project Area

The project area is within Rufiji District in the ecosystems affected by the flooding of the river (floodplain and delta), downstream of the Selous Game Reserve and also including several upland forests of special importance.

Project Implementation

The project is run from the district Headquarters in Utete by the Rufiji District Administration through a district Environmental Management Team coordinated by the District Executive Director. The Project Manager is employed by the project and two Technical Advisers are employed by IUCN.

Project partners, particularly NEMC, the Coast Region, RUBADA, The Royal Netherlands Embassy and the Ministry of Natural Resources and Tourism, collaborate formally through their participation in the Project Steering Committee and also informally.

Project Outputs

At the end of the first five –year phase (1998-2003) of the project the expected outputs are:

An Environmental Management Plan: an integrated plan for the management of the ecosystems (forests, woodlands and wetlands) and natural resources of the project area that has been tested and revised so that it can be assured of success - especially through development hand-in-hand with the District council and the people of Rufiji.

Village (or community) Natural Resource Management Plans: These will be produced in pilot villages to facilitate village planning for natural resource management. The project will support the implementation of these plans by researching the legislation, providing training and some support for zoning, mapping and gazettement of reserves.

Established Wise Use Activities: These will consist of the successful sustainable development activities that are being tried and tested with pilot village and communities and are shown to be sustainable

Key forests will be conserved: Forests in Rufiji District that have shown high levels of plant biodiversity, endemism or other valuable biodiversity characteristics will be conserved by gazettement, forest management for conservation, and /or awareness-raising with their traditional owners.

Executive Summary

This resource economics study was commissioned by the Rufiji Environmental Management Project, as an input into the development of a management plan for the lower Rufiji River floodplain and delta, situated in the Rufiji District, Tanzania. The study area is dominated by the river, its floodplain grasslands and lakes, and a mangrove delta, which are surrounded by bushlands and miombo woodlands and forest. It is home to approximately 100 000 rural Tanzanians in 16 100 households, concentrated into 52 villages. The area is rich in wildlife and plant resources, which form an important part of the livelihoods of the population, in addition to their agricultural activities. However, there is concern that the area's biodiversity is under threat from unsustainable use of these resources, necessitating a sound management plan, which will maximise the value of the area without compromising its ecological integrity and conservation importance. This study serves to articulate the value of these resources to the local population, and to Tanzania as a whole, and investigates some of the economic and other factors which determine household behaviour and threaten the future value of the area's natural resources.

The 720 000 ha study area was divided into three ecoregions, the floodplain area (8700 households), delta area (5093 households), and a 'transition' area between the two (2300 households), where people have access to both floodplain and delta resources. In order to estimate the direct consumptive use value of natural resources (from direct harvesting and value added), a survey was carried out in nine villages across these three ecoregions. In each village, survey methodology involved meetings with village government representatives, village mapping, focus group discussions on a range of natural resources, key informant interviews and informal discussions, and household questionnaire surveys. A total of 128 households were surveyed. The various methods aimed to ascertain the different types of natural resources used, the numbers of users, quantities of different resources used, and a number of other details needed to determine the value of natural resource use. Indirect use values could not be estimated with any accuracy in this study, but are broadly considered on the basis of available information. Value estimates were assigned to different broad habitat types in the study area, using a GIS coverage of the study area to estimate the area of different habitat types within each of the ecoregions. All quantities and values are expressed as annual values. Values are expressed as gross financial value (the total market value of production), net financial value (the total subsistence plus cash value to households net of input costs but not labour costs), cash income, and net economic value (using shadow prices and net of labour inputs).

Numerous natural resources are harvested and processed in the study area, and a high proportion of households are involved in many of these activities (Table I overleaf). Some 1.5 tons of salt is extracted by women in the delta, mainly for sale to fishers. Most households use clay pots for cooking, and about 44 500 pots are produced annually by potters, made from clay collected along the rivers and estuaries. These are only sold locally, as they are not of a high enough quality to be marketed further afield. Grasses, sedges and reeds are used by many households for making fences, mats, chicken coops, grain storage containers and in house construction, but in small quantities relative to other wetland areas. About 23 000 bundles of grass, 1600 bundles of sedges and 19 000 bundles of reeds are harvested annually. Grasses and reeds are widely available, but sedges are fairly scarce in the study area. Bamboo products are also made in the upland areas.

Palms are an important resource in the study area, and the lala palm (milala) and wild date palm (ukindu) are particularly important. Their leaves used for making sleeping bags, mats, drying mats, baskets, bed ropes, hats, food covers, fans, ornaments, brooms and grain silos, with all but the latter being ubiquitous in the households of the study area. Ukindu leaves are superior for this purpose, and are dyed to make multi-coloured products, but they are mainly restricted to the delta area. Some 40 000 bundles of milala and 2.2 million small bundles (vichanga) of ukindu are harvested annually in the study area, and at least 63 000 milala products and 30 000 ukindu products are made annually.

A high proportion of households harvest food and medicinal plants for home consumption. At least 10 species of wild grains and tubers, 20 species of leaf vegetables and 60 types of fruits are harvested from the floodplain, marshes and forests, the starches and vegetables forming an important fallback during the famine season. About 1 720 tons of wild foods are harvested annually. At least 24 species of medicinal plants are used, with an annual harvest of about 98 tons.

Almost all households collect fuelwood from the forest or mangrove areas as a source of energy. It is estimated that over 2.5 million bundles or logs of fuelwood are harvested annually, with very little of this being sold. Charcoal is made in kilns in the woodland areas for commercial purposes. Because the activity requires a licence, much of the charcoal production in the study area is illegal, and it is difficult to get accurate estimates of production. At least 20 500 bags are produced annually in the study area, but the actual production is likely to be substantially higher.

Table I: Percentage of households in each area and in the overall study area engaged in different natural resource-related activities.

Activity	Floodplain	Transition	Delta	Overall
Salt-making	0	0	32.6	10.3
Pottery	9.3	3.4	28.3	14.5
Grass harvesting	25.9	24.1	2.2	18.1
Reeds harvesting	14.8	10.3	6.5	11.5
Sedge harvesting	3.7	0	0	2.0
Medicinal Plant harvesting	55.6	41.4	34.8	47.0
Food Plant harvesting	94.4	99.3	71.7	87.9
Milala harvesting	92.6	55.2	37.0	69.7
Milala Products	90.7	58.6	34.8	68.4
Ukindu harvesting	0	69.0	54.4	27.1
Ukindu Products	27.4	79.3	60.9	45.4
Firewood harvesting	90.7	100	93.5	92.9
Charcoal marking	3.7	3.5	0	2.5
Pole cutting	46.3	20.7	41.3	41.1
Timber cutting	11.1	6.9	4.4	8.4
Furniture making	7.4	10.3	6.,5	7.5
Small wood Products	1.85	6.9	8.7	4.7
Canoe making	0	3.5	4.4	1.9
Jahazi building	0	0	2.2	0.7
Fishing	55.6	51.7	60.9	56.7
Hunting game	0	6.9	2.2	1.7
Hunting birds	5.6	10.3	2.2	5.2
Honey collecting	7.4	20.7	15.2	11.8

Poles of a variety of thicknesses are cut from both forests and mangroves, both for use in construction and, especially in the case of mangrove poles, for export from the district to major urban centres. Over 1.3 million poles, including withies, are harvested from the woodlands, this similar to the estimated amount required annually in local building construction. Relatively few of these are sold. Mangrove pole cutting is a major commercial activity, involving an annual harvest of 126 000 scores of poles, most of which are sold. The commercial demand is for 3 of the 8 mangrove species: *Rhizophera*, *Ceriops* and *Brugiera*. Mangrove pole cutting requires licences, and consequently the business is mainly in the hands of outsiders who may or may not employ locals to do the cutting.

Similarly, timber cutting, a major commercial activity in the woodland areas, is a regulated activity which is largely controlled by businessmen from major centres who sometimes employ locals or buy from local pitsawers. As with pole cutting, the activity is fuelled by high demands from Dar es Salaam and other centres. The most valuable species, *Pterocarpus angolensis* is already scarce due to overexploitation, and the highest demand is now for its substitute, *Afzelia quanzensis*. Several other species are also cut for timber. It is estimated that about 12 000 trees are cut annually in the study area. Some timber is used locally in production of furniture and dhows. Trees are also cut for the production of other wooden products such as dug-out canoes, handles, ladles and ornaments.

Fishing is a highly important activity in the study area, both in freshwater systems and in the estuarine-marine systems of the delta. 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 estuaries and in the shallow inshore waters along the coast. The majority of fishers use nets, a relatively recent phenomenon, although traditional traps and hooks are also still commonly used. Women use fine-meshed nets in the delta. The freshwater fishery is very unselective in terms of both species composition and size: over 40 freshwater fishes occur in the floodplain system, and over 30 species were named in this study as being caught. It is, however, dominated by the most common species, notably the cichlid fish *Oreochromis urolepis* ('Tilapia'), catfishes (*Clarias, Schilbe, Bagrus*) and *Alestes*. A further 30 marine species were named in this study, and several other marine species are also known to be caught in the delta. The most important fish in the delta are *dagaa* (a general term for several small fishes such as mullet) and *mbarata* (clupeid fish such as *Hilsa kelee*). Prawns (*Metapenaeus monocerus*, *Penaeus monodon*, and especially *Peneaus indicus*) are the most valuable fishery in the delta, and form a large proportion of catches in this area. While most fish in the study area are sold dried or smoked, except for a small proportion sold locally, prawns are sold fresh. Prawn dealers supply nets and ice boxes, and are nearly always on hand to ensure the swift export of prawns from the delta. Within the floodplain, fishing is year round, but with a strong seasonal change in effort corresponding to periods of

flooding. In the delta, fishing is year round, with less of a marked seasonal change in catches, as fishers tend to track the changes in availability of prawns along the coast.. The total finfish catch is estimated to be about 9000 tons per year, with freshwater fish making up about 5500 tons, within the estimated sustainable yield of the floodplain area. The artisanal prawn fishery catches in the order of 2 200 tons per year. In addition, at least 113 tons of shrimps and 34 tons of crabs are caught.

Hunting is carried out throughout the study area, mainly by about 265 - 370 'professional' hunters with guns who supply the villages, but also by youths who target smaller species with traps and catapults. Hunting is generally unselective, with over 17 species of mammals and 26 types of birds being hunted, although certain species such as impala and buffalo are preferred. Hunting requires a licence, but control is weak and most hunting is probably illegal. An estimated 160 tons of game and 51 000 birds are hunted annually. Sport hunting is negligible or absent within the study area, although it is carried out in hunting areas nearby.

Wild honey is collected throughout the study area from woodlands and mangroves, and hives are also kept to a limited extent. The estimated annual harvest is 32 000 litres of honey, about half of which is sold locally.

The total estimated value of the different natural resource harvesting and value-adding activities is summarised in Table II. Natural resources in the study area are estimated to have an economic direct use value of $10.3 million per year. The total net financial value (net value to households in terms of home consumption and cash income) of natural resource use is estimated to be $9.2 million, or $575 per household per year, of which a large proportion is realised as cash income. Over 70% of this value is attributable to the area's fisheries.

Table II: Summary of the annual values of natural resource use estimated in this study (US$)

Resource	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Salt	141 140	94 065	132 478	116 127
Clay	12 937	8 763	10 214	9 983
Grass	6 308	6 099	-	6 573
Reeds	6 689	6 556	-	7 036
Papyrus	604	581	-	626
Medicinal Plants	104 426	103 990	58 925	119 144
Food Plants	294 124	293 733	8 197	303 076
Milala	14 662	14 484	797	15 312
Milala Products	234 023	212 506	11 899	220 970
Ukindu	113 309	112 998	84 327	128 668
Ukindu Products	93 713	45 130	16 545	51 608
Charcoal	25 973	25 873	25 973	28 613
Firewood	796 455	792 716	4 885	750 641
Poles & withies	477 002	472 953	315 187	535 257
Timber	268 028	265 746	259 249	313 633
Wood Products	278 141	184 844	231 289	215 165
Canoes	28 239	28 163	24 777	32 773
Jahazi	20 722	20 722	20 722	21 413
Fish & Crustaceans	7 776 486	6 505 568	6 896 038	7 354 530
Mammals & Birds	36 040	29 804	13 469	34 140
Honey	24 958	24 793	12 877	29 138
Total	**10 753 979**	**9 250 088**	**8 127 849**	**10 294 426**
Value Per Hh	668.24	574.79	505.05	639.68

Nearly all households in the study area have fields and consider farming as their primary economic activity. With an average field size of 0.77 - 1.2 ha in the three different areas, the total area planted each year is about 16 242 ha. At least 24 types of crops are grown, with rice, the staple food, being grown by 76% of households in the study area. Rice, maize, sweet potatoes, millet, vegetables and fruits are grown largely for subsistence, but with a proportion being sold for cash income. In addition, crops such as cashew nut, sesame and coconuts are grown primarily for cash income. Crop production is estimated to have a gross market value of $3.8 million annually, with a net economic value of about $2.6 million. Grains, especially rice, make up over half of this value, and cash crops less than 10%. A large proportion of households also keep livestock, mostly fowl, but also goats and cattle to a very limited extent, the latter only being found in the delta. These activities have a total gross value of $784 000. Coconut palms, grown mainly in the delta, provide additional value, in that numerous household products are made from their leaves, sap and husks.

Including rough estimates of income from other business as well as from agriculture and natural resources, it is estimated that natural resources account for 33-59% of net income to households (including subsistence income), and 32-63% of household cash income. Thus natural resources are extremely important in the household economy in the study area. The gross financial value of natural resources in the study area is more than double that of agricultural production, and their net economic value is triple that of agricultural value. Furthermore, natural resources are particularly important in providing livelihood security to poor households and in years of poor agricultural production.

Natural resources do have some drawbacks, however. A high proportion of households suffer damages to crops and livestock from wild animals, with crop damage mainly by wild pigs, elephants, monkeys, warthogs, hippos and birds, and livestock losses mainly to predators such as cats and birds of prey. Crop and livestock losses amount to an estimated $1 million annually in terms of their market value, and an estimated 19% of total crop production is lost. Households also spend time and effort in keeping vigilance against and hunting pest animals.

A comparison of net financial returns to labour time (including subsistence value) for different agricultural and natural resource use activities can explain household strategies to some extent. Returns are highest for timber cutting and prawn fishing, which, coupled with the high demand for these products, explains the abundant and increasing supply of labour for these activities. Returns are also high for canoe production and medicinal plant collection, but both these activities are limited by a relatively low demand. Crop cultivation yields low returns, yet takes up a major proportion of household labour time. The seemingly misspent effort put into growing crop surpluses can be explained by the fact that this activity is predominantly carried out by women, for whom the opportunity cost of time is even lower than the returns to agricultural labour. Most activities carried out by women yield low returns, with the exception of shrimp-fishing and salt-making in the delta, neither of which can be carried out at their fields. Fuelwood collection is another low-value, but time-consuming activity, which is carried out by women out of pure necessity. This is the only low-value activity that may be having a significant impact on the environment, simply due to the scale of the activity.

The values elicited in this study can be attributed to different habitats within the study area. Villagers access natural resources mostly within a radius of about 10km from the village centres, and based on this, the total area used by the study area population is about 720 000 ha. Over 90% of this area is under natural habitats. Of the permanent aquatic habitats, rivers and lakes make up 39 000 ha, the estuaries and inshore areas of the delta make up 82 000 ha, swamps cover 3 000 ha. Floodplain grassland covers 180 000 ha, terrestrial, mainly woodland habitats, cover 295 000 ha, and mangrove forest covers 55 000 ha. Some 58 000 ha are transformed into cultivated lands, and another 3700 ha are under settlements.

The direct use values of the broad habitat types are roughly $192/ha/y for estuaries and inshore waters, $42/ha/y for freshwater systems, $17/ha/y for mangroves, $14/ha/y for bushlands, woodlands and forests, and $2/ha/y for floodplain grasslands. In comparison, cultivated lands are worth $63/ha/y.

However, the above values are only part of the total economic value of natural habitats. These include indirect use value from ecosystem services, recreational use value, option and existence value, all of which were beyond the scope of this study. Indirect use values include flood attenuation, groundwater recharge, sediment retention, inputs to agriculture, water purification, nursery functions, micro-climate regulation and carbon sequestration. Rough estimates can be made for some of these. The annual flooding of the Rufiji River probably contributes about $2.75 million to the agricultural value of the floodplain. The delta provides a nursery function for the offshore commercial prawn fishery, worth some $4.5 million. Carbon sequestration values may be as high as $230 million. Taking these values into account, the value of natural habitats can be seen to be substantially higher, ranging from $17/ha for floodplain grasslands, but with all other habitats having higher values than the $63/ha for cultivated lands. Indeed, the value of grasslands would also undoubtedly be higher if the water purification function could be estimated and if their role in fishery productivity was taken into account. All of these values require further investigation.

The final part of the report considers issues that need to be taken into consideration in devising a management plan for the study area. The importance of ecological sustainability cannot be emphasised enough. This is fundamental to preserving the stocks of natural resources and functioning of ecosystems which will give rise to flows of value in future years. However, the current status of natural resources is little known, as there is a lack of comprehensive assessments or monitoring on individual resources or on ecosystem health. It appears that woodlands in the study area are under a real threat of overexploitation, following trends that have been observed elsewhere in Tanzania. Effective management is urgently required before road access to these areas improves. In the delta, mangrove cutting is selective, and may not threaten the ecology of the delta as a whole. However, this needs to be further investigated. No stock assessments have been carried out for fish and it appears that the

freshwater fishery is already close to or exceeds its sustainable yield. The status of the marine fisheries is unknown and could be under threat. Wild animals are still fairly abundant in the study area relative to other inhabited areas of Tanzania, probably mainly due to the proximity of a large source area (Selous Game Reserve). There are not data to suggest trends in animal numbers, but these resources could be being over utilised. Other plant resource stocks, such as palms and wild foods, appear to be relatively secure, but again, need to be assessed.

There are many reasons that certain resources are apparently being utilised beyond sustainable levels. An appreciation of sustainability issues will not have been engendered in a community which has until only recently had access to abundant resources, and some of the impacts of overutilisation are not likely to be felt by the users themselves. Overexploitation is fuelled by demands from outside the study area, as well as inappropriate or ineffective institutions and systems of control.

There are no quota or effort limits, and the use of several resources is 'controlled' by a licensing system. The licensing system is unwieldy and provides a comparative advantage to wealthier outsiders to enter into trade in natural resources. Locals lack the up-front cash to pay for licences, and obtaining licences also requires travelling to both the area of exploitation and to the district capital. Thus most licenses are in the hands of outsiders. The current licensing system creates an incentive for illegal harvesting of resources. Policing is not strong enough to curtail illegal exports from the area. At the local level, there is no control of resource use within villages, whose boundaries are ill-defined, and all resources are subject to open access. This also creates the incentive to overexploit resources, and no incentive to manage them sustainably. Moreover, villagers probably lack the scientific capacity to manage their resources in an integrated, optimal way.

Securing and improving the future livelihoods of people within the study area requires an optimal mix of development and conservation action within the area, and careful decision-making beyond the study area. Beyond the study area, the onus is on government to address the enormous demand for charcoal and timber in urban centres, through exploring alternatives. National-level decisions also include those which affect broad-scale habitat alteration (e.g. proposed commercial prawn-farming initiatives or oil exploration) or the hydrology of the area (e.g. the proposed dam at Stiegler's Gorge). Other decisions that may be taken at a local government level include those involving development schemes for agriculture or industry. All such decisions need to take the economic consequences of their ecological impacts into consideration, not only at the aggregate scale, but in terms of their impacts on peoples' livelihoods, especially those that do not benefit directly from such schemes. This study suggests that large-scale expansion of agriculture may not be wise, and that a major water scheme could have severe consequences for fisheries, among the most valuable resources in the study area.

Considering the high reliance on natural resources, conservation and the establishment of sustainable use practices within the study area is particularly important. Systems of control need to be revised, starting with establishing well-defined and secure property rights over resources. This involves defining village boundaries and giving village authorities real legal powers. Government intervention will probably be necessary at some level, however, to ensure the conservation and wise use of nationally-important resources. Depending on the resources involved, this may take the form of advice, the introduction of incentives, or quotas allocated at the village level. Licensing systems, if continued, should be administered at a village level, with inputs to government. There is scope for implementing schemes to improve the profitability of resource use, but these should first be carefully analysed in terms of the types of incentives that they would create under the prevailing circumstances. In general, the management strategies employed should be adaptive so that they can be revised on the basis of monitoring and improved information.

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1 Introduction

The lower Rufiji River floodplain and delta, located in the Rufiji District of the Coast Region of Tanzania, is a relatively healthy and productive natural system, whose functioning is tied to the freshwater inputs and annual flood cycles of the Rufiji River. Further upstream, the Rufiji is formed by major tributaries such as the Great Ruaha, Kilombero and Luwegu Rivers which together drain the largest river basin in Tanzania, with an area of some 177 000 km^2. A significant portion of this basin lies within the Selous Game Reserve, where rivers are unaffected by water regulation or pollution, and through which the most of the catchment drainage is channelled before entering the populated lower floodplain and delta.

The floodplain, delta and surrounding woodlands are home to a rich floral and faunal diversity of national and international conservation importance. The floodplain contains a series of large freshwater lakes which support a productive fishery. The delta supports the largest mangrove forest on the East Coast of Africa, and the mangroves in turn support one of the richest prawn-fishing grounds in this region. The fringing woodlands are floristically diverse with substantial endemism, and contain commercially valuable timber.

The area is also home to approximately 100 000 rural Tanzanians whose lifestyles and livelihoods are intricately tied to the biological diversity and functioning of this natural system. As the population in the area increases, and people following their traditional lifestyles become relatively poorer than the populous in more urban centres elsewhere, there will be an increasing pressure on the natural resources of this region. Already people complain that resources are more difficult to find. The present, almost *laissez-faire* or free-for-all, system of management is becoming outdated in the face of looming resource scarcity that never existed in the past: communities are now ever more likely to undermine the very resources upon which they depend.

However, the most proximate pressures on the area are increasingly those of outside forces over which local communities currently have little or no control and from which they gain disproportionately small benefits. The area is under increasing pressure from commercial exploitation of timber, prawns, oil and other natural resources, and the Rufiji River is being looked to for the development of water and hydro-power supply schemes which will modify its hydrological functioning. Unless the value of the area's natural resources to local communities is better understood, decisions will continue to be made which do not take the impacts on local livelihoods, and indeed even national interests, into account. Both policy makers at a national and regional level, and local communities, need to recognise the economic advantage of introducing and strengthening mechanisms to ensure wise use practices regarding resources that are no longer as abundant as they were in the past.

Recognising these potential threats both to biodiversity and livelihoods in the Rufiji basin, the Rufiji Environmental Management Project, working with the Rufiji District Council, aims to develop an understanding of the area's biodiversity and its links to human welfare, in order to formulate a sound management plan for the area. The project aims to provide for the sustainable use of the area while maintaining its ecological integrity and conservation status. It will promote the long-term conservation of the natural resources of the area in such a way that the livelihoods of the area’s inhabitants are secured and enhanced.

1.1 Aims of this study

As one of many studies commissioned by the project, the major objective of this study is to articulate the economic value of key natural resources and ecosystems of the Rufiji floodplain and delta. Secondary aims of this study were to provide information from which financial and economic instruments for sustainable ecosystem management can be developed, and to build capacity in the district for the economic valuation of environmental resources. In particular, the tasks of this study were as follows:

1. Describe the range of natural resources of the Rufiji floodplain and delta;
2. Quantify the economic value of the present major resource utilisation activities;
3. Analyse the value added to wetland resource utilisation at various stages from their primary harvesting, through local processing and trading to their final point of sale or consumption;
4. Provide a distributional analysis to indicate how these values accrue to different social groups and economic groups living within the area, and how they are distributed between groups living in and based outside the District;
5. Mention the potential for further developing existing, past but now defunct or initiating new resource utilisation activities;
6. Quantify resource values for individual activities or actors;
7. Where, and if possible, gather information about the estimated number of users, traders or beneficiaries associated with different resources, to extrapolate values to the whole area;
8. Where possible, quantify the indirect economic values associated with key ecosystem goods and services, such as regulation of water supply and quality, contribution to land productivity, breeding and nursery habitat, flood attenuation and others;
9. Suggest the most appropriate methods of natural resource valuation for the Rufiji floodplain and delta;
10. Identify deficiencies in the present knowledge of resource status and value; and
11. Make recommendations on what steps the Project and the District should take to improve economic resource assessment and valuation, particularly in relation to resources threatened by proposed developments in the region and training needs in natural resource economics at the District level.

2 Study area

2.1 Location and climate

The study area falls entirely within the Rufiji district, in the Coast Province of Tanzania (Fig. 1). The study area centres on the Rufiji River from the boundary of the Selous Game Reserve in the west to the Indian Ocean. It encompasses the floodplain on either side of the river and the extensive mangrove delta at the river mouth. In addition, it includes part of the woodland area surrounding these habitats.

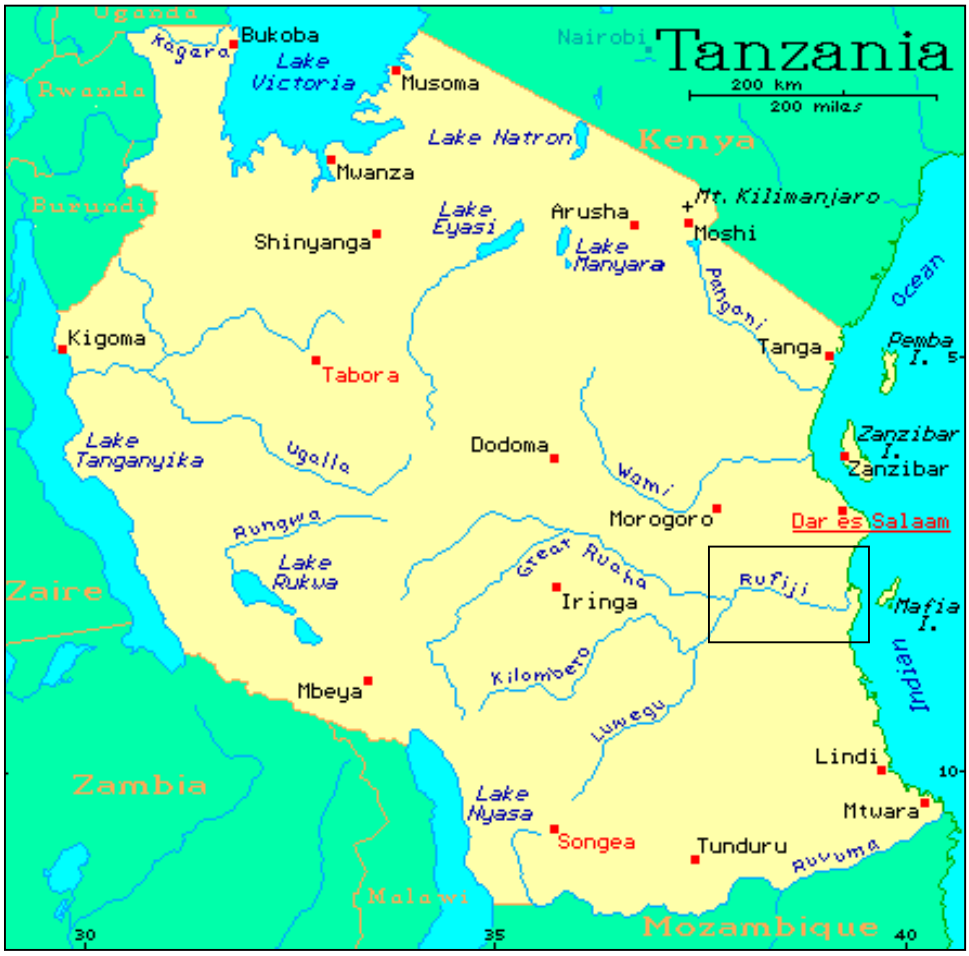

Figure 1:Location of the Rufiji River in Tanzania

Located at about 8˚S, the study area has a tropical climate with little monthly variation in daylength or temperature. Seasonality is mainly determined by rainfall (Fig. 2) and associated flooding. Floods occur from December through to April, varying in intensity and duration from year to year. At the coast, winds are also an important feature affecting fishing and trade. The NE Monsoon (*kaskazi*) blows from November to March, while the stronger SE Monsoon (*kuzi*) blows from April to November.

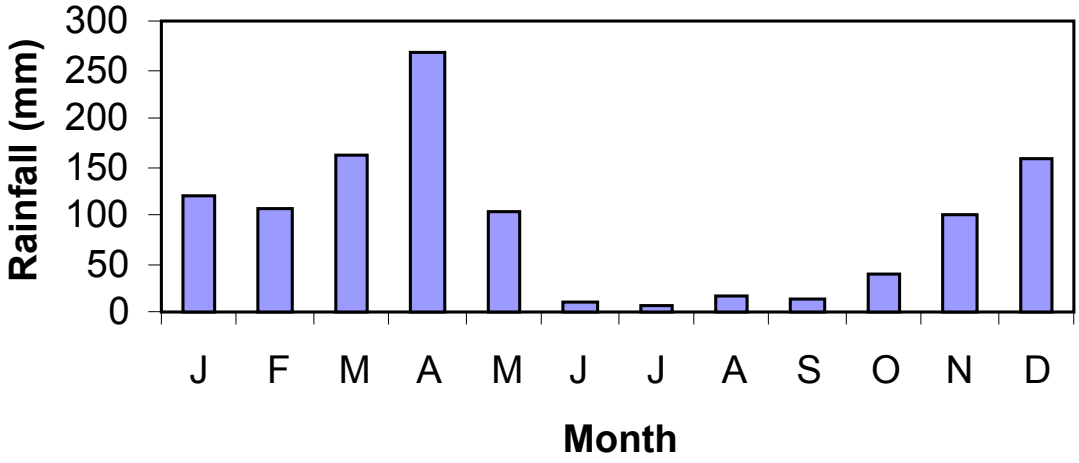

Figure 2: Average monthly rainfall in Mohoro over 21 years (Sørensen 1998).

2.2 Habitats and ecoregions

The Rufiji River enters its floodplain at Stiegler's Gorge, in the Selous Game Reserve, the floodplain ranging from 7 - 30 km wide along its length as far as the delta. The floodplain comprises a mixture of vegetation types, from marshes to open, bushed and wooded grasslands, much of which is seasonally-inundated. Permanent lakes are an important feature of the lower Rufiji floodplain, and make up a total area of 1100ha (FAO 1979). Major lakes below Mloka are Lakes Mtanza, Zumbi, Ruwe, Uba and Umwe on the north side, and Lakes Utunge, Lugongwe, Weme and Ilu on the south side. These permanent water bodies tend to be elongated, and surrounded by forests, and are connected to the river by small inlets or channels. Each year, water enters these channels and the water levels in the lakes rise. Hippos and crocodiles are present in most of the lakes, as well as the river, the latter often presenting a hindrance to fishing activities. Hippos are apparently important in limiting vegetation and in supplying nutrients into the system.

The delta is formed by 8 main distributary channels interwoven with smaller channels and creeks (Sørensen 1998). Mangrove forest covers 53 200 ha (Semesi 1991). The tidal range at spring tides is about 4m, and tidal influence extends about 40km upstream from the coast. After very strong floods in 1963, the main river flow into the delta diverted from a south-easterly direction to a north-easterly direction. This changed and expanded the mangrove distribution, with degradation in the western part of the northern delta, but regeneration eastwards onto more recently formed mudflats. In the southern delta, mangroves have occupied old farmland, and expanded up the Kiechuru River. Total mangrove area increased from 40 000 ha in 1947 to its present extent (Sørensen 1998). Areas of floodplain extend into the inner delta region. The change in flow also changed areas suitable for agricultural reliant on spring tidal surges to flood fields with freshwater. In addition to mangroves, the delta supports an area of about 17 500 ha of intertidal mudbanks (Fottland & Sorenson 1996).

The terrestrial habitats surrounding the floodplain and delta are predominantly miombo woodlands, but also include bushland, thickets and closed forests. In this study, all of these vegetation types are collectively regarded as 'forest' or 'woodland'. The total forested area in the district, excluding mangrove forest, is 323 000 ha, of which about 99 000 ha are in forest reserves.
For the purposes of this study, the study area was broadly divided into three main ecoregions (Fig. 3):

1. Floodplain area (which can be further divided into the western and central floodplain);
2. Floodplain-delta transition area (variously termed the lower floodplain or inner delta); and
3. Delta (which can be further divided into the North and South Delta).

Apart from the broad definition above, and the definition of which villages were included in the study area (see following section), the actual boundary of the study area was not defined *a priori*. The study

area and areas of different habitat types within it were defined *a posteriori*, on the basis of information collected in this study on the extent of travel from villages for resource utilisation, and are reported in the results of the study (Chapter 6).

2.3 Villages and population

There are a total of 52 villages in the study area (Table 1, Fig. 3), with a total population of approximately 100 000, in 16 093 households. The official estimate of 6.19 people per household is slightly lower than the average of 7.4 people found in this study and by Mbiha & Senkondo (2000). Population growth rate is low, at about 1.3% per annum, possibly due to a high degree of outmigration among young people. Over half (53%) of the population resides in the main floodplain area (western and central floodplains), and 36% are in the delta. The remaining 11% live in the lower floodplain-inner delta transition zone.

2.4 Village organisation

The villages of the study area were established in the 1970s, when people of Tanzania were moved into *Ujamaa* villages. The villagisation policy aimed to increase agricultural production and centralise socio-economic services. The process created large tracts of unoccupied land that were made available for conservation (Swai 1996). Each village has a Council of 15-25 members, and a Chairman. The Village Executive Officer is Secretary to the Council. The Council has the capacity to make bye-laws (Sandi 1996).

2.5 Infrastructure

The villages of the floodplain and transition zone are serviced by a network of dirt roads which are generally in average to poor condition, many becoming impassable during the wet season. Most villages in the delta are only accessible by boat. The Rufiji River is currently traversed by two small ferries, but a bridge will be constructed in the near future. There is little in the way of industrial development, no grid-electricity, and telecommunications are poor to non-existent in most areas.

Table 1: Villages, household number and population of the study area by ward and ecoregion (District Profile 1997, extrapolated from 1988 census)

Eco-region	Ward	Village Name	Population	No. Households
Western Floodplain	Ngorongo	Kilimani Mashariki	1768	243
		Kilimani Magharibi	1832	262
		Ngorongo Mashariki	1192	178
		Ngorongo Magharibi	1769	255
		Ndundunykanza	2159	294
		Kipo	1482	198
		Kipogira	1478	183
		Nyaminywili	1640	411
	Mwaseni	Mtanza/Msona	2003	343
		Mwaseni Mibuyu saba	1726	215
		Mloka A&B	2833	368
Central Floodplain	Mgomba	Mgomba Kusini	1300	425
		Mgomba Kati	1819	410
		Mgomba Kaskazini	2080	392
	Umwe	Umwe Kusini	2632	416
		Umwe Kati	3007	439
		Umwe Kaskazini	1880	205
	Ikwiriri	Ikwiriri Kusini	2080	398
		Ikwiriri Kati	1819	305
		Ikwiriri Kaskazini	1300	215
	Utete	Utete Mashariki	1137	220
		Utete Magharibi	5218	1017
		Utunge/Nyanda	1672	255
	Mkongo	Mkongo Kusini	1446	215
		Mkongo Kaskazini	2917	405
		Mbunju Mvuleni	754	123
		Ruwe	1974	310
Floodplain Subtotal			**52 917**	**8700**
Lower Floodplain/ Inner Delta	Chumbi	Chumbi A	2423	443
		Chumbi B	1149	216
		Chumbi C	633	158
		Mohoro	5568	1255
		Ndundu Tawa	1051	228
	Mtunda	Mtunda A	1541	278
		Mtunda B	330	112
		Muyuyu/Njianne	2567	368
		Kikale	930	197
Transition zone Subtotal			**10 824**	**2300**
South Delta	Mbuchi	Mbuchi	2870	382
		Mbwera Mashariki	1974	295
		Mbwera Magharibi	2413	372
	Kiongoroni	Kiongoroni	1322	195
		Jaja	1376	206
		Ruma	1262	188
		Pombwe	1222	182
North Delta	Salale	Kiomboni	1778	297
		Nyamisati	1744	204
		Mfisini/Mchinga/Salale	2617	382
	Mahege	Msindaji/Mchungu	1244	141
	Maparoni	Kiasi	769	301
		Twasalie	1955	325
		Maparoni	5182	292
		Kiechuru	1929	190
		Msala	901	186
Delta Subtotal			**35 926**	**5093**
TOTAL		**N = 52**	**99 667**	**16 093**

3 Methods

3.1 Study approach

The study involved gathering information from reports and the literature, as well as a fieldwork component and a GIS-based analysis. The field survey approach and questionnaires were designed on-site after reviewing existing information, and with inputs from local District government officials. The field study aimed to identify the range of natural resources used and to quantify this use as far as possible, as well as to determine prices and other pertinent information.

3.2 Survey methodology

Information was collected from a sample of nine villages in five different ways:

a. Meetings with village-government representatives

These meetings served to introduce our activities to the village committee and to collect basic statistics on the villages, such as population statistics, control of natural resource use, and numbers of households engaged in different natural resource-based and other activities.

b. Village mapping

A small group of villagers, including elders and members of the village committee, were asked to describe the village area in terms of its general boundaries, natural habitats and access to natural resources. Where possible, distances were indicated on the maps in terms of walking time.

c. Focus group discussions

Focus group discussions were held on several topics in each village, where applicable:
a. (Men) Fishing
b. (Men) Wood products, hunting and honey
c. (Women) Medicinal and wild food plants and fuelwood.
d. (Men and women) Reeds, sedges, grasses, palms, clay and associated production
The discussions were held with groups of 5 to 10 people who were involved in the relevant activities. Although following a questionnaire, the discussions were allowed to deviate from the questionnaire, or to concentrate on a particular aspect, as appropriate. The purpose of these discussions was to collect information of a generally applicable nature, e.g. on seasonality, markets and prices, as well as to collect sufficient information to be able to make a preliminary quantitative estimates of natural resources harvesting and processing and associated economic values (Box 1, Appendix 1).

Box 1: General structure of Focus Group discussions.

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.

d. Key informant interviews and informal discussion

In addition to, and sometimes instead of, formal focus group discussions, informal discussions were held with members of the village. Key informant interviews were held with traditional healers and salt makers, as well as with a member of the Mangrove Management Project in Kibiti. Informal discussions were held on a variety of activities. These were usually initiated by asking a women or man to show the author certain activities in the village such as handicrafts, pottery or fishing. The purpose of these discussions was to actually observe the activities discussed above, to allow for information gathering which had not been anticipated in the formal surveys, and to glean information on things which people are fairly reluctant to disclose when in groups. Women were particularly responsive to this type of "walking and talking", and in all cases, the initial one-on-one interaction ended up with other people voluntarily joining in to provide more information (as opposed to the more forced nature of the focus group method). Because the interviewer (JKT) was female, there was little suspicion, and a great deal more access into the confidence of women than would have been possible from a male interviewer.

e. Household questionnaires

In order to quantify the use of natural resources, household surveys were carried out by five local enumerators. These surveys included questions about the harvesting of all major categories of natural resources over the past year, as well as value added through processing, and income generated. The questionnaire also covered agricultural production. The most difficult questions were posed early in

the questionnaire, with agricultural production at the end, to counter the effects of survey fatigue. Each questionnaire took about 1 hour to complete. The basic structure of the household questionnaire is summarised in Box 2 (full survey in Appendix 2).

Box 2: General structure of the household surveys.

HOUSEHOLD SURVEYS

A. Household information.
Household size and composition

B. Relative value of household production
Respondents were 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 were 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 were 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 the past year,
- amount sold and price per unit
- amount of products produced from natural resources
- amount sold and prices obtained,

D. Livestock Questions were asked on the following:

- numbers of small and large stock
- production and sales over the past year, and prices obtained
- livestock losses to wild animals

E. Crops Questions were asked on the following:

- total area cultivated, and which crops grown
- amount produced in the last year 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 were asked about cash income from wages, pensions, and absent family members.

3.3 Sampling strategy

A representative sample of 9 villages was chosen from the total of 52 villages in the area (Table 2). These included four floodplain villages, two transition zone villages and three delta villages. All of the above-mentioned methods were used in each village, and a total of 128 household surveys were completed, representing 0.8% of households in the study area, and 951 people, or 0.95% of the population. The survey was carried out from 26 July to 10 August 2000. Approximately one and a half to two days were spent in each village.

Table 2: Villages surveyed in the floodplain and delta, giving number of households and the number sampled in the household questionnaire survey. Initial codes given for each village are those used throughout the report.

Eco-region	Village	Code	No households (/ecoregion)	Households in sample
Western Floodplain	Mwaseni	Mw	215	22
	Kipo	Kp	198	10
Central floodplain	Utunge/Nyanda	U	255	7
	Ruwe	R	310	15
Floodplain subtotal			978/**8700**	**54**
Transition zone	Mohoro	Mo	1255	13
	Mtunda A+B	Mt	390	16
Transition zone subtotal			1645/**2300**	**29**
Southern Delta	Kiongoroni	Kg	195	16
Northern Delta	Kiasi	Ks	301	16
	Kiomboni	Kb	297	14
Delta subtotal			793/**5093**	**46**
TOTAL			3416/**16093**	**128**

3.4 Analysis of survey data

Household survey data were entered into a spreadsheet for analysis. All data were checked, and quantities were converted to common units using information collected both in household surveys and focus group discussions. Household surveys were grouped according to their broad ecoregion (floodplain, transition or delta area) and summary statistics were generated for each. For each activity, the percentage of households involved was calculated.

The value of each resource was estimated using a spreadsheet model. The model was developed based on an existing approach developed by Turpie *et al.* (1999), in turn based on a 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 model estimates the current annual financial (private) and economic (societal) costs and returns to natural resource use and agricultural activities as well as total annual production of each type of product. The structure of the model is described in Box 3. All values are converted to US$ at an exchange rate of Tsh 800 = US$1.

Box 3: General structure of the model used for estimating annual use values

STATIC FINANCIAL AND ECONOMIC MODEL
The following were calculated for each ecoregion. Values given in tables in the results section are underlined.

1. Total production and gross income

Annual production was estimated on the basis of percentage households involved and average output per producer household. Annual production was multiplied by the average price per unit output to calculate the gross financial value of production.

2. Cash income

Cash income was calculated as the average amount sold multiplied by average price.

3. Capital input costs

Capital costs were estimated for each enterprise. This included domestic items such as canoes, and tradeable items, such as nets. Annual costs of capital were calculated on the basis of price and durability of each item, as well as how many other purposes the item is used for. Where one input, e.g. a canoe, was used for more than one activity (e.g. fishing and collection of reeds), then the value was divided among the different activities accordingly. The annual cost of capital assets was estimated using straight-line depreciation, based on the average durability of the item.

4. Variable input costs

These include tradable items such as seed and domestic items such as bundles of firewood. Labour costs were estimated on the basis of average time taken to produce a unit of output.

5. Calculation of financial and economic returns

In the financial model, annual net financial value is calculated as gross income less fixed and variable costs. Labour time is not included as a cost. Net financial value reflects the net private or household benefits of the activity, and includes both cash returns and consumption.

In the economic model, annual net economic value is reflects the *net value added to national income*. The economic measure is mostly derived from financial data, to which shadow pricing criteria have been applied to determine social costs and benefits at the national level. Labour costs are included. Net economic value is gross income less economic costs all at economic prices, and provides a measure of economic efficiency. Interest, taxes and subsidies are ignored as transfers, labour prices are adjusted to take account of unemployment (20% of minimum wage, taken as Tsh 2000 per day), a foreign exchange premium (20%) is applied to tradable items to reflect excess demand for foreign exchange, foreign inflows and outflows are treated as benefits and costs respectively, and the costs of land and government sectoral expenditures and working capital costs are excluded.

3.5 Data presentation

For each resource, data are presented in tables on the estimated production of user or producer households, the average production for all households (= total production divided by total number of households in the area), and total production (= average production by user/producer households x number of user/producer households). Values are given as gross financial value (= total production x price), net financial value (= gross financial value minus the costs of inputs other than labour), cash income (= value of production sold by households) and net economic value (= net financial value with adjusted prices and including labour input costs). Net financial value is the value realised by households, and net economic value is a measure of value to the Tanzanian economy.

3.6 Estimation of habitat areas and value

A GIS coverage incorporating most of the study area (REMP/TANRIC 2000), based on 1999 aerial photographs, was used to estimate the boundaries of the study area and the actual area of each habitat type within each of the three ecoregions. The village maps drawn in this study were used to estimate the radius around villages from within which villagers harvest most of their resources. These

distances were expressed on the maps in terms of hours' walking time, and were converted to kilometres under the assumption of an average walking speed of 3-4 km/h. Distances varied from village to village, and depending on the direction from the village, but on average, most utilised resources were located within approximately 10km of a village centre. Using ArcView 3.2, a 10km buffer was created around all villages in the study area, and the outline of the merged buffers was used to delineate the boundary of the study area, and the three ecoregions within it. The ecoregion coverage was then intersected with the original coverage to calculate the areas of each habitat type within each ecoregion. Parts of the ecoregion coverage extend beyond the existing coverage, and thus there is a small degree of underestimation of the actual area used by the inhabitants of the study area, but this error is probably less than 10% of the total area.

The value of each type of resource, including estimated value added beyond the study area, was then assigned to a particular habitat type, or divided among more than one habitat type, as applicable, and total values were calculated as value per ha.

4 Use and value of natural resources

4.1 Introduction

This chapter describes the different resources used within the study area, the degree to which local households, and where information is available, outsiders, are involved in harvesting and processing these resources, estimates of quantities of harvests and production of natural resource products, and their financial and economic value. The resources are presented roughly in 'taxonomic' order (order of organism complexity). Information sourced from focus groups, key informant interviews and informal discussions (collectively referred to as focus groups) is referenced by the code for the village in parentheses (see Table 2).

Numerous natural resources are harvested in the study area, many of which are used or processed by a high proportion of households in the study area (Table 3). The use and value of each of these products is explained and discussed in detail in the following sections.

Table 3: Percentage of households in each area and in the overall study area engaged in different natural resource-related activities (household survey data).

Activity	Floodplain	Transition	Delta	Overall
Salt-making	0	0	32.6	10.3
Pottery	9.3	3.4	28.3	14.5
Grass harvesting	25.9	24.1	2.2	18.1
Reeds harvesting	14.8	10.3	6.5	11.5
Sedge harvesting	3.7	0	0	2.0
Medicinal Plant harvesting	55.6	41.4	34.8	47.0
Food Plant harvesting	94.4	99.3	71.7	87.9
Milala harvesting	92.6	55.2	37.0	69.7
Milala Products	90.7	58.6	34.8	68.4
Ukindu harvesting	0	69.0	54.4	27.1
Ukindu Products	27.4	79.3	60.9	45.4
Firewood harvesting	90.7	100	93.5	92.9
Charcoal marking	3.7	3.5	0	2.5
Pole cutting	46.3	20.7	41.3	41.1
Timber cutting	11.1	6.9	4.4	8.4
Furniture making	7.4	10.3	6.,5	7.5
Small wood Products	1.85	6.9	8.7	4.7
Canoe making	0	3.5	4.4	1.9
Jahazi building	0	0	2.2	0.7
Fishing	55.6	51.7	60.9	56.7
Hunting game	0	6.9	2.2	1.7
Hunting birds	5.6	10.3	2.2	5.2
Honey collecting	7.4	20.7	15.2	11.8

4.2 Salt

Sea salt is extracted by women living in the delta. In villages along or near the coast, sea water collected directly or from holes dug in the mangrove mud (Ks), is boiled in metal trays to produce salt. However, away from the coast, even at Kiongoroni (about 9km from the coast), the water is not sufficiently saline, and a far more complex process is used. Here, women collect mud from mangrove creeks and pile it under a shelter to dry. A pit is made, lined with clay, and covered with sticks. Clay pots with holes in the bottom are placed onto the sticks, and the dried mud is put into these. Water is then poured through the mud and is filtered through a coconut sheath at the bottom of the pot before draining into the pit. This is done three times to extract the salt from the mud. This water is then collected and boiled in a metal tray. One tray-full is boiled for about 1.5 hours, and makes half a 60kg bag (*kiroba*) of salt. The boiling process takes a lot of wood, using about 5 big logs of 6 x ½ ft for one tray (Kb).

All women know how to make salt, with about half the households in Kiasi and most households in Kiongoroni reputedly making salt regularly, and having a saltmaking place (*jangua la chumvi)*.

About 33% of households claimed to have produced salt in the last year in the household survey, yielding an estimated total of 1660 salt making households in the delta.

Salt is made while women are in the villages, over a period of about 4 months (Kb) to 6 months (Ks). During this period they make about 2.5-3 bags per month per household (Ks) although it is possible to produce up to 30-40 bags per month (Kg). During the wet season, when women are at the *shambas*, they generally do not make salt, but will come back to the village to make one or two bags if they are short of money (Kg). A bag of salt sells for Tsh 2500 – 5000 (Kg), or Tsh 4500 (Ks), but bags are often bartered for a bag of rice or maize. Salt is usually sold to fishermen for processing fish, or to outside traders. Using the above-stated average, a producer household makes about 15-18 *viroba* per year, making (@4500) about Tsh 67 500 - 81 000 per year. This is very similar to the estimate obtained from the household survey (Table 4).

Table 4: Estimated production and value of salt in Rufiji floodplain and delta (based on hh survey data).

SALT (Delta only)	Produced (kg)	Sold (kg)	Price per kg (Tsh)	Gross financial value	Net financial value	Cash Income	Net economic value
Per user hh	891	837	76.30	68 006	45 324	63 833	55 954
Per average hh	291	273		22 170	14 776	20 809	18 241
TOTAL	**1 479 841**	**1 389 022**		112 911 901	75 251 738	105 982 381	92 901 314
TOTAL (US$)				**141 140**	**94 065**	**132 478**	**116 127**

4.3 Clay

Clay pots are used in almost every household for cooking and storage. There are a small number of professional potters (*mfinyanzi*) in each village, all women (Table 5). Although other women do occasionally make their own pots, most buy from the professional potters (Mt). Clay (*ufinyanzi*) is collected from a special area (R), usually from the river (Kp), or from mangrove areas in the delta, where it is widely available (Ks). Pots are fired in a ground kiln with grass or firewood (Kp), requiring about 1 bundle of firewood per pot (R). Pots are mostly sold locally within the village of origin (Kp, Kg), there being little in the way of potential markets (Kg). They are not sold to outsiders or tourists, being generally of low quality, undecorative and very fragile. Their durability depends on care, and with care they last for about a year (Ks), although drinking water containers may last up to seven years. The main types of pots produced are small pots of 18cm diameter, for frying, medium-sized pots of about 30cm diameter, for cooking, and large water storage containers, of about 50cm depth (Kp etc). A potter can produce 4-10 pots in one day (Ks, Kb, Kp), and usually waits to sell them before making more again (Ks). It is possible to sell 3-4 per week (Kg), or 60-100 pots per year (R, Kb). Prices range from Tsh150-200 for small pots (Kp, Mo) to Tsh150-300 for medium sized ones (Ks, Kg) and Tsh700-3000 for water containers (R, Ks).

It is difficult to quantify the number of potters, as potters range from professionals to those that make pots only occasionally for their own use. According to focus group discussions, about 2.3% of households contain professional potters (Table 5), which suggests there are about 370 professional potters in the study area. However, 14.8% of households surveyed made pottery, yielding an estimate of 2382 households engaged in this activity on any level.

Table 5: Potters in the study area, based on information from focus groups and from the household survey

			Focus groups -professional potters		Hh survey -all potters
Eco-region	**Village**	**No hh**	**No potters**	**% hh**	**% hh**
Western Floodplain	Mwaseni	215		?	
	Kipo	198	3	1.5	
Central floodplain	Utunge/Nyanda	255	3	1.2	
	Ruwe	310	20	6.5	
Lower Floodplain/Inner Delta	Mohoro	1255	10+	0.8	
	Mtunda A+B	390	7	1.8	
Southern Delta	Kiongoroni	195	>20	10.3	
Northern Delta	Kiasi	301	10	3.3	
	Kiomboni	297	7	2.4	
TOTAL		**3416**	**80**	**2.3**	**14.8**

The total production and value of clay pots was estimated from both focus group data and household surveys. The average household has one big pot for drinking water and about three small to middle-sized pots (Ks). With an average durability of 5 years for big pots and one year for small to medium pots, pot production should be in the region of 51 500 pots per year (3.2*16093hh), worth approximately Tsh11.9m or $14 900. Based on the household survey, it was estimated that 44 000 pots are produced annually, with a gross financial value of $13 000 (Table 6). A large proportion of this value is realised in the form of cash income to user households.

Table 6: Estimated production and value of pots in Rufiji floodplain and delta (based on hh survey data).

CLAY POTS	**Pots produced**	**Pots sold**	**Price**	**Gross financial value**	**Net financial value**	**Cash Income**	**Net economic value**
Floodplain							
Per user hh	7.0	3.4	213	1 491	966	724	1 089
Per average hh	0.7	0.3		139	90	67	101
Total	5 664	2 751		1 206 368	781 591	585 950	881 272
Transition							
Per user hh	10.0		200	2 000	1 250		1 650
Per average hh	0.34			68	42		56
Total	782			156 400	97 750		129 030
Delta							
Per user hh	26.42	22.3	236	6 235	4 253	5 262	4 840
Per average hh	7.48	6.3		1 764	1 204	1 489	1 370
Total	38 080	32 141		8 986 797	6 130 823	7 585 374	6 976 192
TOTAL	**44 525**	**34 892**		10 349 565	7 010 164	8 171 324	7 986 493
TOTAL (US$)				**12 937**	**8 763**	**10 214**	**9 983**

4.4 Grasses, Sedges, Reeds & Bamboo

Grasses, sedges and reeds are all used by households in the study area, but in relatively small quantities compared to other wetland areas, mainly due to the availability of palms as a preferred substitute for many of their uses. While grasses are in abundance throughout the floodplain, reeds, and particularly sedges are less common than expected, and sedges, particularly papyrus *Cyperus papyrus* are notably scarce in the study area. This seems to be a natural condition: Hobson (1979) also recorded the poverty of aquatic macrophytic vegetation as a noteable feature of the area twenty years ago.

Grasses

Grasses harvested include *upanje (Hyparrhenia* spp*), mlimbaya,* and *lalane* from the floodplain, and *lwanwe* from the uplands (Mw, U, R). They are used in some villages to make fences or hedges (up to half of households have these in Ruwe, made from about ten 50cm bundles, and replaced every year), but villagers in the delta rarely use grasses (Ks). In the floodplain, grass is harvested in 50cm bundles, and very rarely sold for Tsh 150-300 per bundle (U, Mw, R). Grasses are available close to or in the villages, and it takes under 1.5h to find and collect a bundle. About 23 000 bundles of grass are harvested annually, mostly from the floodplain (Table 7). This harvest is estimated to be worth just over $6 000 per year, but is almost entirely a subsistence value.

Table 7: Estimated harvest and value of grass in Rufiji floodplain and delta (based on hh survey data).

GRASS	Harvested (bundles)	Sold (bundles)	Price	Gross Financial value	Net financial value	Cash Income	Net Economic value
Floodplain							
Per user hh	9	0	220	1 934	1 877	0	1 989
Per average hh	2	0		501	487	0	516
Total	19 829	0		4 362 479	4 233 570	0	4 486 395
Transition							
Per user hh	5	0	220	1 100	1 043	0	1 263
Per average hh	1	0		266	252	0	305
Total	2 776	0		610 742	579 015	0	701 164
Delta							
Per user hh	3	0	220	660	603	0	641
Per average hh	0	0		14	13	0	14
Total	332	0		72 942	66 627	0	70 854
TOTAL	**22 937**			5 046 163	4 879 211		5 258 413
TOTAL (US$)				**6 308**	**6 099**		**6 573**

Sedges

There is a notable scarcity of sedges in the study area. In particular, papyrus *Cyperus papyrus* (*malilingwa*) is virtually absent in the area. This is an important resource in many wetland areas in Africa, being commonly used to produce mats and various other products (Turpie *et al.* 1999). However, people in this study area reported that they hardly use it, although it is available in places (e.g. Utunge). Children make bird cages from papyrus (Ks), and it is used in ceiling construction. In the household survey, harvests were only reported from the floodplain area, by 3.7% of households there. A total of 1610 bundles are estimated to be harvested annually, with a gross financial value of $600, all of which is realised as subsistence value.

Table 8: Estimated harvest and value of sedges in Rufiji floodplain (based on hh survey data).

SEDGES (Floodplain only)	Harvested (bundles)	Sold (bundles)	Price	Gross Financial value	Net Financial Value	Cash Income	Net Economic value
Per user hh	5.00	0	300	1 500	1 443	0	1 555
Per average hh	0.19	0		56	53	0	58
TOTAL	**1 610**			482 850	464 456	0	500 669
TOTAL(US$)				**604**	**581**	**0**	**626**

Reeds

Reeds *Phragmites australis* (*matete* or *mabuwa*) are not used extensively as they are in other parts of Africa, but are harvested by men and women (mainly men) for various purposes in Rufiji. These include making fences (Mt), chicken coops (Kp), grain storage containers (*kihenge* or *Saga* - Kp), mats (*utefu* - Mo) and in house construction (Mo). Indeed they apparently even provide useful tools for flicking mud at birds in fields! (Ks). A chicken coop (about 1.5m by 40cm high) is made from a bundle of reeds, and sells for about Tsh 1000-1500 in the floodplain and Tsh2500-3000 in the delta (Kb). About a quarter of households have these, the remainder being made of timber. A rice storage container is made like a mat, then rolled up as a cylinder (Kp), lined with rice straws. Covered with an old mat, it keeps rice for 6 months to a year. Reeds are sometimes used for making ceilings, and in

Mohoro, many houses were built using reeds in the walls instead of withies (*fito*). Mats (2.5 x 2.5m) are made from a bundle of reeds, which are split, laid flat and dried, and sell for about Tsh2000 (Mo). These are not preferred mats, and few households have them (Mo, Kb). There is generally no market for reeds, but they can sell for about Tsh200-300 per bundle in the floodplain (U, Mw) and Tsh500 per bundle in the delta (Kb). Reeds are readily availabe, within 15 – 45 minutes walking distance from most villages (Mw, U, R, Kp) or from their fields (Kb).

It is estimated that approximately 19 000 bundles of reeds are harvested from the study area each year (Table 9), with a gross financial value of $6700, all of which is realised as subsistence value. In addition, value is added to reeds through making chicken coops. From the household survey data, it is estimated that about 111 coops are made per year, sold for an average of Tsh 3500, and realising a total financial value of $484 per year.

Table 9: Estimated harvest and value of reeds in Rufiji floodplain and delta (based on hh survey data).

REEDS	Harvested (bundles)	Sold (bundles)	Price	Gross Financial value	Net Financial Value	Cash Income	Net Economic value
Floodplain							
Per user hh	13.6	0	278	3 789	3 732	0	3 979
Per average hh	2.0	0		561	553	0	589
Total	17 562	0		4 882 193	4 808 566	0	5 126 436
Transition							
Per user hh	3.7	0	300	1 101	1 044	0	1 264
Per average hh	0.4	0		114	108	0	131
Total	873	0		261 840	248 250	0	300 618
Delta							
Per user hh	1.7	0	367	624	567	0	607
Per average hh	0.1	0		41	37	0	40
Total	565	0		207 174	188 199	0	201 409
TOTAL	**18 999**			5 351 208	5 245 016	0	5 628 463
TOTAL (US$)				**6 689**	**6 556**	**0**	**7 036**

Bamboo

Two important products are made from bamboo – large carrying baskets (*tenga*), used for fish and agricultural products, and winnowing baskets (*nyungu*). *Tenga* and *nyungu* are sold for Tsh 1000 and Tsh 6-800, respectively. These are made by men in the Mohoro area and elsewhere (e.g. Mikorwa, Kibiti). Most households own these products, but most of the production appears to be outside of the study area, and a value for production within the study area could not be estimated.

4.5 Palms

The study area is rich in indigenous palm trees of a variety of species. Palm leaves are used for a variety of purposes (described below), and fruits are eaten. However, little use is made of palm wood or sap, unlike in other wetland and woodland areas in southern Africa.

Lala palm (*Milala*)

The lala palm *Hyphaene coriacea* (variously called *milala* or *miaa,* and sometimes called *mikoche* or *mingweta)* is the most common and widespread palm in the study area, occurring on sandy islands in the delta as well as throughout the floodplain and woodland habitats. The leaves are used for a variety of purposes, described below. *Milala* palms are generally available close to villages (U, Ks, Mw, Mt), although people in Utunge complain that the prevalence of bush fires is forcing them to go further afield. However, in parts of the delta they are not abundant and have to be bought (Kb). Leaves are harvested in bundles of 60, and sell for about Tsh 300 (U, Mw). Almost all households (93%) in the floodplain harvest *milala*, and fewer do so in the transition and delta areas (55% and 37%, respectively). Most of the harvest is for home use, with the total financial value of the harvest being about $14 700 (Table 10), but generating cash income of only $800, or less than $1 per user household per year on average.

Table 10: Estimated harvest and value of milala palm leaves in Rufiji floodplain and delta (based on hh survey data).

MILALA	Harvested (bundles)	Sold (bundles)	Price	Gross Financial value	Net Financial Value	Cash Income	Net Economic value
Floodplain							
Per user hh	17	1	299	5 095	5 038	383	5 205
Per average hh	3	0		868	858	65	887
Total	25 261	1 898		7 553 176	7 468 463	567 375	7 716 025
Transition							
Per user hh	16	1	313	4 852	4 794	197	5 765
Per average hh	2	0		752	743	31	894
Total	5 526	225		1 729 560	1 709 188	70 298	2 055 100
Delta							
Per user hh	13	0	291	3 739	3 682	0	3 788
Per average hh	2	0		481	473	0	487
Total	8 410	0		2 447 219	2 409 822	0	2 478 782
TOTAL	39 197	2 122		11 729 956	11 587 474	637 673	12 249 907
TOTAL (US$)				**14 662**	**14 484**	**797**	**15 312**

Numerous products are made from *milala* leaves, both by men and women (Table 11). Women are the main producers of mats and sleeping bags, but men are the main producers of rope. Most of these products are common in most households throughout the study area. The large drying mats are the exception, with few people involved in making these. Owners share or hire them for threshing rice. The hire charge is about 8kg of rice per day or 4kg/day for a small mat (Ks).

Table 11: Products made from milala leaves, prices, durability and average number per household, based on focus group data from U, R, Mw, Kp, Mo, Kg and Mt.

MILALA PRODUCTS		Bundles of milala	Price	Durability	Average number per household
Sleeping bags	*Mafumba*	2-3	2-3000	1-3y	4-5 (3-6)*
Mats#	*Vitanga*	1	1-1800	1-2y	1-3@
Drying mats	*Majamvi*	2-5	4-8000	4-5y	A few hh have 2-3, half hh have at least 1
Baskets	*Vikapu*	Up to 1	300-1000	1-2y	2-3/hh, up to 6
Ropes for beds	*Kamba*	2	700	2-3	5-7/hh
Hats	*Kofia*	0.5	150-300	1-3y	75%, Most farmers
Food covers	*Kawa, mifoniko*	0.5	500	1-1.5y	1-2/hh (floodplain)
Brooms**	*Mfagio*	spines	40-150	1y	3-4/hh
Grain silo	*Kitungi*		350-600		Very few

*everyone has one, but some share (e.g. children, couples)
Can be round ("elephant ear") or rectangular ("pembenne").
@ not as common as ukindu mats in the delta and transition zones –about 1-2 per hh.
** In the delta brooms are made from coconut leaves as well as milala

Estimates of the total annual production of milala products based on focus group data (Table 11) and household survey data yield a similar overall value (Table 12), but there are some discrepancies in numbers of certain products produced. Estimates of the numbers of larger items produced are fairly close, but production of smaller items tended to be underestimated by the household survey. This is to be expected because respondents were not prompted to give information on specific products, and are less likely to have named small items they consider relatively insignificant.

Table 12: Estimates of the total production and value of milala products based on focus group data and based on household survey data.

	From focus group data		From household survey data	
	Production per year	Value (US$)	Production per year	Value (US$)
Sleeping bags	36 209	113 153	17 009	106 805
Mats	21 457	37 550	18 027	92 510
Drying mats	2 503	18 775	4 562	23 206
Baskets	26 821	20 116	8 113	3 769
Ropes for beds	32 186	28 163	7 958	4 501
Hats	4 023	1 006	4 421	2 763
Food covers	8 700	5 438	349	218
Brooms	56 325	2 816	2 521	252
TOTAL	**188 224**	**227 017**	**62 960**	**234 024**

Using the household survey data, it is estimated that the total value of milala products produced is in the order of $234 000 per year (Table 13), representing a value added of $212 000 to the palm leaf harvest. Interestingly, only a small proportion of this value (less than 6%) is translated into cash income. Producer households in the floodplain, where most households are involved, sell very few products making just over $1 per year on average. Households in the transition and delta zones sold a much greater proportion of their production, making up to $30 per year. However, most of these sales are local, there being very little marketing of milala products for export from Rufiji District. Even producers living in the vicinity of Selous Game Reserve are unable to market their products there (R, Ms; Selous staff, pers. comm.). A project which attempted to initiate such trade from Mloka apparently did not succeed.

Table 13: Estimated value of products from milala palm leaves in Rufiji floodplain and delta (based on hh survey data).

MILALA PRODUCTS	Products Made	Products sold	Ave Price	Gross financial value	Net Financial value	Cash Income	Net Economic value
Floodplain							
Per user hh	19	3	1772	36 540	33 625	998	33 358
Per average hh	5	0		16 845	15 286	120	15 830
Total	42 367	2 705		146 555 274	132 986 919	1045 495	137 718 262
Transition							
Per user hh	36	20	1843	45 146	42 301	14 340	51 330
Per average hh	4	2		7 250	6 622	1 426	8 072
Total	8 620	3 705		16 675 449	15 230 449	3279 210	18 565 539
Delta							
Per user hh	54	43	1647	50 779	44 369	24 270	41 373
Per average hh	2	1		4 710	4 278	1 020	4 024
Total	11 972	5 773		23 987 762	21 787 680	5194 125	20 492 467
TOTAL	**62 959**	**12 183**		187 218 485	170 005 049	9518 830	176 776 268
TOTAL (US$)				**234 023**	**212 506**	**11 899**	**220 970**

Wild date palm (*Ukindu*)

Ukindu (*Phoenix reclinata)* is found mainly in the delta and transition zone, where it is common and forms an important resource, the leaves being used for making numerous handicrafts (described below). Availability of *ukindu* varies from village to village in the delta, but it is generally widely available. *Ukindu* is also available to villagers in the transition zone, but they have to go further to find it, sometimes up to 2 hours away (Mt). The leaves of *ukindu* are collected while still folded, then dried before packing into small bundles of about 5cm diameter (*vichanga*). Plants reportedly produce a new leaf after 7 days (Kg). Women harvest *ukindu* to make products, while men harvest *ukindu* in much greater quantities for sale to outside traders. Most men harvest *ukindu* during the dry season (when it can be dried). Traders pay between Tsh10 and Tsh50 for a small bundle, with better prices

paid by traders from Zanzibar than those from Dar es Salaam (Ks). People in the floodplain pay up to Tsh 100 per *vichanga* (U).

It is estimated that over two million *vichanga* of *ukindu* are harvested annually from the delta and transition zones, with two-thirds of this harvest coming from the delta (Table 14). The total harvest has a gross financial value of $113 300 per year and over 80% of the net financial value is realised in terms of cash income. Some of the trade in *ukindu* is to households in the floodplain area for making *ukindu* products, but most traded *ukindu* is exported outside the District. It has been estimated that the export value of *ukindu* from the delta is in the region of $400 000 (Sørensen 1998).

Table 14. Estimated harvest and value of ukindu palm leaves in Rufiji floodplain and delta (based on hh survey data).

UKINDU	Harvested (vichanga)	Sold (vichanga)	Ave Price	Gross financial value	Net Financial value	Cash Income	Net Economic value
Transition							
Per user hh	463	319	38	17 743	17 685	12 214	21 234
Per average hh	319	220		12 237	12 198	8 424	14 645
Total	733 906	505 240		28 145 307	28 054 661	19 375 944	33 683 723
Delta							
Per user hh	539	415	42	22 580	22 523	17 372	25 018
Per average hh	293	225		12 272	12 241	9 442	13 597
Total	1 491 700	1 147 632		62 502 218	62 344 044	48 085 767	69 250 614
TOTAL	**2 225 606**	**1 652 871**		90 647 526	90 398 705	67 461 711	102 934 337
TOTAL (US$)				**113 309**	**112 998**	**84 327**	**128 668**

Several products are made from *ukindu* (Table 14), also using a needle from copper or from umbrella wire. This work is done by women. Although many similar products are made to those made from *milala*, *ukindu* is usually dyed before weaving into colourful products. Some dyes (e.g. black and yellow) are made from local vegetable dyes, while others are bought (Kb). Some products, such as covers and ornaments, are made with natural coloured *ukindu*, and then painted in Kibiti, Mafia or Dar es Salaam. *Ukindu* products generally last longer than *milala* products (Kg). *Ukindu* products are not only made in the area of source, but as far afield as Mwaseni in the western floodplain. Indeed, in the delta, milala mats are relatively uncommon, with *ukindu* mats being favoured (Kb). Woven strips of about 2cm wide are first made, at a rate of about 2m per hour (Kg). A mat of 2x2m requires about 100m of strip. The strips are sewn together around a length of wood to make a tube, which is then cut to make a mat. About Tsh2000 worth of *ukindu* is used to make a mat. Mats which sell locally for Tsh6-8000 fetch about Tsh10 000 in Dar es Salaam (Kg). About two-thirds of traded mats are sold locally, the remainder exported to Mafia, Dar es Salaam and Zanzibar (Ks). Mats are generally made for household use, and producers complain of a lack of market for selling (Mt). In this case, the problem is probably due to a lack of marketing, as *ukindu* products are generally of high quality and very attractive.

Again, estimates of the total annual production of *ukindu* products based on focus group data (Table 15) and household survey data yield a similar overall value (Table 16), but there are some discrepancies in numbers of certain products produced. As for milala products, estimates of the numbers of larger items produced are fairly close, but in this case, insufficient data was collected on smaller or uncommon products in the focus groups. Some of the differences can be explained by the fact that a surplus is made for export out of the study area.
Based on household survey data, about 29 000 *ukindu* products are made annually, with a total market value of $93 700 (Table 17). Input costs of this production are relatively high, due to the high value of *ukindu* leaves, and value added to the harvest amounts to about $45 000. *Ukindu* product production yields about $9-12 cash income per producer household.

Table 15. Products made from ukindu leaves, prices, durability and average number per household, based on focus group data from Mt, U, Mw, Mo, Kg, Ks.

UKINDU PRODUCTS		Bundles of ukindu	Price	Durability	Average number per household
Sleeping bags	*Mafumba*	?	?	?	Very few
Mats	*Mikeka*	50-60	6-8000	3-10y	Floodplain: 2-3, but not all hh; Transition: 3-4; Delta: 3; 2-10
Praying mats	*Miswala*	?	1500-2000		Delta: 0.5
Food covers	*Kawa, mifoniko*		300-500	1	Delta, transition: 1-4
Baskets	*Vikapu*				?
Fans	*Vipepeo*	2	200		Few
Hats	*Kofia*	2	150-300	3	?
Ornaments	*Viangaisho*		500-1000		Few

Table 16. **Estimates of the total production and value of ukindu products based on focus group data and based on household survey data.**

	From focus group data		From household survey data	
	Production per year	Value (US$)	Production per year	Value (US$)
Mats	10 183	89 101	16 569	82 454
Praying mats	509	1 114	713	891
Food covers	3 697	2 310	5 876	5 457
Fans	?		3 705	2 851
Baskets	?		2 325	2 060
TOTAL	**14 389**	**92 525**	**29 188**	**93 713**

Table 17. Estimated value of products from ukindu palm leaves in Rufiji floodplain and delta (based on hh survey data).

UKINDU PRODUCTS	Products made	Products sold	Ave Price	Gross Financial Value	Net financial value	Cash Income	Net Economic Value
Floodplain							
Per user hh	4	0	4900	9 800	9 400	0	9 260
Per average hh	0	0		950	942	0	954
Total	2 262	0		8 263 260	8 197 140	0	8 302 062
Transition							
Per user hh	25	12	7162	29 117	13 292	9 459	19 115
Per average hh	5	2		13 437	5 968	2 961	8 656
Total	11 294	3 604		30 904 650	13 727 044	6 810 107	19 907 974
Delta							
Per user hh	20	8	7089	23 420	11 475	7 128	8 924
Per average hh	3	1		7 030	2 784	1 262	2 568
Total	15 632	4 305		35 802 324	14 179 603	6 426 033	13 076 604
TOTAL	**29 188**	**7 910**		74 970 234	36 103 786	13 236 140	41 286 639
TOTAL (US$)				**93 713**	**45 130**	**16 545**	**51 608**

Borassus palm (*Mvumo*)

Less common, but throughout the study area, is the *mvumo*, or borassus palm *Borassus aethiopium*. Probably due to low availability, this species is not commonly used, and no information was collected in the household survey. The leaves are occasionally used for thatching or making chicken coops (Mo), or for building hedges (Mt). The logs are sometimes hollowed out to make chicken coops or canoes (Kp).

Planted (introduced) palms

Two species of palm are commonly grown in the study area. The oil palm (*Michikiti*) is found sparsely throughout the study area, and its fruits are used for cooking oil. Coconut palms are grown in the delta and to a much lesser extent in the transition zone. The latter are an important resource, not only for production of coconuts, but the leaves are a substitute for *milala* as a preferred material

for thatching 'tiles' (*kiungo*) and 'sheets' (*kumba*) for building walls and fences. The leaves are also used to make temporary fish baskets (*pakacha*). Since coconut palms are cultivated resources, their value is not considered here.

4.6 Food plants

Most households in the study area harvest wild foods (94% in the floodplain, 80% in the transition zone and 72% in the delta). Four main categories of food plants are harvested: grains and tubers used for hard porridge (*ugali*), leaves used as vegetables, and fruits. At least ten species of plants are used as substitutes for cultivated grain and root vegetables, and at least 20 species are used as wild leaf vegetables (Table 18). All of these are collected by women.

Grains and tubers are particularly important during the famine season, when they may be used daily, or at least twice per week (Mw). Their use during the rest of the year depends on the circumstances of a household. These plants are seldom traded, but *uwanga*, which appears to be one of the more important species in the delta, is bought in some places (Kb). *Uwanga*, which resembles potatoes, is grated using cartilaginous fish skin (ray - *kitaa*), before drying to make into flour (Kb). *Uwanga* flour sells for about Tsh1000 per pishi (Ks). Some of the famine foods, such as *rwila*, are only eaten during severe food shortages. *Rwila* gives stomach problems when eaten. One bag of *rwila* yields 2 *pishi* (small plastic or tin tub which carries 2.5-3kg rice) of grains. For comparison, a *pishi* of unthreshed rice costs about Tsh500 and yields Tsh 800 worth (2kg) of threshed rice (Ks). Leaf vegetables are mainly available and collected during the wet season, especially when cultivated vegetables are in short supply (Mt, Ks). They are not eaten very commonly, but are considered important during these times.

Numerous types of wild fruits are collected, mainly by children and women. Men help in collection of fruits which are difficult to get to (e.g. *makoche*), and some men collect fruits for trading (U). Over 60 species were named in focus groups and in the household survey (Table 19). Most fruits available during the wet season (or season of plenty), but fruits are available year-round, and are eaten any time. Many households trade in wild fruits and several are used for making juice (Kp).

Wild vegetables are collected from a variety of habitats, including floodplain (*bondeni*), forest (*msitu*), and to a lesser extent, lakes (*mbwawa*) and grassy waterlogged areas (*njacha*). Fruits are mainly collected from the forest. Food plants are collected around villages and fields, usually from within a 2-3 hour radius (U, Mw, R), but finding these plants can take all day (Mw). For the most part, wild foods are collected while women are travelling from their fields etc, but people do make special trips to collect certain species, such as *mwage* (R). As they are locally-collected, there is no overlap in the areas used for collection by neighbouring villages (Mw, U). Interestingly, people report that food plants are easier to find now than several years ago. This is because there are now shops in the villages selling rice and flour, which means that people with money are less dependent on wild foods than they were in the past, easing the pressure on natural resources.

From the household survey it was estimated that a total of 1720 tons of wild foods are collected annually in the study area. With an average price of Tsh130-160 per kg, the gross financial value of this harvest is about $294 000 per year. Most of the harvest is for subsistence use, and it yields a small cash income to households (Table 20).

Table 18. Wild vegetables collected by households in the Rufiji floodplain and delta, named in focus group discussions (village source given) and in the household surveys. Habitats given are forest/woodland (W), island (I), floodplain/fields (F), mangroves (M) and waterlogged areas/*njacha* (N) and lakes (L).

Habitat	Species	Parts	Villages	Comments
I, W	*Uwanga (Gonatous boivinii)*	Tuber	R, Kg, Mt, Kb	Used for *ugali*, at end of wet season and in dry season, especially while waiting for the rice harvest.
W	*Dendego*	Tubers	Mw	Like cassava, used for *ugali*. Poisonous when raw, so ferment then dry
W	*Unyanya*	Roots	U	July
W	*Ubao*	Tuber	Mt	Same time as *uwanga*
F	*Lulindi*	Grain	Mw	Like wild rice, used for hard porridge during famine season
F	*Mbalugwe*	Grain	Mw	Used during famine season, Like a grass, looks like rice after threshing
?	*Lumbalwe*	Grain	U	Wild millet
F	*Rwila (Flagellaria guineensis)*	Grain	R, Ks	Specially during hunger; for *ugali*
F	*Ntago*	Grain	Ks	Available in dry season, when preparing fields
W,W	*Kingonbokombo*	Beans	Mt	
W,F,N;M	*Mwage (Sesbania* spp.*)*	Leaves	Mw, U, R, Mt	Use any time, eat while in fields
F	*Hombo (?Sesamium angustifolium)*	Leaves	Mw	Like wild ochre; Famine
W,F	*Mlonge*	Leaves	Mw, U	Famine
F	*Andarongo*	Leaves	Mw	Famine
F	*Uchicha (?)*	Leaves	U	
L	*Makangasa (*water lily*)*	Leaves	U	Use young shoots; Famine food
	Lundindi	Leaves	U	
F	*Mlenda (Corchorus aestuans)*	Leaves	R	Best used in famine
	Ngandarongo	Leaves	R	
	Lilamba	Leaves	R	
	Kibange	Leaves	R	
	Sunga	Leaves	R	Don't eat much of this
	Mingaoka	Leaves	R	
I	*Mkorontende*	Leaves	Ks	
M	*Korombwani (Sesuvium portulacastrum)*	Leaves	Ks, Kg, Kb, Mt	Eat while in village
F	*Kitengalwala*	Leaves	Ks	Crawling plant
F	*Tombolombo*	Leaves	Ks	Eaten any time
F	*Kiberege (Pychostachus reticulata)*	Leaves	Ks	In wet season
F,M	*Lende (Sesamum angolense)*	Leaves	Mt	
F	*Nyampioko or bintiali*	Leaves	Mt	
F	*Kibange*	Leaves	Mt	

Table 19. Wild fruits collected by households in the Rufiji floodplain and delta, named in focus group discussions (village source given).

Habitat	Local name	Species	Source	Comments
N, I, F, W	*Furu*	*Vitex doniana*	Mw, R, Ks, Kb, Mt	Famine.
	Makoche		Mw	Famine
	Mingweta		Mw	Famine
W, F	*Mabungo*	*Landolphia kirkii*	U, R, Ks, Mt	
W, F	*Mpilipili*	*Sorindea madagascariensis*	U, R, Ks, Kb	
W	*Mkwaju*		U	Jul
W, I	*Matopetope*	*Annona senegalensis*	U, R, Ks, Kb, Mt	Apr.
W	*Imbobo/ingobo*		U	Apr
W	*Mandungutungu*		U	Apr
W	*Manga*		U, R	Apr
W, N	*Ndaba*		U, R	Apr
W	*Mashada*		U	Jul
	Zambarau		R	
	Mambwilu		R	
F, F	*Utende/mitende*	*Phoenix reclinata*	Ks, Mt	(from *Ukindu*)
F, I	*Kingweta/Vingweta*	*Hyphaene coriacea*	Ks, Mt	(from *Milala*)
	Mvumo	*Borassus aethiopicum*	Kp	
I	*Matonga*	*Strychnos spinosa /S. madagascariensis*	Ks	
I	*Mafukuso/mfugusi*		Ks	
F	*Mambele*		Ks	
F, I	*Kitoja/Vitodia*		Ks	
F	*Sambia*		Ks	
I, W	*Muwawa*	*Keetia zanzibarica*	Ks	Black berries
	Mabora		Kb	
	Tende	(orange berry)	Kb	
	Lwila/luida	*Flagellaria guineensis*	Kb	
W	*Ngama*		Mt	
W	*Mitumba/matumba*		Mt	
W	*Mkwaju*	*Tamarindus indica*	Mt	For juice
W	*Ngenyekenye*	*Xylotheca tettensis*		

Other wild fruits named in household surveys

Mahanga	*Micheka*	*Nyamvula*	*Mdamadamu*
Mailu	*Mgongo*	*Ndoba*	*Usambya*
Mesekya	*Noati*	*Mbubudu*	*Nsofu*
Msame	*Mapera*	*Noamba*	*Mugo*
Misade	*Mnawa*	*Mibula/mabula*	*Mjengawa*
Mabolo	*Miwawa*	*Mbuya/Ubuyu*	*Msamatele*
Mangombe	*Mikwaya*	*Myembayemba*	*Mtalah*
Vimbobo	*Ukangaza*	*Mitodya/ vitoya*	

Table 20. Estimated harvest and value of wild foods in Rufiji floodplain and delta (based on hh survey data).

WILD FOOD PLANTS	Harvested (kg)	Sold (kg)	Ave Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	147	0	131	19 309	19 309	1	19 486
Per average hh	139	0		18 228	18 228	1	18 395
Total	1 210 567	82		158 584 240	158 584 240	10 759	160 036 920
Transition							
Per user hh	75	15	130	9 763	9 706	1 976	11 658
Per average hh	60	12		7 742	7 697	1 567	9 245
Total	136 975	27 723		17 806 736	17 702 513	3 604 026	21 263 860
Delta							
Per user hh	102	5	158	16 132	16 075	806	16 749
Per average hh	73	4		11 567	11 526	578	12 009
Total	372 837	18 624		58 908 188	58 699 520	2 942 525	61 160 242
TOTAL	**1 720 378**	**46 429**		235 299 164	234 986 273	6 557 310	242 461 022
TOTAL (US$)				**294 124**	**293 733**	**8 197**	**303 076**

4.7 Medicinal plants

Medicinal plants are not collected as extensively as food plants, with many households claiming that they prefer to consult clinics or traditional healers. It is generally agreed that knowledge and collection of traditional medicines is increasingly the domain of elders and traditional healers (Mw, U, Ks, Kb). There are a few traditional healers in most villages, usually up to 5 or 6 (Kb), but up to 10 in Mohoro. Not all of these healers use plants, however, some relying exclusively on other activities such as dream interpretation. Nevertheless, the household survey showed that a significant proportion of households do collect medicinal plants for home use (56% in the floodplain, 41% in the transition zone and 35% in the delta). Medicinal plants are usually accessible close to villages (U, R, Mt). They are mostly collected from the forest, but some species are taken from the floodplain, rivers and lakes, and from mangrove areas. A traditional healer in Mohoro claimed to earn about Tsh 60 000 per year from this trade (in addition to his agricultural activities), using about half a sack of leaves (~ 5kg) and 25kg of roots and barks per year. In this business, plants are not sold, but treatment is sold. At least 24 species of plants are commonly used for medicinal purposes (Table 21), but traditional healers are reluctant to reveal some of the lesser known species they use. A total of 23 species (Latin names only) were named by Sosavelle *et al.* (1998) as being used in the delta alone, and other studies have named up to 35 species being used in miombo woodlands (Luoga *et al.* in press a).

Based on the household survey, it is estimated that about 98 tons of medicinal plants are harvested annually in the study area (Table 22). With a fairly high value per kg of about Tsh 750 –1400, this harvest has a total market value of $104 000. A high proportion of the harvest in the floodplain area was reputedly sold, yielding substantial cash income to these households.

Table 21. Medicinal plants collected by households in the Rufiji floodplain and delta, named in focus group discussions (village source given).

Species marked with an asterisk were named by a traditional healer in Mohoro as commonly-used species.

Habitat	Species	Parts used	Villages	Uses
Floodplain	*Mnyalanyala*	Roots (*mizizi*)	U	For stomache ache
Forest	*Msisiana*	Leaves, roots	U	Fever, stomach
Forest	*Mpakocha*	Leaves, roots	U	Nausea, *kisunguzungu*
Forest	*Mwegele*	Leaves	U	*Kifafa*
Forest	*Mpiugi*	Roots	U	Mucous, diarrhoea
Forest	*Mtesatesa*	leaves	U	*Kifafa*
Floodplain	*Ntonga-ngumba*	roots	U	Stomach ache
Floodplain, forest	*Mingaoka**	leaves	R, Mo	Fever
Forest	*Nyanyapori*	roots	R	Stomach ache
Forest	*Mzizimia*	leaves	R	Fever
Forest	*Mwarabaini (Fotomiasin)*	leaves	R	Headache, stomach
Forest	*Mkandanga*	Leaves	R	Cough
Forest	*Muruka**		Mo	
Forest	*Mtambapanya**		Mo	
Forest	*Mkiafisi**		Mo	
Forest	*Mtetema**		Mo	
Floodplain	*Unyegele**		Mo	
	*Makangasa**		Mo	
	*Lwila**		Mo	
River	Stones*		Mo	
Mangrove	Some roots*		Mo	
Forest	*Mpera*	Leaves	Mt	
Floodplain	*Nyalanyala*	Roots	Mt	
	Marubaini	Leaves and roots	Mt	Abortion
	Mwembedodo	Mango tree bark	Mt	
	Mfumbamfumba	Leaves	Mt	

Table 22. Estimated harvest and value of wild medicinal plants in Rufiji floodplain and delta (based on hh survey data).

MEDICINAL PLANTS	Harvested (kg)	Sold (kg)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	17	13	756	12 761	12 721	9 752	14 430
Per average hh	9	7		7 090	7 068	5 418	8 017
Total	81 593	62 355		61 684 454	61 491 106	47 140 371	69 748 337
Transition							
Per user hh	7	0	1172	7 911	7 854	0	9 436
Per average hh	3	0		3 274	3 250	0	3 905
Total	6 424	0		7 529 215	7 474 830	0	8 980 673
Delta							
Per user hh	6	0	1419	8 088	8 031	0	9 364
Per average hh	2	0		2 813	2 793	0	3 257
Total	10 097	0		14 327 173	14 225 953	0	16 586 554
TOTAL	**98 114**	**62 355**		83 540 843	83 191 889	47 140 371	95 315 564
TOTAL (US$)				**104 426**	**103 990**	**58 925**	**119 144**

4.8 Fuelwood

Almost all households within the study area collect fuelwood as a source of energy (over 90% in the household survey). Fuelwood is either collected from the forest, using species such as *mlama, mkwala, mkole, mkegembe*, *mpingo, mtonga, mswili* and *mkebo* (Mw, R), or from mangroves in the delta. Mangrove wood reputedly makes better fuelwood than forest wood. Fuelwood is generally collected by women, although men occasionally assist in this, especially for big occasions (Kg). It is generally accessible close to villages and fields (Mw, R, Ks, Mt), and collection of a headload, worth

about Tsh 300, takes up to 3-4 hours. There is little or no overlap in fuelwood collection areas between villages (Mw, R). Collection is usually done about once per week, often on Fridays, which is the Islamic day of rest. There was some disagreement as to how forest burning practices affect fuelwood supply, some saying it made fuelwood collection easier, others saying it was more difficult to find in burnt areas. Women in the delta claim that while they are in the fields, men remaining in the villages rely to a large extent on coconut husks for fuel. There is some trade in fuelwood, with the main buyers being entrepreneurs such as restaurant owners. While fuelwood for home use is usually collected in stick form, salt making requires logs.

It is estimated that over 2.5 million bundles or logs of fuelwood are harvested annually in the study area (Table 23), with a market value of almost $800 000. Most of this is for subsistence use, with a very small proportion of the value realised in the form of cash income. Fuelwood trades for about about Tsh5-15 per kg (Kaale *et al.* 2000). Assuming that an average headload is about 20-30 kg, this yields an estimate of annual per capita consumption of 625kg (total harvest = 62 500 tons). This is similar to the findings of a more detailed study by Kaale *et al.* (2000) of an average annual per capita fuelwood consumption of 523kg in Ikwiriri (urban) and 600kg in Mbunjumvuleni (rural).

Table 23. Estimated harvest and value of fuelwood in Rufiji floodplain and delta (based on hh survey data).

FUELWOOD	Harvested (bundles or logs)	Sold (bundles or logs)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	182	0	241	43 868	43 668	0	38 807
Per average hh	165	0		39 789	39 607	0	35 198
Total	1 434 566	0		346 160 684	344 582 504	0	306 222 219
Transition							
Per user hh	184	2	263	48 366	48 166	447	57 839
Per average hh	184	2		48 366	48 166	447	57 839
Total	422 970	3 910		111 241 110	110 781 110	1 028 330	133 029 332
Delta							
Per user hh	150	2	252	37 750	37 550	605	33 865
Per average hh	140	2		35 296	35 109	565	31 663
Total	713 341	11 429		179 761 896	178 809 505	2 880 030	161 261 320
TOTAL	**2 570 876**	**15 339**		637 163 691	634 173 120	3 908 360	600 512 872
TOTAL (US$)				**796 455**	**792 716**	**4 885**	**750 641**

4.9 Charcoal

Charcoal is made in kilns in the forests in the study area, accessible to residents of the floodplain and transition areas. Charcoal is not made in the delta (Ks). It is marketed and used mostly in the transition area, where up to half of households may use it in addition to firewood (Mo).

Any type of wood is used for charcoal (90% of woody biomass in miombo woodlands is suitable - Chidumayo 1991), but preferred species include *mtondo, mkolwa, mpingo*, and *mkongo*. Any sizes from branches to large trees are used. The use of *mkongo*, a valuable timber species, for charcoal, makes no economic sense, but charcoal makers are seldom timber cutters (and *vice versa*), and it is a case of competition for the same resources (Mo). Charcoal makers first find an area where they can cut enough trees then make a kiln there. From 10 to 100 bags are made in a kiln. The whole process, from cutting, digging a trench, arranging pieces, covering them and then firing for 3 days, takes 15 days for a kiln which produces 20 bags (Mo). A new kiln is made every trip. The kilns are not very far from the villages, at most 1.5hrs away, and there is little or no overlap in charcoal production areas between villages. Bags of charcoal are then transported to market by bicycle, the transportation often being done by entrepreneurs who hire themselves out for this purpose.

Charcoal is always made for commercial purposes, but the activity requires a licence which villagers are reluctant to obtain. Much of the activity is therefore illegal, hence the estimates from this study are likely to be underestimates of total production. Villagers generally claimed that there was little

charcoal making activity in their villages, usually estimating that about 5 households were involved in production (e.g. U), or up to 50 households in Mohoro (20 permanent and 30 seasonal), which has a large market for traffic along the main coast road. Some floodplain villages denied that there was any charcoal making (Mw, Kp). The intensity of charcoal making changes seasonally. It is made all year round, but production increases dramatically during famine (U, Mo). Production is most profitable during the rainy season, when the price is high – about Tsh 1200/bag. During the dry season, when many people are involved in production after returning from their fields, and fuelwood is also more available, the price drops to about Tsh 1000/bag (Mo). Part time people come into business in dry season. When sold locally, charcoal is sold by the tin (*pishi*), at about Tsh100/*pishi* (there are about 20 *pishi* in a bag).

In the household survey, 3.7 and 3.5% of households in floodplain and transition zone claimed to make charcoal. This differs rather substantially from the estimated 54% of households that make charcoal in woodland areas to the north (Luoga *et al.* in press b). The calculated total annual production is about 20 600 bags (762.2 tons, based on average bag weight of 37kg – Kaale *et al.* 2000), worth about $26 000 (Table 24). This is likely to be an underestimate. The total production works out to 7.6kg per capita per year, much lower than the 32kg found by Kaale *et al.* (2000) for a rural village (although this was close to a major centre). Assuming a production recovery of 10% weight for charcoal, the estimated production would require 7 622 tons of wood, also lower than the 10 470 tons estimated by Kaale *et al.* (2000) for the whole study area. However, much of the charcoal produced in the area is not for local consumption, but is exported to major centres outside of the district, which suggests that these estimates are far too low. A casual estimate is that at least 200 bags of charcoal leave the district along the main road north every day (R. Hogan, REMP, pers. comm.), which suggests a total production in excess of 73 000 bags, although this may come from anywhere in the entire district. Interestingly, the area reportedly produced an almost unbelievable 620 000 bags of charcoal in 1979 (Havnevik 1980), and it would probably have been easy to arrive at an accurate estimate during that time, before the activity became regulated. Charcoal then brought more than twice the cash income of the freshwater fishery (Havnevik 1980). The same production now would be worth at least $775 000, locally.

Charcoal bags increase in value as they are exported from the district. Traders pay Tsh 1300 per bag in Kibiti and Tsh 3500 per bag in Dar es Salaam. Thus considerable value is added to this production after it leaves the district.

Making charcoal requires a total licence fee of Tsh 900 (Tsh 300 of which goes to the District Council; K. Mussa, pers. comm.), which is close to the local selling price for a bag. The total amount of charcoal made under licence in the entire district has ranged between 11 687 and 47 441 bags per year (average 27 536) over the last five years (F. Karanja, *in litt.*). At about Tsh 300 per bag, this yields an average district revenue of about $10 000. Although the average is similar to the total production estimated in this study, a large proportion of the licensed production is likely to take place in the extensive woodland areas beyond the study area. This substantiates the suggestion that much of the production within the study area is probably unlicensed and unrecorded in official statistics.

Table 24. Estimated production and value of charcoal in Rufiji floodplain and delta (based on hh survey).

CHARCOAL	Produced (bags)	Sold (bags)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	61	61	1000	61 000	60 800	61 000	66 900
Per average hh	2	2		2 257	2 250	2 257	2 475
Total	19 636	19 636		19 635 900	19 571 520	19 635 900	21 535 110
Transition							
Per user hh	12	12	1200	14 400	14 200	14 400	17 080
Per average hh	0	0		497	490	497	589
Total	952	952		1 142 640	1 126 770	1 142 640	1 355 298
TOTAL	**20 588**	**20 588**		20 778 540	20 698 290	20 778 540	22 890 408
TOTAL (US$)				**25 973**	**25 873**	**25 973**	**28 613**

4.10 Poles

Poles of a variety of thicknesses (e.g. *majengi*, *boriti, tunguo, fito*) are cut from both forests and mangroves, mainly for use in construction. Most houses in the study area are built with poles (Box 4), and households cut their own requirements. Cutting for domestic use is generally overlooked, but cutting for commercial purposes requires paying licence fees. Much pole-cutting is carried out illegally, and in focus groups, people were generally reluctant to reveal the full extent of pole cutting beyond their domestic consumption (Mw, Kp, R, U).

Woodland poles

In floodplain villages, poles are usually cut from the forest within 1.5-3 hours of a village, with smaller poles usually being available very close to villages (Mw, R, U). These are transported by head (either 1 big pole or 5-6 small ones per trip), or out of the area by canoe. Forest areas around villages are often harvested by people from other villages. For example poles around Utunge are reportedly also cut by people from Utete, Nyanwage and Ikwiriri.

At least seven woodland species were named as species selected for cutting poles by villagers in the floodplain area (Table 25).

Table 25. **Forest (woodland) species used for cutting poles**

Species	Local name	Village	Price	Comments
Markhamia sp.	*Mkwara*	Mw, Kp	700	Easiest to find in Mw
Dalbergia melanoxylon	*Mpingo*	Mw, Kp	700	Black wood
?	*Mpagalala*	Mw	700	
?	*Mlanga*	Mw	700	
Spirostachys africana	*Mkulo*	Kp	1000	Kp: Accounts for 80% of poles
Sideroxylon inerme	*Mkambara*	Kp		
Deinbolia borbonica (?)	*Mpangati*	Kp		

It is estimated that approximately 461 new houses are built in the floodplain zone each year (based on structure durability and population growth). Based on needs for house and stilt-house construction (Box 4), this construction would require about 1.1 million poles, of which two-thirds are *fito* (withies - very thin poles). The household survey data yielded a similar estimate of household consumption of poles in the floodplain area, or 1.3 million poles harvested annually (Table 26). Based on pole volumes given in Luoga *et al.* (2000), the total volume of this harvest is about 5000 m^3. The harvest has a value of $115 300, but only a small proportion is realised in terms of cash income. Considering the congruency between the two estimates it appears that most pole harvesting is for local consumption, suggesting that most of the trade is among households in this area. Interestingly the licensed pole harvest is between 16 356 and 26 476 poles (*kongowele*) per year for the entire district (F. Karanja, *in litt*.), yielding government revenues of about $5 225 per year. These would likely be larger poles only, but the estimates are still far lower than the actual harvest for the floodplain area alone. The latter are likely to be harvested mainly by outsiders.

Table 26. Estimated harvest and value of poles in woodlands around the Rufiji floodplain (based on hh survey data).

WOODLAND POLES	Harvested (poles)	Sold (poles)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	503	7	173	26 205	25 605	822	28 797
Per average hh	154	3		10 603	10 373	359	11 722
TOTAL	**1 342 478**	**24 046**		92 244 900	90 249 120	3 122 591	101 979 146
TOTAL (US$)				**115 306**	**112 811**	**3903**	**127 474**

Box 4: Construction of a house

Within villages, families usually have two houses joined by a courtyard – a normal sized house, plus a smaller one (half to three-quarter size). In addition to the main structure is a bathroom, fenced with palm or coconut leaves, or sometimes grass or reeds. In addition, each family owns a small house or shelter (*madungu*) at their fields in the floodplain, usually on stilts. *Madungu* usually have a partitioned room for parents, a room for children, and a room for storing rice. The whole family goes to stay in these during the farming season, except children still in school who stay with their father in the village. Furniture and other possessions are all carried between the village and farm dwellings, and nothing is left in the *madungu* upon their return to the village. Based on focus group information and observation, houses are usually constructed as follows:

Materials used in house construction (U, R, Ks).

Materials	Used for	Quantity used in a normal house (4-6 rooms)	Quantity used in a Stilt house
Poles	Walls, roof beams	120 *majengi* 180 *borito* 100 *tunguo* 800 *fito*	12-18 *majengi*
Mud/clay	Walls	About 6 mounds (2m high) per room (x6).	
Grass	For finishing roof	0-30 15cm bundles	2 bundles
Palm	Roof	60 bundles or 350 *vyungo*	6-12 bundles
Reeds	Simple door	3 bundles	
Timber	Door, windows, furniture	40 pieces (Tsh 1200 ea)	
Reeds/grasses	Fence off toilet		

Poles are taken from the forest in the floodplain zone, and in the delta and transition zones, all houses are made using mangrove poles (Ks, Mt). The main pole structure lasts 20-30 years (U, R). Walls are all lined with mud in the floodplain zone, and in the delta, 40% of buildings used woven coconut leaves (*kumba*) for the walls. Roofs are thatched with milala palm leaves in the floodplain area, and with coconut palm 'tiles' (*vyungo*) in the delta, with a mixture of these in the transition zone. These roofs have to be replaced every 3-6 years (U, R, Ks). About 20% of buildings have corrugated iron roofs, many of these being government or commercial buildings (pers. obs. – Mo, Ks, Kg). Doors are made from a variety of materials, mostly timber, but also coconut leaves or reeds. In the delta, wooden doors are commonly intricately carved, in Zanzibar style.

In addition to the main structure, many households have chicken coops and a few have goat pens. Chicken coops in the floodplain are made of reeds or timber, while those in the delta resemble normal houses in construction. Goat pens are made from about 100 poles. Drinking troughs are made from a hollowed out log (e.g. *Mikuyu*).

4.11 Mangrove poles

Cutting of mangrove poles is a major commercial activity in the delta. The commercial demand is mostly for the middle-sized *boriti*, which are used in construction all over the country (e.g. Dar es Salaam, Zanzibar). Although there are eight species of mangroves in the delta, used for a variety of purposes (Table 27), the commercial demand is mainly for *Rhizophora, Ceriops,* and *Brugiera.*

In the transition zone, which has access to both forests and mangroves, poles are harvested preferentially from the mangrove areas, some 4.5 hours away by foot and canoe (Mt). In the delta, mangrove poles are usually available within a short distance from villages, about 1-2.5h by foot or canoe (Ks, Kg).

Table 27. Mangroves species and their uses in the delta.

Species	Local name	Village and rank	Use
Lumnitzera	*Mkandaa dume*	Ks	Firewood
Heriiera	*Msikundazi*	Kb (6), Ks	Firewood, boats, furniture
Xylocarpus	*Mkomafi*	Kb(4), Mt (2), Ks, Kg	Poles, timber, firewood, poles for building *madungu*
Sonneratia	*Milana/mipira*	Ks, Kg, Kb (5)	Firewood, boatbuilding, net floats
Avicennia	*Mchu*	Kb(7), Ks, Kg	Boats, firewood (saltmaking)
Ceriops	*Mkandaa*	Mo, Kb (2), Mt (1), Ks, Kg	Poles, fito, fuelwood, fishing stakes
Brugiera	*Msinzi/Msingi*	Kb (3), Ks, Kg	Boriti, fuel, fish smoking, stakes
Rhizophora	*Mkaka/Mkoko*	Mo, Kb(1), Ks, Kg (most abundant)	Poles, boriti, fuel, fish traps, stakes

The Rufiji Delta mangrove forest was the first forest reserve in Tanzania, established in 1898 (Sørensen 1998), although harvesting of mangrove poles has always been allowed under concession or licence. A management plan for the mangroves of Tanzania was completed in 1991, initiating the Mangrove Management Project. The management plan hinges around joint management with active participation of local communities, but has had a side effect of making legal cutting rather complicated. Legal commercial cutting of mangrove poles involves getting permission from the Ward and Village Executive Officers (WEOs and VEOs) of the area concerned, then taking the permit to a forest officer to get a licence, and making payments to both parties. Up to 15-20 *korejas* (1 *koreja* = 1 score = 20 poles) can be cut without a permit, ostensibly for domestic use.

Because of the capital required for permits, most permits are in the hands of traders from larger centres, such as Ikwiriri, Mohoro and Zanzibar (there are reportedly about 25 traders based in Mohoro). These traders then employ people to do the cutting. As to be expected, those coming from further afield are usually the ones that provide labour for locals (Mt), whereas those coming from Ikwiriri and Mohoro often bring their own labour. The result is that mangrove cutting around villages in the delta is done by outsiders as well as village inhabitants, much to the consternation of the locals (Kb). It is thus difficult to know who is cutting legally or illegally. Since locals report cutters in their area from other villages in the delta (e.g. villagers from Kiasi, Mbwera, Nganyanga, Beta, Mbumi, Kikali, Nyafweda and Twasalie cutting in Kiomboni), rather than from the major centres where traders originate, it appear that many inhabitants of the delta take advantage of this confusion to cut for the illegal trade. Villagers claim that outsiders come because supplies of the commercially viable species are already depleted in their own village areas (Kb), and that they themselves are having to look further for supplies. Some mangrove areas are shared among neighbouring villages. People from Ruma, Jaja, Pombwe, Mbwera and Mbuchi cut mangroves in Kiongoroni. However, people from Kiongoroni have their fields in Ruma and Mbuchi, so they feel it is a fair, reciprocal arrangement.

According to focus groups, the majority of households in the delta (70-100%) cut poles for traders at one time or another, with only about 5% of households involved in the trade directly (Ks, Kg), and about 10-15 permanent mangrove cutters in Kiomboni (Kb). However, less than half of households in the survey claimed to have cut poles in the last year. The degree to which cutting takes place depends on commercial demand. Women in Kiasi ranked mangrove cutting as the second most important economic activity after agriculture. Mangrove cutting also has an advantage over fishing, in that the returns are less risky, although often less immediate (Kb). It was estimated that each household probably cuts about 2 *korejas* on average in addition to their household needs (Kb).

Small traders may order 10-15 *korejas* (e.g. for local house construction). Major traders order 20-100 *korejas* (bundles of 20) at a time (Kb, Ks), and can cut 100-1000 *korejas* in a month (Kb). There appears to be no strong seasonality in demand or supply (Ks), but people in Kiongoroni reported a higher rate of cutting in March to June, and those in Kiomboni said mangroves were cut mainly from August to December.

About 1 *koreja* can be cut per day (Ks, Kg, Mo), and cutters usually manage about 20-30 *korejas* per month (Mo, Ks, Kg). The poles are transported by head or canoe to a deposition point, then transported by traders to market by boat (*jahazi*). Mangrove cutters are paid about Tsh2000 per *koreja*, and clients can reject some poles. Cutters are paid low prices in comparison to their market value in major centres. This is mainly because they have little bargaining power – there are always other cutters willing to do the job for less. They feel it would be futile to organise themselves, as traders would simply go to another part of the delta.

The legal offtake of mangrove poles in the delta between December 1999 and August 2000 was 9710 *korejas* (Table 28) and yielded $6900 in government licence revenues. This suggests an annual offtake of approximately 14 565 *korejas* and bringing in $10 350 annually in licence fees. This is similar to the Mangrove Management Project estimate of about Tsh7 million per year (R. Njana, MMP, pers. comm.). Officials estimate that the illegal harvest is roughly equivalent to the legal harvest, thus doubling the above estimate to a total offtake of about 30 000 *korejas* per year.

However, the household survey in the delta suggests an annual harvest of about 126 000 *korejas* (Table 29) far greater than the official estimate. About 21% of transition zone households and 41% of delta households were engaged in this activity in the last year. The harvest was worth $360 000 to households, with most of it being sold, bringing in a total cash income of $311 000. User households in the delta earned $153 per year on average. If the estimate of harvest is accurate, then government revenues from traders should have been in the order of $71 383, some $61 000 more than was actually collected.

Table 28. Licenced offtake and government revenues collected of mangrove poles (boriti of different size classes, I = largest) in the Rufiji delta from December 1999 to August 2000.

Source: Ministry of Natural Resources and Tourism: Forest and Beekeeping Division – Mangrove Management Project (Central Zone, Kibiti).

Month	Scores Of Poles (*Koreja*)	Classes					Price Per Unit	Total Royality (Tsh)
		I	II	III	IV	V		
Dec. 99	1230				✔		500	615 000
Jan. 2000	860			✔			800	430 000
Feb.2000	1320				✔		500	660 000
	50					✔	300	15 000
March 2000	1440				✔		500	720 000
April 2000	1210				✔		500	605 000
May.2000	1325				✔		500	662 500
	70					✔	300	21 000
June 2000	1390				✔		500	695 000
	40					✔	300	12 000
July 2000	80			✔			2000	160 000
	90				✔		1000	90 000
Aug 2000	90			✔			2000	180 000
	230				✔		1000	230 000
Sept. 11/09/2000.	150			✔			2000	300 000
	135				✔		1000	135 000
TOTAL	9710							**5,530,500**
TOTAL (US$)								**6913**

Table 29. Estimated harvest and value of mangrove poles harvested in the delta by delta and transition zone households (based on hh survey data).

MANGROVE POLES	Harvested (korejas)	Sold (korejas)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Transition							
Per user hh	24.9	0.8	2960	31 173	30 573	2 221	36 808
Per average hh	4.6	0.2		6 297	6 180	460	7 440
Total	10 640	398		14 484 045	14 214 485	1 057 466	17 111 294
Delta							
Per user hh	77.1	62.5	3140	137 289	136 689	122 343	153 872
Per average hh	22.7	19.7		53 971	53 780	48 688	60 694
Total	115 824	100 142		274 872 976	273 899 194	247 969 725	309 114 798
TOTAL	**126 464**	**100 540**		289 357 021	288 113 679	249 027 190	326 226 092
TOTAL (US$)				**361 696**	**360 142**	**311 284**	**407 783**

4.12 Timber

Timber cutting is a commercial activity which is mainly driven by a large demand from Dar es Salaam and other major centres. Increasing scarcity of the preferred hardwood species *Pterocarpus angolensis* has led to an increase in its price in the major centres. As a result, it is being substituted in furniture making by *Afzelia quanzensis* (*mkongo)* (Wells *et al.* 2000). Ongoing depletion of preferred species has led to the centre of production shifting outwards, towards and beyond Rufiji. This shifting has led to closure of many sawmills and an increased importance of pit-sawing, so that most hardwood on the market today is pitsawn (Wells *et al.* 2000). There are two main ways of organising this production: pairs of pitsawers work independently and sell, or pitsawing contractors serve as a link between labourers who fund the operation and dealers who buy wood, with some contractors also being dealers (Wells *et al.* 2000). The latter facilitates an increase in the scale of production. Much wood is transported into cities in the form of semi-finished furniture, possibly as a response to tightening of regulation, or because materials and labour are cheaper in the supply areas. Pitsawing generates equal amounts of labour for transport and other ancillary operators (Wells *et al.* 2000).

The main tree species harvested in the study area are listed in Table 30. These include species used for making dug-out canoes as well as for sawing timber. The main species demanded for timber is *Afzelia quanzensis (mkongo)*.

Table 30. Woodland tree species extracted for timber and other uses, based on focus group data.

Local name	Species*	Use	Villages & Comments
Mkongo	*Afzelia quanzensis*	Timber & furniture, boats, drums (e.g. in Ruwe)	Mw: Top two species Kp: 90% of timber cut Mo: Top species R: Only species named Mt: Makes up most of harvest
Mndundu	*?*	Timber	Mw: Top two species Mo: Ranks 3rd. Kp
Mkenge/Mkungutanga	*Albizia gummifera*	Timber (Mo), Boats	Mo: Ranks 2nd Kp
Mnangu/Mnungu	*Hymenaea verrucosa*	Timber	Mo (ranks 4th)
Mninga	*Pterocarpus angolensis*	Timber	Kp: don't cut much; Mo, Mt (few, but only other sp named)
Mvule	*Milicia excelsa*	Timber	Kp: don't cut much Mo: cut rarely
Mkangazi	*Khaya anthoteca*	Timber	Mo
Mgama	*?*	Boats	Kp
Mikuyu	*Borassus aethiopium*	Boats, chicken huts	Kp
Mfulu	*Vitex doniana*	Boats	Kp
Mng'ongo	*Sclerocarya birrea*	Boats	Kp
Ngude	?	Boats	Kp
Mhewehewe	?	Boats	Kp

* Species names from Malimbwi (2000).

Timber is harvested in all villages with access to woodland resources. This excludes most residents of the delta, who claim that they harvest very little non-mangrove timber, if any (Ks, Kb, Kg). Around the floodplain and transition zone villages, timber is usually available within 2-3 hours from a village (U, R, Mw, Mt, Mo).

Timber cutting requires a licence and incurs significant transport costs, and as with mangrove pole cutting, is thus largely controlled by outside traders who operate on a large scale. However, not all activity is legal, and licensed traders often cut far greater amounts than permitted. Moreover, local villagers claimed that they no longer rely very much on outside contractors, and most people now work for themselves and sell in the village to traders (Mo). Other small-scale cutters also sell locally to furniture makers (R).

As with mangrove pole cutting, timber traders often bring their own labour, and sometimes employ locals to do the work, through the village chairman. Local villages have little or no control over cutting in their areas. Numerous truckloads were seen being transported from the area during this study, with one truckload of imported labourers taunting a village chairman with the words "we have come to cut all your timber and now we are taking it away!" Nevertheless, many households in the study area do benefit from the trade. According to focus group discussions, about 30 people in Kipo, 7 households in Mwaseni, 10 households in Ruwe and 26 households in Utunge are timber cutters, and in Mohoro there are about 30 pairs of timber cutters (ie up to 60 households). In the household survey, a slightly higher percentage of some 11%, 6% and 4% of households in the floodplain, transition zone and delta, respectively, admitted to having cut timber in the past year. Some timber cutters work at some distance from their villages, staying away for up to 3-5 months (Kp).

Logs (*magogo*) are cut and sold directly, or logs of about 3ft diameter are selected and cut into 6ft lengths before sawing each into at least ten planks of 6ft x 1ft x 1 in. One mkongo tree can yield 40 pieces (Mo). Two people working together in a saw-pit can produce about 10 pieces per day (Kp). Those employed by traders are paid Tsh 2000 for cutting the log and Tsh 500-1000 per plank. "Freelancers' are able to get up to Tsh 3000 per piece if they transport the wood to a major centre such as Mohoro. Traders then sell the same pieces in Dar es Salaam for Tsh 3-6000 (Mw, R).

According to the household survey, local households cut about 233 000 pieces of timber per year (Table 31), equivalent to about 6000 trees. Most of this is sold, for a total of just under $260 000. This could well be an underestimate, and is certainly an underestimate of the total amount of timber removed from the study area. For example, in Iringa region, Tanzania, aerial surveys have shown a high density of pit-sawers, with one pit for every 15 ha of woodland (Minja 1997). Some villagers claim that most cutting is done by outsiders, and in Mohoro, it was estimated that about half of all cutters around the village were from outside areas. If outsiders remove a similar amount to locals, then the total cut could be in the order of 12 000 trees per year (about 18 000 m^3 or 12 600 tons). This is within the range of the 8 500-13 400 trees estimated to have been cut in the last year by an aerial survey (Graham *et al.* 2000).

With timber being marketed for around 5 times the price in Dar es Salaam, the value of timber from the study area marketed there is estimated to be in the region of $2.6 million dollars.

Timber harvesting is licensed per cubic metre, with prices varying from species to species. Licences for *mkongo* (*Afzelia*) and *mpingo* (*Dalbergia*) are Tsh 50 000/m3 and Tsh 70 000/m3, respectively (Kinana Mussa, pers. comm.). These are extremely high when compared with the local value of timber produced from a cubic metre. Between 1 361 and 5 695 m^3 of timber (average 3 500m^3) have been harvested under licence in the entire district over the past five years (F. Karanja, *in litt.*) yielding an average annual revenue to the district government of about $10 700. This licensed harvest is substantially less than the 12 600 tons estimated in this study. Indeed, forestry officials estimate that 80-96% of removals are illegal (Wells *et al.* 2000).

Table 31. Estimated harvest and value of timber cut in the woodlands around the Rufiji floodplain by local inhabitants (based on hh survey data).

TIMBER	Cut (pieces)	Sold (pieces)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	230	227	933	214 590	213 090	211 791	251 408
Per average hh	26	25		23 819	23 653	23 509	27 906
Total							
Transition							
Per user hh	32	32	650	20 475	18 975	20 475	23 070
Per average hh	2	2		1 249	1 157	1 249	1 407
Total	4 419	4 419		2 872 643	2 662 193	2 872 643	3 236 721
Delta							
Per user hh	30	0	650	19 500	18 750	0	22 050
Per average hh	1	0		848	816	0	959
Total	6 646	0		4 320 137	4 153 978	0	4 885 078
TOTAL	**233 177**	**223 633**		214 422 343	212 597 184	207 399 211	250 906 505
TOTAL (US$)				**268 028**	**265 746**	**259 249**	**313 633**

Wood products

There are carpentry workshops in most villages (e.g. 2 in Kipo, 8 in Utunge, 1 in Mtunda), mainly producing furniture. In addition, people make their own furniture. These activities add value to the above timber harvest, but many source their timber from off-cuts or reject timber, or harvest their own (U, Mo, Kp, Mt). Furniture is mainly made from *mninga* and *mkongo*, and also *mbuyo*, *kitumbo*, and *mchakanka.* In workshops, furniture is made for sale in major centres, such as Dar es Salaam. For example, in Kipo, one workshop specialises in making Maputo-style lounge suites, which sell for Tsh 40 000 locally or Tsh 60 000 in Dar es Salaam.

In addition to furniture, numerous other wooden products are produced, many from wood not accounted for in the above timber harvest (Table 32).

Table 32. Types of furniture and other wooden artefacts made from wood and quantities made in the Rufiji floodplain and delta (household survey data)

Product	Price (Tsh)	Quantity produced per year
Miniature canoes (ornaments)	200	793
Stools	1250	1993
Lounge suite	30 000	801
Doors	4000-10 000	2945
Windows	2500-5000	3858
Tables	3750-10 000	3178
Cabinets	53 500	806
Boxes (coffins?)	4000	483
Bed frames	500 - 1000	?
Hoe handle	100-150	20421
Axe handle	500	712
Bushknife handle	300	1107
Miko (stirring spoon or canoe paddle)	100-200	2454
Pawa (small stirring spoon)	50-100	1900
Kata (ladle)	100	397

In addition, every household has a mortar and pestle (*kinu* + *mchi*) made of wood (usually *mtanga, mkongo, mivule, mitanga* or *michu* (Mo, Kb). Mortars cost Tsh 3500-5000, and pestles, Tsh 250-500, and they last for 10-15 years. It is not clear whether these are made within the study area. Most interviewees claimed to they were from major centres such as Kibiti, and none of the survey respondents made any.

An estimated total of about 55 000 wooden products are made annually in the study area, with a retail value of about $278 000 (Table 33).

Table 33. Estimated production and value of furniture and other wooden implements in Rufiji floodplain and delta (from household survey data).

WOOD PRODUCTS	Made (pieces)	Sold (pieces)	Ave Price	Gross Financial Value	Net financial value	Cash Income	Net Economic value
Floodplain							
Per user hh	24	22	7 738	147 913	86 416	128 818	99 854
Per average hh	2	1		10 933	6 395	9 518	7 392
Total	13 269	11 657		95 115 647	55 637 618	82 805 673	64 312 751
Transition							
Per user hh	36	24	12 452	153 646	91 959	96 534	110 556
Per average hh	3	2		15 618	9 275	9 788	11 144
Total	6 258	4 053		35 922 109	21 331 495	22 513 448	25 630 788
Delta							
Per user hh	88	81	7 572	272 840	211 015	237 552	244 905
Per average hh	7	6		17 961	13 922	15 651	16 138
Total	35 117	32 360		91 474 706	70 905 738	79 711 747	82 188 655
TOTAL	**54 643**	**48 070**		222 512 462	147 874 851	185 030 868	172 132 194
TOTAL (US$)				**278 141**	**184 844**	**231 289**	**215 165**

Dug-out canoes (*mitumbwi*) are produced throughout the study area, from woodland trees in the floodplain area and from mangrove species in the delta. They are made by men, and are fairly easy to make. Those made from good quality species can last for over 50 years, while those made from mangrove species are regarded as inferior (Kp, Kb). In the household survey, none of the respondents in the floodplain area had made any canoes in the last year, although they are made there. The estimated total production of canoes was about 900 per year, with a total value of $28 000 (Table 34).

Table 34. Estimated production and value of canoes made in Rufiji floodplain and delta (from household survey data).

CANOES	Produced	Sold	Price	Gross Financial Value	Net financial value	Cash Income	Net Economic Value
Transition							
Per user hh	3.0	3.0	60 000	180 000	179 800	180 000	215 800
Per average hh	0.1	0.1		6 210	6 203	6 210	7 445
Total	238	238		14 283 000	14 267 130	14 283 000	17 123 730
Delta							
Per user hh	3.0	2.0	12 500	37 500	37 300	25 000	41 800
Per average hh	0.1	0.1		1 631	1 623	1 088	1 818
Total	665	443		8 307 956	8 263 647	5 538 638	9 260 602
TOTAL	**903**	**681**		22 590 956	22 530 777	19 821 638	26 384 332
TOTAL (US$)				**28 239**	**28 163**	**24 777**	**32 980**

Jahazi (dhows) are made by skilled craftsmen. There are several *jahazi*-making workshops in the delta, who make according to order. Each 5-15m long boat can take about 3 months or more to make. Based on the household survey it is estimated that over 100 *jahazi* are produced each year (Table 35). *Jahazi* production has low input costs to the manufacturers as all inputs are supplied by the client, including tools and timber. The price paid to the *jahazi*-makers thus does not reflect the total value of the boat.

Table 35. Estimated production and value of *jahazi* made in Rufiji floodplain and delta (from household survey data).

JAHAZI	Produced	Sold	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Delta							
Per producer hh	1	1	150 000	150 000	150 000	150 000	155 000
Per average hh	0.02	0.02		3 255	3 255	3 255	3 364
TOTAL	**111**	**111**		16 577 715	16 577 715	16 577 715	17 130 306
TOTAL (US$)				**20 722**	**20 722**	**20 722**	**21 413**

4.13 Fish and crustaceans

The Rufiji river and floodplain system supports over 40 species of freshwater fishes (Hobson 1979), most of which are adapted to spend at least part of their life cycle in a floodplain environment, and breed seasonally after migrating from the main river into areas, most notably the lakes, inundated by the rising flood. Marginal vegetation, such as reeds and floodplain grass, is important for this process. The flood period is also important for feeding and growth. Thus there is a critical link between the freshwater flows of the Rufiji river and the productivity of the fishery, a factor observed by most freshwater fishers interviewed. There is a transition from freshwater species to a much higher diversity of estuarine and marine species in the delta. Prawns are an important feature of the delta, and their productivity is also positively correlated with the freshwater flows into the delta system.

Fishing areas

In the floodplain area, fisheries are concentrated in the lakes within the floodplain, and to a lesser extent, in the river (Mw, Kp, R, U). Strong currents make river fishing more difficult. In Ruwe, where the lake is 5 minutes away, and the river about 2 hours away, less than a quarter of the catch comes from the river (R). Fishers from the transition area have access to lakes, the river and the delta, and tend to concentrate either on freshwater or marine/estuarine fishing (Mo, Mt). In the delta, fishers operate within the estuarine channels as well as in the inshore coastal areas, but do not go to freshwater areas to fish (Kg). In all cases, fishing areas are close to villages, but seasonality in fish availability necessitates migrations of fishers, particularly in the delta.

There is extensive overlap and movement in the use of fishing areas by people from different villages. In the floodplain, fishers from Mwaseni share their lakes with an equal number of people from other villages (Mw). Locals from Mwaseni claim not to move very far themselves, but it is probable that they make forays into the Selous Game Reserve. Locals from Kipo make up about one-third of the fishers on Lake Zumbi, which is also shared with two other villages (Kp). About a quarter of the fishers using Lake Utunge are from the local village (U), this lake being used by fishers from as far afield as Ikwiriri, Utete, Mkongo, Ruwe, and even Lindi (U). Lake Ruwe is dominated by locals (80%), but others come from Kibiti, Ikwiriri and Mndaru (R). When fishing in this lake declines, locals go to other areas, such as Lakes Weme, Utunge, and sometimes Zumbi (R).

In the transition zone, people from Mtunda fish at Bongora and Kimbokole on Ruhoi estuary, Nyafeda, Bumba (within Twasalie), and Nisanga fishing camps. These camps are also occupied by fishers from a variety of villages. Within the village area, at Bongora and Kimbotole, about 40% of fishers are from other villages, while about 60% of Mtunda's fishers were fishing beyond the village (Mt). They move from one camp to another depending on catches and overcrowding, but do not follow any seasonal pattern, and they are not involved in the prawn fishery in the delta. Fishing effort in this area, which is tidal but freshwater, is said to be relatively constant (Mt). A similar situation of shared fishing areas is found in Mohoro, where four villages (Nyamwage, Chumbi, Ikwiriri and Mohoro) share the lakes (Mwake, Ndota, Kiringi, Lule, Kwanbanda). About 50-75% of fishers on these lakes are from Mohoro (Mo). They also fish on the river at Mbume, Nganyanga, Ngambo and Minazisaba. However, fishers from Mohoro make more use of the delta, going as far as Pombwe, Jaja, Baselona, Kibanjo, Dima, Bunduki, Vikacha, Ndutu and Kibanjo (2 days by canoe or 10h on

foot). Mohoro fishers claim that about 60% of their catch is from the sea, 20% is from estuaries, 15% is from lakes and 5% is from the river.

There are numerous fishing camps in the delta, particularly along the coast, which are occupied by transient fishers from within and beyond the delta. There are 6 camps around Kiongoroni alone, which house about 100 people from other villages, in addition to locals (Kg). Outsiders are not confined to fishing camps, for example, there were about 50-80 outsider fishers residing in Kiomboni village (Kb). The open access and presence of outsiders is not considered a problem (Kg), largely due to the reciprocity involved. Fishing camps in the delta are also occupied by people from outside of the study area. At Dima Rasini, a camp at Kiasi village, most fishers were from Kilwa, and some were from Kechuru. Baselona camp, near Kiomboni, is used by fishers from Mohoro, Kibiti, Jaribu, Bungu, and Mwarusembe. It was estimated that locals from Kiomboni made up about a third of all fishers on the fishing banks in the area.

Fishing methods, equipment and arrangements

The majority of fishers throughout the study area use nets, although traps and hooks are also commonly used. Traps are mainly used during flooding (Kp) and in tidal estuaries, as well as on inshore sandbanks at the coast (pers obs.). Common fishing methods and equipment used in the floodplain are described in Table 36. In the delta, prawn nets are made from 15 pieces to make 250 yards by 150" (Kb). Alternatively prawns may be caught with smaller seine nets, of about 5 x 3 yards with poles on each end (*kutanda*). Gill nets were introduced in the 1960s and only became common in the 1990s (Sørensen 1998).

Average numbers of the most common types of fishing gear reported in the household survey are summarised in Table 37. Numbers of nets recorded in the delta are low, but here most prawn fishers are supplied with nets by the traders. This practice is also carried out, but to a lesser extent, in the floodplain (U). In the latter case, fishers work as labourers for net owners, and are paid for one third of the catch. About half of fishing households own canoes (Table 37). Canoes cost between Tsh 50 000 – 100 000 in the floodplain areas, depending on species of tree used, and much less in the delta.

Table 36. **Fishing methods and equipment described in the floodplain.**

Fishing method & Equipment	Price	Durability	Arrangements	% gear owned in Ruwe
Circle net (*Mkugilo*) – lake Enclose fish. 1000-2000yd	Tsh1000-1200 per 500yds	3y	Can be shared, but not usually	31
Seine net (*Mkoko*) – lake 2000yd, 3 people	Tsh6-8000	2-3y	Normally shared	10
Pulling net (*Juya*) – lake 100yd, poles on each end, pulling ropes, 4 people.	24 pieces @ Tsh1200 = 28 800	2-5mths with daily repair	Don't share, employ people	15
Hooks (*ndoana*) – lake or river Fishbait or grasshopper	100 for hook, 300 for line			(not counted)
Gill net (*Kutega*) – lake or river, Has floats. Leave from afternoon till morning.	Tsh 5-30 000	1 yr with repairs	Not shared	6
***Kimea/Vifaba*,** Cone shaped, weighted at bottom, use with canoe, 2 people, pull to close	Tsh 18 000	2 month	1 or 2 per hh, not shared	34
Ketupwe Net, stake, rope, 1 person. Go 300 yd with net and make circle back to stake then pull	Net 12300, plus sinkers for 500	3-4 months		5
Traps (*Nyando/Wando*) V-shaped trap made from sticks, fish caught with spears, used mainly for ndombe				

In addition to the above, women in the delta commonly fish for shrimps (*uduvi*). These are caught with a mosquito net, held by two women wading against the current. Shrimps are scooped from the net at intervals into a pot balanced on the head.

Table 37. Average numbers of different types of fishing equipment owned by fishing households in three areas of the Rufiji floodplain and delta (from household survey data).

Type of equipment	Floodplain	Transition	Delta
Canoes	0.5	0.5	0.7
Nets (50 yard pieces)	4.1	3.9	1.8
Kifaba/Vifaba	0.4	0.1	0.0
Hooks	16.5	16.7	3.9
Nyando (reeds)	0.4	0.0	0.4
Wando	0.0	0.1	0.3
Jarife	0.0	0.0	0.1
Kutanda (prawn net with poles)	0.0	0.0	0.4

Species and catch composition

Fisheries in the floodplain area are relatively unselective, and numerous species are caught. Over 30 species or types of predominantly freshwater fish species were named by interviewees in this study (Table 38). According to focus groups, the cichlid fish *Kumba* (*Oreochromis urolepis*, often still referred to as *Tilapia*) was by far the most important species in the floodplain catch, at times accounting for most of the catch in some areas (Table 38). Also particularly important are catfishes (*Clarias, Schilbe* and *Bagrus*) and *Alestes*. Recent surveys of fish catches conducted during May to August suggest that during this time *Clarias* are more important than cichlids, accounting for 31% and 23% of catches, respectively, with *Citharinus, Labeo* and *Bagrus* accounting for 39% of the remaining catch (Mr Chirwa, Rufiji District Fisheries Officer, *in litt.*).

Table 38. **Freshwater fish species named by focus groups and in household surveys, giving family and species names where possible.**

Villages in which fish were named and or ranked (some giving percentage of catch) during focus group discussions are given (B = Baselona fishing camp, near Kiomboni), and the percentage of fishers from the floodplain (F), transition (T) and delta (D) areas that named each as targeted species in the household surveys.

PREDOMINANTLY FRESHWATER FISH		Named in focus groups	% fishers naming species in household survey		
Local name	**Species**		**F**	**T**	**D**
Anguillidae (Eels)					
Mkunga	Anguilla spp.	R, Mt	3.3%	0.0%	0.0%
Mormyridae (Elephantfishes)					
Somo	*Marcusenius livingstonii*	Mt	3.3	0.0	0.0
Mbubu	*Mormyrus longirostris*	R, Mt, B	0.0	0.0	3.6
Ngugu	same as above?		0.0	6.7	0.0
Zozo	*Mormyrus hasselquisti*	Mw, U, R			
Ndundundundu	*Mormyrus* sp.	R			
Megalopidae					
Mwanje	*Megalops cyprinoides*	Mo			
Puwa (=pawale?)	could be *Megalops cyprinoides*	Mw			
Cyprinidae (carps)					
Nguchu, Pangapange	*Labeo* sp; *Labeo coubie* - African carp	Mw, U (top 3), R (rank 3, 12%), Mt, Mo,	23.4	6.7	0.0
Distichodontidae					
Tungu, Tungwi	*Distichodus petersii (albini)*	Mw, U, R, Mo, Mt	13.3	0.0	0.0
Citherinidae					
Pele	*Citharinus congicus*	Mw (rain season 70%), U (top 3), R (rank 2, 29%), Mt, (rank 2), Kp	63.3	26.7	0.0

PREDOMINANTLY FRESHWATER FISH		Named in focus groups	% fishers naming species in household survey		
Local name	**Species**		**F**	**T**	**D**
Characidae (Tetras)					
Kange	*Hydrocynus vittatus*	Mw, U (few), Mt, Mo	16.7	0.0	0.0
Alestiidae					
Ngacha, Kasa, Ngasa	*Alestes stuhlmanni* or *Brycinus (Alestes) affinis,* maybe *Petersius conserialis*	Mw, Kp (20%), R (rank 4, 25%), U (few), Mt, Mo.	50.0	26.7	0.0
Kinjampunga, Viliampunga	*Brycinus (Alestes) affinis*, juv)	R	3.3	0.0	0.0
Beme	*Brycinus (Alestes) imberi*	Kp, R (rank 5, 7%)			
Bagridae (Bagrid catfishes)					
Kitoga, mbufu	*Bagrus orientalis*	Mw, Kp, U (few), R, Mt (rank 4, 6%), Mo,	46.7	40.0	0.0
Ngamba	? also *Bagrus*		3.3	0.0	0.0
Shilbeidae (Schilbid catfishes)					
Mbatambata, Pata	*Schilbe moebiusii*	Mw, Mt (rank 5, 5%), Mo,			
Claridae (Air-breathing catfishes)					
Kambale/Kambane	*Clarias gariepinus (*Sharptooth Catfish*)*	Mw, U, R (rank 2, 21%), Mo (rank 3)	66.7 %	73.3 %	0.0%
Ndobe/Ndombe	*Clarias* sp.	U			
Mbua (=Pua?)	*Heterobranchus longifilis*	Mt			
Mochokidae (Squeakers)					
Kogo/ngogo/ngoso	*Synodontis maculipinna*	U (a lot), R, Mt (rank 3, 8%), Mo	36.6	30.0	0.0
Cichlidae (Cichlids)					
Kumba	*Oreochromis (Tilapia) urolepis*)	Mw (dry 90%, wet 30%), Kp (70%), U (top 3), R (rank 1, 22%), Mt (rank 1, 60-75%), Mo (rank 1)	80.0	53.3	3.6
Pelege/Perege	*Sarotherodon* (*Tilapia* spp)	Mo	10.0	13.3	0.0
Fufu	*Haplochromis katavi or H. fuelleborni*		0.0	6.7	0.0
Lutjanidae (Snappers)					
Kungu	*Lutjanus* sp.	Mt	0.0	0.0	3.6
Unidentified freshwater families/species					
Mbano		U			
Mbate		R			
Tumu		Mt			
Sazile		R			
Msafu			3.3	0.0	0.0
Ngado			0.0	6.7	0.0

About 30 types of marine fishes, cephalopods and crustaceans were recorded in focus group discussions and household interviews during this study (Tables 39 and 40). This list is not comprehensive, and does not include several species recorded in other studies, such as tuna, goat fishes, silver biddy (*chaa*), thread fins (*koana*), cobia (*songoro*), rabbit fish (*tasi*) and sail fish (Chirwa 2000). Furthermore, many of the types of fishes in Table 39 represent groups of several species. Of particular note is *dagaa*, which is a name for numerous species of small fish caught at the coast. During this survey, the *dagaa* catch observed was mainly small mullet. A far more detailed study is required to fully describe the marine and estuarine fisheries in this area.

Prawns are by far the most important fishery in the delta from an economic point of view. Even fishers from the transition area (Mohoro) report that prawns make up 75% of their cash income, while

in the delta, prawns are reportedly responsible for about 80% of cash income (Kg). At some fishing camps on the coast, however, fishers were found to be mainly targeting other species, such as sharks, rays and *dagaa*. After prawns, *dagaa* and *mbarata* are the most important types of fish in the delta (Table 39).

Table 39. Marine fish species named by focus groups and in household surveys, giving family and species names where possible.

Villages in which fish were named and or ranked (some giving percentage of catch) during focus group discussions are given (B = Baselona fishing camp, near Kiomboni), and the percentage of fishers from the floodplain (F), transition (T) and delta (D) areas that named each as targeted species in the household surveys.

PREDOMINANTLY MARINE FISH		Named in focus groups	% fishers naming species in household survey		
Local name	**Species**		**F**	**T**	**D**
Elasmobranchs (Sharks)					
Papa-sumbwi, etc	*e.g. Isurus oxyrinchus* or *Scoliodon laticaudus*	Kg	0.0	6.7	3.6
Rajidae (Rays)		Ks, B	0.0	0.0	7.1
Clupeidae (shads, sardinellas etc)					
Mbarata	*Hilsa kelee* (Kelee shad)	Mo (rank 2), Ks (rank 1, 70%)	0.0	13.3	32.1
Mugilidae (Mullets)					
Mkizi	10 possible species of *Liza, Cernimugil, Valimugil, Elops*, and *Mugil*	Mo	0.0	6.7	7.1
Serranidae (Sea basses)					
Chewa	13 possible species of groupers, probably *Epinephelus malabaricus*	Mo, Ks	0.0	6.7	3.6
Clupeidae, Cyprinidae, Leignathidae, etc					
Dagaa	Over 30 species, e.g. mullet	Ks, Kg (rank 2), B	0.0	13.3	21.4
Haemulidae?					
Togo	(grunter?) 8 possible species	Ks			
Ariidae (Sea catfishes)					
Hongwe	*Arius* spp. - 6 possible species	Kg, B	0.0	6.7	7.1
Trichiunidae or Anguillidae					
Mkonge, Tepatepa	*Trichiurus leturus, T.* spp.	B			
Soleidae (Soles)					
Gayogayo	9 possible species	B			
Carangidae (Jacks & pampanas)					
Kolekole	15 possible species	Kg			
Hemiramphidae (Halfbeaks)					
Chuchunge	*Hemiramphus* spp.)	B			
Hemiramphidae/Belonidae/Scomberesocidae					
Ndolo/ mdwalo	(halfbeaks, needlefishes or sauries)	Kg (rank 4))			
Leiognathidae (Soapies)					
Ndofulofu	?	B			
Unkown					
Kombasu		Mo			
Mboki	?	Mo			
Njonjo	?	B			
Mboke/ mbokwe	?	B	0.0	0.0	3.6
Mkipini		B			
Kena	?	Kg			
Bundi	?	Kg			
Chongole	?	Kg (rank 3)			

Table 40. Marine cephalopods and crustaceans named by focus groups and in household surveys, giving family and species names where possible.

Villages in which species were named and or ranked (some giving percentage of catch) during focus group discussions are given (B = Baselona fishing camp, near Kiomboni), and the percentage of fishers from the floodplain (F), transition (T) and delta (D) areas that named each as targeted species in the household surveys.

OTHER MARINE SPECIES		Named in focus groups	% fishers naming species in household survey		
Local name	**Species**		**F**	**T**	**D**
Cephalopods					
Octopus		Kg			
Squid		Kg			
Crustaceans					
Kamba – King	*Metapenaeus monoceros*	Mo (rank 1), B			
Kamba – Tiger	*Penaeus monodon*	Mo (rank 3) Kg (black), B			
Kamba – Whitey	*P. indicus*	Mo, Kg (70-100%), B (90% of prawns)	0.0	6.7	100.0
Uduvi	Shrimps		0.0	0.0	7.1
Crab	e.g. *Scylla serrata*	Kg	0.0	0.0	3.6

Prices and Marketing

In general, fishers prefer to catch small fish than larger ones, due to the greater ease of marketing them. Most species are caught at sizes well below their maximum, and indeed, many of them are juvenile fish of pre-reproductive age. In the floodplain fisheries, *kumba* and *pele* are usually about 15cm or 200g, while other species, such as *nguchu*, *ngacha* and *beme,* are often smaller than this (less than 10cm). Similarly, in the delta, *mbarata* and *dagaa* are usually about 15cm or less. Fresh fish sell for about Tsh 100-300 per kg, and dried fish for slightly more. In the delta, a *tenga* of dried fish is sold for Tsh5000-7000.

Fishers generally sell fresh fish to locals and dried fish to traders. Usually only a small proportion (10-30%) of the fish catch is sold fresh (Mw, U, Mt, Mo, Ks, Kg), although up to 65% may be sold fresh (R). Prawns, on the other hand, are sold fresh, although reject small prawns are dried (probably about 1% of the catch).

Fish and prawn traders generally buy at landing sites. Prawn traders supply nets, ice boxes and ice, and have agents permanently stationed at at least three camps in the delta. Traders are present daily at most landing sites during main prawn fishing periods (see below), and every two to three days in between these periods. There is never a shortage of traders for buying prawns, and thus little wastage. Whitey prawns make up most of the catch, and fetch Tsh1500/kg, Tiger Prawns fetch Tsh2700/kg and King Prawns fetch Tsh5000/kg (Kb). The buyers have the scales, and some of the fishermen are unable to read these spring balances correctly, suggesting that they may be underpaid for their catches. Prawns are transported by traders by boat (*jahazi*) or by road to Dar es Salaam and Zanzibar.

Traders from Ikwiriri and other centres buy dried prawns for Tsh900/kg, which they sell in Dar es Salaam for Tsh1600-1700. Shrimps (*uduvi*) are sold locally for Tsh500/*pishi* (about 2kg).

Fishing effort, seasonality and catch

According to the household survey, approximately 56%, 52%, and 61% of households are involved in fishing in the floodplain, transition zone and delta, respectively. This is a substantial increase from the estimated 19% of floodplain households made twenty years ago (FAO 1979). These estimates are also higher than those found in other recent studies (28.6% - Mbiha & Senkondo 2000, and 45% - Hogan *et al.* 2000). In addition, this does not count the itinerant fishers who hail from outside the study area, and whose numbers could not be estimated in this study. Household effort is approximately 86, 56 and 123 days per year in each of these areas. Fishing is almost exclusively carried out by men in the floodplain and transition areas, but women also fish in the delta, although this fishery is for shrimps, and to a lesser extent, octopus and squid, but not finfish.

Within the floodplain, fishing is a seasonal activity, but seasonality reportedly varies along the river (Fig. 3). Best catches are recorded earlier in the western part of the floodplain than further east. Peak catches in the western and central floodplain (U) coincide with peak floods in April, whereas in Mohoro, peak catches in the freshwater fishery are in September-October (Fig. 3). Fishers in Mtunda described similar seasonal patterns as in Mohoro.

During peak season, fishers in the western floodplain fish nearly every day and can catch about 300 *kumba* per week (Mw). In comparison, those that venture into Selous Game Reserve can catch more than ten times that much (Mw). It is estimated that about 30 canoe-loads of fish leave the Selous each month during the peak fishing months. On one occasion, 19 boats full of dried fish were apprehended in one night. By July in the western floodplain, catches fall to about 80-100 fish per week, or 200 fish per week in Selous, and during the low season, fishers usually only average about 2 days per month (Mw). As in Mwaseni, fishers in Kipo concentrate their effort in March to June, when they manage to catch 30-40 fish per day (about 7kg). This is higher in good flood years.

In the central floodplain, Utunge fishers may catch 3-4000 small *nguchu* per week (30-40kg), but 60-100 per day in the low season. The main fishing season in Ruwe is July to October (Jul-Aug at Ruwe, Sept-Oct in outside areas). However, there is also good fishing in April-May when floods are good, bringing fish from Selous. July catches may be about one tenga per week, and low season catches are about one tenga per month, fishing 15 days per month (R). In Mtunda, catches of about 10kg per boat per day are recorded in July, and 16kg in peak season (Mt). In Mohoro, fishers claimed to be able to catch far more than this in a good flood year.

In contrast, marine catches are fairly constant year-round, as fishers follow the prawns and fish (Mo). Not a single prawn fisher mentioned the closed season for prawns (December to March). However catches and effort vary within the month. Prawn fishing depends on tides, with most fishing activity occurring over neap tides (particularly 4-11 days after full or new moon), i.e. about 14 days per month. Fishing is good in different parts of the delta in different months, dictated by seasonal changes in the trade winds. On good tides it is possible to catch 30kg/boat/day (two people). Half the boats may be this lucky, while the remainder are more likely to catch 10-20kg, or at worst, 5kg per week (Mo).

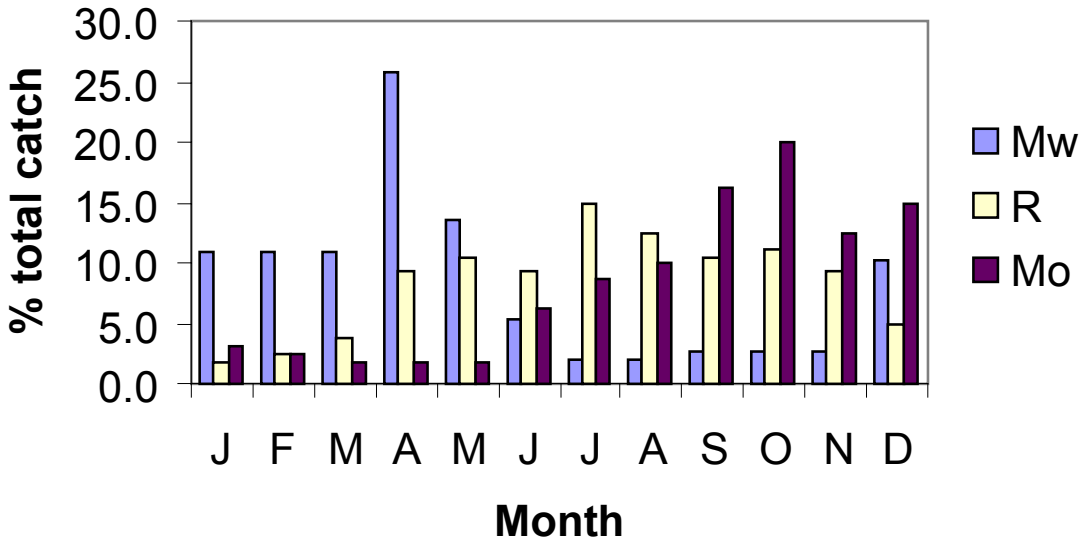

Figure 3: Seasonality in fish catches, as reported by focus groups in Mwaseni (western floodplain), Ruwe (central floodplain) and Mohoro (transition zone), using beans to represent catches.

Normal prawn catch rates of 10-15kg per boat and 10-40kg per boat were reported in Kiomboni and the nearby fishing camp, Baselona. Fishers in Kiongoroni claim to catch up to 10kg of prawns per person per day, but around 2-3kg on a normal day. *Dagaa* or *mbarata* are caught in the same net, the latter being caught in estuaries, the former in the sea. They can catch about 15kg fish per day, but in August to October, this can increase to 50kg (Kg). Most local fishers remain in Kiongoroni year round, except for a short period in December, when they may venture as far as Mbungwe, Pombwe or Jaja. They switch from a main catch of finfish in March to May, to prawns from July. When they move out of the area, they also get squid, octopus, sharks, reef fish and crabs (e.g. at Pombwe).

At the coast, prawn fishing mainly takes place on offshore banks such as Twasebe bank or Bunduki bank off Kiomboni. Fishing in this northern delta area is concentrated in Kibanjo from October to mid March, during the NE winds, then fishers move to Bunduki from April to July, then slightly further north to Baselona from August to October (Kb, Baselona fishers). These coastal fishers claim to catch 30-40kg prawns, sometimes 50kg, or up to 3000 Mbarata on good fishing days (usually targeting one or the other). From September to December, big prawns dominate the prawn catch (>75%), but at other times there is a preponderance of small prawns (>50% of catch), which have to be dried. Fish (*dagaa* or *mbarata*) can make up 25-75% of the catch (Baselona fishers). Fishers near Kiasi claim to catch about 40kg of fish per boat per day, and 6 fishers with shark nets were catching up to 100 rays per week.

Women living in coastal villages in the delta fish for *uduvi*. In Kiasi, women claim that about a quarter to half of them fish for *uduvi*, but further from the coast, this type of fishing is less common. Only 7% of respondents in the household survey gave information on *uduvi*, probably due to a male bias in respondents. Fisherwomen fish for *uduvi* on neap tides, and usually go about 3 times per month. According to these women, catches can range from about 1kg to 2-3 bags (bag = 12-17 *pishi*) per day, and are about 1-2 *pishi* (or 12-15kg) on a normal day (Ks) or 5-10 pishi per day (Kb). *Dagaa* are also part of the catch (about 40%), and sell for slightly more than *uduvi* (Tsh700 *vs* Tsh500). This fishing is done when women are in the village, although they may come back from the fields to fish if necessary. Women in Kiasi claimed to do this on most neap tides, but women in Kiomboni say they do not fish while in the fields. Further from the coast, in Kiongoroni, women claim to fish mainly while at their *shambas*, about once a week.

Total catch and value

Based on household survey data, it is estimated that a total of 9 000 tons of fish are caught in the study area per year (Table 41). If catches by outsiders (especially in the delta) were included, the actual catch would be somewhat higher. It is difficult to estimate total catch with accuracy from a one-off survey, as fish catches are variable from month to month and annual catches are often difficult to recall. Catches estimated here average about 20kg per fishing day, corresponding to average daily catches reported by fishers in the focus group discussions (reported above).

Of the total estimated fish catch, about 5 500 tons comprise freshwater species and 3 500 are estuarine and marine species. The freshwater catch was estimated as about 3 841 tons in 1979 (Hobson 1979). Using Welcomme's (1978) relationship between floodplain area and catch (38kg/ha), the freshwater could potentially be in the region of 7 500 tons. Other preliminary estimates suggest a much higher catch than obtained in this study (R. Hogan, pers. comm.). Coastal catches in the delta have been estimated as between 535 and 5440 tons per year (average 2282 tons) between 1987 and 1992 (Annual statistics reports, Fisheries Division, Ministry of Tourism, Natural Resources and Environment). Euroconsult (1980) estimated the actual and potential catches within the delta to be 1835 and 2980 tons, respectively, and in the Mafia channel to be 6300 and 10 000 tons, respectively. The amount of fish moving through Nyamisati in the delta (not including household consumption) ranged between 1829 and 5934 tons from 1985-1995 (Coast Region Socio-Economic Profile 1997). These estimates suggest that the estimates from this study are likely to be in the right order of magnitude, but may be underestimated. A much more detailed study is required of fisheries to improve the accuracy of these estimates.

Table 41. Estimated total catch of finfish by residents of the Rufiji floodplain and delta (based on household survey data).

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
Per average hh	599	514		246 940	158 658	211 892	162 509
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
Per average hh	422	310		93 195	35 967	68 586	43 631
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
Per average hh	556	349		126 153	103 202	79 203	115 564
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**

According to this study, the total cash value of the catch is in the order of $3.7 million, most of which is realised in the form of cash income to households (Table 41). Fishing households generate incomes of between $213-476 per year, a substantial contribution to household cash income.

Further value is added to part of the catch through trading. Fish sold by fishers for Tsh150-300/kg are sold by traders for Tsh500/kg, and finally in fish stalls for Tsh800-1000/kg. Only about 180 tons of fish are recorded annually as being exported from the district through the Jaribu Mpakani natural resources barrier (based on statistics in Chirwa 2000), which is one of two main export points on land. This suggests that a further $315 000 is added, mostly benefiting people outside the study area. In reality, this estimate should probably be higher, as it is likely that trade through these control posts is underestimated, and it does not include any fish transported by sea.

An estimated 2 200 tons of prawns are harvested by residents of the transition and delta areas (Table 42), with a local market value of $4 million, of which $3.9 million is translated into cash income to households. The catch estimate is slightly higher than those of 360 – 1583 tons recorded in official statistics in 1987-1992, but is closer to the estimated potential catch of 1620 tons made by Euroconsult (1980). The value estimate is higher than the $1.5 million estimated by Sørensen (1998). These estimates are, however, lower than those made by Mbiha & Senkondo (2000), of 1700kg per user household, which would lead to a total catch estimate more than double that in this study. Preliminary estimates of the total artisanal prawn catch, including by outsiders, based on a survey of landing sites, are in the order of 10 000 tons (E. Chirwa, *in litt*.) However, the latter estimate is still rough, and appears unrealistically high.

According to estimates from this study, prawn-fishing households make a substantial income of $725 - $1390 per year. The same prawns are marketed outside the district for at least double the price, with a market value of about $8 million per year. It is estimated that 90% of the prawn catch is exported (Mwalyosi 1993), and it is apparent that traders make a huge effort to meet export standards, with virtually no delays in getting live prawns onto ice before transportation to Dar es Salaam or Zanzibar. Their export value, at $7/kg is in the region of $15 million. Thus the total value of the artisanal fishery probably lies somewhere between $8 million and $15 million.

Table 42. Estimated total artisanal catch of prawns by residents of the Rufiji floodplain and delta (based on household survey data).

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
Per average hh	90	68		87 458	87 458	66 714	104 949
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
Per average hh	392	387		587 249	587 249	579 429	701 759
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**

In theory, this fishing activity should generate government revenues, as licences are required for fishing (Tsh 4700 per year) and trading (Tsh 6000 per year for fish, or Tsh 7200 for prawns), as well as to operate fishing vessels. Fishers never mentioned this licence, and information was not obtained on how many licences are actually paid. Licence fees are thus not factored into the net financial value calculations given above.

In addition, a commercial prawn fishery operates along the coast of Tanzania. This fishery is discussed in Chapter 6.

The total estimated catch of shrimps (*uduvi*) is in the order of 113 tons per year, with a local market value of $25 000 (Table 43). This is ten times lower than the estimated value of $280 000 given by Sørensen (1998). It is quite possible that these estimates are too low, because of a male bias in answering household questionnaire surveys.

Table 43. Estimated total catch of shrimps by women in the delta (based on household survey data).

SHRIMPS	Harvested (kg)	Sold (kg)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Per user hh	341	78	182	62 062	61 562	14 196	65 449
Per average hh	22	5		4 034	4 002	923	4 254
TOTAL	**112 886**	**25 822**		20 545 315	20 379 792	4 699 515	21 666 697
TOTAL (US$)				**25 682**	**25 475**	**5 874**	**27 083**

In addition, an estimated 34 tons of crabs are harvested in the delta, worth some $4000 annually. Most of this harvest is for sale (Table 44). No data were available on the harvest of octopus and squid.

Table 44. Estimated total catch of crabs in the delta (based on household survey data).

CRABS	Harvested (kg)	Sold (kg)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Per user hh	77	69	100	7 700	7 700	6930	8278
Per average hh	6.7	6		670	670	603	720
TOTAL	**34 118**	**30 706**		3 411 801	3 411 801	3 070 621	3 667 686
TOTAL (US$)				**4 265**	**4 265**	**3 838**	**4 585**

Based on all of the above estimates, the fishery has a total gross financial value within the study area of $7.8 million per year, yielding $6.9 million in terms of cash incomes, and having a total economic value of $7.4 million at the district level.

4.14 Birds and mammals

Hunting is a regulated activity within the study area, requiring licences, and having a closed season from January to June. There is a general ban on certain species such as crocodiles, turtles and dugong (Sørensen 1998). However, people are allowed to shoot problem animals in life-threatening situations. Hunting is carried out throughout the study area, with a number of hunters in each village supplying village needs. In addition to 'professional' hunters with guns, many use traps and younger men and boys use catapults. Birds are also sometimes caught with lime from sap of *Euphorbia tirulacii* (Sørensen 1998). Game animals and birds are common throughout the area, especially close to the unfenced Selous Game Reserve in the west. Hunters using traps are unselective, but those with guns target preferred species such as antelopes. Hunters regularly burn areas of woodland to reduce the understorey and encourage production of grass, which in turn attracts grazers such as impala. Burning is particularly frequent in August-October (Mbano & Nyanchuwa 1996), and was commonly observed during the field visit, with significant areas of woodland having been burnt. This practice is particularly detrimental to the production of other forest resources, including timber.

Over 17 species of mammals (Table 45) and 26 types of birds (Table 46, many representing several species) are hunted in the study area. In addition, crocodiles (*mamba*) and tortoises (*kombe*) are also hunted. Impala and buffalo are the most preferred and most common mammal species hunted in the woodland areas within the study area. A large rodent (*ndezi*) is considered to be particularly tasty. Hippo meat is a delicacy and the fat is valuable for boat building in the delta (Sørensen 1998). Dugong is also considered a delicacy. Some of the animals hunted (e.g. baboons, monkeys) are not eaten, but eradicated as a form of pest control. Most of the remaining animals in Table 45 are hunted for food, although many of these also constitute vermin to farmers (e.g. small seed-eating birds, wild pig). Wild pig are eaten, but not by all. Crocodiles are sometimes eradicated, but not eaten due to the belief that they are poisonous (crocodiles reportedly killed 5 people and hurt 7 in the last 1.5 years in Ruwe). Both crocodiles and baboons are associated with witchcraft.

Table 45. Mammal species hunted in the study area (focus group discussions and household survey data).

Swahili	English	Source of information	Swahili	English	Source
Swala	Impala	Mw, Kp	*Mbawala*	Bushbuck	Hh
Nyati	Buffalo	Mw, Kp	*Ngiri*	Warthog	Hh
Nyumbu	Wildebeest	Mw, Kp	*Nungunungu*	Porcupine	Hh
Kiboko	Hippo	Mw, Kb	*Nguruwe*	Pigs	Kb
Sungura	Rabbit	Kp	*Ngedere*	Vervet Monkey	Kb
Ngurungara	?	Kp (during dry season)	*Nyani*	Baboon	Hh
Kongoni	Hartebeest	Kp	*Kima*	Guenon/Sykes' Monkey	Hh
Mbalape	Sable	Kp	*Ndohe*		Hh
Pundemilia	Zebra	Kp	*Nokela*		Hh
Kulo/kuro	Waterbuck	R (skin used for drums)			

Table 46. Types of birds hunted in the study area (from focus group discussions and household survey data).

Swahili	English	Source of information
Kanga	Guineafowl	Mw, Kp (most NB), Kg
Bata	Ducks	Mw, Kp (ranks 2nd), Kg
Bata maji	Geese	Kb (ranks 2)
Bowe	African Fish Eagle	Mw
Kololo		Mw
Tetele	Pigeons & doves	Kp, Mt
Kwale	Spurfowl	Kp
Ngobwane		Kp
Kitokotoko		Kp
Kipeta	(small)	Kp
Mpwete	(small)	Kp
Ninga	Green pigeon	Kp
Watunda	? Speckled pigeon	Kp
Ncheketu	Yellowbilled Stork	Kb
Luamia	(?Saddlebilled) Stork	Kb
Zafarani	Whitish with black dots in tail, long neck	Kb (ranks 1)
Kingoyo	Totally black, long neck (egret?)	Kb
*Kopoangora (*or *–ola)*	Black	Kb, Kg
Ngwarara	Black	Kb
Chorochoro	Black kite	Kb
Horongo		Ks, but not common
Nyanganyanga	Egret	Kg
Shorwe		Mt
Ngwalo	Quelea (?)	Mt
Visige	Small	Mt
Kinjosi	? (*kichozi* = sunbird)	Mt

Exact numbers of hunters are difficult to estimate, because hunting requires a licence and is often carried out illegally. Licences are issued per animal, costing anything from Tsh 300 for a guineafowl to Tsh 6000 for a buffalo (for locals). Many of the more regular hunters purchase licences for one or two animals, but hunt far more than that. Some hunters claim they only get a licence 'for special occasions'. Snares are not used by many hunters, because it is 'more illegal' (ie impossible to get a licence at all). However, one hunter can set about 200 snares in a 5km^2 area (Mbano & Nyanchuwa 1996). Hunters usually go out on 3 day trips, and reportedly have an average success rate of about one animal per day. While bird-hunting is generally carried out by the youth in the floodplain, it also is carried out by 'professionals' with guns in the delta, where hunters set off by canoe to bag larger species such as herons and storks. Meat is sold from peoples' homes. Hunters travel 1-2 hours from a village to hunt, or may go further afield on overnight trips. For example, hunters from Mwaseni range all the way to the Selous boundary (and probably beyond). Focus group and informal discussions indicated that about 1.65% of households have hunters in the study area (Table 47). A total of 2.3% of household survey respondents gave information on their hunting activities. This suggests a professional hunting population of 265 to 370. However, these statistics are notoriously difficult to collect, and these figures may well be an underestimate.

Table 47. Numbers of "full-time" hunters in different villages, and estimated overall percentage of households with full-time hunters.

Village	Number of households	Number of full-time hunters	% hh
Kipo	198	3	1.52
Utete	1237	10	0.81
Mtunda	390	6	1.54
Mohoro	1255	30	2.39
Kiongoroni	195	5	2.56
Total	3275	54	1.65

Villagers reportedly eat wild meat very commonly, and indeed wild meat, and not chicken, was on the menu in some of the restaurants visited. People in two different floodplain villages claimed to eat about 3kg per household per week. In another, it was claimed that most households eat wild meat daily, sometimes for both of their main meals, and that most households eat more game meat than chicken, which costs two to three times as much. Game meat is sold for Tsh300-500 per kg. Birds are sold apiece, ranging from Tsh10 for small passerines to Tsh1500 for a Yellowbilled Stork, or at about Tsh300 per kg. Based on these estimates, a small village such as Kipo (156 households), would require about 33 500kg of wild meat per year. To give an idea of what this means, this quota could be met with the sum of 200 impala, 20 each of buffalo, kudu and warthog, and 2 hippos per year, or whatever other combination may be appropriate. Assuming that hunters make about one trip per fortnight, about 1.6% of households would need to be involved to meet the type of demand described above. This is similar to the estimates given in this study. In the delta it was estimated that households eat about 3 wild birds per month on average.

Based on household survey data an estimated 160 tons of game meat is harvested per year in the whole study area, with a gross market value of $28 000 (Table 48). This is less than 10% of the 1700 tons that would be required to supply 3kg meat to each household per week in the floodplain and transition zone alone. The real value probably lies between these two, as hunters are likely to have been reluctant to reveal their total catches in the household survey, and an estimate of 3kg per household per week, while quite possible for some households, is unlikely to be the overall average. Based on household survey data, a total of 51 000 birds are estimated to be harvested annually in the study area, with a local market value of about $8 000 (Table 49). Again, this is likely to be an underestimate.

Table 48. Estimated total harvest of game meat in the study area. Note: none of the floodplain households surveyed gave information on game meat.

MAMMALS	Harvested (kg)	Sold (kg)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Transition							
Per user hh	970.00	310	128	124 160	110 770	39680	132 934.86
Per average hh	66.93	21.39		8 567	7 643	2737.92	9173
Total	153939	49197		19 704 192	17 579 123	6297216	21096762
Delta							
Per user hh	60	40	400	24 000	5 610	16000	6503
Per average hh	1.32	0.88		528	123	352	143
Total	6723	4482		2 689 104	628 525	1 792 736	728619
TOTAL	**160 662**	**53 679**		22 393 296	18 207 648	8 089 952	21 825 381
TOTAL (US$)				**27 992**	**22 760**	**10 112**	**27 282**

Table 49. Estimated total harvest of birds in the study area (based on household survey data).

BIRDS	Harvested (birds)	Sold (birds)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	91.00	66.7	30	2 757	2 757	2021	1 033
Per average hh	5.10	3.7352		154	154	113	58
Total	44 335	32496.24		1 343 357	1 343 357	984636	503 648
Transition							
Per user hh	14.00	5.3	16	224	224	85	268
Per average hh	1.4476	0.54802		23	23	9	28
Total	3329.48	1260.446		53 272	53 272	20 167	63 926
Delta							
Per user hh	30	10	1 500	45 000	37 833	15 000	43 900
Per average hh	0.66	0.22		990	832	330	966
Total	3361	1120		5 042 070	4 239 074	1 680 690	4 918 819
TOTAL	**51 026**	**34 877**		6 438 698	5 635 702	2 685 493	5 486 393
TOTAL (US$)				**8 048**	**7 045**	**3 357**	**6 858**

Added to the above value is the value of commercial sport hunting in the study area (although this is not very extensive at this stage), and the government revenues from all licensed hunting. There are four hunting concessions in the Rufii district (Samera Safaris, Tanganyika Wildlife Safaris, Tanzania Wildlife Corporation and Intercon Hunting Safaris). These operate in five Tourist Hunting Blocks in the Selous, but not within the study area (E.J. John, Rufiji District Game Officer, *in litt*.). Local hunting is carried out in Ngarambe wildlife management area, Tapika open area (450km^2) and Mloka open area (200km^2), of which the latter falls within the study area. Figures on animal numbers and revenues from game hunting could not be obtained in time for this study.

4.15 Honey

Honey is collected from the wild throughout the study area. In addition, people throughout the study area keep hives, and about 70-80 hives have been introduced in Kipo as part of the Rufiji beekeeping project. The latter are, of course, also dependent on wild vegetation for honey production. Wild honey is collected within a range of 1 hour from most villages. In the floodplain, bees make use of both cultivated tree crops and natural forests, which flower in different seasons, making it possible to harvest honey during two periods - January-April and July-December (Zungiza *et al.* 1999). In the woodlands, bee forage species include *Dombeya burgessiae, D. rotundifolia, Maesa lanccolata, Diospyrus whyteana (msisina), Caesalpinia decapetala, Syzigium spp. (mivengi), Croton macrostachus (muvulungu), Uapaca kirkiana (mikusu), Vitex mombassae (msasati*), and *Myrica salicifolia (mweti*) (Minja 1997). In the delta, honey is harvested during the dry season, from March to July, although Sørensen (1998) reports the season to be from December to April.

Collection methods are destructive: bees are smoked out (using palm leaves, grass or wood) and the hive is destroyed with an axe. Indeed, people argue that beekeepers lose out in that they cannot harvest all the honey from a hive. Hives produce about 25-40kg (Zungiza *et al.* 1999), and villagers claim to extract about 5-10 orange-squash bottles of honey from one hive. Honey is mainly sold locally, for about Tsh500-1000 per bottle in the floodplain (Mw, R) and as little as Tsh300-400 in the delta (Ks, Kg).

A total of 11%, 28% and 20% of households surveyed collected honey in the last year. They were responsible for an estimated total harvest of 32 000 litres of honey, with a local market value of $25 000 (Table 50).

Table 50. Annual harvest and value of honey in the Rufiji floodplain and delta (based on household survey data).

HONEY	Harvested (litres)	Sold (litres)	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	14	6	750	10 613	10 573	4 800	12 341
Per average hh	2	1		1 179	1 175	533	1 371
Total	13 677	6 186		10 257 724	10 219 061	4 639 536	11 928 682
Transition							
Per user hh	7	3	500	3 540	3 483	1 500	4 191
Per average hh	2	1		977	961	414	1 156
Total	4 493	1 904		2 246 378	2 210 117	951 855	2 659 392
Delta							
Per user hh	14	9	531	7 487	7 430	4 726	8 751
Per average hh	3	2		1 465	1 454	925	1 713
Total	14 053	8 871		7 462 393	7 405 439	4 710 305	8 722 249
TOTAL	**32 223**	**16 960**		19 966 495	19 834 617	10 301 696	23 310 324
TOTAL (US$)				**24 958**	**24 793**	**12 877**	**29 138**

4.16 Total value of natural resources to households

In summary, natural resource use by households in the study area is worth over $10 million per year in terms of gross financial value of production, and net economic value. The net value of natural

resources to households is about $9 million per year, or $575 per household, and brings a cash income to households of about $8 million, or $505 per household (Table 51).

Table 51. Summary of the annual values of natural resource use estimated in this study, giving total value and average value per household across the Rufiji floodplain and delta. All values in US$.

Resource	Gross financial value	Net financial value	Cash Income	Net Economic value
Salt	141 140	94 065	132 478	116 127
Clay	12 937	8 763	10 214	9 983
Grass	6 308	6 099	-	6 573
Reeds	6 689	6 556	-	7 036
Papyrus	604	581	-	626
Medicinal Plants	104 426	103 990	58 925	119 144
Food Plants	294 124	293 733	8 197	303 076
Milala	14 662	14 484	797	15 312
Milala Products	234 023	212 506	11 899	220 970
Ukindu	113 309	112 998	84 327	128 668
Ukindu Products	93 713	45 130	16 545	51 608
Charcoal	25 973	25 873	25 973	28 613
Firewood	796 455	792 716	4 885	750 641
Poles & Fito	477 002	472 953	315 187	535 257
Timber	268 028	265 746	259 249	313 633
Wood Prod	278 141	184 844	231 289	215 165
Canoes	28 239	28 163	24 777	32 773
Jahazi	20 722	20 722	20 722	21 413
Fish & Crustaceans	7 776 486	6 505 568	6 896 038	7 354 530
Mammals & Birds	36 040	29 804	13 469	34 140
Honey	24 958	24 793	12 877	29 138
Total	**10 753 979**	**9 250 088**	**8 127 849**	**10 294 426**
Value Per Hh	668.24	574.79	505.05	639.68

Table 52. Summary of the annual values of different groups of resources, and their percentage contribution to overall value of natural resources to households in the study area.

Resource group	Gross Financial Value		Net Financial Value		Cash Income		Net Economic Value	
	US$	%	US$	%	US$	%	US$	%
Salt	141 140	*1.31*	94 065	*1.02*	132 478	*1.63*	116 127	*1.13*
Clay	12 937	*0.12*	8 763	*0.09*	10 214	*0.13*	9 983	*0.10*
Grass, reeds, papyrus	13 600	*0.13*	13 236	*0.14*	-	-	14 234	*0.14*
Food & medicinal plants	398 550	*3.71*	397 723	*4.30*	67 122	*0.83*	422 221	*4.10*
Palms & products	455 708	*4.24*	385 119	*4.16*	113 568	*1.40*	416 559	*4.05*
Timber, poles & products	1 072 132	*9.97*	972 429	*10.51*	851 224	*10.47*	1 118 241	*10.86*
Charcoal & fuelwood	822 428	*7.65*	818 589	*8.85*	30 859	*0.38*	779 254	*7.57*
Fish & crustaceans	7 776 486	*72.31*	6 505 568	*70.33*	6 896 038	*84.84*	7 354 530	*71.44*
Animals, birds & honey	60 998	*0.57*	54 597	*0.59*	26 346	*0.32*	63 278	*0.61*

Fisheries dominate the value of natural resources, making up over 70% of their overall value, and as much as 85% of the cash income generated from natural resources). Timber products are the next most important resource, making up about 10% of values, and charcoal and fuelwood resources are also important, but generate very little in terms of cash income.

In addition to the values summarised here, substantial value accrues to households outside of the study area, though outsider harvesting of resources, and through value added by trade. This includes an additional $2.6 million in terms of the timber resources harvested within the study area, and $15 million from the trade in prawns from the artisanal fishery. In addition, the production and trade in charcoal is likely to be substantially higher than the estimates produced in this study. Thus, the overall economic value of natural resources in the study area is at least $28 million per year, but could be much higher than this.

5 Importance of natural resources in the rural household economy

5.1 Main household occupations

Nearly all households in the study area considered farming as their primary economic activity. In addition to farming, fishing and other uses of natural resources, households also engage in business activities such as trading (much of this being in agricultural and natural resource products), running shops, tea rooms, blacksmiths, tailoring, masonry, hair salons etc. These activities are summarised in more detail in Mbiha & Senkondo (2000). Agriculture is considered the most important activity in the study area, and this activity is described in more detail below.

5.2 Agriculture

Crops

Of the households surveyed, 100% in the floodplain area, 96.6% in the transition zone, and 91.3% in the delta had agricultural fields. These were usually at some distance (often 1-2 hours' walk or more) from the villages in which they are based. Fruit trees, cashewnut trees and coconut palms are located both in or near the villages and around the fields. Farming takes up a large proportion of household labour time, with farmers usually spending more than half the year in their fields. All household members take part in farming activities, but women bear the brunt of the work in the fields, spending more time there than their husbands. Men tend to take greater charge of tree crops.

Average field size was largest in the floodplain (1.2 ha), compared with 1 ha and 0.77 ha in the transition and delta areas, respectively. This yields a total estimated field area of 16 242 ha for the study area, with 10 440 ha, 2 222 ha and 3 580 ha in the floodplain, transition and delta zones, respectively. These figures represent current growing fields, and not total cultivated area (see next chapter).

At least 24 different types of crops are grown in the study area, many of which differ in importance between the main ecoregions of the study area (Table 53). Rice is the most important crop, being grown by 76% of all households in the study area. Nearly 11 000 tons of rice are produced annually, and as it is the staple food of all households, only about a quarter of production is sold (Table 54). A similar pattern holds for maize, which is also produced by a fairly high proportion of households, although on a much smaller scale, but only a small proportion is sold. Vegetables also tend to be grown largely for subsistence use, but all generate income to some extent (Table 54). Nevertheless, a high proportion of households grow cash crops to generate cash income. Of these cashew nuts and sesame are particularly important, and oranges are grown on a limited scale in the transition zone (there is not much suitable growing area in the low-lying study area). The latter crop is highly important in other parts of the district.

Table 53. **Percentage of households in the floodplain (F), transition zone (T) and delta (D) and the overall study area producing different types of crops.**

Crop	F	T	D	Overall	Crop	F	T	D	Overall
Rice	67	90	87	76	Sweet potatoes	9	14	7	9
Maize	74	28	2	45	Cassava	7	3	13	9
Cashewnut	52	17	26	39	Pigeon peas	9	7	2	7
Pumpkins	54	17	2	32	Oranges	0	17	0	2
Vegetables	39	14	22	30	Green peas	2	7	0	2
Mango	22	28	33	26	Limes	0	3	4	2
Cowpeas	35	21	9	25	Custard apple	2	0	2	2
Sugar cane	32	17	15	24	Millet	0	0	4	1
Banana	15	35	26	21	Okra	0	0	2	1
Coconut	0	0	48	15	Pawpaw	0	3	0	0
Sesame	22	7	0	13	Passion fruit				
Tomatoes	15	0	7	10	Oil palm				

Table 54. Annual production of each crop by producer households in the study area, mean prices, total production and the percentage of total production sold by producers, based on household survey data.

		Production per producer hh			Mean	Total	Percentage
Crop	Unit	Floodplain	Transition	Delta	Price	Production	Sold
Rice	Kg	688	933	1084	124	10 720 374	25.3
Maize	Kg	381	231	100	105	2 614 036	17.8
Cashew nut	Kg	85	12	276	345	755 427	97.4
Pumpkins	Units	249	80	70	131	1 202 794	70.4
Vegetables	Kg	86	182	82	127	437 749	23.9
Mango	Units	3587	4881	1159	28	11 950 699	30.7
Cowpeas	Kg	102	100	40	242	377 698	55.0
Sugar cane	Kg	3438	300	1572	49	10 757 461	19.4
Banana	Bunches	40	41	14	541	102 535	40.5
Coconut	Units	0	0	1682	30	4 094 752	72.6
Sesame	Kg	55	225	0	304	141 548	96.3
Tomatoes	Kg	99	0	69	142	150 767	70.7
Sweet potatoes	Kg	105	140	210	122	198 911	7.7
Cassava	Kg	455	500	303	104	532 642	5.2
Pigeon peas	Kg	87	63	5	263	80 950	47.4
Oranges	Kg	0	2643	0	5	1 045 571	91.9
Green peas	Kg	1	15	0	450	2 546	56.1
Limes	Units	0	3000	203	1	279 057	?
Custard apple	Kg	80	0	13	100		?
Millet	Kg	0	0	450	100	98 550	?
Okra	Kg	0	0	5	100	560	?
Pawpaw	Units	0	3000	0	100	234 600	?

Crop production within the study area is estimated to be worth $3.8 million annually (Table 55), generating some $1.2 million in cash income to households. Taking the value of labour as well as other estimated input costs into account, its net economic worth is in the region of $2.7 million. The contribution of different types of crops to the gross financial value is summarised in Fig. 4.

Table 55. Value of crop production in the Rufiji floodplain and delta, based on household survey data.

CROPS	Gross financial value	Net financial value	Cash Income	Net econ value
Floodplain				
Per user hh	196 788	185 448	62 087	35 365
Per average hh	196 788	185 448	62 087	35 365
Total	1 712 054 103	1 613 396 103	540 160 840	307 675 074
Transition				
Per user hh	207 029	207 029	96 918	425 600
Per average hh	199 990	199 990.19	93 623	411 129.27
Total	459 977 439	459 977 439	215 333 374	945 597 315
Delta				
Per user hh	193 621	411 323	48 038	188 596
Per average hh	176 776	375 538.23	43 859	172 188.17
Total	900 322 261	863 737 940	223 372 135	876 954 357
TOTAL	3 072 353 803	2 937 111 482	978 866 349	2 130 226 746
TOTAL (US$)	**3 840 442**	**3 671 389**	**1 223 583**	**2 662 783**

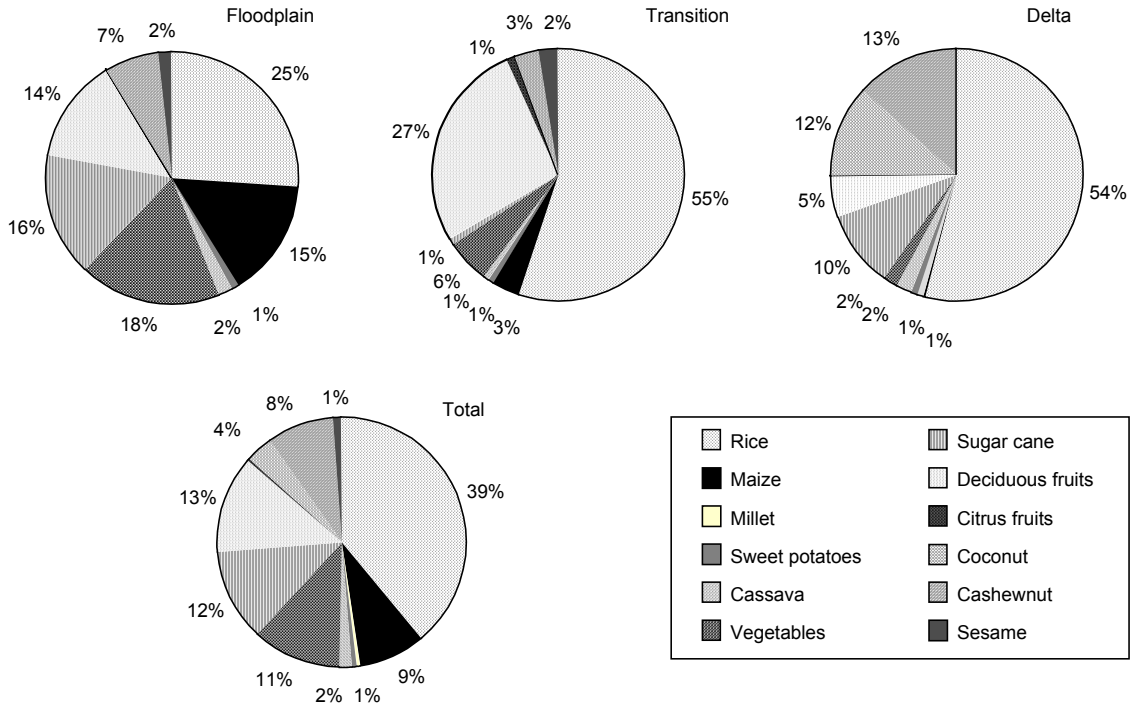

Figure 4: Percentage contribution of different types of crops to the value of agricultural production in the floodplain, transition and delta areas, and in the overall study area.

Grain crops, particularly rice, make up about half of the overall value of crop production, with cash crops making up less than 10% of the value. Farmers in the delta rely mostly on rice, cashewnuts and coconuts, the latter being absent from other areas. Tropical fruits (mangos, bananas, pawpaws, etc) are more important in the transition and floodplain areas. Most of the vegetable crop comes from the floodplain. Sugar cane is important in the floodplain and delta areas, but not in the transition zone (Fig. 4).

Livestock

In addition to growing crops, a large proportion of households in the floodplain, transition and delta areas, respectively, kept some type of livestock (Table 56). Most households kept chickens, and cattle were only kept in the delta, where the problem of tsetse fly is less intense than further from the coast. Pigs are not kept in the study area, where almost the entire population is muslim. Cattle and goats are kept for meat, and raised by men. Chickens are raised by women.

Table 56. Percentage households keeping different types of livestock (based on household survey data).

	% households keeping livestock		
	Floodplain	**Transition**	**Delta**
Any livestock	81.5	37.9	56.5
Domestic fowl (chickens, ducks, geese)	79.6	34.5	54.3
Goats	1.9	3.4	10.9
Cattle	0	0	2.2

About 440 000 fowl (mainly chickens), 14 000 goats and 1 300 cattle are produced from domestic stocks annually. Domestic fowl production has a gross financial value of some $600 000, as compared to $150 000 and $34 000 for goats and cattle, respectively (Tables 57-59). Egg production is included in the calculation of domestic fowl values, but is relatively low, suggesting the value could have been underestimated, or there is a disproportionately high effort in chick-rearing rather than eggs as a final product.

Table 57. Value of livestock production in the Rufiji floodplain and delta (based on household survey data).

DOMESTIC FOWL	Fowl produced	Eggs produced	Price (fowl, eggs)	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	46	38	1 052	50 693	50 693	14 553	57 351
Per average hh	37	30	50	40 351	40 351	11 584	45 652
Total	321 329	260 388		351 057 779	351 057 779	100 779 666	397 169 638
Transition							
Per user hh	41	11	960	39 597	39 597	26 404	47 516
Per average hh	14	4	50	13 661	13 661	9 109	16 393
Total	32 295	8 332		31 420 220	31 420 220	20 951 574	37 704 263
Delta							
Per user hh	31	24	1 090	35 394	35 394	20 335	40 178
Per average hh	17	13	85	19 219	19 219	11 042	21 817
Total	84 624	66 372		97 882 072	97 882 072	56 236 422	111 111 666
TOTAL	**438 249**	**335 091**		480 360 070	480 360 070	177 967 662	545 985 567
TOTAL (US$)				**600 450**	**600 450**	**222 460**	**682 482**

Table 58. Value of goat production in the Rufiji floodplain and delta (based on household survey data).

GOATS	Goats produced	Goats sold	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Floodplain							
Per user hh	6	-	9 000	54 000	54 000	-	64 350
Per average hh	0	-		1 026	1 026	-	1 223
Total	992	-		8 926 200	8 926 200	-	10 637 055
Transition							
Per user hh	38	8	8 500	323 000	323 000	63 750	387 600
Per average hh	1	0		10 982	10 982	2 168	13 178
Total	2 972	587		25 258 600	25 258 600	4 985 250	30 310 320
Delta							
Per user hh	18	-	8 500	151 300	151 300	-	180 225
Per average hh	2	-		16 492	16 492	-	19 645
Total	9 881	-		83 992 228	83 992 228	-	100 049 566
TOTAL	**13 845**	**587**		118 177 028	118 177 028	4 985 250	140 996 941
TOTAL (US$)				**147 721**	**147 721**	**6 232**	**176 246**

Table 59. Value of cattle production in the Rufiji delta (based on household survey data).

CATTLE	Cattle produced	Cattle sold	Price	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Delta							
Per user hh	12	10	20 000	240 000	240 000	200 000	243 000
Per average hh	0	0		5 280	5 280	4 400	5 346
TOTAL	**1 345**	**1 120**		26 891 040	26 891 040	22 409 200	27 227 178
TOTAL (US$)				**33 614**	**33 614**	**28 012**	**34 034**

Coconut palms: a natural resource substitute

Coconut production, which is concentrated in the delta area, has numerous spin-offs which benefit households, providing a substitute for indigenous palms and other resources. Several products are made from coconut trees (Sørensen 1998, this study):

- Window and door frames from coconut wood;
- Coconut juice (*madafu*);
- Milk (*tui*) from grated coconut (*nazi*);
- Oil from copra (*mbata*);
- Pam wine from sap;
- Famine food (growing point of tree);
- Mosquito repellent, from burning coconut husks;
- Twine, rope, brushes, mattress stuffing from husk fibres;
- Thatch (*kiungo*), mats (*mikeka*), baskets (*pakacha*) from coconut leaf fibres;
- Brooms, fish traps (*wando*) from coconut leaf midribs;
- Ladles (*kata*) from dried shells (*kifuu*);
- Fuel from leaf stalks, dried shells and husks (*makumbi*); and
- Knife sheaths from furled growing point.

In particular, coconut leaves form a substitute for palm leaves in roofing throughout the delta and in parts of the transition zone, and are also used for walls of at least a quarter of houses in the delta. Making of these woven tiles and other products is an income-generating activity, particularly for women in the delta.

5.3 The relative contribution of natural resources to income

In this study, detailed household questionnaires were used to estimate the value of agricultural activities and natural resource use in the study area. The values reported thus far at a household level include value added by processing of these resources, but not value added by middlemen trading in the resources. Furthermore, details on other business activities were not established in this study. In the household survey, a single final question was asked about income from these other activities, as well as from pensions, relatives, etc. Values given were relatively high, ranging from $280 in the floodplain to $485 in the delta. These could be overestimates, especially if enumerators were not clear about the difference between total income and the meaning intended by the question. Indeed, some of the enumerators expressed doubt that this question had been tackled accurately. This should be borne in mind in interpreting the following results.

Based on the estimates in this study, the total cash income to households in the study area ranges from an average of $690 and $670 in the floodplain and transition zone, to $1500 in the delta (Table 60). Most of the difference in the delta is made up from prawn fishing income. These cash incomes are low: they represent a household expenditure budget of $1.84 (Tsh 1500) to $4.15 (Tsh3300) per day, or about $0.26 (Tsh 210) - $1.59 (Tsh 475) per person per day. Household budgets are mostly spent on food and consumer goods, but also have to cover various costs involved in agriculture, fishing, transport, medicine, etc. (Hogan *et al.* 2000, Agris 2000a,b, Mbiha & Senkondo 2000).

Total net incomes account for capital and variable costs in income production as well as including the value of agricultural products and natural resource products consumed by the household. Total net incomes are from $230 to $300 higher than cash incomes (Table 60), reflecting this subsistence value minus certain household costs (e.g. agricultural and fishing equipment). In other words, the gross subsistence values of agricultural production and natural resources are somewhat greater than this difference (they are equal to the difference between gross financial income and cash income). Natural resources account for 32-63% of cash income and 33-59% of the total net income to households in the study area (Table 60).

Estimates produced in this study of the relative value of different types of activities are fairly similar to how they are perceived to be by households themselves, except for two notable differences (Fig. 5).

Firstly, cash incomes from other sources, such as business, given in the household surveys were greater than the estimated net income from agriculture, whereas respondents estimated these incomes to be much less at the beginning of the household surveys. This suggests that these could indeed be overestimated due to misinterpretation of the question. Secondly, income from fishing is very high in the delta relative to in other areas, and relative to agricultural income, again quite different from the original indication of the respondents. Most of the difference in the fishing value between areas is made up from prawn fishing. In casual conversation, some fishers in the delta claimed to make considerably more than the value reported here, but this value may well be an overestimate. There was no outward evidence that people in the delta were almost twice as wealthy as people in other parts of the study area, as the results in Table 60 suggest, and Mbiha & Senkondo (2000) found no significant differences in wealth between the different areas on the basis of household assets. However, the actual difference is not great, and would hardly classify those households in the delta as wealthy.

Table 60. Estimated annual total net income (including subsistence value) and cash income per household in the Rufiji floodplain and delta. Values in US$.

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**

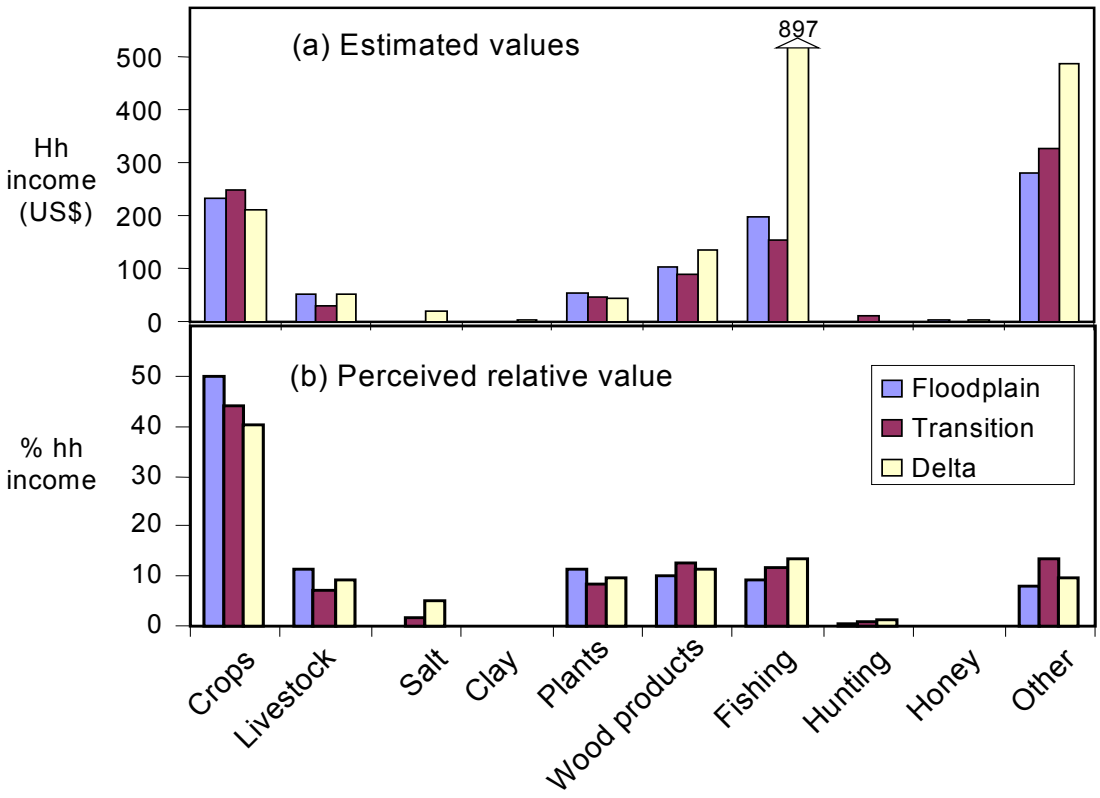

Figure 5: Estimated contribution (US$ per year) of different sources of income to household income in the three parts of the study area, compared with their relative value (% household cash + subsistence income) as perceived by households.

Within the whole study area, the gross financial value of natural resources is more than double that of agricultural production, and their economic value is worth three times that of agricultural production (Table 61). In terms of cash income to households, sales of natural resources and their products provide more than 5 times as much as sales of agricultural produce (Table 61). It should also be emphasised that, while this report concentrates on the monetary value of resources, natural resources are also important in sustaining rural livelihoods. They form a fallback for households that do not have other income-generating options, and are particularly important for poorer households.

Table 61. Estimated total value of natural resources compared with total value of agricultural production within the Rufiji floodplain and delta.

	Gross Financial Value	Net Financial Value	Cash Income	Net Economic Value
Natural resources	10 753 979	9 250 088	8 127 849	10 371 344
Agriculture	4 622 227	4 453 175	1 480 286	3 555 546
TOTAL (US$)	**15 376 206**	**13 703 263**	**9 608 135**	**13 926 890**

5.4 Negative impacts of wildlife on agricultural income

A high proportion of households claimed to have suffered crop or livestock losses to wild animals during the past year. In fact crop losses were claimed by the majority of respondents (Table 62). Several types of animals were blamed for crop losses, most notably wild pigs, monkeys, warthogs and elephants. Even fish are known to eat rice seedlings or grains (Sørensen 1998). A different suite of animals were blamed for livestock losses, including many of the predatory animals and birds of the area (Table 62). Based on respondents' estimates of their crop losses, wild animals inflicted damage on at least 12 major types of crops (Table 63). The greatest losses were to the two major crops, rice and maize, with estimated losses being in the order of 3750 tons and 1 500 tons, respectively. These

losses amount to some 26% and 36% of the total production of rice and maize, respectively. Losses of other crops ranged between 1 and 19% of total production. The total market value of these crop losses is estimated to be in the order of $888 000 per year, which amounts to a loss of 19% of the total agricultural output. In addition, large numbers of livestock, particularly chickens, are reportedly lost to wildlife each year (Table 64). These losses are worth over $100 000, representing 13% of the gross value of livestock production.

Total agricultural losses amount to some $1 million per year in terms of their gross financial value. This is far greater than the estimated benefits from hunting wildlife (between $36 000 and $360 000). However, in most cases the species involved do not coincide. Taking precautions against wildlife losses is also time consuming. People sometimes fence against hippos around fields or across pathways, and keep watch against pests throughout the growing season. Many pest animals are hunted, trapped or poisoned. In the delta, one village has an annual lion hunt (Sørensen 1998).

Table 62. Percentage of respondents in the floodplain (F), transition (T) and delta (D) areas that claimed to have experienced crop or livestock losses to wild animals during the past year, and percentage of respondents that named different types of animals as the culprits.

Crop losses	F	T	D	Livestock losses	F	T	D
Experienced?	92.6%	93.1%	80.4%	Experienced?	53.7%	27.6%	37.0%
Wild Pig	85.2%	82.8%	71.7%	Monkeys	14.8%	0.0%	0.0%
Elephant (*tembo*)	59.3%	37.9%	0.0%	Bush cat (*kusongo*)	14.8%	10.3%	17.4%
Vervet (*ngedele*)	59.3%	72.4%	39.1%	Ratel (*nyegele*)	13.0%	0.0%	2.2%
Warthog (*ngiri*)	46.3%	13.8%	17.4%	*Kipanga*	11.1%	0.0%	15.2%
Hippo	44.4%	41.4%	28.3%	Baboon (*nyani*)	7.4%	0.0%	0.0%
Birds	0.0%	20.7%	26.1%	Wild birds	7.4%	3.4%	10.9%
Baboons (*nyani*)	11.1%	0.0%	0.0%	*Bwena*	7.4%	3.4%	0.0%
Ndezi (rodent)	5.6%	3.4%	4.3%	Cheetah (*duma*)	5.6%	3.4%	0.0%
Porcupine (*nungunugu)*	3.7%	0.0%	0.0%	Leopard (*chui*)	3.7%	6.9%	2.2%
Gedente ngani	1.9%	0.0%	0.0%	Hyaena (*fisi*)	3.7%	6.9%	4.3%
Bushbuck (*mbawala*)	1.9%	0.0%	0.0%	Hawk (*mwewe*)	3.7%	3.4%	6.5%
Guineafowl (*kanga*)	1.9%	0.0%	0.0%	*Mbweche*	1.9%	0.0%	0.0%
Kwaru	1.9%	0.0%	0.0%	*Mkuli*	1.9%	0.0%	0.0%
Syke's monkeys (*kima*)	1.9%	0.0%	2.2%	*Nkwanda*	1.9%	0.0%	0.0%
Bamboo	0.0%	3.4%	2.2%	*King'enge*	1.9%	10.3%	0.0%
Galagos (*komba*)	0.0%	3.4%	2.2%	Civet cat (*fungo*)	0.0%	0.0%	6.5%
Kowe	0.0%	6.8%	2.2%	*Lukhwele*	0.0%	0.0%	6.5%
Crabs (*ngowe*)	0.0%	0.0%	2.2%	*Vitololo*	0.0%	0.0%	2.2%
Insects	0.0%	3.4%	2.2%	*Vizongo*	0.0%	0.0%	2.2%
				Snakes	0.0%	3.4%	0.0%

Table 63. Estimated losses of agricultural produce, based on household survey data.

LOSSES	Annual production after losses	Total losses	% of production lost	Value of lost production (Tsh)	US$
CROPS					
Rice (kg)	10 720 374	3 747 286	26	464 663 498	580 829
Maize (kg)	2 614 036	1 491 900	36	156 649 480	195 812
Coconuts	4 094 752	620 017	13	18 600 522	23 251
Mangos	11 950 699	498 228	4	13 950 391	17 438
Pumpkins	1 202 794	126 369	10	16 554 366	20 693
Sugar cane (canes)	10 757 461	88 611	1	4 341 944	5 427
Cashews (kg)	755 427	56 164	7	19 376 667	24 221
Oranges	1 045 571	39 655	4	178 448	223
Simsim (kg)	141 548	32 222	19	9 795 556	12 244
Bananas (bunches)	102 535	9 262	8	5 010 959	6 264
Sweetpotatoes (kg)	198 911	7 138	3	870 828	1 089
Cassava (kg)	532 642	6 216	1	646 467	808
TOTAL				710 639 125	888 299
LIVESTOCK					
Chickens	518394	80 145	15	80 145 000	100 181
Eggs	346163	11 072	3	553 600	692
Goats	14288	443	3	3 876 250	4 845
Cattle	1677	332	20	6 640 000	8 300
TOTAL				91 214 850	114 019
TOTAL					**1 002 317**

5.5 Returns to labour from different types of activities and the implications

A comparison of returns to labour time (Table 64) can at least partially explain individuals' behaviour in the study area, by illustrating some of the incentives they face for choosing one activity over another. Returns are highest for timber cutting and prawn fishing, suggesting that there will be a ready and increasing supply of labour for these activities as long as these returns remain high relative to other activities.

Table 64. Main household activities, the predominant actors (gender), and their net financial returns to labour per day. The right-hand columns give mean returns per day and per hour. Certain activities are highlighted in bold for ease of comparison.

	Actors		Returns to labour (US$/day)			mean	mean
Activity	Men	Women	Floodplain	Transition	Delta	$/day	$/h
Timber	XX		11.58	7.53	7.81	8.97	1.12
Prawns	XX			6.50	9.99	8.24	1.03
Honey	XX		7.47	4.92	10.54	7.64	0.96
Canoes	XX			11.99	2.49	7.24	0.90
Furniture	XX		5.59	8.72	7.12	7.14	0.89
Animals	XX			7.14	5.84	6.49	0.81
Medicinal plants	X	XX	3.77	5.82	7.04	5.54	0.69
Salt		XX			3.81	3.81	0.48
Poles	XX		3.87	3.28	3.54	3.56	0.45
Charcoal	XX		2.49	2.96		2.73	0.34
Birds	XX		0.30	0.16	6.31	2.26	0.28
Fish	**XX**	**X**	**1.32**	**2.13**	**3.10**	**2.18**	**0.27**
Crabs	X	X			2.00	2.00	0.25
Ukindu	XX	X		1.09	2.79	1.94	0.24
Papyrus	XX		1.92			1.92	0.24
Fito	XX		1.81	1.79	1.84	1.81	0.23
Shrimp		XX			1.81	1.81	0.23

Table 64 cont.

	Actors		Returns to labour (US$/day)			mean	mean
Activity	**Men**	**Women**	**Floodplain**	**Transition**	**Delta**	**$/day**	**$/h**
Goats	XX		1.80	1.70	1.70	1.73	0.22
Grass	XX		1.71	1.67	1.61	1.66	0.21
Crops	**X**	**XX**	**0.86**	**1.15**	**2.97**	**1.66**	**0.21**
Reeds	XX		1.83	1.42	1.67	1.64	0.20
Handles, ladles	XX		0.30	2.95	1.43	1.56	0.20
Jahazi	XX				1.50	1.50	0.19
Milala	X	XX	1.48	1.55	1.43	1.49	0.19
Clay pots		XX	1.38	1.25	1.61	1.41	0.18
Food plants		XX	1.31	1.29	1.57	1.39	0.17
Cattle	XX				1.33	1.33	0.17
Fowl		XX	1.05	1.28	1.09	1.14	0.14
Milala products		XX	0.99	0.95	0.80	0.90	0.11
Firewood		**XX**	**0.80**	**0.87**	**0.84**	**0.84**	**0.10**
Ukindu products		XX	0.92	0.45	0.43	0.50	0.06
Miniature canoes	XX			0.45		0.45	0.06

Apart from canoe production and medicinal plant collection, which are limited by demand, the same principle would apply to all other activities yielding high returns. In an open access situation, the relatively high returns for timber and furniture making, fishing, pole cutting, honey and hunting are all ominous for sustainable use and conservation. Under secure ownership, the opposite would be true.

Crop cultivation yields relatively low returns, yet takes up a major proportion of household labour time. Crop cultivation is carried out not just for subsistence, but also for surplus production for sale. While it is understandable that households would engage in subsistence farming in an area which is remote from markets, it might seem surprising, considering the low returns, that they would devote extra time to producing a surplus when that time could be spent more productively in other activities. There are two possible explanations for this. Firstly, households grow their crops in fields away from their villages, where most other activities take place. While based at the fields, it might be less effort to increase the area of fields for extra-production, than to try and engage in additional commercial activities for which resources or markets are more distant or much reduced (e.g. greater distance to forests, fewer people in villages during farming season). Secondly, most of the work done in the fields is by women, and the opportunity cost of their labour time (even just in terms of other productive activities) is relatively low. Most of the other activities undertaken by women yield lower returns than agriculture, and those that do not are activities which take place near villages rather than near their fields (shrimp fishing, salt making). The latter activities are only possible in the delta. Women's activities include collection of *milala*, and the processing of *milala* and *ukindu* products. Collection of *ukindu*, which yields higher returns, is mostly carried out by men.

Another low-value, but major time-consuming activity, is firewood collection. This activity, also relegated to women, is essential due to the lack of cheaper alternatives for meeting household energy needs. A reduction in time spent in firewood harvesting might only be expected if alternative sources of energy become cheaper than firewood, or due to introduction of more efficient cooking apparatus, or if the labour time involved started to carry significant opportunity costs (e.g. due to job opportunities for women), which would induce the purchase of more expensive alternatives. The latter scenario is highly unlikely in the near future.

Apart from firewood collection, all low-value activities are less of a threat to the conservation of natural resources in the study area than those which offer high returns. The extent of most of these activities is determined by household needs, and thus by population size, with relatively little surplus production for sale beyond the area. The reason that firewood differs in this respect is due to the high quantity demanded per household simply to meet household energy needs. Indeed, apart from firewood, there is no strong evidence that any of the low-value activities are taking a major toll on the environment. Firewood collection, however appears to be altering the biodiversity of the study area:

casual observation suggests a significant reduction in the numbers of hole-nesting birds in the area as compared with numbers in the Selous Game Reserve (pers. obs.).

6 The Direct and indirect use value of natural habitats

6.1 Area of different habitats in the study area

The total extent of the study area was estimated to be approximately 720 000 ha, of which 44% falls within the floodplain ecoregion, 30% in the transition zone and 26% in the delta (Table 65, Figure 7). Some 90% of the total study area is natural habitat, with the remainder being transformed by agriculture and settlements. A total of 58 500 ha (10% of the terrestrial area) is estimated to be cultivated lands. This is substantially higher than the 16 000 ha reported in the previous section. The apparent discrepancy probably lies mainly in the fact that the former estimate considers only 'currently active' fields, and did not account for fallow lands. If both estimates are accurate, it suggests an average, fairly short, fallow period of about 3.5 years. Other possible sources of error are a possible underestimate of population, and thus inaccurate extrapolation of household data, or the fact that agricultural lands were digitised in large blocks, without accounting for uncultivated lands in between fields. If these errors exist, then the fallow period is even shorter than the above estimate.

Table 65. Area (ha) of different types of habitats in each of the component ecoregions of the study area, and summaries of different categories of land types.

HABITAT AREAS	Floodplain	Transition	Delta	Total
River, lakes	17 785	21 465		39 250
Estuary, inshore + intertidal			82 373	82 373
Swamp / Marsh	416	1 753	1 112	3 281
Floodplain grassland	82 344	71 875	25 380	179 599
Bushland, thicket, woodland and forest	181 369	90 910	22 537	294 817
Mangrove Forest		11 255	43 899	55 154
Mixed Cropping	29 851	16 903	5 860	52 614
Cultivation With Tree Crops	514	1 648	3 681	5 842
Settlement	3 237	325	168	3 730
TOTAL	**315 515**	**216 134**	**185 010**	**716 659**
Total area of water and marsh	18 200	23 218	83 485	124 904
Total wetland/floodplain area	100 544	95 094	108 865	304 503
Total area of natural habitat	281 914	197 259	175 301	654 474
Total cultivated area	30 365	18 551	9 541	58 456

6.2 Direct use value

Direct use values (net financial values) were assigned to different habitats within each of the ecoregions, and aggregated to estimate the total value of different habitats in the study area (Table 66). Permanent waterbodies together produce the most value in the study area, with an annual net financial value of over $17.5 million per year, of which most is attributed to the estuarine and coastal inshore habitats of the delta. The per hectare values are more directly comparable. Of the natural habitats, estuary and inshore waters have the highest value, followed by the freshwater systems of the study area (Table 66). These are far higher than the values generated by mangroves and woodlands, although it is likely that the woodland values, especially in terms of timber and charcoal, are underestimates. Floodplain grasslands, by comparison, have a relatively low direct use value ($2/ha), but when converted to agriculture, yield a high value of $63 per ha. Thus it is easy to see that conversion to agriculture is an attractive option. However, the indirect use values of these different habitats should also be taken into account in comparing the value of different land types, as discussed below.

Table 66. The total area and direct use value (US$) of different habitat types within the study area, given as total annual values and values per ha per year. Values include value added beyond the study area.

USE VALUE PER HA	Rivers, lakes & swamp	Estuaries, inshore & intertidal	Floodplain grasslands	Woodlands	Mangroves	Cultivated Lands
Area (ha)	**42 531**	**82 373**	**179 599**	**294 817**	**55 154**	**58 456**
Salt		94 065				
Clay	1 099	7 663				
Grass, reeds & papyrus	7 137		6099			
Food & medicinal plants			146866	250 856		
Palms & products			192559	192 559		
Charcoal				64 682		
Fuelwood				636 258	156 458	
Timber, poles & products				2 905 041	771 789	
Fish	1 777 103	708 711				
Crustaceans		14 992 292				
Animals & birds				29 804	6 085	
Honey				15 537	9 257	
Crops						3 671 389
Total	**1 785 339**	**15 802 731**	**345 525**	**4 094 738**	**943 589**	**3 671 389**
Value per ha	**42**	**192**	**2**	**14**	**17**	**63**

6.3 Indirect use values

In addition to the their provision of economic goods such as timber and fish, natural habitats, and aquatic systems in particular, are also well known for their provision of economic services, which are provided by the functioning of these systems. Through these ecological functions, natural systems indirectly support local and national economies, and these values are hence referred to as indirect use values. Some of the types of ecosystem services provided by the habitats within the study area are discussed below. The actual estimation of these values often requires complex and detailed information, the collection of which was beyond the scope of this study, and these data requirements are also explained in the following discussion.

Flood attenuation

Floodplains and their associated wetlands and lakes, play a role in attenuating floods which may otherwise damage downstream areas. By acting as sponges which 'absorb' the headwaters of floods, these areas serve to lower the peak flows carried downstream and reduce flow velocity. They also help to maintain dry season water supplies, because stored water is then released slowly. These functions are particularly important where areas below wetlands and floodplains are developed or densely inhabited. However, the study area is in fact the lowest reach of the system, and it is really the floodplain areas upstream in the Selous that are of most value to the population in the study area in this regard. Nevertheless, the wetlands and lakes in the floodplain of the study area are likely to be of value to inhabited and cultivated lands in the transition zone and delta. Without these wetlands, flood damage to infrastructure and fields in these areas would be more frequent and more severe. In addition, more intensive flooding would be likely to impact on mangroves through freshwater damage. In order to estimate these values, it is necessary to use a hydrological model of the system to predict flood frequencies and intensity under scenarios where wetlands are included or excluded from the system.

Groundwater recharge and water supply

Floodplains and their associated wetlands and lakes may also play a role in the recharge of groundwater which is drawn off beyond the area from boreholes. Not all wetlands function in this way, as in some cases the movement of groundwater may be in the opposite direction, serving to

augment river flow. Where groundwater is recharged by wetlands, a reduction of this function can be costly in terms of degradation of terrestrial habitats as well as increased costs in accessing deeper water supplies in terrestrial areas. An estimate of the value of this function requires a detailed understanding of the geohydrology of the area, as well as information on the use of groundwater. Consequently, few practitioners have managed to place accurate estimates on this value.

Sediment retention

The reduced velocity of water flow in floodplain wetlands, combined with the dense vegetation cover, means that they trap sediments, retaining them in the wetland area and preventing their transport downstream. During times of peak water flow, when sediment loads are high, floodwaters deposit sediments and nutrients onto the floodplain. As well as depositing nutrient-rich silt on the floodplain, and thereby enhancing soil fertility, the retention of sediments enhances water clarity (Postel & Carpenter 1997). The trapping of sediments is often of major importance in securing the lifespan of dams downstream, but this function does not apply within the study area. In this case, enhanced water clarity is of particular importance in maintaining the productivity of the estuarine and offshore waters in the delta area. In degraded systems, silt carried out to sea can have a major impact on coral reefs. The prawn fishery and the important reefs located in the Mafia channel are thus indirectly protected by the Rufiji floodplain and mangroves. Estimation of this value requires an understanding of sediment loads and transport in the system as well as the complex interactions that determine productivity of coastal systems. In this case, the value is likely to be large.

Inputs to agriculture

The deposition of nutrient-rich silts in the floodplain adds to the productivity of floodplain agriculture. Yields are often significantly higher in floodplain areas than in corresponding dryland areas, and often require far fewer inputs in terms of water or fertiliser. This value is directly associated with the maintenance of the floodplain function by maintaining flows and flood regimes in the river, rather than the maintenance of floodplain vegetation *per se*. In the case of crops such as vegetables or maize, the value of flooding can be estimated on the basis of different value of production net of input costs in floodplain versus in upland areas. The production of crops such as rice which cannot be grown in upland areas, can be ascribed wholly to the flooding function. Assuming that the net financial value per ha of dryland crops which can be grown on seasonally flooded areas is doubled in floodplain areas, a rough estimate of the value of this function in the study area is approximately $2.75 million per year.

Water purification

Aquatic systems often play an important role in the removal or dilution of human-generated wastes. River flow serves to dilute the concentration of waste products, thereby reducing its potential effects. Aquatic vegetation both traps and absorbs some of the pollutants which enter aquatic systems from throughout their catchment areas, notably those associated with human wastes and agricultural pesticides and fertilisers. People in the study area collect their drinking water directly from the rivers and permanent lakes in the floodplain, or from boreholes in the delta. They are thus highly reliant on this ecosystem service for their health. Degradation of water flows or floodplain vegetation would be costly in terms of the direct costs of treating illness as well as the associated loss of human productivity. Within the study area, the application of agricultural pesticides and fertilisers is probably minimal, but there is probably substantially more input from upland agriculture in the catchment as a whole. Most villagers utilise pit latrines which soak into groundwater supplies, some of which may enter the Rufiji River. The estimation of this value requires an investigation of the polluting inputs into the system, and the ability of the system to ameliorate these impacts, as well as an understanding of the relationship between water quality and the prevalence of diseases such as diarrhoea.

Nursery function

As well as providing habitat for many organisms that are harvested within the system (captured in this study as direct use values), natural systems may act as nursery areas for organisms which are harvested elsewhere. For example, wetlands and lakes within the Selous Game Reserve improve the

recruitment of fish into the study area. Similarly, the mangrove delta within the study area acts as a nursery area for many marine species which are fished offshore by commercial vessels and artisanal fishers elsewhere along the coast. The delta is particularly noteworthy as a nursery area for prawns. Penaeid prawns spawn at sea, and following hatching, the eggs and larvae are carried to estuarine areas, where they remain and grow before returning to the sea as sub-adults (FAO 1979). Recruitment depends on the carrying capacity of the estuarine system, and productivity depends on freshwater inputs with the associated nutrient load.

A commercial prawn fishery operates along the coast of Tanzania, a significant proportion of the catch probably coming from the area offshore of the Rufiji delta. About 20 commercial permits are issued per year, of which about 12-15 foreign vessels actually operate, the remainder being national vessels which seldom run. The total allowable catch is 2000 tons, but actual catch is about 800 tons per annum (John Walsh, commercial prawn fleet owner, pers. comm.). The prawns are exported from Dar es Salaam. At the export value of $7 per kg, the total commercial catch is worth in the region of $5.6 million, of which about $4.5 million is probably from the Rufiji delta area – based on the fact that 80% of the Tanzanian prawn catch is from Rufiji (Mwalyosi 1993, Sasevelle *et al.* 1998). Most of this income goes to foreign companies. The Tanzanian government receives $2000 per permit (ie about $30 000 per year), plus a 2.5% levy on the export value of the catch ($112 500), or a total of about $142 500 per year.

Thus, the nursery function of the study area is worth at least $4.5 million per year, but the actual total is probably somewhat greater, as this does not include the value of other offshore fisheries which are dependent on the nursery function of estuaries. These functions are dependent both on mangrove habitat and on maintenance of freshwater flows into the delta, and can be severely impacted by flow regulation caused by dams (Gammelsrod 1996).

Micro-climate regulation

Wetlands and forests play a role in influencing local climate conditions and in stabilising regional climate. However, it is difficult to say how they regulate these functions in the study area, and the estimation of this value would be extremely difficult.

Carbon sequestration

Because the growth of plants requires carbon dioxide, vegetation acts as a net carbon sink for atmospheric gases (Winpenny 1991). Vegetation thus helps to mitigate the effects of global warming and its associated economic costs. This function is highest in areas of highest standing stock biomass, and forests and mangroves are thus important in this regard, although wetland vegetation and their organic soils also play a role. The most common method of valuing carbon sequestration is to assume carbon sinks save on the mitigation costs necessary to remove an equivalent amount of carbon during economic production. Watson *et al.* (1996) estimated that mitigation costs for carbon releases are in the range of $0.5-$29 per ton of carbon, and estimates usually fall within the range of $10-20. Pearce (1990) estimated the indirect use values associated with carbon storage by tropical forests to be US$1 300 per hectare. The value of tropical wetland areas may be in the order of $1-30 per ha (Turpie *et al.* 1999). Assuming that the woodlands of the study area store half the carbon of the forests considered by Pearce (i.e. $650/ha), and assuming a value of about $15 per ha for floodplain vegetation, a rough estimate of this value for the study area is about $230 million.

6.4 Preliminary overall estimates of habitat value

The estimates given in the above two sections are combined in Table 67 to provide preliminary estimates of the value of natural habitats in the study area. With the inclusion of indirect use value estimates, of which estimates are only given for three types of value, habitat values can be shown to be substantially higher than when only direct use values are considered. According to these preliminary estimates, the value of floodplain grasslands still appear to be somewhat lower than the value of agricultural conversion. However, these values would be substantially higher if the value of water purification was taken into account, and in addition, the floodplain grasslands contribute to the value of freshwater fisheries (here only included under freshwater habitats).

Table 67. Preliminary estimates of the direct and some of the indirect use values of different natural habitat types in the study area (US$).

DIRECT + INDIRECT VALUES	Rivers, lakes & swamp	Estuaries & inshore	Floodplain grass	Woodlands	Mangroves
Direct use value	1 785 339	15 802 731	345 525	4 094 738	943 589
Indirect values					
Inputs to agriculture	2 750 000				
Nursery function		2 250 000			2 250 000
Carbon sequestration			2 693 981	191 630 817	35 850 143
TOTAL	**4 535 339**	**18 052 731**	**3 039 506**	**195 725 555**	**39 043 732**
Value per ha	**107**	**219**	**17**	**664**	**708**

7 Sustainability, TRADE-OFFS and maximising welfare

7.1 The importance of sustainability

"Sustainability" is open to a vast array of interpretations, depending on the interpretation of what needs to be sustained. For example, so-called "sustainability" policies may be aimed at sustaining local cash incomes or they may be aimed at sustaining broader societal values, including those emanating from ecosystem functioning and biodiversity conservation. In general, it is argued that the latter goal makes more economic sense, in that it retains greater overall values, including indirect use values and option values that may be realised in future by local communities. Thus the term "sustainability" is used henceforth in its broader sense.

Sustainable use of natural resources entails a level of use which can be maintained indefinitely. For a single type of resource harvested in isolation, this would mean harvesting at a rate which is less than or equal to the maximum rate of growth of the resource stock, and would entail maintaining the stock at roughly half of its maximum attainable level. Where multiple species are involved, the relationship is more complex, as the exploitation of one resource may impact on the productivity and benefits obtained from another. Thus in complex ecosystems, the sustainable levels of use of resources may be lower than for each of those resources considered in isolation. In other words, sustainable use of one resource may constitute overexploitation at a broader level. For example, exploitation of mangrove resources may impact on the productivity, or growth rate, of fishery resources, and burning practices for hunting may impact on timber and honey resources. Similarly, the options for future ecotourism development may be reduced by overexploitation of woodland resources, including dead trees (which are necessary for avian diversity) and game animals.

Ensuring sustainability is fundamental to preserving the stocks of natural resources and functioning of ecosystems which will give rise to flows of value in future years. The economic consequences of unsustainable use are to increase present incomes at the expense of future incomes. Moreover, the economic losses go beyond this, in that a shortage of natural resources necessitates replacement by more expensive or inferior substitutes. Substitutes often require cash, already a scarce commodity, and this drives the need for further opportunistic exploitation. Sustainable use, such that the stocks and functioning of ecosystems are maintained, ensures security of income as well as greater option value.

7.2 The current status of natural resource use

No comprehensive inventories have been made of resource stocks in the study area, and their status (e.g. level of decline) is not well understood. In addition, little is known of the productivity and sustainable yields of stocks, either in isolation or in an ecosystem context. There are also no earlier comprehensive studies with which to compare present levels of resource use. At present, an assessment can only be made on the basis of preliminary inventories, current levels of resource use, the opinions of the resource users, and the appearance of natural habitats.

Woodlands are threatened by increasing demands for timber, and extensive cutting of poles, firewood and wood for charcoal making. According to recent estimates, woodland areas in the study area have a standing volume of about $70m^3$ per ha, and a mean annual increment (MAI), or sustainable yield, of $2m^3$ per ha (Malimbwi 2000, Kaale *et al.* 2000). With a woodland area within the whole district (excluding Selous) of about 355 000 ha, the sustainable harvest for the district is estimated to be in the order of 710 000 m^3, or 497 000 tons. There are about 210 000 ha of closed woodlands and forest in the study area, which would yield a sustainable harvest of 294 000 tons. Harvests of timber, poles, fuelwood and wood for charcoal estimated in this study make up about 40 500 tons, suggesting that current levels of use are sustainable. However, the latter is most certainly an underestimate, and the total value could be as high as 262 000 tons if earlier estimates of charcoal production are used (Havenik 1980). Moreover, it should also be cautioned that the estimates of MAI provided by Malimbwi (2000) are based on limited sampling within forest reserves, often at a long distance from any villages. Thus actual standing stocks and sustainable yields may well be substantially lower, and hence current harvests may well exceed sustainable levels. For example, the miombo woodlands

along the Dar es Dalaam - Morogoro highway, where utilisation is relatively heavy, the standing stock volume is only 45m^3 per ha (Luoga *et al.* in press b). Indeed, evidence suggests that timber harvests may be unsustainable. It is reported that tree densities within the area of 4-5km around villages, where such activities are prevalent, are declining rapidly (Kaale *et al.* 2000). Areas far from villages or relatively inaccessible by road are likely to be in a better condition, but many are probably not out of reach of pit-sawers. The trend in timber supply to Dar es Salaam is of particular concern. Timber has been systematically depleted from areas closer to Dar es Salaam and the demand has now extended southwards to Rufiji district. This suggests that Rufiji may also be mined of its timber stocks unless some kind of control is introduced. In this study, many timber cutters reported a constantly decreasing amount of timber, and some villagers expressed doubt that their children would ever know the *mninga* or *mkongo*. Thus current levels of use may well be unsustainable for certain species. At present, timber is cut mainly in the dry season, the trade being seasonal because of bad road access during the rainy season. Improvement of these roads would have a major impact on timber stocks if nothing else is done to control this activity. Timber stocks and productivity is also affected by other activities, most notably by altered burning regimes. Vast tracts of woodland are burnt annually for hunting, in the processes diminishing the value of many other resources.

No estimates have been made of the sustainable yield of mangrove cutting in the delta in terms of volume, and managers have instead opted for a system of rotation, whereby certain areas are designated for depletion or recovery. Information was not obtained for this study on the inferred allowable levels of use under this policy for comparison with actual levels of use. Nevertheless, actual harvests are several times higher than licensed harvests, and pole-cutters in the delta express concern over the diminishing of commercially-valuable species. Perhaps because commercial cutting mainly affects three species out of nine, there is no apparent largescale loss of mangrove habitat. However, mangrove areas are also impacted on by clearing for agriculture, and the status of mangrove resources in general remains to be investigated.

As one of the most valuable resources in the study area, the status of fishery stocks is also of particular importance, but no stock assessments have ever been carried out. In most freshwater areas fishers report a decline in catches and an increase in the numbers of fishermen, although some claim that fish have been scarce for a long time. Many fishers do not believe there has been a significant change in catch composition, which is often a telltale sign of a depleted fishery. However, this is not necessarily a sign of a healthy fishery in this case, due to the unselective nature of the fishery. In general, it appears that the freshwater fishery may be over-extended, but is not severely overexploited. Much of the catch is of juvenile fish, which would otherwise undergo high natural mortality (Hobson 1979, FAO 1979). The healthy hydrological functioning of the system and protected areas upstream are probably factors which have helped to sustain the area's fisheries. It is more difficult to assess the status of the estuarine and marine fisheries. Delta fishers interviewed in this study were not overly concerned about the effect of commercial trawlers on the artisanal fishery, although this subject has frequently been raised as a matter of concern in REMP project meetings (R. Hogan, pers. comm.).

The densities of mammals and birds are lower in the study area than in protected areas to the west, probably due to habitat alteration as well as hunting pressures. Again, there are no data series to suggest the current trend in animal densities. Densities of waterbirds in the delta were lower than expected, suggesting that hunting pressures may have a significant impact. Grasses and reeds are not likely to be under threat at this stage, and the status of palms is probably not of major concern, but remains unknown. Thus it appears that the most urgent concerns are around timber, mangrove and fishery resources, but the status of several other resources also needs to be investigated. The overall impression is that the study area is still in relatively good ecological condition at present, but that current or increased levels of resource use may threaten both ecosystem integrity and people's livelihoods in the near future. It is a blessing in terms of ecosystem health that there is an almost complete lack of livestock in the area.

7.3 Reasons for unsustainable use practices

There are many factors that may encourage overexploitation of resources, or fail to encourage sustainable use practices. Firstly, an appreciation of sustainability issues may not have been

engendered in a community which until only recently has had access to abundant resources. In general, there is a lack of appreciation or understanding of sustainability and conservation issues among local communities within the study area, and protected areas (Selous Game Reserve and the forestry reserves) are not valued or respected by much of the population. Lack of awareness of these issues may also be due to the fact that the impacts of unsustainable use practices have probably been fairly gradual, and in some cases would not yet have had significant effects. Secondly, exploiters seldom appreciate the impacts of their activities on others' activities. Thirdly, some of the impacts of overexploitation (e.g. on biodiversity, or ecosystem functions of value beyond the area) are not likely to be of concern to local communities. Most importantly, however, unsustainable use practices are being fuelled by demands from outside the study area, as well as outdated, inappropriate or ineffective property rights institutions and systems of control. The latter, discussed in more detail below, create disincentives for wise use.

Government control and licensing systems

With the current lack of knowledge of the annual productivity of natural resources in the study area, it comes as little surprise that the government does not enforce any quota systems, although this may be due in part to lack of realisation of the relevance of measures to ensure sustainable use. There is presently no control by the forest department over the location and extent of timber harvesting (Wells *et al.* 2000), and similar situations apply for most other regulated resources. The use of certain resources is 'controlled' by means of licensing systems, while others are unregulated. The latter category includes fuelwood and all other non-woody plant resources. Licenses are required for harvesting timber, poles, fishing, hunting and producing charcoal. These licences are small in dollar terms, but are not trivial to locals, who are often unable to produce cash up front, *before* the exploitation of the resources, and especially to do this on a commercial scale. Moreover, the bureaucratic procedures to be followed are time-consuming for people who lack transport. Someone seeking a licence has seek permission from village in which the exploitation is to occur (if applicable), and has to travel to the district capital, Utete, to obtain the licence. Payments often have to be made to both parties. The current system of regulation of harvesting resources is thus cumbersome, time consuming and generally unworkable.

The licensing system is presumably aimed to control effort as well as to secure government revenues. It currently does neither very efficiently. There are two main consequences of this system of control. Firstly, the licences form a barrier to entry into significant commercial-scale activity by local would-be entrepreneurs. This means that licences usually fall into the hands of more well-to-do entrepreneurs from major centres, usually from outside the study area. Locals are then used as labourers, and are their economic gains are thus much less than they could be. Licence holders do provide much-needed employment, but a large proportion of labourers used are also outsiders who usurp potential jobs for locals. Secondly, the licensing system fuels the demand for illegal harvesting activities. Illegally obtained resources have lower input costs, and can thus be sold for lower prices while realising greater profits. This may not be the case under a system of strong policing, but enforcement is reputedly weak and the system is easily corruptible. While the licensing system probably does reduce effort by locals to some degree, by the sheer inconvenience of having to operate under cover, there seems to be no limit to the harvest of resources by outsiders.

The licensing system has failed to generate the revenues attributed to the total quantity of resources harvested, due to largescale evasion. Probably in recognition of this, licence fees for harvesting mangrove poles have just been increased. This increase will be translated into higher prices for mangrove poles, and is unlikely to bring increased revenues to the labourers that harvest them. The net impact is likely to be even greater demand for illegal harvesting to supply poles at lower prices, a practice which already appears to be rife. As long as enforcement is poor, it will not be worthwhile for entrepreneurs to go to the trouble and expense of obtaining licences.

There is little or no policing of natural resource use activities within the study area. Even in Selous Game Reserve, poaching is rife due to lack of enforcement capacity, and wild animals remain the most effective source of effort control! The main enforcement in place is in the form of natural resource control barriers at the boundaries of the district. These are to secure the payment of

government revenues for resources which are exported from the district, which includes a large proportion of the two most valuable resources harvested - timber and fishery resources. However, it is reportedly easy to smuggle goods through these borders, by travelling un-barriered routes, by concealing valuable resources at the bottom of truckloads of other 'difficult-to-unpack' resources, such as oranges, or by using fake documents and other forms of corruption. Officials at these barrier points are apparently not immune to the occasional bribe, a reality wherever officials have low incomes.

Local control of natural resources
Village governing bodies exert little control over resources harvested in village areas, and most resources are subject to open access. Certain resources, by virtue of their widespread availability, are generally only used within village areas by village locals. Others are openly used by outsiders. The problem of open access resources is that they engender the rationale: if I don't exploit it, then somebody else will. Thus, there is no incentive to manage stocks to maximise their long-term economic returns. Villages at present do not even have well-defined boundaries within which to manage resource use. In addition, traditional knowledge systems are likely to be outdated under the current conditions of resource scarcity and demands, and villagers probably lack the scientific capacity to manage their resources in an integrated, optimal way.

7.4 Securing future livelihoods and biodiversity

One of the main objectives of the Rufiji Environmental Management Plan will be to ensure the optimal and sustainable use of the area's natural habitats in a way which does not compromise the biodiversity or functioning of the area. In addition to the fundamental questions around management of natural resources *per se*, issues that are bound to arise include the question of how much effort should go into managing and conserving natural habitats or into conventional development as a means of improving the welfare of the area's inhabitants, or for improving national economic welfare.

Securing and improving the future livelihoods of people within the study area requires an optimal mix of development and conservation within the area. At a national level, this involves addressing the high demands for natural resources for which alternatives exist, and reforming the way in which large-scale development decisions are made through a more holistic analysis of trade-offs. Similar principles apply to development decisions or policies made at the district government level, in that economic impacts of ecological degradation should be taken into account. Of utmost importance is the need for reform of property-rights institutions which control the use of natural resources.

Reduction in demand for certain resources
Much of the overutilisation of natural resources in the study area is driven by high demand, especially for timber, poles and charcoal, in urban centres outside the study area. However, very little can be done at a local level to influence this demand, and the responsibility lies with policy makers at a national level to explore the possibility of diversifying to other means of meeting these needs. Without such action, the continued use of energy as the main urban domestic fuel in Tanzania will result in the progressive disappearance of the miombo woodlands (Luoga *et al.* 2000).

National and local-level planning and development decisions
Government policy and decision-making is geared towards the goal of improving welfare by increasing per capita income. However, national economic performance statistics are aggregates which fail to take into account the distribution of income, the subsistence value of natural resources or the opportunity costs of resource depletion incurred in generating national income. Furthermore, the role of natural resources in contributing to livelihoods and income is scarcely recognised because these contributions have seldom been quantified in monetary terms. Thus policies and decisions tend to favour large-scale developments with measurable economic benefits, and seldom take into account the opportunity costs in terms of natural resource degradation. By the same token, total conservation of an area may also have opportunity costs in terms of foregone high-income generating projects that could be developed. It is thus necessary to consider all the economic trade-offs in development, land use and natural resource management decisions. Placing monetary values on natural resources helps

to elucidate the full trade-offs that need to be considered in decision-making, by communicating their value in a more conventionally-understood currency.

While it is acknowledged that development plays an important role in improving the welfare of rural communities, not all types or levels of development are wise or sustainable. Certain types of development impact on natural systems, reducing their functioning and productivity. Thus a knowledge of the value of ecosystem goods and services helps to identify the opportunity costs of potential developments. In this regard, environmental values should now be included in conventional environmental impact assessment (EIA) and strategic environmental assessment (SEA) studies.

National-level decisions include whether and how to implement largescale developments which bring about broad-scale habitat alteration (e.g. proposed commercial prawn-farming initiatives or oil exploration) or the hydrology of the area (e.g. the proposed dam at Stiegler's Gorge). The ecological impacts of such developments may have a significant impact on the economy as a whole, where they affect valuable environmental functions and the direct use of resources such as major fisheries. In some cases, however, the impacts of largescale projects on local communities may appear to be insignificant when aggregated costs are compared to their aggregated economic benefits at a national level, and purely in monetary terms. However, analysis should take into account the degree to which these values, even if small, contribute to local livelihoods.

Other decisions that may be taken at a local government level include those involving development schemes for agriculture or industry. Local development projects may also impact on natural ecosystems, and such decisions need to take the economic consequences of their ecological impacts into consideration, not only at the aggregate scale, but in terms of their impacts on peoples' livelihoods, especially those that do not benefit directly from such schemes. The trade-offs involved in land conversion to agriculture or other uses are not necessarily the same as the average values per ha presented in this study. Actual trade-offs depend on the amount of land earmarked for one use or another, and need to be considered at the margin. In other words, one needs to know the costs involved in converting an extra area of land from one use to another, and this cost will differ depending on how much land has already been converted. The more land that has been or will be converted, the higher the trade-offs will be. A much more detailed analysis is required to work out the optimal levels of development and conservation.

Natural resource management: revision of systems of control

By showing the importance of natural resources in providing subsistence needs and in the generation of cash income, this study also demonstrates the potential cost to local communities if natural resources in the area are allowed to be degraded through overexploitation or habitat loss. It is clearly important to set in place management strategies that will secure these incomes for future generations through the implementation of wise and sustainable use practices. This study has also alluded to the important role of economic incentives in driving peoples behaviour towards conserving or degrading natural habitats. It is thus also important to address these incentives in the design of management and conservation strategies.

Systems of control need to be revised, starting with establishing well-defined and secure property rights over resources. This involves defining village boundaries and giving village authorities real legal powers. Local-level ownership of resources is essential to eliminate open access systems, and to enable communal owners to gain maximum benefits from their resources over the short and longer term. Under secure ownership there is more incentive to manage resource use for optimal benefit, and resource owners can determine the amount of use, or conditions of use, to be granted to outsiders. Secure ownership also confers the incentive for self-policing of the use of resources, but where outsiders are also allowed access to resources, this has to be backed up by real legal powers at a local level.

Government intervention will probably be necessary at some level, however, to ensure the conservation and wise use of nationally-important resources, and to provide scientific input into sustainable use policies. Depending on the resources involved, this may take the form of advice, the

introduction of incentives, or quotas allocated at the village level. Licensing systems, if continued, should be administered at a village level, with inputs to government. For important resources for which demands are high (e.g. timber, poles, fish, prawns), it is recommended that comprehensive assessments are carried out to determine their optimal off-take, and that a system of quotas is introduced and allocated at the village level in a participatory process. Villages owning these quotas should be accountable to government through a monitoring process, and should be able to propose their own systems of licensing or allocation as applicable, with some share going back to district government. This would allow villages to benefit from local exploitation by outsiders through the imposition of fees or employment conditions, and should also confer greater opportunity to villagers to enter into more profitable trade arrangements. To enable this process, property rights need to be revised, firstly through the establishment of village boundaries, and then through the accession of natural resource ownership. The establishment of boundaries and rights will not be an easy process in a society which has never been exposed to such restrictions, and is likely to lead to some initial conflict. However, such measures are probably long overdue. With well-defined property-rights, villagers can control the use of resources within their boundaries, much more easily than is possible from a government level. Villages in the study area are small and thus easily policed on an internal level.

Mobile resources, notably fisheries and wild animals, present more of a problem in terms of institutionalising local-level control. Fishers and hunters themselves do not see an obvious solution to the problem. Existing measures of control of otherwise (spatially) open-access fisheries elsewhere include restrictions on gear, size limits, daily catch limits and closed seasons. Of these, the latter is technically the most easily controlled, and size and catch limits are often futile measures. Gear restrictions for hunting and fishing and closed seasons for hunting and prawn fishing already exist in the study area, but these are not well observed. Many see the introduction of closed seasons as a futile exercise, saying that they are too dependent on fishing year-round in order to generate cash income. It may be more important to have a steady, year-round income, than a higher income which is gained in a shorter time period. Whatever measures are applied, fishers are unlikely to co-operate under an open-access situation, as transgressors stand to benefit. With clearly-defined ownership, fishers stand to benefit from, for example, a closed season during spawning aggregations, and will be more likely to co-operate if they are secure in gaining these benefits. In this case, the need for year-round income may be obviated by improved income over a shorter time period. Although some fishers in the floodplain do see the logic in establishing better-defined fishing access rights in spatial terms, those in the delta would find it difficult to operate under such a regime because of the highly motile nature of the fishery. Nevertheless, considering the high value of the delta fisheries, it would be conceivable to institute local level control whereby visiting fishers pay licences directly to controlling villages.

The changing of systems of control and allocation of quotas will not be an easy process. Thus it is critical that management plans and strategies are adaptive so that they can be revised on the basis of experience, monitoring and improved information.

Maximising income from natural resources

Firstly, it should be noted that if the use of resources is generally limited by improved systems of control, their value is likely to increase. There is also scope for implementing schemes to improve the profitability of resource use, but these should first be carefully analysed in terms of the types of incentives that they would create under the prevailing circumstances. Under open-access, projects which add value to resources are at a high risk of creating the incentive for further overexploitation. Under secure ownership, this is less likely to be the case, and there is an incentive for high-value resources to be better controlled. It must be borne in mind, however, that both high and low-value resources are vulnerable to overexploitation in situations of dire poverty. In the study area, it would be feasible to improve incomes from natural resources, as long as ownership of resources is secured, but it is equally important to improve incomes from other sources, such as marketing of agricultural products.

Villagers currently rely on traders to transport their goods to markets, and traders, many of whom come from outside the area, profit from these transactions. This situation is often seen to be

disadvantageous to the harvesters, but is in fact the best workable system, as transportation is costly and time-consuming, and producers may not have the same bargaining power as traders in markets. In fact, traders or middlemen are to be encouraged, as they create income-earning opportunities for harvesters. Nevertheless, locals do lose out to middlemen to some extent due to their weak bargaining powers. This is because of a lack of organisation or centralisation of trading with middlemen, rather than due to the existence of middlemen. Co-operative bargaining needs to be encouraged, for example by a representative acting on behalf of a group of producers. The situation could also be improved if a greater proportion of traders were locals, perhaps supplying to longer-distance traders at centres such as Ikwiriri. Large centres do provide such market opportunities, but the cost of trading licences may currently discourage locals from entering the business. Not all markets opportunities have been developed, however. In Selous, for example, rest camp managers find it more efficient to obtain their groceries and curios from Dar es Salaam, despite the much higher expense. The issue here is one of reliability, and in some cases, quality, of supply. While traders of high value goods such as timber, prawns and fish are plentiful, there are clearly not enough traders for certain resources to encourage production for sale. These include handicrafts, notably *ukindu* mats. The problem here is probably a lack of organisation of production so that traders might encounter a large enough, reliable supply to warrant the effort.

Several resources tend to be sold in raw form by collectors for eventual processing elsewhere. These include timber and other resources such as ukindu. An obvious way to increase the local value of natural resources is to encourage processing at, or close to, source. In some cases this might require access to training to meet the standards of production required by distant markets. In this regard, value could also be added to salt production by introduction of iodising techniques.

There are also opportunities for realising new types of value from natural systems in the study area. This includes development of new products and entering into hunting and ecotourism businesses. The latter are poorly developed, in spite of the opportunity provided by the proximity to Selous and the outstanding natural features of the study area (e.g. lakes, delta). Indeed, operators in Selous frequently take guests on trips to the delta. Tourism enterprises could generate revenues far greater than any current uses of these natural areas. Communities themselves lack the capital and know-how to start up such ventures, but partnerships with private entrepreneurs could easily be encouraged. The effective commercialisation of beekeeping and marketing of bee products, such that incomes are significantly augmented, may be a good way of encouraging the conservation of woodland areas upon which the bees depend.

8 Conclusions

This study has shown that natural resources play a critical role in the lives of people living in the Rufiji floodplain and delta. Numerous species are utilised and processed for subsistence and for income generation. Further value accrues beyond the boundaries of the study area from trade in natural resources between Rufiji and major centres. Tanzania and the international community benefits from the maintenance of biodiversity and associated option values, and from ecosystem functioning in the study area, most notably in the form of commercial prawn fishing in the delta. However, there is evidence that many resources may be being utilised at levels which cannot be sustained in the future, a practice which may have serious implications for the future welfare of the area's inhabitants. Yet, there is a critical lack of understanding of how to use resources in the study area sustainably in order to maximise their benefits over the longer term. This primarily due to the fact that comprehensive information on stocks and biology of resources is almost completely lacking or has only been carried out at a superficial level. In order to manage for sustainability, it is necessary to understand the sustainable offtake of natural resources of all kinds, and how their exploitation impacts on other resources in the system. At the very least, managing for sustainability requires regular monitoring of resource stocks and harvests. Even basic monitoring of the licensed use of many resources is not being carried out effectively at the district level.

This study, conducted over a short period, has produced initial assessments of value, erring on the side of caution where necessary. Certain values, such as fishery values, are particularly difficult to assess in a one-off study and require more detailed follow-up studies. It was not possible to estimate most indirect use values, which require detailed modelling as well as considerable additional information on the system. If natural resources of the study area are to be effectively conserved to secure local livelihoods and biodiversity, it will be necessary to improve on the current state of knowledge of the area's resources and revise current systems of property rights and control. This includes:

- Conducting detailed assessments of the stocks and status of natural resources, such as timber, other plant products, wild animals, fish and prawns;
- Determining the productivity of resources;
- Determining the sustainable yield of resources, both in an isolated sense and in the sense of maintaining the optimal balance of resources and ecosystem functions to maximise economic value;
- Addressing the issues of ownership and responsibility for resource management and implementing new systems of control, including local-level quota systems;
- Addressing incentives for responsible and wise use of natural resources at a local and government level; and
- Implementing monitoring programmes to assess the success of management and incentive strategies.

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10 Appendices

10.1 Appendix 1: Example Focus Group Instrument

FOCUS GROUP 1: MEN –TIMBER, POLES, CHARCOAL, HUNTING, HONEY

Village_____ Date _____ Interviewer: _____ Translator_____

Introductions. We are working with the Rufiji Environmental Management Project based in Utete. As you probably know, the overall goal of this project is to secure and enhance people's livelihoods by promoting long-term conservation and wise use of the natural resources in Rufiji district. You have probably met with the various people who have been studying the way people live and the natural resources of the region. We are here to do a study on the economic value of the natural resources of this area. What this means is that we are trying to show how important natural resources are in the daily lives of people living here, and to show how valuable the natural habitats, such as the rivers and forests, are to the people that live here. This study will help us to help you find ways of getting the maximum benefit from the resources that you have, and to help protect your resources from outside influences that may threaten them. We are having meetings with different groups of people about different activities and resources. In this group, we would like to ask specifically about the harvesting of timber, poles, charcoal, animals, birds and honey by people of this village. We are not interested in whether people have licences to collect these resources. We understand that some people just go out and collect resources without a licence when they need to. We would like to know about everything that is collected because it is important for you that we are able to show how valuable these natural resources are to the community.We would greatly appreciate if you would join us in a discussion for about one hour.

Participants
Please could you introduce yourselves.

Name	Sex	Age est.	Position with respect to resource
1			
2			
3			
4			
5			
6			

Charcoal & fuelwood
How many households or people in this village make charcoal?_____
What type of trees are used for charcoal?

How many charcoal kilns are there around this village?_____
How far from here is the furthest kiln belonging to someone in this village?_____
Do people from other areas also have kilns in the same area of forest?_____
Do people take all the nearest wood to a kiln, or do they go some distance from the kiln? ___
What maximum distance from a kiln is wood collected for making the charcoal?_____
How much charcoal is produced by this village in a month at the moment?_____
Is the same amount produced during wet season months, or how much would be produced per month then?_____
Do any men in this village collect fuelwood?_____
Is this for home consumption or sale?_____

Timber & poles

What proportion of households harvest timber or poles? ._____
What equipment is used for cutting timber and poles? ._____
How much does it cost? ._____
Does every household have this equipment? ._____
Do most people harvest for their own needs or to sell? ._____
Where do people go and how far do people from this village usually travel to harvest poles or timber_____
What is the maximum distance people from this village ever go? _____
Do people from other villages also enter these areas._____
How is the wood transported from these areas?_____
When harvesting timber, how much is usually cut on one trip _____, and how long does it take (including the journey). _____
When harvesting poles, how many poles are usually cut on one trip _____, and how long does it take (including the journey). _____

Who buys the timber harvested from people in this village? _____
How many people in this village make furniture for their own use?_____
How many people make furniture to sell? _____
Who buys the poles harvested from people in this village?? _____

Could you show us what proportion of timber is collected by people of this village from the forest, mangroves or floodplain, and then what proportion of poles are collected from these three areas: (record number of beans)

	Floodplain	Forest	Mangrove
Timber			
Poles			

Timber

If people from this village collect timber or pole from the forest or floodplain then ask the following: Please tell us about the different species collected from the forest and floodplain for timber or poles, and how are they used? (Get local names). What is the usual diameter for each. How much are they sold for (give units). Which is the most important species in terms of income, next most important, and so on (rank).

Forest & floodplain Species	Forest/ Flood-plain	Timber / poles & diameter	Use	Price (describe unit)	Rank

Please show us how much you use (in terms of volume) of each of the top 5 species compared with each other and all the rest, using beans.

Species 1	Species 2	Species 3	Species 4	Species 5	The rest

What is the status of timber and pole resources around the village? Are they abundant, enough or scarce? Are any species in particular becoming much harder to find nowadays? Have people changed the types of species they collect over the years?

Mangroves

If people from this village collect timber or poles from the mangrove forests then ask the following: Please tell us about the different species collected from the mangrove forest for timber or poles, and how are they used? (Get local names). What is the usual diameter for each. How much are they sold for (give units). Which is the most important species in terms of income, next most important, and so on (rank)..

Species	Timber / poles & diameter	Use	Price (describe unit)	Rank	Relative Amount Used
Mkandaa dume *(Lumnitzera)*					
Msikundazi *(Heriiera)*					
Mkomafi *(Xylocarpus)*					
Milana (*Sonneratia)*					
Mchu *(Avicennia)*					
Mkandaa *(Ceriops)*					
Msinzi *(Brugiera)*					
Mkaka *(Rhizophora)*					

If this pile of beans represents all the mangrove wood harvested by people in this village, please show us how much comes from the different species. (*fill in numbers of beans on table above*).

Wild animals and birds

We would like all of you to tell us about the animals and birds that are hunted around here. Again, we are not interested in whether people have licenses to collect these resources or whether their activities are legal. We would like to know about everything that is collected because it is important for you that we are able to show how valuable these natural resources are to the community.

Do all households consume meat from wild animals and birds from time to time, either from their own hunting or by buying the meat?_____

How much wild meat is consumed in an a normal household in a month _____

What types of wild meat from animals or birds is it possible to buy or obtain in this village? Give species and price. Which are the most commonly eaten species? (please rank in order of importance)

Animal Species	Price per kg	Rank	Bird Species	Price per kg	Rank

Who hunts **birds**, and what proportion of households are involved this type of hunting? _____

Please describe the equipment used in hunting **birds:**

Type of equipment, and what it is made from	Cost	How long does it last	How many in the village

Do most **bird** hunters hunt for their own needs or to sell? ._____

How far do people from this village **usually** travel to hunt birds _____

What is the **maximum** distance people from this village ever go on a bird hunting trip?____

Do people from other villages also hunt birds in enter these areas._____

How long is a normal bird hunting trip, and how much would you normally catch on such a trip?_____

Who hunts **animals**, and what proportion of households are involved this type of hunting? _____

Please describe the equipment used in hunting **animals:**

Type of equipment, and what it is made from	Cost	How long does it last	How many in the village

Do most animal hunters hunt for their own needs or to sell? ._____

How far do people from this village **usually** travel to hunt animals_____

What is the maximum distance people from this village ever go on a hunting trip for animals?_____

Do people from other villages also hunt in these areas._____

How long is a normal animal hunting trip, and how much can you expect to get on such a trip?_____

Which habitats does the meat from wild animals and birds come from, and in what proportions (illustrate using beans)

	Forest	Mangrove	Floodplain	Wetlands	River	Lakes
Animals						
Birds						

Honey

Do most households in the village eat honey?
How many households in the village have bee hives?
About how many hives do they have
How many households are involved in harvesting honey from the wild
At what times of year is wild honey collected?
How long is a honey collecting trip?
How much honey is collected in one trip
How many hives does this come from?
What equipment is used
How much firewood used at one hive?
What are the costs of firewood for one collecting trip
Who is the honey sold to?
What is the price obtained locally.
Do any traders take the honey to sell outside the village?

Time budgets

Lastly, we would like to understand how men spend their time in different activities at different times of the year.
Could you describe, using beans, how much time you spend in agriculture (working in the fields) over the different months?

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

If this pile of beans represents all the time during daylight hours of a man, could you show us how your time is divided between these different activities during this month, July (see table for activities). Repeat the exercise for the month of most and least time in the fields (refer to above table), and for December.

	July	Month of highest time in fields	Month of least time in fields	December
Time in fields				
Time spent fishing				
Time collecting natural resources (timber, poles, hunting, honey)				
Time in trading or other business				
Leisure time				

10.2 Appendix 2: Household Survey

Village_____ Interviewer_____ Date_____

Introductions. We are working with the Rufiji Environmental Management Project based in Utete. The overall goal of this project is to secure and enhance people's livelihoods by promoting long-term conservation and wise use of the natural resources in Rufiji district. We are here to do a study on the economic value of the natural resources of this area. What this means is that we are trying to show how important natural resources are in the daily lives of people living here, and to show how valuable the natural habitats, such as the rivers and forests, are to the people that live here. This study will help us to help the communities to find ways of getting the maximum benefit from the resources that you have, and to help protect your resources from outside influences that may threaten them. We are having meetings with different groups of people about different activities and resources. We are also surveying a number of households, to ask specifically about the amount of natural resources used by people. In this survey, we would like to talk to both male and female members of the household if possible.

1. General household information

Name of the Household head	
Gender of household head	
Age of household head	
Number of wives	
Main occupation of household head	
Education of head of household	
Household size	
Male adults	
Female adults	
Children 12-17 years	
Children < 12 years	
Tribe	

2. Please list the main **economic activities** which help to sustain your household, and **rank** in order of priority. Please **consider the value** (value of products consumed or used in the household plus cash from selling, etc) you get from all of these sources in a year, and show us **what proportion** of this value comes from these different activities (*using beans*).

Activity	**Rank**	**Proportion of income (number of beans)**
Agriculture		
Fishing		
Hunting (animals & birds)		
Wood products harvested from forest (timber, poles, firewood, charcoal)		
Plant products harvested (Palms, reeds, grasses, wild food plants, medicinal plants)		
Salt making		
Livestock		
Other cash income from trade, jobs (or other – specify)		

Fishing

3. Is anyone in this household a full-time, part time, or occasional fisher, or employed to work as a fisher? (*fill in table*)
4. How many days per month do they go fishing? (*fill in table*)

	full-time	part-time	occasional	employed
Number in household				
Days fishing per month				

5. What fishing equipment does the household own (boats, nets, etc., give quantities)?

___ _____
_____
_____

Please describe your fishing activities for all fishing members of the household (including women):

6. What are the main species targeted? _____
7. (*Delta only*) Does anyone in the house collect other small animals from the intertidal mudflats? Describe_____
8. Catch statistics:

Type of fish	Average weekly catch (kg)	Estimated annual catch (kg)	Proportion of annual catch sold (by weight)	Price per kg
Finfish				
Prawns				
Crab				
Octopus, squid				
Other				

9. Have you lost any equipment or part of your catch to wild animals (e.g. crocodiles) in the past year? Give details_____

_____

Fish trading

10. Does anyone in this household buy fish to trade? _____
11. Where do you sell? _____
12. Please give details:

Type of fish	**Amount traded per year**	**Average difference between bying and selling price per kg (or other specified unit)**	**Costs per year (transport, processing, packiaging, etc)**
Finfish			
Prawns			
Shellfish (crabs, squid, octopus)			

Wood products (timber, poles)

13. Please tell us how much of these products were harvested or produced by this household in the past year.

Type of product	**Total amount harvested/ produced by household in 1 year**	**Amount sold**	**Price per unit**
Logs (Magogo)			
Poles (boriti, fito)			
Pieces (Vipande)			
Firewood (kuni)			
Charcoal (Mkaa)			

14. What are your annual costs in harvesting these? _____

Value added to timber

15. Does anyone in the household make furniture, carvings or any other products from wood? __
16. Please give details:

Product	**Made from**	**Amount made in the last year**	**Amount sold**	**Price**

17. What equipment do you have in this household for making these products?_____

_____

Honey

18. Does this household have any beehives? If so how many? _____
19. Does anyone in the household collect wild honey?_____
20. How many honey-collecting trips were made in the last year?_____
21. How much honey is collected per trip or in the last year?_____
22. How much of this was sold?_____
23. At what price?_____
24. How much firewood was used per trip?_____

Hunting - Animals & birds

25. What animals or birds have members of this household hunted **in the last year**, and how many (*we are interested in small ones as well as big ones*)? Please give details:

Species	**Amount hunted (give units)**	**Amount sold (give units)**	**Selling price (give units)**

Reeds, papyrus and grasses, palm leaves

26. Please tell us how many bundles of reeds, papyrus and grasses were collected by this household **in the last year**? How much of this was sold?, and What is the price of a bundle?

	Bundles harvested (give size)	**Bundles sold (give size)**	**Price/bundle**
Reeds			
Papyrus			
Grasses			
Palm leaves – ukindu			
Palm leaves – miaa/milala			
Palm leaves – other species			

Value added to plant products

Does anyone in the household make mats, baskets or any other products from reeds, papyrus, grasses or palm leaves? _____ Please give details

Product	**Made from**	**Amount made in the last year**	**Amount sold**	**Price**

What equipment does this household have for making these products?_____

Food and medicinal plants

27. What quantity of wild vegetables does this household use in a normal week?_____
28. Does this household harvest wild plants for medicinal use?_____
29. Please give details on quantities harvested and sold:

Type of product	Amount harvested per year (give units)	Amount sold	Price per unit
Medicinal plants (Madawa)			
Medicinal bark(magamba)			
For food: Leaves & stems (majani na shina)			
For food: Roots (mizizi)			
Fruits (matunda)			

30. Has this household made any drinks**,** such as **palm wine, soft drinks, beer** in the last year?

Type of drink	Made from	Quantity made	Amount sold	Price
Palm wine				
Soft drink				
Beer				

Clay

31. Does anyone in this household collect clay to make pottery?_____
32. How many pots did she make in the last year? _____
33. How many of these were sold? _____
34. What price for a pot? _____

Salt

35. Please give details on any saltmaking by members of this household.

Amount made last year	Amount sold	Price

Livestock production

Type	Present number of stock	Household yield per year	Amount sold	Price
Chicken				
Eggs	--------n/a----------			
Goat meat				
Cattle meat				
Milk	--------n/a----------			
Other				

Have you lost any livestock to wild animals in the past year? Please give details:

_____

Agriculture

What is the size of the fields belonging to this household? _____
Which crops are grown by this household, and what is your production in a normal year?
What proportion of this is sold, and what is the usual price?

Crop/Tree Zao		Production per year (give units)	Proportion sold	Unit price
Rice	Mpunga			
Maize	Mahindi			
Cassava	Muhugo			
Pumpkins	Maboga			
Cowpeas	Kunde			
Green Peas	Choroko			
Pigeon Peas	Mbazi			
Other legumes	Zao lingine aina ya mikunde			
Green vegetables	Mboga za majani			
Sweet potatoes	Viazi			
Sugar cane	Miwa			
Coconut	Nazi			
Cashew nut	Korosho			
Simsim	Ufuta			
Mango	Miembe			

Banana	Mgomba			
Other fruits	Matunda mingine			
Other crops	Zao ningine			

Have you experienced crop losses to wild animals in the last year? _____
Which animals, and what were the losses (estimate quantities if possible)?

_____
_____

What happens when there is a shortage of food from your fields?

Buy food	
Harvest food plants from wild	
Beg assistance from others	

What is the annual **cash income** to this household from wages, pensions or members of the family living elsewhere? _____