

**Rufiji Environment Management Project¹
Environmental Management and Biodiversity Conservation of Forests,
Woodlands, and Wetlands of the Rufiji Delta and Floodplain**

**An analysis of smallholder opportunities in
fisheries, coastal and related enterprises in the
floodplain and delta areas of the Rufiji River,
Tanzania**

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**Technical report No. 25
February 2002**

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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

Visits were made to the Rufiji District floodplain and delta areas during October and November 2001 to examine aspects of the trade, marketing and preservation of aquatic products, and to consider options for increasing the profitability from aquatic resources. Ten fisheries-related or other potential enterprises that might assist in improving local communities' profits are considered for piloting in the District.

The two main fishery products marketed from the Rufiji District are finfish (both from freshwater and marine sources) and prawns. A specific commercial network governs each product. The prawn fishery supplies an export market via a capitalised structure, and finfish fisheries supply an extensive domestic market, characterised by low individual buying power. The general marketing of aquatic products was found to be similar in structure to that of other small-scale fisheries in East Africa, the sector being characterised by a large number of product-specialised intermediaries with detailed knowledge of particular products and particular markets. The relationships between traders of different levels and between traders and fishers are generally intricate and bonding, the latter improving security of supply for the trader and ensuring both a market and a source of inputs for the fisher. The marketing of other fishery products, presently of considerably less significance than prawns and finfish, are also described. These include the trade in octopus, sea cucumbers, lobsters, freshwater shrimps, sergestid shrimps ('uduvi') and mud crabs.

Few losses are associated with the prawn fishery since fishers rarely fish when there are no buyers for prawns. Trading losses in finfish are mostly associated with poor quality smoking. The wider availability of ice would have a positive impact on many of the finfish fisheries as well as on trade in prawns. The economic viability of such an enterprise will depend on investment and operation by the private sector.

Marine resource management issues pertinent to the Rufiji Delta are highlighted, with a focus on the artisanal prawn fishers and the activities of the industrial fleet of 20 trawlers. The need to incorporate environmental and resource messages in an educational context is discussed and research topics considered to be priorities for the better understanding of the various aquatic resources and their future management are briefly presented.

Descriptions are provided on the use of various aquatic resources of the floodplain and delta areas. Future development options are examined, and ways to improve or develop existing enterprises associated with these resources described. The potential to develop small-scale prawn farming in the delta is discussed but not encouraged at this stage.

While considering possible enterprises for piloting in the District, the present study focused on the delta area, thus deliberations on the floodplain fishery are based more on brief discussions and the available literature than on field visits. With indications that the floodplain fishery approaches or exceeds the maximum yields no suggestions are made to increase fishing effort in existing water bodies. Instead, a proposal to boost the productivity of the floodplain lakes is provided through the introduction of brushwood enclosures (acadja-enclos). The development of three different freshwater fish culture systems for the floodplains is also described. The first of these is the practice based on excavations of shallow ponds in natural depressions to trap and culture the African air-breathing catfish. The second is tilapia fish farming using ponds and the third is a cross between catfish ponds and tilapia fish culture whereby an extension of existing lakes is dug to trap and culture fish as the lake recedes. The resulting 'finger ponds' are then used to grow a mix (or polyculture) of fish with agricultural pursuits on the raised land in between.

Recognising that the preservation of fish, and other products, with wood smoke is so vital to the delta

and the floodplain, one wide-reaching recommendation is to improve the fish smoking techniques currently in use. Similarly, the fishery for mud crabs already exists but on a small scale. The development and expansion of this fishery is supported. Fishing for large neritic fish species, such as jacks, barracudas, and kingfish is considered under longline fishing gear development. The exploitation and marketing of alternative timbers such as coconut wood is proposed, as is the encouragement of environmental and cultural tourism in the District, particularly in the delta area. Finally, the supply of seafood to the Selous Game Reserve lodges and the description of associative enterprises are synthesised.

The final section of this report compares and contrasts the ten potential enterprises described above to determine the “wisest” choices for immediate piloting in the district. The wider application of catfish ponds in the floodplain, the introduction of brushwood enclosures in floodplain lakes, and the development of the delta mud crab fishery were selected for piloting and guidelines for each of these are provided. The importance of the private sector is recognised throughout the study, since without a strong economic incentive, no development is likely to be supported.

Acknowledgements

The staff of the REMP are acknowledged for their time and efforts in making the visit to the floodplain and delta so successful. In particular we would like to thank Rose Hogan, Albert J. Mkama, Olivier Hammerlynck, boatman Omari Chaugambo, the vehicle drivers Clement Charles Ndali and Samson Mrema, and Wahida Shah (IUCN Nairobi). Mr Ezekiel B. Chirwa, Mr. Revocatus Nandi and Ms Pili A. Mambeso (of the Division of Fisheries and Agriculture) are thanked for their dedicated assistance during the fieldwork. We also thank Mr Frank Sima and Mr. Michael Abu of the Mangrove Management Project for their support in Nyamisiati and for use of their boat. Representatives of the following institutions are acknowledged for giving freely of their time to answer numerous queries: Tanpesca Ltd., Ocean Safaris Ltd., Songas (especially Dorah Swai and Naima Abdallah), Division of Fisheries, Mangrove Management Project (Dar es Salaam office), Rufiji River Camp, Matemwe Bungalows, Sand Rivers, and the Mafia Island Marine Park. Captain Eric Toyer (retired prawn trawler skipper) and Jim Anderson (fisheries specialist) deserve note for their various contributions with useful comments and suggestions. Catharine Muir is acknowledged for supplying various unpublished data on Dugong records for the Rufiji, and the headmaster of Mbagala Charambe Secondary School is thanked for showing us his tilapia ponds. Lastly, the many fishers, farmers, traders, smokers, village representatives and investors met with in the field and in Dar es Salaam are heartily thanked for their patience, cooperation in for providing so much useful information.

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Notes

1. Exchange rate at the time of the study US\$1 = 900 TSh
2. Nomenclature All scientific names are in *italics* with local names in ‘single quotations’.

Abbreviations

ALCOM	Aquatic Resource Management for Local Community Development Programme
CLUSA	Cooperative League of the USA
FAO	United Nations Food and Agriculture Organisation
GIS	Geographic Information System
KMFRI	Kenya Marine Fisheries Research Institute
IMS	Institute of Marie Sciences
IUCN	World Conservation Union
MMP	Mangrove Management Project
NEMC	National Environment Management Council
REMP	Rufiji Environment Management Project
SNV	Dutch Volunteer Programme
TAFIRI	Tanzania Fisheries Research Institute
TANRIC	Tanzania Resources Institute
TCMP	Tanzania Coastal Management Project
UDSM	University of Dar es Salaam
WIOMSA	Western Indian Ocean Marine Science Association
WWF	World Wildlife Fund for Nature

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1 Introduction

The Rufiji Environment Management Project (REMP) based at Utete, the administrative headquarters of the Rufiji District of Tanzania, has as its goal “*to promote the long-term conservation through “wise use” of the Lower Rufiji forests, woodland 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*”.

The project was initiated in 1998 and the three main objectives of the project’s first five-year phase are:

- (a) To promote the integration of environmental conservation and sustainable development through environmental planning within the Rufiji Delta and floodplain;
- (b) 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, and;
- (c) 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 emphasising the non-sectoral, multi-biome, integrated approach to the environment.

The aquatic resources of the Rufiji floodplain and delta are vital to the people of the Rufiji, with prawns and finfish from the delta and finfish from the floodplain lakes being some of the main products driving the economy of the District. Other resources of significant importance derive from agricultural production, forestry products and wildlife; however, none of these engage as much effort, nor generate as much income locally as the aquatic resources.

Recent studies undertaken by the REMP indicate that both the finfish and prawn fisheries are being over-exploited, with local fishers reporting declining yields. Immature fish are also being landed and the fishery of the lakes appears to be depleted each year forcing illegal, and dangerous, fishing in the Selous Game Reserve. Several factors are thought to contribute to the current situation. These include the growth in the human population dependent on the resources (including temporary migrants) and the increasingly commercialised nature of the fishery (supporting businesses outside the District). The activities of the industrial prawn trawlers, damaging inshore habitats and generating high bycatch of non-commercial species and, the general expansion in the use of destructive fishing gears are also believed to be contributing factors.

Objectives of the Study

The purpose of this study is to consider methods and techniques that assist in improving local communities’ profits from a sustainably-managed fishery and to investigate possible opportunities for piloting other fisheries-related and alternative coastal enterprises in an effort to reduce pressure on the fishery. Full details of the terms of reference are provided in Appendix 1.

2 Approach and Methods

A visit was made to the floodplain and delta areas by the team of four consultants between October 30 and November 9, 2001. At the start of the visit the REMP staff requested that the consultants focus on the delta area, rather than the floodplain. A summary of the itinerary and list of key informants consulted are provided in the Appendix.

Details of the **marketing systems** currently in place in the delta and floodplain were documented through a series of focused interviews held with traders and fishers, and through direct observation of market prices and costs of products from the landing sites through to consumer markets or points of export. In selected sites, group interviews were made, using visual participatory tools including network maps and activity calendars, in order to gather more detail on the social and commercial structure of the market as well as seasonal variations.

In considering the range of opportunities for **sustainably increasing productivity** of aquatic resources review of maps and available coastal habitat survey data were undertaken. Site visits to communities, in areas identified as being suitable, were combined with broad surveys of existing land use, mangrove forest composition, topography, and soil types. Available information on physical aspects (tidal regimes, climatic conditions) and on biological aspects (recruitment of larvae or juveniles and seasonality) of prawn and crab fisheries records were examined. Exploitation of non-mangrove plant species, fish preservation methodology, and the potential of tourism development and marketing of seafood to the tourism industry were also investigated.

Through interviews with community leaders and government officials, the existing **land tenure** systems, timber and aquatic **resource management** practices, aquaculture and silviculture **traditions** were reviewed, as was the potential for single household and community level co-operative aquaculture farming initiatives. The reported loss of productivity in the small-scale fishery associated with the activities of industrial and semi-industrial vessels in the delta was investigated through discussions with representatives of affected villages and through interviews with representatives of the trawler fleet and the Division of Fisheries. Proposed steps for improved resource management and improved conflict resolution are discussed.

A preliminary survey of representative areas and resources for **potential mangrove aquaculture** production was undertaken to provide the basis for development of recommendations for appropriate integrated farming systems and concepts for pilot demonstration farms. These form part of a series of **proposed enterprises** described for the delta and floodplain areas. Searches were made through the relevant literature, drawing experience from other African and SE Asia fisheries projects that have sought to promote economic diversification and improve commercial conditions in small scale fishing communities. To help structure subsequent analysis the opportunities and constraints associated with each enterprise are described under the following broad headings: cultural and social issues, financial issues, policy support, environmental and resource issues, market characteristics, and technology and skills requirements.

A **comparative analysis** of the enterprises was undertaken focusing on the expected benefits and important constraints to each, identifying key weaknesses and threats to success, and allowing the “wisest” choices to be identified. Finally, for each of the “wisest choice” enterprises implementation guidelines are provided.

3 Background – The Rufiji District

3.1 Physical Geography and Climate

The Rufiji District extends from the Mafia Channel westward to the interior of the Selous Game Reserve (see Fig. 1 & 2). Most of the District lies east of the Selous, occupying an area of about 8,300 km² (830,000 ha). Through the central lowlands of the District meanders the lower portion of the Rufiji River, running roughly from west to east, with its origins beyond the Selous (Fig.1). This is Tanzania’s largest river, in eastern Africa second only to the Zambezi River in terms of freshwater transport (Sørensen, 1998).

The two largest tributaries of the Rufiji River are the Great Ruaha and Kilombero Rivers. Together these combine to form the Rufiji River Basin extending for almost 177,000 km² or about 20% of the surface of Tanzania (see Fig 1). The entire Selous Game Reserve is included in this catchment area. The confluence of the Great Ruaha River is upstream of Stiegler’s Gorge, the narrow portion of the river proposed as a site for a hydroelectric dam in the 1970’s (never approved). The Great Ruaha River traverses 70 km of the Selous, having its origins over 600 km to the southwest, near Mbeya. The Kilombero River also originates from the southwest, and traverses a large area of swamps and marshes in the Kilombero Valley before entering the Selous.



Figure 1: Map of Tanzania showing the Rufiji River and its main tributaries. The Rufiji District is indicated by a boxed outline (see Fig. 2 for more detail).

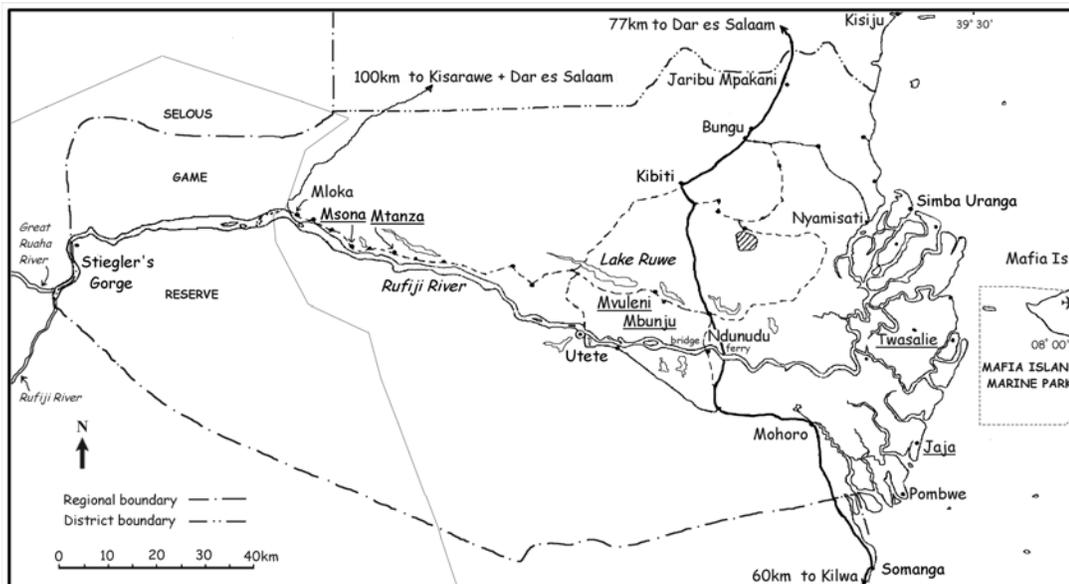


Figure 2: The Rufiji District within Tanzania (see box in Fig. 1). Names of pilot villages are underlined.

Within the Rufiji District, a dozen lakes flank the shores of the Rufiji River, mostly on the northern shores. Numerous additional smaller, seasonal lakes emerge as the flood recedes. Flooding of the Rufiji River and floodplains occurs during the wet season between March and May when about half the annual rainfall of about 1,000 mm is experienced (Fig. 3). However, rainfall in the District only marginally affects the floodplains; the up-country rain being responsible for swelling the lower Rufiji River downstream and flooding 20% of the District, an area of about 1,500 km². During the flood season, both shores flood with a depth depending on the amount of rainfall. Some larger portions of land between the delta branches (e.g. around the village of Twasalie) also flood. Air temperature throughout the year is between 24-31 C.

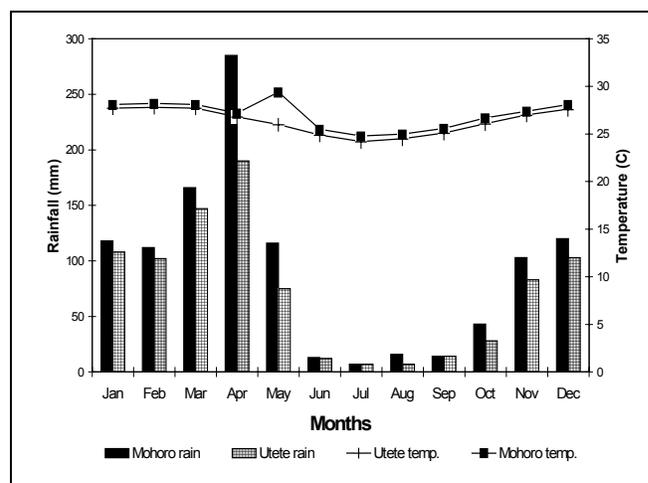


Figure 3: Rainfall and air temperature at Mohoro and Utete, Rufiji District (data from Oxford Uni. (1992) in Koffa *et al.*, 2001).

About 30 km from the coast, the lower Rufiji River branches out into a series of channels forming an impressive delta, covering approximately 1,200 km² with about 530 km² covered by mangrove forests (Fig. 4). It is recognised that this figure is over ten years old and needs revising. The four northern branches of the delta presently carry the bulk of the discharge of the Rufiji River. This came about in 1963 when heavy rains caused the previous course to veer north, just seaward of Msomeni. Previously, the bulk of the Rufiji River was carried to the southern delta. The change in hydrology had serious repercussions on agricultural practices, the entire ecology of the affected area of delta (e.g. mangrove growth, fisheries species and hence productivity), and on erosion and deposition processes (see Sørensen, 1998).

Tidal influence in the delta is considerable, affecting both ecological processes and human activities. Tidal ranges, typical of Tanzania, approximate 3.3 m on spring tides, exerting an influence inland along the numerous branches in the delta for 25 km, reaching the village of Msomeni (Mwalyosi, 1986). About 17 million tonnes of silt are carried annually to the delta (see Hogan *et al.*, 1999).

The Mafia Channel, into which the Rufiji River water, nutrients and sediments discharge, is a shallow passage between the island of Mafia (Fig. 4) and the mainland. This has its narrower portion opposite the Rufiji Delta village of Msala, where the width is about 17km, and widens both to the north and south of this point. Along the northern portion, off Simba Uranga, a large shallow shelf of less than 10m depth extends out for 10-20 km, north to Kisiju. Unlike the more central and deeper parts of the Mafia Channel, the Simba Uranga shelf lacks coral outcrops or small islands and is likely to be shifting silts and sands. Off the southern delta, the nearshore shelves more steeply and the equivalent area of less than 10m depth is much closer inshore, within 3 km of the beaches of Jaja and Mbwera. Many smaller islands and coral reefs exist in the Mafia Channel, though most of these are associated with the Districts of Mafia and Kilwa. Simaya Island and the reefs off Pombwe are the few exceptions.

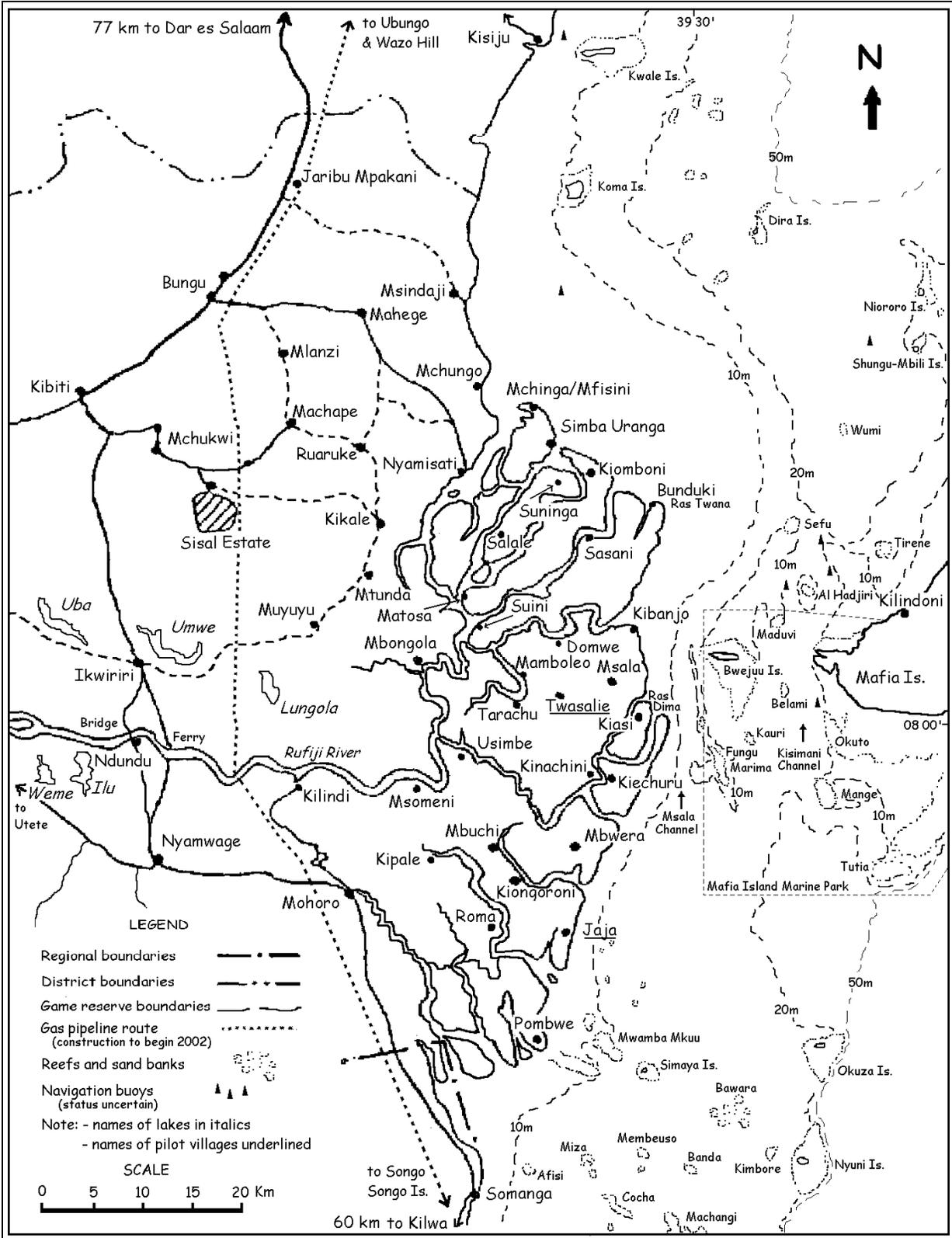


Figure 4: Rufiji Delta and Mafia Channel.

3.2 Socio-Economic Profile

The study area includes 52 villages and a population of about 100,000, of which about 53% live in the main floodplain area and about 36% live in the 36 villages of the delta (Turpie, 2000). The majority of the population are of the Wandengereko ethnic group, though several other groups are also represented, and Islam is widely adopted (Mbiha & Senkondo, 2001a).

Agriculture and fisheries are the predominant activities, with fisheries being more important in the delta than the floodplain (e.g. Hopson, 1979; Mwalyosi, 1986; Sørensen, 1998; Hogan *et al.*, 2000). Turpie (2000) found that fisheries in the floodplain was a close second to production of crops, but in the delta fisheries provided the greatest contribution to incomes by over ten times the nearest activity of wood production. Other household income-generating activities are also described by Turpie (2000) and in general, most households are poor, with annual incomes generally below 500,000 Tsh (Hogan *et al.*, 2000). At present, tourism activities are mostly restricted to four lodges in the Selous Game Reserve, providing very little involvement of the wider District, though the relatively large village of Mloka has benefited by its proximity to the Selous and these lodges.

In general, the Rufiji District lacks adequate schooling (Kulindwa *et al.*, 2000), electricity supply is non-existent throughout most of it and transport relies on un-surfaced roads that are seriously affected during the wet season and even during the short rains in December. Transport across the District relies on the ferry crossing at Ndundu, notorious for its unreliability.

The future production and transportation of gas from the nearby Songo-Songo gas fields and the possibility of oil reserves within the District are likely to have social, economic and environmental repercussions on the District. For example, installation of the 232km gas pipeline from Songo Songo island to Dar es Salaam across the Rufiji District (see Fig. 4), includes a social development programme (including village electrification and micro finance credit schemes) with benefits to villages along the pipeline route (Songas, 2001). Construction of the pipeline and implementation of the village development programme with associated benefits to affected villages is expected to begin during 2002. Development of the Rufiji District is likely to receive a further boost when the road from Dar es Salaam to Kilwa is finally paved, and the bridge is completed (latest forecast being end of 2002).

The new process of national decentralisation aims to devolve authority to the District level, away from the thirty-year old regional level of government administration. This move is widely seen as a positive step towards simplifying administration, allowing districts to take full responsibility for services such as education, electricity supply and roads.

Over the last four years, the REMP initiative has surveyed the socio-economic situation of the floodplain and delta in some detail. The numerous reports forthcoming from this work form a useful background to any attempt to develop additional or novel enterprises in the area. Their activities have created particular relationships with the village administration in four “pilot villages”: Mtanza-Msona, Mbunju-Mvuleni, Twasalie and Jaja (see Hogan *et al.*, 1999, and Fig. 2).

3.3 Aquatic Resources and Biodiversity

Between the floodplain and the delta there are significant differences regarding resources, participants, gear used, season effects, production and economic importance of the various fisheries (see Sørensen, 1989; and Turpie, 2000). The basic particulars of the two biogeographic portions of the Rufiji District are summarised below.

The Floodplain Fishery

The Rufiji River and floodplain system supports over 40 species of freshwater fishes, 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 inundated by the rising flood (Hopson, 1979). It is, however, dominated by the most common species, notably the cichlids of the tilapia group including various *Oreochromis* spp. ('Kumba' and 'Perege'), *Citharinus congicus* ('Pele') and the African catfish *Clarias gariepinus* ('Kambale'), the sardine-like *Alestes* ('Ngacha', 'Beme'), *Labeo* spp. ('Ngocho') and *Bagrus* spp. (catfish, 'mbufu').

Most freshwater fishing takes place in the numerous permanent lakes of the floodplain, with very little fishing in the river. The river is populated by crocodiles and hippos, is of varying water depth and flow, and notorious for shifting banks and submerged debris (mostly uprooted trees). The preference for lake fishing is justified. The use of simple 1½ - 3" mesh gill-nets, similar to those used throughout the delta is widespread. Within the floodplain, fishing is year round, but with a strong seasonal change in effort corresponding to periods of flooding.

The annual flooding provides vital breeding habitat for fish whose populations are replenished most years. The only annual production estimate of the floodplain is 3,841 tonnes, made by Hopson in 1979, during his short study. More recently, Turpie's (2000) household surveys suggested that 5,500 tonnes of freshwater species be caught. Turpie also applied Welcomme's (1975) estimate of the mean production from 13 African floodplain fisheries (37.5kg/ha) to the Rufiji floodplain area (again, using Hopson's (1979) estimate of 1,450 km²) and obtained a value for total production of 7,500 tonnes. Other preliminary estimates suggest a much higher catch (quoting R. Hogan, *pers. comm.*). No accurate estimate for the Maximum Sustainable Yield (MSY) exists. Turpie (2000) concludes that in general the freshwater fishery may be over-extended, but not severely over-exploited. With annual floods and hence floodplain area and productivity varying from year to year, often unpredictably, establishing fisheries productivity and MSY values will be very difficult. Much more data are needed before attempts to calculate either value can be made.

Reasons for high productivity include the healthy hydrological functioning of the Rufiji system and the protected areas upstream in the Selous Game Reserve that provide a continuous supply of fish larvae and nutrients. The western area of the Selous was described by Hopson (1979) as the "Internal Delta", an area of numerous lakes, channels and marshes extending for about 40km that he considered to be important to the fisheries of the lower Rufiji. Clearly, the production of the floodplain is likely to vary between years. Much more studies are nevertheless required.

The Delta Fishery

The Rufiji River delta is Tanzania's single most important prawn producing area, accounting for about 80% of the national industrial catches (Siegel, 1986). Finfish also provide an important contribution to catches and incomes in the District. The most important prawn species are *Ferropenaeus indicus* (formerly of the genus *Penaeus*) as shown in Plate 1, *Metapenaeus monocerus*, *Penaeus semisulcatus* and *P. monodon*. Size categories exist for prawns with "white" tending to include *F. indicus* and "king" representing *P. monodon*.



Plate 1: The prawn *Ferropenaeus indicus*. One of three species that comprise the bulk of prawn catches from the Rufiji Delta.

In addition to penaeid prawns, sergestid shrimps ('uduvi') and mangrove or mud crabs (*Scylla serrata* 'kaa') are also caught in the immediate delta areas. Various marine molluscs (clams, cockles, marine snails, octopus and squid), sea cucumbers and lobsters are caught, processed and traded in the delta

region.

Fishing in the delta is year-round, with less of a marked seasonal change in catches, as fishers tend to track the changes in availability of prawns along the coast. The majority of fishers use light-weight gill-nets of mesh size 1½ - 3” (see Plate 2) though a total of 13 different gear types are used (Hogan *et al.*, 1999). Traditional traps and hooks are also still commonly used. Women use fine-meshed nets in the delta. Most fish in the study area are sold dried or smoked, except for a small proportion sold locally and prawns are sold fresh. Prawn dealers supply nets and iceboxes, and are nearly always on hand to ensure the swift export of prawns from the delta.

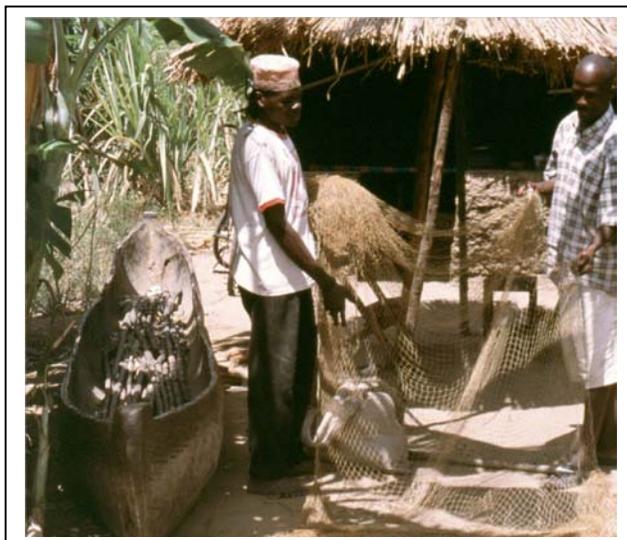


Plate 2: Fishers at Mbongola display their 2-3” mesh gill-net, with the common canoe ‘mtumbwi’ to one side.

Over 30 marine fish species have been named from the delta, and several others are also known (Hopson, 1979), though no more precise or recent figures on fish species numbers for the Rufiji Delta have been reported. In studies on bycatch of prawn trawlers, conducted in 1992 and 2001, the combined list revealed over 100 species of finfish (see Bwathondi *et al.*, 2002). Of the delta fish the most important is thought to be ‘mbarata’, the fivespot herring *Hilsa kelee*, of the sardine family Clupeidae (Plate 3). Other regularly caught finfish include *Chanos chanos* (milkfish, ‘mwatiko’), various Mugilidae spp (mulletts, ‘mkizi’), members of the Engraulidae (anchovies, ‘njonjo’), *Rachycentron canadum* (cobia, ‘songoro’), *Epinephalus* spp. (groupers, ‘chewa’), *Trichiurus lepturus* (hairtail, ‘mkonge’), *Caranx* spp. (trevallies, ‘kolekole’), *Anguilla* spp. (eels, ‘mkunga’), *Scomberoides* spp. (queenfish, ‘pandu’), *Arius* spp. (sea catfish, ‘hongwe’), *Hemiramphus* spp. (halfbeaks, ‘msusa’), *Upeneus* spp. (goatfishes, ‘mkundalji’), Belonidae spp. (needlefish, ‘ngarara’), *Sphyaena* spp. (barracuda, ‘mzia’), *Carcharhinus* spp. (sharks, ‘papa’) and rays (‘nyenga’ and ‘taa’). Coral reef species are generally less abundant in the immediate vicinity of the delta due to the absence of suitable habitat.

The delta artisanal finfish fishery is estimated at producing between 1,800 tonnes (Mwalyosi, 1986) and 4,500 tonnes and the artisanal prawn fishery is reported to catch in the order of 2,200 tonnes per year (Hogan *et al.*, 2001). However, no reliable fisheries data is known to exist that would help confirm any estimates from this sector. Bwathondi & Mwaya (1984) reported that the artisanal prawn catches, using traditional gears, contributed more than 50% of the total catches, for which documented evidence has been provided more recently (Autrand & Carles, 1996). In addition to prawns and finfish, at least 113 tons of shrimps and 34 tons of crabs are caught. No figures are available for the harvest or value of the other invertebrate resources, though given the physical features of the delta, it seems likely that the contribution to the economy of the District made by these other marine resources is small.



Plate 3: The five spot herring *Hilsa kelee* or ‘mbarata’. An important marine species caught in the delta and mostly smoked (as shown).

Depending on the product, markets range from local (within Rufiji), to Dar es Salaam, Lindi, Mtwara, Zanzibar, Mafia and overseas including Europe, Singapore, China and Japan. The characteristics of the markets and the quantities of the various products that leave Rufiji for these markets are not documented. However, the trading system for prawns are documented to some extent, because of formal interest in the revenue from trade, but there is little information about the finfish trade. Some women are involved in the fish trade, but they are not usually local women. The fishery licensing regulations do not pretend to limit the number of artisanal fishers and are largely ignored, thus an “open access” situation exists. Some fish traders pay licence fees and also pay proportional levies to village, ward and district revenue collectors.

In 1986, there were thought to be 200 fishers in the delta, mainly using canoes (Mwalyosi, 1986). More recently, there are an estimated 1,500 canoes being used in the prawn fishery (Sørensen, 1998), implying a minimum of 3,000 fishers. However, Sørensen also quotes an earlier figure from Fottland & Sørensen (1996) where “at least 7,000 fishermen are estimated to be working in primary fishing activities in the delta at any time”. In 2001, a catch survey, using trained village recorders, was attempted in the delta and floodplain by the District Fisheries staff and REMP. Intended to cover the wet and dry seasons it should have covered March to through August, however its organisation was fraught with difficulties and finally data were collected for about 3 months (mid May to mid August 2000). The results reveal that there were 441 fishers, using 207 canoes, 10 out-rigger canoes and 2 ‘boats’ (Division of Fisheries, *pers comm.*). The discrepancies in the various estimates reflect the difficulty in establishing an accurate figure for the number of fishers in the Rufiji Delta. Not only is there very little known about the identity of the artisanal fishers, but the situation is further confounded by the fact that visiting fishermen from other areas move to the delta during times of the best prawn fishing (see Sørensen, 1998).

Biodiversity Status

In 2001 the mangrove environment of the Rufiji Delta was identified by WWF and others as one of eight areas of global biodiversity importance within the Eastern African Marine Ecoregion, one of about ten marine ecoregions identified on earth. As such this area should be the focus of attempts to preserve its biodiversity integrity and status.

4 Processing and Marketing of Fishery Products

The marketing of marine products in the Rufiji Delta and floodplain is generally of similar structure to that other small-scale fisheries on the East African coast: it is characterised by a large number of product-specialised intermediaries with detailed knowledge of particular products and particular markets (see Wilson *et al.*, 1996a). The relationships between traders of different levels and between traders and fishers are generally intricate and bonding, the latter improving security of supply for the trader and ensuring both a market and a source of inputs for the fisher. It is important to note that although this may be viewed as exploitative, it is based on a level of symbiosis.

As described in the previous section, the two main fishery products marketed from the Rufiji District are finfish (both from freshwater and marine sources) and marine prawns. The commercial networks for finfish and prawns are however very different. The prawn fishery supplies an export market via a capitalised structure, while the finfish fishery supplies an extensive domestic market, characterised by low individual buying power. Both of these are described in more detail below.

Other fishery products of note from the District include octopus, sea cucumbers, lobsters, freshwater shrimps, marine sergestid shrimps and mud crabs. Though the contribution made by these products at present is marginal by comparison to the prawn and finfish trade, a brief analysis of the processing and marketing features of each is provided. A short description of the small-scale trade in shells of certain marine snails and bivalve molluscs is provided in section 5.6.

4.1 Finfish

The freshwater finfish from the District, dominated by tilapia and catfishes, are mostly traded in smoked form. Salted, fried and fresh produce is less commonly traded (see Box 1). Similarly, marine and brackish water finfish are found fresh only very rarely, at local consumer markets away from coastal villages, and in general all finfish are salted and/or sun-dried. The notable exception is ‘mbarata’ that is most commonly smoked.

Box 1. A note on fresh finfish

Finfish from the delta and floodplain is invariably traded without ice, and transported in woven baskets, usually with some form of foliage as cover. Transportation may be on foot, by bicycle, canoe, and for longer distances by local bus or other motorised vehicle. Tilapia is often cleaned (gutted) before sale. If fresh fish is not sold within 12 or so hours it will be processed by either smoking, salting / drying or frying. Both fishers and traders will attempt to sell fish fresh as a first resort, and only that which either cannot be sold fresh by the end of the day, or for which there is no perceived accessible fresh market, will be processed. Few bulk buyers for fresh freshwater finfish exist. One Dar es Salaam buyer (DAOCEAN) provided ice and purchased 500-1,000 kg twice a month from Mbongola. The product was thought to be for export, but the operation ceased after a year.

There is no set pattern as to who will process fish, the allocation of the task being more determined by on the day availability of fish and buyers. If the fisher fails to find a buyer then processing of the catch will be undertaken. A trader of processed fish however may buy either fish ready processed by the fisher or fresh fish and undertake the processing. In the latter case, the trader may carry out the work or it may be subcontracted out to a specialised smoker (‘mchomaji’). Such persons tend to only operate in fishing camps and villages where fish is consistently produced in larger quantities.

In particular markets, such as that at the Ndundu ferry crossing and even Ikwiriri, marine demersal fish are found fried, ready for immediate consumption. Fresh-water finfish from other regions is also found

in some markets in the district, including the sun-dried (without salt), small, sardine-like ‘daga’ from Lake Victoria and Lake Tanganyika (found at Kibiti, Ikwiri and Utete markets).

4.1.1 Processing Finfish

Salted and dried finfish

The technique used for salting and drying fish varies with the size and type of fish. Smaller fish may be sun-dried on raised racks or simple ground mats, sometimes without salting (Plate 4). Should they be salted, a dry salting technique is used and fish are kept packed in layers of fish and salt in a woven bag, prior to sun-drying. Larger fish will be split open, cleaned and individually salted, and then sun-dried (Plate 5).



Plate 4: Close-up of sun-dried small fish on Jaja, Rufiji Delta. These fish are washed-up bycatch discarded by industrial prawn trawlers (Nov 2001).



Plate 5: Split, salted and dried barracuda, Kibanjo, Rufiji Delta.

Smoked finfish

The smoking of fish is done using simple table kilns, often open at all sides. Temporary kilns tend to have no protection whatsoever (Plate 6). Permanent and seasonal kilns tend to be protected with ‘makuti’ (palm-thatch) roof and walls, offering basic protection from the elements but still allowing smoke to diffuse within the hut (Plate 7). The table and structure are often constructed from mangrove poles. The smoking process takes 3-6 hours depending upon the size and species of fish and the atmospheric conditions. Thicker fatty fish, such as large catfish may require 2-3 days of intermittent smoking before the flesh is cured.



Plate 6: Temporary smoking kiln with three African catfish ‘kambale’, Mbunju, central floodplains.



Plate 7: Traditional smoking kiln, Kibanjo. Note the green plastic sheeting used here to help reduce smoke loss and improve weather proofing.

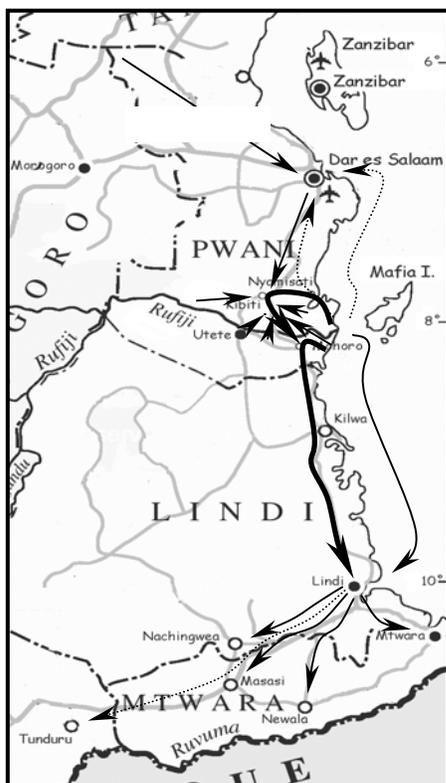
4.1.2 Transport and Markets for Finfish

The transport of smoked and dried fish from the delta inevitably starts on the water. The product may go directly to the destination region (Dar es Salaam to the north or Lindi to the south) by sea on a ‘mashua’². More often (roads permitting), travel continues from the landing station to a point where reliable road transport can be found, usually Mohoro from the southern delta, or Nyamisati from the northern delta (see Fig 4, page 12). To get to these ports fish will inevitably be taken by hired canoe. From the coastal village of Jaja to Mohoro the journey requires an overnight stop. Once at one of the ports, smaller-sized fish tend to be taken south to the markets of Lindi, Masasi and Newala (Fig. 5a), whilst larger fish (especially salted & sun-dried) will go north to Dar es Salaam (Fig. 5b). Larger smoked fish can be taken either north or south of Tanzania. Traders explained that this was simply because of market preference, and larger fish were difficult and slow to sell in the south. It is considered that this is actually due to a combination of factors. Firstly, there is a much greater purchasing power of the urban market in Dar es Salaam. Secondly, there are regularly abundant local supplies in Dar es Salaam of small sized, fresh, fish (especially when sardine boats are operating) and thirdly, the local production of larger dried fish in the south, mostly from ‘jarife’ gill-net fishers making monthly trips to northern Mozambique.

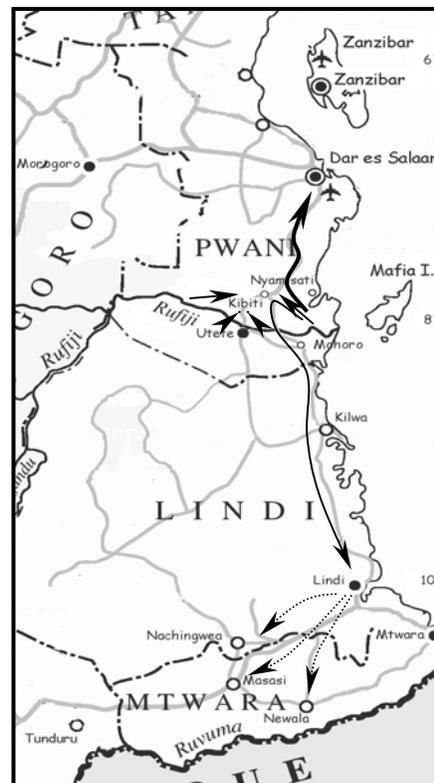
From the floodplain, the relatively better transport network makes it possible for smaller scale traders to enter the market and fish can be taken from the fishing camps and lakeside landing sites by bicycle. It should be noted that this scale of activity is not possible in the more remote parts of the delta. “Bicycle” traders may either cycle the entire way to the market, or go as far as the main road and then catch a bus. On many occasions, such traders hire bicycles for the journey. Fish from the floodplain

² ‘mashua’ is a small sailing or motorised wooden dhow, usually 8-12m length.

may also travel to market in greater quantities, transported by wholesalers who spend some time in the fishing camps amassing larger ‘tenga’³. From the inland lakes, the focus markets are those of Ikwiriri, Kibiti and others on the Dar es Salaam road. During times of higher production (October – April) the product reaches Dar es Salaam.



Distribution of smaller fish, mostly smoked five-spot herring ('mbarata').



Distribution of larger fish, mostly smoked tilapia and larger catfish

Figure 5

4.1.3 Distribution Networks for Finfish

The distribution of finfish is conducted through a network of intermediaries, spread between the landing sites (fishing villages or camps), intermediate and retail markets. The distribution chains are many and varied. Figure 6 below illustrates some of the routes identified, showing not only who sells to whom, but also where that sale takes place.

Generally, the smaller the amount purchased, the shorter the distance that traders will take the product before selling. Traders taking fish to Lindi and beyond will therefore invariably take large quantities (up to 30,000 ‘mbarata’ in a single ‘tenga’), whilst bicycle traders from the lakes in the low season will only go to local markets. The major intermediate market (where fish is sold on in bulk to a trader who will take it further afield) for small smoked finfish is Lindi, and for larger fish Dar es Salaam. Lesser intermediate markets and the principle retail markets are on the main Dar es Salaam road and include Ikwiriri, Kibiti, Bungu and Kimanzechana, serving both consumers and short distance traders. Traders planning to buy fish to be subsequently transported long distances will always go as near as possible to the source to make the initial purchases.

³ ‘tenga’ is a transportation basket for dried or smoked fish. These vary in weight from tens to several hundred kg.

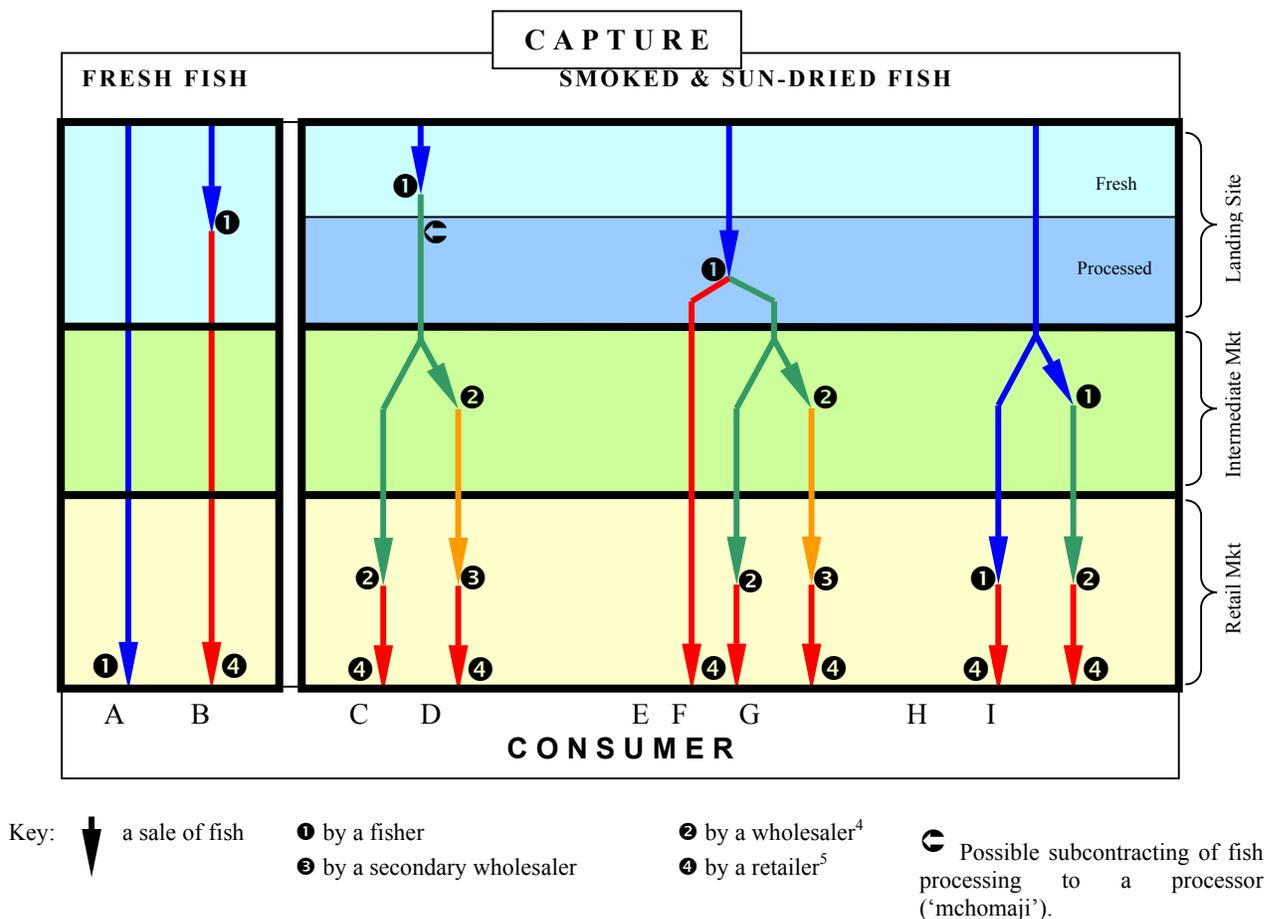


Figure 6 Processed finfish-trading chart for the Rufiji District, Tanzania.

Summary of Network Options

It is important to note that a fisher may be involved in any of the routes (A - I) identified in Fig. 6. Reasons for this are related to season, time of day, weather, condition of the roads, etc.

Fresh Fish

Route A is the only occasion whereby a fisher will sell directly to a consumer. This can be achieved either at the landing station or when the retail market is geographically close by, such as Ikwiriri from Lake Umwe. In the trading of fresh fish there is usually one intermediary, (the retailer) who travels to the landing station, rather than the fisher coming to the market. The latter case is demonstrated by route B.

Fish for frying and direct sale will often be purchased fresh in the market where it will be retailed. Fryers may buy from fishers or other intermediaries. Possibly due to social pressure, younger women fryers not to travel extensively.

Processed Fish - Option 1: fisher sells catch on the coast

Along routes C and D the fisher sells his fish fresh, but this is processed prior to reaching the market.

⁴ a wholesaler is defined as one who buys fish and sells on to a trader rather than a consumer. Sales are usually made in bulk, either by weight or larger volumes ('tenga'). Note that there may be many different scales of wholesaler.

⁵ a retailer is defined as a trader who sells directly to the final consumer.

The most common distribution routes for smoked fish are C and F, where the retailer conducts all of his business in his home market, leaving travelling and transport of goods to the wholesaler(s). When fish is sold fresh but needing processing (C and D), the buyer may subcontract the smoking to a processor. When the fish is sold by the fisher already processed (E, F and G), it may be purchased by a trader taking it directly for retail (route E). This is only likely with ready-processed fish, as the retailer is normally market-based and will be keen to spend as little time as possible at the landing site purchasing or processing product. Fishers tend to seek routes C and D, i.e. that where the fish is sold without any processing by the fisher. Routes E, F and G are more typical of landing stations which do not have many traders present, obliging the fisher to process and store.

Processed Fish – Option 2: fisher travels to market to sell catch

The routes H and I demonstrate example when a fisher travels with his fish to either an intermediate market or a retail market. Fishers do generally not favour this as it implies absence from the fishery. It can however be used when the fisher has a specific purchase to make (such as nets), in which case product will be stored and saved and taken to be sold as close to the consumer as possible. The route can also be used in fisheries that are highly influenced by lunar or tidal phases, the fisher making use of the period unfavourable for fishing to travel and sell his product. This was noted with ‘jarife’ (large mesh gill-net) fishers in the southern delta. A fisher may also be forced to travel with product when no buyer comes to the landing station or fishing camp.

Summary of Participants

Fishers

Marine fishers of ‘mbarata’ are often the same persons who fish for prawn and are described in more detail in section 4.2.2. ‘Mbarata’ is both caught as bycatch and specifically targeted when conditions are not favourable for fishing for prawns. Fishers for ‘mbarata’ are generally owner-operators of fishing gear and vessels. Should a fisher not have a canoe, it is quite normal to hire one on a daily basis.

Although the fishers of larger neritic fish species are numerically fewer as mentioned above, they are of interest due to the difference in social and capital structure of the fishery. The gear is much heavier and bulkier than smaller mesh gill-nets, requiring a higher level of investment, a larger more seaworthy vessel and more crew. As a result of this many ‘jarife’ gill-nets and their vessels are owned by individuals, and fishers will be share workers, owning no part of the productive assets.

Floodplain fishers are less permanently committed to fishing, with agriculture playing a more important part in the annual cycle of economic activities. This is without doubt heavily influenced by significant seasonal fluctuations in floodplain fish resources.

Processors

Processors are only reported in larger coastal fishing camps and fishing villages, where consistently large landings are observed. Such larger quantities are invariably ‘mbarata’ and hence processors are dedicated to smoking rather than sun-drying. Marine processors charge on a per fish basis, and may also be involved in fishing activities. In the floodplain, fishers tend to process their own catch, though it is considered probable that during periods of high catches some sub-contracting of processing will occur.

Wholesale Traders

Wholesalers are both dynamic and mobile, travelling between retail markets and fish landing sites. They are responsible for the wider distribution of fish and, at times, the capitalisation of the fishery through loans and equipment-based bonds with fishers. The scale of activity of wholesale traders varies from someone who works independently, transporting one small ‘tenga’ (a volume of 0.12 – 0.15 m³)

by bicycle to those working with permanent assistants and transporting several large ‘tenga’, whose total weight may exceed 1 tonne, by truck. Although mobile, wholesalers will choose their destination markets with care, on the basis of prior experience, family or personal contacts (to reduce accommodation and storage costs), transport costs and reliability and second hand market information from colleagues. Individuals tend to dominate certain routes and certain products, seldom choosing to diversify and experiment with either new locations or new products. This is due in part to the importance of personal links with either the source or the market and the tendency to make bonds with fishers, who themselves tend to be specialised. Wholesalers encountered during this study were committed to the trade all year round and did not spend a period of the year farming. In the delta they were exclusively male, although women wholesalers were met in Kariakoo market, Dar es Salaam. The ability of women to participate in trading which requiring extensive travel is often limited (see detailed analysis by Bowen, 2000).

Retail Traders

Retail traders are considerably less mobile than wholesalers, preferring to both buy from wholesalers and sell to consumers in the same market place. This is particularly the case in markets frequented by wholesalers such as Kibiti, Bungu and others along the Dar es Salaam road. In Ikwiriri however, retailers appeared to be much more accustomed to travelling to collect product in the fishing camps (route E in Fig. 6). Retailers tend to buy bulk volume each time and sell the product as individual fish or in small piles, in keeping with individual sizes.

Whilst retailers and wholesalers of smoked, dried and fresh finfish are men, women dominate the processing and selling of fried fish. This and the fishing of ‘uduvi’ are the only occasions where women are seen participating regularly in fishing and fish trading. Fried fish sellers tend to be specialised, selling nothing else apart from fried fish, and often confined to a physically different part of the market. These fryer-vendors will purchase the fresh product, collect (or in urban environments buy) fuel-wood, processes the fish and then sell it on to consumers.

4.1.4 Price Structure for Finfish Trade

The price structure of the main processed products (smoked tilapia and ‘mbarata’) for the local and distant markets are shown in Tables 1-3. Each table shows the composition of price for the intermediaries involved. The pie charts illustrate the overall composition of the consumer price for each product. The average prices shown in these tables hide very large variability. It must be noted that market prices showed not only very large variations between sellers in any one market, but also rapid short term fluctuations as suppliers came and went.

Wholesaler		Retailer	
Quantity/# (no. fish/lot purchased)	600	Quantity purchased	600
Days to sell all fish	2	Days to sell all	10
Transport per person (Tsh)	2500		
Transport costs for goods =Tenga (Tsh)	1500		
District Tax (Tsh)	na	District Tax/day (Tsh)	100
Market costs (Tsh)	na	Table Hire/day (Tsh)	200
		Mkt Tax/day (Tsh)	10
Annual licence (Tsh)	2800	Annual licence (Tsh)	6000
No. cycles/yr	20	Cycles/Yr	15
Physical losses - damaged	5%	Damaged	15%
Financial losses - value of that damaged	50%	Loss of value of that damaged	70%

Table 1a Components of trading of tilapia (‘kumba’) for local markets.

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Wholesaler		Retailer	
<i>Expenditure</i>		<i>Expenditure</i>	
Purchase	70 Floodplain	Purchase	110 Kibiti
Transport	10.8	Transport	-
Annual License	0.2	Annual License	0.7
District Tax	0.3	District Tax	1.7
Market Tax	0.0	Market Tax	0.2
Table Hire	-	Table Hire	3.3
Losses	2.8	Losses	21.0
<i>Income</i>		<i>Income</i>	
Sell	110 Kibiti	Sell	200 Kibiti
<i>Margin</i>	26 Tsh/fish	<i>Margin</i>	63 Tsh/fish
<i>Net Annual Income</i>	309,800 Tsh	<i>Net Annual Income</i>	568,500 Tsh

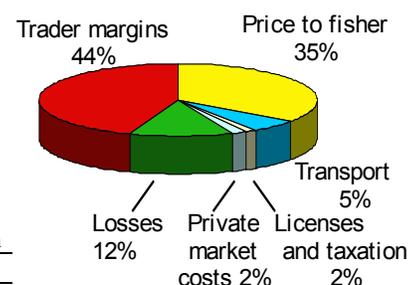


Table 1b Price composition for tilapia ('Kumba') at the local markets.

The tables draw upon information obtained from particular traders and illustrate the structure of costs and prices. It remains important to recognise that the prices are very dynamic and the nature of the present study only permitted a limited analysis. Attempt has been made to estimate the fish trader's annual net income, based upon stated commitment to the business and estimated net income per trip. Although some margins may appear excessive, such as that of the retailer in Table 1b, the total income remains not far above subsistence level.

Wholesaler		Retailer	
Quantity/# (no. fish/lot purchased)	30,000	Quantity purchased	30,000
Days to sell all fish	7	Days to sell all	10
Transport per person (Tsh)	2,500		
Transport costs for goods =Tenga (Tsh)	1,500		
Village Tax/tenga (Tsh)	300	District Tax/day (Tsh)	100
District Tax/tenga (Tsh)	3,000	Table Hire/day (Tsh)	200
		Mkt Tax/day (Tsh)	10
Annual licence (Tsh)	2,800	Annual licence (Tsh)	6,000
No. cycles/yr	20	Cycles/Yr	15
Physical losses - damaged	5%	Damaged	15%
Financial losses - value of that damaged	50%	Loss of value of that damaged	70%

Table 2a Components of trading of 'mbarata' for local markets.

Wholesaler		Retailer	
<i>Expenditure</i>		<i>Expenditure</i>	
Purchase	7 Kibanjo	Purchase	11 Kibiti
Smoking	1.5	Transport	-
Transport	0.2	Annual License	0.0
Annual License	0.0	District Tax	0.0
District & Village Tax	0.1	Market Tax	0.0
Market Tax	0.0	Table Hire	0.1
Table Hire	-	Losses	1.1
Losses	0.3		
<i>Income</i>		<i>Income</i>	
Sell	11 Kibiti	Sell	15 Kibiti
<i>Margin</i>	2 Tsh/fish	<i>Margin</i>	3 Tsh/fish
<i>Net Annual Income</i>	1,134,800 Tsh	<i>Net Annual Income</i>	1,275,000 Tsh

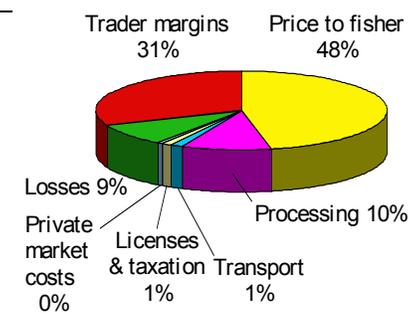


Table 2b Price composition for five-spot herring (Hilsa kelee, 'mbarata') at local markets.

Tables 2 and 3 show the price composition for the trading of 'mbarata', for local markets (on the Dar es Salaam road) and distant markets (e.g. in the south of Tanzania). As expected transport plays a more significant part in the consumer price as distance increases.

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Wholesaler		Retailer	
Quantity/# (no. fish/lot purchased)	30,000	Quantity purchased	10,000
Days to sell all fish	7	Days to sell all	20
Transport per person (Tsh)	8,000	Transport per person (Tsh)	12,000
Transport costs for goods =Tenga (Tsh)	15,000	Transport costs for goods =Tenga (Tsh)	20,000
Village Tax/tenga (Tsh)	300	District Tax/day (Tsh)	100
District Tax/tenga (Tsh)	3,000	Table Hire/day (Tsh)	200
		Mkt Tax/day (Tsh)	10
Annual licence (Tsh)	2,800	Annual licence (Tsh)	6,000
No. cycles/yr	6	Cycles/Yr	10
Physical losses - damaged	5%	Damaged	15%
Financial losses - value of that damaged	50%	Loss of value of that damaged	70%

Table 3a Components of trading of five-spot herring (*Hilsa kelee*, ‘mbarata’) at distant markets.

Wholesaler		Retailer	
<i>Expenditure</i>		<i>Expenditure</i>	
Purchase	7 Kibanjo	Purchase	16 Lindi
Smoking	1.5		
Transport	1.0	Transport	4.4
Annual License	0.0	Annual License	0.1
District & Village Tax	0.1	District Tax	0.2
Mkt Tax	0.0	Market Tax	0.0
Table Hire	-	Table Hire	0.2
Losses	0.4	Losses	3.7
<i>Income</i>		<i>Income</i>	
Sell	16 Lindi	Sell	35 Masasi
<i>Margin</i>	7 Tsh/fish	<i>Margin</i>	15 Tsh/fish
<i>Net Annual Income</i>	1,302,120 Tsh	<i>Net Annual Income</i>	1,044,500 Tsh

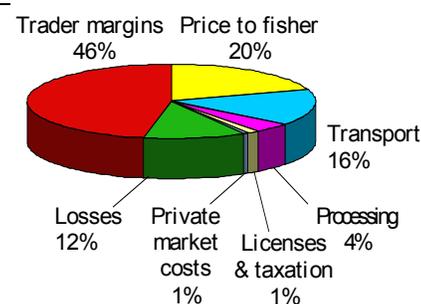


Table 3b Price composition for five-spot herring (*Hilsa kelee*, ‘mbarata’) at distant markets.

From Table 3a it can be noted that there is a higher level of damage of the product (in this case smoked ‘mbarata’) at the retail level (due to distance), slower retail turnover and break of bulk when wholesaler sells.

In all of the above examples the lack of weight of taxation in the final price is perhaps surprising, especially in the light of many complaints about the tax structure. It is considered that the current level of local taxation of the trade is not excessive, but the system is prone to both evasion by traders and double taxation by local authorities.

4.1.5 Losses in Finfish Trade

Finfish losses can be divided into two, those that occur due to poor processing and those from post-processing. There is clearly a link between the two, with poorly processed fish being more susceptible to spoilage and damage than better-processed fish.

Processing Losses

Losses in processing are economic in nature rather than physical and are due entirely to quality control issues during processing. Buyers of processed fish discriminate between well and poorly smoked fish, the latter being valued at around only 60% of the good quality product (4 Tsh rather than 7 Tsh in the case of ‘mbarata’). Before paying, the buyer sorts all the fish into two classifications based on aspect (especially if the fish looks either burnt or un-smoked), dryness, physical condition and size. During the course of this study, it was not possible to establish how widespread the practise is in the delta area, nor to estimate with confidence the “normal” proportion of fish falling into each category. On the occasions when sorting was witnessed, about 25% of the fish fell into the lower value category,

representing a total loss of value of product of around 10%. The loss due to poor processing quality falls to the owner of the fish whilst it is being processed – often the fisher.

Post-Processing Losses

Physical losses once finfish have been processed may be due to a variety of factors:

- Moisture – either due to low drying of the fish during processing or contact with rain / sea water. Moisture will result in the affected fish rotting and having no market value for human consumption;
- Fragmentation – this will occur whenever fish is packed and transported, and results in the fish losing value but not being totally lost (the fragments are sold);
- Infestation – both smoked and salted fish are prone to infestation by the *Demestes* beetle (and its furry larval stage) and fly maggots. The latter tends to be worse when product has a high moisture content. Beetle infestation in dry fish will result in accelerated fragmentation. Both infestations result in lower product value, and ultimately total loss of value.

The incidences of post-processing losses are almost entirely borne by traders. The fisher usually does not retain fish for long enough to be affected by infestation, and he usually aims to avoid travelling to sell product, hence moisture and fragmentation do not affect him. Discussions with traders revealed that reduced losses would result in them having more product to sell at the normal price, i.e. in the charts alongside Table 1 - Table 3, reduction in these losses would result in an expansion of the trader's margin, rather than any reduction in consumer price.

Traders estimated the degree of post-processing losses to be up to 10%, i.e. up to 10% of the product was damaged or spoiled. In many cases however reported losses were much less than this (<3%). The spoiled product was invariably sold, at 50%-30% of the normal value. Losses depended largely on factors that they considered beyond their control such as handling during transport and the weather. It is interesting to note that none of the traders contacted raised the issue of *Demestes* infestation without prompting.

4.2 Prawns

The marketing of prawns is divided between that for the national market and that for either export or premium urban markets. Export markets are mostly supplied by production from the 20 industrial prawn trawlers licensed in Tanzania, all of which complete processing activities on board. However there is also a developed network of collection of prawn from the small-scale fishery in the delta. These account for about 50% of total production of prawns from the delta area (as described in section 3 and 6). Size categories for prawns purchased from the artisanal sector are: 'white' (60-100/kg), 'king' (25-60/kg) and 'jumbo' (up to 25/kg), each which with its own price range. Prawns that fail to enter that market will be smoked for the national market.

Production of prawns is dominated by *Ferropenaeus indicus* and *Penaeus monodon* all of which, when destined for the export market, are sold fresh to traders with ice. Some prawns may not enter the export market route due to small size, low quality or the absence of a trader with ice and these will be smoke-dried using the same kilns as those described above.

4.2.1 Transport and Markets for Prawns

Transport of prawns is made by sea and land routes. From the delta, most prawns from the artisanal sector is collected by ice-carrying collector vessels and taken to the Tanpesca processing barge (W Mafia). From there it is sorted, frozen, packed and shipped to Dar es Salaam for export (Fig. 7). The ice-carrying collector vessels will also make the journey to Dar es Salaam, which facilitates the replenishment of ice but may result in lower quality prawn.

Some fresh prawn is also taken out by road, going from the fishing camps to Nyamisati by ice-carrying boat and from there to Dar es Salaam by truck. A significantly smaller quantity of prawns leave the delta by more precarious means, being taken by individual small scale traders travelling by canoe with insulated ice boxes. From the southern delta, such traders would leave via Mohoro to Dar es Salaam, and from the northern delta via Nyamisati.

4.2.2 Distribution Networks for Prawns

The distribution mechanism for fresh prawns has several specialised intermediaries. Obligation and bonding is very prevalent as buyers vie for consistent supply, fishers attempt to secure inputs and both minimise capital investment. A generalised schematic illustration of the organisation of prawn collection for export is presented in Figure 8.



Figure 7: Map of prawn distribution network from the Rufiji.

Fishers supply prawns via local agents ('wakala') who are based in the fishers' villages and camps. The agents are as mobile as the fishers themselves and will move between fishing areas with "their" suppliers. The local agent deals directly between the fishers and a collector, who will operate a motorised ice carrying collector vessel or (less often) an insulated truck. The function of the local agent is to facilitate the work of the collector who, often being both external to the community and only periodically present, would find it difficult to establish and maintain the necessary links with the fishers to secure supply. In addition to this, when working in a village or camp, the collector need only work with a few agents rather than many fishers. The more perishable the product, the more important it will be for the collector to conduct his business quickly and efficiently, and the greater the need for a local agent. Although the fisher might want to deal directly with the collector in the hope of obtaining a better price, both the agent and the collector will strive to avoid this.

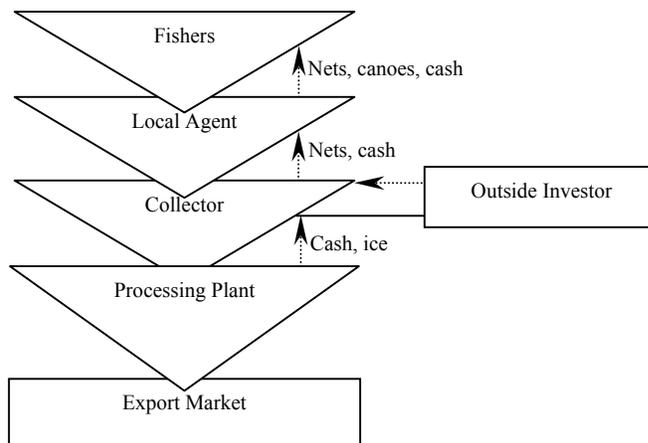


Figure 8: Prawn trading diagram.

The structure of the trading network is such that a local agent will deal with many fishers but only one

collector. Likewise, a collector will have links to many local agents but only one processing plant. The processing plant will deal with many collector vessels, but even this is further simplified as key negotiations are made with owners (outside investors), who may own more than one vessel.

Summary of Participants

Fishers

Prawn fishers met were exclusively male and involved full-time with the fishery. Fishers all acknowledged having access to a 'mashamba' (farming plot) and some divide the year between fishing and farming, principally rice cultivation. None of those encountered during the visits reported that they themselves abandoned fishing for prawns completely for a period in favour of agriculture. A regular bycatch of five spot herring ('mbarata'), most for smoking, supplements the catch of the gill-net fishers. Effort varies within the month according to the tidal phase, with most fishing occurring over neap tides. Some of the fishers are migratory, choosing to fish in the south of the delta during the NE monsoon ('Kaskazi'), and in the north of the delta during the SE monsoon ('Kusi') (see section 6.1). Prawn fishers work in two's from a dugout canoe, each taking an equal share of the catch, but with account being made for ownership of the net and the canoe. These are each considered of equivalent value.

Agents

Agents are internal to the fishing community, having normally started out as fishers themselves. They participate in the same seasonal movement as fishers, following those with whom they have formed a bond. Although the step from fisher to agents is generally perceived as a progressive one, agents appeared less committed to the fishery than fishers. For example, some agents from the southern delta reported that during the SE monsoon (June – November), when catches were generally lower, they might leave the fishery in favour of agriculture.

Collectors

Collectors are a step removed from the fishing communities, and are full time employees of an external investor. Although they have a certain degree of autonomy as to how business is conducted in the field, important decisions are determined by the external investor (such as to whom they should sell their product). As employees, they do not divide their time between fishery-related activities and any other.

External Investors

External investors, owners of collector vessels, were reported to be urban business persons. To the processors, these are the *de facto* suppliers of raw material, and it is with these 'tajiri' that prices are negotiated. Processors appear to buy from different suppliers at different prices, presumably reflecting varying negotiating skills, and capital, relations and scale.

Processors

The processing and exporting companies are all based in Dar es Salaam. There are reportedly eight such companies, all taking prawn from the small-scale fishery in the Rufiji Delta. The companies have sorting, grading, freezing and cold storage facilities as well as a supply of ice. To operate in this business requires significant amounts of capital, not only for investment in infrastructure and equipment but also for working funds. Cash flow control is particularly difficult as money is tied into pre-financing the supply of raw material, the processed prawn in storage and transit, and that delivered but not yet paid for. Processors will therefore tend to be established business persons, with access to significant capital resources. Those sending product to the European market have to conform to rigorous international hygiene standards and quality control methods (HACCP).

The most important buyer at present, Tanpesca, has a processing barge stationed off Kilindoni, western Mafia, equipped with ice, freezing and storage capacity, thus significantly reducing the journey time

for their suppliers. The company is currently renovating the old Hellas processing plant in Kilindoni and building a long jetty. Once these are completed the barge will not be required off Mafia and all products will be processed ashore, with the ice-boats bringing the product from the fishermen camps and landing sites in the delta.

There used to be a processing plant at Nyamisati that purchased prawns and sold ice to fishers and traders. The African Fishing Company bought the plant, but since the latter enterprise has ceased operations, the plant has fallen into disrepair and no longer functions.

Bonds and Links

The bonds between the trading levels are summarised in Table 4. In all cases, the link is made in return for exclusivity of supply. The most remarkable feature of the capital structure of the market for prawn is that the buying is totally pre-financed by the processing plants, with neither the intermediaries nor the external investor making any significant investments of their own in day to day operating capital.

Intermediaries	Bond Items	Notes
Processor – Collector	Working capital, Ice	Negotiated through the external investor, owner of collector vessel(s).
Collector - Agent	Working capital, Nets, (Ice)	Some equipment (nets) may be financed by the external investor. Working Capital is that supplied by the processing plant.
Agent - Fisher	Nets, Canoe, Cash advances	All financed by money from the collector

Table 4: Summary of bonds and links associated with the trade in prawns.

Exclusivity of supply is considered binding only when the buyer is actually able to purchase. An agent will be free to use “his” fishers to supply another collector should the collector to whom he is tied be absent and not have left any deposit facility (such as an insulated box with ice). It should be noted that the perishability of prawns and low value of smoked prawns (see section 4.2.4) often results in fishers not going fishing at all should there be no collector present at the landing station.

4.2.3 Price Structure for Prawn Trade

As stated above, the average values conceal considerable variation in the collected data. Typical sequences of selling prices for fresh prawns are shown in Table 5.

“White”	Tsh/kg	“King”	Tsh/kg
Fisher	1,200	Fisher	5,000
Local agent	1,400	Local agent	5,400
Wholesaler (to Mafia based barge)	2,500	Wholesaler (to Mafia based barge)	6,500
		Wholesaler (to Dar es Salaam)	10,000
Estimated export value (FOB ⁶)	5,000-7,000	Estimated export value	14,000

Table 5 Typical selling prices for fresh “white” and “king” prawns (see Wilson *et al.*, 1996b).

The costs incurred by the different intermediaries vary greatly. The local agent’s margin (200 Tsh/kg in the case of “white” prawn above) does not have to pay for anything except the agent’s services. The margin obtained by the wholesaler (900 Tsh/kg for “white” prawn in the case above) is taken by the external investor, owner of the collector vessel. This has to pay for the following:

⁶ FOB = Free on Board. Implies that all local costs, taxes and duties have been paid and that the goods are on board ship at the port of export.

- Vessel and iceboxes capital cost
- Investments made in making tying bonds
- Vessel operating cost
- Salary / bonus for the wholesaler
- Local taxes on the prawns

The margin extracted by the processor / exporter working with the Mafia based barge 3,500 Tsh/kg for “white” and 7,500 Tsh/kg for “king”, >100%) likewise pays for:

- Investment costs of barge, transport vessels, storage infrastructure
- Barge and transport operating costs
- Export royalty
- Prefinancing of purchasing capital
- Ice
- Investments in tying bonds
- Risk

The scope of the study did not permit a detailed analysis of the financial operations of prawn intermediaries, but from the above it is clear that the local agent extracts a considerable fee at no risk and for no investment. The margins charged by the external investor (via the wholesaler, his employee) and the processor/exporter are considered normal. It is however clear that in the case of the barge operating from Mafia, its monopoly position enables it to take a great share of the available margin between fisher and export. The price paid to the wholesaler in Dar es Salaam more than compensates for transport costs from Rufiji, and reflects a more competitive market.

4.2.4 Losses in the Prawn Trade

Losses in the marketing of prawn were reported as low, although processors commented that it continues to be difficult to create a habit of effective and consistent use of ice, especially in fishing vessels. The most significant losses to prawn fishers are market rather than processing related – in the event that there is no wholesaler present that day fishers will either not go fishing for prawn or be forced to smoke the catch. For the smoked (and dried) product fishers are paid around 950 Tsh/kg for smoked prawn - only 15-20% of the value of the same fresh product. It is not possible to quantify the degree of incidence of this “loss”, as fishers adjust their behaviour and movements to maximise the chance of having a trader present. There are times of the year when catches at particular sites are so low that it is not worthwhile for a collector to visit. The little that is landed is then inevitably smoked.

4.3 Other Products

4.3.1 Freshwater shrimps

The freshwater shrimps of the Lower Rufiji are believed to be mostly of the genus *Macrobrachium* (see section 5.5). Hopson (1979) reported these during his visit in June-August “to be caught at almost all stations”. During the present study these were not encountered, though it was reported that trade in freshwater shrimps (from the description likely to be of the genus *Macrobrachium*) does take place at 100 Tsh for pile of about 30 shrimps. Such trade was reportedly known from markets in Kikale and Mtunda, though it is not known whether the product was fresh or smoked. From the little that is known it would seem that the trade and market for freshwater shrimps is small and engages a few fishers with small-scale traders supplying a very small local market.

4.3.2 Sergestid shrimps ‘Uduvi’

The Family Sergestidae include small inshore shrimps that are fished in shallow coastal waters exclusively by women and are always sold sun-dried. Fishers process the day’s catch immediately on returning from the beach.

The marketing of ‘uduvi’ and smoked prawns is similar to that for smoked and dried fish. The perishability of the product dictates that the fishers carry out the processing and the product is stored until a buyer comes or the fisher has sufficient quantity to warrant a journey to sell at a market town. The most usual distribution mechanisms are types E and F in Fig. 6. There tend to be no fixed ties or bonds, this being confined to fresh prawn marketing.

Fishers of ‘uduvi’ are exclusively women, this being the only observed participation of women in fishing. The fishing of ‘uduvi’ is not a full time occupation as it is both seasonal (better in the wet season) and more productive at certain phases of the tide (declining spring tides). However, a day allocated to the fishery does not allow for other activities, such as agriculture, as time must also be set aside for immediate drying of the shrimp. The women fish in pairs, each getting an equal share of the catch. Catches also include a proportion of small fish and juveniles that are consumed locally and/or sold for frying.

Wholesalers and retailers of ‘uduvi’ are similar to those for smoked fish, as described in 4.1.4 above.

4.3.3 Lobsters

For the same reasons that sea cucumbers and octopus are not major contributors to the delta resource base i.e. the lack of reef environment, the fishery for lobsters is thought not to be of major importance to the Rufiji Delta villages. Reefs around Mafia however are extensively fished and sale of fresh lobster to boat traders depends on size with prices graded: A (>500g): 4,000 – 5,500 Tsh/kg; B (<500g) 1,500 Tsh/kg.

4.3.4 Mud crab *Scylla serrata* ‘Kaa tope’

The trading of mud (or mangrove) crabs in the delta area is extremely limited, but follows two generalised paths: some live crab is collected from the delta by artisanal fishers and sold to the Tanpesca barge off Mafia island for subsequent processing and export. The same intermediaries who collect shrimp also collect mud crabs. Crabs that are sold via this route fetch a price of 300 Tsh/kg at the barge, and an estimated 150-200 Tsh/kg to the producer. Individual traders also take crabs from the delta area. Such persons appear periodically in coastal communities either together with specialised teams of crab collectors or on their own searching for the product from the local community. Should they come with their own specialised team, the trader will simply camp until his order is filled. Mangrove areas with good access to roads are fished first. Such persons were not encountered during the course of this study and it was not possible to establish typical prices. Local suppliers of crab are mainly those who set and attend fixed traps in the immediate coastal area, catching crabs during their cyclic migrations from mangroves to deeper water and back. There appear to be few if any fishers in the delta coastal communities who specialise in the capture of mud crabs, this activity being more the focus in Kisiju village area to the north of the delta.

Those crabs that are caught are taken to Dar Salaam where they are cleaned and prepared for live export. Primary destination markets include Hong Kong, Singapore and Taiwan. Crab prices are based on size, and in Dar es Salaam individuals weighing less than 700g are purchased for 700 Tsh/kg and those over 700g bought for up to 1,600 Tsh/kg. Exporters describe the business as "marginal" with the Far Eastern market reported to have declined significantly in recent years. Although the fresh product price remains reasonably cheap, export royalties, packaging and freight remain expensive. In addition

to this, any mortality above an agreed level will be to the cost of the exporter. Current export prices (CIF⁷) are reported to be between US\$ 4.2-6/kg (3,780-5,400 Tsh/kg) and the cost of royalty, packaging and freight around US\$ 2.30/kg (2,070 Tsh/kg). Some sales to local restaurants and hotels, both in Dar es Salaam and on Zanzibar is undertaken by small-scale traders, though the market is also seasonal and variable.

Considering that the technology needed to capture mud crabs is neither unknown nor expensive, it is worth analysing why the industry has not developed in the delta. It is considered that whilst stocks exist around Kisiju to the north, considerably more accessible than the delta, traders will continue to source their supplies from there. The lack of other entrants into the business must either be an indication of either truly unfavourable market conditions, or a genuine lack of market information.

4.3.5 Octopus

A trader from Somanga (Kilwa District) reported that the trade in octopus was a component of the fishery of that area. Because of the general lack of reefal environments along the Rufiji coastline, it is unlikely that octopus will be caught in any numbers (see section 5.4).

The sale of the fresh product was reported as 300 Tsh/kg to the Mafia ice-boats. These supply the Tanpesca barge and the product is then exported from Dar es Salaam. A small amount is sold locally in the village and dried for local trade, but ultimately to buyers in Dar es Salaam.

4.3.6 Sea cucumbers

Fishers collect these sessile benthic echinoderms from reef areas where salinity is close to full strength sea-water much of the year. Section 5.9 describes the reasons why the delta is not likely to support vast populations of commercially sea cucumbers and why the nearby Mafia and Songo Songo reefs do provide large areas suitable for the proliferation of these invertebrates. Within the delta, a few villagers are likely to engage at least some time in this small-scale fishery.

During the present visit, a single trader of sea cucumbers was met in Somanga in the Kilwa District. Trading product brought there from collection sites around Kilwa and Kilwa Kivinje. Specimens are bought fresh or processed, but all must be processed for transport. Processed product sold by weight according to a grading system from Grade A to E, where A = 7,000-8,000 Tsh/kg and E = 2,500 Tsh/kg. Fresh specimens are sold for half the price.

Once processed (gutted and boiled) the dried product can be stock-piled for later sale to visiting buyers. There are also buyers at Kilwa Masoko. The entire product is then sold on to Dar es Salaam where there are many buyers. All sea cucumbers are exported from Dar es Salaam as a dried product, in containers shipped to the ports of Hong Kong, Taiwan, Singapore. These SE Asian ports also import dried sea cucumber from other parts of the Indo-Pacific, from Galapagos (Ecuador), to the Great Barrier Reef (Australia) and Yemen.

One problem reported by one trader was the unreliability of the Dar es Salaam buyers, with changes in their operating status, and thus problems with access to the market. Prices too are reported to vary considerably, even within one species over time, responding to variations in supplies from other parts of the tropics. The demand is therefore variable, both in volumes, species preference and prices. This flux in the market extends to the markets for the product in Dar es Salaam, to the frustration of the fishers.

⁷ CIF = Cost, Insurance and Freight. The price which includes all costs up to the port of import, excluding import duties, off-loading and storage etc.

4.4 General Comments on Loss Reduction

There are two evident ways in which losses may be reduced in the trading network. In the trading of finfish, the use of more effective (and efficient) smoking kilns would not only reduce the proportion of catch that is classified as lower quality but also reduce the amount of fuel wood consumed. In addition, they may also help to reduce fragmentation (worse in excessively dry product), beetle infestation and increase product shelf-life. Applicable technologies and potential benefits are described further in section 8.1.

Extended use of ice in the prawn fishery would reduce losses and even potentially increase producer revenues, especially under the present system where the cost of ice is supported totally by the processor / exporter. However, considering the highly commercialised nature of the prawn fishery and the key role of the private sector, a question is raised as to responsibilities and priorities. It is considered that the production of ice should be in the hands of the private sector – there are no examples of the State successfully producing ice in East African fisheries on a sustainable basis. The role of the State should be to facilitate and provide (fiscal) incentives rather than intervene directly. The State could play a role in education and awareness raising but Rufiji District has limited extension capacity, especially in the fisheries sector. It is difficult to see exactly who would complete the task, and based on what experience. The entity that might gain most, and be best placed to accomplish such extension work, is probably the processing / export companies.

5 Sustainably Increasing Productivity

In this section, descriptions are provided on the use of the various aquatic resources of the floodplain and delta areas. Each resource described here has either been considered in the past, has presently been identified by the REMP as being worthy of investigation, or has been shown by our analysis to merit further development.

In the descriptions of the resources that follow, the development options are examined, and ways to improve or develop existing enterprises associated with these resources described. All have as a central theme to exploit, on a sustainable basis, the productivity of the floodplain and delta areas of the Rufiji District. At the outset however, it must be understood that a range of social, environmental and economic forces of varying intensity govern the various fisheries of the District, and that suggestions to radically change the *modus operandi* of these fisheries are not being entertained. It is also accepted that the fishing effort engaged in pursuing the lucrative prawn (and to a lesser extent the fishery of 'mbarata' herrings) of the delta and the seasonal floodplain and lake fisheries will continue as long as it remains lucrative to do so. The issue of management of these fisheries is a complicated and challenging subject, beyond the scope of this study, though a brief overview has been provide in section 6.

The present study focused on increasing productivity in the delta area, thus deliberations on the floodplain fishery are based more on brief discussions and the available literature than on field visits. Indications are that the fishery of the floodplain lakes and river approaches the maximum, with fishing effort adapting to seasonal changes in the geographical size, distribution and productivity of the resource (Turpie, 2000). Given this situation, no suggestions are made to increase fishing effort. Instead, a proposal to boost the productivity of the existing lakes is provided through the introduction of brushwood enclosures and development of freshwater fish culture systems, described in full in section 7.

5.1 Seaweed Farming

Seaweed farming is a success story as far as mariculture development in Tanzania is concerned. A number of coastal communities now cultivate seaweed on a commercial basis, mostly on the east coast of Unguja Island, Zanzibar, and more recently on the east coast of Mafia Island. The majority of villages devote their attention to the cultivation of *Eucheuma denticulatum* and *Kappaphycus alvarezii*.

In the Kilwa Distict, the village of Somanga (see Fig. 4) supports a small women-group of about 12 seaweed farmers (previously 60), divided into two groups. The experience from there has been disappointing. This is not surprising since successful seaweed farming depends on careful site selection. The following general guidelines are used in the preliminary evaluation of sites (Tronro, 1993):

- Reefs far from freshwater sources are preferred because *Eucheuma* and *Kappaphycus* are stenohaline species and salinities below 30‰ may have adverse effects on growth;
- Potential areas should be protected from the destructive effects of wave action, and waters should be clear;
- Sandy to corally bottom substrate subject to moderate water currents have been found to support good seaweed growth. Fine sandy or silty areas are generally not good farming sites, and;
- Water depth at low tide should be 0.6-1.0m. Deeper areas are hard to cultivate since the construction of the support system and both planting and harvesting in deeper water will entail higher costs in labour and materials.

From the above attributes, it can be concluded that Rufiji Delta areas are unsuitable for seaweed cultivation.

5.2 Small-scale Prawn Farming

The importance of this practice for the people of the Rufiji Delta and the ecoregion are recognised. This section has therefore been expanded in an attempt to include all the issues and arguments, reviewing the various aspects associated with the development of prawn farming in the Rufiji Delta. This is not only of importance to the country, but also to the greater eastern Africa region, in particular neighbouring Mozambique and Kenya. In the section below the subheadings used are the same as those in the Potential Enterprises portion of this report (sections 7 and 8), included here to provide a framework for comparing small-scale prawn farming with other potential enterprises for the District. At the present time, given the environmental uniqueness of the Rufiji Delta and the potential for increasing other economic activities the promotion of small-scale prawn farming is not recommended.

Social and Cultural Issues

Interviews conducted in the northern delta revealed deeply held opposition to development of prawn farming, or indeed any form of aquaculture. There is no doubt that these strong feelings arise from the history of the development of the proposal for the very large semi-intensive farm by the African Fishing Company. Many inhabitants of the delta feel that their livelihoods and indeed traditional way of life are under threat (Sørensen, 1998). During the present study the following three opinions were strongly voiced:

- Villagers in Kiomboni were very strongly opposed to prawn farming and were suspicious of discussing the issue, even development of household-scale enterprises. Many of the villagers were among the 2,000 participants in the law-suit against the African Fishing Company. Consequently, the village Chairman considered the subject *sub judice*, and therefore inappropriate to discuss with strangers. The villagers were clearly politicised and informed on fisheries-aquaculture conflicts elsewhere (they cited parallel examples of Honduras, Ecuador and India). Although a decline in fisheries was acknowledged, there was no support for aquaculture. As one elder villager put it "If God is causing the decline in fisheries, then why should you put prawn or fish in ponds?"
- In Kibanjo there was also outspoken opposition to prawn farming (or aquaculture in general). When it was explained that we were interested in the potential for small-scale enterprises for households in the villages, the response was that this would lead to escalation, with risk of eventual displacement of villagers from the delta. However, this view was not universally-held; some villagers said that it would be acceptable to develop their own small-scale aquaculture enterprises, in which they controlled and sold the products.
- The Secretary for Msala village, himself a rice farmer and prawn fisher, expressed the view that the vocal anti-aquaculture stance does not represent everyone's interests. If technical training was provided, it was proven that there were no negative environmental impacts and there was assurance that it was economically viable then small-scale prawn farming should be acceptable. However, the Secretary also pointed out that Msala village joined Kiomboni in the lawsuit against the African Fishing Company, and he recommended that no development should be considered until the case is settled. The Chairman of Kibanjo confirmed this view. He stressed that despite his being receptive to the idea, all affected villages would have to be convinced or there would be a risk of "scaring" them again with concerns about being barred from fishing, if prawn farming is introduced. Similarly a Councillor for Salale Ward expressed the view that the people he represented were completely opposed to aquaculture and that it would be inappropriate to attempt to introduce any type of aquaculture project at this stage.

This series of interviews clearly indicates that, in the northern delta at least, the communities are already polarised in their views on aquaculture and that conditions are in fact ripe for further fishers vs. prawn-farming conflict. In an unattributed statement, direct action against any aquaculture venture was considered a real possibility. It is considered inappropriate, purely from the socio-political standpoint, to consider introducing a small-scale prawn culture project to the Rufiji at this point in time.

Financial Issues

Prawn yields per hectare of pond in extensive ponds in SE Asia range from 100-400 kg/year (Primavera 1988). Johnston *et al.* (2000) reported a mean yield from mangrove-prawn farms in the Mekong Delta of 286 kg/ha/year. Although these yields are low, they represent a low-investment, low-risk but low return strategy for coping with the unreliability of prawn farming in the region, and are considered appropriate for modelling likely yields from small-scale extensive farms in the Rufiji Delta.

Secondary aquatic products, such as fish and crabs, may increase yields by 25% to 335kg/ha/year. Further income can also be generated from fruit and vegetable production. Mangrove poles are harvested on a 20-yr-production cycle with thinning at 5, 10 and 15 years. However, mangrove trees, in existing forests, are a State-owned resource in the Rufiji Delta and harvesting of 'boriti' does not require investment in silviculture. Hence, potential income from this component of an aqua-silviculture system must be discounted. This is based on the argument that so long as the option exists (whether legal or not) to harvest natural stands of trees, in which there has been no investment costs, then silviculture will not be viable or attractive.

Considerable labour investment is required to clear land, dig ponds and construct dykes, even for a small household prawn farming enterprise of 3-5 ha. This would require capital investment to pay for labour or mechanical excavation (if feasible). Once the pond is constructed, labour for maintaining comparable systems in Indonesia is estimated as 0.4 workers /ha (Muluk & Bailey, 1996). Thus a 3-5 ha plot, would require 1-2 people full time for maintenance and production management.

Assuming a yield of 250 kg/ha for a farm of 3 ha in the Rufiji Delta with 50% pond area, this represents a gross prawn yield of 375 kg from labour of 1.2 people. Current, value of white prawn (*F. indicus*) is 1,200 Tsh/kg, giving a gross yield of US\$ 500 per 3 ha farm. Net return to labour for a comparable mangrove-prawn farm in the Mekong Delta has been calculated as US\$ 3/day (Binh *et al.*, 1997).

In comparison, current average yields from prawn fishing are 4 kg/boat/day. Allowing for 100 days of fishing per year this gives a gross yield of 400 kg/boat/year, and a corresponding net return to labour of around 4,100 Tsh (US\$ 4.5) per day, including fishing bycatch value, but not allowing for alternative economic activities during neap tide periods. Investment required for setting up a small farming enterprise would be considerably greater than that required to purchase a boat and nets. There is also direct labour investment conflict with prawn fishing as alternative activities. Greatest labour requirement is during spring tides when water exchange and harvesting would take place, which may preclude pond operators from prawn fishing as a secondary source of income (and *vice-versa*).

Even optimally-managed extensive prawn ponds can only be expected to produce 500-1000 kg/ha/year, in which case supplemental stocking of post-larvae and some feeding is required (Fast & Lester 1992). Estimates for economic rent for fishery production supported by intact mangrove range widely between US\$ 500-11,000 ha/yr (Ronnback 1999, Primavera 2000). Applying a fairly conservative economic rent value of US\$ 750/ha/year for fisheries products, net benefits from prawn pond production are likely to be marginal. In effect, fishing effort is transferred to farming, enabling "ownership" of the resource but with no net gain in fisheries productivity. Applying the predicted estimates of pond production at 250 kg/ha/yr, conversion to ponds would be expected to result in a net loss in fisheries production.

Policy Support

Any aquaculture development proposal needs to be considered within the national or regional aquaculture development plan. The TCMP has initiated the development of policy and guidelines for aquaculture development in Tanzania, but formal policy as yet has not been adopted.

The development of aquaculture in mangrove areas is restricted under the Mangrove Management Plan to Zone IV Development Areas (Ministry for Tourism, Natural Resources and Environment, 1991). Within the mangroves of the Rufiji Delta these are extremely limited, with only a very few Zone IV areas designated. Even then, only aquaculture activities without significant environmental impact are likely to be permitted and clearance of trees for pond construction is unlikely to fall into this category. Ironically, one of the only four Zone IV areas in the delta is adjacent to Kiomboni village, where the strongest opposition to aquaculture development was expressed.

Even within a protected zone there is a mechanism for establishing an aquaculture project. A village may apply for permission to the Division of Forestry & Beekeeping. The Chairman has authority to grant exemption for a particular development and may refer to the MMP for technical advice. The Director of the MMP suggested that he would support small-scale low-density aquaculture, and pointed out that there is already a system of licence fees in place. However, given the MMP's desire to limit clearance of mangrove trees for rice production, it seems unlikely that they would want to encourage further mangrove cutting for aquaculture. The Mariculture Working Group (1999) has identified conflicts between prawn aquaculture development and mangrove habitat conservation as a key issue, and has recommended that the enforcement of the Mangrove Management Plan Zoning system should be reinforced.

Environmental and Resource Issues

An aquaculture development within a sensitive area, in this case mangrove, should be subject to mandatory environmental impact assessment (EIA) by the NEMC. It is highly likely therefore, that any pilot project that might arise from the recommendations of this report will have to submit an EIA before approval (Hambrey *et al.*, 1999a).

The Report on Preliminary Shrimp Culture Site Selection to the Government of Tanzania (Autrand & Carles 1996) identified several areas in the Rufiji Delta as prime sites for development of semi-intensive shrimp farming. In particular they recommended that farms should be sited on areas of bare salt flats in the higher shore. These areas have soils of high clay and low organic content suitable for pond construction with low risk of acidification (i.e. low acid sulphate soils). Such salt flats occur naturally relatively high on the shore, typically within and behind the upper *Avicennia* belt (McNae 1968), and are probably only flooded on high spring tides. Their infrequent tidal inundation is indicated by the high salt-content of the muds (up to 80 ppt in soil water). One of these sites (adjacent to Kibanjo village) was visited during the present survey.

We agree that they might be suitable for extensive or semi-intensive production, in which water is pumped into the ponds. However, the extensive small-scale ponds now proposed would rely on tidal exchange of water. To do this effectively, allowing adequate control of water quality and salinity will depend on significant excavation of the higher saline soils and construction of canals. As mechanical excavation is not an option, this may prove impractical.

However, digging ponds lower on the shore is not advised as it would inevitably require clearance of trees to make way for ponds, even in an integrated mangrove-pond model (Primavera, 2000). In addition, soils lower on the shore are likely to be prone to acidification, reducing the potential for long-term, sustainable, production.

Even if a pilot extensive pond was considered environmentally acceptable, following the

recommendations of GESAMP (2001) and Hambrey *et al.* (1999a) the potential for *cumulative impacts* must be taken into account. A proposed semi-intensive prawn farm in Bagamoyo was refused permission, due to the potential for its success attracting further aquaculture development (Hambrey *et al.*, 1999b). Similarly, in the Rufiji Delta, a single 5 ha pilot site may be considered environmentally sustainable, even exemplary, but if successful, it would encourage further similar development. In a successful scenario, 200 households might take up the enterprise, resulting in 1,000 ha of mangrove being converted to prawn production. This is equivalent to a substantial commercial farm development. If these were successful, then there would be escalating pressure to convert mangrove to ponds; if 800 households took up prawn farming (at 5 persons per household this represents 15% of the delta population, Sørensen, 1998) there might be 5,000 ha of mangrove converted to prawn production. This would be equivalent to the projected scale of development by the African Fishing Company after 5 years. Furthermore, there would be little remaining political justification for withholding permission for, or social resistance to, development of commercial scale semi-intensive production. Indeed, the number of small-scale producers would themselves justify (or demand) establishment of a hatchery to supplement natural recruitment with more valuable *P. monodon* postlarvae and a shift to more intensive production methods would seem inevitable. It is worth noting that the evolution of prawn farming in much of SE Asia from extensive to present-day intensive farms, with the associated history of environmental problems, has taken place almost entirely through development of small-scale 3-5 ha farms. It is in those regions that low technology, intertidal systems have initially proliferated and tended to intensification that the greatest problems of un-sustainability have arisen.

There are no data on abundance of post-larval prawn in the Rufiji Delta. Studies in the largest mangrove estuary on Zanzibar, Chwaka Bay, reveal that the recruitment of penaeid post-larvae stage (7 mm) was year-round with a maximum during the warmer months from December to March, with February to March considered the peak recruitment period (Subramaniam, 1990). Le Reste & Marcille (1976) found that in Madagascar March-April was also the period of maximum spawning and November as a secondary spawning for *F. indicus*. The post larvae of *F. indicus* were found to move inshore with the flood tide, with significantly higher post-larvae catches during spring tides. The analysis provided by Siegel (1986) also confirms that for Tanzania peak in postlarval recruitment into estuaries occurs between February and March and that the main spawning occurs during the hot season. Fishers at Simba Uranga reported that the best season for juvenile prawn was June-July further up the estuary. If their interpretation of juvenile prawns is 5 cm length, then the post-larval recruitment (at 7 mm length) probably did occur around March.

Low recruitment has been identified as one of the key factors resulting in low yields in mangrove-prawn farms in the Mekong Delta (Johnston *et al.*, 2000b). The most abundant prawn species in the Rufiji Delta fisheries is *F. indicus* that is able to tolerate relatively low salinities. However, there are very likely to be significant fluctuations in abundance and distribution in the estuary, in relation to changes in freshwater flow with the rainy and dry seasons. Such fluctuations may have a significant impact on viability and location of extensive prawn ponds, and would need to be surveyed through at least one annual cycle. Hatchery-produced postlarvae are not yet available in the delta, though a *P. monodon* hatchery will shortly be established on Mafia Island only a few miles distant.

Market Characteristics

Accessibility to the market for prawn is excellent, due to the existing system of prawn buyers.

Technology and Skills Requirements

The high variance in yields between mangrove-prawn farms in the Mekong Delta is principally attributable to experience and skill of the farmer in pond design, construction, maintenance & management (e.g. reducing leakage from dykes, excavating accumulated sediment, controlling water exchange & recruitment) (Johnston *et al* 2000). Consequently, provision of adequate training to potential farmers is considered of paramount importance to the sustainability of any prawn aquaculture

development in the Rufiji. This is particularly true, given the lack of any history of mariculture in the community, or even nationally.

Undoubtedly, a demonstration project would be required not only to prove technical feasibility but also to act as mechanism for training/extension. However, there are extremely few Tanzanian specialists in mariculture who might provide national or local training/extension support. This is a significant bottleneck in the development of aquaculture in Tanzania, and one that needs to be addressed beyond the scope of this report. It would seem a very high-risk enterprise to try to introduce a completely new farming system, at the local household level, when the relevant government agencies (e.g. Divisions of Forestry and of Fisheries, MNRT) do not yet have the trained staff to deliver critical extension support. This is by no means meant as a criticism of those agencies, more an identification of a key requirement for successful aquaculture development.

In summary, small-scale extensive prawn production is considered relatively high risk due to:

- a) Mistrust and resentment of aquaculture development;
- b) Lack of knowledge and experience in the village communities;
- c) Lack of training and extension staff;
- d) Dependence on establishing farms in potentially acid-sulphate intertidal soils, and;
- e) Lack of information on distribution and abundance of prawn seed in the estuaries of the delta.

5.3 The Freshwater Shrimp Fishery

Hopson (1979) states that freshwater prawns were caught at almost all stations (during June-August), with *Macrobrachium* and *Caridina* thought to be the genera concerned. During the present study these were not encountered, though villagers at Twasalie, a floodplain area in the delta, reported that a freshwater shrimp known as 'kamba kitumbo' was caught in large numbers during the wet season, due to low levels of seawater intrusion, with reduced amounts in the dry season. Other information gained during the study suggests that the best period for the capture of these shrimps is between December and April. These are caught with sheets of cloth (presumably like the 'uduvi' fisherwomen), with baited traps or with ½ - ¾" mesh nets.

Irrespective of its identity, the resource is obviously seasonal, and whether the trade could be expanded was not determined during this study, though it is thought unlikely. However, of the 19 species of freshwater shrimps adapted to farming conditions, either experimentally or at an industrial level, the vast majority belong to the genus *Macrobrachium* (Swift, 1993). The so-called giant freshwater shrimp of the Indo-Pacific region, *Macrobrachium rosenbergii* grows to a length of 30 cm, excluding the long front claws, is now successfully farmed in many countries. Salinity control is important for larval development for 2-3 weeks, after which transfer to freshwater grow-out ponds allows shrimps to reach market size (30-40 g) in 5-6 months. Feeds and fertilisers are usually added to boost productivity.

Farming of this shrimp has not expanded like that of penaeid prawns as Lee (1997) explains. This has been due to its aggressive behaviour, hindering more intensive production and, most critically, its flesh is generally not as highly prized as that of penaeids. An additional problem with *Macrobrachium* is the rapid perishability of the flesh. Given the abundance of penaeid prawns and the strong demand for that product, the market for freshwater shrimps is unlikely to develop beyond one based on curiosity, certainly not enough to encourage aquaculture enterprises.

5.4 Lobster Resources

The lobster fishery on Tanzania is restricted to coral areas. It is likely to have started in Zanzibar in the 1950's with *Panulirus ornatus* accounting for the bulk of catches (Hall, 1961). During 1959, an estimated 23 tonnes were landed on Zanzibar by spear-fishermen, yet the following year a decline of 31.6% was reported. It is thought that the steep offshore slope results in a slow recruitment from the

deeper waters to fished areas. In the Mafia Channel lobsters occur among coral reefs, often under table corals. Fishers use hand spears and nets to collect lobsters, usually from shallow waters, though use of SCUBA gear has increased over the last ten years allowing fishers to collect from waters to 40 m depth, or more.

In the vicinity of the Rufiji Delta, as for sea cucumbers, the absence of clear, saline waters precludes this coral–reef dependent resource from developing. The waters around Kilwa Kivinje, Songo Songo, Mafia Island and Somanga do however support a lucrative fishery (see Marshall *et al.*, 2001) that supplies the Tanpesca barge based at Mafia and the buyers in Dar es Salaam. The bulk of the production is exported to Europe and SE Asia.

The larval period of *Panulirus* lobsters can last for several months, and Hall (1961) argues that there is little that can be done to realistically control the fishery for lobsters since recruitment is largely beyond control and probably dependent on populations hundreds of miles away. Reduction of habitat destruction and size limits should be the first areas of focus.

5.5 Crab Fishery and Farming

Mud crabs, *Scylla* spp., represent a valuable component of small-scale coastal fisheries in many countries in tropical and subtropical Asia, for which there has been a general trend of increased exploitation in recent years (Angell, 1992; Keenan *et al.*, 1999).

The Rufiji Delta is an ideal habitat for the mud crab and given the scale of delta it is likely that there is a substantial population of crabs. The species present (*Scylla serrata*) is the largest of the four mud crab species and as the fisheries is effectively unexploited, large (and hence higher value) crabs should be abundant. The fishery reportedly involves women in collecting and supplying crabs to buyers at some fishing camps in the delta. In Jaja the best time to collect mud crabs was reported to be over the neap tide period.

The only estimate of the potential yield for mud crabs from the Rufiji Delta is that provided by the Anon (1978) in a report entitled *Macrotrade-Tanzania Fisheries Venture Report* where a yield of 20.64 tonnes per month was quoted. This report could not be located and hence the methodology employed to calculate this estimate has not been verified. Turpie's (2000) household questionnaire survey documented only an annual harvest of 34 tonnes of crabs from the delta. Siegel (1986) suggested that the mud crab fishery could become an important source of income, quoting a prediction by Anon (1981) that a well-managed mud crab fishery could generate as much revenue as the entire prawn fishery presently operating in the Rufiji Delta. However, an accurate assessment of the crab stock should be conducted before development of exploitation.

Approaches to more sustainable "mangrove friendly" aquaculture systems in Asia have included farming of mud crabs (*Scylla* spp.) as an economically viable, lower-risk alternative activity particularly in areas where prawn farming is no longer viable (due to disease) and where conservation or rehabilitation of mangrove habitats is a high priority (Keenan & Blackshaw, 1999). In previous reports (Mariculture Working Group 1999; Division of Fisheries development proposal, 2001) aquaculture of mud crabs have been cited as a development option for the mangrove areas of the Rufiji Delta. While it is certainly the case that mangrove pen and cage culture can be successfully integrated into mangrove management or rehabilitation it is premature to consider introducing such techniques to the Rufiji. The main reason for this is that the market for fished crabs is as relatively undeveloped, and the value of crabs relative to prawns remains low. However, it is reasonable to anticipate that development of crab fishing as an economic activity will develop markets, motivate fishers and support the accumulation of knowledge and experience required for crab aquaculture to become a viable option. For this reason crab culture is identified as a potential means to increase productivity in the

future. In particular, if crab fishing becomes established, some of the techniques for value-adding (especially see culture methods 3-6 below) could quickly become economically attractive. An integral component of development of a crab fishery will entail establishment of improved holding systems for crabs before transport out of the delta. Such systems (cages or pens) could provide an intermediate development step to aquaculture of crabs.

Crabs have been farmed in Asia in a variety of systems (Keenan & Blackshaw 1999);

1. Large semi-intensive ponds (ca. 1 ha). Grow out from small juvenile (10g) to market size over four months, supplementary feeding with snails, trash fish, offal.
2. Mangrove aquasilviculture farming systems (3-5 ha). Grow out from small juvenile (10g) to market size over four months, with little if any supplementary feeding.
3. Small intertidal pen enclosures, which can be set up amongst mangroves (200-1000m²). Undersize juveniles (85-100g) are grown to market size over 3 months, and are fed with snails, trash fish, offal.
4. Floating cages from juveniles (85-100g) to market size over 3 months. Fed with snails, trash fish, offal.
5. Small pen or cage "value adding". Short term fattening of undersize (250-350g) and recently moulted crabs to increase value. Similarly, female crabs may be held until mature (crabs with roe are a premium value product in Asia).
6. Soft shell production. Holding of crabs in cages of small pens until moult, then selecting soft crabs. Product may be frozen.

Mud crab culture in mangrove pens (enclosed by wooden/bamboo fence and/or polyethylene materials) can generate yields of approximately 1,000 kg/pen from 2 crops/yr, but is dependent on 'trash' fish that may form part of the diet of local communities. Snails and fish or animal offal can also be used as feed. Both systems are dependent on wild seedstock, with small juveniles collected in a specialised fishery by push net or by hand at night, and larger juveniles of undersize crabs from the main crab fishery landings.

Viability of culture of crabs will depend ultimately on the market value of the product. Such systems are viable in Asia, where farm-gate prices for crabs may be US\$ 2-4/kg (more for mature females), which is substantially higher than current value in the Rufiji.

It should be noted that crab value-adding or farming would be subject to the same mangrove use zoning regulations described for prawn culture (section 5.2). However, the low-impact nature of the activity and its compatibility with mangrove conservation would suggest that the Division of Forestry and the Mangrove Management Project are more likely to view such a proposal favourably. It is unclear if any small-scale development of this type would require an EIA.

5.6 Marine Clams, Cockles, Mussels and Oysters

Throughout Tanzania's coastline marine clams, cockles and snails are collected, mostly from seagrass and coral areas. In addition to their value as food, marine molluscs are also of economic importance because of the value of their shells (see Box 2). Unfortunately many food species have shells that are not of economic importance.

This section and the one that follows considers the capture and culture of species such as clams, oysters and the like, and snails for food production.

Box 2. A note of the trade in sea shells

The shells of certain clams and oysters and especially of marine snails (gastropods) have been traded across the worlds' oceans for thousands of years. The shells of some oysters are used for inlays in woodwork, others for buttons and some for sale as curios and souvenirs. In Tanzania, this trade is important to many isolated coastal communities who can stock-pile the shells and sell to buyers that visit once or twice a year. The shells that are in high demand are mainly of species that are coral-reef associates. With the absence of large reef areas near the delta, this resource is not likely to be significant. On the whole, in Tanzania this type of economic activity should not be encouraged since the international shell trade has resulted in considerable conservation and environmental concern (Wells, 1981). Since molluscs are collected live, it is feared that they are being over-collected and their habitats damaged by shell collectors (Evans *et al.*, 1977).

Mwaiseje (1982) suggested that for Tanzania as a whole it would be a good thing if consuming molluscs were popularised to combat protein deficiency. In many parts of the coastline of Tanzania, marine molluscs (both bivalves such as clams and cockles) and marine snails (gastropods) do form an important component of diet for the coastal people. In the Rufiji District however, molluscs do not appear to contribute to the diet of humans.

Hogan *et al.* (1999) noted that in the village of Mbwera Mashariki there was fishing for two species of bivalve clams, locally known as 'Ngowe' and 'Chanjagaa'. Subsequently, these have been identified as crabs. Though the fishery for bivalves (e.g. clams, cockles and oysters) is not known from the delta area, it is suspected that there may be a resource, perhaps limited to a few sites, where further research is needed. In other parts of Tanzania and the tropics, bivalve molluscs are cultured. The two most suitable examples are described below:

Blood cockles (*Anadara* spp.) have a high potential for mariculture development as they grow fast, from spat to 2.4cm in one year (Kayombo, 1985), are a popular seafood food locally and are traditionally harvested by women and children. Although experimental culture of cockles was successfully conducted in Tanzania (Kayombo, 1991), their culture was not adopted by the local communities due to lack of knowledge and experience. Kayombo & Mainoya (1985) found that off Dar es Salaam blood cockle populations demonstrated two spawning peaks, in October-November and March-April. They suggest that restriction of harvest during these periods would ensure species propagation. Increasing productivity of intertidal mud flats by transfer of spat from spat-fall areas is an option that is practised in SE Asia (see Hamilton & Snedaker, 1984) and might be applicable to parts of the delta. Again, further research would be needed to identify spat-fall areas. For the Rufiji Delta resource such management intervention, aiming at long-term productivity, should only be considered once the resource has been more fully studied.

Rock or mangrove oysters of the genus *Crassostrea* are collected and farmed in many parts of the tropics. In West Africa the existing fishery for oysters relies on wild caught animals being scraped from mangrove branches and roots (Cham, 1992), though attempts are currently being made in the Gambia to culture oysters in estuarine areas. Though not traditionally consumed in Tanzania, the culture of the local rock oyster (*Crassostrea cucullata*) could potentially add to the economic diversification of delta areas. Successful trials of the rock oyster were undertaken in Zanzibar in the early 1990's (see Jiddawi, 1997), and later in Bagamoyo (Mgaya, 2001) both demonstrating good spat-fall and potential for growth and culture.

South of Mombasa in Kenya, a project to culture rock oysters was developed with a women's group in 1994. While the site was suitable for the culture on racks, the main obstacle was the marketing, transport costs and demands (affected by the tourism industry as a whole) (Anon, 1997a). The culture of rock oyster has also been attempted in Tanga during the late 1990's by villagers with support from the TCZCDP, but failed due to a number of problems including siltation, freshwater influx, predation by crabs, competition for space from other organisms, and a poorly developed demand for the product. In the Rufiji District, finding a market for fresh oysters is a challenge that must be solved, because potential markets are distant and transportation costs are prohibitively high. The development of the tourism industry in the region is in its infancy, with only four small lodges on the east of Mafia Island, thus local demand is likely to be low. Further increase of the demand is however probable off Mtwara (with soon to be developed Marine Park) and off Kilwa. As road infrastructure becomes more reliable in the District access to markets will certainly improve.

C. cucullata is known to tolerate salinities down to as low as 2.5 ppt during monsoon rains, but in general does not grow well in low salinities. Though no evidence of mangrove oysters was noted in the present study it is recognised that the southern delta, subjected to less freshwater influxes than the northern delta during the wet season, may provide suitable oyster growing and culturing conditions. Spat fall may also be locally present off Mafia. Both the salinity and availability of spat would need to be ascertained. However, without any local tradition to grow bivalves, wider spread culture of any molluscs will remain a challenge unless suitable culture systems are demonstrated, seed availability assured and technical assistance provided.

5.7 Gastropod Resources

In the previous section, a brief description of the trade in shells of marine bivalves and snails, is provided (see Box 2). Use of snails in general seems to be a minor activity in the District, and this brief section considers the species that have been noted.

During the study visit, two freshwater snails on the floodplains were observed the African Landsnail *Ianthina* and the *Pila ovata* (Plate 8). It would appear that both these snails are of little use, though small specimens of *Ianthina* (5-8 cm long) are used when harvesting rice, with the narrow sharp edge of outer lip as a cutting blade. Generally, these snails are a pest of cultivated rice. The suggestion that these be harvested and used as a feed of catfish ponds is described in section 7.1. Culture options for these species might be considered.

In other parts of Tanzania the mud whelk (*Terebralia palustris*), locally known as 'suka', is used as a food and the hermit crabs that subsequently adopt the empty shells as bait for fish traps. This common member of the mangrove community was not observed in the delta, nor was there any evidence of its presence or use at the sites visited in the present study.

On Simaya Island, southeast of Jaja (see Fig. 4) some collecting of marine gastropods was reported as a food supplement or for bait, interestingly of species of high value for the curio trade (Caras, 2001). Also reported was the collecting of the opercula of the tulip shell *Pleuroploca trapezium* or 'kome'. This species is associated with seagrass beds and coral reefs, thus its occurrence in the delta is very localised. In general, most marine snail species are associated with hard substrates (such as rock or coral) or seagrass beds. Though Simaya Island is considered to be in the Rufiji District, and supports a small reef area, the total area suitable for marine snails within the District is still small, and thus unlikely to support a productive marine snail fishery.



Plate 8: *Pila ovata* from the floodplains of Twasalie

5.8 Cephalopod Resources

Squid, cuttlefish and octopus comprise the members of the Cephalopoda class of molluscs. All are marine, active predators and females lay fertilised eggs in clusters usually under stones or among corals or seaweed. In Tanzania, there are important fisheries for all three groups, depending on location, season and water depth. In the Rufiji Delta area, only the fishery for octopus was reported, from the southern village of Somanga, with some collected from Simaya Island (Caras, 2001).

Consultation with the coordinator of the Octopus Fishery Study of Tanzania (Martin Guard) confirmed that for the Rufiji Delta area there is probably little scope for any expansion over and above what is already happening. This is partly due to the lack of suitable rocky and coral reef, a necessary requirement for octopus, and certain other marine invertebrates (as described in section 3.1). There is however an extensive fishery for octopus centred at Songo-Songo, and off Somanga to the south, and the islands to the north of the delta. During the present study the trade in octopus at Somanga recorded sale of fresh octopus for 300 Tsh/kg.

5.9 Echinoderm Resources

Of the six classes that comprise the phylum Echinodermata, only the sea cucumbers (Class Holothuroidea) are of commercial interest in Tanzania. Of the estimated 136 species of holothurians in the shallow waters of eastern Africa (Richmond, 1999) only 20 can be considered to be of commercial value. These slow-moving, invertebrates that live on sand and rubble close to coral reefs, support the trade in dried sea cucumbers, known internationally as 'beche de mer' or 'trepane', and in kiswahili as 'maji ngoo'. This is an important export product for Tanzania, with much of the trade centred on Zanzibar, however Marshall *et al.* (2001) conclude that stocks of the most valuable species have been overexploited in Tanzania.

Most sea cucumbers are coral reef associates and do not have a tolerance to low salinity. As a result the resource is unlikely to contribute significantly to the economy of the Rufiji Delta and the possibilities of developing the fishery in the Rufiji Delta area is therefore un-realistic. The small patchy reefs off Jaja, north of the Jaja River mouth have not been investigated to date. The non-reef areas around these patches are frequently targeted by the industrial prawn trawlers and are considered one of the better grounds in the area. It is therefore unlikely that these coral patches would also yield high quantities of the commercially important sea cucumbers that normally thrive in areas of full salinity and of clear waters. A trader in Somanga confirmed that catches originated around the reefs of Kilwa (see section 4.3).

6 Fisheries Management Issues and Awareness

This section briefly highlights some of the main issues associated with the management of the Rufiji River floodplain and delta areas. Suggestions are then provided of ways to include fisheries resource information and awareness into the formal education structure in the District. Finally, a description is provided of several research topics that we consider to be important in contributing to the long term, sustainable, management of the fisheries resources of the Rufiji District.

6.1 Lower Rufiji River and Floodplain Fisheries

There are few reported conflicts among floodplain fishers over ownership or use rights for lakes, with most villages claiming their lakes and its use regime. Lake Kimbisi for example, located in the southern part of the village of Ndundunyikanza, in the western floodplain, is used solely for providing drinking water, made possible through the use of village by-laws (Mbiha & Senkondo, 2001b). Also in the western floodplains, Lake Mtanza has a closed season for fisheries (second year now) for a few months. It seems to be well adhered to and the results have been positive. A closed season was also proposed by Mbunju-Mvuleni for Lake Uba but not accepted by Mpima sub-village which has no alternative site while the fishermen of Mbunju have access to Lake Ruwe.

In the delta floodplain village of Twasalie, the right to close the upper section of the Tarachu River is another example of co-management. On this portion of the Tarachu River all fishing was banned for three months (June to August). A system of licensing (1,000 Tsh per fisher) was implemented, with fines of 12,500 Tsh for fishing without a licence. Certain gears (cast nets, seining with smaller than 2½” mesh) are banned, with fishers acting as policing agents, reporting to the village government. For the first two weeks following the opening of this section of the river catches were reported to be very good, returning to the ‘normal’ levels thereafter. In northeast Nigeria, a similar management intervention is described by Neiland & Ladu (1997), referred to as “Stew-ponds” whereby the village head prevents fishing in two local recessional pools on the floodplain for at least two months. A fishing festival is then organised to harvest all the fish, which have grown larger, and there is an equitable distribution of the catch among all the community at a time of low food availability (dry season). The Tarachu River intervention in the Rufiji however created a conflict with the fishers from the nearby village of Mtunda A who claimed not to have been consulted.

6.2 Delta Fisheries

The background information to this study indicated that there is potentially a resource conflict between the artisanal and industrial fishers in the delta area. Neither resource managers (District officials, Village-level officials, REMP) nor fishers were certain of the legal framework, particularly that governing the activities of the industrial fishery.

For the Rufiji district at present there is concern over whether the delta fishery is being exploited beyond its maximum sustainable yield (MSY). To determine if this is the case, the stock size and recruitment rates of fish and prawns into the area need to be ascertained. Often this is extremely difficult to determine, especially in the complex fisheries of estuaries. An alternative is to establish whether the catches are declining over time and by how much. To measure this an effective data collection programme needs to be in place. The use of catch per unit effort data to compare catches from different areas and times is also very important. The collection of accurate length data for target species would also contribute to understanding whether there are changes in size composition of the catches.

The management of the Rufiji Delta fisheries is a subject that should not be considered lightly. However, a full analysis is beyond the scope of the terms of reference of the present study. This section therefore collates the existing, and widely dispersed, information associated with the fisheries of the

Rufiji River delta and only briefly describes some of the more salient aspects of the artisanal and the industrial sectors. Information on the industrial fishery was obtained through direct consultations with industrial vessel operators, the Division of Fisheries as well as (to a lesser extent) artisanal fishers.

The Artisanal Sector

Migration of fishing effort - The artisanal prawn fishers in the Rufiji move throughout the delta at different times of the year, relying on simple dugout canoes to reach fishing grounds. These low-freeboard vessels cannot operate in rough sea conditions. Sørensen (1998) describes the movement of fishers as being related to perceived changes in productivity and exposure of fishing grounds to wave action. We consider sea conditions and hence access to fishing grounds to be the main factor governing the exploitation of the resource by the artisanal fishers, though the possibility that prawns migrate to different parts of the delta during the year cannot be discounted. In the northern delta, prawn catches at Simba Uranga are reportedly highest during the months of September and November. At the time of our visit in first week of November, prawn fishers were preparing to head further south, to the more centrally placed Kibanjo fishing camp. The reason for this shift was the strengthening of the NE monsoon winds, causing rough sea conditions along the northern parts of the delta. During this period in the southern delta village of Jaja, fishers informed the field team that catches of prawns were very small, and that the best prawn fishing for their village was later, between November and May. The latter is the time of year when the Jaja section of the delta benefits from being in the lee of Mafia Island (see Fig. 4) during which time the local seas are thus relatively calm. The strong winds associated with the southeast monsoon (June-September) would prevent access to their open-water grounds. Quantities of artisanal-caught prawns from the delta for the first ten months of 2001, based on purchases made by the Tanpesca barge, did not reflect any clear seasonal trends.

The marine finfish fishery - The five-spot herring *Hilsa kelee* or 'mbarata', is thought to be one of the most important marine finfish caught in the delta. In three West African estuaries members of the sardine family are also numerically dominant, representing 61-85% of catches (Baran, 2000). According to Van der Elst (1988) *H. kelee* is usually confined to coastal waters and breeding occurs from September-February when small shoals of adults enter the shallows to spawn. Juveniles of 2-4 cm enter lower estuaries 1-2 months later, remaining for 2-3 months before returning to sea. Sexual maturity is reached after one year, at 15-17 cm. This species attains 40 cm, but is commonly caught at 15 cm with 1½ - 3" mesh gill-nets. cursory observations indicate that most of the fish caught in the Rufiji Delta are either immature or have just reached the length of first maturity.

Unlike the prawn fishery, finfish catches are reported to be the same throughout the Rufiji Delta, but with clear season trends – the best months being between March and June, i.e. during the full wet season, when freshwater fish species dominate the delta. Traders of smoked fish at Mbongola confirmed that trade during the wet season months is the busiest, suggesting that the larger, freshwater fish move down into the delta area during the rainy season. Fishers from Jaja, on the seaward side of the delta, report that the "cooling" effect (and presumably freshwater input) from the rains, accompanied by the colder season to September encourages marine fish to move inshore. Catches during this period are dominated by 'mbarata' (see also Sørensen, 1989). With the "warming" of the delta waters, through greater input of sea water and less river flood, productivity is likely to drop and the marine species move slightly offshore, eventually beyond the reach of the fishers. With the onset of the wet season, the cycle repeats itself.

The Industrial Sector

The industrial prawn fishery has been monitored and managed with greater success than the artisanal fishery because of the following reasons: it is centred in Dar es Salaam, and therefore more easily accessed; there are relatively few vessels involved; and export earnings are significant to the country. Despite this, many aspects of the fishery of the Rufiji Delta are confusing and have not been well publicised. Some of these are described below.

Industrial prawn landings and fishing effort - Bwathondi & Mwaya (1984) describe the first experiments for commercial prawns by the East African Marine Fisheries Research Organisation (EAMFRO) in 1959 that prompted the introduction of industrial trawlers. About ten years later, a joint venture with Japanese investors, forming a company called New Mwananchi Ocean Products (NMOP) resulted in the first industrial focus on the prawn fishery of Tanzania. Prawn production soon reached 500 tonnes per year, declining to about 300 tonnes by 1972 when NMOP wound up activities. In 1976, Tanzania Fisheries Corporation (TAFICO) resumed trawling operations deploying nine trawlers. The early 1990's involved several private companies in the prawn business, with 14 companies involved by the mid-1990's, out of which nine were foreign-owned (Autrand & Carles, 1996). Production increased from about 1,000 tonnes in 1984 (with ten trawlers) to about 2,000 tonnes in 1988 (with 13 trawlers). Current production estimates are still of the order of 1,000 tonnes per year (see Bwathondi *et al.*, 2002), from 20 trawlers (under 500Hp) operated by 7-8 companies. In general, prawn catches are best in the early part of the season (March-July), around 500-800 kg per vessel per day, falling to 200-300 kg per day in July-November (Nhwani *et al.*, 1993; E. Toyer *pers. comm.*).

Presently, management measures include a season of 9 months, with December to February (inclusive) being closed season. Night fishing is prohibited, and transshipping outside of Dar es Salaam harbour is illegal. A system of on-board observers from the Division of Fisheries is in place with the observer's main responsibility to ensure that the vessel keeps to the allocated zone and that fishing is confined to daytime only. There are no catch quotas.

It is important to note that the trawler fleet includes vessels of various sizes, age and performance. Not all vessels operate throughout the year, with some being forced to abandon activities due to mechanical problems. The experience and fishing strategy of the trawler skippers are also certain to vary. Consequently, comparison of the fishing effort (number of vessels) and total landings, in order to obtain some measure of catch per unit effort (CPUE) is not appropriate. A measure of fishing effort such as standard fishing days (see Nhwani *et al.*, 1993) must be used instead. The accuracy of the data reported by the trawlers, in particular the size categories that indicate the maturity of the prawns is also very important, especially if these data are used to determine how much fishing effort should be engaged each year.

Nhwani *et al.*, (1993) argued that for the Rufiji Delta the maximum sustainable yield (MSY) proposed in 1988, based on 1,114 standard days fishing with nine vessels of 500Hp, was too high. They recommended that the number of vessels should not exceed nine (of 500Hp) and that the duration of fishing should not exceed 800 standard fishing days per year, equivalent to three vessels fishing for nine full months. This recommendation has received support recently from a study into the Rufiji (and Bagamoyo) prawn fishery commissioned by the Division of Fisheries (Bwathondi *et al.*, 2002). The latter authors calculated the MSY for the Rufiji Delta as 638.3 tonnes, and suggested that the exploitation levels of 60% should be the aim, i.e. a catch of approximately 383 tonnes, less than half of the current levels.

Fishing zones and water depth - The Government of Tanzania has divided the coastline into three fishing zones. Zone 1 extends from the Kenya border to Dar es Salaam; Zone 2 extends from Dar es Salaam south, to Ras Twana in the northern Rufiji Delta, and Zone 3 stretches from Ras Twana south to the border with Mozambique. The Rufiji District therefore, is part of two zones meeting at Ras Twana.

The fleet of 20 vessels is divided into 3 permanent groups of 6-7 vessels. Each group fishes each zone in turn, shifting to a different zone every month, hence during the course of the nine-month season each vessel fishes each zone for 3 one-month periods. With 6-7 vessels fishing each zone, a maximum of 14 vessels might be fishing off the Rufiji Delta at any time during the season.

Whilst fishing in a particular zone, vessels of that group are allowed unrestricted access to the zone, the exception being those areas in the north of Zone 1 that were gazetted as exclusion zones under the Tanga TCZCDP project. In any other area, vessels may, if they wish, legally fish right up to the beach – there being no exclusion zone set aside for artisanal fisheries operations. The draft of the vessels however limits their operations to waters more than 3 m deep, but it is acknowledged that, depending upon the time of the year and rainfall, better concentrations are found in shallower rather than deeper waters. Generally, most trawling is conducted at depths between 4-10 m though vessels do occasionally trawl in deeper waters.

General Operations - At the beginning of the season all vessels in the industrial fleet are allocated their monthly fishing zone rota, a system that ensures that every vessel gets an opportunity to fish all zones. The change takes place at the start of every month. The operational cycle of the trawlers is around a month, with generally 28 days out and a three-day turnaround. Vessels are able to process, package and freeze prawns on board. At each month's end they return to Dar es Salaam for off-loading, refuelling and restocking before proceeding to the next month's fishing zone. Depending on the productivity of each zone, trawlers may fish the zone for the entire month, thereby carrying their turnaround time into the next month and a different zone. Conversely, if the fishing is poor in a particular zone, the skipper may decide to leave the zone well before the end of the month so that after turnaround the vessel will be ready to fish on the first day of the next month in a different zone. During the night vessels may either travel or remain at anchor.

Spatial distribution of the resource - It is of particular interest to note that in a given zone there are several known "hot spots" where concentrations of prawns are likely to be found. The general geographic distribution of fishing effort in any one zone is reported to be concentrated on such known areas, with much of the zone being left relatively un-fished. In the Rufiji Delta area, these include an inshore area off Mchungu in the south of Zone 2 and another off Jaja in the north of Zone 3. At times when good prawn concentrations are found, a maximum of 14 vessels might be fishing along the shores of the Rufiji District: seven vessels off Jaja at the same time as seven vessels are fishing off Simba Uranga. Villagers met with in the present study, and those reported in Hogan *et al.* (1999), confirmed the regular presence of 6-7 trawlers off Jaja.

Trawler bycatch - Capture of incidental catch (bycatch) consisting of species that are not the target of prawn fishing operations is unavoidable. Operators maintained that typical bycatch landings were of the order of double the catch of prawns. Although it is difficult to make comparisons between different areas, this ratio appears low. In Mozambique for example, the prawn to bycatch ratio is estimated at 1:4, with other tropical areas being of the order of 1:6 or 1:7. Fishing trawler trials conducted by TAFIRI in 2001 found that prawns to bycatch ratio varied from 1:1.5 to more than 1:8, depending on the month (Bwathondi *et al.*, 2002).

Not all bycatch is discarded. Industrial operators in Tanzania treat bycatch as a valuable source of local currency and its sale covers operating expenses. It is therefore in the interest of a vessel operator to retain and sell as much bycatch as possible – discarding bycatch is a last resort. Companies reported that they had agreements with private operators based in Kisiju (north of the delta) who collected frozen bycatch from the vessels at sea, thus relieving freezer space without the need to return to Dar es Salaam. It is noteworthy that the trading of bycatch does not involve artisanal canoe-based collectors, as has evolved in other parts of East Africa (Mozambique, Madagascar).

Bycatch is sorted and that which is of commercial value is bagged and frozen on board. That of little commercial value (such as pony fish, hairtails), small prawns and other invertebrates is discarded, incurring high mortality. For Tanzania at present, a overall figure for bycatch discard is not known, but Nhwani *et al.* (1993) reported that about 28% of catches from prawn trawlers are discarded at sea. The proportion that is discarded varies from vessel to vessel, the smaller vessels retaining less on account

of limited on-board storage capacity and the obvious priority to fill freezer space with prawns rather than low-value finfish. The amount of discard is also likely to be affected by the season, the fishing grounds and catch rates at that particular time of the month. For example, bycatch discard is more significant when vessels are operating in zone 3 (southern delta), being too far from Kisiju to warrant collection by the private operators. However, even here vessels will still try to retain as much as possible, but will discard bycatch of commercial value should prawn catches be good and hold space become a priority. This agrees with reports from Jaja of bagged bycatch washing up on the beach – presumably discarded already frozen. It would appear that none of the fishers from Jaja are involved in supply or trade with the trawlers, as takes place of Kisiju.

Interaction with artisanal fishers - It is apparent that industrial fishing activity affects the artisanal fishery in the following ways. Firstly, the lack of any near shore exclusion zone implies that, in areas where prawns are close inshore, daytime artisanal fishing activities may be interrupted and there is a risk of physical gear conflict. Although artisanal fishers spoke of such conflicts and the destruction of gear, it appeared not to be a common event, and there was no record of the number of cases reported. Trawler operators reported that it happened “occasionally”, but because of the time lost in resolving the problem with the owner of the gear and that taken to clear entangled gear they would do their utmost to avoid such interactions. Secondly, discards of bycatch can have a negative effect on the inshore fishing and coastal environment. It may however attract and feed scavenging species such as crabs. Thirdly, in the immediate inshore zone both artisanal and industrial fishers compete for the same resource. In these areas, the legal framework and physical size of the industrial vessels result in artisanal fishers having only secondary access to the resources. Finally, in some areas, communities trade fresh foodstuffs and other goods with the trawlers whilst anchored at night, with evident commercial benefits for those communities.

The Government position - The position of the Division of Fisheries regarding interactions between the industrial fishery and other sub-sectors of the fishery is that there are no discernible negative effects. Reports had been received of gear conflicts and other problems but the aggrieved fishers had not managed to prove to the satisfaction of the Division exactly who was responsible. District fisheries officers however acknowledged that negative interactions did occur. Better identification of vessels, through mandatory display of clearly visible vessel identity codes would facilitate local policing and may appease local objection to trawlers. However, it is clear, and to a certain extent rational, that under present macro-economic conditions the Government has no choice other than to offer some level of support to export-orientated industries such as the prawn fishery, and it is not in the national economic interest to see these constrained. It is in the national interest that the prawn stocks of Tanzania are not harvested beyond their maximum sustainable yield, thus ensuring export earnings for the future from a productive and well-managed fishery.

With respect to the Rufiji District, the long-term productivity of the prawn industry relies on maintenance of the quality of the Rufiji river water (i.e. without pesticides or other pollutants), and of the nursery and feeding grounds in the delta and slightly offshore. It is likely that the trawlers adversely affect the latter, thus on environmental grounds a reduction in trawlers would be in the best interest of the District. Bwathondi *et al.* (2002) suggest that areas with water depth less than 5 m be set aside to protect stocks of juveniles. Revenues accrued to the District from the prawn fishery include those from taxes to the artisanal fishers and from taxes of transported prawns at the check-points. Again, a reduction in the activity of trawlers, accompanied by an increase in the number of artisanal fishers, and therefore of their landings, should benefit the District. A situation whereby artisanal fishers are responsible for managing their own prawn fishing grounds could also be an option for consideration, as currently being undertaken in Tanga. The present fishing relies on small nets operated from dugout canoes. One scenario that might be examined is that where the artisanal fishers are encouraged to upgrade their vessels allowing them to fish in deeper waters and in all seasons, thus reducing the need for trawlers. One final aspect on the artisanal fishery for prawns that must be carefully considered

regards the levels of hygiene and quality of the product. Autrand & Carles (1996) note that 80% of the artisanal catch is sold to exporters but that a great proportion of their catch is unfit for export. Currently there is a tendency for the European Community to tighten importation regulations on all sea food products. This development is particularly important to the Rufiji since the bulk of prawns from Tanzania are destined to European markets.

6.3 Promoting Fisheries and Environmental Issues

Local schools in Tanzania generally lack education aids and reference materials. The Rufiji District is known to have a lower education standard than most other parts of the country (Hogan *et al.*, 2000). Though environmental issues are slowly gaining footing in formal curricula, existing materials are scarce. We strongly support the development and distribution of resource materials for teachers and students. The WWF-Tanzania Environment Education Programme for example has produced a series of at least five schoolteacher aids since 1997, all in Kiswahili. These 50-odd page booklets separately cover the topics of climate, water, wildlife and general environment, with one on marine issues currently being printed. WIOMSA has produced a similar schoolteacher's guide to the marine environment, in English, that is also for free distribution. REMP could greatly facilitate the adoption of these, simply by assisting in their distribution to all District schools. In view of the fact that many teachers have difficulty with English and few have experience with such teaching aids, a more thorough approach would be the development of a formal programme for the introduction of these materials focused on the teachers. Such an initiative might benefit from the collaboration of other agencies that share the objectives of environmental education, such as the MMP.

In a recent consultancy to the District, Koffa *et al.* (2001) recognised the value of the distribution to villages of current REMP environmental information. They suggested that involving politicians and policy makers should augment the innovation. Use of tri-media (print, radio and video showing) was also recommended. Mbiha & Senkondo (2001b) further highlighted the need to incorporate educational campaigns and sensitisation whenever a new development is proposed. The need for a system of dissemination of environmental awareness was also identified at the second stakeholders planning workshop (see Karanja *et al.*, 2001).

The design and implementation of an education programme for the entire Rufiji District, as hinted at by Hogan *et al.*, (2000), would ultimately be the better solution to resolving some of the short-comings of the current education system. Such a programme could produce a dedicated set of materials and/or school activities that cover the broad themes such as district resources, ecology and trading systems. Design of appropriate environmental messages and materials should involve elders (influential members of the villages); government natural resources representatives; senior education officers; natural resource and environmental education specialists. The CARE-Tanzania project on Misali Island, Pemba, is also involved in the development of fisher awareness materials and activities from where some shared experienced would be useful. In addition, cross-visits by farmers and fishers, village chairmen and elders to their equivalents in the main villages of the Mafia Island Marine Park would contribute to widening the general resource knowledge. Such visits would provide ideal opportunity to discuss topical and sensitive issues such as reasoning for 'closed' areas, co-management and enforcement.

6.4 Research Priorities

In the late 1980's a detailed and broad research proposal to study and monitor various environmental and geomorphological aspects of the Rufiji River was prepared by a team comprising staff of the University of Dar es Salaam and of the Kunduchi Fisheries Institute. Most of the topics are still relevant. Some of them are duplicated below:

6.4.1 Bycatch

Only two studies on bycatch from the Rufiji are known (see Nhwani *et al.*, 1993 and Bwathondi *et al.*, 2002). These reports identify the problem, provide estimates of the ratio of prawns to finfish, and the species composition of the bycatch. Further work is needed to estimate the scale of the loss from discards and the amounts of bycatch that are sold. Future work, in collaboration with the trawler operators, fisheries authorities and TAFIRI, should be conducted to accurately define the scale of the problem and then if necessary establish some objectives for improving the situation. Such a study should be in the interest of all parties, operators, skippers, the artisanal fishers, and the long-term fishery for prawns and finfish. Examination of the need for turtle exclusion devices (TEDs) and fish-prawn separator devices (e.g. "Topgrid") could also be incorporated in such a programme.

6.4.2 Dugong populations

There is an important need to focus renewed research on the Rufiji Delta, especially around the villages of Pombwe, Jaja and the reefs of Mwamba makuu (in the SE) from where recent sightings and a recent stranding are reported (June 2000). In the southern delta off Jaja and Pombwe, around the reefs called Mwamba Mkuu fishers often see Dugong. Last year one stranded in a pool and was then caught and eaten. Ray (1968) noted that though he did not visit the Kilwa area, farther south than the above-mentioned spot, is known to be one of the last areas where the Dugong exist. The Mafia Island Marine Park staff have also received numerous recent reports of sightings, strandings and captures particularly from Koma Island, Ras Dima, Bwejuu Island, Simaya Island, Mbwera Pombwe and Somanga (C. Muir *pers. comm.*). These recent reports confirm that the Dugong continues to reside off the Rufiji Delta, but there may be only a hand-full of individuals, perhaps not even enough to form a viable population. There is thus an urgent need to collaborate with the wildlife authorities, fishers, tourism developers, MIMP and trawler skippers to safeguard the continued existence of this marine mammal in Tanzania.

6.4.3 Fisheries Data Analysis

Hopson (1979) recommended that a statistician advise the fisheries authorities of the District on how to upgrade the collection of fisheries statistics with suggestions for data collection at Kibiti checkpoint. The need for fisheries statistical support remains an important hindrance to understanding more fully the fisheries production of the District. Presently there exists a set of fisheries catch and effort data for the floodplain at the REMP offices that should be examined more closely. Cooperation with MIMP on marine fisheries issues and with other fisheries data initiatives e.g. DFID-supported RFIS project and the IUCN Fisheries Project, is strongly encouraged.

6.4.4 Production of maps

During the study the consultants were fortunate to be able to use a GIS-based map of scale 1:250,000 of the Rufiji District, produced by TANRIC (UDSM). This valuable resource should be developed further to produce a series of maps that can be used by the wider public and authorities. With new roads and the bridge soon to be completed, increased development and traffic is likely and the local demand for good maps certain to grow. The following three maps are suggested:

The Rufiji Delta (scale: 1:250,000 or 4 cm = 10 km)

To include the bathymetry of the Mafia Channel, the main prawn trawling grounds and the precise mangrove forest cover, settlements, navigation channels, tidal lines and freshwater influence. Possible inclusion of the entire MIMP in the map might also be considered. Sponsorship of the production of these maps might involve the trawler companies since the majority of their vessels are active in the Rufiji Delta, split between patches off Jaja to the South and off Simba Uranga and further north. Their participation would contribute valuably through the provision of geo-referenced depth data. Songas (the company installing the gas pipeline from Songo Songo to Dar es Salaam) may also be approached for support with the production of such a map since their presence in the District will certainly be felt

once work on the pipeline begins.

The Rufiji Floodplain (scale as above)

To include all lakes (temporary and permanent), the ‘usual’ and the ‘El Nino’ floodplain borders, roads, paths and channels, main land uses and settlements.

The Rufiji Watershed (scale 1:4,000,000 or 1 cm = 40 km)

A map that covers the entire Rufiji River watershed, all tributaries, land uses and settlements.

6.4.5 Genetic studies of prawn stocks

Studies into the genetic identity of the prawn stocks of Tanzania should contribute to a better understanding of the resource. For example, if a single stock were identified that extended over a large geographical area, the implication would be that the nursery function of the Rufiji Delta probably supports prawn populations beyond the present study area (and vice versa). Any management initiatives should be focused at the stock level. Such research is being undertaken in Mozambique at the Instituto de Investigação Pesqueira (IIP) in Maputo. The findings should be of interest to the industrial and the artisanal sectors. During the recent trawler trials conducted by TAFIRI in the Bagamoyo and Rufiji areas, samples of prawns were collected for genetic studies (Bwathondi *et al.*, 2002), however analysis has not been undertaken. Support to TAFIRI to conduct analysis of the material would provide the first results on the genetic identity of prawns in Tanzania.

6.4.6 Length frequency distribution of prawns

It is important that the length frequency for prawns caught in the artisanal (and industrial) fishery be examined to make recommendations on mesh sizes of nets. Presently the artisanal fishery seems to be contributing about 50% of the catches from the Rufiji Delta. This is caught mainly inshore in very shallow waters, where the bulk of the juveniles are to be found. A cursory examination of a beach-seine catch at Nyamisati revealed a substantial quantity of juvenile prawns, and the possibility exists that the artisanal fishers are negatively affecting recruitment of juveniles into the fishery. Austrand & Carles (1996) reported that over 50% of the artisanal catches are sub-adult. This could have repercussions on the stocks. These authors note that “fortunately their [the artisanal fishers] catch per unit effort is very much lower compared to large fishing vessels” implying that there may not be a serious impact on the resource. However, considering that there may be over 3,000 artisanal prawn fishers, the scale of the impact may have been overlooked.

In the recent trawler trials conducted by Bwathondi *et al.* (2002) in the Rufiji area, the majority of *F. indicus* caught had reached the size of first maturity, though the bulk of catches of *Peneus semisulcatus* and *Metapeneus monoceros* were immature. Detailed analysis of the industrial catches would therefore also be relevant to better understand the overall contribution of immature prawns to the catches from the Rufiji Delta.

6.4.7 Estuarine fish fauna

In a recent analysis of the biodiversity of tropical West African estuarine fish faunas Baran (2000) highlights the important contribution towards resource management made by knowledge of the fish fauna, its geographic specificities and its natural driving forces. For the Rufiji estuary, apart from being regarded as the largest single mangrove stand in eastern Africa, there is very little information on any of the above. Hopson’s research concerning the proposed Stiegler’s Gorge represented the first fisheries studies on the Rufiji River in 1979. He identified the resources and recommended that the lower reaches, beyond the Ndundu ferry crossing, and the delta fringes be sampled and the estuarine fauna determined. As far as we are aware, this has never been done.

6.4.8 Floodplain lake fisheries studies

In 1979 Hopson suggested that year-round biological studies of fish should be conducted on one of the floodplain lakes, identifying Lake Ruwe as a suitable example. His recommendation extended to identifying two additional lakes (in the “Internal Delta” of the Selous and on the main channel of the Lower Rufiji) for comparative purposes. The issues contained in his recommendations include importance of river recharge, seasonal changes in biomass and population structure in fished areas, and feeding and reproduction. Hogan *et al.*, (2000) also stressed the need to research the floodplain lake fishery, identifying fish species and recruitment as priority areas.

6.4.9 Freshwater shrimp taxonomy

Hopson (1979) thought *Macrobrachium* and *Caridina* were the genera for freshwater shrimp he encountered. All material collected was sent to Dr. D. I. Williamson of the Marine Biological Station, Port Erin, Isle of Man, for identification, with a report on their possible commercial importance to be prepared in due course. A follow-up during the present study revealed that there are no records, specimens or reports to be found at Port Erin. Dr. Williamson, now retired, does recall seeing, but not the identity of, the material. The identity of the freshwater shrimps therefore still remains to be ascertained.

7 Potential Enterprises for the Floodplain

Some of the existing fisheries of the floodplain and delta may benefit from enhancement techniques in an attempt to increase productivity. Welcomme & Bartley (1998) describe several enhancement practices, ranging from culture-enhanced capture fishery to intensive aquaculture. Many of these are adopted in a step-wise sequence that leads to a progressive increase in production per unit area. Yields increase from the most basic e.g. minimum stocking with a maximum of 1 tonne/year to several hundred tonnes per year under hyper-intensive systems of aquaculture (see Table 6).

Enhancement technique	Approx. Yields (tonnes/ha)	Type of system
Raceways	200-1,000	hyper-intensive
Cages	60-700	hyper-intensive
Completely fed + aerated ponds	12-110	intensive
Fertilised + fed ponds	10-70	intensive
Fertilised ponds	5-12	semi-intensive
Brush parks and pens	1-10	semi-intensive
Heavily stocked + fertilised (2,000-3,00 ha)	0.7-7	extensive
Extensive stocked unfertilised (500-2,000 ha)	0.1-1	extensive
Natural production + stocking (>500 ha)	0.1-1	extensive
Tropical natural production	< 0.1-0.8	natural

Table 6 Production from different fisheries capture systems (modified from Welcomme & Bartley, 1998).

As can be seen from Table 6 stocking is the first real step towards intensifying fishery production in order to elevate productivity. It is also the most widespread measure for management of inland fisheries in use today (Welcomme & Bartley, 1998). There are various issues associated with this application, ranging from types of stocking, origin of stocking materials, natural versus hatchery production, size of stocked material, dynamics of stocking and stocking rates. Fertilisation is often a requirement of stocking, especially where the stocked population exceeds the natural carrying capacity of the recipient water body, in the extreme leading to direct introduction of specially designed feeds. Elimination of unwanted species, the construction of multi-species faunas of selected species (polyculture), modification of the environment (to improve shelter, feeding and breeding grounds), cage culture of target species, and genetic modification are additional management interventions.

In the context of the lower Rufiji floodplain, where fish ponds are barely present, the development of stock production facilities (preferably driven by the private sector) seems unlikely in the short term, it being considered better to first create the demand. The recommendations that follow are all associated with the improvement or development of fisheries productivity in the floodplains. The existing fisheries were briefly described in section 3 and have been more carefully described by others (Hopson, 1979; Sørensen, 1989; Turpie, 2000). The recommendations presented here specifically focus on developing activities that are realistic given the constraints of poor communications, access and general lack of funding prevalent in the area.

The field visit in November 2001 found for the first time the practice of excavation of shallow ponds in natural depressions to trap and culture catfish. The promotion and improvement of this practice is suggested. The field visit also included a visit to a site where a single concrete pond is being used to culture tilapia fish. Again, the promotion and development of this practice is supported. A cross between the catfish ponds and tilapia fish culture would be a new practice to the area whereby an extension of existing lakes is dug to trap and culture fish as the lake recedes. In the resulting 'finger ponds' a mixed (or polyculture) of fish is nurtured with agricultural pursuits on the raised land in

between. Finally, the introduction of brushwood parks or (“Acadja-enclos) to existing water-bodies is a tried and tested technique for boosting fish production in West Africa and its application to the Rufijij floodplain seems natural.

7.1 Expansion of Catfish Ponds

During the field visit to the delta village of Twasalie a detailed description was provided by the villagers of a practise not known from any other sites in the District. Four dug ponds were visited from where the villagers of Twasalie trap and grow the African air-breathing catfish *Clarias gariepinus* (‘kambale’). This was the first time that this activity had become known to the REMP staff, despite this village being one of the four pilot villages in the District.

The ponds of Twasalie are dug in naturally low-lying areas of the plains, as evidenced by the presence of marshes, where catfish probably accumulated as the flood receded (see Plate 9). The first pond was apparently dug by a villager from neighbouring Msala village, but on Twasalie land. It is thought the African Fishing Company prawn farming initiative may have influenced the concept. During the dry season, the villagers from Twasalie, in groups of three six men, take a week to dig a pond, using poles as levers to remove clods of baked mud.

Plate 9 One of 12 excavated ponds in the Twalasie flooplains used for the culture of catfish *Clarias gariepinus* or ‘kambale’



At present, there are reportedly 12 ponds, each between 20-40 m in diameter (ca. 700 m²), of 1-2 m depth in the centre, scattered over an area of floodplain. By the end of the wet season in June, when floods have receded, the ponds will be the only areas holding water, and fish. The bulk of the fish that accumulate in the pond are the catfish *Clarias gariepinus*. In the Rufiji area it is considered the species of highest commercial value (Tamatamah, 1994). In northeast Nigeria a similar practice exists whereby villagers dig ponds on the floodplain of a specific river to retain water and fish as the annual flood recedes (Neiland & Ladu, 1997).

Indications are that production from each pond is high, with as many as 20,000 small fish (or "straight fish" that cannot be bent before being smoked) and 15,000 large fish (easily bent onto the pectoral spine) reported to be harvested each season. Conservative estimates based on calculations of larger fish weighing 300 g and 'straights' weighing 100 g produce a yield of about 50 tonnes/ha/yr from a pond of 40 m diameter. This production rate ranks as 'intensive' (see Table 6) and is equivalent to fertilised or fed ponds. It was estimated that production from the 12 ponds contributed 50-60% of the freshwater fish landed in Twasalie. The number of fishers (or farmers) involved was not clear but indications were that at present between 40-60 men participated in the activity. Involvement required some casual labour to dig ponds and several weeks of focused attention during harvest and processing.

Harvest is usually conducted in October, when the ponds eventually dry out, unfortunately when prices for the product are reported to be low. All fish collected are smoked on site over temporary, very basic kilns. No feeds are added, but the floating Nile Cabbage (*Pistia* spp. 'Kiyungiyungi') may be added to the pond to reduce evaporation from the surface and create shade for the fish. It was claimed that extracted soils were too salty for agricultural use.

The villagers noted that female catfish bear up to 5,000 eggs at the end of the dry season, producing fingerlings in November/December. In Nigeria *Clarias* spawns throughout the year but Ayinla & Nwadukwe (1992) demonstrated that maximum egg production occurred during the wet season, with a yearly production ranging from 11,900-37,600 eggs/kg body weight.

Villagers claim the rights to the pond by digging the area and continuing to use it. There exists no formal procedure of requesting land from the village government.

Social and Cultural Issues

The culture of grow-out of catfish in dug ponds has existed in Twasalie for three years and seems to be well accepted, therefore no social reasons are predicted for not going ahead. However, the pond-makers were cautious of publicity or large-scale experimentation by outsiders reminiscent of the problems associated with the African Fishing Company conflict. Theft was also reported from ponds where no supervision was provided and temporary housing was constructed nearby to reduce this risk. Potentially there is an increase in the breeding of mosquitoes and thus increase of malaria vectors.

Financial Issues

The main and single cost associated with this activity is labour costs. Opportunity costs of the land used are not known but likely to be low. Opportunity costs for the labour is also low since the ponds are dug once during the dry months (July to December) during which period the labourers (small-scale farmers or fishers) may find the time on an *ad hoc* basis. In Uganda, it is known that the opportunity costs of farmer's time may be highly variable during the course of the year (Jagger & Pender, 2001). On the Rufiji floodplains the main harvests are completed by June, therefore labour is likely to be readily available for pond digging.

Policy Support

Favourable government reaction to this activity is expected.

Environmental and Resource Issues

Minimum negative environmental consequences are predicted, as the areas are likely to be very small in comparison to the floodplains. Possible effects on local populations of amphibians and reptiles that regularly use the marshy areas of the floodplains and certain reed or marsh plants may be negatively impacted through the digging of ponds. If this practice can be more widely applied, it will contribute positively to biodiversity through reduction on pressure of natural fish stocks. There is an element of risk associated failure of floods to provide the natural replenishment of brood stock, hence the need for careful site selection.

Market Characteristics

The already established market for smoked catfish would absorb the production.

Technology and Skills Requirements

Expertise is available in Twasalie village and throughout Africa this catfish has been reared for almost 20 years with mixed success. TAFIRI is conducting trials on this species around Mwanza, and there is a vast literature on the fish, culminating in an FAO manual by de Graaf & Janssen (1996) on its artificial reproduction and pond rearing techniques in Sub-Saharan Africa.

7.2 Expansion of Tilapia Pond Culture

This title for this section could have been “development of tilapia pond culture”, except for the fact that within the Ikwiriri environs this practice is already underway, originating from a national radio programme many years previously. The headmaster of a Islamic secondary school for boys at Mbagala Charambe, close to Dar es Salaam, inspired 4-5 years previously by a radio programme on tilapia farming, travelled to Morogoro to obtain fingerlings that he introduced to his four purposely-dug ponds (see Plate 10). Rice bran and general wastes are added and ducks use the ponds. In 2001 the headmaster decided to expand the culture to a subsidiary school in Ikwiriri where a concrete pond (5x12m) was constructed where soils would not hold water. Local fish were tried but failed to survive and the tilapia species originally obtained from Morogoro are now used (see Plate 11). No data on production rates were available.



Plate 10 One of four fishponds of the Mbagala Charambe Secondary school, close to Dar es Salaam

It is not sure who provided advice for the use of concrete, however for small-scale community-based the emphasis should be to propagate earthen pond culture technology to encourage natural production in ponds.

Experimental work with tilapia in freshwater ponds started in Tanzania during the early 1950s (e.g. Talbot & Newell, 1957; Bailey, 1966). Wilkinson (1984) describes how in the early 1980's in the southern Tanzania districts of Mtwara and Lindi, a British-funded project attempted to resuscitate a long disused 8-pond complex at Mahiwa. The first stocks of 80 *Tilapia melamopleura* fingerlings were obtained from the FAO Agriculture Project at Morogoro and 650 *Oreochromis (Sargocentron) niloticus* were imported from the Bamburi fish farm north of Mombasa.

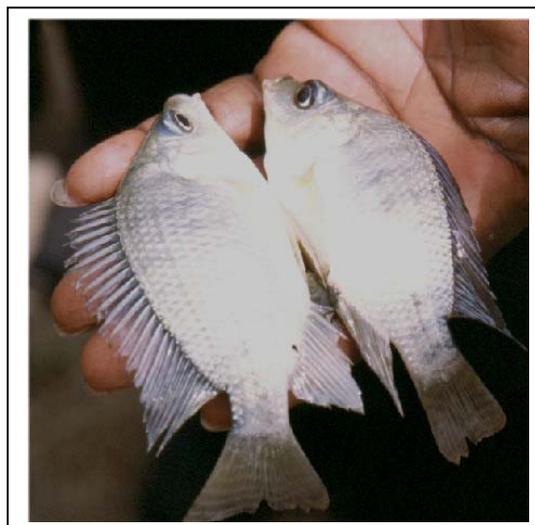


Plate 11 Unidentified tilapia species from the ponds at Mbagala Charambe Secondary school, close to Dar es Salaam

O. niloticus is known to grow from average stocking size of 1-3 cm to 25-30 cm in 6-7 months. The average yield after 6 months from a pond of 0.75 ha with feeding was 1.4 tonnes, equivalent to 3.7 tonnes/ha/yr. A flock of 25 ducks were also established (using the local Muscovy duck *Cairina moschata*) having two useful functions: increasing primary productivity and decreasing the *Bilharzia* vecting snail endemic to the area. The analysis concludes that tilapia culture is well suited to village conditions in East Africa and that it should be supported and encouraged, since it produces animal protein direct to the community reducing their distribution costs. By far the most widely used and popular species of fish for culture in Africa are the tilapia, of which at least 31 species have been tested with, in order of most widely used: *Oreochromis niloticus*, *Tilapia rendalli*, *O. macrochir* and *T. zilli* (see Balarin, 1988). The main problem of these tilapia species is that if left uncontrolled, the pond soon becomes overpopulated and the fish become stunted.

Even the use of tilapia species in more brackish or even full strength seawater has been shown to be profitable (on a trial basis). Of 301 juvenile tilapia (40-80mm length) from freshwater stream on Zanzibar stocked into a shallow marine pond (0.2 ha) behind mangroves, after six month a total of 248 fish were collected, with the majority being over 120mm (Talbot & Newell, 1957). They also found that of the original stock, about 27% survived and had reached the weight of about 200g. One interesting intruder to the system was *Chanos chanos* the milkfish that on harvesting the pond yielded about 500kg. Despite this positive outlook, and perhaps because of the lack of proper management and use of inappropriate technology, the majority of the ponds constructed in Tanzania during 1960s through 1990s have turned out to be mostly non-productive (Mafwenga, 1994).

Possibly the most recently-documented example of fish farming in Tanzania is the SIDA/FAO project at Morogoro (from where the fish in Plate 11 may have originated). Between 1993-96 that initiative aimed at developing semi-intensive fish farming techniques and extension packages for small scale farmers (Wetengere *et al.*, 1998). It is regarded as being partially successful and involved 40 farmers, constructed 47 ponds of average area 154m² and introduced the practices of stocking, fertilising and feeding the ponds. A team comprising an aquaculture specialist, a fisheries biologist and a socio-economist led the activity. Between them they succeeded in establishing the adoption of the improved fish farming technology without the external financial assistance. The programme also found that although fish farming proved to be more profitable than other farming activities, the level of priority given by the farmers and the adoption rates were low. Lessons learnt from this initiative are likely to be directly relevant to the situation in the Rufiji District.

The involvement of the private sector in the development of this enterprise is seen as an important condition for success, rather than government-led facilities that have a history of un-sustainability. In northeast Nigeria for example, the government-led management intervention, building a hatchery to provide fingerlings to pond farmers, never took off (see Neiland & Ladu, 1997).

Yields from existing ponds elsewhere in the country are still very low; nonetheless, the socio-economic impact at the community level is quite significant since tilapia provide high protein food and cash income (TCMP, 1999). Success with tilapia culture is due to several factors, including the requirement for a relatively low level of technology. Despite availability of good sites for pond culture in the Rufiji floodplain and delta, there has not been any development in this direction, with the exception of the single concrete pond in Ikwiriri described earlier. Hopson (1979) recommended, with some urgency, the long-term pilot project of fish culture in the lower Rufiji Basin, identifying sites at Mkongo and Ikwiriri for pilot fish farms. The urgency of that recommendation was related to the construction of the dam and the drying effect that it would have on the floodplain lakes, recognising that the fish supply to the human population of the floodplains would be severely affected. Despite the dam never being built, the needs of the present human population, 22 years later, may be well served by the development of this activity in the floodplains. We believe this enterprise should be encouraged, with investigations into sustainable, non-destructive, low impact aquaculture.

Social and Cultural Issues

At first, there was no enthusiasm due to lack of familiarity but villagers are interested in learning more about this activity. The main risk associated with tilapia pond culture is theft, as with the catfish ponds above, and other fish farming initiatives (e.g. in Tanga, J.C. Horrill *pers com.*).

Financial Issues

Access to finances by local communities is a major constraint for development of pond culture. However, it should be pointed out that initial investment is not expected to be high for small-scale farming based operations.

Policy Support

The Government has specifically stated interest and support for this activity (URT, 1997); the recently published guidelines are reinforcing the Government's support to aquaculture.

Environmental and Resource Issues

Some environmental impacts include water quality deterioration, loss of biodiversity caused by harvesting of wild stocks as a source of seed. However, the development of extensive systems of production at the community level poses fewer problems to the environment. Experimentation with species that naturally occur in the floodplain (e.g. *Oreochromis urolepis*) should be the first focus, avoiding the introduction of "foreign" species that may work themselves into the river system with unforeseen environmental consequences (cf. Nile perch in Lake Victoria). The use of the "foreign" species in the concrete pond at Ikwiriri should also be examined more closely. Adequate water supply is critical. Careful site selection should help mitigate many risks e.g. flooding or drought.

Market Characteristics

Tilapia is highly acceptable in local and urban markets. The villagers are familiar with the marketing of the species (see section 4.1).

Technology and Skills Requirements

The technology involved in the production of tilapia ponds is relatively simple and easy to understand. Natural seed is usually easily available, and labour and capital costs are low. Expertise is available in various parts of Tanzania and neighbouring Kenya, and numerous manuals and guidelines are published that should assist with some of the basic issues associated with site selection, water quality

management, fertilisations and feeding.

7.3 Development of Fingerpond Polyculture

Fingerponds utilize innovative extensive/semi-intensive fish production techniques to provide additional protein in the dry season. Ponds are dug from the landward edge of wetlands and extend like fingers into the swamps. Soil from the ponds is heaped between to form raised beds for cultivation (vegetables, etc.). Seasonal flooding of wetlands will concentrate natural fish stocks in the ponds. As the water recede, trapped fish can be cultured in the ponds enriched with natural organic wastes (e.g. kitchen waste, manure).

The fingerponds idea has developed from flood retreat farming and flood-based fishing practices found in many seasonally-flooded areas such as the Sudd (Howell *et al.*, 1988) and Lake Chad (Sarch & Birkett, 2000). Those systems are described as semi-intensive: ponds are normally stocked from aquaculture fishpond sources and water levels are controlled. By contrast, in the system proposed for Rufiji, changes in water levels are left to nature and fish from local populations become self-stocking during flood retreat. Fish culturing will be based on polyculture techniques used in SE Asia and the Pacific Rim with nutrient enrichment from kitchen waste such as banana skins and organic wastes such as cow, chicken or duck manure from village compounds. Essentially, this system optimizes fish production by subsistence agriculturists.

Social and Cultural Issues

Though fingerpond is a “new technology” it is expected that local floodplain farmers or fishers will adopt it because the technology is based on aquaculture and agriculture principles. For example, agricultural wastes (from the raised-bed cultivation) are used to fertilise the ponds, and soil from the ponds is used to enrich the raised beds. The acceptance of this technology by the local communities will depend on adequate extension services. The enterprise is vulnerable to theft of stock from ponds, as with the previous pond culture enterprises described above.

Financial Issues

Fingerpond technology will involve digging of the ponds using family labour, hence keeping financial investment low. Natural stocking of fish (as with the catfish ponds, section 7.1) also implies that there is no expenditure on seed procurement.

Policy Support

The same positive response to tilapia and catfish pond culture applies to the fingerpond activity.

Environmental and Resource Issues

Environmental impacts from fingerponds are expected to be very benign because of the minimal human interference with the natural environment. If the technology can be successfully applied, it will contribute positively to biodiversity through alleviating the pressure on natural fish stocks. Lack of (or poor) seasonal flooding are considered to be the main risk elements associated with the fingerpond polyculture development, as with the catfish ponds, and to a lesser extent tilapia ponds.

The siting of ponds should be preferably located in the floodplain or at the riverine ends of lakes. This is the where the villages are generally located, thus there are benefits in surveillance against theft, and this is also where access to roads is best, thus facilitating delivery of agricultural goods (as feeds) and marketing of products. By contrast, the higher ends of the lakes are often marshy with water lily beds and thus naturally protected from fishing. Such areas should be left undisturbed as they are important to fish nurseries, as wildlife drinking areas during the dry season, and important for resident and migrant birds.

Market Characteristics

The existing markets for fresh or smoked product, as with catfish and tilapia ponds, are predicted to readily absorb the new production.

Technology and Skills Requirements

As mentioned earlier (see Social and Cultural section above) the technology, though “new” is not complicated. Fingerpond technology combine and exploit traditional ecological knowledge practised by riparian communities in Africa with current agro-piscicultural developments. Site selection is critical – success depends on flooding regime, good soils, and presence of fish in the floodwaters and availability of manure.

7.4 Brushwood (or “Acadja-enclos”) Fishery Enhancement

The brushwood or acadja method for enhancing fisheries has been widely used in lakes and lagoons in West Africa, particularly in Benin (Konan 1988), and can generate significant improvements in yields. The principle is to set dense masses of branches in shallow water, which initially attracts fish from the surrounding lake. This results in a short-term population gain of about 1 tonne/ha after approximately 2 months. In well-managed acadjas, the population may increase exponentially over the following months, reaching a maximum of typically 5-10 tonnes/ha after about one year, but with yields of up to 21 tonnes/ha recorded (Welcomme 1972). These gains are thought to result from initial immigration of wild fish to the brushwood refuge, followed by growth and reproduction within the protected population. Thus the enhancement technique, when used over a short period of time (2-3 months), can be considered simply as a fish trap or a fishing gears, being reliant on attraction and capture. However, when utilised over a longer period of 6-12 months, acadja may act as culture systems with breeding, propagation, natural feeding and growth taking place prior to capture.

Once the fish in the acadja are breeding, emigration may enhance the fish population in the lake. In an experiment to test the efficacy of the acadja-enclos versus non-enhanced lakes, a ring of closely-set bamboo poles of 12 m diameter, was filled with bundles of 1-1.5 m branches (each weighing 8-12 kg). After 12 months the yields from the enhanced lake was eight times greater than that from the normal lake (Hem, 1992).

A variety of acadja systems have been developed, but in general they all require a water depth of 1-1.5 m, a mud bottom that can hold branches and shelter from currents. The type of wood used varies, depending on local sources, but generally, thin branches of 1-2 cm diameter, up to 2-m lengths are ideal. Branches are bound together, with twine or vines, into bundles of 10-20 kg. Simple small acadja, comprise single isolated circular (5-14 m diameter) structures with stronger hardwood branches typically used for the outer framework, with finer soft-wood branches used for infill. Such systems are relatively cheap to construct and may be built and managed by individual fishers. Larger acadja require considerable investment in construction and in maintenance with about 50% of the brushwood being replaced each year. This maintenance may be done after fishing, during which the enclosure is encircled by a net, the brushwood removed and fish harvested. Production methods have been developed in Côte d'Ivoire, in which brushwood is replaced by bamboo poles and nets surround the enclosures to prevent larger fish from emigrating. Greater productivity may be possible to the owners of such a system, as more fish are retained in the enclosure, though there may be less benefit to the surrounding fishery. In some places bamboo poles are split and stuffed with manure then bound together, acting as a slow-release fertiliser.

Acadja may also be used in floodplain lakes. For example, in northeast Nigeria the local fishers make a large circle of cut branches with the permission of the village head in a floodplain specific lake that forms after the peak flood. Fish take refuge here from predators and poachers. No fishing is allowed for two months until the head organises a fishing festival for invited fishers only (see Neiland & Ladu,

1997). In this case, the acadja may be considered a fish aggregating device rather than a resource enhancement technique.

Social and Cultural Issues

The successful development of acadja fisheries methods in the Rufiji will require their acceptance by all users of the lake resources, to reduce potential for conflict and poaching.

In the western end of the Lower Rufiji floodplain the lake used by the fishers of Mtanza-Msona is reported to be subjected to overfishing, annually being “fished out” (Hogan *et al.*, 2000). The latter study also documented that in the past, the villages commanded some rights over the fisheries of the lake, with arrangements for closing the fishery for specific periods (see also section 6.1). Situations such as these may be the best suited for the development of acadja fishery enhancement clusters. Whatever the sites selected for such a development, investigations of the options for the creation of village by-laws to formalise the ownership and use of the acadja-enhanced lake is strongly recommended.

Financial Issues

The main investment costs are the labour for collection of brushwood, construction of the enclosures, maintenance and purchase of nets. These can be considerable, beyond the reach of individual owners, and some form of village-level participation is likely to be required. Depending on the actual level of investment and the productivity of the systems used, a pay-back period of 1-2 years is likely.

The cost of branches needs to be investigated as this could vary considerably. For example, sites close to areas where natural forests have or are already being cleared might provide branches at no cost. During the study visit, it was observed in many places that piles of thinner branches (such as those suitable for acadja) were being burnt to clear the land for cultivation, with trunks and thicker branches being presumably used for timber and charcoal or fuel wood respectively. In such situations, transportation to the lake may be the main cost. Other possibilities are in areas where forests are managed and periodic branch thinning takes place, producing quantities of branches that are too thin for other uses. The options for supply of brushwood has a direct bearing on the main environmental concern – the clearing of existing forests (see below).

Policy Support

Favourable government reaction to this activity is expected.

Environmental and Resource Issues

Experiences in West Africa suggest that there is relatively little impact from acadja systems in the aquatic environment, except for potentially increase sedimentation around the enclosures. There may also be some impact in terms of encouraging population growth in herbivorous fish species. The greatest potential for negative effects is in encouragement of brushwood cutting in the area around the lakes. This would need to be considered in the context of existing cutting of timber, and the status of forest resources in the lakes region (see financial heading above). This should be done in the context of environmental impact assessment, undertaken prior to development of any acadja-fishing project.

Market Characteristics

Market access for freshwater fish species, including the tilapias that predominate in acadja systems, already exists in the Rufiji.

Technology and Skills Requirements

Introduction of acadja or brushwood enclosures to the Rufiji will require the expertise of a specialist with experience of the development of such systems elsewhere in Africa. It is strongly recommended that development of a pilot project should be initiated by seeking advice from such a specialist.

8 Potential Enterprises for the Delta

Recognising that the preservation of fish with wood smoke is so vital to the delta, and the floodplain, the first wide-reaching recommendation is to improve the fish smoking techniques in use. Similarly, the fishery mud crabs (*Scylla serrata*) already exists but on a small scale. The development of this fishery is supported. Fishing for large neritic fish species such as jacks (carangids), barracudas and kingfish are considered under longline fishing gear development. The exploitation and marketing of alternative timbers such as coconut wood is proposed as is the argument for the encouragement of environmental and cultural tourism in the District. Finally, the development of associative enterprises and the supply of seafood to the Selous Game Reserve lodges are synthesised.

8.1 Fish Smoker Improvements

As discussed in section 4.16, the use of improved smokers could improve the value of catch to the fisher, reduce fuel-wood consumption and reduce post-processing losses. The most well known improved smoker is the Chorkor kiln, originating in West Africa (Fig. 9). Recently there have been some successful attempts at its introduction in Nampula Province in Northern Mozambique, but apart from this, its use in East Africa is not common. The kiln consists of a 2 x 1 m smoke chamber made from baked brick walls about 0.6 m high. The chamber has two stoke holes and may be divided into two by an internal wall to allow for processing of smaller quantities of fish. Fish for processing is placed in mesh bottomed trays on top of the smoke chamber, and these may be stacked up to 6-8 trays high. Variations on the trays include racks from which fish are hung either individually or in bunches.

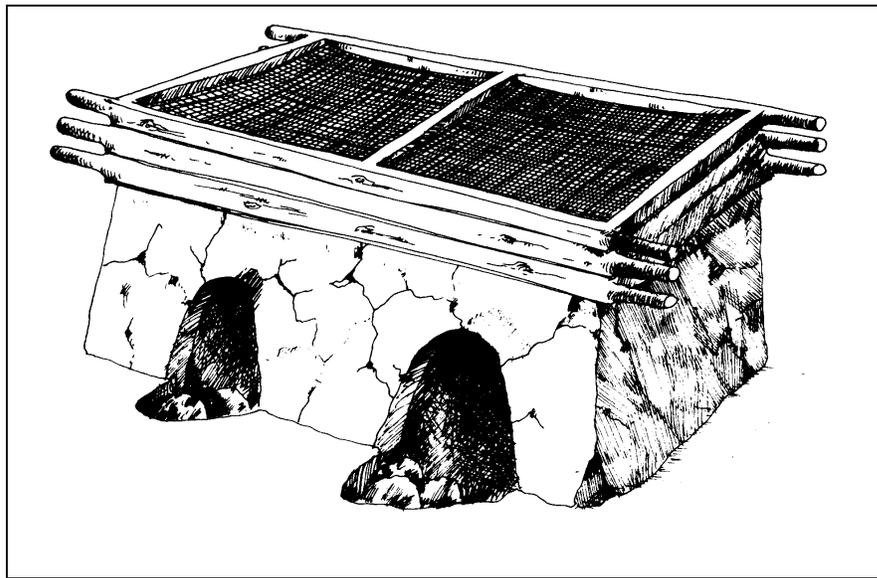


Figure 9 Chorkor kiln or smoker, as used in West Africa (source: UNIFEM, 1993).

The effect of the kiln is to concentrate smoke and heat on the fish, reducing the fuel-wood requirement, and improving uniformity of drying. The kiln can be equally used for processing of shrimp as well as fish, the former only requiring the placing of open weave mats in the drying trays. On the negative side, the kiln needs investment in burnt bricks, some maintenance and periodic replacement of the drying trays. As a result of this, such kilns are better suited to more permanent landing stations and fishing camps where a consistent supply of fish can be guaranteed. In Mozambique the introduction of an improved kiln based on the Chorkor design has been successfully facilitated by the organisation of group operation and ownership of the kiln (see section 8.7), thus reducing individual capital outlay and ensuring consistent use of the kiln.

Social and Cultural Issues

Socially the use of the Chorkor kiln is relatively neutral – as with the traditional kiln, it can be operated by one person and reduced smoking times have been recorded. There is less labour requirement for the sourcing of fuel-wood. The most significant social difference is that the Chorkor kiln would represent a fixed asset and may therefore become a target for non-participating investors, whereas the current kilns all appear to be owner-operated and are not considered a significant investment.

Financial Issues

The investment requirements for the Chorkor kiln are about 95,000 Tsh per kiln. This is considered a maximum price and may be reduced should the processor build his/her own shelter, fire his/her own bricks or even use shorter-lived unbaked bricks. The main item that needs to be purchased is the wire mesh, locally known as ‘kashati’. This diamond-shaped mesh grill is widely used for rat-proofing windows in Tanzania and is expected to be available in main villages in the District where it is likely to retail for 4,000-5,000 Tsh per roll (1.2 x 2.4 m). The investment costs of the Chorkor kiln are estimated to be about 3 times that of the traditional kiln, which may even be built at no monetary cost should the owner collect the wood and complete the construction him / her self.

The financial viability of the kiln is very sensitive to utilisation, the cost of firewood, and the achieved improvement in fish value over the traditional kiln. For low intensity usage (200 loads of 40 kg (fresh weight) per year) in an environment where firewood could be obtained at no cash cost, the kiln must be able to increase the ratio of first:second grade fish from 75:25 to 93:7 to be viable (see Anon, 1997b). However, in the coastal communities the cost of a canoe-load of firewood is around 1,500-2,000 TSh, enough to smoke a ‘tenga’ (around 10,000) of ‘mbarata’. Under these conditions the kiln must be able to increase the ratio of first:second grade fish from 75:25 to 90:10 to be viable over the traditional kiln.

Should the operator be able to achieve 97% first grade fish, net return (including depreciation) per day of usage (return to labour per day) would rise from around 5,800 Tsh to 6,200 Tsh. With more intense use of the kiln (more loads / day or more operating days per year) net return rises rapidly - with 300 loads per year, returns per day rise from 8,700 (traditional) to 10,000 Tsh (Chorkor). In areas where firewood has only very small real cost, the financial incentive for adoption of an improved smoking kiln will be very limited.

Policy Support

The promotion and use of improved post-harvest technology is specifically referenced in policy statement 4 of the National Fisheries Sector Policy and Strategy Statement.

Environmental and Resource Issues

Use of the Chorkor kiln would have a positive environmental impact through the reduction in demand for fuel-wood for fish smoking. Over the traditional kiln, the Chorkor should reduce the consumption of fuel-wood per kg of fish smoked by a factor of 2.5. The working environment of the ‘mchomaji’ would also be improved through reduced exposure to heat and smoke. One possible constraint would be problems of raw material supply. Should the processor not be able to achieve sufficiently improved quality or fail to get access to a sufficient quantity of fresh fish, then the kiln will not be financially viable.

Market Characteristics

The market for smoked fish is well established and the product from the Chorkor kiln would not differ significantly from the better quality smoked fish produced by the traditional open smoker. Hence the marketing of the product from the kiln is not considered to be a problem, and would not require new market development.

The market for the kiln itself however requires some examination. As indicated above, the kiln is most

suited to areas with one or both of the following characteristics:

- a consistent and high level of production of fish.
- poor local availability / high local cost of fuel-wood.
- a primary market for smoked fish that discriminates (through price) between good and poor quality.

It is very possible that the use of a kiln at a seasonal fishing camp (be it on a lake or on the coast) would be possible, especially if the structure could be protected from degradation during the non-fishing season. However, the kiln would clearly not be suitable (without some modification) for use in areas subject to tidal influence, such as Kibanjo.

Technology and Skills Requirements

The technology required to construct a Chorkor kiln is clearly both suitable and accessible to fisher communities. The required materials and skills are all available locally in fisher communities. However, one risk associated with the kiln is related to operator skill, reduced by adequate training.

8.2 Expansion of the Mud Crab (*Scylla serrata*) Fishery

As described in section 5.5 indications are that the Rufiji Delta crab fishery is operating at low levels, with outputs of 34 tonnes per year (Turpie, 2000) but with the potential for much more (Siegel, 1986). In southern Java, the Segara Anakan mangrove estuary, an area of 90km², supported a fishery for crabs with an average of 22 tonnes per month (Wasilun, 1991). The Java fishery involves between 164 and 354 fishers each month using baited lift-nets and bamboo box traps, catching on average 3.5 kg and 4.5 kg respectively per day, with lift-net fishers fishing on average 24 days per month and trap fishers 17 days. Based on the Java estimate the yield for the Rufiji Delta could be of the order of 124 tonnes per month. Current yields from the Rufiji Delta are probably between 2-3 tonnes per month, with a maximum of 36 tonnes per year, though there is seasonality in the fishery, thus the average monthly catches could be on the lower side of this range. Nevertheless, the potential to increase the catches of this resource is recognised and we support the development of this enterprise.

Social and Cultural Issues

In terms of labour, organisation, gender, acceptability, both men and women in the delta are already participating in crab fishing. Development of the trap fishery using boats would probably be a male preserve, but there is also potential for expansion of women's involvement especially in the collection of crabs by hand, on foot at low tide.

Financial Issues

From interviews with fishers in the delta, current prices for mud crabs paid by traders is relatively low (about 300 Tsh/kg or US\$ 0.3/kg). However, exporters in Dar es Salaam are buying crabs from middlemen at between 680-1,500 Tsh/kg (US\$ 0.76-1.75/kg), depending on size. The price paid by traders to fishers may increase once the market demand for crab in the delta develops. There is also scope for increasing the value of the catch. According to traders, fishers often collect soft-shelled crabs (up to 30% of catch), which are of little value because they have recently moulted and have a low meat content. The value of these animals may be increased by short-term holding in floated cages or pens, while the shells harden followed by a period of feeding to increase meat content.

Hand collection of crabs is very low-capital enterprise. Therefore, although the price of crabs may be lower than that for prawns, there is no entry barrier to the fishery in terms of investment in boat and nets. Catches may not be so great, but this fishing method is accessible to both women and men, and could therefore be a supplementary household income in addition to prawn and 'uduvi' fishing. In Mozambique, intertidal hand-collection of crabs is largely an activity of women.

Introduction of traps should also be considered, thus prawn fishers could also take up this more efficient fishing method. As most prawn fishing takes place on neap tides, there may be scope for fishing for crabs using boats, during spring tide periods, providing an additional source of income to prawn fishing households. The cost of traps will need to be determined based on most appropriate design and materials. Roberston (1989) using box traps in experimental fishing in Natal, recorded yields of up to 17-23 crabs/trap/day in areas of relatively high crab abundance and for traps that were emptied regularly during the day. Of course, one of the critical steps in the development crab fishing in the Rufiji would be to estimate crab abundance and potential yields in experimental fishing. However, if similar yields can be achieved then economic returns from crab fishing might approach those of shrimp fishing (15 crabs @ 500g = 7.5 kg, @300 Tsh/kg = 2,450 Tsh/day). This return might be further improved by higher prices through improved market access and product quality. There is demand for high value female crabs in Asia. However, exploitation of females presents potential conflicts with sustainable management of the fishery and should not be encouraged. In Australia, landing of female mud crabs is illegal, and there is a minimum landing size for males (150 mm-carapace width). Implementation of such regulations in the Rufiji would require the co-operation of exporters.

Policy Support

At the District, village and national levels, diversification of fisheries would be consistent with the development priorities expressed by villages in the delta, and at the District level. Expansion and diversification of fisheries is a priority identified by the Fisheries Division proposal for the Rufiji. Sustainability of the crab stock, and measures to avoid over-exploitation, would be a concern that must be addressed, especially in the context of any proposed change in conservation status of the delta.

Environmental and Resource Issues

In general, crab fishing should have a low environmental impact. Specialised gear such as traps and collections by hand are highly selective. However, extraction of crabs from burrows amongst *Rhizophora* trees by axing roots and digging will need to be discouraged. Without effective management of a developing fishery, it is likely that the crab population will come under increasing pressure from fishing. In other countries overfishing has resulted in declining crab landings and smaller maximum sizes (Le Vay, 2001).

The lack of reliable crab stock assessment in the delta needs to be addressed, though it is felt that there should be a large exploitable resource. Preliminary stock assessment over at least one annual cycle (and then on-going) is required to ensure that the crabs abundance will support greater exploitation. This should include seasonal variation in catches and both hand and trap fishing. Once the level of exploitation is established, some level of management of the fishery (e.g. size restriction, limitation of landings of females) through co-operation with buyers and exporters will be an essential component of sustainable exploitation of the crab resource.

Market Characteristics

While there appear to be an opportunity for expansion of crab fishing in the delta, and fishers have said that they would fish more actively for crabs if there were a market, buyers in Dar es Salaam claim that they require more secure supplies of higher quality and greater volumes. Lodges in the Selous also require supplies of seafoods such as live crabs (see section 8.6).

Along the coast south from Dar es Salaam crabs are currently being bought from traders who visit mangrove areas, usually those nearest the roads (Kisiju). The traders either motivate a few fishers to join them collecting, or organise their own teams. Crabs from the delta are usually sold to traders who may transport crabs by boat to Kisiju and then on by road to Dar es Salaam.

Assuming that stocks proved to be sufficiently large to support greater exploitation, development of

crab fishing in the delta will require a project in the delta, working in cooperation with buyers to improve consistency and quality of the supply to the market. This may require investment in a holding facility in Dar es Salaam, allowing exporters to accumulate larger shipments, and ensuring high meat quality. At the same time, fishing techniques need to be proved and introduced in the delta, and small-scale low-tech holding systems introduced to fishers or middlemen.

Technology and Skills Requirements

At present crabs are collected by simple hand collecting from burrows at low tide, using a stick. They also may be caught occasionally in prawn gill-nets, and are caught in fixed fish traps. Specialised traps are not presently used. This form of fishing requires very little training.

In established mud crab fisheries elsewhere, a variety of specialist gear is used including baited lift-nets, baited box-traps, collapsible box-traps, gill-nets, baited gill-nets, drag-nets, baited bottom set longlines, and fyke-nets. For the selection of fishing methods appropriate to the Rufiji Delta, a phase of consultation with fishers and experimentation with traps made with locally available materials would be necessary. Making and use of traps or other specialised fishing gear would require some initial training, but this likely to be very quickly assimilated by experienced fishers.

One area that would require training and extension is the development of techniques for holding crabs. Most likely, this enterprise would be undertaken by traders, who would act in a similar way to the shrimp buyers' middlemen. Floating cages or small pens in intertidal mangroves could be used to hold animals until sufficient numbers were accumulated before transport to Dar es Salaam. The quality of crabs declines rapidly if not fed during holding, a problem identified by traders in Dar es Salaam. Consequently, training in feeding techniques would be required. As the value of crabs is determined in part by meat content and moult stage, traders would also need to learn techniques for determining if a crab has recently moulted or is about to moult. As the trade in crabs in for live animals to Asia, it seems likely that holding cages in the delta and a holding facility in Dar es Salaam (perhaps owned/operated by exporters) will be required. Such facilities will ensure that quality and consistency of supply are maintained, thus encouraging exporters to develop the market.

8.3 Expansion of Longline Fishery for Large Neritic Fish Species

Although the delta fishery is by no means “unimodal” it does exhibit a surprising lack of diversification, especially with respect to resources outside of rivers and river mouths. The most common gear being small meshed gillnets for catching prawns and ‘mbarata’.

Demersal (bottom-set) longlines are known but not very widespread and their use is confined to shallow protected estuarine or riverine waters. The neritic resources such as kingfish, queenfish, trevallies and barracudas both in and outside the estuary are little fished – some fishers use handlines (‘mshipi’) and a few ‘jarife’ gill-nets exist. It is considered that an inshore fishery for these larger estuarine and near-shore neritic species may be viable with surface set longlines. It should be possible to set and haul such longline gear from a canoe, although this will evidently limit the amount of gear that can be used. Due to the experimental nature of such a fishery, it would be necessary to embark upon a controlled period of trials before supporting its promotion on a wide scale.

Social and Cultural Issues

The social implication of the promotion of a mid-water longline fishery is considered neutral. The fishery would generate similar levels of employment per vessel as other methods, it being possible to fish in sheltered waters and small amounts of gear with one person per canoe, but two persons would be required for larger amounts of gear or more distant fishing grounds.

Financial Issues

The viability of a mid-water longline fishery must be viewed in the context of the most accessible alternative opportunity costs, namely the prawn fishery. From the outset it is evident that the existing market for fresh prawns will make it unlikely that such an alternative fishery will be as lucrative and with such a secure market. However, with reported increases in the number of fishers engaged in the prawn and ‘mbarata’ fisheries, and the reported decrease in individual catches (probably as a result of the latter) the attractiveness of alternative fisheries is likely to improve, if only on a part-time or seasonal basis.

Data collected during the survey indicate a net return per day in the prawn fishery of 8,200 Tsh (US\$9.11) of which around 80% (US\$7.6) is due to prawn and the remainder ‘mbarata’ bycatch. This appears to be of the same order as the estimates made by Turpie (2000, Table 64), but it should be noted that when the crew size is taken into account, returns to labour estimates are half or less than this, making Turpie’s estimates appear very high.

The mid-water longline with an estimated mean catch of 3 larger neritic specimens per 100 hooks per day would produce a net return of only around 2,500 Tsh (US\$2.8). Should it be possible to operate the vessel with one person, then the return to labour may be acceptable. With a crew of two however, the operation would not be economic. It is interesting to note that based on financial criteria alone the longline appears to be quite a sound investment.

Item	Prawn net		Longline ⁸	
	TSh	US\$	TSh	US\$
Capital Investment	80,000	88.8	57,000	63.3
Daily Maintenance and Replacement Costs	1,008	1.1	522	0.6
Net Return per Operating Day	8,192	9.1	2,478	2.8
Net Return to Labour	4,096	4.6	2,478	2.8
Capital Investment per Employee	40,000	44.4	57,000	63.3
Internal Rate of Return	>1000%		>400%	

Table 7 Comparative prawn gill-net versus longline performance indicators.

The lower investment requirement makes the longline gear of potential interest to less capitalised operators, especially considering the significantly lower operating and maintenance requirements (see Table 7). Both fisheries require a 40,000 Tsh investment in canoes, but of the remaining investment, longlines require only 30% (17,000 TSh) for gear, compared to 50% in the prawn fishery. This may also make it of interest to fishers as an alternative source of income, for use when either the prawn fishery is at a seasonal low for that part of the coast or when the prawn market is inaccessible due to the absence of a collector vessel. Smoked or salted and dried fish can be stored and transported inland to the markets along the main road (see Market Characteristics below).

The levels of investment are not significantly different from other fishing methods, with the advantage over prawn gill-nets of lower maintenance costs. The technology remains therefore accessible to owner operators – an important aspect considering that ‘tajiri’ (businessmen/ investors) and other external financiers are likely to maintain the focus of their investments on the established and known prawn industry.

Policy Support

Although current fisheries policy does not contain any specific statement related to diversification of resource use, the promotion of a mid-water longline fishery is considered to be in keeping with policy

⁸ based on an estimated catch of 3 fish per day, observed market conditions for such fish, purchased bait and a single 200 hook longline.

statement 4: “encourage the use of environmentally friendly fishing technologies and gear”.

Environmental and Resource Issues

Artisanal longline fishing gear is considered to have a limited negative environmental impact, the gear being selective by nature (dependent on the choice of hook size and where it is actually set). Thus the capture of juveniles is unlikely. In this respect, longlines are more environmentally favourable than small-mesh gill-nets.

The most significant environmental concern relating to the promotion of neritic fisheries is the resource itself. The lack of knowledge and experience of the resources presents the principle risk to this enterprise. It is unknown whether the fishery will in fact be viable (hence the need for trials), and what scale of effort may be sustained by the resource. There are some specific dangers associated with particular stocks such as that of barracuda which is known to enter river estuaries during part of the reproductive cycle but, although barracuda is present in the area, it is unknown as to whether the Rufiji plays an important role in its biology. In general, however neritic resources, especially migratory species, are less susceptible to excessive fishing effort by artisanal fisheries compared to stocks of more sedentary, demersal species.

Of the assemblage of neritic fish species, many tend to be seasonal, exhibiting radically different abundance and catchability throughout the year. Not only is the seasonal variation in the delta area unknown, but also such variability has implications for fisher livelihoods, requiring the identification of complementary economic activities for any low season. The problem of processing during the wet season presents a possible risk that if proven to be unsurpassable would imply the curtailing of mid-water fishing during that period.

Market Characteristics

The market for products from a neritic longline fishery presents some problems. As indicated in section 4, the national market is dominated by smaller species, and mid-water longlines will fish larger species. A market for larger species exists, predominately in Dar es Salaam, but the links with that market are significantly less well-developed in the delta than those for prawn and smaller fish. They do however exist, and the development of a longline fishery would need some parallel activity to improve relevant marketing linkages. At an early stage it may be necessary for the fisher to take an active part in marketing, taking his product to Kibiti, Kimanzechana or even as far as Dar es Salaam itself. The sale of large fresh fish might be possible depending on the demands of the newly renovated fish processing plant on Mafia and on the development of a fish processing plant at Kilwa.

Technology and Skills Requirements

Mid-water longlines can be made from material that is readily available in the larger towns near the delta such as Ikwiriri and Mohoro. Major items include polyethylene rope for the headrope, hooks and heavy monofilament for snoods (droppers). In the absence of suitable monofilament, polyethylene can also be used for the snoods. Other items such as floats, sinkers and anchors can be improvised locally. Although no particular skill is necessary in the construction of the gear, the specifications such as snood pitch and length, depth of set below the surface etc. will require some tuning to suit target species, tidal phase, time of day, etc.

The gear has particular applicability in the delta as, in limited quantities, it can be used from a canoe, and does not require investment in a ‘mashua’ (larger wooden planked vessel). In addition, the abundance of locally caught ‘mbarata’ will serve as a good source of bait. The use of an outrigger-canoe (‘ngalawa’) might be deemed necessary and add to overall expenses.

Fish will probably require salting and sun-drying, a technique which is both well known and well practised, especially in the southern delta (Pombwe). It is worth noting that final product quality is

influenced by salt quality, and the securing of a good supply of salt will be important. This commodity is also regularly available locally. During months with high rainfall and ambient humidity (see Fig. 3), March – May, salting and sun-drying will be more difficult and it may be necessary to develop alternative techniques such as smoking. This may however result in a new and unknown product whose acceptance by a market that is quite conservative in nature may be problematic.

8.4 Coconut Timber Exploitation and Pit Saws

Koffa *et al.* (2001) draws on the few studies conducted so far that examine the research on timber use in the Rufiji District, focusing on the four pilot villages (Jaja and Twasalie in the delta, and Mtanza-Msona and Mbunju-Mvuleni in the floodplain). They describe for each of these the existing tree-growing regimes and make recommendations for improved management including the possible use of alternative tree species as well as selecting existing stands of native trees for commercial management. The findings of Koffa *et al.* (2000) suggest that farmers depend almost entirely on the forests to meet their firewood, timber and non-timber product needs with none or little management but resorting instead to extractivism as an approach to obtaining timber products. Their recommendations include the suggestion that farmers improve management regimes for the existing cultivars of the five species of greatest commercial importance (Oil palm, Coconut, Cashew, Banana and Mango). These trees all produce fruits or seed products, and none can be are generally regarded as trees for timber use.

Of the trees and their uses listed for each village, the only ones that were identified as being of use for timber/furniture are shown in Table 8. A total of 22 species of tree are identified, three of them being mangrove trees. Interestingly the coconut tree was not included in the species of use for timber or furniture. In both Jaja and Twasalie the only tree species that was used for timber or furniture encountered was *Albizia versicolor*, and in both villages all are “retained” trees.

In light of the absence of any local tree being used for timber and furniture the suggestion presented here is to develop the use of coconut wood in the delta. The longer term benefits of planting relatively fast growing timber trees such as *Tectonia grandis*, *Casuarina equisetifolia* and the lowland bamboo *Oxytenanthera abyssinia* (‘mwanzi’) might also be entertained.

Turpie (2000) described coconut production as being concentrated in the delta, with the multiple uses of the tree and its products. Her data indicates that 15% of households in the delta produce coconuts. However, evidence of the use of coconut timber was not found in the present study. Sørensen (1998) notes that coconut wood and two species of mangrove trees, *Xylocarpus granatum* and *Heritiera littoralis* (or ‘msikundazi’) are used for the construction of window and door frames. She also mentions the fact that though coconut coir rope, while used in the delta for tying roof thatch (coconut palm shingles called ‘kiungo’) and stringing for beds, it is imported from Mafia Island. Indeed, the coconut plantations on Mafia are vast compared to those on the few islands in or near the delta where coconuts are cultivated.

Sørensen (1998) mentions an unidentified disease that has devastated most coconut trees on some islands. During the present visits evidence of a disease or pest was noticed among the tallest trees, particularly in Twasalie village, where the bases of the trees appear to be eaten away by boring pests. Some trees however were also devoid of the palm crown though the bases seemed unaffected. Possibly there are two different agents at work. Hogan *et al.* (1999) report on disease among the coconut trees of Mbwera Mashariki in early 1999, suggesting it might be a viral disease carried by the Rhinoceros beetle, “depleting the standing tree numbers at an alarming rate”. In Twasalie the fallen trees appear to be left to rot on the ground, with no or little interest in the use of the timber. Removal and or destruction of the diseased trees may be an approach to reduce the pest presence. The eastern portion of Jaja Island is largely a coconut plantation, with a mixture of mature and middle-size trees. There too, no use of the timber was apparent. On the beach area of Simba Uranga coconut trees are common and

many have fallen due to beach erosion - the trees left to rot on the sand.

Scientific name	English name	Local name	Jaja	Mtanza	Mbunju
<i>Sonneratia alba</i>	mangrove	'mlilana'	√	-	-
<i>Xylocarpus granatum</i>	mangrove	'mkomafi'	√	-	-
<i>Avicennia marina</i>	mangrove	'mchu'	√	-	-
<i>Albizia versicolor</i>	Poison-pod albizia	'mtanga'	*	-	-
<i>Tectonia grandis</i>	Teak	'mtike' 'msaji'	or **	-	-
<i>Dalbergia melanoxylon</i>	African blackwood	'mpingo'	*	√	**
<i>Azelia quanzensis</i>	Lucky-bean tree	'mkongo'	*	√	*
<i>Pterocarpus angolensis</i>	African teak	'mninga'	-	**	**
<i>Albizia lebbek</i>	East Indian walnut	'mkenge'	-	(*)	-
<i>Terminalia catapa</i>	Indian almond tree	'mkungu'	-	*	-
<i>Azadirachta indica</i>	Neem tree	'muarobaini'	-	*	-
<i>Eucalyptus</i> spp.	Gum tree	'mkaratusi'	-	**	-
<i>Syzygium giuneense</i>	Waterberry	'mzambaru'	-	**	-
<i>Brachystegia bussei</i>	Large-leaved brachystegia	'myombo'	-	**	-
<i>Sterculia africana</i>	African star chestnut	'muuya'	-	**	-
<i>Brachystegia spiciformis</i>	Bean-pod tree	'mtondo'	-	-	√
<i>Erythrophleum africanum</i>	na	'mpangapanga'	-	-	**
<i>Kigelia africana</i>	Sausage tree	'mundundu'	-	-	**
<i>Bombax rhodognaphalon</i>	Wild kapok	'msufi'	-	-	**
<i>Erythrina melanacantha</i>	na	'mnyamabela'	-	-	**
<i>Swartzia madagascariensis</i>	Snake bean tree	'msekeseke'	-	-	**
<i>Milicia excelsa</i>	Mvule	'mvule'	-	-	**

Table 8 Tree species used for 'timber' or 'furniture' in the survey by Koffa *et al.* (2001)

Note: √ indicates presence, * less abundant, ** scarce; na not available.

In general the use of timber from coconut trees has not been widely adopted in Tanzania mainly because the wood is extremely hard and thus wearing on the saw used to cut the planks and on the planer used to smooth plank surfaces. Additional hard woods such as 'mvule' (*Milicia excelsa*) and 'mninga' (*Pterocarpus angolensis* or African teak) are by comparison softer to work with and continue to be available, despite the prices for these hard woods continuing to rise as the mainland forests from where they are extracted become depleted. In the delta, and probably the floodplain villages, the low cost of mangrove poles probably provides little incentive to develop alternative timber sources. The relatively low human populations and low local demand also means that the visible effects of timber extraction in areas where forests are seemingly inexhaustible have again provided little impetus to search for other materials.

Coconut Timber Use on Zanzibar

On Zanzibar the use of coconut timber is perhaps greater than it is anywhere else in Tanzania. During the years of Arab rule, massive coconut plantations were established and presently there are several millions mature trees that were planted in rows in fairly accessible locations. Most of these trees are over forty years old, of reduced productivity in terms of the production of coconuts and palm fronds, of consequently of lower value than younger trees. There is therefore in Zanzibar some incentive to remove the tall trees. The widest use of the coconut logs ('gogo') is as fuel for lime kilns. In addition to this use as fuel wood, the wood is also roughly hewn and used as a general timber in roofing joists, particularly in the poorest and most remote villages of Unguja (e.g. Kigomani) where the mangrove pole alternative is not locally available. In the early 1990's a donor-funded project (BBB) promoted the use of coconut wood and associated carpentry skills. This created a limited market for the additional coconut wood products, mainly furniture and doors. For the last five years the demand for

high-density timber has been strongly promoted by a single carpentry workshop (ScanZa) that produced high quality furniture made from coconut wood.

One main difference between coconut timber and other local timbers is that the coconut log varies in wood density within and along the trunk. This is due to the fibrous nature of the timber. A mature, approximately 40-year-old African Tall coconut yields three 12-foot (3.5 m) logs ('gogo'). Beyond the bottom 36 feet (10 m) towards the palm crown, the timber becomes too soft to be of use. The base of the tree for about 2 (60 cm) feet must also be neglected for similar reasons.

Across the trunk, the outer portion is extremely hard, referred to as 'high-density'. Planks of 'medium-density' and 'soft' wood are cut from the central portion of the log. The central portion is soft and pithy and consequently of little use as a wood (see Fig. 10).

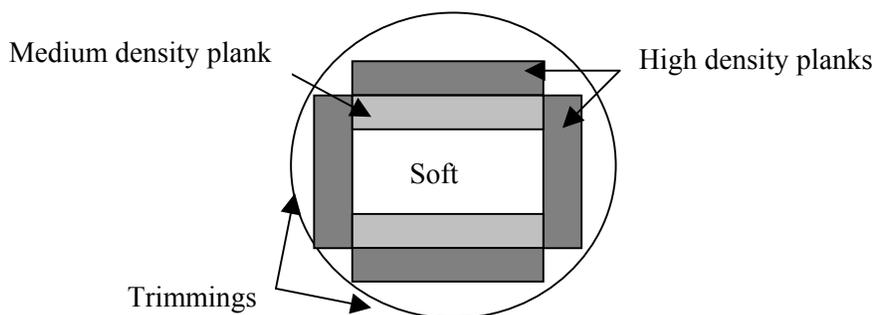


Figure 10: Schematic cross-section through a coconut log showing the outer high-density, medium-density and soft wood portions

Typically a 12 foot log is cut into a series of 6"x1" planks. Thicker planks, of 2" can also be cut. Cutting of the timber is best done when the tree is recently felled, as the drying wood becomes harder over time. The planks most usually obtained on Zanzibar from a typical coconut log are four high-density planks, two medium-density planks, two soft planks and four trimming planks (Fig. 10). Narrower logs provide only two high-density planks instead of four. Additional miscellaneous fees and costs include the cost of tree on site, the Forestry Department permit to cut the tree and the fee to village chief ('sheha') = 1,900 Tsh. Plus, cost of felling tree (1,000 Tsh), rolling logs to vehicle (250 Tsh), clearing access area for vehicle (19,000 Tsh) and transport (25 logs 18,000 Tsh). On Zanzibar, the sale price for high density is 3,500 Tsh, for medium 2,000 Tsh, soft 1,100 Tsh and the trimmings sell for 300 Tsh a piece.

Unlike other trees the different densities of the wood resulting from coconut trees allows a range of uses. The high-density planks are generally equivalent to the present alternatives provided by regular hard woods ('mvule' and 'mninga'). These include furniture, window and door frames, windows and doors, beds, floors, plus a variety of smaller products from lamp bases to egg cups. Medium-density planks are more prone to fungus and insect pests than the high-density planks, but nevertheless the timber is used in ceiling joists and doors. The main use of the soft-density portion is planking for bed slats or as pin boards and backing to dart boards. The curved trimmings, being extremely hard sections are widely used for fencing on chicken pens, fencing and house walls. The sawdust has been successfully used for smoking fish.

Cutting logs requires a team of two men ('mpasuaje') (see Plate 12). The top cutting pairs normally cut a single log in a day. The less experienced take two days to cut a log. On Zanzibar the cutting teams are paid simply to cut the timber. They are involved in the supply of logs, transport or the trade in the cut

timber. The primary coconut wood-cutting centre on Unguja is the village of Zingwe Zingwe. Here 40 woodcutters, mainly temporary immigrants from Tabora and Shinyanga Regions are engaged in 20 saw pits. Of the 2-3 varieties of coconut trees present on Unguja, the most common and suitable for timber extraction is the 'African Tall'.

On Jaja no timber sawing takes place. This is presumably the same on Twasalie. Furniture is also not made from coconut timber. Instead, planks of other species are purchased for making large sailing dhows 'jahazi' mostly, with some small usage for household frames. Timber is imported via Mohoro from Kilwa or from Rufiji District's woodlands. 'Mninga' planks are probably only 20% of the timber bought, due to unavailability, 'mvule' being more common.



Plate 12: Pit saw coconut cutters in Zingwe Zingwe, Zanzibar.

Social and Cultural Issues

The only social considerations are the interactions between the cutting crews with the local community. On Zanzibar this has not been a problem, and in villages like Jaja and Twasalie the social interaction may have beneficial spin-offs. If local villagers adopt the skills then the latter interaction ceases to exist.

Financial Issues

The materials needed for six months of operation include an 8 foot saw (45,000 Tsh), four metal files ('tupa' = 1,000 x 4 = 4,000 Tsh), miscellaneous ropes (5,000 Tsh), totalling 94,000 Tsh. The saw can be used for six months after that is not good for coconut wood but can be used for other softer timbers. Ropes are needed to secure the pit frames, secure the log to be cut onto the frame over pit and, when dipped in ink, mark the cutting lines. A small curved saw called a 'biringo' is used to cut the tree and the logs, costing 18,000 Tsh.

With one log cut every two days, a cutting team of two men, working for 20 days per month would cut ten logs, producing 40 high-density planks, 20 medium-density planks, 20 soft planks and 40 trimming planks (from four trees). Cutting fees on Zanzibar, depending on wood density, are 100 Tsh per foot for high density, 600 Tsh per plank for medium density and 500 per plank for soft. Thus a high density ten foot 6x1" plank costs 1,000 Tsh to cut.

Comparative costs for the Rufiji Delta are difficult to measure. Certainly the costs of alternative, traditional hard woods are cheaper since they are more readily available than on Zanzibar. For example, prices on Jaja for 'mninga' are reported to be approximately 3,500 Tsh for a 12x1" ten foot plank, and 2,500 Tsh for the same measurements in 'mvule'. Given that the coconut plank is half the width, its comparative cost is thus slightly more than 2,000 Tsh, accepting that cost of the tree, felling the tree and any village fees will add a little. Costs for transport and land clearance are not likely to be high on Jaja. The result is that the coconut plank is marginally cheaper than the 'mvule' and certainly cheaper than 'mninga'.

Policy Support

The position of the State on timber cutting is not known, but is unlikely to act against a small-scale saw industry focusing on coconut timber usage. The practice was encouraged by the government on Zanzibar in the mid-1980's and such support is also expected from the mainland authorities.

Environmental and Resource Issues

The amount of mature, old, less-productive coconut trees needs to be ascertained before the development of coconut timber usage. There is no risk of cutters removing immature trees since the timber is not appropriate, however there is always the risk that cutters begin targeting species of trees that are ecologically important or endangered. The cutting is conducted during the dry season thus, vagaries of the wet season do not affect the enterprise. The removal of older standing coconut trees, especially diseased trees, and the planking of already fallen trees, will be of direct benefit to the pilot village.

Market Characteristics

The local market within the delta region would primarily absorb the resulting timber. Canoe transport would be adequate and cheap for transport within the delta thus making the timber available to enterprises that require construction and furniture wood supplies that are cheaper than the imported hardwoods from southern Tanzania.

Technology and Skills Requirements

With the existence of many (illegal) pit-saws in the Rufiji District, there would be no need to import the technology from the Lakes region, though transfer of the knowledge to the interested villagers of the coast (e.g. Jaja or Twasalie) might be appropriate. This enterprise can take on two forms: the local community be trained in the skills needed to cut timber; or, the demand rise to the point that the skilled cutters visit on a seasonal basis and work for a local business person who coordinates the operation. Support for a demonstration site may assist both development avenues.

8.5 Development of Environmental and Cultural Tourism

The attractions of the Rufiji floodplain and delta have not to date been marketed by the tourism industry and its potential is not fully exploited (Karanja *et al.*, 2001). There is great biological interest and cultural heritage of the District, including the following:

- Some of the tallest and best-developed mangrove forests in eastern Africa, much of which remains in pristine condition.
- The presence in the upper reaches (and in some lower areas) of hippopotami and crocodiles.
- A presence in the lower reaches of at least one species of dolphin and the Dugong.
- The presence of at least two species of marine turtle, both nesting in the area.
- Unrivalled bird life. A recent study by Nasirwa *et al.* (2001) provided data that ranks the Rufiji Delta as a Globally Important Bird Area, and as a wetland of international importance for two reasons: the total number of waterbirds recorded, and the presence of internationally significant populations of at least seven shore or seabirds. In December 2000, they observed 40,000 waterbirds of 63 species.
- Nearby presence of coral reefs on Simaya Island.
- Good sport-fishing opportunities.
- A range of extensive and diverse fisheries, providing rich and exotic seafood.
- A short distance (25km) from the Mafia Island Marine Park.
- The presence of two World War I wrecks (the Somalia and the S.M.S. Königsberg, though the latter is no longer visible).
- The probable site of one of the oldest coastal civilisations in eastern Africa, the city of Rhapta.

Turpie (2000) recognises the opportunities for local involvement in partnerships with the private sector to develop tourism facilities in the floodplain and delta. She comments on the fact that some Selous tourism operators for example do occasionally take guests on trips to the delta. During this study no evidence of this activity was found. Nevertheless, the impressive biodiversity, scale and uniqueness of the delta and the floodplains are likely to be attractive to the tourists sector. The recommendation whereby the private sector is approached and encouraged to develop the industry is endorsed here, particularly, the development of low-impact, environmentally sensitive and culturally interested tourism initiatives. Potential tourists would have to be made aware of the adventurous nature of such a delta experience so that expectations are satisfied.

Since there is an existing tourism industry based in the Selous, it is unlikely, at least initially, that the floodplain area can offer much competitive difference in terms of the wildlife viewing and wilderness, thus the main focus of this potential enterprise is on the coast. The coastal village of Jaja is considered to be one of the possible sites, as are the villages along the northern delta (e.g. Simba Uranga and Kibanjo). At Kibanjo, the village chairman expressed a definite interest in tourism development. The initial stages of development of environmental and cultural tourism might be the establishment of a semi-permanent accommodation facility on the beach areas of these sites. Local involvement with logistics, activities, tours and food supply would be strongly recommended. One of the activities that would be particularly well-suited to environmental, low-impact, tourism development is sport fishing (see Box 3).

Box 3. A note on sport fishing

The demand for good sites for tourism sport fishing exists, both from the six lodges inside the Selous Game Reserve and from the main tourism centres of Dar es Salaam, Zanzibar and Arusha. Hopson (1979) explains that sport fishing is poor on the Rufiji River because of the turbid nature of the water and catches being limited to catfish on baited lines. Predicting an increase in water transparency both of the river and the lake created by the impoundment of the river (as a consequence of the proposed Stiegler's Gorge dam), he suggests that tiger fish will provide good sport. The presence of this species in the various floodplain lakes needs to be confirmed.

For sport fishing, the District can be divided into two main areas, lakes and river, and the delta. With respect to the Rufiji floodplain the only possibility of developing such an industry would be to ensure that certain portions of the Rufiji River, or better still, specific lakes, were not fished. This would only work with the support of the local community. Such exclusion areas would allow the resident fish populations to flourish and the target species to grow to the large sizes that industry demands. Freshwater species of interest that can be caught with hook and line, based on Hopson's notes, include various large catfish species, the tigerfish (*Hydrocynus vittatus* 'kange') and several tilapia species. In the delta areas the species described under the longline fishery (see section 8.3) would also be viable candidates for the sport as would a fish called 'kumbasi' reported to occur in the area (provisionally identified as the tripletail (*Lobotes surinamensis*), known to be a particularly good sport fighting fish).

Social and Cultural Issues

Depending on the tourism that develops, there may be some minor social conflicts over dress, particularly that of female tourists. The involvement of a social anthropologist is recommended at least in the initial stages of development.

Financial Issues

The private sector would bear most of the costs, and as a result, most of the profits. Some profits would likely accrue directly to local partners or associates. The employment of local staff and the purchase of foodstuffs would directly benefit local inhabitants.

Policy Support

Such a development is seen as being totally in agreement with the Government's policy of encouraging tourism enterprises in new areas, especially if the emphasis is on the environmental and cultural tourism market.

Environmental and Resource Issues

Environmental and cultural tourism developments would also lend support and encouragement for conservation, at least in the target areas. Educational tours and trips for tourists are likely to improve the local community's recognition of the value of their biodiversity and environment. On the negative side, the presence of biting sand-flies, several day-biting mosquito species in addition to those that transmit malaria, poor supply of freshwater and the poor hygiene (e.g. with seasonal presence of cholera) need to be considered by tourism developers and the partner villages. Potential problems of sewage and rubbish disposal and the effects of motorised boat traffic on the environment must also be recognised.

Market Access

This would at least initially be externally directed. The existing tourism activities in Selous and on Mafia are likely to provide the main thrust for any further development in the Rufiji District (floodplain and/or delta). The risk of market failure (i.e. negative tourism publicity for Tanzania) is beyond the control of the national tourism industry.

Technology and Skills Requirements

There may be the need to provide considerable assistance to local partners or associates, for example with advice in negotiating contracts with the private investors, as well as in the preparation of food and improvements in hygiene. Some introduction to the culture of tourism might also be appropriate. Lessons learnt from Zanzibar and other areas would be usefully transferred. The private sector is however likely to provide most of the technical assistance needed.

8.6 Supply of Seafoods from the Delta to the Selous

At present, four tourism lodges are located at the eastern end of the Selous Game Reserve, close to the western border of the Rufiji District. They are mostly scattered along a stretch of the Rufiji River, for about 70km, all of them on the northern bank. The lodges are, with increasing distance from Mloka village: Rufiji River Camp, Mbuyu Camp, Selous Safari Camp and Sand Rivers (see Fig. 11). Most of the lodges operate between July through February, closing for the wet season months of March through June. At peak tourist times, especially between the months July and August, a maximum of 100 odd guests could be staying at these lodges each night.

The lodges require constant supplies of fresh vegetables, fruits, rice, meats and fish. Since there is no official cultivation, stock keeping or trade of foodstuff inside the Selous Game Reserve, purchases are made outside. The lodges situated to the western extreme are within 35km of the Fuga Halt railway station on the TAZARA line from Dar es Salaam to Zambia. These lodges obtain some or all of their produce from the railway station settlement or through supply lines that use it. The two eastern lodges, closer to the Rufiji District of Mloka, tend to purchase their foodstuffs from Dar es Salaam, via road and air. During peak season, almost 70 guests and managers may be residing at these two lodges.

Mloka is a large village that engages in some market gardening and fruit cultivation, though quantities produced are insufficient to meet the demand from the lodges and the supply is unpredictable. In all cases, the Dar es Salaam prices are higher than those in rural areas, to which are added the high costs of transportation. Consequently, there is strong interest in the possibility of purchases of fresh foodstuffs from local sources, especially if these can be transported to Mloka. Staff from the lodges regularly visit Mloka, with some having relatives living there, while others visit for social reasons.

The development of a supply network to Mloka village with good quality fresh foodstuffs is likely to benefit suppliers, traders and the tourism industry. Examples of local produce that is of interest to the lodges include fresh vegetables (tomatoes, cabbages, onions, pumpkins, lettuce, etc.), fruits (mangoes, oranges, limes, etc.), spices, assorted meats, chickens, eggs, fish (in particular high quality tilapia and the larger catfish species, as well as a range of high value marine species), shellfish (especially prawns and mud crabs).

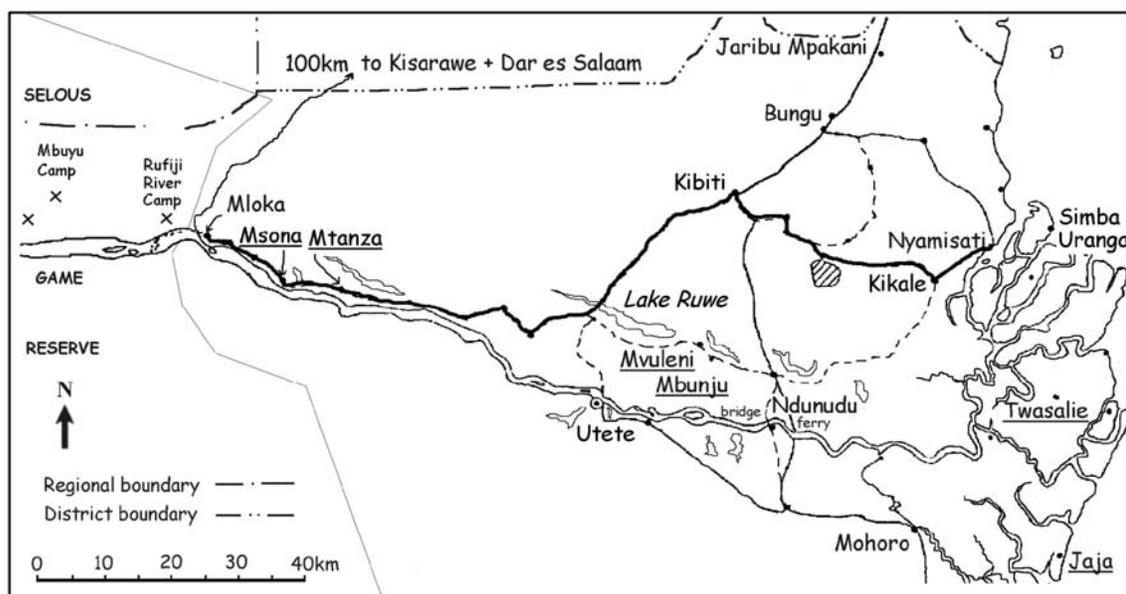


Figure 11: The route for the proposed trade in mud crabs from Nyamisati to Mloka.

The marketing of fruits and vegetables could be encouraged at floodplain pilot villages or other areas where these products are produced in good quantities. The supply of seafoods should be focused at sites from which the product can easily reach road and thus bus access. To begin with the trade of live *Scylla serrata* might be attempted. These crabs, once tied up, can easily survive transport in damp sacking for several hours, and if moistened on a regular basis can be kept for three days. They are also likely to fetch a price significantly higher than that for which they are currently sold to the Rufiji Delta buyers, at around 300 Tsh/kg (US\$ 0.3/kg). To buy small quantities in Dar es Salaam lodge operators would have to pay 1,350-2,700 Tsh/kg (US\$ 1.5-3.0/kg). The other advantage of beginning with live crabs is that there is limited risk of product deterioration, despite packaging of live crabs not requiring ice or cold storage. The lodges need quality food and would be prepared to pay a good price for live crabs only. Thus, the understanding that dead crabs would not be purchased eliminates confusion and expectations. Existing or new traders from Mloka or the pilot village of Mtanza might be supported with establishing this trade route. Mangrove crabs are a highly desired seafood for taste, attractive once cooked, and versatile in its use in the kitchen. Once cooked, the meat can be extracted and frozen for later use in a variety of dishes. Thus, at least to begin with, weekly supplies would be adequate.

As with virtually all trade in the Rufiji District, cost and reliability of transport are vital considerations. To successfully transport live mangrove crabs from the coast inland, over a distance of more than 140km, the choice of route is critical. Of the various delta villages, Nyamisati, situated on the northern shores of the delta, is likely to be best starting point for the transportation for this venture. There are several advantages of beginning with this village. These include the existing regular transport of seafood products, that crabs can be caught in the vicinity of the village and thus loaded on to the bus within a few hours of being caught, and the route to the west avoids the need to cross the Rufiji River.

Social and Cultural Issues

The large amount of trade that already exists in the District means that the addition of a very specific and small, new route would be readily accepted.

Financial Issues

According to crab traders, the best months for catches are between March through August. The latter part of this period coincides with some of the high season months of tourism. To begin with the transportation should be limited to a weekly supply of for example 100 crabs, equivalent to ca. 30kg (current delta trade value 8,000-13,500 Tsh = US\$ 9-15). Transport costs would all be within the district, hence border crossing fees do not apply. It is expected that the product would reach Mloka in a good condition thus fetching a price somewhere in the range of 900-1,800 Tsh/kg (US\$ 1.0-2.0/kg), to the benefit of customer and trader.

Costs for single trip for a fresh crab trader from Nyamisati to Mloka would include:

a) cycle ride to Kikale	1,000
b) bus Kikale-Kibiti	1,500
c) overnight Kibiti	2,000
d) bus Kibiti-Mloka	2,000
Total	6,500 Tsh (US\$ 7.22)

In summary, maximum costs: 13,500 30kg crabs + 13,000 (6,500x2) for transport + 3,500 misc. costs = 30,000 Tsh. Minimum sale value: 1,500/kg x 30 = 45,000 Tsh. Expected return per trip = 15,000 Tsh (US\$ 16.67).

If successful, once a regular supply is established and confidence exists that products will be purchased other fresh products and eventually ice-packed seafoods might be attempted. For the latter, the lodges could supply small ice-boxes with ice that could be transported empty to the coast to collect the product (such as prawns).

Policy Support

It is in the interest of the District to promote business in general and thus this form of enterprise.

Environmental and Resource Issues

The crab resources of the delta are considered under-exploited and suggestions exist for increasing their exploitation (see section 8.2). There are not expected to be any environmental impacts of the trade in crabs though expanding the fishery for wild caught crabs may have small negative impacts. Risks associated with losses due to transport failure are difficult to quantify but since most trade will be conducted in the dry season these are predicted to be small.

Market Characteristics

The market is specifically the Selous tourism lodges from where the demand exists. Because the order for the crabs should be placed in advance, the risk of failure to purchase is minimal.

Technology and Skills Requirements

The transport of the product does not require any technical skills and existing transports routes are to be utilised. Some advice on packaging of the crabs might be needed, as with assistance to introduce the trader to the supplier and customer.

8.7 Associative Enterprises

Although not an enterprise option *per se*, there are some important regional experiences with associative enterprises that are very relevant to the delta and floodplain fisheries of the Rufiji. In Mozambique, there is a recent (post-colonial) history of successive failures of co-operative and associative organisations. Following a path very similar to that of Tanzania, the State encouraged and even obliged producers to form organisations in order to facilitate improved production, organise markets and benefit from the supply of (often-subsidised) inputs, including credit. The net result was a dependency on the State for basic inputs, an expectation that these would be supplied either free or significantly subsidised, complete protection from the open market and an idea that credit did not really have to be repaid. As the State withdrew from this position, following the start of the structural adjustment process, co-operatives became more exposed and less supported, inevitably failing. This experience and the legacy discouraged both present day producers and administrators from considering formal corporations as a serious way forward.

However, some recent success in Mozambique has been achieved through a cooperation with the American NGO CLUSA and the local NGO “Olipa”. Their support methodology originates from the UK in 1843 in the textile industry. This has been developed and refined through years of experience and is now a viable framework guiding both group development, as well as interaction and hierarchy of such groups.

Group development focuses around a single common economic productive activity in which all members are already involved, and the belief that through some element of co-operation, members could improve their business operations. Associates continue to be independent operators and resources and production are not necessarily pooled. There are several distinct phases in group development, including collection of information about the group, self analysis, a study of the group’s activity, preparing for start-up, implementation, examination of financial balances, the establishment of a associative structure, training of leaders and legalisation. It should be noted that, from the outset, the objective of association is not a shortcut to obtaining credit. Any funding needs by the group must be met from within the group until the group has reached an advanced stage of development. The successful securing of credit may be a result at the end of the process but it is not the objective at the beginning.

The development of groups rises from simple associations to forums (a group of associations), federations and co-federation, these all operating on a similar basis – the collective resolution of problems that could not be solved individually.

In Mozambique CLUSA/Olipa started working in Nampula province with agricultural producers, (especially those involved with tobacco and cotton) and achieved some notable successes. They also broke the long standing bonds formed around the supply of inputs by larger trading companies in exchange for the obligation to supply outputs to that company at below market prices. In the fisheries sector Olipa has been working through the Nampula Artisanal Fisheries Project (contact details in Appendix 12.3) for only 14 months but has already achieved notable successes, especially with fish salters and smokers. The latter have often advanced through the construction of an improved (Chorkor-style) kiln, jointly used for the members independent businesses. Work with fishers themselves is less well advanced, primarily due to a complex social structure. The most promising of the fisher groups are vessel owners who surprisingly are becoming more involved with the trading of inputs (nets, etc.) rather than output markets.

Olipa is also involved in the organisational development aspects of a project co-funded by SNV and IUCN in Memba (Mozambique) which focuses on community development and resource co-management.

It is considered that the model which has been developed by CLUSA / Olipa would be very relevant to the Rufiji Delta area, enabling the development of enterprises that might otherwise be unable to progress on a stand-alone basis. However, further investigation and an open dialogue with CLUSA will be necessary to see how it might be adapted and applied.

9 Comparative Analysis of Potential Enterprises

The ten potential enterprises described in the previous two sections are individual and particular with respect to their deployment, economic benefits and sphere of influence. The merits of each enterprise also vary on geographical and temporal scales. However, they all share a single objective: to enhance livelihood assets of the communities in the Rufiji District. This section attempts to compare and contrast the enterprises and determine the “wisest” choice for piloting.

To compare the ten enterprises, the social and cultural, financial, and others issues associated with each are re-examined. Salient issues are highlighted and the potential constraints to successful implementation of the enterprises identified (see Table 9).

Activity	Social & cultural	Investment	Market	Environmental & resource	Skills transfer
Smoker improvement	low	low	low	low	high
Lake brushwood	high	?	low	low	high
Catfish ponds	high	low	low	low	high
Fingerponds	high	low	low	low	high
Tilapia ponds	high	high	low	low	high
Crab fishery	low	high	high	?	high
Longline fishery	low	high	high	?	high
Tourism	low	high	high	high	high
Coconut wood pit-sawing	low	high	low	low	high
Trade with Selous	low	low	high	low	high

Table 9: Summary of potential constraints to successful implementation of proposed enterprises (drawn from the description of the potential enterprises in sections 7 and 8).

Social and cultural issues were not generally significant for most enterprises. However, all pond-based activities are vulnerable to the widespread problem of theft. The rights over usage of lakes for inclusion of brushwood enclosures are potentially a problem that needs to be addressed.

The investment expected to be associated with each potential enterprise varies from physical labour costs (for all pond aquaculture options) which is unlikely to involve transfer of cash, to situations where small amounts of cash are required. The latter include purchase of equipment or materials, such as with crab and longline fisheries, smoker improvement, coconut wood pit sawing and possibly brushwood enclosures for lake fishery enhancement. Substantially greater investments are associated with tourism development or intensive tilapia pond culture.

Policy support towards all the proposed enterprises is regarded as positive, though in some (trade with Selous and the development of pit sawing for coconut timber) there may not be a specific commitment towards encouraging the enterprises.

Markets for the product of each enterprise are an important component that varies widely. There are well-established markets for smoked catfish or tilapia, but market issues are potential constraints to the success of trade between the delta and the Selous and the trade of mud crabs and longline catches. For the development of environmental or cultural tourism by contrast, the market is not locally present and therefore external assistance in its development is needed.

Tourism and the trade in mud crab are the only enterprises proposed where a risk element exists totally beyond the influence of the District (weather or infrastructure), as recently, and painfully, experienced by the tourism sectors of Zanzibar and the Mombasa (Kenya). Changes in the focus of tourism

destinations, brought on by political instability in host countries (e.g. Tanzania and Kenya) or tourist exporter regions (e.g. Europe or USA) can seriously, and unpredictably affect local tourism enterprises. The trade in mud crabs is subject to a similar risk since the product is aimed at the export market (mostly SE Asia) which itself is vulnerable to local economic instability.

Environmental and resource issues affecting the enterprises are varied. Most enterprises are expected to have minimal negative environmental impacts, while for some there are expected to be overall positive environmental outcomes (e.g. need for less fuels wood with improved fish smokers, or raised environmental awareness through tourism). Resource uncertainty however does affect enterprises that are seeking to increase catches of wild species - longline fishing and the expansion of crab fishery. Any enterprise in the Rufiji District is inevitably subjected to the risks associated with poor infrastructure, itself influenced by the weather, in particular rainfall. This is not regarded as a constraint to success, though weather strongly affects productivity in coastal and inland waters, partly due to the extent and duration of wet season flooding.

Transfer of skills is the main technical aspect affecting all proposed enterprises except the trade of mud crabs with Selous where it is minimal. Inputs are needed in most cases with specialist assistance for short periods over one or two years, thus the levels of support and the time frame over which that is provided also varies.

Two other important factors that need to be considered in determining the “wisest” choices for piloting are relative profitability and potential sphere of influence of the enterprises. All three pond aquaculture systems, improvement of fish smokers, use of brushwood enclosures in floodplain lakes and mud crab fishery have the potential to involve thousands of fishers or farmers at the production stage, with fewer beneficiaries in the trading and retail sectors. By contrast, the beneficiaries of environmental tourism development, long-line fishing in the delta, trade with Selous, and coconut pit sawing would be far fewer, probably less than a few hundred.

Based on the above deliberations, the following three enterprises were considered at this moment in time to be the “wisest” choices: (1) the expansion of catfish ponds on the floodplains, including those in the delta; (2) the introduction of brushwood parks to floodplain lakes; and (3) the development of the mud crab fishery in the delta.

There are potentially several thousand beneficiaries associated with each of the three choices, but there are specific reasons for selecting the three. The expansion of the catfish pond enterprise was chosen for piloting for the following main reasons: (1) it has potentially wide positive economic impacts for very little investment; (2) it requires the cooperation of small groups of farmers or fishers, itself a social experience that should be promoted; (3) the enterprise merits attention as being possibly the only aquaculture-based activity in the delta, based on a short but successful local history; (4) it requires a limited amount of technical skills; and (5) it already strongly involves one of the four existing pilot villages of the REMP.

The introduction of brushwood parks to floodplain lakes was selected because: (1) it bears little technical risk despite being regarded as a “new” enterprise; (2) the activity relies on cooperation among a number of fishers (maybe 50-100) over the use of lake resources, hence promotes cohesiveness among the community; (3) by providing shelters for fish the enclosures promote biodiversity; and (4) it makes good use of brushwood, often burnt to clear the ground for agriculture.

The expansion and development of the mud crab fishery in the delta is supported because: (1) it benefits a large number of independent individuals (fishers) who have no need to cooperate with each other; and (2) it has the potential to be highly profitable for businesses in and outside of the District with export earnings accruing to central government.

10 Guidelines for Piloting ‘Wisest’ Choices

Guidelines are provided below for the three “wisest” choice enterprises: expansion of catfish ponds, development of brushwood fishery enhancement enclosures for floodplain lakes and the development of the mud crab fishery. Piloting of all three activities should be possible over a two-year period. Before proceeding with the guidelines to the pilot choices, two brief comments are made, firstly on the enterprises that have not been selected at present but should still be encouraged, and secondly on recognition of the importance of the private sector to development.

Staff of the UDSM Fingerpond Project is presently undertaking the initial development of the fingerponds with facilitation by the REMP. Continued support for this initiative is strongly recommended. The development of tilapia pond aquaculture may slowly take place naturally over the coming years perhaps boosted by the new fingerpond intervention, or its wider adoption may develop as a natural progression once catfish pond culture has become established. To pilot the enterprise would require a two pronged approach: one based on the existing (though single) school network, the second focused on the fishers and the business community.

With catfish ponds, fingerponds and lake fishery enhancements all aiming to produce greater quantities of fish, the improvement of fish smokers is proposed as an activity that accompanies these and could be promoted simultaneously. The enterprise requires transfer of technology (facilitated by an extension officer or specialist), plus some investment and some educational materials.

In piloting tourism development, contact with the private sector as a first step is essential, followed by site identification and local community support. Longline fishing would require an approach similar to that of the mud crab fishery where stock assessment (through trial fishing) is conducted, target groups of individuals are identified and skills transfer facilitated (with additional technical input where necessary). Use of coconut timber for building and furniture construction also requires a skills transfer once the pilot village or group has been identified and the interest in this product confirmed (or generated). Trade with the Selous requires first, the identification of suitable traders and then, the facilitation of the development of purchase agreements for seafood products from the tourism lodges, with technical support provided where necessary.

The necessary involvement of the private sector has been mentioned in many places in this report, and it is recognised that business persons and investors have a critical role to play with respect to development in the Rufiji District. Many of the enterprises described above have the possibility to and should attract investors.

During the present study, three potential investors were met. Options being considered ranged from securing commitment of fishers in the delta and on the floodplain lakes, in exchange for supply of credit and equipment, to construction of semi-industrial scale fish smokers. It is also recognised that REMP has an equally important role to play in facilitating, advising and guiding this interest.

Guidelines for the three pilot enterprises follow with the inclusion of estimates for time of specialists, extension officers and other inputs from which costs can be calculated where needed.

PILOT ENTERPRISE 1. Expansion of Catfish Ponds

Main objective: increase production of catfish from ponds in the floodplains of the Rufiji River.

Piloting this enterprise essentially requires the transfer of technology within the District, perhaps using a combination of existing local plus imported knowledge. The existing practice at Twasalie needs to be more closely examined to measure production rates to determine whether additional technical inputs

are required. Twasalie itself or a nearby village could be selected for piloting, as well as one other village in the central floodplains. Groups of interested individuals within pilot villages need to be identified and taught the basic skills associated with this form of extensive aquaculture. Specialist input is needed on a range of issues and the recommended duration is over two seasons.

1. Site selection The choice of pilot site for testing this enterprise is critical to its success. Three main priorities must be satisfied:

a) Physical features: The supply of water and fish to the ponds relies on the natural flood regime. Topographical considerations are thus of paramount importance. These can be determined by visiting the potential sites before the flood and through consultation with floodplain farmers or fishers. Examination of detailed maps, aerial photographs and satellite images (where available) would also be of use. The installation of simple depth measuring staffs would also assist in measuring flood heights over the floodplains. Such an exercise should involve the local community in recording the water depth.

b) Social aspects: Village interest and support in the enterprise is necessary and may not be immediate. Village groups need to be identified since digging of ponds will require the efforts of several individuals. Proximity to habitation is also important to safeguard against theft.

c) Market access: Determination of the routes to and the condition of the market (month by month) for the smoked product needs to be ascertained, so as to target harvesting to periods of maximum return. A suitable supply of materials for smoking the product must also be identified.

2. Pond construction Ponds need to be dug during the dry season (August-December). Possible improvement on existing digging tools should be considered, as a result of which additional equipment may need to be purchased. Size, shape and depth of ponds may depend on soil conditions and on water supply, and manpower or group size.

3. Pond management Water levels, feeds, shade plants and fertilisers are aspects of management that need to be investigated during the trial of this form of aquaculture. Monitoring of catches is important to verify yields and thus economic performance. The production rates reported from Twasalie seem high and need to be confirmed. To raise production, the introduction of feeds (e.g. of the common land snail species), and increase of fry survival (in open ponds this is normally less than 10%) through the installation of shelters into ponds should be examined.

Proximity to permanent water may allow fish culture to continue for longer, thus siting of ponds close to main rivers would be an advantage, though this may require excavation of a narrow supply canal. However, in siting ponds, consideration must be given to proximity to river banks for extra water supply, especially since the law requires that a distance of 60m be observed between river banks and construction. The obvious risk from river erosion increases with proximity to the water flow and should not be discounted.

4. Harvest, preservation and sale Water management and market forces will dictate when the ponds should be harvested. In Twasalie this is during October as the ponds dry out. The introduction of improved fish smoking techniques could be promoted as part of this trial (but should be monitored as a separate activity).

Budgetary notes:

a) Equipment: Costs are minimal, possibly include some digging materials.

b) Technical needs: For the site selection a relevant aquaculture specialist would be required for some months, with an extension officer from a national institution involved over the year. Post harvest periods may require specialist input to improve smoking techniques.

c) Logistics: Field costs for the deployment of the above personnel (e.g. transport, accommodation etc.), include the need for vehicles (and/or boats) for operation in the floodplain.

PILOT ENTERPRISE 2. Brushwood Fishery Enhancement for Lakes

Main objective: promote the adoption of brushwood fishery enhancement in Rufiji River floodplain lakes to increase fish production.

This enterprise requires the cooperation of the users of the pilot lake(s) and the full support of the government of the village(s) involved. This is needed because the benefits (increase fish production) from the investment (labour and possible cost of brushwood) will be shared among the users of the pilot lake(s). Despite the potentially high investment required, the technical risk in development of the brushwood enclosures would be relatively low, particularly if implemented through a well-designed pilot project, with specialist advice, over a period of two seasons.

1. Identify pilot lakes Important factors to be considered are ownership or user rights, flood regime, and availability of suitable brushwood supply or sources.

a) Group Acceptance: The successful development of this fisheries enhancement method requires its acceptance by all users of the lake resources. Potential conflict between brushwood operators and fishers, who may feel that they are being excluded from areas where they traditionally fish, must be eliminated as much as possible. Hence it is strongly recommended that a process of participatory stakeholder consultation be undertaken at the outset of any pilot project. Some form of village-level supervision of the lake will be required to reduce poaching.

b) Previous history: Discussions with lake fishers of the dozen or so lakes is important to assess the level of existing knowledge of the concept of creating shelters to increase fish production. It is thought likely that in some areas this approach is recognised. Such previous experience would greatly facilitate acceptance and eventual support for the activity.

c) Lake Selection: Two lakes might be considered, one seasonal and one permanent. Within each lake the precise number, size, and location for siting the brushwood enclosures should be agreed through discussions with local lake users. Need for nets around the enclosures would be determined through consultation and may depend on the brushwood available.

2. Construction of brushwood bundles The quantity and size of the bundles has to be determined once the lake(s) has been selected and available brushwood resources have been sourced. Where possible, different woods are used (e.g. bamboo) to test fish aggregating influences and duration.

3. Fisheries monitoring Fish catch assessment should be made in the pilot lakes and in 'control' lakes. Species diversity in particular should be examined. Trial fishing should be conducted in and outside enclosures over the flood season to record fish species interactions and preferences if any.

4. Post harvest inspection After the flood has receded the brushwood enclosures should be closely inspected to evaluate the condition of the materials and determine the second year's approach.

Budgetary notes:

- a) Equipment: Costs potentially include that of brushwood bundles, transport of brushwood and nets. Traps and nets for trial fishing are also needed.
- b) Technical needs: For the selection of pilot lakes, design of enclosures and post harvest inspection, a fisheries specialist would be required for some months, with an extension officer from a national institution for a year. Trial fishing and monitoring would require a year's effort of a fisheries or extension officer's time.
- c) Logistics: Field costs for the deployment of the above personnel (e.g. transport, accommodation, etc.) include the need for boats on the lake (s) and vehicles for operation in the floodplain.

PILOT ENTERPRISE 3. Expansion of the Mud Crab Fishery

Main objective: Increase wild capture and trade of mud crabs *Scylla serrata* from the Rufiji Delta.

The development of mud crab fishing as an enterprise in the Rufiji Delta will require a project-led initiative to develop and introduce fishing gear and techniques, with cooperation from the buyers and exporters in financing of fishing gear, development of market access and possibly holding facilities for crabs. The main processes that need to be addressed and the order in which this must be done are highlighted below.

1. Private sector (exporters) The exporting companies in Dar es Salaam must be involved in any attempt to develop the crab fishery for the Rufiji Delta. The market opportunities need to be verified and the involvement of exporters is critical as the only apparent scope for market expansion is via export. Exporters will require technical advice on establishing a holding facility for live crabs in Dar es Salaam that would ensure product quality in live crabs before shipment (reducing risk of losses through rejection of batches and mortality during airfreight). A chain of middlemen is required to collect crabs from fishers in the delta area, prior to transport to Dar es Salaam. The development of an NGO-private sector partnership to assist development of the fishery is considered appropriate. The role of the NGO would be training and micro-enterprise development, with investment from the private sector (middlemen and exporters).

Buyers in Dar es Salaam should be involved early in project development, to encourage investment in development of the market (e.g. sending their own middlemen to buy from the Rufiji and through investment in traps). If fishing becomes more established, buyers/exporters should be encouraged to develop a holding facility in Dar es Salaam.

2. Crab stock assessment Preliminary survey of crab stock prior to any development of the fishery is necessary. An accurate assessment of the crab resource should be conducted, to establish guidelines for sustainable exploitation. This should include year round monitoring of crab population (size-frequency, reproduction) as well as an index of relative abundance (using traps). Pilot areas might be initially considered for estimates of local abundance. The participation of a consultant fisheries specialist with experience from other areas where the same species occurs (e.g. South Africa, SE Asia) is necessary, together with support from local institutions (UDSM and/or Fisheries Division).

3. Trial fishing Through working with fishers of the pilot villages, test designs and fishing methods will need to be conducted, leading to identification of suitable methods, training needs and investment requirements. Various gears are used in SE Asia to catch mud crabs (e.g. box traps and lift-nets) and the most appropriate for use in the Rufiji must be ascertained. Trial hand collection by groups of fishers should also be included - this should also be accessible to women. It is anticipated that after initial trials the fisher-middlemen-exporter relationship would be the vector of investment in fishing

gear essential to sustainable fishery development. Note: this component should only proceed if the previous two have been successful.

4. Training needs Training requirements fall into several priorities:

a) Fishers: Training and extension in gear construction and fishing techniques should be available to fishers in selected villages in the delta. This training should then be passed on from fisher to fisher. If experimental fishing has been successful, middlemen should be encouraged to invest and provide gear to fishers (as with shrimp nets).

b) Middlemen: Instruction in techniques for temporarily holding crabs (e.g. cage and pond design, stocking densities, feeding regimes, identification of moult stages) is needed for wild caught crabs prior to shipment to Dar es Salaam. Financial support might also be included (for building and management of local crab holding facilities), improvement of efficiency of transport of relatively large batches of crabs. In effect, these would have the same role as chill-boxes in the shrimp in the market. Note: this component could be expanded to include a trader that might be encouraged to transport and trade mud crabs from the delta to the tourism lodges in the Selous (see section 8.6).

c) Exporters: Assistance with setting up and running suitable holding facility for live crabs in Dar es Salaam is an essential requirement prior to the shipment of live animals. Existing buyers/exporters should be contacted and provided with technical advice on design and management of a crab holding facility, which would support market development through enabling large batches to be shipped (thereby reducing unit transport cost), improving meat quality, and reducing the risk of mortality in transit).

5. Management considerations Following stock assessment, the need for management restrictions to safeguard the resource is likely, as recognised in other areas where this resource is fished (e.g. Australia). Examples of interventions include size restrictions and closed areas. Consultation is required with exporters and buyers, as well as fishers.

On-going monitoring of landings and fishing activities should be undertaken as an essential component of sustainable resource management. This could be set up through a simple system of recording catches by individual fishers (possibly by buyers) to give a catch-per-unit effort as a relative index of crab abundance (see Le Vay *et al.*, 2001).

Budgetary notes:

a) Equipment: It is anticipated that costs of traps, construction of holding pens in the delta and holding facilities in Dar es Salaam should be contributed by the private sector as a matching fund contribution to the project.

b) Technical needs: For the stock assessment a fisheries specialist would be required for some months, with an extension officer from a national institution for a year. Trial fishing would require a year's effort of a fisheries or extension officer's time and post harvest training (holding facilities and operation) would require specialist input.

c) Logistics: Field costs for the deployment of the above personnel (e.g. transport, accommodation etc.), include the need for boats and vehicles for operation in the delta, and for time spent in Dar es Salaam working with exporters.

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12 Appendices

12.1 Terms of Reference and Tasks of the Consultancy

Objectives of the consultancy

The two objectives of the consultancy are;

- to assess the present situation regarding the economic and environmental status of fisheries and related enterprises
- to make recommendations towards improvement of profitability of fisheries, coastal and related enterprises

Tasks of the Consultancy

The study will include the following tasks;

i. Describe the marketing systems for finfish and shrimps/prawn:

Trace and describe (in terms of, location, distance from primary source, whether wholesale, retail, direct to consumer or other, of product type and standard) the markets for finfish, shrimp/prawn, and other aquatic products from Rufiji floodplain and delta.

1. List and characterise all the operators from fisher, to drier/smoker, to packer to small trader, to bigger trader, to final consumer type.
2. Describe the pricing system
3. Describe the costs of preservation and transportation.
4. Estimate the level of physical and trading losses along the chain and reasons for these losses
5. Make recommendations for the reduction of these losses (if it is a wise option for improving profitability).

ii. Describe a range of opportunities for sustainably increasing productivity of aquatic resources

Suggested examples include the possibility of attempting micro-scale silvi-shrimp production, the exploitation/and or human-assisted production of a wide range of fauna (crustaceans, echinoderms, cephalopods, gastropods and others and floral species other than mangrove trees (such as climbers, ferns, sedges, macro and micro-algae)

iii. Consider other coastal enterprises which might be appropriate for adoption by communities in the Rufiji Delta.

iv. Consider and propose enterprises which might be attractive diversifications for the fishers of the Rufiji floodplain.

v. Compare and contrast the proposed opportunities and enterprises from both economic and environmental perspectives and make recommendations as which are the “wisest” choices for piloting.

vi. Supply guidelines for implementing/piloting the most suitable choices.

Outputs

A detailed report covering the findings of tasks 4.1 to 4.6 above.

Expertise required

The consultant will have specialist qualifications in Fisheries, Aquatic resources, and freshwater and coastal enterprises with at least five years practical experience of working with such enterprises. Monitoring and Evaluation and or economics or business skills are also required. Swahili language skills will be an advantage.

12.2 Summary of Itinerary

Date	Consultant	Issues/locations/travel details/etc..	Overnight location
30/10	MR.JW.YM	Study planning with YM (UDSM); TRAFFIC-TZ office.	DSM
30/10	JW.MR	Study planning with RH.	Ikwiriri
31/10	JW.MR	With RH - Ikwiriri Madrasa fish pond; fish market, Lake Umwe, Fishing tackle store; Ndundu ferry crossing; travel to Utete.	Utete
01/11	JW.MR	With RH - Utete DED, DC, District Fisheries general issues; travel to Somanga traders, general issues; travel to Mohorro.	Mohorro
02/11	JW.MR	Travel to Jaja. Prawn and fish fisheries, Traders, 'uduvi' fisherwomen, Agents,	Jaja
03/11	JW.MR	Fisheries, Traders, Salt producers, Smokers. Travel to Mohorro, Utete.	Utete
03/11	YM	Travel to Ikwiriri	Ikwiriri
04/11	JW.MR	Travel to Ikwiriri ;Traders, Fishers Lake Umwe, Ube,	Ikwiriri
04/11	MR	Travel to DSM to meet LL	DSM
04/11	LL	Arrival DSM	DSM
05/11	MR.LL	Travel to Nyamisati	Nyamisati
05/11	YM.JW	met RH Lake Ruwe, Ikwiriri Market traders,	Ikwiriri
06/11	YM.JW	Kibiti Market, Kikale Market taders. Full team met in Nyamisati pm. MR + RH travel on to Twasalie.	Nyamisati
06/11	MR.LL (YM.JW)	Simba Uranga traders, Prawn fishers, Village Chairman various issues, met RH.JW.YM.	Nyamisati
06/11	MR	MR + RH travel to Twasalie	Twasalie
07/11	MR	Floodplain fishers	Twasalie
07/11	YM.JW.LL	Travel to Kiomboni via sea - village admin, Traders Fishers, Traders, Village admin. Travel to Kibanjo via sea.	Kibanjo
08/11	YM.JW.LL	Kibanjo village admin, fishers, site visit rice salt-areas travel to Nyamisati, via inner delta.	Nyamisati
08/11	MR	Mbongola traders, smokers, village elders; travel to Nyamisati via inner delta.	Nyamisati
09/11	MR.JW.YM.LL	Travel to Kibiti for briefing; onward to DSM	DSM
10/11	MR.JW.YM.LL	DAY OFF	
11/11	MR.JW.YM	Kigamboni fish market traders; summary meeting at UDSM with YM; LL travel to UK pm.	DSM
12/11	MR.JW	FAO refs, admin., reporting.	DSM
13/11	MR.JW	Admin., Mangrove Mngt Project, ex-trawler skipper, Kariakoo dried fish traders; reporting.	DSM
14/11	MR.JW	Fisheries dept., Mbagara Charambe; MR/JW travel to ZNZ	ZNZ
16/11	MR.JW.	Tanpesca (prawn fisheries and export); reporting.	DSM
20/11	MR	Ocean Safaris (lobster and crabs fishery and export)	DSM

12.3 Useful Contacts

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