THE ECONOMIC VALUE OF THE ZAMBEZI DELTA

BY

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EXECUTIVE SUMMARY

The broad objective of the study was to estimate the economic value to the goods and services in the Zambezi Delta - i.e. the Marromeu Complex – under the prevailing water management regime. The specific objective for the study was to determine the annual economic value of the Zambezi Delta and as such the study estimated the principal economic values associated with the Zambezi Delta focusing on the Zambezi Delta, including the value of: (i) water supply, (ii) fisheries, (iii) smallholder agriculture, (iv) energy, (v) wildlife, including birds, (v) timber and non-timber products, and (vi) carbon sequestration.

To value the different value components, a total of 613 households were interviewed; community group discussions were held; and interviews were held with coutada owners, forestry concession owners, and commercial fishers. A combination of travel cost and the production function approaches were used to estimate the producer surplus as a measure of economic value.

The study estimates that the annual total value of the Zambezi Delta ranges between US$0.93 billion and US$ 1.6 billion. An analysis by type of value shows that in a normal year of this total economic value (TEV) about 65.67% is direct use value, 32.3% is the option value and the non-use value only about 1.9%. An analysis by source of value shows that of the total economic value about 57.3% derives from the water, about 26.1% derives from the standing stocks of timber, and about 6.1% of the annual value derives from the stock of wildlife.

An assessment of the distributional aspects showed that of the TEV, the percent TEV attributed to the rural and urban households in the Delta ranges from 2.4% to 3.9%. About 1.3% to 2.7% of the TEV can attributed to the global economy as the value of carbon sequestration and the value of habitats for birds, including birds of international importance. The remainder of the TEV of between 93.4% and 96.3% is attributed to commercial activities – i.e. timber production and harvesting; coutada management and safari hunting, and commercial sugar production.

The study recommends that the following needs to be considered in future valuation studies for the Zambezi Delta:

i. Valuation of wild vegetables and medicinal plants for the rural households;
ii. Valuation of the Marromeu Complex Game Reserve;
iii. Determining the indirect use values derived from the microclimatic stabilization of the wetlands and the value of mangroves in shoreline stabilization; as habitat for shrimp production, and other functions; and

iv. Estimating the economic impact and value of natural resources of the Zambezi Delta under different river flow regimes, some of which take into account the preferences of smallholder farmers as well as commercial fishers. Making these impacts and economic values explicit will be a necessary input into informed decision making concerning changes in river flow management.

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INTRODUCTION

The Delta of the Zambezi River is an extensive swamp that forms a triangle of around 12,000 Km^2 (Figure 1.1). It starts in the confluence of the Zambezi and Shire rivers and extends 120 Km down to the Indian Ocean. It also extends 200 Km along the coastline, from the Cuacua River, in Zambeze Province, down to the Zuni River delta, in Sofala Province. To the north-west, the Delta is limited by the Morrumbala escarpment whilst in the South it includes the extensive Cheringoma escarpment. To the south-east, the Delta includes the Marromeu sugar plantation and two Forest Reserves – Nhampakué and Inhamitanga. The southern part of the Delta is mostly made of the "Zambezi Delta", a 6,880 Km^2 Ramsar site that includes the Special Buffalo Reserve of Marromeu, the Coutadas (Hunting Blocks) 10, 11, 12 and 14, forest concessions, and half of the Cheringoma escarpment.

The Zambezi Delta is a wetland system of profound conservation and resource value. The Delta is home to about 350000 rural villagers who depend on the delta's rich natural resources for their livelihood. The delta is also the largest wetland system in the Zambezi catchment, and supports a great mosaic of wetland vegetation communities, including palm savanna, mangrove forests and payrus swamps. Vast, seasonally flooded grasslands support diverse and abundant wildlife populations, including many water bird species of international concern, and, until recently legendary concentrations of buffalo, waterbuck, and hippopotamus. The flood plain provides spawning grounds for riverine and anadromous fishes and critical dry season grazing lands for domesticated livestock and wildlife. Extensive coastal mangroves and estuaries support lucrative prawn fishery (Beilfuss, Dutton, and Moore, 2001; Beilfuss and Bento, 1997).

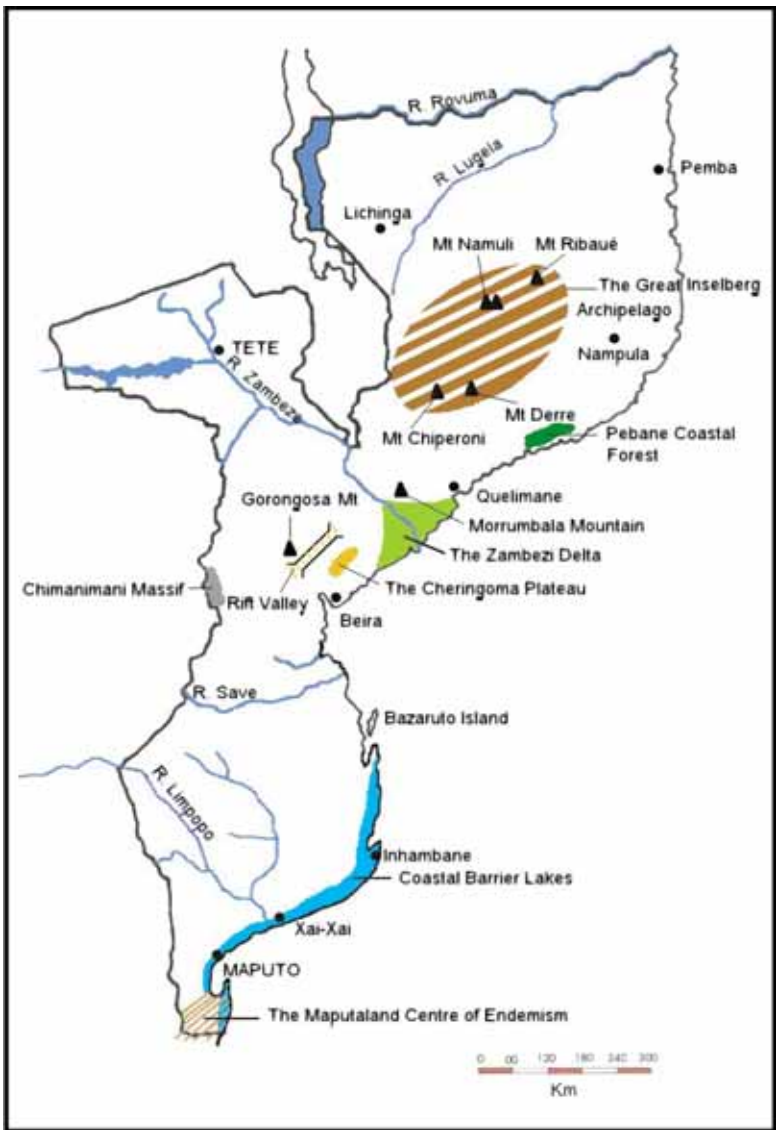


Figure1.1 : The Zambezi Delta

The fact that the Delta is rich in biodiversity, with natural resources abundance, private sector investment, local communities among many other characteristics, attracts concerns about its management. It was in this perspective that the Lower Zambezi Project was designed with the aim to benefit local communities and industries from an integrated management plan of the area and improved water management of the Zambezi River, hence contributing to the development and sustainable use of natural resources in the Delta.

1.1 Study Objectives

Altering the management regime of water resources in the Zambezi river basin will evidently have direct economic impacts, as many people in the basin depend on the ecosystem services provided for subsistence or economic activities and growth rely on the availability of natural resources. Although such economic impacts will be felt locally initially, they will spread to a much larger area or trigger other economic effects or even affect entire sectors. Making the economic impact of the river flow regime explicit is not only a necessity for input in decision making processes, but will also provide for leverage to engage in relevant political fora.

It is assumed by several NGO's that the prevailing controlled water flows on Zambezi River (driven by mono-function use of the dam for hydropower) have negative impacts on the ecosystem services the basin can provide and the subsequent socio-economic development opportunities of the people downstream of the Cahora Bassa. However, the extent of the impacts in economic terms is still unknown.

As such, the broad **objective** of this study is to estimate and attribute an economic value to the goods and services in the Zambezi Delta - i.e. the Marromeu Complex - under prevailing water management regime. The specific objective for the study is to determine the annual[1] economic (not necessarily monetary) value of the Zambezi Delta. The outcome of the assignment will serve as a baseline on what is the present economic value of goods and services and future studies on alternative natural resources management options in the Delta[2].

The study provides a full accounting, to the extent possible, of the **principal economic values** associated with the Zambezi Delta focusing on the Zambezi Delta, including the value of: (i) water supply, (ii) fisheries, (iii) smallholder agriculture, (iv) energy, (v) wildlife, including birds, (v) timber and non-timber products, and (vi) carbon sequestration.

1.2 Outline of the report

The next section gives an overview of the economic valuation approach. This is followed by a section each for the valuing of water, fisheries, agriculture, energy, wildlife, timber and non-timber forest products, the Delta as habitat, and finally carbon sequestration. The last two sections summarize the results of the valuation exercise, conclude and provide recommendations of the study.

[1] Annual could be interpreted as year 2007.

[2] The Terms of Reference for the Study are presented in Appendix 1.

2. APPROACH TO THE STUDY

Wetlands are among the Earth's most productive ecosystems. The features of the system may be grouped into components, functions and attributes. The **components** of the system are the biotic and non-biotic features which include the soil, water, plants and animals. The interactions between the components express themselves as **functions**, including nutrient cycling and exchange of water between the surface and the groundwater and the surface and the atmosphere. The system also has **attributes**, such as the diversity of species. These are discussed in an economic valuation context.

2.1 Why Economic Valuation?

In this section, it is suggested that a major reason for excessive depletion and conversion of wetland resources is often the failure to account adequately for their non-market environmental values in development decisions. By providing a means for measuring and comparing the various benefits of wetlands, economic valuation can be a powerful tool to aid and improve wise use and management of global wetland resources.

Loss of environmental resources is an economic problem because important values are lost, some perhaps irreversibly, when these resources are degraded. Each choice or option for the environmental resource – to leave it in its natural state, allow it to degrade or convert it to another use – has implications in terms of values gained and lost. The decision as to what use to pursue for a given environmental resource, and ultimately whether current rates of resource loss are

'excessive', can only be made if these gains and losses are properly analyzed and evaluated. This requires that *all the values* that are gained and lost under each resource use option are carefully considered.

Valuation is only one element in the effort to improve management of environmental resources such as wetlands. At the same time, decision-makers must take account of many competing interests in deciding how best to use wetlands. Economic valuation may help inform such management decisions, but only if decision-makers are aware of the overall objectives and limitations of valuation.

The main objective of valuation in assisting wetland management decisions is generally to indicate the overall *economic efficiency* of the various competing uses of wetland resources. That is, the underlying assumption is that wetland resources should be allocated to those uses that yield an overall net gain to society, as measured through valuation in terms of the economic benefits of each use less its costs. Who actually gains and loses from a particular wetland use is not part of the efficiency criterion *per se*. Other important considerations are (i) distributional aspects, and (ii) political considerations for the various options for wetland use.

2.2 A Framework for Assessing the Economic Value of the Zambezi Delta

The concept of *total economic value* (TEV) provides a framework for distinguishing and grouping wetland values. Simply put, total economic valuation distinguishes between *use* values and *non-use* values, the latter referring to those current or future (potential) values associated with an environmental resource which rely merely on its continued existence and are unrelated to use (Pearce and Warford, 1993). Typically, use values involve some human 'interaction' with the resource whereas non-use values do not.

The total economic valuation framework, as applied to the Zambezi Delta wetlands is presented in Table 1.1. Use values are grouped according to whether they are *direct* or *indirect*. For the Zambezi Delta, the direct values include commercial activities sugar production, charcoal production and fishing; and non-commercial activities such as subsistence agriculture, fuel wood harvesting, harvesting of non-timber forest products, and hunting of game meat.

Table 1.1: Classification of total economic value for the Zambezi Delta wetlands

USE VALUES			**NON-USE VALUES**
Direct Use Value	**Indirect Use Value**	**Option and Quasi-Option Value**	**Existence Value**
• fish	• nutrient retention	• potential future uses (as per direct and indirect uses)	• biodiversity

• agriculture	• flood control	• future value of information	• culture, heritage
• fuel wood	• groundwater recharge		• bequest values
• timber harvesting			
• transport	• micro-climatic stabilization		
• wildlife harvesting	• shoreline stabilization		

In contrast, various *regulatory ecological functions* of the Zambezi Delta wetlands have important indirect use values. Their values derive from supporting or protecting economic activities that have directly measurable values. The indirect use value of an environmental function is related to the change in the value of production or consumption of the activity or property that it is protecting or supporting. However, as this contribution is un-marketed, goes financially unrewarded and is only indirectly connected to economic activities, these indirect use values are difficult to quantify and are generally ignored in wetland management decisions. For the Zambezi Delta, this includes mangrove systems which are (i) breeding grounds and nurseries for shrimp and fish that are essential for coastal and marine fisheries, and (ii) important in shoreline stabilization; the natural floodplains recharge groundwater used for dryland agriculture, and grazing livestock, etc.

A special category of value is *option value*, which arises because individuals may be uncertain about their future demand for a resource and/or its availability in the wetland in the future. In most cases, the preferred approach for incorporating option values into the analysis is through determining the difference between *ex ante* and *ex post* valuation. If an individual is uncertain about the future value of a wetland, but believes it may be high or that current exploitation and conversion may be irreversible, then there may be *quasi-option value* derived from delaying the development activities. Quasi-option value is simply the expected value of the information derived from delaying exploitation and conversion of the wetland today. Many economists believe that quasi-option value is not a separate component of benefit but involves the analyst in properly accounting for the implications of gaining additional information.

In contrast, however, there are individuals who do not currently make use of wetlands but nevertheless wish to see them preserved 'in their own right'. Such an 'intrinsic' value is often referred to as *existence value*. It is a form of non-use value that is extremely difficult to measure, as existence values involve subjective valuations by individuals unrelated to either their own or others' use, whether current or future. An important subset of non-use or preservation

values is *bequest value*, which results from individuals placing a value on the conservation of wetlands for future generations to use. Bequest values may be particularly high among the local populations currently using a wetland, in that they would like to see the wetland and their way of life that has evolved in conjunction with it passed on to their heirs and future generations in general.

Three broad categories of issues are of most relevance to the economic analysis of wetlands. Corresponding to each of these three evaluation objectives would be a specific economic assessment approach. These are:

- *impact analysis* – an assessment of the damage inflicted on the wetland from a specific external environmental impact (e.g., oil spills on a coastal wetland)
- *partial valuation* – assessment of two or more *alternative wetland use options* (e.g., whether to divert water from the wetlands for other uses, or to convert/develop part of the wetlands at the expense of other uses)
- *total valuation* – assessment of the *total economic contribution*, or net benefits, to society of the wetland system (e.g., for national income accounting or to determine its worth as a protected area).

For purposes of this paper, the economic assessment approach to be used is the total valuation approach. The general approach to the report is that the specific methodological approach to valuing the different functions and services provided by the Zambezi Delta are outlined under the specific sections.

2.3 Data Collection Methods

The study was done from the 1st of May till the 30th of June, 2008. The schedule of activities for the study is presented in Appendix 2. The main steps followed in data gathering include the following:

1. A focused literature review. Relevant and readily available secondary data was collected and tabulated (where necessary) and collated.
2. Based on the findings of the secondary data, checklists, community group discussion and household questionnaires for interviews and discussions with the smallholder farmers and key informants were developed. The developed checklists and semi-structures questionnaires for the interviews are briefly discussed here (see Appendix 3 for details):
   - ***(i) Community focused group discussion questionnaire.*** This questionnaire was designed to collect data for a representative average community household. The questionnaire covers detailed data needs on crop production and livestock production; effort in harvesting fish, wildlife, water birds, wild fruits, wild vegetables, and medicinal plants; effort in the collection of firewood and charcoal making; effort in the collection of water for drinking, cooking, and washing; and effort expended in the collection of building materials.
   - ***(ii) Household questionnaire:*** this questionnaire is similar to the group discussion questionnaire in terms of resources covered. The questionnaire however mainly focuses on asking households if they harvest the different natural resources and timing of harvesting; an estimate of the income they obtain from these natural resources; and details on crop and livestock production.
   - ***(iii) Wildlife and tourism checklist:*** Information collected includes - trends in stock of wildlife – species and numbers. Trends for the whole hunting area and the Buffalo Reserve; allocated and actual trophy hunts by types over years; fees to government for hunting permits; number of visitors over years; prices and average number of game viewing rides by non-hunting visitors; and price of trophy hunts by species over time.
   - ***(iv) Agriculture checklist:*** The checklist covers commercial agricultural activities done in the Zambezi Delta; number of farmers, crop types, hectares, output, numbers of animals over time; smallholder agricultural

activities that are done in the Zambezi Delta; number of farmers, crop types, hectares, output, numbers of animals etc over time.

(v) ***Environment checklist:*** issues covered include changes in animal (land and water based) and plant species over time in the delta area; magnitude of charcoal production in the Zambezi Delta; effect of floods on populations of animal and plant species; and meteorological data.

(vi) ***Commercial timber checklist:*** Aspects covered include the level of logging; costs of logging, the level of value addition, and species harvested.

(vii) ***Commercial fisheries checklist:*** the checklist covers volume of shrimp from the delta over the years; price per ton of catch in the delta; employment in the processing industry; and wage bill of the processing industry.

(viii) ***Commercial sugar production checklist:*** covering the area, yields and production trends over the years; cost of production per ton; planned expansion/potential sugar area.

The questionnaires were translated into Portuguese and back to English to ensure they could be used to collect the required data.

3. Semi-structured interviews were be conducted with key informants including:
    a. The Department of Fisheries;
    b. Department of Agriculture;
    c. Department of Tourism;
    d. Department of Forestry;
    e. Representatives of Coutadas 11 and 14;
    f. The Management of SENA Sugar Estates;
    g. Government officials in Cheringoma and Marromeu Districts;
    h. Non-governmental Organizations; e.g. GPZ; and
    i. Management of forestry concessions, e.g. TCT.

4. A total of 8 enumerators were trained on implementing the household questionnaire over two (2) days. Two of the enumerators were also trained on how to implement the group discussion questionnaire.
5. Data collection in Marromeu and Cheringoma was done over a period of two and a half weeks. The dates of community visits, the number of group discussion attendants and the number of participants participating in each focused group discussion is presented in Table 2.1.
6. After data collection, all data was entered into excel or the Statistical Package for Social Sciences (SPSS) for analysis. All data was cleaned before analysis.

A total of 15 communities were visited and a total of 613 household[3] heads were interviewed (Table 2.2). The overall sampling fraction for the survey is about 7%. About 50% of the communities in the Zambezi Delta were visited.

[3] A 'household' is defined as persons or collection of persons, whether related or not, that habitually live in the same private dwelling, that tend to their life needs together, and eat from the same pot for at least six months of the year.

Table 2.1: Group Discussion Attendants and Focused Sub-Group Discussion Members by Community

		No. of Participants in Sub-Group:											
Name	**Date**	**Total**	**Agriculture**	**Fisheries**	**Livestock**	**Wildlife**	**Water birds**	**fruits & NTFP**	**Firewood**	**Charcoal**	**Building materials**	**Water supply**	**Mangroves**
Chueza	8-May-08	75	15	16	15	12	12	32	32	32	32	16	32
Migugu ne	9-May-08	74	20	16	20	19	19	19	18	18	18	16	18
Safrik	10-May-08	61	14	15	14	16	16	16	12	12	12	15	12
Salone	12-May-08	55	16	13	16	13	13	13	15	15	15	13	15
Inhame	13-May-12	75	18	25	18	16	16	16	22	22	22	25	22
Chiburib uri	14-May-08	71	16	21	16	17	17	17	20	20	20	21	20
Mponda	15-May-08	25	7	7	7	8	8	8	10	10	10	10	10
Chirima dzi	16-May-08	23	7	7	7	9	9	9	7	7	7	7	7
Nangue	16-May-08	34	11	11	11	9	9	9	14	14	14	14	14
Gorra	17-May-08	44	16	16	16	11	11	11	17	17	17	17	17

Cine	18-May-08												
Mangazi	19-May-08	45	15	15	15	15	15	15	15	15	15	15	15
Matondo	21-May-08	45	15	15	15	15	15	15	15	15	15	15	15
Guma	22-May-08	45	15	15	15	15	15	15	15	15	15	15	15
Chidanga	23-May-08	45	15	15	15	15	15	15	15	15	15	15	15

Table 2.2: Community Size, Questionnaires Administered, and Survey Sampling Fraction

District	Community	No. of Households Interviewed	Community Households	Sampling Fraction (%)
Marromeu	Chueza	25	2,504	1.00
	Migugune	34	2,315	1.47
	Safrik	37	702	5.27
	Salone	52	167	31.14
	Inhame	69	n/a*	n/a
	Chiburiburi	35	501	6.99
	Mponda	31	946	3.28
	Nangue	29	96	30.21
	Gorra	34	293	11.60
	Cine	3	10	30.00
	Mangazi	34	n/a	n/a
Cheringoma	Chirimadzi	27	402	6.72
	Matondo	82	899	9.12

	Guma	69	234	29.49
	Chidanga	52	n/a	n/a
	Total	613	9,069	6.75

*n/a – Data not available

3. WATER SUPPLY

3.1 Methodology to Valuing Water Resources

A key value of the Zambezi Delta ecosystem is the provision of water for domestic needs of both rural and urban populations, and for agricultural use by both smallholder and commercial producers. To assign a value of this water provision service the study proceeded in two ways. First, it estimated a price of water using a travel cost method. Second, it estimated demand for water by smallholder rural domestic users, urban users and commercial sugar producers. No irrigation water demand was estimated for smallholders since most crops and vegetables in the Complex is grown under recession agriculture needing insignificant supplementary irrigation. The value of the whole Complex water use was then calculated as the product of total demand and the price of water less the cost associated with water abundance (i.e. effects of water related illnesses).

To compute the price of water information on daily collection of water for drinking and cooking, and for washing and bathing, as well as the walking and queuing times to get that water was collected through group discussions and household surveys. The labor time used to collect water was then valued using the national minimum wage to get the cost of effort. The volumes of water collected went into computation of demand for water for domestic purposes by the rural communities. The value of collection effort divided by the volume of water collected (in liters) gave the price of water per liter.

To estimate demand in the urban communities the study took the average water demand in urban populations of the SADC region (Hirji, Johnson, Maro, and Matiza, 2002) as the per capita demand in Complex urban communities. This was then multiplied by the urban populations to yield urban demand for water. Commercial irrigation demand was based on information provided SENA Sugar agronomists in the form of millimeters of irrigation water applied per month on sugar crops. This was scaled up for the whole year and planted area to get total demand. For both urban and commercial water demand, the value of water was estimated by multiplying the annual demand for water by the derived water prices for the rural households.

3.2 Water Use in the Zambezi Delta

All along the Zambezi Delta, people depend on the river for water for drinking, cooking, washing, and bathing. People generally depend on well water for drinking and cooking, and water from the Zambezi River for washing clothes and dishes and for bathing. In the upper stretches of the Zambezi Valley where the river is more confined to its channel, access to water has not changed significantly. In the lower reaches, however, the groundwater table in the floodplain has dropped substantially due to the loss of floodwater recharge from the river. On the south bank of the Zambezi Delta - in the Salone Depression, the water table has decreased by as much as 7 meters. Local villagers now use deep wells to collect water in areas that were formerly flooded with shallow surface water for much of the dry season (Beilfuss, Chilundo, Isaacman, and Mulwafu, 2002).

3.2.1 Smallholder farmers' water demand

The major water uses in by the smallholder sector is mainly in drinking and cooking and washing. The main sources of water for these uses are the (i) community well, (ii) community borehole, (iii) the river, and (iv) water ponds or lagoons (Table 3.1). In some of the communities like Chueza, communities are provided with treated water. Only 1.3% of the households across the Zambezi Delta communities irrigate vegetable crops.

Table 3.1: Sources of Water for Drinking & Cooking and Washing by Community by District

		Drinking / cooking				**Washing**			
District	Community	Community well	Community borehole	River	River Treated	Community well	Community borehole	River	River Treated
Marromeu	Chueza				x			x	
	Miguguna	x				x			
	Safrik	x				x			
	Salone	x				x		x	
	Nhame	x						x	
	Chiburiburi		x				x		
	Mponda	x	x			x	x		
	Nangue		x				x		
	Gorra	x	x			x	x		
	Mangazi			x				x	
Cheringoma	Chirimadzi		x				x		
	Matondo	x	x			x	x		
	Guma	x				x			
	Chidanga		x				x		

Table 3.2 shows that the most important source of water for cooking & drinking and washing, irrespective of type of year and season of the year, is the community borehole being used by about 66% of the households. The community borehole is especially an important source of water during the dry season and during the drought and flood years. The river and community well are the second important sources of water for cooking and drinking and washing. About 20% of the households use the community well or the river as a source of water for cooking and drinking and washing.

The mean household[4] daily water collection for drinking, cooking and washing ranges from 126 liters in a drought year to about 168 liters in a flood year (Table 3.3). An analysis by district shows that the mean daily water collection during normal and drought years is higher in Cheringoma at about 148 liters compared to 135 liters and 104 liters respectively for Marromeu. During a flood year, the mean daily water collection is higher in Marromeu at about 176 liters compared to about 161 liters for Cheringoma. The total annual water demand for drinking, cooking, and washing is estimated at about 0.759 million m^3 during a drought year, 0.907 million m^3 during a normal year and 1.124 million m^3 during a flood year. Overall, on a per capita basis, the daily water demand during a drought year is 11% lower than in a normal year. Similarly, the daily water demand during a flood year is about 19% higher than in a normal year. These results imply that the demand for water is positively related to water availability, and that rural households are able to adjust and use less water during periods of water scarcity.

Table 3.2: Percent Households Using Sources of Water for Cooking & Drinking and Washing by Type of Year by District

		Wet Season					Dry Season				
Year	Community	Community well	Borehole	Piped water	River	Ponds	Community well	Borehole	Piped water	River	Ponds
Normal Year	Marromeu	17.8	27.9	0.52	18.3	2.9	16.2	69.2	0.3	18.8	2.9
	Cheringoma	24.3	39.6		19.6	3.5	23.5	62.2		19.1	2.6
	Overall	20.2	32.3	0.33	18.8	3.1	18.9	66.6	0.3	18.9	2.8
Drought Year	Marromeu	17.2	71.0	0.3	18.0	2.9	16.4	68.4	0.3	18.8	2.9

[4] The mean household size is estimated at 6.7 persons for Marromeu District and 6.5 persons for Cheringoma District.

	Cheringoma	24.3	60.4		19.6	3.5	23.5	62.2		19.1	2.6
	Overall	19.9	67.0	0.2	18.6	3.1	19.1	66.1	0.2	18.9	2.8
Flood Year	Marromeu	16.7	69.7	0.3	20.1	2.6	16.4	67.6	0.3	20.1	2.6
	Cheringoma	23.9	57.8		19.6	6.5	23.5	62.2		18.7	2.6
	Overall	19.4	65.3	0.2	19.9	4.1	19.1	65.6	0.2	19.6	2.6

Table 3.3: Daily and Annual Water Demand (Liters) by District

District	Type of Year	HH Daily Water Demand		Annual Water Demand	
		Total	Per capita	Total	Per capita
Marromeu	Normal Year	135.1	20.2	647,168,717	7,358
	Drought Year	104.1	15.5	498,543,165	5,668
	Flood Year	175.6	26.2	841,403,198	9,567
Cheringoma	Normal Year	147.9	22.8	260,143,108	2,958
	Drought Year	147.9	22.8	260,143,108	2,958
	Flood Year	160.8	24.7	282,760,068	3,215
Overall	Normal Year	141.5	21.4	907,311,824	7,608
	Drought Year	125.9	19.1	758,686,273	6,362
	Flood Year	168.2	25.5	1,124,163,265	9,426

3.2.2 SENA Sugar Estates water demand

Currently, the SENA Sugar Estates irrigate sugar at 70mm per month, an equivalent of 700 m^3 per hectare per month. This translates to 4.2 million m^3 of water per month for an area of 6000 ha which is currently under irrigation. An analysis of monthly rainfall data for Marromeu since 2003 shows that the number of months requiring irrigation per year ranges from five (5) to eight (8) months. On average, irrigation is required for 6.4 months per year. Thus the total annual water demand per annum for sugarcane irrigation is estimated at 26.88 million m^3.

3.3.3 Urban domestic water demand

For the urban areas of Marromeu and Inhaminga (in Cheringoma) it is assumed that the water demand per person per day is 35.6 liters per day (Hirji, Johnson, Maro, and Matiza, 2002). With an estimated urban population of 31 774 and 2 817 persons in Marromeu and Cheringoma respectively, this gives a total annual water demand of about 449 500 m^3 per year.

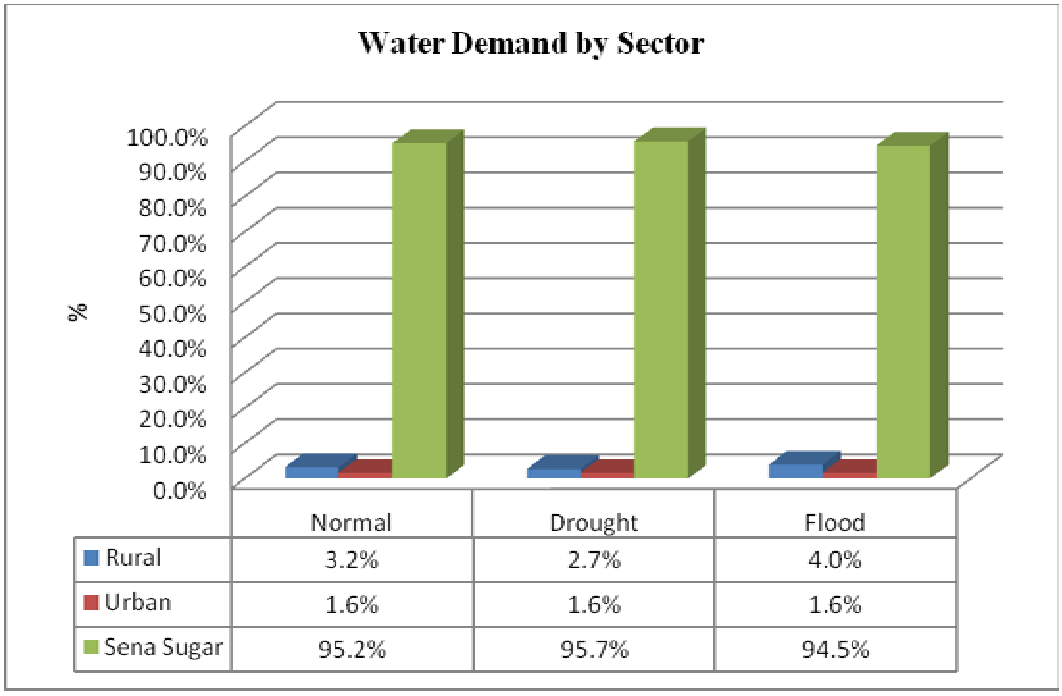
3.3.4 Total water demand

The estimated annual water extraction ranges is 28.08 million m^3 during a drought year, 28.23 million m^3 during a normal year, and 28.5 million m^3 during a flood year. An analysis of water demand by sector shows that SENA Sugar Estates uses about 95% of extracted water in the Zambezi Delta (Figure 3.1).

Water demand for the following sub-sectors was not estimated:

i. tourism in the Coutadas,
ii. commercial manufacturing and/or processing (e.g. for sugar processing), and
iii. smallholder shelter construction,
iv. smallholder pottery and brick making, and
v. Smallholder crop production.

Figure 3.1: Percent Water Demand by Sector by Type of Year



	Normal	Drought	Flood
Rural	3.2%	2.7%	4.0%
Urban	1.6%	1.6%	1.6%
Sena Sugar	95.2%	95.7%	94.5%

3.3 Value of Water Resources

3.3.1 Value of water use by smallholder households

The derived values of water per liter range from US$0.022 to US$0.034 in Marromeu and US$0.012 in Cheringoma. Multiplying the price by the total demand of water per district gives the gross value of water. Given that there is no market for water in the rural communities, this computed value for water is a measure of the gross consumer surplus.

Rural households in the Zambezi Delta incur some water-related costs because they reside in the flood plains. These include the costs of water-borne diseases like diarrhea, and incidences of drowning or people being attacked and/or killed by crocodiles. Only the costs of water-borne diseases were estimated.

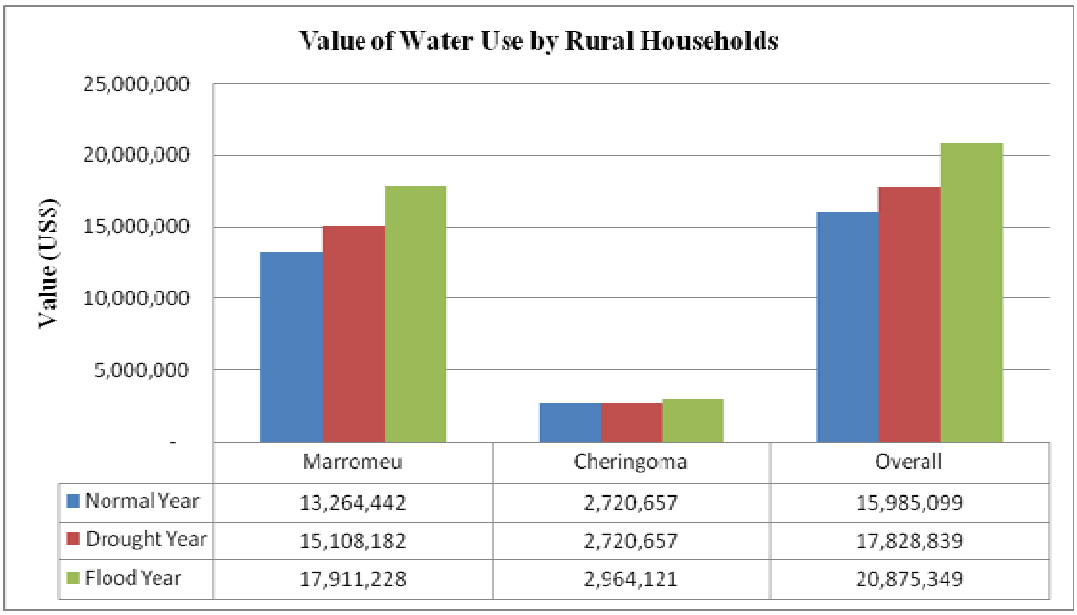
This cost is the value of time lost when people fall ill due to water borne diseases like diarrhea and they have to visit the clinic or some traditional doctor. About 59% of the rural households in the Zambezi Delta are affected by water borne diseases. The analysis assumes that when a household member is affected by a water-related illness, all household members are affected. The time lost due to illness is converted to adult equivalent labour days by multiplying the average household size by a factor of 0.8.

Due to illness from water borne diseases the time lost per year is about 299 000 labour days for rural Marromeu and about 145 700 labour days for rural Cheringoma. Multiplying the lost time by the opportunity cost of labour (i.e. the minimum daily wage rate of US$0.47125) gives an estimate of water-related costs. Thus the estimated annual costs of water in the Zambezi Delta are US$1.13 million for rural Marromeu and US$0.55 million to give a total of about

US$1.7 million. Subtracting these costs from the gross value of water for rural households gives a measure of the net value (consumer surplus) of water for rural households.

The overall net annual value of water use by rural households ranges from about US$16 million during normal years to about US$20.9 million during flood years (Figure 3.2). This translates to a per capita annual value of US$134, US$149, and US$175 for a normal, drought, and flood year respectively.

Figure 3.2: Value of Water Use by Rural Households by Type of Year by District

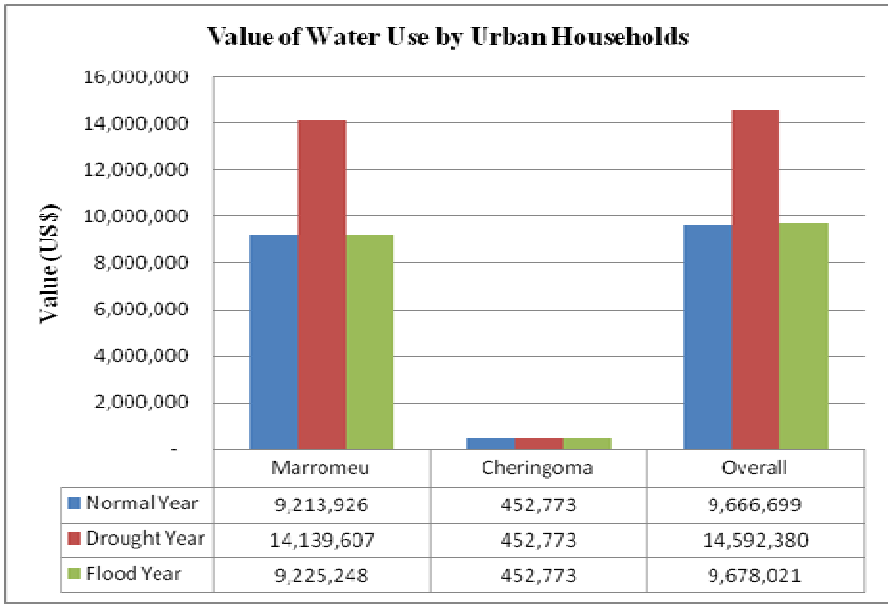


	Marromeu	Cheringoma	Overall
Normal Year	13,264,442	2,720,657	15,985,099
Drought Year	15,108,182	2,720,657	17,828,839
Flood Year	17,911,228	2,964,121	20,875,349

3.3.2 Economic value of urban water use

The overall annual value of water use by urban households in Lower Zambezi is about US$9.7 million during normal and flood year and about US$14.6 million during drought years (Figure 3.3). The per capita annual value for urban water use is US$81 during normal and flood years and US$122 during drought years.

Figure 3.3: Value of Water Use by Urban Households by Type of Year by District



	Marromeu	Cheringoma	Overall
Normal Year	9,213,926	452,773	9,666,699
Drought Year	14,139,607	452,773	14,592,380
Flood Year	9,225,248	452,773	9,678,021

3.3.3 Value of water for sugar irrigation

The analysis of the value water for sugarcane irrigation assumes that water for irrigation is required for 6 months during a normal year, 8 months during a drought year, and for 5 months during a flood year. The estimated costs of irrigation of commercial sugar include the costs of (i) irrigation equipment, (ii) electricity to pump water, and (iii) labour for irrigation. However, these detailed costs were obtained. Hence only the gross values of irrigation water for SENA Sugar are presented. Given, estimated price per liter of water of US$ 0.022 during normal and flood years and US$0.034 during drought years, the annual value of water for irrigating sugar over the current 6 000 ha irrigated land ranges from US$462 million during flood years to US$1.14 billion during drought years (Table 3.4). At an estimated cost of irrigation of US$1200 ha^{-1} yr^{-1} (Kundell, 2007), the annual value of water per hectare irrigated ranges from US$77 000 during flood years to US$190 600 during drought years.

Table 3.4: Net Value of Irrigation Water per Year by Type of Year

Type of Year	USD	USD/ha
Normal Year	555,180,826	92,530
Drought Year	1,143,499,337	190,583
Flood Year	462,026,578	77,004

3.3.4 Total value of extracted water

The estimated total consumptive value of water in the Zambezi Delta is about US$500 million during flood years, US$588 million during normal years, and US$1.18 billion during drought years (Table 3.5). The percent distribution of the value of abstracted water shows that about 95% is attributed to commercial sugar irrigation, whilst only about 5% can be attributed to rural and urban domestic water use (Figure 3.4).

Table 3.5: Total Consumptive Use Value of Water in the Zambezi Delta

Year	Sector			TOTAL
	Rural	Urban	Commercial	
Normal Year	15,985,099	9,666,699	555,180,826	580,832,624
Drought Year	17,828,839	14,592,380	1,143,499,337	1,175,920,555

Flood Year	20,875,349	9,678,021	462,026,578	492,579,948

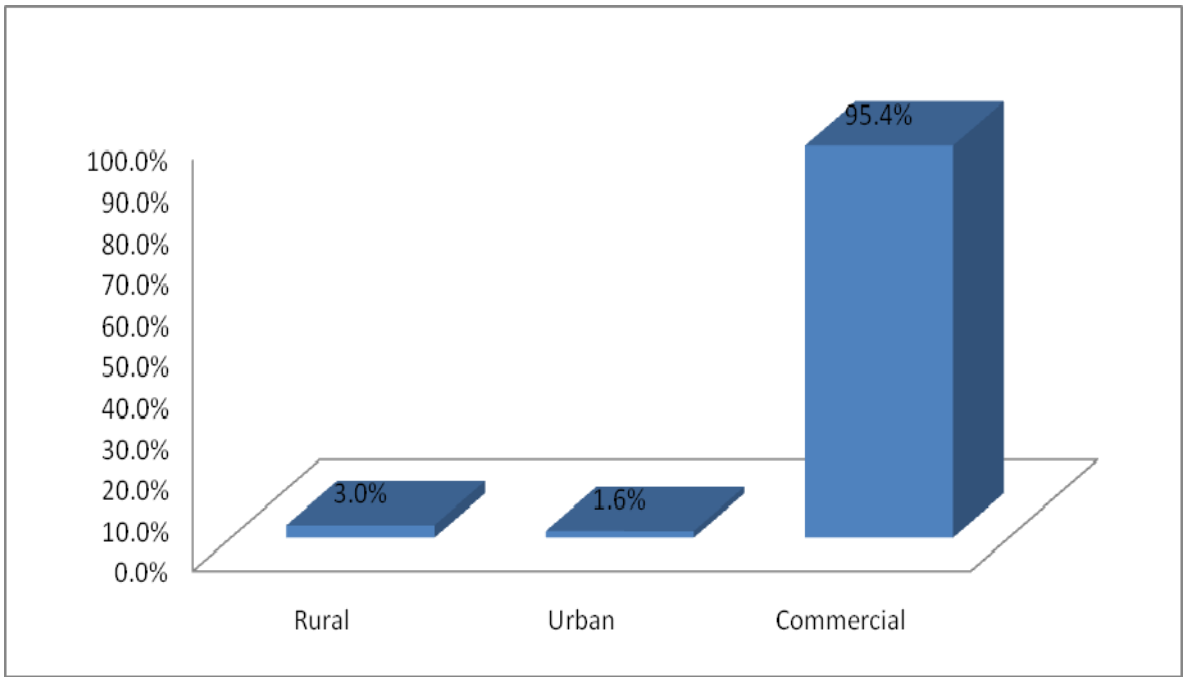


Figure 3.4: Percent Distribution of Use Value of Water in the Zambezi Delta by Sector

4. FISHERIES

4.1 Methodology to Valuing Fisheries Resources

The Zambezi and the tributaries that cover most of the Zambezi Delta provide an abundance of fish that are exploited by smallholder households. The Complex's contribution is measured as the net income generated from fishing. Quantities of fish caught and sold by a typical fishing household were obtained from group discussions as well as the household survey. In addition information was sought on prices on urban and local markets. The days fishing per month, the average hours fishing per day the number of household members involved fishing effort were collected to estimate fishing effort. Given this information, the value of fish can be derived from the following relationships:

Value = [Kilogrammes caught per household x price of fish – days fishing x hours per day fishing x number of members per household fishing x hourly wage] x [% household fishing x Zambezi Delta population households)

There are no corporate fishing ventures within the Zambezi Delta rivers. The corporate fishers benefit indirectly from the services of the mangrove system which provide feed and are a temporary habitat for the prawns, an industry which forms the basis for off-shore prawn fisheries that contribute immensely to the Mozambique economy (MICOA, 1998). The value of prawn fishing attributed to the Zambezi Delta is estimated using the relationship:

Value = Percent of Sofala Bank prawn catch attributed to the Zambezi Delta system x total catch of prawns x price of prawns - cost per ton of prawn caught.

4.2 Fisheries in the Zambezi Delta

Fish are the most important source of protein for the delta population, especially during drought periods. Since 1979, the floodplain fishery in the delta has crashed, and been replaced by riverine and near-shore coastal fisheries. The change in volume and value of catches is unknown. SWECO (1983) estimated a total Zambezi Delta floodplain harvest of about 10 000 tons per annum under normal flooding conditions. Floodplain fisheries comprise some of the most productive available but are dependent upon the annual flood and drawdown for their maintenance.

4.2.1 Subsistence fisheries

Table 4.1 shows the distribution of the main fish species harvested in the communities that were visited during the study. The fish species harvested by most communities in order of decreasing importance are Macacana /pende (*Oreochromis mossambicus*), Mussopo or Nsomba (*Clarias ngamensis & C. gariepinus*), Simbo *(Labeo altivelis & L. congoro)*, and Ngene. An assessment by the communities of the relative abundance of the stocks of these fish species over time shows that:

- Macacana, Nsomba and Simbo may be increasing; and
- Ngene, Nkonokono (*Synodontis zambezensis*), Ulauwa, Chenga (*Distichodus schenga*), Mambele, and Nkupe

(*Distichodus mossambicus* & *Mormyrus longirostris*) may be decreasing over time.

An assessment of the size of the commonly harvested fish shows that in general the size for:

- Macacana, Simbo, Ngene, Nkonokono, and Mambele are perceived to be decreasing over time; and
- Mussopo, Chenga, and Nkupe are perceived to be increasing over time.

From the community group discussions the following observations are made on some of the conservation aspects for Lower Zambezi subsistence fisheries:

i. The conservation status of fish habitat in the visited communities is reasonable to high in 43% of the communities;
ii. In the majority of the communities (71%), the perception is that there are no regulations on the months when fishing is allowed;
iii. In those communities where there are fishing month rules, the level of compliance is generally very low to low;
iv. There are regulations on fishing gear in about 57% of the communities; and
v. In those communities where there are fishing gear regulations, the level of compliance is at least fair in 50% of the communities and it is very low to low in the other 50% of the communities.

Table 4.1: Presence of Fish Species by Type by Community by District

District	Community	Tenke / Macacana	Mussopo / Nsomba	Simbo / Massimbo	Ngene	Nkonokono	Ulauwa	Chenga	Mambele	Nkupe
Marromeu	Chueza	√	√	√	√	√	√	√		
	Miguguna	√	√							
	Safrik	√	√	√	√	√				
	Salone	√	√	√						
	Nhame	√	√	√		√				
	Chiburiburi	√	√	√	√	√				
	Mponda	√	√	√	√	√		√	√	√
	Nangue	√	√	√	√					
	Gorra	√	√	√	√			√		√

	Mangazi	√	√	√	√			√		
Cheringoma	Chirimadzi	√	√							
	Matondo	√	√							
	Guma									
	Chidanga									

The percent households using different fishing gear in the visited communities show that the most commonly used fishing gear are nets and lines (Table 4.2). The use of traps is more prevalent in the Marromeu communities than in the Cheringoma communities.

The percent households involved in fishing activities is 51.7 in Marromeu and 17% in Cheringoma. Overall the percent households involved in fishing activities is 38.7%. On average, about 1.4 persons per household are involved in fishing activities. The average number of days fishing per month is similar between Marromeu (13 days) and Cheringoma (15 days). The mean fishing effort is estimated at 14.7 labour days per month per fishing household in Marromeu communities and 4.7 labour days per fishing household in Cheringoma communities.

There are two fishing seasons in the Zambezi Delta – (i) the main (January to May) season, and (ii) the second (June to December) season. The mean fish caught per fishing day during the main season is about 41 kilograms in Marromeu communities whilst it is about 30 kilograms for Cheringoma communities (Table 4.3). During the second season, the mean fish catch per day is estimated at 32% of the main season catch. The effective number of months fishing during the second season is five months.

Table 4.2: Percent Fishing Households Using Fishing Gear by Type by Community by District

District	**Community**	**Net**	**Line**	**Spear**	**Trap**	**Other Gear**
Marromeu	Chueza	76.2	61.9	0.0	19.0	0.0
	Megugune	36.8	94.7	0.0	5.3	5.3
	Safrik	57.1	42.9	0.0	7.1	7.1
	Salone	10.7	82.1	0.0	3.6	10.7
	Nhane	55.2	41.4	0.0	27.6	3.4

	Chiburiburi	50.0	66.7	0.0	22.2	0.0
	Mponda	16.7	83.3	0.0	16.7	0.0
	Nangue	61.5	100.0	0.0	38.5	0.0
	Gora	66.7	71.4	0.0	0.0	0.0
	Mangazi	82.6	60.9	8.7	17.4	0.0
Cheringoma	Chirimadzi	25.0	50.0	0.0	25.0	0.0
	Matondo	47.1	64.7	5.9	0.0	11.8
	Guma	0.0	94.1	0.0	5.9	5.9
	Chidanga	0.0	100.0	0.0	0.0	0.0

Table 4.3: Mean Fish Catch per Day (kg) by Community by District (HH survey)

District	Community	Tilapia	Catfish	Squeaker	Tiger fish	Labeo	Shrimp	Crab	Other	Total
Marromeu	Chueza	11.6	12.8	18.1	5.5	11.0	3.8	0.0	0.3	63.2
	Megugune	8.2	11.5	3.7	2.0	4.2	2.6	2.1	1.1	35.3
	Safrik	13.4	10.6	3.1	1.4	3.8	0.0	0.0	1.4	33.8
	Salone	5.7	2.3	0.0	0.3	1.6	0.0	0.0	0.0	9.8
	Nhane	9.3	9.4	3.8	1.4	6.0	0.0	0.0	2.1	32.0
	Chiburiburi	14.9	14.6	8.6	7.1	12.5	0.0	0.0	2.2	59.9
	Mponda	13.9	9.0	1.3	0.5	5.4	0.0	0.0	0.0	30.0
	Nangue	9.8	10.8	2.4	3.2	2.9	0.0	0.0	1.5	30.6
	Gora	24.7	14.9	9.3	3.5	4.5	3.8	0.0	5.8	66.5
	Mangazi	17.4	14.6	7.2	3.7	7.4	0.0	0.0	0.2	50.6
	Total	12.6	10.8	5.9	2.8	5.9	1.1	0.2	1.5	40.7
Cheringoma	Chirimadzi	8.7	50.9	5.0	0.0	6.5	0.0	0.0	0.0	71.0
	Matondo	21.1	11.2	3.8	0.0	6.8	0.0	0.0	0.0	42.8
	Guma	2.0	4.5	0.2	0.0	2.3	0.0	0.0	0.8	9.8
	Chidanga	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0

	Total	10.9	12.2	2.3	0.0	4.6	0.0	0.0	0.3	30.4
Total		12.3	11.0	5.3	2.3	5.7	0.9	0.2	1.3	39.0

**** Means are for HH involved in Fishing Only**

Table 4.4: Mean Fish Sales (kg) by Community by District (HH survey)

District	Community	Tilapia	Catfish	Squeaker	Tigerfish	Labeo	Shrimp	Crab	Other	Total
Marromeu	Chueza	8.5	10.7	13.6	4.6	10.8	3.8	0.0	0.1	52.2
	Megugune	3.2	5.4	2.2	0.4	2.6	2.1	1.6	0.8	18.2
	Safrik	7.7	5.1	1.1	0.9	0.9	0.0	0.0	0.0	15.6
	Salone	1.2	0.5	0.0	0.0	0.4	0.0	0.0	0.0	2.2
	Nhane	5.8	4.5	2.7	0.9	3.4	0.0	0.0	1.9	19.1
	Chiburiburi	6.9	5.3	3.3	2.1	5.4	0.0	0.0	2.2	25.3
	Mponda	7.8	5.2	0.5	0.0	2.6	0.0	0.0	0.0	16.0
	Nangue	8.0	7.1	2.1	1.6	2.5	0.0	0.0	1.5	22.9
	Gora	21.2	12.3	7.6	2.3	2.2	3.8	0.0	4.6	54.0
	Mangazi	10.3	5.6	3.3	0.8	3.9	0.0	0.0	0.0	23.8
	Total	7.8	6.0	3.8	1.4	3.5	1.0	0.2	1.2	24.8
Cheringoma	Chirimadzi	5.6	46.8	0.3	0.0	1.4	0.0	0.0	0.0	54.0
	Matondo	13.0	7.6	2.5	0.0	3.4	0.0	0.0	0.0	26.4
	Guma	0.1	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.8
	Chidanga	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	6.3	8.3	1.1	0.0	1.7	0.0	0.0	0.0	17.4
Total		7.6	6.3	3.3	1.1	3.2	0.8	0.1	1.0	23.6

**** Means are for HH involved in Fishing Only**

Given these parameters, the estimated total fish catch by the smallholder sector is 26 826 tons per annum. Of this total catch, 91% is caught by households in Marromeu whilst the remaining 9% is caught by households in Cheringoma. Of the total fish catch, about 61% (Table 4.4) is sold to non-fishing households within a community and also to urban Marromeu, Caia, and Inhaminga. Thus, about 10460 tons of fish are consumed by the fishing households.

4.2.2 Commercial shrimp harvesting

The crash of the coastal prawn industry has important implications for the national economy. Hoguane (1997) estimated that the regulation of the Zambezi River is leading to a loss of US$10 – 30 million per annum. However, this loss of income has limited impact on the local subsistence economy (Beilfuss, Dutton, and Moore 2001).

The prawn fishery off the delta coast, which began in 1965, is one of the most important sources of foreign currency in Mozambique. The catch rate of the shrimp is reported to be decreasing at an alarming rate since the early 1980s (Gammelsrod 1992b). The shrimp catch on the Sofala Bank, off the Zambezi river mouth, is related to river discharge. The number caught per hour is positively correlated with flood levels. Catches declined from 10 000 – 12 000 tons in 1974-76 to 8 000 tons in 1983 and 7 900 tons in 1998. During flood years, Gammelsrød (1992) estimated that the catch per unit effort could be increased by about 20%, or 1 500 tons per year. The catch is mainly comprised of three species – *Penaeus indicus* (48 %), *Metapenaeus monocerus* (42 %) and *Penaeus monodon* (10 %).

The Zambezi Delta contains □ve percent (5%) of Mozambique's estimated 400 000 ha of mangroves (Gift to the Earth, 2003). Thus the estimated mangrove area that can be attributed to the Zambezi Delta is 20 000 ha. This represents 14.81% of the Sofala Bank mangrove area of an estimated 135 000 ha (MICOA, 1997). Assuming a total catch level of 12 000 tons (see Box 1) of prawns per annum during a normal year for the whole Sofala Bank, the estimated catch that can be attributed to the Zambezi Delta is 1 800 tons of prawns. During flood years, the estimated prawn catch is 2 200 tons.

Box 1: Shrimp Fishing Operations by Pescamar

It is estimated that 30 companies operate at the industrial (on board freezer) level within the Sofala Bank (*Banco de Sofala)* fishing grounds. This covers a large area that is not entirely dependent on the Zambezi breeding grounds.

Pescamar is the largest operator in the prawn fishing industry in Sofala province and in Mozambique. The company is currently comprised of the fishing companies Pescamar, Efrebel, and Pescabom. The Company employs between 1000 and 1200 people. The Company operates a shipyard for maintenance. The Company has a compliment of 33 industrial fishing vessels:

i. 26 large haulers with onboard freezing facilities. Each vessel has a capacity of 140 – 150 tons.
ii. 7 smaller haulers with onboard freezer facilities, each with a capacity of 100 tons.

The fishing season runs between 1st March and the 30th October with the first 2 months seeing the best catches. New legislation to be put into effect within the next year will see the legal season decrease by one month to become 1st March to 30th September.

During normal years the average landing per large vessel falls between 120 and 130 ton for the first two months of the season (March and April) with catch decreasing thereafter. The big haulers set sail for about 30 to 45 days, before returning to empty their catch in Beira.

The total estimate of the prawn industry (not including by-catch) per year is EUR 80 million. The EU is the largest market for prawns with other markets demand being negligible. Spain, Portugal, France and Ireland are the largest consumers (respectively).

The break even mark of prawn catch per day is 400-500kg per large vessel. The first 4 months of the season are reported to be profitable whilst the last 2 months rarely make a profit.

The 2008 quota for the industrial fleet is 9000 ton. The total quota for the year is estimated at 15000 ton. This leaves 6000 ton for semi-industrial (ice-based) vessels. The average price per ton of prawn is between 6000-7000EUR. This price is reported to be falling in recent years, but is unlikely to reach as low as 5000EUR per ton. This fall in the prawn prices is a direct result of the prawn-farms that are mushrooming around the world, mainly in Asia and Latin America.

4.3 Value of the Fisheries

4.3.1 Value of subsistence fisheries

The annual gross value of subsistence fisheries in the Zambezi Delta is estimated at US$6.55 million (Table 4.5). The annual gross sales revenue of fish is about US$4 million. The annual total net value of subsistence fisheries in the Zambezi Delta is estimated at US$6.2 million per annum). The overall annual per capita value of subsistence fisheries is about US$52.

Table 4.5: Consumptive Value of the Zambezi Delta Subsistence Fisheries (US$)

District	Gross Value of Fish	Gross Sales Revenue	Net Value
Marromeu	5,892,616	3,568,203	5,591,748
Cheringoma	661,518	417,693	602,907
Total	6,554,134	3,985,895	6,194,656

4.3.2 Value of commercial shrimp fisheries

The present market value for prawns is between US$9 and US$11 Kg^{-1} (Box 1). Taking the mid-value of US$10 Kg^{-1}, the annual gross benefit from shrimp catches that can be attributed to the Zambezi Delta during a normal year is estimated at US$18 million. During flood years, the additional average catch of 400 tons is in the order of US$4 million per annum.

The value of effort in shrimp harvesting is obtained as follows:

i. For a 150 ton vessel to break even over a 45 day round trip, a total of 20.25 tons of shrimp is required.
ii. The total value (cost) to break even per round trip is US$202500.
iii. Dividing the resulting figure by 15000 Kg, gives an average harvesting cost of US$1.35 per Kg.

Subtracting the costs of effort for the total shrimp catch from the gross value of shrimps gives a net value of shrimp fishing of US$15.6 million in a normal year. During a flood year the incremental net value of shrimps is estimated at about US$3.5 million.

4.3.3 Total value of fisheries

The total annual net value of Zambezi Delta fisheries is estimated at US$21.7 million during a normal year and US$25.2 million during a flood year (Table 4.6). During a normal year, subsistence fisheries contribute about 29% to the total value of the fisheries. During a favorable flood year, subsistence fisheries contribute about 25% to the total value of the Zambezi Delta fisheries.

Table 4.6: Total Annual Net Value of Zambezi Delta Fisheries

Fishery	Normal Year	Flood Year
Subsistence	6,194,656	6,194,656

Commercial	15,570,000	19,030,000
Total	21,764,656	25,224,656

5. AGRICULTURE

5.1 Methodology to Valuing Agriculture Production

The Zambezi River and its tributaries in the Zambezi Delta provide abundance due to its ground water recharge and fertility enhancing functions of periodic flooding. The direct benefits of these ecosystem functions are through their effects on productivity of traded and non-traded agricultural production activities. That is, the ecological functions act as inputs into the production of agricultural produce. The contribution of the ecological functions to the realized income of the outputs is estimated as the revenue of the product(s) net of costs of production. Smallholder communities in the study area do not use fertilizers hence the main inputs that are factored out are family labor and seed.

To estimate the agricultural benefits the study collected information on percent households cropping each crop, cropped area, labor input and yields of the various crops grown by households in Cheringoma and Marromeu districts. Data was collected for each of the two agricultural seasons per year. Respondents were asked to assess the agricultural production variables under normal, drought, and flood years to get an idea of the changes in productivity due to floods or droughts. For each crop, the gross revenue net of labor and seed costs is computed for a typical or average household. The minimum wage is used as the price of labor input while prices of crops in local markets provided the basis for revenue computations. Scaling-up the net revenue for the typical household to the whole Zambezi Delta provides an estimate of the total net income and hence the value agricultural production for the smallholder farmers in the Zambezi Delta.

To estimate agricultural benefits for the only large-scale commercial farming operation in the Zambezi Delta – sugar production at SENA Sugar, data was collected on area cultivated, yields, water use, harvesting labor, fertilizer and pesticide use levels. Information on factory production costs and operation profitability could not be obtained. To derive the net value from sugarcane production and processing the study depend on industry level average of costs of sugar production and processing as well as sugar selling prices in published literature.

In addition to crop production, the communities of the Zambezi Delta derive benefits from livestock. A significant number of smallholder households keep goats, free-ranging pigs and chickens. Due to tsetse fly prevalence cattle are not kept by Zambezi Delta inhabitants. The economic benefits of keeping livestock are estimated as the sum of revenue from sales of livestock less the cost of labor effort for tending livestock for an average household. The result is then scaled-up to get the total economic value for the Zambezi Delta.

5.2 Agriculture in the Zambezi Delta

5.2.1 Smallholder crop production

Across all the Zambezi Delta communities, the main method of land clearing for crop production is by slashing and burning. Due to lack of mechanization for land preparation, this is the most effective method for land preparation.

The mean farm size for the smallholder farmers is 1.83 ha. The mean land holding is higher for Cheringoma District households at 1.93 ha compared to 1.73 ha for Marromeu District households. The most commonly crops grown, in descending order of importance, are maize, millets, cassava, sorghum, sesame seed, rice, sweet potatoes, cow peas, bananas and papaya (Table 5.1). Overall, maize is grown by about 98% of the households, millets is grown by about 74% of the households, and cassava by about 40% of the households. Vegetables and sugarcane are produced by only 10% and 6% of the households respectively.

Table 5.1: Percent farmers growing different crops by District

District	Maize	Millets	Rice	Cassava	Cow peas	Sweet potato	Sorghum	Sesame Seed	Vegetables	Sugarcane	Banana / Papaya
Marromeu	97.6	66.0	46.4	44.8	16.4	31.3	28.6	22.3	10.1	7.4	26.8
Cheringoma	98.3	87.8	18.3	31.0	34.5	17.5	28.8	30.1	9.2	3.5	16.2
TOTAL	97.9	74.2	35.8	39.6	23.3	26.1	28.7	25.2	9.7	5.9	22.8

Crop production is done over two seasons in a year: the main season and the second season. The mean area by district under different crops by season is given in Table 5.2. On average a larger area is put under crops during the main season than during the second season. Irrespective of season, the largest hectarage is put under maize followed by millets. With respect to area allocation, the following crops are more important in Cheringoma than in Marromeu are: maize, millets, cow peas, sorghum, and sesame.

Table 5.2: Area Under Main Crops (ha) by Season by District

	MAIZE		MILLETS		RICE		CASSAVA		COW PEAS		SWEET POTATO		SORGHUM		SESSAME SEED	
District	MS	SS	MS	SS	MS	SS	MS	SS	MS	SS	MS	SS	MS	SS	MS	SS

Marromeu	0.61	0.51	0.51	0.41	0.43	0.24	0.23	0.24	0.19	0.25	0.17	0.22	0.26	0.17	0.56	0.56
Cheringoma	0.99	0.92	0.86	0.86	0.30	0.01	0.17	0.38	0.26	0.63	0.02	0.77	0.60	0.50	0.83	0.65
Total	0.75	0.63	0.67	0.52	0.41	0.23	0.21	0.28	0.23	0.45	0.14	0.35	0.39	0.21	0.68	0.59

MS – Main Season SS – Second season

Scaling-up the mean areas under cultivation for a typical household to the district, the analysis estimates total area under crop production in Marromeu District is estimated at 25 300 ha (Table 5.3). The cultivated area for Cheringoma district is estimated at 10 200 ha. This estimation excludes the area under fallow, which was not estimated. The results compare very well with estimates obtained from the districts for 2007/2008 season: 21 172ha for Marromeu and 9 394 ha for Cheringoma.

Table 5.3: Estimated Total Area (ha) Under Crop Cultivation by Season by Year Type by District

	Marromeu			Cheringoma
Season	Normal Year	Flood Year	Drought year	All Years
Main season	14,726	12,814	12,988	7,528
Second season	10,571	6,259	6,624	2,686
ANNUAL TOTAL	**25,297**	**19,073**	**19,612**	**10,214**

Table 5.4 presents the mean crop yields by district for the Zambezi Delta. The estimated crop yields are well within the estimated obtained from the Districts agricultural offices (e.g. for Marromeu District, the average cereal yields are 900 kg ha^{-1}, tuber-crop yields are 4.51 ton ha^{-1}, and legume yields are 467 kg ha^{-1}). An analysis of crop yields in Table 5.4 shows that:

(i) during the main season in a normal year, the crop yields are higher in Marromeu communities than in Cheringoma communities for the maize, millets, rice, cassava, sorghum, and sesame seed;
(ii) Overall, crop yields are highest during a normal season; and
(iii) Generally, crop yields during drought years are higher than crop yields during flood years. That farmers are able to get some reasonable yields during drought years illustrates the importance of wetlands in terms of drought prevention.

Table 5.4: Estimated Crop Yields (Kg ha^{-1}) for Zambezi Delta Communities by Season

	Marromeu						Cheringoma					
	Main Season			Second Season			Main Season			Second Season		
Crop	Normal Year	Flood Year	Drought Year	Normal Year	Flood Year	Drought Year	Normal Year	Flood Year	Drought Year	Normal Year	Flood Year	Drought Year
Maize	822.5	104.1	205.8	500	300	0	770.8	208.3	197.9	400	150	0
Millets	868.3	100	188.9	0	0	0	662.5	150	218.8	0	0	0
Rice	1371.4	320	100	0	0	0	200	300	150	0	0	0
Cassava	957.1	0	692.9	1466.7	42.9	881.3	425	25	300	150	100	50
Cow peas	350.8	0	170.4	250	250	250	352.8	0	54.2	0	0	0
Sweet potato	0	0	0	4496.5	2100	1625	0	0	0	1000	0	500
Sorghum	425	187.5	100	200	100	100	250	125	125	0	0	0
Sessame	703.6	83.3	356	0	0	0	575	125	0	0	0	0
Vegetables	2000	0	2000	2757.3	0	1930	0	0	0	0	0	0
Sugarcane	6000	4666.7	4333.3	6750	8125	6000	25000	25000	15000	0	0	0
Banana	3503.3	2250	2755.6	3450	2216.7	2744.4	5120	5120	5060	5180	5180	5120
Papaya	2533.3	2366.7	2366.7	2550	2550	2550	0	0	0	0	0	0

A further analysis of the yield effects of floods is presented in Table 5.5. Across the majority of crops and across all seasons, the percent households obtaining zero yields are higher during the flood years than both the normal and drought years. In addition, about 64% of the communities indicated that floods result in the abandonment of some of the agricultural land. Thus the occurrence of floods seems to result in reduced food security in the Zambezi Delta. The implication of this result is that the current water release regimes from the Cahora Bassa and normal rainfall floods seem to result in overall low crop productivity during the years they occur. However, farmers perceive that floods are associated with higher rice yields – the higher the floods, the better are the yields.

Farmers do not use chemical fertilizers in crop production. None of the farmers irrigate their major crops. Only vegetables are irrigated and at a very small-scale.

The main crop market outlets for different crops in order of decreasing importance by crop type are presented in Figure 5.1. Across all communities, the main crop market outlets are the local community, followed by Marromeu urban, then Caia and Inhaminga. However, the analysis did not assess the volume of products being marketed through the different market outlets.

Table 5.5: Percent Households with Zero Crop Yields by Season by Type of Year by District

		MAIN SEASON			SECOND SEASON		
Crop	District	Normal YR	Flood YR	Drought YR	Normal YR	Flood YR	Drought YR
Maize	Marromeu	9.1	82.7	55.1	0.0	79.3	78.4
	Cheringoma	0.0	86.0	71.4	0.0	54.2	55.7
Millets	Marromeu	0.0	42.4	16.4	0.0	25.5	10.5
	Cheringoma	0.0	64.1	43.6	0.0	21.9	14.5
Rice	Marromeu	0.0	29.0	18.2	0.0	9.5	5.0
	Cheringoma	0.0	5.3	5.1	0.0	0.0	0.3
Cassava	Marromeu	0.0	28.0	6.5	0.0	18.4	2.0
	Cheringoma	0.0	7.4	3.8	0.0	8.2	2.0
Cow peas	Marromeu	0.0	8.1	1.8	0.0	2.9	0.5
	Cheringoma	0.0	5.9	6.7	0.0	0.0	0.4
Sweet potato	Marromeu	0.0	16.3	8.6	0.0	9.5	2.4
	Cheringoma	0.0	5.4	3.7	0.0	0.8	0.8
Sorghum	Marromeu	0.0	15.0	3.7	0.6	6.5	1.7
	Cheringoma	0.0	5.4	3.4	0.0	0.0	0.6
Sessame seed	Marromeu	0.0	14.8	4.0	0.0	7.6	2.1
	Cheringoma	0.0	11.2	9.1	0.0	0.7	1.3

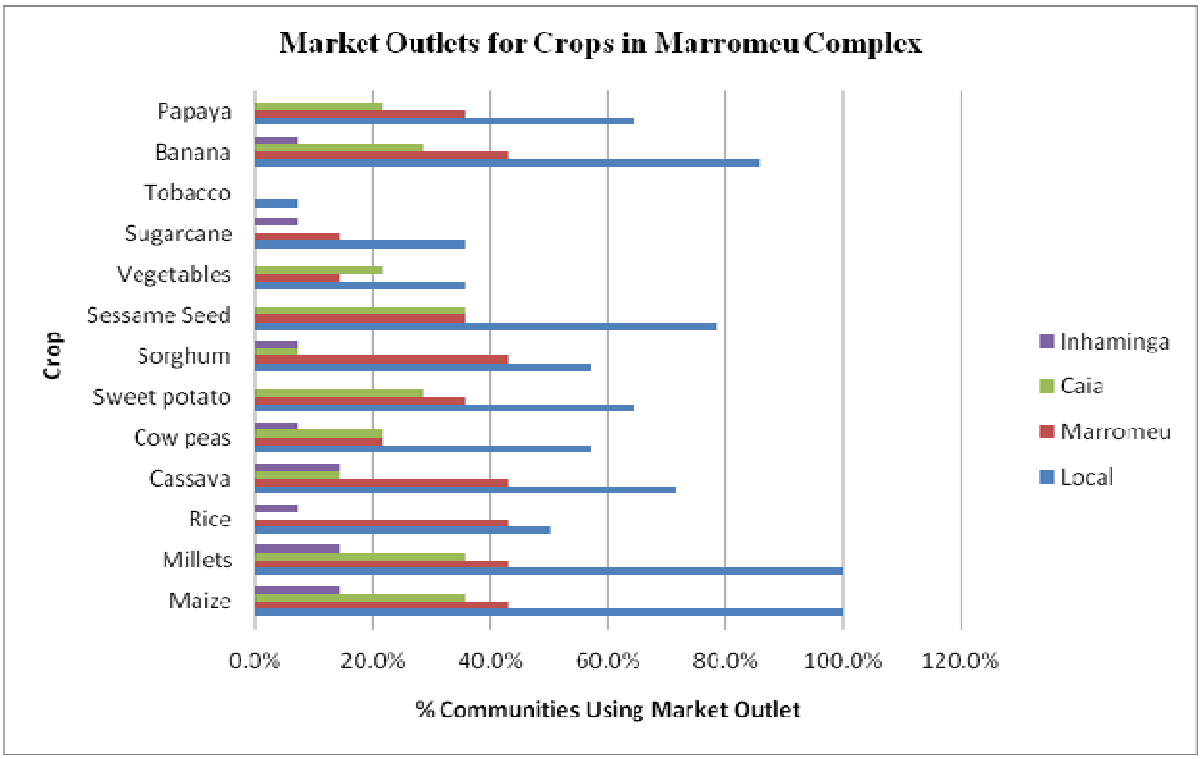


Figure 5.1: Percent Zambezi Delta Communities Using Market Outlets for Crops by Type of Crop

5.2.2 Smallholder livestock production

The main livestock owned by communities in the Zambezi Delta are goats, pigs, and poultry. About 77% of the households own poultry; about 21% own goats, and about 9% of the households own pigs (Table 5.6). The mean livestock ownership is, for those who own the respective livestock, 13 chickens, 7.26 goats, and 4.6 pigs (Table 5.7). The estimated total number of livestock owned in the Zambezi Delta is 28 000 goats, 7 700 pigs, and 175 800 poultry/chickens (Table 5.8).

Livestock are kept for consumption and for sale. An average household consumes about one (1) goat, one (1) pig, and about six (6) chickens per annum from own production (Table 5.8). The estimated total annual livestock consumption is about 4 450 goats, 1 700 pigs, and 77 900 chickens (Table 5.9). The estimated total annual sales is 5 700 goats, 1900 pigs, and 56 150 chickens. Similarly, the mean number of livestock sold per year is about 1.5 goats, one (1) pig, and four (4) chickens. For a typical household in the Zambezi Delta, the total annual income derived from livestock sales is about US$53.

As part of human-wildlife conflicts, households loose some of their livestock to wildlife. The percent households loosing livestock to wildlife in Marromeu is 7.3% whilst it is 11.3% for Cheringoma. A total of 175 goats, 39 pigs and 10 900 chickens are lost to wildlife per year (Table 5.9).

Table 5.6: Percent Households Owning Livestock by Type by District

Community	Goats	Pigs	Poultry

Marromeu	24.5	12.3	74.4
Cheringoma	15.7	2.2	81.7
TOTAL	21.2	8.5	77.2

Table 5.7: Mean Livestock Ownership by District

Community	Goats	Pigs	Poultry
Marromeu	6.54	4.17	12.67
Cheringoma	9.25	8.80	13.22
TOTAL	7.26	4.60	12.88

Table 5.8: Mean Annual Livestock Consumption, Sales and Income (Mtn) by Community by District

Community	Goats Consumed	Goats Sold	Income from Goats	Pigs Consumed	Pigs Sold	Income from Pigs	Poultry consumed	Poultry sold	Income from poultry
Marromeu	0.99	1.48	388.62	1.00	1.02	439.76	5.76	4.23	350.16
Cheringoma	1.67	1.25	719.23	1.00	2.40	733.33	5.49	3.77	281.92
TOTAL	1.17	1.42	462.72	1.00	1.15	483.80	5.66	4.05	319.66

Table 5.9: Global Livestock Estimates for the Zambezi Delta

Livestock Variable	District	Goats	Pigs	Poultry
Estimated livestock numbers owned	Marromeu	21,032	6,732	123,732
	Cheringoma	6,997	933	52,038
	TOTAL	28,029	7,665	175,770
Estimated annual livestock consumption	Marromeu	3,184	1,614	56,251
	Cheringoma	1,263	106	21,610
	TOTAL	4,447	1,720	77,861
Estimated annual livestock sales	Marromeu	4,759	1,647	41,309
	Cheringoma	946	254	14,840
	TOTAL	5,705	1,901	56,149
Estimated annual livestock lost to wildlife	Marromeu	175	39	6,864
	Cheringoma	-	-	4,029
	TOTAL	175	39	10,892

5.2.3 Commercial sugarcane production

The current total area under commercial sugarcane is 14 000 ha. Of this, 6000 ha is under irrigation whilst 8 000 ha is rain-fed. The projection by SENA is to have a total of 20 000 ha under sugarcane, with a total of 12 000ha under irrigation. The fertilizer application rate is 500kg per ha annually. The total herbicide application is 50 000 litres per year and insecticides are applied at 1500 liters per year.

The sugarcane yields increased from 48 ton ha^{-1} in 2006 to 53 ton ha^{-1} in 2007. The target is to achieve yields of 75ton ha^{-1}. The main constraint to increased yields is energy availability for improved irrigation. SENA is not currently on the national power grid and depends on own generators with which they run the entire processing plant, the residential village and irrigation. Sugarcane at SENA is harvested at 18 months. The harvest season lasts for 185 days. Sugarcane is harvested at a rate of 3 tons per person per day. The current processing yield is estimated at 5.5 ton ha^{-1} of white sugar and a corresponding 1.9 ton ha^{-1} of molasses.

5.3 Value of Agricultural Production

5.3.1 Economic value of smallholder crop production

The total annual gross value from production is US$23 million during a normal year, US$5.6 million during a flood year, and US$6 million during a drought year (Table 5.10). Of this total gross value, 88%, 81%, and 84% is derived from Marromeu District during a normal year, flood year, and drought year respectively. During a normal agricultural season, about 67% of the annual gross value of crops is attributed to the normal season (Figure 5.2). During flood and drought years about 50% of the annual gross value of crops is derived from both the main and second seasons.

After accounting for labour and seed costs in crop production, the analysis shows that the producer surplus generated from smallholder agriculture production is positive only during normal years (Table 5.11). During a normal agricultural year, the net value of smallholder crop production is estimated at about US$1.9 million with an annual per capita value of US$16. During flood and drought years the annual net value of crop production is negative. The negative producer surpluses during the flood and drought years are a result of the low crop yields resulting from the high labor effort inputted by the households to produce food. For Cheringoma district, the producer surplus is negative irrespective of the agricultural season or type of year.

Table 5.10: Annual Gross Value (US$) of Crops in the Zambezi Delta by District

Marromeu	Normal year	Flood year	Drought year
Main season	13,287,329	1,923,775	2,448,515
Second season	6,998,734	2,621,923	2,805,361
Total	20,286,063	4,545,698	5,253,876
Cheringoma			
Main season	2,050,477	705,784	713,310
Second season	634,643	328,088	238,889
Total	2,685,120	1,033,872	952,199
Overal (Marromeu + Cheringoma)			
Main Season	15,337,806	2,629,559	3,161,826

Second Season	7,633,377	2,950,011	3,044,249
Total	22,971,183	5,579,570	6,206,075
Overall Annual per Capita Value	193	47	52

Figure 5.2: Percent Annual Gross Crop Value by Season

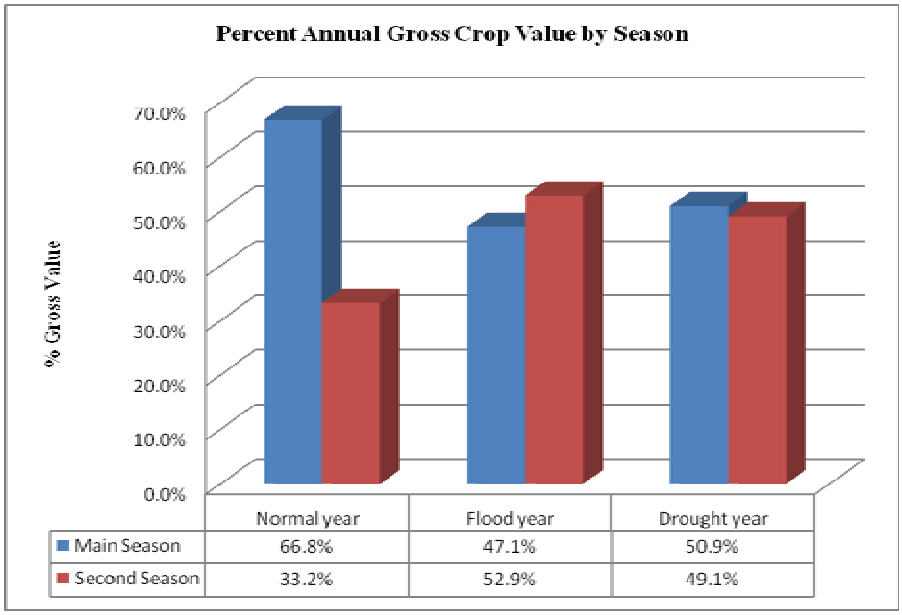


Table 5.11: Annual Value (US$) of Crop Production by District

Marromeu	Normal Year	Flood Year	Drought year
Main season	7,767,115	(2,879,528)	(2,419,961)
Second season	3,036,172	275,669	322,242
Total	10,803,287	(2,603,859)	(2,097,719)
Cheringoma			
Main season	(771,427)	(2,116,119)	(2,108,593)
Second season	(372,389)	(678,944)	(768,143)
Total	(1,143,816)	(2,795,064)	(2,876,737)
Overal (Marromeu + Cheringoma)	1,892,355	(2,519,394)	(2,554,494)
Annual per capita	16	(21)	(21)

5.3.1.1 Costs of current flood regimes

The current flood regimes, either through the untimely flood release up-stream at Cahorra Bassa or through rain-floods that occur between January through March seem to negatively affect smallholder agricultural production. The cost of floods when compared to a normal year is estimated to about US$4.4 million. Discussion with smallholder farmers indicated that the best timing of floods for them is if the floods, especially the regulated floods from the Cahorra Bassa, could occur during November / December right at the start of the rain season. The reasoning by farmers is that these earlier floods will enable them to have a longer second agricultural season, which is then expected translate into higher yields.

5.3.1.2 Value of drought prevention in subsistence agriculture production

The Zambezi Delta has an important function of drought prevention under smallholder agriculture production. Overall, during drought years, the Zambezi Delta wetlands generate a gross value of US$6.2 million per year (Table 5.10) from smallholder agriculture production. This value in agricultural production can be directly attributed to the ground water recharge of the wetlands.

5.3.2 Economic value of smallholder livestock

The total annual consumption value of value of livestock for the Zambezi Delta communities is US$356 800 (Table 5.12). Of this value 73.2% is derived from chickens; 18.3% from goats, and 8.5% from pigs. Similarly, the annual gross revenue from livestock sales is estimated at US$296 300. Of this total 63.7% is attributed to chickens, 25.2% to goats, and 11.1% to pigs.

The value of livestock lost to wildlife is estimated at US$38 900 per year. Of this value, 93.2% is attributed to chickens, 5% to goats, and 1.8% to pigs.

To obtain the net value of livestock, the following relationship is used:

Consumption Value + Sales Value – Value of Loss to Wildlife – Cost of Labor

The cost of labor is estimated by assuming that a household spends three (3) hours on livestock activities per day. The labor is valued at the opportunity cost of labor (i.e. minimum wage rate for unspecialized activities) of US$0.47125 per hour.

After accounting for the costs of looking after livestock, the annual net value of livestock is US$605 100 with an annual per capita value of US$5. Of the total annual net value, 67.3% is derived from chickens, 22.5% from goats, and 10.2% from pigs.

Another important aspect in the valuation of livestock is the value of the stock of livestock. The value of the stock of livestock represents an option value for the future sale or consumption of livestock. The current stock of livestock is valued at the current price of livestock. The stock of livestock in the Zambezi Delta is valued at US$1.1 million. Of this total option value, 52.6% is derived from chickens, 35.5% from goats, and 11.9% from pigs.

Table 5.12: Total Annual Consumption, Sales Revenue, and Loss to Wildlife Value of Livestock (US$)

Estimated annual value of livestock consumption				
District	Goats	Pigs	Poultry	Total
Marromeu	34,833	29,003	194,018	257,854
Cheringoma	30,285	1,349	67,334	98,969
TOTAL	**65,118**	**30,352**	**261,352**	**356,822**
Estimated annual gross revenue from livestock sales				
District	Goats	Pigs	Poultry	Total
Marromeu	52,073	29,583	142,482	224,138
Cheringoma	22,669	3,239	46,238	72,146
TOTAL	**74,741**	**32,822**	**188,721**	**296,284**
Estimated annual value of livestock lost to wildlife				
District	Goats	Pigs	Poultry	Total
Marromeu	1,919	707	23,674	26,300
Cheringoma	-	-	12,553	12,553
TOTAL	**1,919**	**707**	**36,227**	**38,853**

Table 5.13: Net Value of Livestock Activities in the Zambezi Delta (US$)

	Goats	Pigs	Poultry	Total	Per capita value
Marromeu	83,471	57,118	308,225	448,814	5.10
Cheringoma	52,597	4,538	99,164	156,300	4.99
TOTAL	**136,069**	**61,656**	**407,389**	**605,114**	**5.07**

Table 5.14: The Value of the Stock of Livestock Resources in the Zambezi Delta

	Goats	Pigs	Poultry	Total
Marromeu	230,106	120,942	426,773	777,821
Cheringoma	167,747	11,875	162,141	341,764
TOTAL	**397,853**	**132,818**	**588,914**	**1,119,585**

5.3.3 Economic value of commercial sugar production

Assuming that sugar is sold at US$500 per ton (Lourens, 2007), the annual economic value of commercial sugar production on the Zambezi Delta is estimated at about US$24 million. An additional value to the value of sugar production is the:

i. value of about 26 000 tons of molasses; and
ii. value of employment. SENA Sugar Estates employs 8000 workers of which 5 000 are permanent workers and the remaining 3000 are seasonal workers.

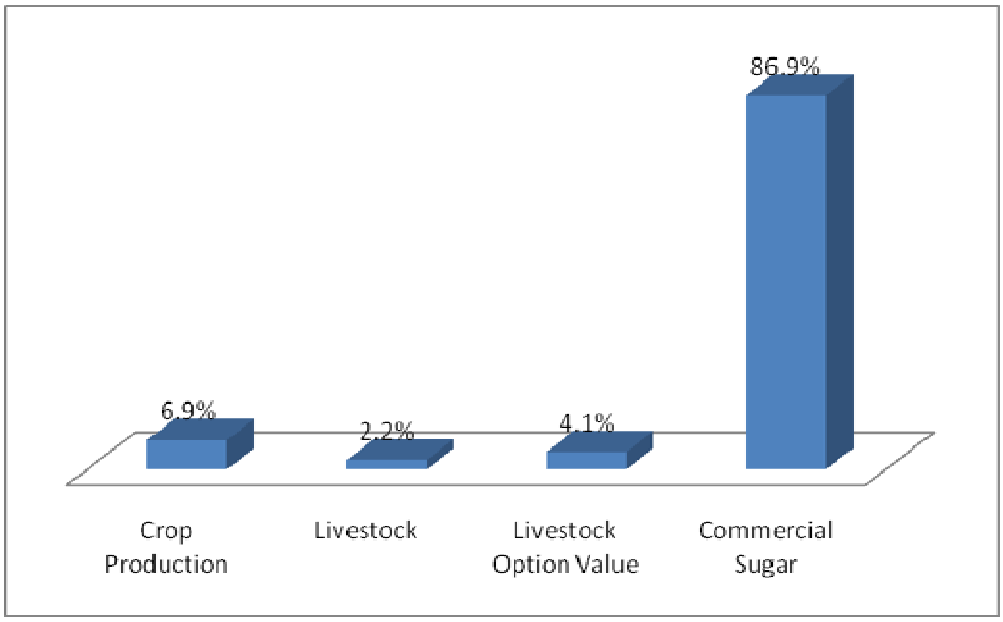
5.3.4 Total economic value of agriculture

The total monetary economic value of agricultural activities in the Zambezi Delta is US$23.16 million during a drought year, US$23.19 million during a flood year, and US$27.61 million during a normal year. During normal agricultural seasons, commercial sugar production contributes about 87% to total economic value of agricultural activities; subsistence crop production contributes about 7%; livestock option value contributes about 4%; and smallholder livestock contributes about 2% of total value (Figure 5.3).

Table 5.15: Total Economic Value of Agricultural Activities by Source of Value

Source of Value	Normal Year	Flood Year	Drought Year
Crop Production	1,892,355	(2,519,394)	(2,554,494)
Livestock	605,100	605,100	605,100
Livestock Option Value	1,119,585	1,119,585	1,119,585
Commercial Sugar	23,989,205	23,989,205	23,989,205
TOTAL	27,606,245	23,194,496	23,159,396

Figure 5.3: Percent Contribution of Agricultural Activities to Total Agricultural Economic Value



6. ENERGY

6.1 Methodology to Valuing Energy Resources

Two forms of energy benefits are derived from the Zambezi Delta environment – firewood and charcoal. The study approached the valuation of the two services differently due to their level of integration in open markets. Whereas there is a well developed market for charcoal in the urban parts of the Delta – in Marromeu and Inhaminga (Cheringoma District Centre) – firewood is mainly collected for own consumption. To value firewood the study used the cost of effort expended in collecting firewood as the opportunity cost of wood. For charcoal the study used the net factor income approach. That is the value of charcoal (both home consumed and sold) as the revenue (or potential revenue) from selling charcoal less the cost of effort expended in the whole charcoal making process - from cutting down trees, building the kiln, tending the kiln, and packing the charcoal. To value both firewood and charcoal, the national minimum wage is used as the price of labor.

To operationalise the above approaches data was collected in two ways. In the group discussions community members mainly involved in charcoal or firewood collection were interviewed on the process and effort required to achieve typical levels of output. This information was supplemented by survey information on collection or production as well as sales levels of charcoal or firewood.

The value of firewood per average household per month is obtained as follows:

$$FwValPy = [Wood * \frac{Trips * (WalkTime + CollectTime)*wage}{Wood}] * 12$$

Where FwValPy is the value of firewood per month (US$);

Wood is the amount of firewood collected per month (kg);

Trips is the number of trips made to collect firewood per month;

WalkTime is the walking time for a round trip of wood collection (hours);

CollectTime is the time taken to collect firewood at the source (hours); and

Wage is the national minimum wage (US$ per hour).

Trips * (WalkTime + CollectTime)*wage is the value of effort in firewood collection;

$\frac{Trips * (WalkTime + CollectTime)*wage}{Wood}$ is the estimated price of wood per Kg (US$).

Wood

Scaling-up to get the value of firewood for the Zambezi Delta:

$$TotFwVal = FwValPy * PropFw * DeltaHH$$

Where TotFwVal is the total annual value of firewood;

PropFw is the proportion of households collecting firewood; and

DeltaHH is the number of rural households in the entire Zambezi Delta.

Since firewood is mainly collected for own consumption, TotFwVal is a measure of total producer surplus.

Similar computations are made to value the effort in charcoal production. However, the net value of charcoal production (CharcVal) per average household is:

$$CharcVal = CharcProd * CharcPrc – CharcEfort$$

Where CharcProd is the annual charcoal production (Kg);

CharcPrc is the selling price of charcoal per Kg (US$); and

CharcEfort is the value of effort expended in charcoal production per year.

Scaling-up to the whole Zambezi Delta is done by multiplying CharcVal by the proportion of sample households producing charcoal and by the total number of rural households in the Zambezi Delta.

6.2 Smallholder Farmer Energy Sources

The main source of energy for heating and cooking for the smallholder or rural households in the Zambezi Delta is firewood (Table 6.1). Overall, about 97% of the households use firewood as a source of energy. Only 4% of the smallholder households use charcoal for heating and cooking. Twenty-three percent of the households use kerosene for lighting whilst only 0.43% of the households have access to electricity through the use of diesel generators.

Table 6.1: Percent Households Using Different Sources of Energy by Community by District

District	Community	Firewood	Charcoal	Gas	Kerosene	Electricity
Marromeu	Chueza	96.0	8.0	0.0	60.0	4.0
	Megugune	100.0	8.8	0.0	47.1	0.0
	Safrik	97.3	10.8	0.0	62.2	0.0
	Salone	100.0		0.0	26.9	0.0
	Nhane	81.2	11.6	0.0	58.0	0.0
	Chiburiburi	100.0	2.9	0.0	22.9	0.0
	Mponda	100.0		0.0	51.6	3.2
	Nangue	100.0	6.9	0.0	41.4	0.0
	Gora	97.1		0.0	23.5	0.0
	Cine	100.0		0.0	33.3	0.0
	Mangazi	100.0		0.0	11.8	0.0
	Total	**95.8**	**5.2**	**0.0**	**38.1**	**0.52**
Cheringoma	Chirimadzi	96.3	7.4	0.0	29.6	0.0
	Matondo	98.8		0.0	26.8	1.2
	Guma	98.6	2.9	0.0	15.9	0.0
	Chidanga	98.1	1.9	0.0	23.1	0.0
	Total	98.3	2.2	0.0	23.0	0.43
Total		**96.7**	**4.1**	**0.0**	**32.5**	**0.49**

6.2.1 Firewood collection

About 89% of the households in the Zambezi Delta harvest or collect firewood (Table 6.2). Figure 6.1 shows the seasonal calendar for firewood harvesting. All households in Cheringoma District harvest firewood throughout the year. However, the percent households harvesting firewood in Marromeu District is highest during September and October. Only 2% of those who harvest firewood sell the firewood. The wood for heating and cooking is mainly obtained from the uplands across all the communities. The three main species used as fuelwood for heating and

cooking in order of decreasing importance are Nhongue or Chongue (*Antidesma venosum*), Mussequesse (*Piliostigma thonningii*), and Nkarara (*Burkea Africana*). Other wood species used for heating and cooking are Mussassue(Podranea brycei) , Pacassa (*Lonchocarpus capassa*), palm timber (*pau pique*), Mugerenge(*Albizia adiantthifolia*), Mudikwa or Palmeira (*Borassus aethiopicum*), Umbila (*Pterocarpus angolensis*), and Salvo.

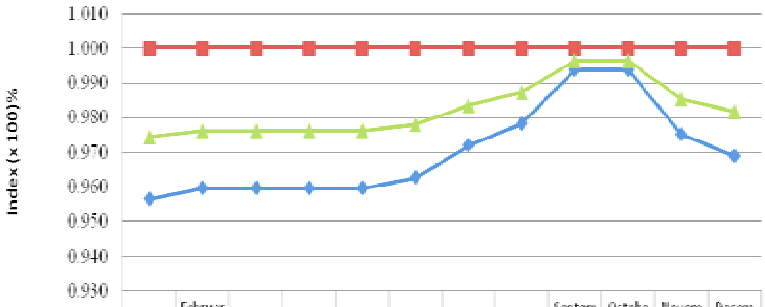
Table 6.2: Percent Households Harvesting and Selling Firewood by Community by District

District	Community	% Harvesting Firewood	% Selling Firewood[f]
Marromeu	Chueza	72.0	11.1
	Megugune	82.4	7.1
	Safrik	75.7	3.6
	Salone	82.7	0.0
	Nhane	63.8	4.5
	Chiburiburi	91.4	3.1
	Mponda	96.8	10.0
	Nangue	100.0	0.0
	Gora	97.1	0.0
	Cine	100.0	0.0
	Mangazi	100.0	0.0
	Total	**84.1**	**3.4**
Cheringoma	Chirimadzi	96.3	0.0
	Matondo	97.6	0.0
	Guma	98.6	0.0
	Chidanga	100.0	0.0
	Total	**98.3**	**0.0**
Total		**89.4**	**2.0**

[f] As % of those harvesting firewood

Besides heating and cooking, firewood is also used for burning bricks and for burning pottery. The most important wood species for pottery burning in order of decreasing importance are Mussassue (*Podranea brycei*), Chongue (*Antidesma venosum*), Mussequesse (*Piliostigma thonningii*), and Pacassa (*Lonchocarpus capassa*). The most important wood species for burning bricks in order of decreasing importance are Chongue (*Antidesma venosum*), Mussequesse (*Piliostigma thonningii*), Pacassa (*Lonchocarpus capassa*), Nkarara (*Burkea Africana*), and palm timber (*Pau pique*).

Figure 6.1: Seasonal Calendar and Index of Households Harvesting Firewood



	January	Februar y	March	April	May	June	July	August	Septem ber	Octobe r	Novem ber	Decem ber
Marromeu	0.957	0.960	0.960	0.960	0.960	0.963	0.972	0.978	0.994	0.994	0.975	0.969
Cheringoma	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Total	0.974	0.976	0.976	0.976	0.976	0.978	0.984	0.987	0.996	0.996	0.985	0.982

The status of tree species used for firewood is presented in Table 6.3. Overall, the status of tree species used as fuelwood is mostly not depleted. The tree species that may be highly depleted in some of the communities are Chongue (*Antidesma venosum*), Mussequesse (*Piliostigma thonningii*), Salvo, Mugerenge (*Albizia adiantthifolia*), and Panga-panga (*Millettia stuhlmannii*). The results show that the tree species that may be moderately depleted in some of the communities are Chongue (*Antidesma venosum*), Mussequesse (*Piliostigma thonningii*), and Mussassue (*Podranea brycei*).

The amount of firewood harvested for heating and cooking per season range between 120 000 to 140000 tons during normal and drought years (Figure 6.2). During flood years, the amount of firewood harvested per season falls to between 90 000 and 100 000 tons. The total amount of firewood harvested per year for heating and cooking is estimated at 374 000 tons during a normal year, 383 000 tons during a drought year, and 292 000 tons during a flood year (Table 6.4). Assuming clear-felling and that the stock of wood per ha is 42 tons (Bradley and McNamara, 1990 in Campbell, 1993), the area of woodland cleared per year is estimated at between 7 000 to 9 000 ha per year.

These results translate to an annual per capita wood harvesting for heating and cooking of 3.14 ton, 3.2 ton, and 2.5 ton in a normal, drought, and flood year respectively (Table 6.5). Other studies indicate that the annual per capita firewood use is about 1.23 ton (FAO, 1998). Thus, households in the Zambezi Delta seem to be using at least twice as much firewood compared to households elsewhere in Africa.

Table 6.3: Status of Tree Species for Firewood by Community by District

District	Community	Ngungue	Road (Trans timber)	Mango	Mussequesse	Umbila	Salvo	Ngegengere	Mudikwa	Mussassue	Pacassa	Nkarara	Panga-Panga
Marromeu	Chueza	ND			HD		HD						
	Miguguna	ND		ND					ND				
	Safrik		ND	ND		ND							
	Salone	MD			ND			ND					
	Nhame	HD		ND	HD					MD			
	Chiburiburi	HD			ND					ND	ND		
	Mponda	ND			MD							ND	HD
	Nangue				ND					ND		ND	
	Gorra											ND	
	Mangazi		ND					HD		MD	ND		
Cheringoma	Chirimadzi									MD			
	Matondo	MD								ND		ND	
	Guma					ND				ND			
	Chidanga		ND			ND					ND		ND

ND – Not Depleted **MD** – Moderately Depleted **HD** – Highly Depleted

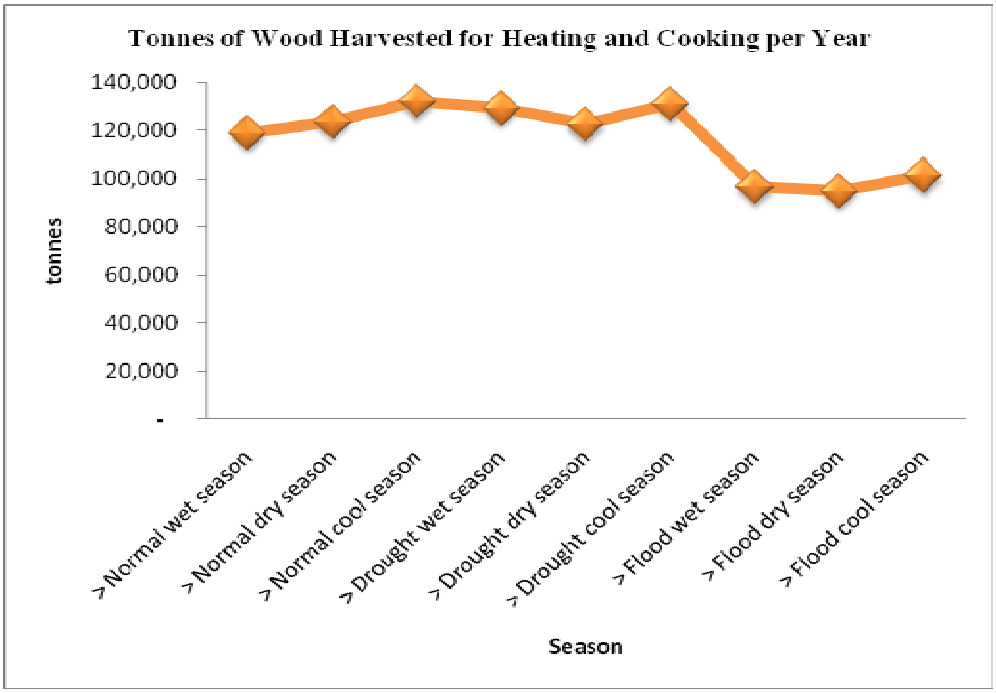
Table 6.4: Estimated Total Annual Firewood Harvested and Estimated Clear-Felling Area for the Zambezi Delta

Year	Estimated Total Harvest		Est. clear-felling area (ha)
	Tons	M^3	
Normal Year	374,328	517,922	8,9127
Drought Year	382,673	529,469	9,111
Flood Year	292,480	404,677	6,963

Table 6.5: Per Capita Firewood Harvest for Heating and Cooking for the Zambezi Delta

Year	Kg per Year	Kg per Day	M^3 per Year
Normal Year	3,138	8.60	4.34
Drought Year	3,208	8.79	4.44
Flood Year	2,452	6.72	3.39

Figure 6.2: Estimated Annual Wood Harvest for Heating and Cooking by Season

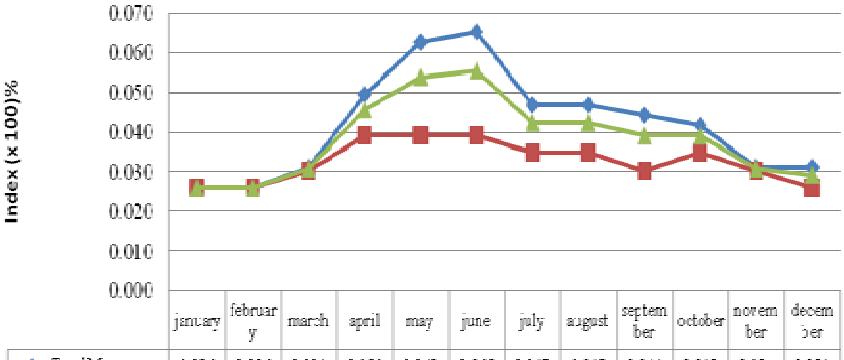


6.2.2 Charcoal production

About 6% of the households in the Zambezi Delta are involved in charcoal making (Table 6.6). Figure 6.3 shows the seasonal calendar for charcoal making. Overall, the percent households making charcoal is highest during the months of May and June. The percent households making coal is higher for Marromeu District over the period April to October. About 84% of those who are making charcoal sell charcoal.

The tree species for making charcoal are mainly obtained from the adjacent the river(s) across all communities. Wood for charcoal making is obtained from the flood plains in only 14% of the communities. The most important wood species for charcoal making in order of decreasing importance are Mussassue (*Podranea brycei*), Mugerenge (*Albizia adiantthifolia*), Nhongolosi[5], Pacassa (*Lonchocarpus capassa*), Kokoro (*Brachystegia bussei*), Mussequesse (*Piliostigma thonningii*), and Teme. The other wood species used for burning charcoal are mussacossa (*Afzelia quanzensis*), Umbila (*Pterocarpus angolensis*) , Chongue (*Antidesma venosum*), Tamarinheiro (*Tamarindus indica L.*), Cwhite, Panga-panga (*Millettia stuhlmannii*), and Nkarara (*Burkea Africana*).

Figure 6.3: Seasonal Calendar and Index of Households Making Charcoal



The status of tree species used for charcoal making is presented in Table 6.7. Overall, the status of tree species for charcoal making is mostly not depleted. The tree species that may be highly depleted in some of the communities are Mugerenge (*Albizia adiantthifolia*), Mussequesse (*Piliostigma thonningii*), Mussassue (*Podranea brycei*), Cwhite, and Nhongolosi. The results show that the tree species that may be moderately depleted in some of the communities are Mugerenge (*Albizia adiantthifolia*), mussacossa (*Afzelia quanzensis*), Mussassue (*Podranea brycei*), Chongue (*Antidesma venosum*), and Tamarinheiro (*Tamarindus indica L.*).

[5] During fieldwork tree species were recorded, though often only a phonetic identification was possible and it has not been possible to identify scientific names for all tree resources cited.

The total amount of charcoal production per year is estimated at 1 240 ton during a normal year, 1 600 ton during a drought year, and only 200 ton during a flood year. Given that a bag of charcoal weighs 28.6 kilograms, and assuming that it requires 0.348 m^3 to make a bag of charcoal (Herd, 2007) this translates to about 15 000 m^3 of wood being harvested for charcoal making during a normal year; 19 300 m^3 of wood harvested during a drought year; and 2 400 m^3 being harvested during a flood year. It is important to note that during a drought year charcoal making is higher as households make more charcoal for sale to raise cash for subsistence needs. Assuming clear-cutting and that a hectare of woodland has about 58 m^3 of wood, the estimated area cleared for charcoal making is 334 ha during a drought year; 260 ha during a normal year; and 41 ha during a flood year.

Table 6.6: Percent Households Making and Selling Charcoal by Community

District	Community	% Making Charcoal	% Selling Charcoal[f]
Marromeu	Chueza	0.0	0.0
	Megugune	5.9	50.0
	Safrik	5.4	0.0
	Salone	11.5	83.3
	Nhane	2.9	50.0
	Chiburiburi	8.6	66.7
	Mponda	6.5	100.0
	Nangue	24.1	100.0
	Gora	2.9	100.0
	Cine	0.0	0.0
	Mangazi	5.9	100.0
	Total	7.0	77.8
Cheringoma	Chirimadzi	22.2	100.0

District	Community	% Making Charcoal	% Selling Charcoal[f]
	Matondo	0.0	0.0
	Guma	1.4	100.0
	Chidanga	7.7	100.0
	Total	4.8	100.0
Total		6.2	84.2

[f] As % of those harvesting firewood or those making charcoal

Table 6.7: Status of Tree Species for Charcoal Making by Community by District

District	Community	Mugerenge	Mussacossa	Mussassue	Umbila	Mussequesse	Chongue	M'pacassa	Tamarinheiro	Cwhite	Panga-panga	Nkarara	Kokoro	Nhongolosi	Tenne
Marromeu	Chueza	MD	ND	MD											
	Miguguna		MD												
	Safrik	ND			ND	ND									
	Salone	ND		ND		ND									
	Nhame	HD		ND		HD									
	Chiburiburi					ND	ND	ND							
	Mponda								MD	ND	ND	ND			
	Nangue												ND	ND	ND
	Gorra												ND	ND	ND
	Mangazi			HD			MD	ND		HD					
Cheringoma	Chirimadzi												ND	ND	ND
	Matondo			ND										HD	
	Guma														
	Chidanga							ND			ND				

ND – Not Depleted **MD** – Moderately Depleted **HD** – Highly Depleted

6.3 Economic Value of Energy Resources

6.3.1 Economic value of firewood resources

The estimated annual total economic value of firewood resources for heating and cooking ranges from US$5.6 million in a drought year to US$6.37 million in a flood year (Table 6.8). The annual per capita value of firewood resources is about US$50.

Table 6.8: Economic Value of Firewood Resources in Zambezi Delta

	Total Wood Value		Per capita Value	
Type of year	Meticais	US$	Meticais	US$
Normal Year	136,854,970	5,702,290	1,148	47
Drought Year	134,426,473	5,601,103	1,127	46
Flood Year	152,967,849	6,373,660	1,283	53

6.3.2 Economic value of charcoal production

The estimated annual total economic value of charcoal resources ranges from about US$ 0.36 million in a flood year to US$4.4 million in a drought year (Table 6.9). The annual per capita value of charcoal resources ranges from US$3 in a flood year to about US$37 in a drought year.

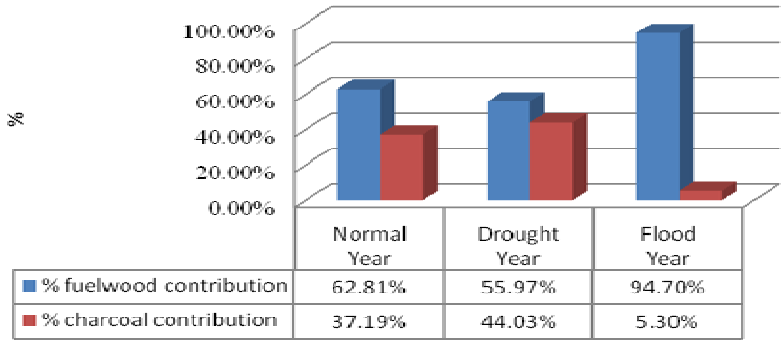
Table 6.9: Economic Value of Charcoal Resources in the Zambezi Delta

	Total Charcoal Value		Per capita Value	
Type of year	Meticais	US$	Meticais	US$
Normal Year	81,041,673	3,376,736.37	680	28.31
Drought Year	105,761,638	4,406,734.92	887	36.95
Flood Year	8,563,895	356,828.94	72	2.99

6.3.3 Total economic value of energy resources

The estimated annual total economic value of energy resources (firewood and charcoal) in the Zambezi Delta is US$9.1 million in a normal year, US$10 million in a drought year, and US$6.73 million in a flood year. During a drought year, charcoal accounts for about 44% of the total economic value of energy resources (Figure 6.4). The contribution of charcoal to the total economic value of energy resources during a flood year is only about 5%.

Figure 6.4: Percent Contribution of Fuelwood and Charcoal to the Value of Energy in the Lower Zambezi Delta



7. TIMBER AND NON-TIMBER FOREST PRODUCTS

7.1 Methodology to Valuing Timber Products

This section derives the value of wild fruits, building materials, and commercial timber. To value the wild fruits, the same methodology used to value firewood is adopted - the effort expended to collect the fruits is valued at the opportunity cost of labor for an average household. The result is then scale-up to the Zambezi Delta population given the percent households collecting wild fruits.

To value the building materials for the rural households in the Lower Zambezi, an initial attempt was to derive the value of trees for building materials using a similar methodology to that used in valuing charcoal – that is assessing quantities needed to build house, labor used to collect and process the materials for building and obtaining the net value of the trees as the product of quantity of timber collected and average value of effort used to collect unit quantity. The value of the effort to collect the building materials is the opportunity price of timber in the absence of markets for building timber. However, variability in types of building structures and multiple combinations of timber products used within and between communities made the attempt rather unreliable. As an alternative to valuing building materials, given an established market for fix-and-supply building artisans within each community, the cost of making a standard hut was used as basis of summarizing and quantifying the benefits of using trees for building by the communities of the Zambezi Delta. To do this, information was sought through the household survey and group discussions on how often households replace huts and the average numbers replaced each year. This was valued using the cost of fix and supply of a typical house and scaled up to the Zambezi Delta level using population giving an annual value of trees for building purposes.

For commercial timber valuation the information was obtained from the Forestry Department of the Ministry of Agriculture, Forestry and Fisheries for all timber concession holders in the Cheringoma district on the: (i) volumes by tree species of allowable cuts, and (ii) actual volumes harvested by tree species. The value of logs is obtained by multiplying the volumes of timber harvested by the ruling prices of log timber by species less the costs of logging and transportation to Beira. An estimate of the extra value generated by the sawing industry in Beira is estimated through the difference between rough sawn timber values obtained from industry participants in Beira and the value of logs. The sum of log and the value-addition for all the timber harvested from the Zambezi Delta is taken as the total economic value of commercial timber harvesting.

7.2 Use of Timber and Non-Timber Forest Products

Management of forest resources fall under four categories: concessions, simple licenses, customary laws, and protected areas. Concessions were introduced in 2002 to regulate the commercial exploitation of forest resources to ensure sustainability of harvesting, control production volumes, and promote value addition to forestry products. Concessions are allocated to those willing to commercially exploit forest resources and they are normally granted for areas measuring up to 50,000 ha, with a maximum annual cut of up to 4,000 m^3 per year. Concessions are granted for 50 years, but subject to stringent review every five years based on a properly developed management plan (NDC, 2004; Albano, 2002). Concessionaires can only get title or concessions with the authority of the community and are obliged to respect community land and forest use rights including subsistence farming (EFI, 2003). They are also required to process the wood they harvest prior to export (Reyes, 2003).

The simple license allows Mozambican nationals and local communities to exploit forestry resources in limited quantities for their own consumption or income generation. Licenses are issued by provincial authorities and specify the period, volume and species to be harvested (Albano, 2002). Simple license holders can contract concession holders to process their wood (Reyes, 2003).

The forestry areas are divided into protected areas such as reserves, game areas and national parks (about 6.7 million ha.), productive forests (19 million ha.) and multiple use forest areas (26 million ha.). Protected areas are managed by the state while productive forests are reserved for commercial timber concessions for the private sector. Ungazetted forests are used for a variety of purposes including conversion to agricultural land, energy harvesting and other materials (Nhantumbo, 2000; AfDB, 1995).

7.2.1 Smallholder use of non-Timber Forest Products

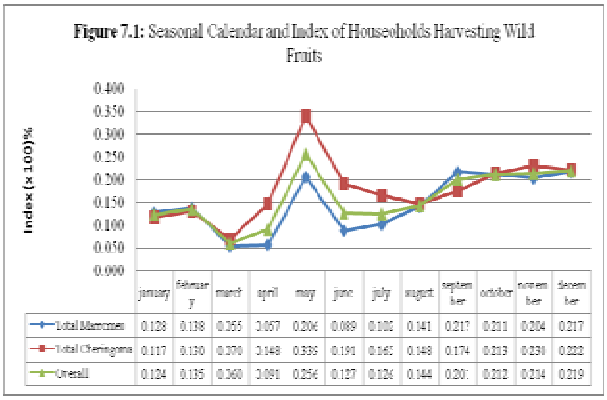
Across the Zambezi Delta communities about 57% of the households collect wild fruits (Table 7.1) whilst about 37% collect wild vegetables and 15% collect medicinal plants. Wild fruits harvesting is important during the period May to December (Figure 7.1). The percent households harvesting wild fruits is highest during the month of May. The percent households collecting wild vegetables is lowest during the months of June to August and is highest during December to February (Figure 7.2). The percent households harvesting medicinal plants is almost constant throughout the year (Figure 7.3). Of those who collect wild fruits, about 8% sell the fruits; and of those who collect wild vegetables, about 5% sell the wild vegetables. The estimated total quantities of fruits harvested per annum for

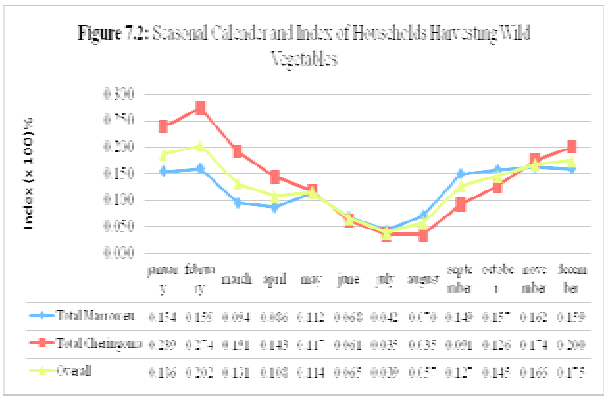
the whole Zambezi Delta is about 3 400 tons during a normal year, 2 700 tons during a drought year, and 3300 tons during a flood year

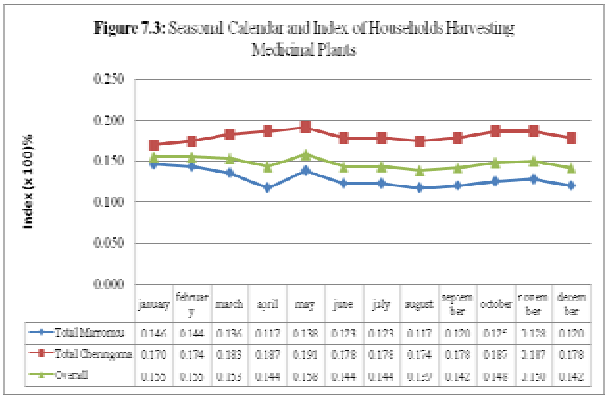
Only 4% of the households in the complex harvest timber and of those who harvest timber, about 32% sell the timber. Sale of the timber and non-timber forest products is mostly in the local communities. The timber sold locally is mainly used as building material. The percent rural households collecting timber is highest during the months of May and August (Figure 7.4).

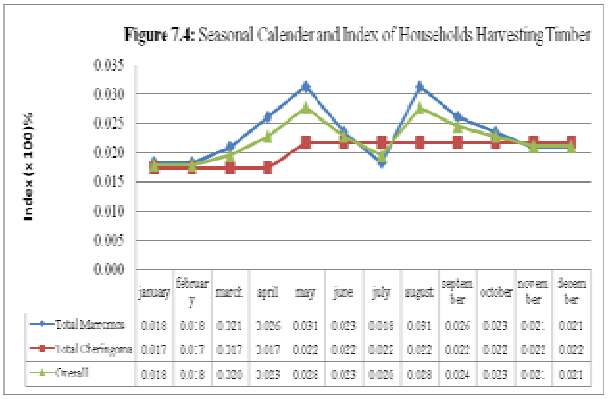
Table 7.1: Percent Households Collecting Timber and Non-Timber Forest Products by District

District	Community	Vegetables		Fruits		Timber	
		Harvesting	Selling	Harvesting	Selling	Harvesting	Selling
Marromeu	Chueza	28.0	0.0	36.0	11.1	8.0	0.0
	Megugune	26.5	0.0	35.3	16.7	5.9	50.0
	Safrik	27.0	10.0	29.7	9.1	5.4	100.0
	Salone	32.7	5.6	38.5	14.3	3.8	0.0
	Nhane	34.8	4.2	43.5	16.7	2.9	50.0
	Chiburiburi	48.6	17.6	54.3	21.1	0.0	0.0
	Mponda	35.5	9.1	67.7	14.3	6.5	50.0
	Nangue	34.5	10.0	65.5	10.5	13.8	25.0
	Gora	29.4	0.0	76.5	3.8	2.9	0.0
	Mangazi	52.9	5.6	79.4	7.4	5.9	0.0
	TOTAL	34.7	6.7	51.4	12.1	5.0	31.6
Cheringoma	Chirimadzi	48.1	0.0	77.8		14.8	50.0
	Matondo	40.2	6.1	54.9	8.9	0.0	0.0
	Guma	36.2	0.0	73.9	2.0	0.0	0.0
	Chidanga	40.4	0.0	69.2		3.8	0.0
	TOTAL	40.0	3.3	66.5	3.2	2.6	33.3
OVERALL		36.7	5.3	57.1	8.2	4.1	32.0









7.2.2 Building Materials

The natural resource-based building materials used by the smallholder farmers include bamboo, reeds (canico), micheu, capim, mdicua, palm timber (pau pique), muculala, and lacalaca. The resource used in all the communities as building material is capim followed by reeds used by about 79% of the communities and then pau pique and lacalaca which are used in 50% of the communities (Figure 7.5). The least used resource across communities are micheu and midicua. All the resources used as building materials are harvested from either the flood plain or adjacent to the river (Table 7.2).

The conservation status of the resources used as building materials are mostly not depleted across the majority of the communities (Table 7.3). However, there is localized moderate to high depletion of bamboo, reeds, midicua, and pau pique in some of the communities.

An average household on the Zambezi Delta owns an average of three huts (Table 7.4). The huts are replaced every 2 – 3 years. The cost of the materials for constructing a hut ranges between US$22 and US$32.

Figure 7.5: Percent Communities Using Natural Resources by Type for Building Materials

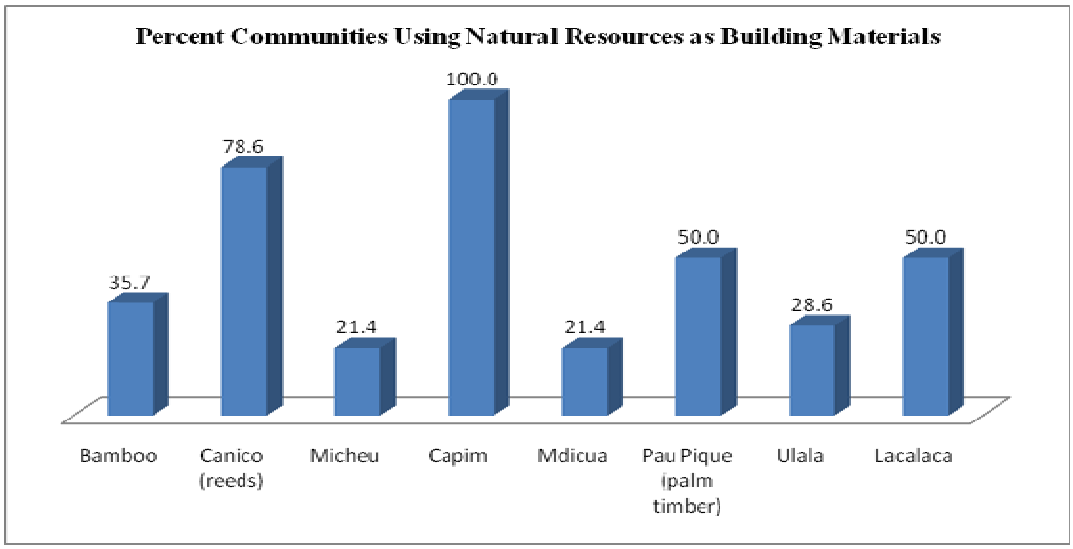


Table 7.2: Source of Building Materials by Community by District

		Bamboo	Canico (reeds)	Micheu	Capim	Mdicua	Pau Pique (palm timber)	Muculala	Lacalaca
Marromeu	Chueza	FP	FP	AR	FP				
	Miguguna	FP	FP	AR	FP	AR			

		Bamboo	Canico (reeds)	Micheu	Capim	Mdicua	Pau Pique (palm timber)	Muculala	Lacalaca
	Safrik		FP		FP		FP		
	Salone			AR	AR	AR	FP		
	Nhame	AR	FP		FP		AR	AR	
	Chiburiburi		FP		FP		AR	FP	AR
	Mponda		FP		AR	AR	AR	AR	AR
	Nangue		FP		AR			AR	
	Gorra		FP		AR		AR		AR
	Mangazi		FP		FP				AR
Cheringoma	Chirimadzi		FP		AR		AR		AR
	Matondo		FP		FP				AR
	Guma	FP			FP				
	Chidanga	AR			AR				AR

FP – Flood Plain **AR** – Adjacent to River

Table 7.3: Status of Building Materials by Community by District

		Bamboo	Canico (reeds)	Micheu	Capim	Mdicua	Pau Pique (palm timber)	Muculala	Lacalaca
Marromeu	Chueza	MD	ND	ND	ND	.	.	.	.

		Bamboo	Canico (reeds)	Micheu	Capim	Mdicua	Pau Pique (palm timber)	Muculala	Lacalaca
	Miguguna	ND	ND	ND	ND	ND	.	.	.
	Safrik	.	ND	.	ND	.	ND	.	.
	Salone	.	.	ND	ND	MD	MD	.	.
	Nhame	ND	MD	.	MD	.	ND	ND	.
	Chiburiburi	.	MD	.	ND	.	ND	ND	ND
	Mponda	.	HD	.	MD	HD	ND	MD	ND
	Nangue	.	ND	.	ND	.	.	ND	.
	Gorra	.	MD	.	ND	.	HD	.	ND
	Mangazi	.	HD	.	ND	.	.	.	ND
Cheringoma	Chirimadzi	.	HD	.	ND	.	ND	.	ND
	Matondo	.	MD	.	ND	.	.	.	MD
	Guma	HD	.	.	ND	.	.	.	.
	Chidanga	HD	.	.	ND	.	.	.	ND

ND – Not depleted **MD** – Moderately depleted **HD** – Highly depleted

Table 7.4: Mean Number of Huts, Huts replacement Rate, and Hut Construction Costs by District

District	Average No. of Huts	Hut replacement rate (years)	Average Hut Cost (US$)	
			Lower bound	Upper Bound
Marromeu	2.6	2.95	23.96	31.46
Cheringoma	3.5	2.00	21.88	23.96

7.2.3 Commercial Harvesting of Timber

There are 7 commercial timber harvesting concessions on the Zambezi Delta with a total area of 239 439 ha (Table 7.5). There are 36 major timber species that are currently being harvested in the timber concession areas of which fourteen (14) are classified as Precious species; fourteen (14) are classified as Class1 species; and eight (8) are classified as Class2 species (Table 7.6).

For the Zambezi Delta timber concessions, the allocated quotas and the actual harvested timber has been increasing over time (Figure 7.6). The timber harvested as a percentage of the allocated quota decreased from about 75% in 2003 to about 32% in 2007. For 2007, the allocated quota and harvest by species is presented in Table 7.7. Box 2 highlights the operations by TCT Forest Industries and issues in the commercial timber harvesting. A total of 6 139 m^3 of timber were harvested. In terms of percentage contribution to total harvest, the three most important species in 2007 were muhimbe (41%), panga-panga (25%), and messassa (15%). Assuming there are 58 m^3 of timber per hectare (Campbell, 1993), and assuming clear-cut felling, an estimated 106 ha of woodland are cleared per year.

Table 7.5: Area (ha) Under Timber Concessions by Name of Company

Company	**Area (ha)**
TCT Forest Industries	24,821
Industrial Madeira de Mozambique	21,423
Carpintaria (CMU)	9,862
CMM	27,852
Eco Timber	33,671
Industrial Marfer	75,571
Levasflor	46,239
TOTAL	**239,439**

Table 7.6: Major Timber Species of the Zambezi Delta by Class

Precious	
Commercial / Local Name	**Scientific Name**
Chakate-preto	*Guibourtia conjugata*

Mugonha	*Breonardia microcephala*
Mecrusse	*Androstachys johnsonii*
Pau-preto	*Dalbergia melanoxylon*
Pau-rosa	*Berchemia zeyheri*
Sandalo	*Spirostachys africana*
Tule	*Milicia excelsa*
Class 1	
Commercial / Local Name	**Scientific Name**
Banga-Wanga	*Amblygonocarpus*
Chacate	*Guibourtia conjugata*
Chanfuta	*Afzelia quanzensis*
Mepiao	*Inhambanella henriquesii*
Missanda	*Erythrophloeum suaveolens*
Mondzo	*Combretum imberbe*
Mutondo	*Cordyla africana*
Panga-panga	*Millettia stuhlmannii*
Pau-ferro	*Swartzia madagascariensis*
Tanga-tanga	*Albizia versicolor*
Umbaua	*Khaya nyasica*
Umbila	*Pterocarpus angolensis*
Class 2	
Commercial / Local Name	**Scientific Name**
Mefuta	*Bombax rhodognaphalon*
Mepepe	*Albizia adiantthifolia*
Messassa	*Brachystegia manga / Brachystegia spiciformis*
Mucarati	*Burkea africana*

Mugonha	*Breonardia microcephala*
Muhimbe	*Julbernadia globiflora*
Mungoroze	*Pteleopsis myrtifolia*

Table 7.7: Timber Harvesting Quotas and Actual Harvest by Species - 2007

Species	Quota (m^3)	Harvest (m^3)	% Total Harvest
Chanfuta	389	279	4.5
Mepiao	40	40	0.7
Messassa	7218	900	14.7
Monzo	772	180	2.9
Muimbe	2578	2540	41.4
Mutondo	1658	520	8.5
Panga-panga	2448	1550	25.2
Pau-preto	114	20	0.3
Sandalo	354	50	0.8
Umbila	578	60	1.0
Total	18863	6139	100.0

Box 2: TCT Forest Concession

The TCT along with the "Levas Flores'" forest concession, are the only two certified timber concessions in the Zambezi Delta. TCT bears the Forestry Stewardship Council (FSC) seal of good forestry management. With this seal, TCT can position itself and expand its market for timber products into the European market. The company believes that other concessions will soon be subject to more stringent rules of forestry management and, should that happen; TCT is already in a better position.

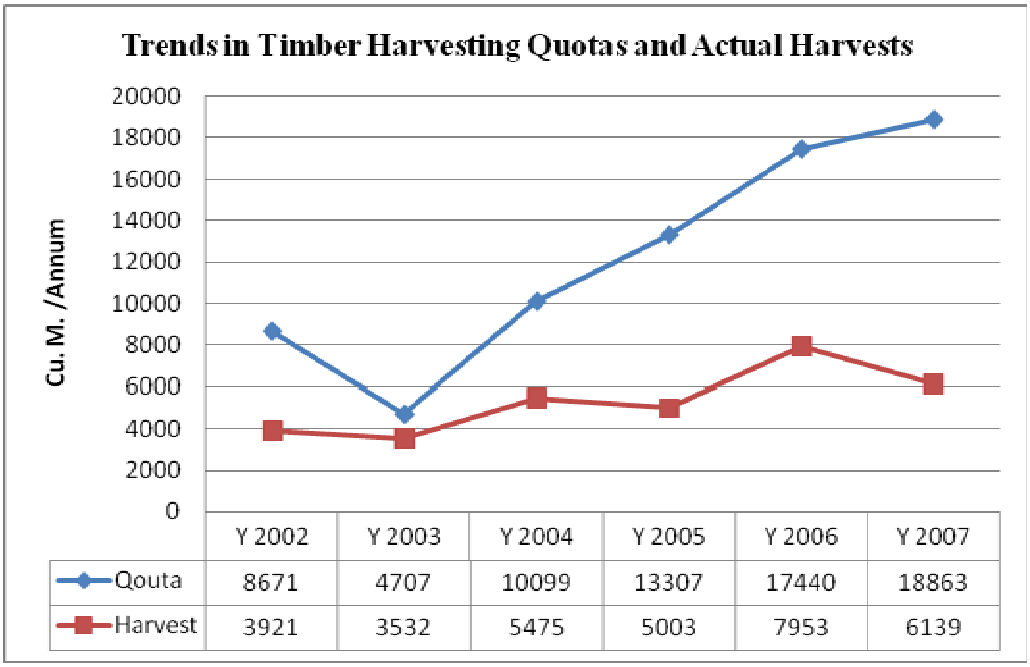
The total area under the concession is 40 000 hectares. The hectarage is divided into blocks that are explored sequentially, respecting the ageing requirements of the forest to re-grow itself naturally. By the time all subsequent blocks are harvested, the first block to be harvested will have been given sufficient time to re-grow into a mature woodland. This management plan was approved by the FSC, which visits the site once a year to check for compliance. All major trees in the whole area are number-sealed and tagged by latlong.

The concession has two ways of re-growing the native forest: (i) producing seedlings, and (ii) the preferred method of managing the natural vegetative re-growth from the cut stumps. Currently, seedlings are planted during the wet season in areas within the concession that were cleared by slash and burn activities before the TCT was operating the concession.

The concession does not harvest any timber during the rainy months of December to March. TCT harvests about 2 400 m^3 per year at an average of 300 m^3 per month. The main timber species harvested by TCT are Panga-Panga and Chanfuta of which the main product is panga-panga. The average volume of timber per tree is about 3 m^3 and it can go up to 4 m^3. Of the total harvest, 72 m^3 per month (or 24% of the production) is exported to Germany and Italy, while the remainder goes to TCT workshop in Beira for the production of furniture. TCT already cuts the parquets of wood at the concession in accordance to the requirements of the final furniture products. No logs ever leave TCT, but are processed onsite and leave for Beira using out-sourced transport. A generator supplies all the power needs of both machinery and facilities on-site, at least until Cahora Bassa main grid is installed. Once electricity is installed, the company estimates a saving of up to 200 liters of diesel per week. None of the sawdust and wood chips are marketed, and are currently burnt onsite.

As an off-shoot business, eight (8) of the workers work at an atelier that makes kitchen utensils and decorative material - candle holders, vases, etc. - from wood debris. Currently the products are not significant in the overall turnover of TCT. These products are sold only in Beira and Maputo through a showroom and through the restaurant and lodging place situated very near to the office at the concession.

Figure 7.6: Trend in Timber Harvesting Quotas and Actual Harvest (2002 – 2007)



7.3. Economic value of Timber and NTFPs

7.3.1 Economic value of wild fruits

Wild fruits are valued at US$407 400 per annum during a normal year (Table 7.8). During a flood year the value of wild fruits is highest at US$477 155. The annual per capita value of wild fruits is about US$. An economic value for wild vegetables was not computed.

Table 7.8: Estimated Annual Economic Value of Wild Fruits by Type of Year

	Total Value		Per Capita Value	
	Meticais	US$	Meticais	US$
Normal year	9,777,615	407,400	82	3.4
Drought Year	9,414,888	392,286	79	3.3
Flood Year	11,451,743	477,155	96	4.0

7.3.2Value of building materials

The estimated annual economic value of natural resource based building materials ranges between US$462 000 and US$566 000 (Table 7.9). The per capital annual value of building materials for rural households in the Zambezi Delta is between US$4 – 5.

Table 7.9: Estimated Annual Economic Value (US$) of Building Materials by District

District	Lower Bound (US$)	Upper Bound (US$)
Marromeu	277,166	363,931
Cheringoma	184,439	202,005

Total	**461,605**	**565,936**

7.3.3 Economic value of commercial timber

The annual total value of commercial timber activities is estimated at US$295.66 million per annum and it is composed of three components: (i) the value of harvested logs, (ii) the value addition from log processing, and (iii) the option value of mature timber that is conserved for future harvesting. The estimated economic value of timber logs per annum is estimated at about US$7.7 million (Table 7.10). Of this total value, about 3% is attributed to Precious timber species, 62% is attributed to Class 1 species, and 36% is attributed to Class 2 species. The processing of timber, which is done mostly in Beira, results in an additional value of about US$23.98 million per annum (Table 7.11). Precious timber species contributes about 2% to total value addition; Class 1 species contribute about 44% to value addition; and Class 2 species contribute about 54% total value addition.

Tables 7.10 and 7.11 show the potential value of logs and value addition that could be obtained if all allocated timber were harvested and processed. The potential total value of timber is therefore estimated at US$87.67 million per annum. However, given the area under timber and sustainable yields of 0.043 m^3 per year per hectare for miombo woodlands (EFI, 2003; Fath, 2002; NDC, 2004), the results indicate that harvesting to achieve the indicated potential values would result in gross over-exploitation of the timber resources. The current harvest levels of between 6 000 m^3 to 8 000 m^3 are within the estimated permissible annual sustainable yield of about 10 200 m^3.

Table 7.10: Economic Value of Commercial Timber Logs (US$) by Class - 2007

	Precious	Class 1	Class 2	Total
Actual	196,000	4,732,200	2,752,000	7,680,200
Potential	1,926,400	12,573,000	8,952,000	23,451,400

Table 7.11: Value-Addition in Beira (US$) by Class - 2007

	Precious	Class 1	Class 2	Total

Actual	560,000	10,516,000	12,900,000	23,976,000
Potential	5,504,000	27,940,000	30,772,500	64,216,500

Not all mature timber is currently harvested. This timber is left as standing stock for harvesting in the future. Thus, there is an option of harvesting this timber in the future. Hence the value of this timber can be treated as an option value. To value the standing stock of mature timber, the following assumptions are made:

Total timber harvested the past 7 years			36031.3	m^3
Estimated area cleared assuming 58 cu.m. per ha			621.23	Ha
Estimated total concession area still intact			23,8807.77	Ha
Percent timber that is harvestable as logs			93.62%	
Percent timber that is mature at any given time			8.59%	
Estimated total stock of harvestable or mature timber			1,114,552	m^3
Distributed as follows:	Precious timber @	0.3%	3,866.61	m^3
	Class1 timber @	67.9%	756,751.61	m^3
	Class2 timber @	31.8%	353,934.18	m^3

Valuing the estimated standing stock of mature timber at the price of logs for timber by class gives the option value for commercial timber. The estimated value of the stock of mature timber is valued at US$264 million.

The total economic value of timber and non-timber forest products is summarized in Table 7.12. Of the total economic value of US$296 million, only 0.35% contributes towards the welfare of the rural population. The economic value of timber is mostly in the value of standing stocks of mature timber.

Resource	**Economic Value**	**Percent Contribution to total value**
Wild fruits	477,155	0.16
Building Materials	565,936	0.19
Harvested timber	31,131,600	10.51
Standing stock of mature timber	264,051,952	89.14
TOTAL	**296,226,643**	**100.00**

8. WILDLIFE

8.1 Methodology to Valuing Wildlife

The abundant Zambezi Delta wildlife provide wild meat products to smallholder households while four protected hunting areas (Coutadas 10, 11, 12 and 14) generate income from international trophy hunting safaris. In each smallholder community there is a small group of people that are specialist hunters. From group discussions the number and species of wild life harvested for community consumption were estimated for different seasons of the year. The group discussions also estimated the effort involved in harvesting the wildlife. Using average carcass weights of the species harvested the study arrived at estimated amounts of meat harvested and distributed within the communities. The value of wild meat was then computed as the revenue from meat sales net the value of hunting effort. The revenue was based on local meat prices while effort value was based on the minimum wage rate. Those communities next to protected areas that are restricted from hunting bigger game in the Coutada buffer regions benefit from meat from trophy hunting operations. This meat is also valued in a similar way.

The basis of the study's approach to valuing wildlife benefits from sport hunting hinges on the following processes that are involved in determining how much is harvested and how trophy prices are determined:

- Based on submissions by Coutada operators, the Ministry of Tourism makes a determination on allowable harvest on all the coutadas;
- From the allowable harvest the operator decides how much of this it commits to through payment of requisite fees to the Ministry;
- Operator and/or its out-fitter or international agencies attend Safaris International where auctions of safaris take place and this is where prices of hunts are set;
- Value of the hunt to the hunter is based on the trophy prices plus travel costs, licence fees and accommodation cost incurred during the hunt.

To derive the value for trophy hunting the study makes use of a case of one of the coutadas which had complete hunting information for the 2007 season. For the coutada, information was available on: (i) the number of visitors, (ii) countries of origin of all hunters, (iii) numbers of accompanying non-hunting members or visitors, (iv) duration of stay, (v) the total number and species of animals hunted, and (vi) the trophy prices of the hunted animals. From this information the following total costs were derived:

- cost of stay,
- costs of travel to and from the safari, and
- hunting expenses.

From this the average cost of safari for a hunter is estimated. This is taken as the unit economic value of a hunt. Based on average annual total number of hunters received by all coutadas in the Zambezi Delta, the annual economic value of hunting safaris is derived. An estimate is also made of the value of standing wildlife in the Zambezi Delta by using estimated populations of key species and their unit trophy price.

The value of birds in the Lower Zambezi is estimated using the benefit transfer methodology. Estimates from other studies on the value of wetland habitat for birds are used to estimate the value of bird habitats and hence the value of birds in the Zambezi Delta.

8.2 Use of Wildlife Resources

8.2.1 Hunting wild meat for subsistence consumption

It is believed that around 80% of rural households still depend on wild animal protein as a supplement to their diet including hunting of plains game animals (Chambal, 1997). The hunting is usually carried out by males within the communities. Although the children were allowed to accompany the adult males, big game hunting was restricted to adult males while small game hunting, like mice and birds, was left to the children. The prevailing hunting methods used by adults were snares, dog chasing and traps for the children.

Although, the legislation states that permission to hunt requires a license, in practice rural hunters do not hunt on licenses for subsistence. In addition to own consumption, game meat is also sold along the main roads or other local markets. In the communities of the Zambezi Delta, about 85% of the communities have specialist game meat hunters. Overall, 7.3% of the households in the Zambezi Delta are involved in game hunting (Table 8.1). Of those households who hunt wild game in addition to own consumption, overall, 53.3% sell the meat. The proportion of hunting households selling meat in Marromeu District is 55.6% and it is 50.0% in Cheringoma District.

Table 8.1: Percent Households Hunting Wildlife by Community by District

District	Community	% Households Hunting
Marromeu	Chueza	4.0
	Megugune	14.7
	Safrik	5.4
	Salone	13.5
	Nhane	4.3
	Chiburiburi	8.6
	Mponda	6.5

	Nangue	0.0
	Gora	2.9
	Cine	0.0
	Mangazi	8.8
	Total Marromeu	**7.0**
Cheringoma	Chirimadzi	14.8
	Matondo	6.1
	Guma	8.7
	Chidanga	5.8
	Total Cheringoma	**7.8**
Overall		**7.3**

The seasonal calendar for game meat hunting is presented in Figure 8.1. Generally, the percent households hunting game is higher during the dry season and is highest during the months August to October. In those households that are involved in game meat hunting, an average of 4 household members is involved in hunting.

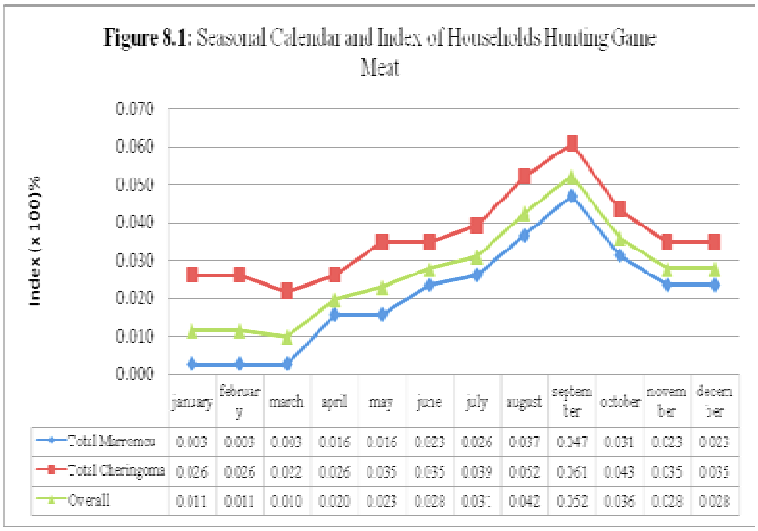


Figure 8.1: Seasonal Calendar and Index of Households Hunting Game Meat

The major species hunted for wild meat include, in order of decreasing importance, warthog, gazelle, wild pigs, buffalo, hippopotamus and monkeys. In addition, those communities close to hunting coutadas benefit from meat from trophy hunting. The meat from trophy hunting is distributed either free in case kills are effected close to the community boundaries or sold to the community by coutada employees if the kills are well within the hunting concessions.

8.2.1.1 Hunting effort

Hunting is done over two seasons, the wet and dry seasons, with each season lasting over 5 months. The effort expended in hunting by an average hunting household per season is derived as follows:

HUNTEFORT = DHUNTPM * HRSHPD * HHMEM * MONTHS

Where:

HUNTEFORT is days per month hunting,

DHUNTPM is hours per day hunting,

HRSHPD is number of household members involved in hunting, and

MONTHS is number of months hunting per season.

Dividing the above computation by eight (8) gives the hunting effort in labor days expended in hunting per season by a hunting household. The average effort expended in hunting by district is presented in Table 8.2. On average hunting effort is higher during the dry season compared to the wet season. The average total hunting effort is similar for normal, flood, and drought years – it is highest for a normal year (107.5 labor days) and is lowest for a flood year (100.5 labor days).

Table 8.2: Hunting Effort (labor days) by Smallholder Communities in the Zambezi Delta

District	Wet Season			Dry season		
	Normal Year	**Flood Year**	**Drought Year**	**Normal Year**	**Flood Year**	**Drought Year**
Marromeu	55.6	48.8	50.2	59.3	56.2	58.5
Cheringoma	44.6	44.6	44.6	44.6	44.6	44.6
Overall	52.4	47.6	48.6	55.1	52.9	54.5

8.2.1.2 Level of wild game harvest

The estimated number of wild animals harvested per year in the Zambezi Delta is presented in Table 8.3. Except for gazelle, hippo, and monkey, the level of harvesting of other wild animals species is highest during a drought year. There may be an over-estimation of the number of hippos harvested in a year.

Table 8.3: Estimated Number of Game Animals Harvested Per Year in the Zambezi Delta

	Normal Year	**Flood Year**	**Drought Year**
Gazelle	4,756	4,756	3,171
Hippo	2,912	3,200	1,047
Warthog	6,847	4,901	13,613
Wild pig	19,710	29,488	42,527
Buffalo	553	-	774
Monkey	2,004	288	1,874

Converting the number of animals hunted into kilograms of meat shows that 551.7 tons of meat are harvested during a normal year, 639.5 tons during a flood year, and 945.1 tons during a drought year (Table 8.4). The annual per capita meat supply from game meat for rural households in the Zambezi Delta is between 4.5 – 8 kilograms. Wild pigs contribute the highest to the meat from game hunting at 64% (Figure 8.2). The lowest contribution is from buffalo at 1%.

Table 8.4: Total Estimated Annual Game Meat Harvest (Kg) by Species

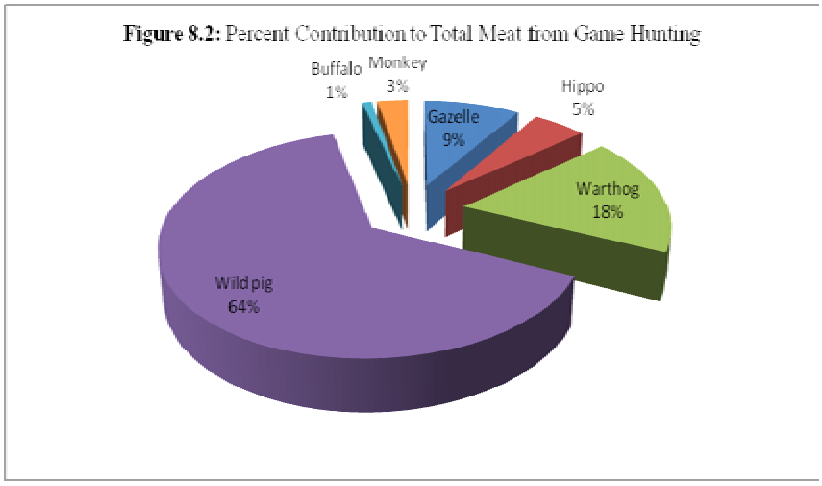
	Total Meat Harvested per Year		
	Normal Year	Flood Year	Drought Year
Gazelle	71,344	71,344	47,562
Hippo	43,677	48,001	15,711
Warthog	102,706	73,520	204,199
Wild pig	295,643	442,325	637,899
Buffalo	8,290	-	11,606
Monkey	30,055	4,324	28,105
TOTAL	**551,715**	**639,513**	**945,082**

Per capita meat	4.63	5.36	7.92

8.2.2 Professional hunting areas

The Zambezi Delta is home to four hunting concessions – Coutada 10, 11, 12 and 14. Bahati Hunting Safaris holds the concession over Coutada 10, which covers an area of 200 000 hectares of unfenced, wild hunting grounds. The area was formally proclaimed some 47 years ago during the time of Portuguese rule. It is considered the best area to hunt Buffalo, Sable, Lichtenstein Hartebeest, Eland, Nyala, Reedbuck, Bushbuck, Lion, Leopard, Bush pig, Warthog as well as Blue duiker, Red duiker, Suni and Oribi. There are a few permanent rivers with many Hippos and Crocodile in the area, with the Zambezi River having the largest numbers. Coutada 10 has the unique advantage of having a much higher level of rainfall due to its close proximity to the Indian Ocean which forms a 50 kilometre border for the coutada. Thus, depending on the time of year, up to 30% of the area is wetland. The coutada also have the advantage of bordering the un-hunted Marromeu Buffalo Reserve and so its wildlife population is much stable. As a result Coutada 10 can manage to host as many as 40 hunts per season.

Figure 8.2: Percent Contribution to Total Meat from Game Hunting



Coutada 11 is run by Nyala Safaries (Box 3) while Coutada 12 is run by Marks Hallgren Safaris of South Africa. These two coutadas occupy areas furthest away from the Marromeu Buffalo Reserve hugging the drier Cheringoma Plateau.

As a result game densities are much lower but there is better prevalence of species that do not like the water logged environment of the other coutadas. As a result of the lower wild animal densities these two coutadas host on average 13 to 15 hunting visits per year between August and October. Though the Safari is official open for hunters starting in June, between June and July the grass in the area is still too tall for effective hunting.

Box 3: Nyala Safaris – Game Hunting and Local Employment Creation

On average Nyala receives 13-15 hunters a season some of them accompanied by non-hunters. Non hunting visitors are mainly friends or family accompanying the professional hunters though occasionally they have hosted scientific visits. The main origin of hunters is from the USA, constituting approximately 80% of the hunters. Most hunts are brokered by Outdoor Outfitters in the USA at their January meeting in Reno, Nevada, USA.

The duration of hunts is predetermined through rules set by the international board governing safari operations, Safari International. These stipulate that hunts are set according to the type of trophy animal such as:

- 2 weeks for buffalo hunts
- 18 days for leopard
- 21 days for lion or elephant.

The duration is built into the bid price. Usually hunts are in the form of a bag of animals involving one of the BIG FIVE animals and a number of the other minor animals.

The average hunter from north America would be expected to pay US$15 000 to US$18 000 for buffalo, US$25 0000 for leopard, and US$30 000 for lion. The current restriction on export of elephant trophies excludes elephant hunts. Nyala in 2007 got permission to harvest 15 buffalo, 4 nyala, 1 leopard, 1 hippo, 1 elephant, 6 baboons, 10 crocodiles, 15 duikers, and no lion nor eland.

Operations on the safari camp are helped by a permanent staff complement of 19 people. Twelve are employed as guards while 4 maintain the camps, one is a mechanic and 2 are professional guides who work with client hunters. Between May and July the park employs some 200 casual laborers to help in opening up game drive trails and to aid in the hunting season. During the hunting months proper, guards assist professional hunt guides in locating wildlife.

Guards earn between 1980 and 2500 MTN per month. In addition they also get incentive payments for identifying traps within the forest – 50MTN for small traps and 100MTN for finding large traps. Thus on average guards get an extra payment

Coutada 14 is run by Nyati Safaris (Box 4). The Coutada which sits right next to the Zambezi main channel also borders the Marromeu Buffalo Reserve. It therefore enjoys much high concentrations of game animals. However to the north the coutada is bordered by the communities of Safrik, Meguguni and Makwere (i.e. the part of Chueza community closest to Coutada 14). The coutada also borders with the SENA sugar company and the town of Marromeu. It therefore has to deal with many incidents of wildlife-human conflicts. However, the high density and quality of trophy animals means Coutada 14 can afford more trophy hunts. On average it receives 30 to 40 hunters each season.

Box 4: Coutada 14: Wildlife – Human Conflicts

8.3

Wildlife-Human Conflicts: Conflicts between humans and animals occur with especially in the Miguguni Community. For example, in early May a hippo was reported destroying farmers' fields. Elephants have been reported straying into sugar fields. Coutada professional hunters contend this has been due to people moving into traditional elephant paths. Human encroachment into hippo habitat has reduced their numbers. Hippos perform an important function of controlling vegetation that clogs rivers and hence keep river channels open.

Employment: Nyati Safaries employs 17 anti-poaching guards that operate as parts of three teams. Some of the guards are from the three communities that reside within the Coutada boundaries. During the hunting season some of these guards assist in the hunts. In addition 25 people are employed at the only camp on Coutada 14. The main camp has a diesel generator that is run 10 hours a day consuming some 25 liters of fuel.

Hunting packages: Hunts are hinged on the big five (lion, leopard, hippo, elephant and buffalo). A typical hunt will have one of the big five plus a combination of other minor species. Leopards, lion and hyenas have not been seen on the coutada for the past 2 years. This has probably been due to the recent wetness over the two years. Thus these have not constituted recent hunt seasons. The major species in hunts is the buffalo followed by hippo and elephant.

Costs of the hunts are inclusive of the costs of trophy hunt, gun import license (at least 3 months before the hunt), transfer from Beira to the site and all the food and drinks. The safari coordinates the shipping of the trophies with the customer footing the costs.

Before the beginning of the season the company applies to the Department of Tourism for allocations of various animal species. The Department of Tourism grants the allocations which they offer the companies. The company chooses the number of animals by species they want hunted and pays the government stipulated permit fees for the animals

Valuation of the Zambezi Delta Wildlife

8.3.1 Value of smallholder bush meat

Multiplying the estimated amount of game meat harvested by the average price of meat (i.e. US$ 0.875 Kg^{-1}) gives the gross value of bush meat. The gross value of bush meat ranges from about US$451 200 during a flood year to US$1 million during a drought year (Table 8.5). After accounting for the value of effort expended in hunting, the net economic value of game meat is presented in Table 8.6. The net economic value from game meat hunting is negative

during a flood year. During a normal year the net value of game meat is about US$67 000 and during a drought year the net value is about US$540 000. The low and negative economic value is mainly due to the large effort expended on hunting little game by the rural households in Marromeu District.

Table 8.5: Gross Value of Bush Meat Harvest by Smallholder Households

	Marromeu	Cheringoma	Total
Normal year	294,158	296,995	591,153
Flood year	188,593	262,579	451,172
Drought Year	482,750	559,574	1,042,325

Table 8.6: Net Economic Value of Bush Meat Harvest by Smallholders Households

	Marromeu	Cheringoma	Total
Normal year	- 103,812	170,547	66,736
Flood year	- 175,122	136,132	-38,991
Drought Year	106,409	433,127	539,536

8.3.2 Valuing professional wildlife hunting

To value sport hunting, the hunting safari data of one Coutada were utilized to estimate total cost of a typical hunting safari. Key cost items for the hunter include travel and transfer costs, accommodation, additional charges prior to hunt, and finally the price of trophy animals in the hunter's chosen bag. These are outlined below.

Travel and Transfer Costs: All hunters to the Zambezi Delta arrive through Johannesburg, South Africa. They spend at least one night in South Africa and proceed to Beira the following day. Most of the hunters take a chartered plane

into Beira and are collected by truck to the coutadas. The level of expenditure incurred by hunter to get to the safari and back to their homes is presented in Table 8.7.

Table 8.7: Travel Costs

Airport taxes per person(US$)	90
Mozambique Visa per person(US$)	60
Return charter flight from South Africa (Per flight, not per person) (US$)	3250
1 Night in South Africa (US$)	420
London-JBG Return Ticket (US$)	3286.8
Atlanta-JBG Return Ticket (US$)	2140.32
Budapest-London Business Class(US$)	407.16
Lisbon-London Return Business Class Airfare(US$)	274.56
Madrid-London return Business Class Airfare(US$)	187.2
Road Transportation between Biera and Camp per vehicle Return (US$)	500

Accommodation: The hunter has to pay for accommodation and for him- or herself as well as for the professional hunter who will be assisting the hunt. This amounts to about US$1050 per day when the hunter has sole responsibility for a professional hunter or US$900 if the hunter is sharing the responsibility with another hunter. In addition if the hunter has accompanying non-hunter members in his party then an additional payment is made of US$250 per day per person for food and accommodation.

Additional costs: In addition to the above costs the hunter needs to pay a number of fees and charges to be allowed to hunt in the country as well as export trophies back to their homes. These are outlined in Table 8.8.

Table 8.8: Additional Fees Hunting Related Fees

ITEM	**US$**

Hunting License	300
Rifle and Ammunition Permit:	
One Rifle	200
Two Rifles	300
Three Rifles	400
Trophy Export Documentation per hunter	650
Preparation, dipping & packing for export per trophy	100

Application of the above costs on the hunters that hunted at the case coutada resulted in individual hunting party costs, less price of trophy costs presented in Table 8.6. The analysis shows that the ten hunters and accompanying observers spent about US$ 256,401 during the hunting season.

The hunting party shared 43 trophy animals between them. The trophy price and license fees for the animals hunted totaled US$ 98,650 (Table 8.9). Thus the hunters spent between them US$355,051 or an average of US$ 35,505 per hunter. Given that an estimated 110 hunters visit the coutadas of the Zambezi Delta every year, the above analyses imply the value of wildlife (visitors multiplied by average cost of a hunting safari) of US$ 3.9 million per year.

Table 8.6: Costs Incurred by the Case Hunters Less the Cost of Trophy Animals

Hunter	Origin	Stayed (days)	Observers	Trophies	Travel Costs (US$)	Transfer Costs	Hunter Lodging Costs	Observer Lodging Costs	Extra Charges	TOTAL COSTS
1	USA	10	1	1	4,281	4,890	10,500	2,500	1,250	23,421
2	USA	28	0	7	2,140	4,320	29,400	-	1,250	37,110
3	USA	15	2	2	6,421	5,460	15,750	7,500	1,250	36,381
4	Spain	12	0	2	3,474	4,320	12,600	-	1,250	21,644
5	Spain	12	1	2	6,948	4,890	12,600	3,000	1,250	28,688
6	USA	18	0	4	2,140	4,320	18,900	-	1,250	26,610
7	Hungary	7	2	10	11,082	5,460	7,350	3,500	1,250	28,642

8	Portugal	7	1	5	7,123	4,890	7,350	1,750	1,250	22,363
9	USA	7	0	3	2,140	4,320	7,350	-	1,250	15,060
10	Portugal	7	0	7	3,561	4,320	7,350	-	1,250	16,481
										256,401

In addition the study estimated the value of the stock of wild life in the protected areas based on estimated stocks and trophy price of various key species of animals. This is the lower bound of the option value of wildlife in the Zambezi Delta. This gave an estimated economic value of about US$62 million (Table 8.10).

Table 8.9: Cost of the Harvested Animals

Harvested Animals	**Number of Animals**	**Price**	**License Fee**	**Total Costs**
Buffalo	15	2,500	750	48,750
Leopard	1	3,500	850	4,350
Elephant	1	12,500	6,000	18,500
Hippo	1	2,200	600	2,800
Nyala	4	2,000	500	10,000
Duikers	15	750	100	12,750
Baboons	6	200	50	1,500
				98,650

Table 8.10: Valuing Standing Wildlife

Species	Survey of Stock in one Coutada Nov 2006	Estimated Whole Complex Stock	Price (US$)	Value (US$)

Buffalo	1212	5175	3,250	16,817,285
Chango	500	2135	750	1,601,036
Crocodile	200	854	2,250	1,921,244
Elande	96	410	3,100	1,270,582
Elephant	105	448	18,500	8,293,368
Facocero	1342	5730	400	2,291,830
Gondonga	351	1499	2,000	2,997,140
Hippopotamus	60	256	2,800	717,264
Imbambala	401	1712	1,400	2,396,858
Impala	150	640	650	416,269
Inhacoso	274	1170	1,600	1,871,718
Inhala	402	1716	2,500	4,290,777
Macaco-cao	600	2562	250	640,415
Pala-pala	952	4064	4,000	16,257,990
Hiena malhada	40	171	1,500	256,166
				62,039,942

8.3.3 Value of habitat for birds

The term habitat refers to the natural environment of plants and animals and goes beyond the vegetation. Some species are specifically related to habitats, during their complete life or during a part of their lifecycle. The Zambezi Delta is a breeding site for a number of water birds, some of them of international importance. At least 42 bird species have been identified on the Zambezi Delta (Bento and Beilfuss, 2000). Of these, at least eleven species of waterbirds of international concern are utilizing the Marromeu Complex, including the African Skimmer, Wattled

Crane, Eastern White Pelican, Pinkbacked Pelican (*Pelecanus rufescens*), Woolynecked Stork (*Ciconia episcopus*), Openbilled Stork, Saddlebilled Stork (*Ephippiorhynchus senegalensis*), Yellowbilled Stork, Black Stork (*C. nigra*), Redwinged Pratincole (*Glareola pratincola*), and Caspian Tern (*Sterna caspia*) (Brooke 1984).

The Wattled Crane (*Bugeranus carunculatus*) is a Globally Endangered resident of sub-Saharan Africa. In undisturbed floodplain systems elsewhere in Africa, the breeding and feeding requirements of the Wattled Cranes are intimately linked to the natural flood cycles of rivers. Wattled Crane pairs are "triggered" to nest as flood waters begin receding after peak flooding. With the present erratic and mis-timed flooding of the Lower Zambezi system, Wattled Crane pairs may not be induced to initiate nesting. They may also lack wetland habitat with an adequate supply of tuber producing sedges. Where nesting is attempted, unanticipated water level rises can drown nests and food sources. Rapid water level drawdown in the floodplains may expose nests to wildfires and predators and limit food availability (Beilfuss, Dutton, and Moore, 2001). Thus, water resources developments in the Lower Zambezi system may be contributing to a significant decline in the Wattled Crane population of the Marromeu Complex.

Historical accounts indicate that the Wattled Crane was previously more abundant and widespread than today. Annual surveys during 1995–2002 suggest a core population of about 120 breeding pairs remains in the Zambezi Delta region. Wattled Cranes in the delta are exclusively associated with sedges of the genus *Eleocharis*, the tubers of which provide the adult cranes' main food supply. The main *Eleocharis* areas in the delta, and those supporting the highest density of Wattled Cranes, occur below the adjacent Cheringoma escarpment, where unregulated streams flow onto the floodplain. These wetlands experience some seasonal inundation in all years — conditions essential for the production of underground tubers — and high soil penetrability to enable the cranes to extract tubers. *Eleocharis* tuber production and soil penetrability is extremely low in the remaining vast areas of the delta that no longer receive regular annual flooding due to regulation of the Zambezi River. Significant differences in crane density between the Eleocharis beds of the Cheringoma and Zambezi floodplains suggest that the carrying capacity of the delta for cranes has been reduced. Simulation modeling suggests that the present population of Wattled Cranes in the Zambezi Delta is viable, despite the long-term, severe hydrological degradation of large parts of the floodplain. Restoration of the hydrological conditions in the delta may have global implications for the species, however. In 1990, an estimated 2 570 Wattled Cranes (more than 30% of the global population) were observed in the delta. This was likely an occasional flock from elsewhere in southern Africa, as prolonged regional drought resulted in failed floods, low tuber productivity and relatively impermeable soils in the region (Bento, Beilfuss, Hockey, 2007).

Other birds also threatened by water resources development activities include:

i. The African Skimmer (Rhynchops flavirostris), now extinct in South Africa and restricted to a few river basins in southern Africa, occurs in small numbers in the Lower Zambezi;
ii. The Redwinged Pratincole;
iii. Further attempts to stabilize the Zambezi flow regime will greatly diminish the availability of sandbar habitats and threaten one of the largest populations of Openbilled Storks reported in Africa.
iv. Large numbers of White and Pink-backed Pelicans fed in the Zambezi Delta floodplains during the 1960s and 1970s. In recent years, pelicans have abandoned the dry floodplains of the Zambezi Delta and now feed in Lake Urem of Gorongosa National Park. They continue to roost and breed in the coastal delta, but appear to be able to meet their feeding requirements there no longer.

The fates of these and other waterbird species in the Marromeu Complex are also linked to water resource developments in the Lower Zambezi. These impacts and these changes include the degradation of breeding habitats for some species and the impoverishment of feeding grounds for others. As with pelicans, Saddlebilled Storks (*Ephippiorhynchus senegalensis*), Goliath Herons (*Ardea goliath*) and many other piscivorus waterbird species depend on concentrations of laterally migrating fish that are trapped in shallow floodplain depressions as floodwaters recede. Saddlebilled Storks nest at the end of the wet season, and fledge their chicks during the dry season when food is concentrated and easy to obtain (Hancock et al. 1992). Goliath Herons feed on large fish in lake edges and shallow waterbodies of the floodplain (Hancock & Kushlan, 1984). Such species are now unable to utilize the vast areas of the Marromeu Complex that no longer receive overbank flooding sufficient for fish to migrate to floodplain spawning grounds from the main channel.

To capture the value of habitats for water birds, a benefit transfer methodology is used. The value of wetland habitat and nursery is estimated at between US$1 500 ha^{-1} yr^{-1} (Brander, et.al., 2006) and US$2 630 ha^{-1} yr^{-1} (Van Beukering and Sultanian, 2005; Zwarts, Van Beukering, Kone, and Wymenga, 2005). However, a meta-analysis of 190 wetlands by Brander, et.al. (2006) estimate the median value of wetland habitat and nursery at about US$85 ha^{-1} yr^{-1}. This median value is used to value wetland habitat for birds in the Zambezi Delta.

The estimated habitats area for water birds in the Zambezi Delta is 457,000 ha (Beilfuss, Moore, Bento, and Dutton, 2001). However, the effective area conducive for breeding and feeding for the birds is assumed to be half (i.e. 228,500 ha) of the total suitable land due to the noticed degradation of the habitats. Using a conservative value of US$85 ha^{-1} yr^{-1} (Brander et. al., 2006), the annual total value of habitats for water birds is US$19,422,500. Since, the same habitats as required by birds of international importance are also conducive habitats for all other water birds in the Zambezi Delta this value can be interpreted as a measure of the value of all birds in the Zambezi Delta.

8.3.4 Total economic value of wildlife in the Zambezi Delta

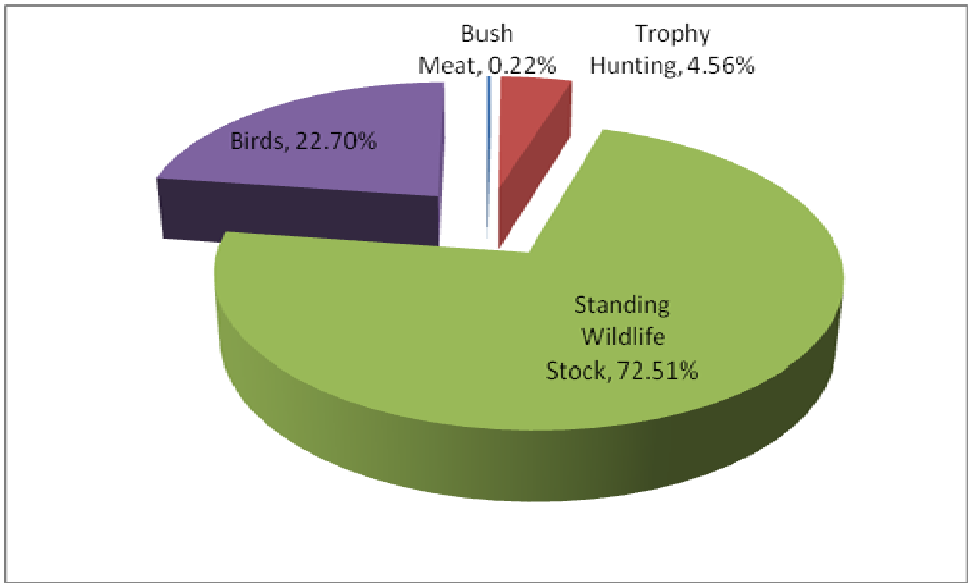
The estimated total annual economic value of wildlife resources in the Zambezi Delta is at least US$85.33 million in a flood year; US$85.43 million in a normal year; and US$85.91 million in a drought year (Table 8.11). Of this annual total value bush meat harvesting contributes less than one (1) percent. Trophy hunting contributes about 4.6% to the total economic value of wildlife (Figure 8.3).

Table 8.11: Total Economic Value of Wildlife in the Zambezi Delta

Source of Value	Normal Year	Flood Year	Drought Year
Bush Meat	66,736	- 38,991	539,536

Trophy Hunting	3,905,556	3,905,556	3,905,556
Standing Wildlife Stock	62,039,942	62,039,942	62,039,942
Birds	19,422,500	19,422,500	19,422,500
TOTAL	85,434,734	85,329,007	85,907,534

Figure 8.3: Percent Contribution of Bush Meat, Trophy Hunting, and Standing Wildlife Stock to Annual Total Wildlife Economic Value



9. CARBON SEQUESTRATION

Carbon dioxide (CO_2), methane (CH_4) and NO_2 belong to the class of substances termed greenhouse gases (GHG) that have immensely contributed to global warming and climate change. This phenomenon has been deemed serious enough to warrant the world community to establish the Intergovernmental Panel on Climate Change (IPCC) in 1988 with the responsibility to undertake an assessment of the science, impacts, adaptation, and mitigation options in relation to climate change and advice the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).

Forest vegetation is a major component of the global carbon (C) cycle and is estimated to store at least 350 Pg C. World-wide, forests: (i) contain about 45% of the global stock of C, the larger part of which is found in the forest soils, and (ii) annually remove close to 40% of the CO_2 that is currently added to the atmosphere by human activity (Dixon et al. 1994). This is subject to increase or decrease as a result of factors such as harvest, re-growth, conversion to other land uses, with resulting changes in C fluxes to the atmosphere. The Zambezi Delta vegetation and economic activities have potential to contribute to or reduce atmospheric concentrations of GHGs. Vegetations of the Delta including the wetlands and forest areas have potential to reduce concentrations of the GHGs through photosynthesis. Economic activities such as agriculture have potential to both increase GHGs through the nature of land operations and decrease GHGs through plant growth. Uses of timber resources as energy have a potential to add to GHG concentration both in their production and use. This section assesses the net GHG absorptive capacity of the Zambezi Delta vegetation and economic activities.

In order to limit emissions of GHGs Developed countries has stipulated allowable quotas on how much GHGs their companies can emit. This has led to some companies innovating and reducing emissions to levels below set quotas. Such companies have been allowed to sell the earned credits from innovating to companies that cannot meet their allocated emissions levels. These emissions trading systems provide a basis for revealing the value of carbon sequestration used in this study. In the largest market for CO_2 – Europe's ETS - the current price of CO_2 is about £16 or US$31.70 per tonne[6].

9.1Carbon Sequestration in Forests of the Zambezi Delta

In the following we assess the amount of carbon(C) stored in the forest biomass, how much is sequestered each year and the value of yearly carbon sequestration.

9.1.1 Assessing carbon sequestered in forests

For carbon accounting purposes, the total carbon stock for a given area, which may be a soil or LUT polygon, or a PCC, present in the current land-use pattern, can be calculated from (FAO, 2007):

$$C_{stock\ total} = C_{ag} + C_{bg}$$
$$C_{bg} = C_{bg\text{-}biom} + C_{soil}$$
$$C_{stock\ total} = C_{ag} + (C_{bg\text{-}biom} + C_{soil})$$

[6] "Strengthening the EU emissions trading system", by Stavros Dimas, European Commissioner for Environment, World Finance Magazine, 12 February 2008, www.worldfinance.com

where $C_{stock\ total}$ is the total stock of C in the ecosystem, including aboveground (C_{ag}) and belowground (C_{bg}) pools. The constituents of the belowground pool are the carbon content in roots and all belowground biomass ($C_{bg\text{-}biom}$) and the C in the soil (C_{soil}) as organic C in soil organic matter (SOM).

Total carbon content from forest inventories is determined as (Gallagher, Hendrick, and Byrne, 2000):

SV *RVF* DWD * CC * BEF

Where:

SV is the standing Volume (m^3),
RVF is the reduced volume factor,
DWD is Dry Wood Density (t m^{-3}),
CC is Carbon Content Coefficient, and
BEF is Biomass Expansion Factor.

The dry wood densities for the tree species in the study areas are provided in Table 9.1 and Table 9.2. However, given that detailed data on the area under individual tree species is not available, an average dry wood density is used. The estimated wood density for Nhambita, which is within the Zambezi Delta ranges from 560 Kg m^{-3} (Williams, Ryan, Sambane, Fernando and Grace, 2008) to 788 Kg m^{-3} (Herd, 2007). For purposes of this study, an average of 722.75 Kg m^{-3} is used.

Table 9.1: Dry Wood Densities (Kg per M^3) for Trees Species in Zambezi Delta

Species	Kg per M^3
Albizia[1]	605
Amarula[2]	590
Cashew[3]	520
Gliricidia[3]	620
Mbila[2]	640
Muhimbie[1]	780
Panga-panga	720

Red mahogany[2]	590
Tamarind[1]	750
Ziziphus[1]	760
Average	657.5

Source: [1]Brown, 1997; [2]Goldsmith and Carter, 1981; [3]University of Edinburgh, 2005

Table 9.2: Dry Wood Density by Species (t m^{-3})

Species	**Dry Bulk Density (t m^{-3})**
Mangifera indica	0.40
Khaya anthoteca	0.45
Acacia nigrescens	0.46
Commiphora mossambicensis	0.47
Sclerocarya birrea	0.47
Entada abyssinica	0.51
Brachystegia boehmii	0.52
Xeroderris stuhlmannii	0.52
Piliostigma thonningii	0.53
Combretum apiculatum	0.55
Philenoptera vilacea	0.55
Albizia amara	0.57
Diplorhynchus condylocarpon	0.60
Julbernardia globiflora	0.63
Brachystegia spiciformis	0.63
Albizia lebbeck	0.63

Species	Dry Bulk Density (t m^{-3})
Burkea Africana	0.63
Erythrophleum africanum	0.64
Millettia stuhlmannii	0.68
Pterocarpus rotundifolius sub sp. Rotundifolius	0.65
Cleistochlamys kirkii	0.71
Average	0.56

The carbon content is assumed to be 50% of dry weight of all biomass (Gallagher, Hendrick, and Byrne, 2000; Williams, Ryan, Sambane, Fernando and Grace, 2008). Cruickshank et al. (2000) uses carbon content figures with a range of 0.42 – 0.46. In the absence of detailed data on forest inventories in the Zambezi Delta, it is assumed that in both the upper land Coutadas (i.e. 11 and 12) and Forestry Concessions, the stock of wood is an average of 42 t ha^{-1} (Bradley and McNamara, 1990 in Campbell, 1993). Given the estimated average wood density of 0.72225 t m^{-3}, this translates to 58 m^3 ha^{-1}. These parameters were utilized to estimate the amount of carbon stored in the above ground biomass of the Zambezi Delta forest areas amounting to about 22 million tons (Table 9.3).

Table 9.3: Carbon Sequestered in Above-Ground Standing Forests of the Zambezi Delta

Estimated area under forest concessions and Coutada 11 and 12	728,429	ha
Volume of timber per ha	69	m^3
Reduced volume per ha	58.65	m^3
Dry Wood density	0.60875	t per m^3
Carbon Content (CC) as percent of dry weight	50%	
Estimated carbon from FC forest vegetation	30.35	t per ha
Total carbon sequestrated	22,106,152	tonnes

Measuring and predicting changes in soil carbon stocks is extremely difficult. This is mainly due to high spatial variability and the fact that changes are usually very small relative to the total carbon stock. Carbon stored in forest

soils is estimated to be a very significant component of the forest ecosystem storage (Byrne and Farrell, 2001). An estimate of the average carbon store in forest soils is 305 t C ha^{-1} (COFORD 2001). Based on Sileshi et.al. (2007), it is estimated that soil C content for miombo woodlands is estimated at about 257.56yr t ha^{-1}. Given the land area under forest concessions, this means the potential C stock in forest soils is about 187,614,173 tonnes. Thus the total carbon stored in the Marromeu Forest areas is approximately 209,720,325 tons.

9.1.2 Valuation of annual carbon sequestration in the wooded forest areas

The stream of carbon sequestration services provided by the Complex woodlands is better reflected by how much the woodlands absorb from the atmosphere during each year. Biomass yield in the forest of the Zambezi Delta is not known with certainty. To arrive at estimates we had to work back from estimates from commercial timber estimated log sustainable yields. In Mozambique the highest potential log production is in Sofala province with a potential sustainable yield of 0.043 m^3 ha^{-1} yr^{-1} (Fath, 2002). Assuming a logging residue coefficient of 50% the above ground biomass production of Sofala forests is estimated at 0.086 m^3 ha^{-1} yr^{-1}. Assuming root biomass is 20% and litter is 10% of above ground biomass, respectively, litter and soil biomass accumulation should be at the rate of 0.0258 m^3 ha^{-1} yr^{-1} for a total forest biomass production rate of 0.112 m^3 ha^{-1} yr^{-1}. Based on timber density of 0.60875 t m^{-3} this gives a biomass yield of 0.081 t ha^{-1} yr^{-1}. Assuming 50% C content this gives an annual C sequestration rate of 0.0405 t ha^{-1} yr^{-1}.

Wooded forest areas include the forest concession areas of Cheringoma as well as the upland hunting areas of Coutada 12 and 11. Coutadas 10 and 14 as well as the Marromeu Game Reserve are largely wetland grassland vegetation. It is estimated therefore that wooded forest area covers 728,429 ha of the Zambezi Delta. Thus estimated carbon sequestrated each year amounts to 29,462 tons C per year equivalent to 108,123 tons CO_2 per year (3.67 CO_2 is equivalent to a ton of C). At a cost of US$ 31.70 per ton this gives a value of carbon sequestration of US$ 3,427,513 per year.

9.2 Carbon Sequestration in Wetlands Vegetation

Coutadas 10 and 14 as well as the Marromeu Game Reserve are largely wetland grassland vegetation and cover an area equivalent to 485,000 ha. There are no studies on soil carbon stocks of wetland grasslands. In this study a low bound estimate of 258 t C per ha of savannah drylands is adopted. Based on this estimate the C sequestered in the wetland vegetation amounts to 125,130,000 t of C.

For valuation a yearly rate of carbon assimilation is needed. In the absence of estimated carbon assimilation rates of the Marromeu wetland areas results from elsewhere are used. According to Lal, natural wetlands have a potential to accumulate C net of methane emissions at the rate of 0.2 to 0.3 t ha^{-1} yr^{-1} (Rattan Lal, 2003). Thus estimated C accumulated each year amounts to 121,250 tons C per year which is equivalent to 444,988 tons CO_2. At a CO_2 price of US$31.70 per ton this represents a sequestration value of US$14,106,104 each year.

9.3 Carbon Emissions from Charcoal Production and Use, and Firewood Use

Charcoal and firewood contribute to global warming through emissions of carbon dioxide during their production and its use as a source of energy. Table 9.4 derive the Carbon dioxide emissions from charcoal production and use and from direct wood use as energy.

Table 9.4: Charcoal and Firewood Emissions Parameters

Charcoal Produced (kg)	1
Wood biomass used (kg)	5.7
Additional wood biomass wasted in production (kg)	2.0
Total Biomass Required to Produce a kilogram of Charcoal (kg)	7.7
CO_2 emissions generated in producing 1 kg Charcoal (kg)	6.4
CO_2 emissions from combusting 1 kg Charcoal (kg)	3.3
Total CO_2 emitted in producing and using 1 kg of Charcoal (kg) = CO_2 emitted in using 7.7 kg of firewood	9.7
Thus CO_2 emitted in combusting 1 kg of Firewood (kg)	1.26

Source: Alastair Richard Craster Herd, 2007.

Computations in Table 9.4 imply production and use of a tonne of charcoal emits 9.7 tonne of CO_2. Annual charcoal produced in the Zambezi Delta ranges from 1 240 tons during a normal year, 1 600 tons during a drought year, and only 200 tons during a flood year. This implies that CO_2 emissions due to production and use of charcoal are approximately 12028 tons in a normal year, 15,520 tons in a drought year and 1,940 tons during flood years. Based on a CO_2 price of US$31.70, the corresponding costs of emissions are thus US$381,288 in normal years, US$ 491,984 during drought years and US$ 61,498 in flood years.

An estimated 374 000 tons, 383 000 tons and 292 000 tons of firewood are collected by the Zambezi Delta rural households during normal, drought and flood years, respectively. These generate CO_2 amounting to 471,240 tons, 482,580 tons and 367,920 tons during normal, drought and flood years, respectively. The corresponding costs of emissions are thus US$14,938,308 in normal years, US$ 15,297,786 during drought years and US$ 11,663,064 in flood years.

9.4 Emissions from Livestock

Livestock production is a major economic activity of the Zambezi Delta inhabitants. Livestock contribute to global warming through production of CH_4 during enteric fermentation. The main livestock kept are goats, pigs and poultry. Chickens produce 1kg CH_4 per head per year, pigs produce about 1.5 kg CH_4 while goats produce 5 to 8 kg CH_4 per head per year (US-EPA, 1998). CH_4 has 21 times the global warming effect of CO_2 or 21kg of CO_2 is equivalent to a kg of CH_4. The estimated total livestock in the Zambezi Delta is 28 000 goats, 7 700 pigs, and 175 800 poultry/chickens.

Table 9.5 uses this information to estimate contributions of the Zambezi Delta livestock to GHGs per year and the cost in US dollar terms of such emissions. The results of Table 10.5 show that livestock activities contribute the equivalent of 8,050 tons of CO_2 valued at about US$ 255,196.

Table 9.5: Valuation of Livestock GHG Emissions

Livestock	Total Number in Zambezi Delta	CH_4 Emissions per head per year (kg)	CO_2 equiv Emissions per Year (tons)	Cost of Emissions(US$)
Goats	28,000	7	4116	130,477
Pigs	7,700	1.5	242.55	7,689
Chickens/poultry	175,800	1	3691.8	117,030
Total				255,196

9.5 Carbon Sequestration on Cultivated Lands

Two systems of production are practiced in the Zambezi Delta – smallholder subsistence farming and commercial sugar production. These have different abilities to sequester carbon.

9.5.1 Valuation of net carbon assimilation from smallholder croplands

Very few studies have been undertaken on the carbon sequestration or losses under cropland in Africa. Most of the studies estimate C loss following conversion of forest to cropland. The majority in the communities of the Zambezi Delta have been continuously cropping their land – particularly the rice fields. The only study that looked at soil C loss under continuous cropping was in western Kenya which showed losses of 0.9 t C per hectare per year (Woomer et. al. 1997). This is the estimate used in this study. Based on the estimated number of rural households of 17,944 and average land holdings of 1.83 hectares, the carbon loss from cropping amounts to 29,554 tons C equivalent to 108,462 tons CO_2. At a ton cost of US$ 31.70 this amounts to a global warming cost of US$ 3,438,256.

9.5.2 Valuation of net carbon sequestered from commercial sugar production

Sugar production by SENA Sugar is under conversional tillage with manual harvesting after pre-harvest burning. Bayer et al. (2000) found a C accumulation rate of 1.6 tons per hectare per year for a 9 year no-tillage system compared with 0.10 tons per hectare per year for the conventional system in the first 30 cm layer of an Acrisol in the southern part of Brazil. When sugar cane is burnt greenhouse gases like CH_4 and N_2O are emitted to the atmosphere. Macedo (1998) shows that 6.5 kg of CH_4 per hectare are released from pre-harvest burning of sugar cane. SENA Sugar also uses bagasse to provide energy during the processing of sugar thereby saving fossil energy. These

parameters are used to estimate carbon emitted and sequestered during the sugar production cycle of SENA Sugar. Results from Table 9.6 shows that the sugar processing cycle of SENA Sugar results in a net positive carbon sequestration of 98,264 tons CO_2 valued at about US$ 3.115 million.

Table 9.6: Estimated Valuation of Net Emissions from SENA Sugar Operations

ITEM	Conversion Parameters[7]	Total based on SENA's 14000 ha at 53t cane ha^{-1} (tonnes CO_2)
Emissions from fossil fuel utilization in cane and sugar production	From the energy balance, 236 MJ/ton cane leading to 17.2 kg CO2/t cane	12,762
Emissions of methane from sugar cane burning	6.5 kg methane/ha	91
Emissions of N_2O from soil	3.17 kg CO_2 (equiv.)/t cane	2,352
Soil Carbon Sequestered	0.10 t C per hectare(3.67 tonnes of CO2 = 1 tonne of carbon)	5,138
Fossil Fuel Emissions Avoided in Sugar Manufacture	0.146 t of petro-oil CO2 emissions per ton cane avoided by using bagasse in processing	108,332
Net Carbon Sequestered	Total CO_2 emitted – sequestered – avoided emissions	98,264
Value of Carbon Sequestered	Price(US$31.70 EU ETS)	3,114,983

9.6 Summary Assessment of the Value of the Lower Zambezi Carbon Sequestration Function

Table 9.7 summarises estimates of carbon sequestered and emitted by the vegetation and economic activities undertaken in the Zambezi Delta. The results show that the Zambezi Delta is a net carbon sink sequestering 51,595 tons of CO_2 per year valued at US$1.636 million during normal years. During drought years the ability to sequester carbon declines to 36,763 tons CO_2 per year worth US$ 1.165 million while in flood years it increases to 165,003 tons CO_2 worth about US$ 5.23 million.

[7] ... http://ftp.mct.gov.br/Clima/ingles/comunic_old/coperal3.htm "Net Emissions for the Sugar Cane to Sugar Cycle of Brazil, 1990-1994"

Table 9.7: Summary Estimates of Net Carbon Sequestrated and Its Value

Sector		**Net Carbon Sequestered per Year (CO_2-equiv.)**	**Value (US$/year)**
Forest Areas		108,123	3,427,499
Wetland Grasslands		444,988	14,106,104
Charcoal	Normal	-12,028	- 381,288
	Drought	-15,520	- 491,984
	Flood	-1,940	- 61,498
Firewood	Normal	-471,240	-14,938,308
	Drought	-482,580	-15,297,786
	Flood	-367,920	-11,663,064
Livestock		-8,050	-255,196
Smallholder Agriculture		-108,462	-3,438,256
Commercial Sugar Production		98,264	3,115,000
Total	**Normal**	**51,595**	**1,635,555**
	Drought	**36,763**	**1,165,381**
	Flood	**165,003**	**5,230,589**

10. TOTAL ECONOMIC VALUE OF THE ZAMBEZI DELTA: SUMMARY AND RECOMMENDATIONS

The objective of the study was to estimate the annual economic (not necessarily monetary) value of the goods and services provided by the Zambezi Delta wetlands under prevailing water management regime. The study provided a full accounting, to the extent possible, of the associated with the Zambezi Delta focusing on: (i) water supply, (ii) fisheries, (iii) smallholder and commercial agriculture, (iv) energy, (v) timber and non-timber products, (v) wildlife, including birds, and (vi) carbon sequestration. This section provides a summary of the total economic value of the Zambezi Delta wetlands.

Using a combination of the production function and travel cost approaches, the study determined the total economic value of the Zambezi Delta wetlands, where total economic value (TEV) is:

$$TEV = DUV + IUV + OV + NUV$$

Where,

DUV is Direct Use Value,

IUV is Indirect Use Value,

OV is Option Value, and

NUV is Non-Use Value.

The estimated values are organized according to the TEV approach and are summarized in Tables 10.1 to 10.3 for a normal, flood, and drought year respectively.

10.1 Total Annual Economic Value of the Zambezi Delta

The annual total value of the Zambezi Delta is about US$1.013 billion in a normal year (Table 10.1). An analysis by type of value shows that of this total value about 65.67% is direct use value, 32.3% is the option value and the non-use value only about 1.9% (Figure 10.1). An analysis by source of value shows that of the total economic value about 57.3% derives from the water, and about 26.1% derives from the standing stocks of timber (Figure 10.2). About 6.1% of the annual value derives from the stock of wildlife.

The annual total value of the Zambezi Delta is about US$928 million in a flood year (Table 10.3). An analysis by type of value shows that of this total value about 62.1% is direct use value, 35.3% is the option value and about 2.1% is the non-use value (Figure 10.3). An analysis by source of value shows that of the total economic value about 53.1% derives from

water, 28.5% is from the standing stocks of timber, and 6.7% is from the stock of wildlife (Figure 10.4). About 2.7% of the annual value derives from the stock of wildlife.

The annual total value of the Zambezi Delta is about US$1.61 billion in a drought year (Table 10.3). An analysis by type of value shows that of this total value about 78.0% is direct use value, 20.3% is the option value and about 1.2% is non-use value (Figure 10.5). The increase in value during drought years is mainly resulting from an increase in direct consumption value, as well as from the drought prevention value of the Zambezi Delta wetlands. An analysis by source of value shows that of the total economic value about 73.0% derives from water, and 16.4% is from the standing stocks of timber (Figure 10.6). About 3.9% of the annual value derives from the stock of wildlife.

Table 10.1: Total Economic Value (US$) of the Zambezi Delta in a Normal Year

Source of Value	Direct Use Value	Indirect Use Value	Option Values	Non-Use Values	Total
Water	580,832,624				580,832,624
Fisheries	21,764,656				21,764,656
Crops (Subsistence & commercial)	25,881,560				25,881,560
Subsistence livestock production	605,100				605,100
Rural stock of livestock			1,119,585		1,119,585
Timber & NTFP	32,174,691				32,174,691
Stock of timber			264,051,952		264,051,952
Wildlife	3,972,292				3,972,292
Stock of wildlife			62,039,942		62,039,942
Habitat				19,422,500	19,422,500
Carbon sequestration		1,635,555			1,635,555

TOTAL	665,230,923	1,635,555	327,211,479	19,422,500	1,013,500,457

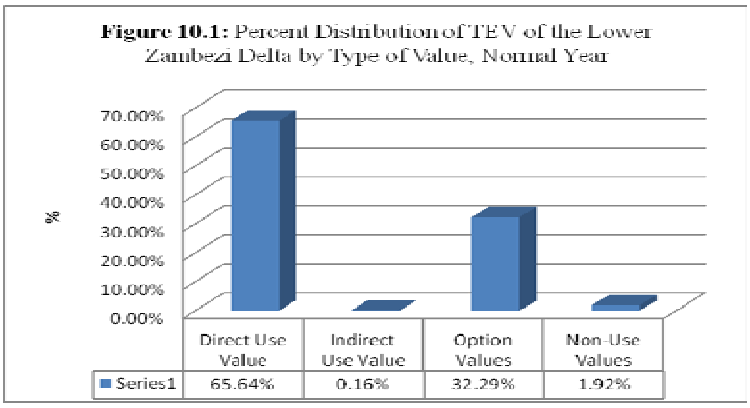


Figure 10.1: Percent Distribution of TEV of the Lower Zambezi Delta by Type of Value, Normal Year

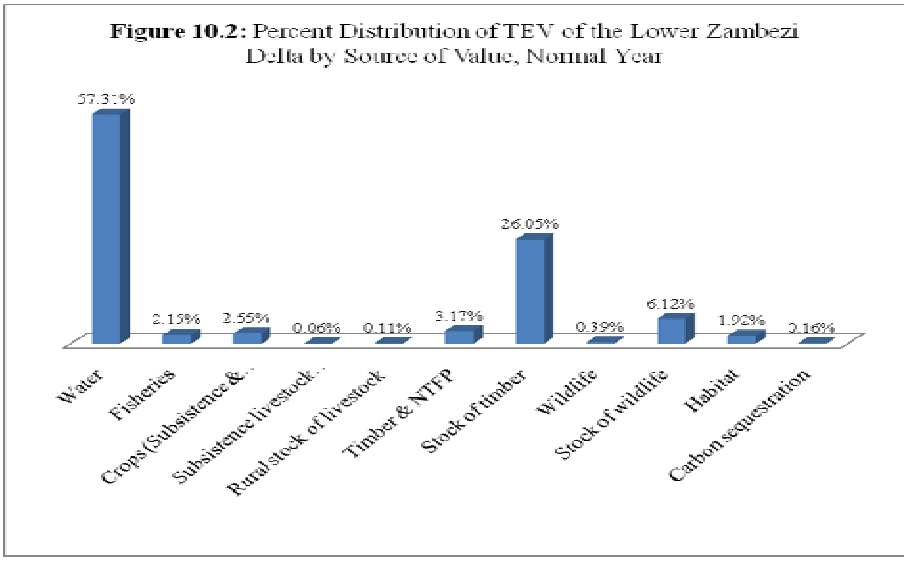


Figure 10.2: Percent Distribution of TEV of the Lower Zambezi Delta by Source of Value, Normal Year

Table 10.2: Total Economic Value (US$) of the Zambezi Delta in a Flood Year

Source of Value	Direct Use Value	Indirect Use Value	Option Values	Non-Use Values	Total
Water	492,579,948				492,579,948
Fisheries	25,224,656				25,224,656
Crops (Subsistence & commercial)	21,469,811				21,469,811
Subsistence livestock production	605,100				605,100
Rural stock of livestock			1,119,585		1,119,585
Timber & NTFP	32,174,691				32,174,691
Stock of timber			264,051,952		264,051,952
Wildlife	3,866,565				3,866,565
Stock of wildlife			62,039,942		62,039,942
Habitat for birds				19,422,500	19,422,500
Carbon sequestration		5,230,589			5,230,589
TOTAL	575,920,771	5,230,589	327,211,479	19,422,500	927,785,340

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Figure 10.3: Percent Distribution of TEV of the Lower Zambezi Delta by Type of Value, Flood Year

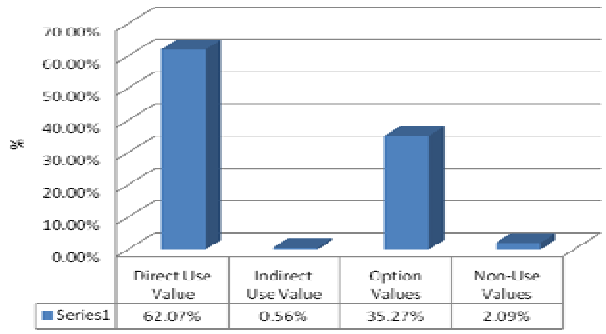


Table 10.3: Total Economic Value (US$) of the Zambezi Delta in a Drought Year

Source of Value	Direct Use Value	Indirect Use	Option Values	Non-Use	Total

		Value		Values	
Water	1,175,920,555				1,175,920,555
Fisheries	21,764,656				21,764,656
Crops (Subsistence & commercial)	21,434,711				21,434,711
Drought prevention for subsistence agriculture		6,206,075			6,206,075
Subsistence livestock production	605,100				605,100
Rural stock of livestock			1,119,585		1,119,585
Timber & NTFP	32,174,691				32,174,691
Stock of timber			264,051,952		264,051,952
Wildlife	4,445,092				4,445,092
Stock of wildlife			62,039,942		62,039,942
Habitat for birds				19,422,500	19,422,500
Carbon sequestration		1,165,381			1,165,381
TOTAL	1,256,344,805	7,371,456	327,211,479	19,422,500	1,610,350,241

Figure 10.5: Percent Distribution of TEV of the Lower Zambezi Delta by Type of Value, Drought Year

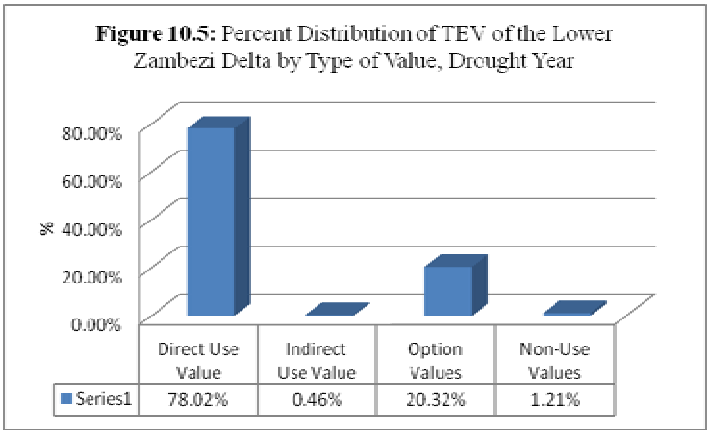
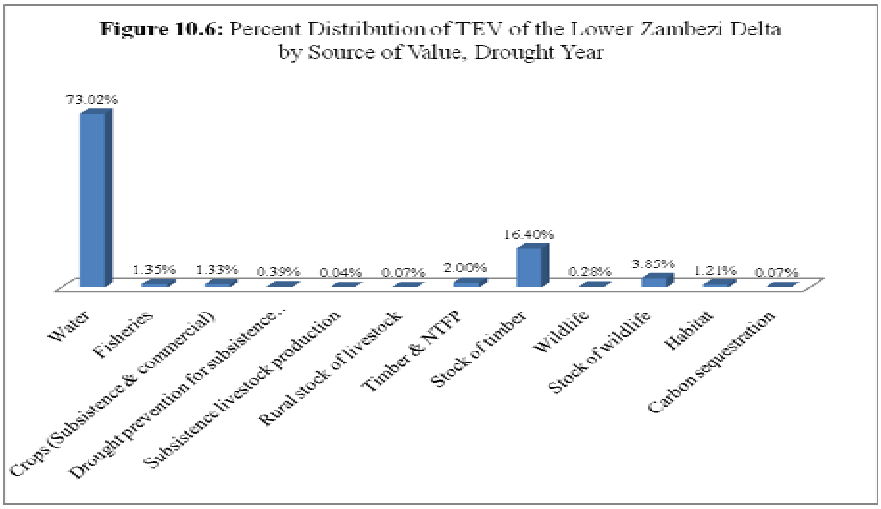


Figure 10.6: Percent Distribution of TEV of the Lower Zambezi Delta by Source of Value, Drought Year



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10.2 Distributional Issues

From the analysis of TEV by resource, the following distributional results are indicated:

Water resources: The percent distribution of the value of abstracted water shows that about 95% is attributed to commercial sugar irrigation, whilst only about 5% can be attributed to rural and urban domestic water use.

Fisheries: During a normal year, subsistence fisheries contribute about 29% to the total value of the fisheries. During a favorable flood year, subsistence fisheries contribute about 25% to the total value of the Zambezi Delta fisheries.

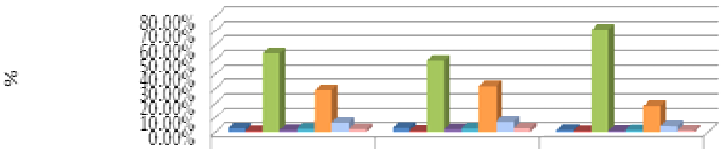
Agriculture: During normal agricultural seasons, commercial sugar production contributes about 87% to total economic value of agricultural activities; subsistence crop production contributes about 7%; livestock option value contributes about 4%; and smallholder livestock direct use value contributes about 2% of total value

Energy resources: During a drought year, charcoal accounts for about 44% of the total economic value of energy resources. The contribution of charcoal to the total economic value of energy resources during a flood year is only about 5%.

Timber and NTFP: Of the total economic value of US$296 million, only 0.35% contributes towards the welfare of the rural population.

Wildlife: Of this annual total value bush meat harvesting contributes less than one (1) percent. Trophy hunting contributes about 4.5% to the total economic value of wildlife whilst the value of birds of international importance contributes about 22.6% of the total economic value of wildlife.

Figure 10.7: Percent Distribution of TEV of the Lower Zambezi Delta by Sector



	Normal Year	Flood Year	Drought Year
Rural	2.65%	2.94%	1.54%
Urban	0.95%	1.04%	0.91%
Commercial water	54.78%	49.80%	71.28%
Commercial Fisheries	1.54%	2.05%	0.97%
Commercial Agriculture	2.37%	2.59%	1.50%
Commercial Timber	29.13%	31.82%	18.40%
Commercial Wildlife	6.51%	7.11%	4.11%
Global	2.08%	2.66%	1.28%

Overall Distribution: The distribution of TEV of the Zambezi Delta by Sector is presented in Figure 10.7. For a normal year, the rural and urban sectors derive only 3.6% of TEV; the commercial sector derives 94.3% of the TEV whilst the global economy (through the value of carbon sequestration and habitats for birds) derives 2.1% of the TEV. For a flood year, the result is similar - the rural and urban sectors derive only 3.9% of TEV;

A

the commercial sector derives 93.4% of the TEV whilst the global economy derive 2.7% of the TEV. During a drought year, the rural and urban sectors derive only 2.4% of TEV; the commercial sector derives 96.3% of the TEV whilst the global economy derives 1.3% of the TEV. Thus the main beneficiary of the Zambezi Delta is the commercial sectors.

10.3 Non-Monetary Values

This sub-section summarizes the direct use values, option values, indirect use values, and existence values which were not valued.

Direct use value - wild vegetables and medicinal plants for rural households. The most important medicine plants are generally obtained from the bush and forests, rather than from the floodplain, and have not changed in availability over time. During times of drought, when he harvest fails due to the lack of rains, many people go hungry and survive by eating roots that are found in the riverbeds, called "nyika" or "nanunfar". These roots do not have any nutritional value, and are blamed for stomach problems and malnutrition. In addition to these roots, some wild herbs and grains, including nyalissosa, nyatunco, cundi, pundi, and nyanguaroguaro, are harvested near the river, but have little nutritional value (Beilfuss, Chilundo, Isaacman, and Mulwafu, 2002). In addition, in the delta region, there has been a dramatic increase in *Borassus aethiopum* and *Hyphaene coriacea* palms in response to drying conditions on the floodplain. Palms are used extensively for palm wine production, and there are some efforts underway to market the alcohol regionally.

The following **option values** were not derived: (i) standing stock of wildlife (other species not valued); and (ii) standing stock of timber in the coutadas. Due to lack of data on the extent of timber or firewood harvesting in the coutadas, the standing stock of timber that is not being harvested was not valued. Wildlife whose standing stock was valued include: buffalo, chango, crocodile, eland, elephant, warthog, gondonga, hippopotamus, imbalabala, impala, inhacoso, inhala, baboon, Pala-pala, hyena, and malhada. Wildlife species whose stock value were not determined include abetarda, cabroto(a), francolino, galinha do mato, cocone, kudu, lion, leopard, porco bravo, zebra, and patos.

At present, the **Marromeu Complex Game Reserve** in the Zambezi delta is the only officially protected area within this eco-region. Situated in the Zambezi delta, this protected area consists of a range of habitats including floodplains, rivers, mangrove swamps, muddy intertidal zones and sea grass beds. Historically famous for its massive herds of buffalo, Marromeu in the late 1980's was still home to a range of animals such as zebra, Southern reedbuck, bushbuck (*Tragelaphus scriptus),* eland*,* oribi*,* suni *(Neotragus mochatus),* nyala*,* greater kudu *(Tragelaphus strepsiceros),* wildebeest*, (Connochaetes taurinus),* common duiker (*Sylvicapra grimmia)*, blue duiker (*Cephalophus monticola)* and red duiker (*C. natalensis)* (IUCN 1987). Elephant and black rhino were also known to occur.

The **indirect use values** were not determined: (i) the microclimatic stabilization of the wetlands; and (ii) the value of mangroves in shoreline stabilization; as habitat for shrimp production, and other function. The Zambezi Delta contains ve percent of Mozambique's estimated 400 000 ha of mangroves – essential for the sustainable productivity of the wild-caught shrimp shery which is one of Mozambique's largest export earners (Gift to the Earth, 2003). Mangroves important feeding grounds for the larvae of shrimps, being washed away to the recruitment areas in the sea by the flooding of the Zambezi River every year (Envirotrade, 2007). Penaeid shrimps, at all stages of development, use mangrove as a preferred nursery habitat (Taylor, Ravilious, and Green, 2003).

Molluscs and crustaceans, such as mangrove crabs, Scylla serrata, mud creepers, *Terebralia palustris*, and shore crabs, Matuta lunaris, collected from mangroves represent an important source of protein for human populations in Mozambique, especially on Inhaca Island (Taylor, Ravilious, and Green, 2003). Mangroves are also vitally important as wildlife habitat, and for coastal protection against the impending threat from climate change and erosion.

Coastal mangroves are affected by selective-cutting and clear-cutting practices. Mangroves are used for construction, firewood, charcoal production, tannins, fruit, fencing, fish traps and medicine in Mozambique. Eight of the nine mangrove species are known to be harvested for construction poles and firewood (DNFFB, 1998). SWECO (1983) reported that clear-cutting practices are widespread in the delta region, and this is the single-most important reason for the decrease of coastal mangrove. Large areas of mangrove have been transformed into cultivated land, or degraded to shrub thicket after clear-cutting for termite-resistant building materials. Threats to mangroves could be particularly damaging to Mozambique's economy as the shrimp fisheries of the Sofala Bank are valued as high as US$50 to 60 million per year, 40 per cent of the country's net foreign exchange earnings.

10.4 Conclusion and Study Recommendations

10.4.1 Study conclusions

The annual total value of the Zambezi Delta ranges between US$0.93 billion and US$ 1.6 billion. Of this value, the percent TEV attributed to the rural and urban households in the Delta ranges from 2.4% to 3.9% and from 1.3% to 2.7% is attributed to the global economy. Thus, the remainder of the TEV of between 93.4% and 96.3% is attributed to commercial activities.

10.4.2 Study recommendations

Based on the valuation results and experiences during data collection for the study the following are recommended:

Inventory of data and resource use monitoring: For the improved management of the Zambezi Delta forest, wildlife, and water resources, there is need for keeping up-to-date data sets of inventories for these respective resources. For example in the forest sector, an analysis of the quotas allocated per year, if all this was utilized, would result in over-exploitation of timber resources. An up-to-date inventory of forest resources would enable an allocation of quotas within the allowable sustainable yields. Similarly for wildlife, an inventory of wildlife numbers would enable the sustainable harvesting of wildlife resources.

Water resources: One of the key issues pertaining to water resources is the timing of the controlled floods from the Cahorra Basa. Both the rural farming communities and the commercial fishers indicated that they are likely to benefit more if flood release would occur around end of November and during December. For the rural farming communities, this will mean their crop is not destroyed with the floods and that they will be able to extent and manage better the second cropping season. For the commercial fishers, the early floods will enhance shrimp production.

Fisheries resources: Fishery surveys to estimate the stock of fish for the Zambezi Delta are required. The surveys will enable the establishment with some level of accuracy, (i) the stock of fish on the flood plains, (ii) and the harvest rates for the fish for the sustainable utilization of fish resources by the rural communities. In almost all the communities, it seems fishing regulations in terms of timing of fishing and fishing gear are not being enforced or followed. Community-based fisheries management institutions may need to be put in place for the improved management of the fisheries.

Agriculture: For purposes of evaluating the value of agriculture for the Zambezi Delta, monitoring data is required on the actual measurement of cropped areas and crop yields (through crop-cutting experiments). From the study, there seems to be extensive intercropping. The extent and value of inter-cropping was not adequately captured by this study.

Firewood use: Firewood use seems to be at least twice the requirements elsewhere in Mozambique and Africa. Thus some firewood use surveys involved actual wood harvesting and utilization is required. If the level of firewood use as reported here is correct, then firewood saving technologies may be needed. For these to be adopted, they will need to be developed in collaboration with the rural households.

Charcoal making: The level of charcoal making in the Zambezi Delta does not seem to be extensive. However, further studies similar to the one by Herd (2007) are required to assess the efficiency of rural households in burning charcoal. Extension on the improved technicalities for charcoal burning may be required. More importantly, there may be need to promote, either (i) woodlot development targeted at charcoal burning, or (ii) improved management of the current natural forest resources jointly by the rural communities and coutada or timber concessionaires for charcoal burning. Given the experiences from TCT, communities could be involved in raising and managing nurseries of indigenous timber species for re-planting in the natural forests or they could be involved in managing natural vegetative re-growths.

Timber and non-timber forest products: For the sustainable utilization of timber resources, there may be need to have all the commercial concessionaires to register for FSC for sustainable harvesting of forestry resources. Timber harvesting permits would only then be renewed for those operating within the sustainable management regulations.

Carbon Sequestration: Projects and sub-projects may be initiated, especially with the rural communities, to participate in carbon credits trading. A Delta-wide program that would involve both coutada operators and timber concessionaires can also be initiated so that these can also start benefiting from the carbon sequestration potential of the Delta. Such an initiative would also go a long way in ensuring the sustainable utilization of the forest and flood plain resources and habitats.

Future valuation studies: The following needs to be considered in future valuation studies for the Zambezi Delta:

i. Valuation of wild vegetables and medicinal plants for the rural households;
ii. Valuation of the Marromeu Complex Game Reserve;
iii. Determining the indirect use values derived from:
    a. the microclimatic stabilization of the wetlands; and
    b. the value of mangroves in shoreline stabilization; as habitat for shrimp production, and other functions.
iv. Estimating the economic impact and value of natural resources of the Zambezi Delta under different river flow regimes, some of which take into account the preferences of smallholder farmers as well as commercial fishers as noted above. Making these impact and values explicit will be a necessary input into informed decision making and also provide leverage to engage in relevant political fora in an effort to assess the benefits accruing to different stakeholders deriving from changes in river flow management.

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APPENDICES

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APPENDIX 1: TERMS OF REFERENCE

I. Background

The Delta of the Zambezi River is an extensive swamp that forms a triangle of around 12,000 Km^2. It starts in the confluence of the Zambezi and Shire rivers and extends 120 Km down to the Indian Ocean. It also extends 200 Km along the coastline, from the Cuacua River, in Zambeze Province, down to the Zuni River delta, in Sofala Province. To the north-west, the Delta is limited by the Morrumbala escarpment while at South it includes the extensive Cheringoma escarpment. To the south-east, the Delta includes the Marromeu sugar plantations and two Forest Reserves – Nhampakué and Inhamitanga. The southern part of the Delta is mostly made of the "Marromeu Complex", a 6,880 Km^2 Ramsar site that includes the Special Buffalo Reserve of Marromeu, the Coutadas (Hunting Blocks) 10, 11, 12 and 14, and half of the Cheringoma escarpment.

The fact that the Delta is rich in biodiversity, with natural resources abundance, private sector investment, local communities and many other exciting characteristics, attracts concerns about its management. It was in this perspective that the Lower Zambezi Project was designed with the aim to benefit local communities and industries from an integrated management plan of the area and improved water management of the Zambezi River, hence contributing for development and sustainable use of natural resources in the Delta. To attain this, project activities will (i) focus on gathering and compiling necessary information which will support lobbying to change of the Zambezi River Flows regime and (ii) promote activities and partnerships to improve the livelihoods of local people.

II. Terms of Reference

Altering the management regime of water resources in the Zambezi river basin will evidently have direct economic impacts, as many people in the basin depend on the ecosystem services provided for subsistence or economic activities and growth rely on the availability of natural resources. Although such economic impacts will be felt locally initially, they will spread to a much larger area or trigger other economic effects or even affect entire sectors. Making the economic impact of the (any) river flow regime explicit is not only a necessity for input in decision making processes, but will also provide for leverage to engage in relevant political fora.

It is assumed by several NGO's that the prevailing controlled water flows on Zambezi River (driven by mono-function use of the dam for hydropower) have negative impacts on the ecosystem services the basin can provide and the subsequent socio-economic development perspectives for the people downstream Cahora Bassa. However, the extent of the impacts in economic terms is still unknown.

Objective

This **objective** of this assignment will be to *attribute an economic value to the good and services in the Zambezi Delta under prevailing water management regime*. The outcome of the assignment will serve as a baseline on what is the present economic (not necessarily monetary) value of goods and services and future studies on alternative natural resources management options in the Delta.

Accounting of Economic Values

It is expected that the study will provide a full accounting, to the extent possible, of the **principal economic values** associated with the Zambezi Delta and adjacent habitats in the study area. We assume that the applied valuation approach will be derived from the Total Economic Value (TEV) approach that includes all major goods and services. These include ones that are easily valued using quantities and market prices (e.g. fish, agricultural and recreational uses) and ones that are more difficult to value (e.g. ecosystem services and cultural roles). The TEV approach explicitly acknowledges the role of direct use benefits (both consumptive and non-consumptive) and non-use benefits (including option values, bequest values, and existence values).

Due to the nature of the Linking Futures program the to analyse 'good and services' or 'functions' need to – at least – be related to environmental flows on the one hand (functions impacted by altering river regimes) and livelihoods on the other hand. It is proposed to derive functions from the function categories as identified under the DRIFT model. Furthermore, small-holder agriculture (rain fed and irrigated) and fisheries should receive careful attention due to their direct relation with subsistence. .

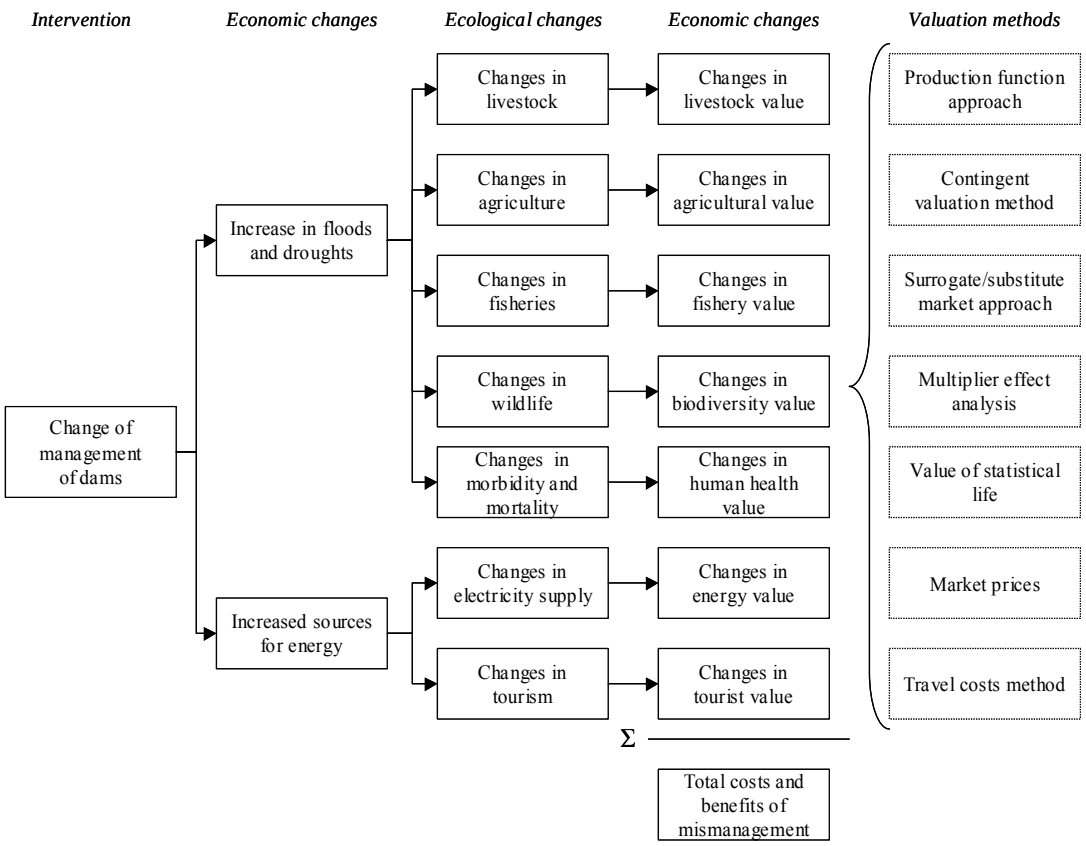
Concerning 'use values' and 'non-use values' it is expected that all important 'use values' are analysed on their economic benefits. It is acknowledged that valuation on 'non-use values' is a major challenge given the available time frame and the fact that many 'non-use values' are located more upstream. Although these values can probably not be extensively analysed, it is expected to receive a first indication of 'non-use values' and recommendations concerning future analysis. Analysis needs to be most of all practical applicable in project implementation terms. The following suggestions are therefore made as to find a practical approach (concerning or as alternative) to valuating complicated 'non-use values':

- ⇒ Visualisation of the **location** of (use value) benefits to get an impression of the distribution of benefits within rural versus urban areas.
- ⇒ Visualisation of distribution of benefits concerning different **stakeholders**.
- ⇒ The two analyses above could serve as practical tool to discuss wealth distribution issues in the context of livelihoods and development.
- ⇒ Consider to approach indirect effects (social and cultural, like social coherencies or health) via impact on the transport sector or impact on migration patterns.

In conclusion, the study will focus on the geographical confined **Lower Zambezi** area and on the **present** economic benefits. In the light of the above, the specific objective for the study will be to *determine the annual*[8] *economic (not necessarily monetary) benefits of functions in the Lower Zambezi Delta by implementing a TEV derived and local applicable approach*.

It is **not expected** that the study will deal with impacts of different environmental flow options! The study will focus on the present situation. Economic valuation of environmental flow option will be subject of future research if relevant.

[8] Annual could be interpreted as year 2007



III. Tasks

The consultant will work with the Lower Zambezi team both in the field and in the office. To achieve the objective the following tasks are considered necessary:

1. Review the existing biophysical and socio-economic studies as well as the project area and provide concise summary
2. Agree with project team upon functions to be analysed on their economic benefits (see discussion above)
3. Propose methods/techniques to valuate specific functions (use value and non-use value) to the project team for approval (including data collection and survey technique if relevant),
4. Identify and gather all necessary instruments and means for the economic valuation of natural resources
5. Collect and analyse all relevant information for the economic valuation using the approved methods/techniques,
6. Participate in debates about the economic value of the natural resources in the Delta and related workshops
7. Prepare and compile a data-base of the economic scientific data produced and available for the project area
8. Present recommendation concerning future economic valuation of functions in the Zambezi **basin** and specifically concerning project implementation issues.
9. Present draft and final version of the report and recommendations to the project team and possible invited partners for in depth discussion with experts.

IV. Expected Output

The consultancy should produce a good quality report titled “Economic Valuation of the Lower Zambezi delta and Associated Natural Resources under prevailing natural resources management conditions”.

Tentative Table of Contents

Executive summary
1. Introduction
2. Economic Valuation
3. Water supply
4. Fishery
5. Flood and drought prevention
6. (Small-holder) Agriculture
7. Hydro-electricity
8. Eco-tourism
9. Biodiversity
10. Carbon Sequestration
11. Non-timber forest products
12. Timber
13. Generic results
14. Summary and conclusions

References

V. Timeframe
Report to be submitted within two months

VI. Other conditions

1. WWF will have full ownership of all data and other information collected
2. Software used will be made available to WWF in good working order
3. Other conditions are stated in the contract.

APPENDIX 2: ACTIVITY SCHEDULE, LOWER ZAMBEZI VALUATION STUDY

MONTH	DAY	DATE	ACTIVITY
APRIL	WED	30	Travel to Beira
MAY	THUR	1	Logistics meetings with WWF
	FRI	2	Designing data collection instruments
	SAT	3	Designing data collection instruments
	SUN	4	
	MON	5	Enumerator training
	TUE	6	Enumerator training
	WED	7	Travel to Marromeu - Courtesy Call Cheringoma DA - Courtesy Call Marromeu DA
	THUR	8	Visit to Sena Sugar
			Data Collection (DC) Chueza
	FRI	9	DC Megugune
	SAT	10	DC Safrik (Coutada Community)
			Coutada operator meeting
	SUN	11	Consultants travel to Beira
	MON	12	DC Salone
	TUE	13	Chiburiburi
	WED	14	DC Cine
	THUR	15	DC Coutada 12 Community
	FRI	16	Mozambque Regional Natural Disaster Coord. Center (Caia)
			Gora
	SAT	17	Mponda
	SUN	18	Daniel and Danny Travel to Beira
	MON	19	TCT - forestry concession operator (Caia)
	TUE	20	DC Chirimadzi
	WED	21	DC Caia Main Road Community
	THUR	22	DC Matondo
	FRI	23	DC Guma
	SAT	24	Team Travels to Beira
	SUN	25	
	MON	26	Household Survey Data Entry (DE)
	TUE	27	DE
	WED	28	DE
	THUR	29	DE
	FRI	30	DE
	SAT	31	DE

MONTH	DAY	DATE	ACTIVITY
JUNE	SUN	1	DE
	MON	2	DE
	TUE	3	DE
	WED	4	DE
	THUR	5	DE
	FRI	6	DE
	SAT	7	
	SUN	8	Consultants travel from Harare to Beira
	MON	9	Data Analysis and Write-up
	TUE	10	Data Analysis and Write-up
	WED	11	Data Analysis and Draft Report Write-up
	THUR	12	" " " "
	FRI	13	" " " "
	SAT	14	" " " "
	SUN	15	" " " "
	MON	16	" " " "
	TUE	17	" " " "
	WED	18	" " " "
	THUR	19	" " " "
	FRI	20	" " " "
	SAT	21	" " " "
	SUN	22	Consultants leave for Harare
	MON	23	Report finalization
	TUE	24	" " "
	WED	25	" " "
	THUR	26	" " "
	FRI	27	" " "
	SAT	28	" " "
	SUN	29	
	MON	30	Submit report

APPENDIX 3: VALUATION STUDY CHECKLISTS & QUESTIONNAIRES

Appendix 3.1.1: Community Group Discussion Semi-Structured Questionnaire – English Version

WWF

COMMUNITY GROUP DISCUSSION SEMI-STRUCTURED QUESTIONNAIRE

All questions to be discussed in group discussions. The group will have an overall introduction and first discussion. After first 30 – 45 minutes group divided into 3 plus groups (depending on attendance) to discuss several aspects by age group or by gender or by specialty.

Date of group meeting: _____/_____/2008 District: _____

Zone: **0.** Lowland ☐ **1.** Upland ☐

Community: **0.** Coutada ☐ **1.** Non-Coutada ☐

TOTAL NUMBER OF PARTICIPANTS: _____

GROUP ALLOCATION:

Themes	Group Coordinator	Number of participants
Agriculture		
Fisheries		
Livestock		
Wildlife		
Waterbirds		
Fruits and plants for food and medicine		
Fuelwood		
Charcoal		
Building material		
Water supply		
Mangroves		

1. AGRICULTURE

Community:_____

1.1 With respect to a **normal** **drought** **flood** season, what is the area under crops for a typical household in this community?
What is your total production for each crop?
What is the proportion of crops produced that is sold?

		Main Season (Oct. – Jan.)			Dry Season (April – Jun)		
CROP	**SPECIFY UNIT**	**Area Cultivated (ha/acres/ plots)**	**Quantity Produced**	**Sales (Kg)**	**Area Cultivated (ha/acres/ plots)**	**Quantity Produced**	**Sales (Kg)**
Maize							
Sorghum							
Millets							
Rice							
Cotton							
Cow peas							
Sweet potato							
Cassava							
Vegetables							
Sugarcane							
Tobacco							
Fruits							
Other (specify)							

1.2 On the use of chemicals and fertilizers:

_____

_____

1.3 On the technique utilized to clear land:

_____

_____

1.4 On the use of irrigation:

_____

_____

1.5 On the difference between "upland" and "floodplain" for crop production:

_____

_____

1.6 What is the average area of agricultural land that is abandoned due to reduced flooding (specify unit)?

_____

_____

1.7 On the possible increase in the area suitable for rice production given flood events:

_____

_____

1.8 What are the market outlets for the different agriculture products?

For each market what are the prices?

CROP	Markets						
	Local Village	**Marromeu**	**Caia**	**Inhamitanda**	**Dondo**	**Beira**	**Other**
Maize							
Sorghum							
Millets							
Rice							
Cotton							
Cow peas							
Sweet potato							
Cassava							
Vegetables							
Sugarcane							
Tobacco							
Fruits							
Other (specify)							

1.9 What is the potential area available for agricultural activities during normal, drought, and flood seasons?

Type of Year / Season	**Main Season (Oct. – Jan.)**	**Dry Season (April – Jun)**
Normal year		
Drought year		
Flood year		

Other observations:

_____
_____
_____
_____
_____
_____
_____

2. FISHERIES

Community:_____

2.1 How many species of fish occur in this area? (List the species).
Which species are no longer present in this area?
Approximately, when did you last see the species?
What is relative abundance of each species over time?
What is your perception of the size of fish species captured over time?

Fish Species	**Indicate with "Y" if species is no longer seen**	**When species was last seen (year)**	**Relative abundance** **1. Decreasing** **2. No Change** **3. Increasing**	**Size of fish** **1. Decreasing** **2. No Change** **3. Increasing**

2.2 What is the average fish catch per day/night during normal, drought, or flood year types per person (kg)?
Approximately what is the quantity of the daily catch that is sold (kg)?

Months	**Number of days per month**	**How many hours are spent per day**	**Normal**		**Drought**		**Flood**	
			Catch	**Sales**	**Catch**	**Sales**	**Catch**	**Sales**
January								
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
December								

2.3 On the kind of fish sold, if its dry, smoked or salted:

_____

_____

2.3 On average, how many people go to fish per household each fishing day? _____

2.4 What is the local price of fish per Kg? _____ Metical

2.5 On the breeding grounds conservation status:

2.6 On the awareness that breeding sites are more productive by flooding events:

2.7 Are there rules and regulations for fish harvesting?
To what extent do communities comply with the rules and regulations?

Rule / regulation	**Yes**	**No**	**Where**	**Extent of compliance**				
				Very low	**Low**	**Fair**	**High**	**Very high**
Fishing months								
Fishing gear								
Others (specify)								

2.8 On the willingness to pay for flood release to avoid further loss of a fish species (Current and Future use):

Other observations:

3. LIVESTOCK

Community:_____

3.1 For a typical household, which livestock do you keep? Do you consume some of your livestock? If yes, how many did you sell and what is the total income you obtain for each livestock type?

Livestock Type	No. Owned	Number consumed past 12 months	Do you sell?	Number sold past 12 months	Estimated total income realized past 12 months (Mtn)
Cattle					
Donkey					
Sheep					
Goat					
Pigs					
Chicken					
Other (*specify*)					

3.2 On the production and sale of milk and eggs:

_____

_____

3.2 For your cattle, provide the following information regarding livestock type:

Season	No. owned today	No. of bulls (> 3 years)	Number of cows (> 3 years)	No. of cows in calf	Number of Steers (1 – 3 years	Number of heifers (1 – 3 years)	No. male calves	No. female calves	No. male calves died past 12 months	No. female calves died past 12 months	No. adult cattle died past 12 months
Normal											
Drought											
Flood											

3.3 For your sheep and goats provide the following information:

Season	No. owned	No. females	No. of females with lamb/kid	No. males	No. male lambs/kids	No. female lambs/kids	No. kids died past 12 Months	No. adult animals died past 12 months
Normal								
Drought								
Flood								

3.4 What is the average travel time to taken to obtain grazing for livestock during different seasons?

Season (within a year)	**Dry season**	**Wet Season**
Normal		
Drought		
Flood		

3.5 What is the average monthly costs on vet medicines / services for your grazing / browsing livestock during different seasons?

Season (within a year)	**Dry season**	**Wet Season**
Normal		
Drought		
Flood		

4. WILDLIFE Community: _____

4.1 How many species of wild animals occur in this area? (List the species).
Which species are no longer present in this area?
Approximately, when did you last see the species?
What is relative abundance of each species over time?
Rank the relative species as source of meat for the community, with 1 = most important.

Wild Animal Species	Indicate with "Y" if species is no longer seen	When species was last seen (year)	Relative abundance 1. Decreasing 2. No Change 3. Increasing	Relative Importance for meat (1 is most important)

4.2 On the willingness to pay to avoid the loss of wildlife species (Current and Future use):

_____

_____

4.3 For a household that hunts wildlife what is the average number of animals caught per month (across all species)?
How many of these animals are consumed by the household (the rest not consumed are sold)?
What is the total income realized from the monthly sales of the wildlife?

Month	Normal			Drought			Flood		
	No. Catch	No. Consumption	Income (Mtn)	No. Catch	No. Consumption	Income (Mtn)	No. Catch	No. Consumption	Income (Mtn)
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

4.4 On the outlet market for game meat or parts (local vs. external):

_____

_____

4.5 On hunting sites:

_____

4.6 On average, how many days per month are spent hunting _____
And number of people involved _____

4.7 On average, how many days per month do hunters go to hunt bush meat?

Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal												
Drought												
Flood												

4.8 On the investment needed in hunting gear (guns, traps):

_____

_____

4.9 On the breeding grounds conservation status

_____

_____

4.10 Are there rules and regulations for bush meat hunting?
To what extent do communities comply with the rules and regulations?

Rule / regulation	Yes	No	Where	Extent of compliance				
				Very low	Low	Fair	High	Very high
Hunting months								
Hunting gear								
Others (specify)								

4.11 On who is benefitting from subsistence hunting (distributional issues):

_____

_____

Other observations:

_____

_____

_____

_____

_____

_____

_____

5. WATERBIRDS Community:_____

5.1 How many species of wild birds occur in this area? (List the species).
Which species are no longer present in this area?
Approximately, when did you last see the species?
What is relative abundance of each species over time?
Rank the relative species as source of meat for the community, with 1 = most important.

Waterbird Species	**Indicate with "Y" if species is no longer seen**	**When species was last seen (year)**	**Relative abundance 1. Decreasing 2. No Change 3. Increasing**	**Relative Importance for meat (1 is most important)**

5.2 On the willingness to pay to avoid the loss of waterbird species (Current and Future use):

_____

_____

5.3 For a household that hunts wildbirds, what is the average number of animals caught per month (across all species)?
How many of these animals are consumed by the household (the rest not consumed are sold)?
What is the total income realized from the monthly sales of the wildlife?

Month	**Normal**			**Drought**			**Flood**		
	No. Catch	**No. Consumption**	**Income (Mtn)**	**No. Catch**	**No. Consumption**	**Income (Mtn)**	**No. Catch**	**No. Consumption**	**Income (Mtn)**
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

5.4 On the outlet market for bird meat or parts (local vs. external):

_____

_____

5.5 On hunting sites:

_____

5.6 On average, how many days per month are spent hunting birds _____
And number of people involved _____

5.7 On average, how many days per month do hunters go to hunt waterbird meat?

Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal												
Drought												
Flood												

5.8 On the investment needed in hunting gear (guns, traps):

_____

_____

5.9 On the breeding grounds conservation status

_____

_____

5.10 Are there rules and regulations for waterbird hunting?
To what extent do communities comply with the rules and regulations?

Rule / regulation	Yes	No	Where	Extent of compliance				
				Very low	Low	Fair	High	Very high
Hunting months								
Hunting gear								
Others (specify)								

5.11 On who is benefitting from subsistence waterbird hunting (distributional issues):

_____

_____

Other observations:

_____

_____

_____

_____

_____

_____

_____

6. FRUITS AND PLANTS FOR FOOD AND MEDICINE Community:_____

6.1 How many fruit tree species and other non-timber forest products occur in this area?
Which fruit tree species and other NTFPs are no longer available in this area?
Approximately, when did you last see the fruit tree species and NTFPs?
What is relative abundance of each fruit tree species and NTFPs over time?

Fruit Tree Species	**Indicate with "Y" if species/NTFP is no longer seen**	**When species/NTFP was last seen (year)**	**Relative abundance 1. Decreasing 2. No Change 3. Increasing**
NTFPs			

6.2 On the willingness to pay to avoid the loss of fruit tree species (Current and Future use):

_____

_____

6.3 On the willingness to pay to avoid the loss of NTFP (Current and Future use):

_____

_____

6.4 For a household that collects fruits and other NTFPs what is the estimated amounts collected per month (across all species)?
Of the collected amounts, what amounts are consumed by the household (the rest not consumed are sold)?
What is the total income realized from the monthly sales of the wild fruits and NTFPs?

Month	**Normal**			**Drought**			**Flood**		
	Amount collected	**Amount consumed**	**Income (Mtn)**	**Amount collected**	**Amount consumed**	**Income (Mtn)**	**Amount collected**	**Amount consumed**	**Income (Mtn)**
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

6.5 On the outlet market for fruits and NTFP (local vs. external):

_____

_____

6.6 On average, how many people go fetch wild fruits and NTFPs each day? _____

6.7 On average, how many days per month do the average household collect wild fruits and NTFPs?

On average how many hours per day are spent gathering fruit trees or/and NTFPs?

	Season	Normal		Drought		Flood	
Month	**Resource**	**Fruits**	**NTFPS**	**Fruits**	**NTFPS**	**Fruits**	**NTFPS**
Jan	**Days**						
	Hrs/day						
Feb	**Days**						
	Hrs/day						
Mar	**Days**						
	Hrs/day						
Apr	**Days**						
	Hrs/day						
May	**Days**						
	Hrs/day						
Jun	**Days**						
	Hrs/day						
Jul	**Days**						
	Hrs/day						
Aug	**Days**						
	Hrs/day						
Sep	**Days**						
	Hrs/day						
Oct	**Days**						
	Hrs/day						
Nov	**Days**						
	Hrs/day						
Dec	**Days**						
	Hrs/day						

6.8 Are there rules and regulations for fruit and NTFP collection?
To what extent do communities comply with the rules and regulations?

Rule / regulation	**Yes**	**No**	**Where**	**Extent of compliance**				
				Very low	**Low**	**Fair**	**High**	**Very high**
Fruit collection								
NTFP								
Others (specify)								

Other observations:

_____
_____
_____

7. FUELWOOD

Community:_____

7.1 On the burning of pottery – who burns them?

_____

7.2 On the burning of bricks – who burns them?

_____

7.3 On the extent that fuel wood comes from adjacent to the river vs surrounding hill sides (uplands):

_____

7.4 What are the sources of fuelwood for cooking & heating, burning pottery, and burning bricks?

Cooking and heating	0.. Flood plain / adjacent to river	☐	1.. Upland/hillside	☐
Burning pottery	0.. Flood plain / adjacent to river	☐	1.. Upland/hillside	☐
Burning bricks	0.. Flood plain / adjacent to river	☐	1.. Upland/hillside	☐

7.5 Which tree species do you use as fire wood for cooking, heating, burning pottery, and burning bricks?
Rank the tree species in terms of preference of wood quality for firewood with 1 being the most preferred tree species. What is your perception of the state of the fire wood species?

Tree Species Used for Fire Wood	**Rank species for:**			**Perception of the state of the fire wood species**		
	Cooking & heating	**Burning pottery**	**Burning Bricks**	**Highly depleted**	**Moderately depleted**	**Not depleted**
1.						
2.						
3.						
4.						

7.6 Provide the following information for fuelwood collection for heating and cooking per month.

Calendar		**Type of Year**		
		Normal	**Drought**	**Flood**
Wet season (indicate months)	Headlots Collected per month			
	Number of trips for wood collection per month			
	Walking time to collect firewood per trip			
	Time taken to collect fire wood per trip			
Dry Season (indicate months)	Headlots Collected per month			
	Number of trips for wood collection per month			
	Walking time to collect firewood per trip			
	Time taken to collect fire wood per trip			
Cool Season (indicate months)	Headlots Collected per month			
	Number of trips for wood collection per month			
	Walking time to collect firewood per trip			
	Time taken to collect fire wood per trip			

7.7 What is the estimate price of selling a headlot of fire wood? _____(Mtn)

7.8 Provide the following information for fuelwood collection for burning pottery per month.

Calendar		Number of months involved in production	**Type of Year**		
			Normal	**Drought**	**Flood**
Wet season (indicate months)	No. of pottery items made per month				
	Number of trips for wood collection per month				
	Walking time to collect firewood per trip				
	Time taken to collect fire wood per trip				
Dry Season (indicate months)	No. of pottery items made per month				
	Number of trips for wood collection per month				
	Walking time to collect firewood per trip				
	Time taken to collect fire wood per trip				
Cool Season (indicate months)	No. of pottery items made per month				
	Number of trips for wood collection per month				
	Walking time to collect firewood per trip				
	Time taken to collect fire wood per trip				

7.9 What is the estimate price of selling a pottery unit? _____(Mtn)

7.10 Provide the following information for fuelwood collection for burning bricks per month.

Calendar		Number of months involved in production	**Type of Year**		
			Normal	**Drought**	**Flood**
Wet season (indicate months)	No. of bricks made per month				
	Number of trips for wood collection per month				
	Walking time to collect firewood per trip				
	Time taken to collect fire wood per trip				
Dry Season (indicate months)	No. of bricks made per month				
	Number of trips for wood collection per month				
	Walking time to collect firewood per trip				
	Time taken to collect fire wood per trip				
Cool Season (indicate months)	No. of bricks made per month				
	Number of trips for wood collection per month				
	Walking time to collect firewood per trip				
	Time taken to collect fire wood per trip				

7.11 What is the estimate price of selling 1 000 bricks? _____(Mtn)

7.12 Who is buying bricks? What is the demand of bricks like?

_____

_____

8. CHARCOAL

Community:_____

8.1 What are the sources of fuelwood for burning charcoal?

0.. Flood plain / adjacent to river ☐ 1.. Upland/hillside ☐

8.2 Which tree species do you use for burning charcoal?
Rank the tree species in terms of preference of wood quality for firewood with 1 being the most preferred tree species.
What is your perception of the state of the fire wood species?

Tree Species Used for Burning Charcoal	Rank	Perception of the state of the fire wood species		
		Highly depleted	Moderately depleted	Not depleted
1.				
2.				
3.				
4.				

8.3 Provide the following information for burning charcoal per month.

Calendar		Type of Year		
		Normal	Drought	Flood
Wet season (indicate months)	Bags of charcoal produced per month			
	Hours per month cutting wood			
	Hours per month making oven			
	Hours per month packing charcoal			
Dry Season (indicate months)	Bags of charcoal produced per month			
	Hours per month cutting wood			
	Hours per month making oven			
	Hours per month packing charcoal			
Cool Season (indicate months)	Bags of charcoal produced per month			
	Hours per month cutting wood			
	Hours per month making oven			
	Hours per month packing charcoal			

8.4 What is the local wage rate for a day's work per person? _____ (Mtn)

8.5 What is the cost per empty bag used for packaging charcoal? _____ (Mtn)

8.6 What is the estimate price of selling a bag of charcoal locally? (Mtn)

Wet Season ☐

Cool Season ☐

Dry Season ☐

8.7 Besides the local market, what are the market outlets for charcoal?
What is the price of charcoal per bag per market outlet?

Market Outlet	Price per charcoal bag (Mtn)		
	Wet season	Dry season	Cool season

8.8 On the value chain of charcoal:

_____
_____

Other observations:

_____
_____
_____
_____
_____
_____

9. BUILDING MATERIALS

Community:_____

9.1 Which tree species do you use for burning charcoal?

Rank the tree species in terms of preference of wood quality for firewood with 1 being the most preferred tree species. What is your perception of the state of the fire wood species?

Resources used for hut / house construction	**Source** **0.** Flood plain / adjacent to river **1.** Upland/hillside	**Perception of the state of the house hut construction resources**		
		Highly depleted	**Moderately depleted**	**Not depleted**
1. Stake or Cane				
2. Mitete wood				
3. Mangrooves				
4. Grass				
5. Palm leaves				
6.				
7.				
8.				
9.				
10.				

9.2 What is the average number of huts per households? _____

9.3 What is the frequency of construction of new huts per household?

Frequency	No. of huts
Every 6 months	
Every year	
Every 2 years	

9.4 Provide the following information for each of the building materials, for the construction of an average hut.

Season	**Normal**		**Drought**		**Flood**	
Resource	**Travel time to harvest resource (min)**	**Time taken to harvest resource (hours)**	**Travel time to harvest resource (min)**	**Time taken to harvest resource (hours)**	**Travel time to harvest resource (min)**	**Time taken to harvest resource (hours)**
1. Stake or Cane						
2. Mitete wood						
3.. Mangrooves						
1. Grass						
2. Palm leaves						

Other observations:

_____

_____

10. WATER SUPPLY

Community:_____

10.1 Water demand and supply, and valuation of water supply

	Drought Year		Normal Year		Flood Year	
	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
How many buckets of water do you fetch per day for drinking?						
Source of drinking water 1. Community Well 2. Borehole 3. River						
Distance to drinking water source/time taken per trip						
How many buckets of water do you fetcher per day for washing and bathing?						
Source of washing water 1. Community Well 2. Borehole 3. River						
Distance to washing water source/time taken per trip						
How much area can you potentially put under irrigation?						
What crop is usually put under irrigation?						

Other observations:

_____

_____

COMMUNITY CHARACTERISTICS FOR VALUATION

What is your perception of the extent of natural resources availability during the following periods – normal year, drought year or flood year? (*Tick relevant*)

Resource	**Normal Season**			**Drought Season**			**Flood Season**		
	S	M	A	S	M	A	S	M	A
Fish									
Prawns / shrimps									
Fuelwood									
Charcoal									
Grazing									
Wildlife									
Birds									
Fruits									
Wild vegetables									
Medicinal plants									
Clean and safe water									
Mangroves									
Building materials									

Key: S – Scarce M – medium A – readily available

What is your perception of the distances you travel to harvest natural resources during normal, drought, and flood seasons?

Resource	**Normal Season**					**Drought Season**					**Flood Season**				
	VF	**F**	**M**	**N**	**VN**	**VF**	**F**	**M**	**N**	**VN**	**VF**	**F**	**M**	**N**	**VN**
Fish															
Prawns / shrimps															
Fuelwood															
Charcoal															
Grazing															
Wildlife															
Birds															
Fruits															
Wild vegetables															
Medicinal plants															
Clean and safe water															
Mangroves															
Building materials															

What is your perceived extent of food security (number or percent households) in community during normal, drought, or flood periods?

_____

_____

NORMAL SEASON

None				Medium				Very High

DROUGHT SEASON

None				Medium				Very High

FLOOD SEASON

None				Medium				Very High

What is the perceived distance to the following community infrastructure / amenities?

Infrastructure	**Very Far**	**Far**	**Medium**	**Near**	**Very near**
Roads					
Shops					
Health center (Clinic / hospital)					
Grinding mill					
Post office					
Electricity					
Piped water					
Banks					
Employment					

Appendix 3.1.2: Community Group Discussion Semi-Structured Questionnaire – Portuguese Version

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DISCUSSÃO COMMUNITARIA EM GRUPOS

Todas as questões serão discutidas em grupos. Os grupos terão uma introdução ao projecto e seus objectivos, seguidos por discussões em grupo. Depois de 30-45 minutos o grupo será dividido em 3 ou mais subgrupos (dependendo do atendimento) para discutir vários aspectos conforme idade, sexo ou área de especialidade.

Data do encontro: _____/_____/2008 Distrito: _____

Zona: **0.** Baixa ☐ **1.** Alta ☐

Comunidade: **0.** Coutada ☐ 1. Não-Coutada ☐ **2.** Concessão florestal ☐

NUMERO TOTAL DE PARTICIPANTES: _____

ALLOCACAO DOS SUBGRUPOS:

No.	Tema	Coordenador do subgrupo	Número de participantes
1	Agricultura		
2	Pesca		
3	Animais de criação		
4	Animais Selvagens		
5	Aves Selvagens		
6	Frutas selvagens e plantas selvagens para consumo ou uso medicinal		
7	Lenha		
8	Carvão		
9	Material para construção		
10	Agua		
11	Mangal		

PERGUNTAS PARA AQUECIMENTO (depois de termos nos apresentado e explicado a razão do estudo)

Qual a percepção do nível de segurança em relação a comida durante anos normais, anos de enchentes e anos de seca?

ANO NORMAL

Nenhum				Médio				Alto

ANO DE SECA

Nenhum				Médio				Alto

ANO DE CHEIAS

Nenhum				Médio				Alto

Quais são os principais métodos de adaptação às enchentes?

_____

_____

Qual é a distancia percebida da comunidade até os seguintes lugares?

Infra-estrutura	**Muito longe**	**Longe**	**Médio**	**Perto**	**Muito perto**
Estradas					
Lojas					
Clínica / Hospital					
Moinho					
Posto de correio					
Acesso a electricidade					
Agua canalizada					
Banco					
Trabalho (formal)					

1. AGRICULTRURA

Comunidade:_____

1.1 Considerando-se anos normais, de cheia (ex. 2001) e de seca (ex. 1992), qual é a área que tem-se plantada? Qual é a produção total para cada tipo de cultura? Qual é a proporção da produção que é vendida?

TIPO DE CULTURA		Unidades		Período das Chuvas (Out. – Jan.)						Período da Seca (Abril – Julho)					
				Área Cultivada			Produção			Área Cultivada			Produção		
	0. Não 1. Sim	Área	Produção	Normal	Cheia	Seca	Normal	Cheia	Seca	Normal	Cheia	Seca	Normal	Cheia	Seca
Milho															
Mapira															
Sorghum															
Arroz															
Mandioca															
Feijão Nhemba															
Batata doce															
Machoeira															
Gergelim															
Verduras															
Cana-de-açúcar															
Tabaco															
Algodão															
Frutas (# de arvores)															
Outros															

1.2 Sobre o uso de adubos (químicos ou orgânicos):

_____

_____

1.3 Sobre o método mais utilizado para preparar a terra:

_____

_____

1.4 Sobre o use de irrigação:

_____

_____

1.5 Sobre a diferença entre machambas altas ou baixas para a produção de plantas agrícolas:

_____

_____

1.6 Qual é a área agrícola (média) abandonada devido às faltas de cheias (especificar unidade)?

_____

_____

1.7 Sobre o possível aumento de áreas boas para plantar arroz caso as enchentes fossem mais frequentes (anuais):

_____

_____

1.8 Quais são os mercados para a venda de produtos agrícolas?
Para cada mercado quais são os preços?

TIPO DE CULTURA	**MERCADO**						
	Mercado local	**Marrome u**	**Caia**	**Inhamita nda**	**Dondo**	**Beira**	**Outro**
Milho							
Mapira							
Sorghum							
Arroz							
Mandioca							
Feijão Nhemba							
Batata Doce							
Machoeira							
Gergelim							
Verduras							
Cana-de-açúcar							
Tabaco							
Algodão							
Árvores de Fruta							
Outros							

1.9 Qual a potencial área disponível para actividades agrícolas durante um ano normal, de seca, e de cheia?

Tipo de ano / Período do ano	Período das chuvas (Out. – Jan.)	Período da seca (Abril – Jun)
Ano Normal		
Ano Seco		
Ano de Enchentes		

Outras observações:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

2. PESCA

Comunidade:_____

2.1 Quantas espécies de peixe se encontra nesta área? (Listar as espécies).
Quais espécies já não se encontram mais nesta área?
Mais ou menos, quando foi a última vez que viu a espécie?
Qual é a abundância relativa de cada espécie ao passar o tempo?
Qual a sua percepção do tamanho dos peixes ao passar o tempo?

ESPECIE DE PEIXE	**Indique com Y se a espécie já não é mais encontrado aqui**	**Ultima vez que foi visto a espécie (ano)**	**Abundância relativa 1.Diminuindo 2. Estático 3.Aumentando**	**Tamanho do peixe 1.Diminuindo 2. Estático 3.Aumentando**

2.2 Qual a quantidade media pescado por dia/noite de pesca a respeito um ano normal, seco, e de enchentes por pessoa (Kg)? Na media que quantidade da pesca pescado por dia é vendida (Kg)?

Meses	**Numero de dias por mes**	**Quantas horas por dia se pesca**	**NORMAL**		**SECA**		**ENCHENTE**	
			Quanti. Pescado	**Quanti. Vendida**	**Quanti. Pescado**	**Quanti. Vendida**	**Quanti. Pescado**	**Quanti. Vendida**
Janeiro								
Fevereiro								
Marco								
Abril								
Maio								
Junho								
Julho								
Augusto								
Setembro								
Outubro								
Novembro								
Dezembro								

2.3 Sobre o tipo de peixe vendido (fresco, defumado, seco):

_____

_____

2.3 Na média, quantas pessoas no seu agregado familiar pescam por dia de pesca? _____

2.4 Qual é o preço local de peixe por kilo? _____ Meticais

2.5 Sobre o estado de conservação das áreas de reprodução do peixe:

_____

_____

2.6 Sobre a percepção da comunidade entre as enchentes e a quantidade de peixes pescados a seguir:

_____

_____

2.7 Existe regulamentos e regras de pesca?
Até que ponto são respeitadas as regulações?

Regra/regulamentos	**Sim**	**Não**	**Aonde?**	**Nível de respeito às regras/regulamentos**				
				Muito baixo	**Baixo**	**Razoável**	**Alto**	**Muito alto**
Meses de pesca								
Método de pesca								
Outros (especificar)								

Outras observações:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

3. Animais de Criação

Comunidade:_____

3.1 Quais são os animais que criam? Estes são consumidos/vendidos?
Quantos são consumidos e quantos são vendidos e qual é a renda total por cada tipo de animal?

Tipo de animal	No. possuído	No. consumido nos últimos 12 meses	Você vende?	No. vendido nos últimos 12 meses	Renda total nos últimos 12 meses (Mtn)
Gado					
Galinhas					
Patos					
Pombo					
Ovelha					
Cabrito					
Porcos					
Outros (especificar)					

3.2 Sobre a produção e venda de leite e ovos:

_____

_____

3.2 A respeito dos gados: Provem as seguintes informacoes sobre o tipo de gado:

Tipo de ano	No. possuído hoje	No. de boi (> 3anos)	No. de vacas (> 3 anos)	No. de vacas grávidas ou amamentando	No. de Steers (1 – 3 anos	No. de heifers (1 – 3 anos)	No. de bezerros M	No. de bezerros F	No. de bezerros M faleceram no ultimo ano	No. de bezerros F faleceram no ultimo ano	No. de gado faleceram no ultimo ano
Normal											
Seca											
Enchente											

3.3 A respeito as ovelhas e cabritos, provem as seguintes informacoes:

Tipo de ano	No. possuído	No. fêmeas adultas	No. de fêmeas lamb/kid	No. machos adultos	No. de masculinos lambs/kids	No. kids faleceram no ultimo ano	No. animais adultos faleceram nos ultimo ano
Normal							
Seca							
Enchente							

3.4 Quanto tempo leva na média para encontrar terreno útil para pastagem?

Tipo de ano / Período do ano	Período de seca	Período de chuvas
Normal		
Seca		
Enchente		

3.5 Qual são as despesas na média gasto em veterinário ou remédios para os animais de fazenda durante os tipos de anos e períodos dos anos respectivos?

Tipo de ano / Período do ano	Período de seca	Período de chuvas
Normal		
Seca		
Enchente		

3.6 Se haver uma falta de animais de fazenda disponível para a comunidade, listar a relativa importância das razoes principais:

Possível razão	Importância relativa (1 = mais importante razão)
Falta de acesso aos animais	
Mortalidade devido a doenças	
Preço de animais muito caro	
Outros (especificar)	

Outras observações:

_____
_____
_____
_____
_____
_____
_____
_____
_____

4. Fauna Bravia Comunidade_____

4.1 Quantas espécies de fauna bravia ocorrem nesta área? (Listar espécies).
Quais espécies já não se encontram mais nesta área?
Mais ou menos, quando foi que viu a espécie da ultima vez?
Qual é a abundância relativa de cada espécie ao longo do tempo?
Listar a relativa espécie como fonte de carne para a comunidade com 1 sendo o mais importante

Espécie de Fauna Bravia	**Indique com Y se a espécie já não é mais encontrado aqui**	**Ultima vez que foi visto a espécie (ano)**	**Abundância relativa 1.Diminuindo 2. Estático 3.Aumentando**	**Importância relativa como fonte de carne (1 a mais importante)**

4.2 Para um agregado familiar que caca animais bravias, qual o numero, na media, de animais caçados por mes das três espécies listadas como mais importante acima?
Quantos destes animais caçados são consumidos pelo agregado familiar (não consumido é vendidos)?
Qual é a renda total realizado através das vendas de animais bravias por mês?

Espécies listadas acima	**Período do ano**	**Ano Normal**			**Ano de Seca**			**Ano de Enchente**		
		No. Caçado	**No. Consumido**	**Renda (Mtn)**	**No. Caçado**	**No. Consumido**	**Renda (Mtn)**	**No. Caçado**	**No. Consumido**	**Renda (Mtn)**
1:	Chuvas (Out.-Jan)									
	Secas (Abr-Jun)									
2:	Chuvas (Out.-Jan)									
	Secas (Abr-Jun)									
3:	Chuvas (Out.-Jan)									
	Secas (Abr-Jun)									

4.3 Sobre o Mercado para a venda de animais bravios (local vs. externo):

_____

_____

4.4 Sobre as áreas aonde se pratica caça:

_____

_____

4.5 Na media quantos dias por mês passam caçando animais bravios?

Tipo de ano / Mes	Jan	Fev	Mar	Abr	Maio	Jun	Jul	Ago	Set	Out	Nov	Dez
Ano normal												
Ano de seca												
Ano de enchentes												

4.6 Comportamento da caça:

Quanto tempo o grupo de caca (ou individuo) passa fora caçando?	
Quantas pessoas estão envolvidas na caça?	

4.7 Sobre o investimento em material utilizado para a caça (pistolas, armadilhas, barracas):

_____

_____

4.8 Sobre o estado de conservação das áreas aonde os animais bravios reproduzem?

_____

_____

4.9 Existe regras a regulamentos a respeito da caça de animais bravios?
Ate que ponto são respeitados os regulamentos?

Regra/regulamentos	Sim	Não	Aonde	Nível de respeito as regras/regulamentos				
				Muito baixo	Baixo	Razoável	Alto	Muito alto
Meses de caca								
Material de caça								
Outros (especificar)								

4.10 Sobre quem se beneficia da caça de subsistência (aspecto distributivo):

_____

_____

Outras observações:

_____

_____

_____

_____

_____

_____

_____

5. Aves Bravias Comunidade:_____

5.1 Quantas espécies de aves bravias se encontram nesta área? (Listar as espécies).
Quais espécies já não se encontram mais nesta área?
Mais ou menos, quando foi a última vez que viu a espécie?
Qual é a abundância relativa de cada espécie ao passar o tempo?
Listar as espécies de aves bravias para consumo na comunidade, com 1 sendo o mais importante.

Espécie de aves bravias	**Indique com Y se a espécie já não é mais encontrado aqui**	**Ultima vez que foi visto a espécie (ano)**	**Abundância relativa 1.Diminuindo 2. Estático 3.Aumentando**	**Importância relativa como fonte de carne (1 a mais importante)**

5.2 Para um agregado familiar que caça aves bravias, qual o numero, na media, de aves caçadas por mês das três espécies listadas como mais importante acima?
Quantos destas aves caçadas são consumidos pelo agregado familiar (não consumido é vendidos)?
Qual é a renda total realizado através das vendas de aves bravias por mes?

Espécies listadas acima	**Período do ano**	**Ano Normal**			**Ano de Seca**			**Ano de Enchente**		
		No. Caçado	**No. Consumido**	**Renda (Mtn)**	**No. Caçado**	**No. Consumido**	**Renda (Mtn)**	**No. Caçado**	**No. Consumido**	**Renda (Mtn)**
1:	Chuvas (Out.-Jan)									
	Secas (Abr-Jun)									
2:	Chuvas (Out.-Jan)									
	Secas (Abr-Jun)									
3:	Chuvas (Out.-Jan)									
	Secas (Abr-Jun)									

5.3 Sobre o mercado para a venda de aves bravias (local vs. externo):

_____
_____

5.4 Sobre as áreas aonde caçam:

_____
_____

5.5 Na media quantos dias por mes passam caçando aves bravias?

Tipo do ano / Mes	Jan	Fev	Mar	Abr	Maio	Jun	Jul	Ago	Set	Out	Nov	Dez
Ano normal												
Ano de seca												
Ano de enchentes												

5.6 Comportamento da caça:

Quanto tempo o grupo de caca (ou individual) passa fora caçando?	
Quantas pessoas são envolvidas na caça?	

5.7 Sobre o investimento em material utilizado para caça (armas, armadilhas, barracas):

_____

_____

5.8 Sobre o estado de conservação das áreas aonde os pássaros selvagens reproduzem

_____

_____

5.9 Existem regras e regulamentos a respeito da caca de aves bravias?
Ate que ponto são respeitados os regulamentos?

Regra/regulamentos	Sim	Não	Aonde	Nível de respeito as regras/regulamentos				
				Muito baixo	Baixo	Razoável	Alto	Muito alto
Meses de caca								
Método de caça								
Outros (especificar)								

5.10 Sobre o assunto de quem se beneficia da caça de subsistência (aspecto distributivo):

_____

_____

Outras observações:

_____

_____

_____

_____

_____

_____

_____

_____

6. FRUTAS SELVAGEMS & PLATAS PARA COMIDA E MEDICINAIS

Comunidade:_____

6.1 Quantas espécies de frutas selvagens e produtos florestais não madeira (PFNM) tem na área?
Quais espécies já não se encontram mais nesta área?
Mais ou menos, quando foi a última vez que viu a espécie?
Qual é a abundância relativa de cada espécie ao passar o tempo?
Listar as espécies para consumo na comunidade, com 1 sendo o mais importante.

ARVORES FRUTIFERAS	**Indique com Y se a espécie já não é mais encontrado aqui**	**Ultima vez que foi visto a espécie (ano)**	**Abundância relativa 1.Diminuindo 2. Estático 3.Aumentando**
PFNM			

6.2 Para um agregado familiar que arvores frutíferas e PFNM, qual a quantidade, na media, por mes consumido?
Destas quantidades, quanto é consumidos pelo agregado familiar (não consumido é vendidos)?
Qual é a renda total realizado através das vendas de arvores frutíferas e PFNM por mes?

Espécies de frutas selvagens do listagem acima	**Período do ano**	**Ano Normal**			**Ano de Seca**			**Ano de Enchente**		
		No. Caçado	**No. Consumido**	**Renda (Mtn)**	**No. Caçado**	**No. Consumido**	**Renda (Mtn)**	**No. Caçado**	**No. Consumido**	**Renda (Mtn)**
1:	Chuvas (Oct.-Jan)									
	Secas (Abr-Jan)									
2:	Chuvas (Oct.-Jan)									
	Secas (Abr-Jan)									
3:	Chuvas (Oct.-Jan)									
	Secas (Abr-Jan)									

PFNM	Período do ano	Ano Normal			Ano de Seca			Ano de Enchente		
		No. Caçado	No. Consumido	Renda (Mtn)	No. Caçado	No. Consumido	Renda (Mtn)	No. Caçado	No. Consumido	Renda (Mtn)
1:	Chuvas (Oct.-Jan)									
	Secas (Abr-Jan)									
2:	Chuvas (Oct.-Jan)									
	Secas (Abr-Jan)									
3:	Chuvas (Oct.-Jan)									
	Secas (Abr-Jan)									

6.3 Sobre o mercado para a venda de arvores frutíferas e PFNM (local vs. externo):

_____

_____

6.4 Em média, quantos dias por mes passam a buscar produtos de arvores futiferas e PFNM?

Frutas selvagens Tipo de ano / Mes	Jan	Fev	Mar	Abr	Maio	Jun	Jul	Aug	Set	Out	Nov	Dez
Ano normal												
Ano de seca												
Ano de enchentes												
PFNM												
Ano normal												
Ano de seca												
Ano de enchentes												

6.5 Comportamento de recolha para **frutas selvagens**:

Quanto tempo o grupo (ou individual) passa fora recolhendo?	
Quantas pessoas estão envolvidas na colecta de frutas selvagens?	

6.6 Comportamento de recolha para **Produtos Florestais Não Madeira**:

Quanto tempo o grupo (ou individual) passa fora recolhendo?	
Quantas pessoas estão envolvidas na colecta de PFNM?	

6.7 Existem regras ou regulamentos a respeito da colecta de produtos de árvores frutíferas PFNM? Ate que ponto são respeitados os regulamentos?

Regra/regulamentos	**Sim**	**Não**	**Aonde**	**Nível de respeito as regras/regulamentos**				
				Muito baixo	**Baixo**	**Razoável**	**Alto**	**Muito alto**
Frutas Selvagens								
PFNM								
Outros								

Outras observações:

_____
_____
_____
_____
_____
_____
_____

7. LENHA Comunidade_____

7.1 Sobre a queima de **porcelana,** quem e que % da comunidade esta envolvido?

_____

7.2 Sobre a queima de **tijolos,** quem e que % da comunidade esta envolvido?

_____

7.3 Sobre o assunto do local de aonde a lenha é colectado (nas áreas na beira dos rios, ou das áreas mais elevadas):

_____

7.4 Quais são as fontes lenha para cozinhar, aquecer, a queima de porcelana e a queima de tijolos?

Cozinhar e aquecimento	0.. Áreas baixas/beira rio		1.. Áreas elevadas/nos morros	
Queima de porcelana	0.. Áreas baixas/beira rio		1.. Áreas elevadas/nos morros	
Queima de tijolos	0.. Áreas baixas/beira rio		1.. Áreas elevadas/nos morros	

7.5 Quais espécies de arvores costumam ser utilizadas como lenha para cozinhar, aquecimento, queima de porcelana e queima de tijolos?

Liste as espécies de árvores em termos de preferência de qualidade da lenha. 1 sendo a mais preferível.
Qual é a percepção do estado de abundância das espécies seleccionadas?

Espécie de árvore utilizada como lenha	**Listar espécie em termos de:**			**Percepção quanto a abundância de madeira para queima**		
	Cozinhar e aquecimento	**Queima de porcelana**	**Queima de tijolos**	**Muito acabado**	**Moderadamente acabado**	**Abundante**
1.						
2.						
3.						
4.						

7.6 Complete as seguintes informações para a colecta de **lenha para cozinhar e aquecimento** por mes.

Calendário		**Tipo de Ano**		
		Normal	**Seca**	**Cheia**
Período de chuvas (Nov Dez, Jan, Fev, Mar, Abr**)**	Quantidade de (unidades a definir) colecto por mes			
	Numero de colectas por mes			
	Tempo a caminhar por a colecta			
	Tempo levado por a colecta			
Período Seco (Ago, Set, Out**)**	Quantidade de (unidades a definir) colecto por mes			
	Numero de colectas por mes			
	Tempo a caminhar por a colecta			
	Tempo levado por a colecta			
Período Frio (Maio, Jun, Jul**)**	Quantidade de (unidades a definir) colecto por mes			
	Numero de colectas por mes			
	Tempo a caminhar por a colecta			
	Tempo levado por a colecta			

7.7 Qual o preço médio para vender (unidade:_____) de lenha? _____(Mtn)

7.8 Provem a seguintes informações para a colecta de lenha para a queima de **porcelana** por mes.

Calendário		**Tipo de Ano**		
		Ano Normal	**Ano de Seca**	**Ano de Enchente**
Período de chuvas (Nov Dez, Jan, Fev, Mar, Abr**)**	Quantidade de itens de porcelana feita por mes			
	Numero de colectas por mes			
	Tempo a caminhar por a colecta			
	Tempo levado por a colecta			
Período Seco (Ago, Set, Out**)**	Quantidade de itens de porcelana feita por mes			
	Numero de colectas por mes			
	Tempo a caminhar por a colecta			
	Tempo levado por a colecta			
Período Frio (Maio, Jun, Jul**)**	Quantidade de itens de porcelana feita por mes			
	Numero de colectas por mes			
	Tempo a caminhar por a colecta			
	Tempo levado por a colecta			

7.9 Qual o preço médio para vender um item de porcelana? _____(Mtn)

7.10 Provem a seguintes informações para a colecta de lenha para a queima de **tijolos** por mes.

Calendário		**Tipo de Ano**		
		Ano Normal	**Ano de Seca**	**Ano de Enchente**
Período de chuvas (Nov Dez, Jan, Fev, Mar, Abr**)**	Quantidade de tijolos feitos por mes			
	Numero de colectas por mes			
	Tempo a caminhar por colecta			
	Tempo levado por colecta			
Período Seco (Ago, Set, Out**)**	Quantidade de tijolos feitos por mes			
	Numero de colectas por mes			
	Tempo a caminhar por colecta			
	Tempo levado por colecta			
Período Frio (Maio, Jun, Jul**)**	Quantidade de tijolos feitos por mes			
	Numero de colectas por mes			
	Tempo a caminhar por colecta			
	Tempo levado por colecta			

7.11 Qual o preço médio para a venda de (unidade:_____) de tijolos? _____(Mtn)

7.12 Quem compra os tijolos? Qual é a demanda de tijolos?

_____

_____

Outras observações:

_____

_____

_____

_____

8. CARVAO

Comunidade:_____

8.1 Quais são as principais fontes de Madeira para produzir carvão?

0.. Áreas baixas/beira rio ☐

1.. Áreas elevadas/nos morros ☐

8.2 Quais espécies de arvore são utilizadas para produção de carvão?

Liste as espécies de arvore em sua preferência para a fabricação de carvão, sendo 1 o mais preferível. Qual e a percepção quanto a abundância das espécies seleccionadas?

Espécie de arvore utilizada na produção de carvão.	**Ordem**	**Percepção da abundância de espécies**		
		Muito acabado	**Moderadamente acabado**	**Abundante**
1.				
2.				
3.				
4.				

8.3 Provem a seguintes informações referente a produção de carvão por mes.

Calendário		**Tipo de Ano**		
		Ano Normal	**Ano Normal**	**Ano Normal**
Período de chuvas (Nov Dez, Jan, Fev, Mar, Abr**)**	Sacos de carvão produzido por mes			
	Horas por mes cortando madeira			
	Horas por mes preparando forno			
	Horas por mes embalando carvão			
Período Seco (Ago, Set, Out**)**	Sacos de carvão produzido por mes			
	Horas por mes cortando madeira			
	Horas por mes preparando forno			
	Horas por mes embalando carvão			
Período Frio (Maio, Jun, Jul**)**	Sacos de carvão produzido por mes			
	Horas por mes cortando madeira			
	Horas por mes preparando forno			
	Horas por mes embalando carvão			

8.4 Qual o salário local por pessoa para um dia de trabalho na produção de carvão? _____ (Mtn)

8.5 Quanto custa um saco (vazio) utilizado para empacotar o carvão? _____ (Mtn)

8.6 Na media, qual é o preço de um saco de carvão vendido Localmente (metical)

Período das chuvas	
Período seco	
Período de frio	

8.7 Alem do mercado local, quais outros mercados existem para a venda do carvão?
Qual é o preço por saco de carvão vendido nos diversos mercados?

Mercado	Preço de um saco de carvão (Mtn)		
	Período de Chuvas **(**Nov, Dez, Jan, Fev, Mar, Abr**)**	Período de Secas **(**Ago, Set, Out**)**	Período de Frio **(**Maio, Jun, Jul**)**

8.8 Sobre a cadeia de valor do carvão:

_____
_____

Outras observações:

_____
_____
_____
_____
_____
_____

9. MATERIAL PARA CONSTRUCAO Comunidade:_____

9.1 Quais espécies de arvores são utilizadas para material de construção?
Ordene as espécies de árvores em termos de preferência de qualidade para uso em construção, sendo 1 a mais preferível tipo de espécie. Qual é a percepção do estado de abundância das espécies seleccionadas?

Recursos utilizados para construção de casas (stake or cane; mitete wood, mangrove; grass; palm leaves)	**Fonte** **0.** Áreas baixas/beira **1.** Áreas elevadas/nos morros	**Percepção da abundante de recursos utilizados na construção**		
		Muito acabado	**Moderadamente acabado**	**Abundante**
1.				
2.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				

9.2 Qual o numero, na media, de cabanas por agregado familiar? _____

9.3 Qual é a frequência de novas construções de cabanas/casas por agregado familiar?

Frequência	No. de cabanas/casas
Cada 6 meses	
Cada ano	
Cada 2 anos	

9.4 Provem as seguintes informações para cada um dos seguintes materiais utilizados na construção de uma casa/cabana comum

Tipo de ano	**Ano Normal**		**Ano de Seca**		**Ano de Enchentes**	
Recurso	**Tempo de viajem para colher recurso (min)**	**Tempo levado para extrair o recurso (horas)**	**Tempo de viajem para colher recurso (min)**	**Tempo levado para extrair o recurso (horas)**	**Tempo de viajem para colher recurso (min)**	**Tempo levado para extrair o recurso (horas)**
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Outras observações:
_____
_____
_____

10. AGUA Comunidade_____

10.1 Demanda e oferta de água e sua valoração.

	Ano de Seca		Ano Normal		Ano de Enchentes	
	Período das Secas	**Período de Chuvas**	**Período das Secas**	**Período de Chuvas**	**Período das Secas**	**Período de Chuvas**
Quantos bidões de agua para beber na media são colectadas por dia por agregado familiar?						
Fonte de agua potável? 1. Poço Comunitário 2. Bomba Comunitária 3. Rio						
Distancia para fonte de agua para beber e tempo levado por viajem.						
Quantos bidões de agua na media são colectadas por dia por agregado família para lavar roupa e tomar banho?						
Fonte de agua para lavar 1. Poço Comunitário 2. Bomba Comunitária 3. Rio						
Distancia para fonte de agua para lavar e tempo levado por viajem.						
Potencialmente qual a área de terra sua que poderia ser irrigado?						
Que tipo de cultivo é normalmente irrigado?						

Outras observações:

_____

11. MANGAIS Comunidade_____

11.1 Quais recursos naturais normalmente são colectados do mangais?

Liste os recursos de acordo com sua importância, 1 sendo a mais preferível tipo de recurso provenientes do mangal. Qual é a sua percepção do estado do mangue?

Recursos colectados dos mangais	**Quantidade media colectado por mes**	**Percepção do estado dos recursos do mangue**		
		Muito acabado	**Moderadamente acabado**	**Abundante**
1.				
2.				
3.				
4.				
5.				
6.				

11.2 Na exploração de madeira prevenindo do mangue, quem e que % da comunidade esta envolvida?

Há um mercado estabelecido para a venda de madeira prevenindo do mangal? Se sim, quem consome e como?

_____
_____
_____
_____

11.3 Na exploração do mangai para produtos comestíveis, quem e que % da comunidade esta envolvida?

Há um mercado estabelecido para a venda de produtos comestíveis prevenindo do mangal? Se sim, quem consome e como?

_____
_____
_____
_____

Outras observações?

_____
_____
_____
_____

Appendix 3.2.1: Household Questionnaire – English Version

WWF®

MARROMEU COMPLEX HOUSEHOLD SURVEY QUESTIONNAIRE

Date of Interview:_____/_____/2008 District:_____

Village Name and Number:_____

Name of Enumerator:_____

Name of Household:_____

Name of Interviewee: _____

Zone:	**0.** Lowland		**1.** Upland	
Community:	**0.** Coutada		**1.** Non-Coutada	

PART A: DEMOGRAPHIC INFORMATION

A.1 Gender of household head *(tick)*:

1. Male	
2. Female	
3. De facto female	
4. Male-child headed	
5. Female-child headed	

A.2 Marital Status of household head *(tick)*:

1. Married	
2. Divorced	
3. Single	
4. Widower	
5. Widow	

A.3 How many people are in this household? _____

A.4 How long have you been living in this community for? _____ years

PART B: HOUSEHOLD OFF-FARM INCOME, ASSETS, AND EXPENDITURES

B.1 Are you formally employed? If yes, where? _____

B.2 Have you been given any AID in the last 12 months? If yes, please specify:
What: _____ How much: _____

B.3 What is the estimated total off-farm income for your household per month (Mtc)? *(tick)*:
(eg. wage employment, remittances)

0. 0 - 250	
1. 251 - 500	
2. 501 - 750	
3. 751 - 1.000	
4. 1.001 - 1.500	
5. > 1.501	

B.4 Which of the following assets does your household own?

Productive Assets Agriculture	**Own 0. No 1. Yes 2. Access**	**Productive Assets Fisheries**	**Own 0. No 1. Yes 2. Access**	**Non-Agriculture and Non-Fisheries Assets**	**Own 0. No 1. Yes 2. Access**
Plough		Canoes		Bicycle	
Scotch cart		Nets		Radio	
Tractor		Rods		Television	
Wheel barrow		Traps (curral)		Brick house	
		Drying facilities		Cell phones	
		Smoking facilities			

B.5 How many times in the last 12 months have you visited the:

Traditional doctor	
Clinic	

PART C: AGRICULTURE

C.1 Do you have agricultural land? (*tick*)

1. No	0. Yes

C2. If yes, what is the size of your land? _____ha( ) acres( ) plot( )

C.3 What is the area under production for each of the following crops? What was your total production for each crop?

CROP TYPE	Pro-duce	Main Season (Oct. - Jan.)						Dry Season (April – Jun)					
		Area Cultivated			Production			Area Cultivated			Production		
	Crop	Normal	Flood	Drought	Normal	Flood	Drought	Normal	Flood	Drought	Normal	Flood	Drought
	0. No 1.Yes	ha, acre, plot or % of total			number of bags (50 kg)			ha, acre, plot or % of total			number of bags (50 kg)		
Maize													
Sorghum													
Millets													
Rice													
Cotton													
Cow peas													
Sweet potato													
Cassava													
Sugarcane													
Tobacco													
Vegetables													
Fruits(# of trees)													
Other (specify)													

C.4 Do you apply fertilizer to your crops? (*tick*)

0. No	1. Yes

C.5 If no to the above go to C.6:
Did you use <u>less</u> fertilizer during the growing season following the flood of 2000/2001?

0. No	1. Yes

C.6 How many of each type of the following livestock do you own?

Livestock Type	**No. Owned**	**Number consumed past 12 months**	**Number sold past 12 months**	**If you sell, how do you do it? 0. Live 1. Meat**	**Estimated total income realized past 12 months (Mtc)**
Cattle					
Donkey					
Sheep					
Goat					
Pigs					
Chicken					
Other (specify)					

PART D: FISHERIES

D.1 Does at least one member of your household fish? If yes, how many? _____

D.2 Which methods do you use? Nets Line and hook Spear Other (Specify)

D.3 Which species do you catch and the amount per fishing day? (tick all applicable)

	Tilapia	Catfish	Labeo	Tigerfish	Shrimp	Crab
0. No / 1. Yes						
Catch (specify unit)						
Sold (amount)						
Sold (revenue)						

PART E: HOUSEHOLD WATER AND ENERGY NEEDS

ENERGY

E.1 Specify your utilization of the following energy sources per day:

Material	**Use 0.No 1. Yes**	**Quantity used for cooking**	**Quantity used for heating**	**Quantity for other uses (specify)**	**Cost if purchased (Mtc)**	**Time spent gathering (daily) if collected**
Charcoal						

Firewood						
Gas						

WATER

E.2 How much water does the household consume per day? _____ buckets (or specify units _____)

E.3 From this amount, how much is: Collected _____ or purchased _____

E.4 Do you use water for irrigation? (*tick*)

0. No	1. Yes

E.5 What is your normal (or regular) water source? (*tick*)

	Main Season (Oct. - Jan.)			**Dry Season (April – Jun)**		
	Normal	**Flood**	**Drought**	**Normal**	**Flood**	**Drought**
Community deep well						
Community borehole						
Piped water scheme						
River						
Other (specify)						

PART F: NATURAL RESOURCE USE

F.1 Do you have access to the following resources?

Resource	**Harvest resource? 0. No 1. Yes**	**Consume Resource 0. No 1. Yes**	**Months Harvested?** (*tick*)												**Sell resource? 0. No 1. Yes**	**Est. income from resource per month (Mtc)**				
			j	f	m	A	m	j	j	a	s	o	n	d		0 - 250	251 - 500	501 - 750	751 - 1000	> 1001
Wild vegetables																				
Wild Fruits																				
Timber																				
Firewood																				
Charcoal																				
Honey																				
Wild Meat																				
Wild Birds																				
Medicinal animals																				
Others (*specify*)																				

THANK YOU FOR YOUR TIME!

Appendix 3.2.2: Household Questionnaire – Portuguese Version

WWF®

INQUERITO DA UNIDADE FAMILIAR DO COMPLEXO MARROMEU

Data do inquerito:_____/_____/2008 Districto:_____

Nome e numero da communidade:_____

Nome do inqueridor:_____

Nome da unidade familiar:_____

Nome do Inquerido: _____

Zona:	**0.** Baixa		**1.** Alta	
Comunidade:	**0.** Coutada		**1.** Nao-Coutada	

PART A: INFORMACOES DEMOGRAFICAS

A.1 Sexo da cabeça da casa *(marque)*:

1. Masculino	
2. Femenino	
3. De facto femenino	
4. Filho	
5. Filha	

A.2 Estado civil da cabeça da casa *(marque)*:

1. Casado	
2.Divorceado	

3. Solteiro	
4. Widower	
5. Viuvo	

A.3 Numero de membros na unidade familiar? _____

A.4 Ha quanto tempo reside nessa communidade? _____ anos

PART B: ATIVOS, RENDA E DESPESAS NÃO AGRICOLAS

B.1 Você tem um emprego formal? Se sim, aonde? _____

B.2 Você recebeu alguma doacao nos ultimos 12 meses? Se sim, especificar:

O que (ex. comida, medicamento): _____ Quanto: _____

B.3 Qual é o rendimento nao-agricola da sua unidade familiar (em Meticais)? *(marque)*: (ex. salario, dinheiro enviado de fora)

0. 0 - 250	
1. 251 - 500	
2. 501 - 750	
3. 751 - 1.000	
4. 1.001 - 1.500	
5. > 1.501	

B.4 Marque os recursos que a sua unidade familiar possui?

Recursos agriculas	**Tem 0. Não 1. Sim 2.Aces so**	**Recursos para a pesca**	**Tem 0. Não 1. Sim 2.Aces so**	**Recursos nao produtivos**	**Tem 0. Não 1. Sim 2.Aces so**
Plough		Canoa		Bicicleta	
Scotch cart		Redes		Radio	
Trator		Linha e caretel		Televisao	
Wheel barrow		Curral		Casa de tijolo	
		Estructura para secar		Celular	
		Estructura para defumar			

B.5 Nos ultimos 12 meses, quantas vezes voce teve que visitar o:

Medico tradicional	
A clinica	

PARTE C: AGRICULTURA

C.1 Você tem terras para agricultura? (*marque*)

1. Não	0. Sim

C.2. Se sim, qual é o tamanho da area? _____ha( ) acres( ) machamba ( ) pedaco( )

C.3 Qual a area de produçao das seguintes plantas? Quantidade total produzido para cada tipo de planta?

TIPO DE PLANTA		Periodo das chuvas (Oct. – Jan.)						Periodo da seca (Abril – Jun)					
		Areá Cultivada			Produçao			Areá Cultivada			Produçao		
	Plantas?	Normal	Enchente	Seca	Normal	Enchente	Seca	Normal	Enchente	Seca	Normal	Enchente	Seca
	0.Não 1.Sim	Ha, acre, plot ou % do total			Numero de sacos (50 kg)			ha, acre, plot ou % do total			Numero de sacos (50 kg)		
Milho													
Sorghum													
Millets													
Arroz													
Algodão													
Cow peas													
Batata doce													
Cassava/Mandioca													
Cana de açucar													
Tabacco													
Verduras													
Frutas (numero de arvores)													
Outros (especificar)													

C.4 Você ultiliza algum tipo de fertilizante? (*marque*)

0. Não	1. Sim

C.5 Se nao para a C4 vai para C.6:

Na temporada de cultivo apos as enchentes do ano 2000/2001,

voce ultilizou menos fertilizantes?

0.Não	1. Sim

C.6 Quantos dos seguintes tipos de animais voce tem?

Animal	**Numero que tem?**	**Numero consumido nos ultimos 12 meses?**	**Numero vendido nos ultimos 12 meses?**	**Se voce vende, como o faz?** **0. Vivo** **1. Carne**	**Rendimento nos ultimos 12 meses?** **(Mtn)**
Gado					
Burro					
Ovelha					
Cabrito					
Porcos					
Galinhas					
Outros (especificar)					

PART D: PESCA

D.1 Quantos membros da sua unidade familiar practicam a pesca? _____

D.2 Quais sao os metodos ultilizados? Redes ( ), Vara/anzol ( ), Lanca ( ), Outros (especificar):_____

D.3 Quais especies voce pesca, e quanto de cada por dia de pesca? (selecione todos que se aplicam)

	Tilapia	Catfish	Labeo	Tigerfish	Camarão	Caranguejo
0. Não / 1. Sim						
Quantidade (especificar unidade)						
Quantidade vendida						
Rendimento da venda						

PARTE E: NECESSIDADES BASICAS DA UNIDADE FAMILIAR: AGUA E ENERGIA

E.1 ENERGIA Especificar a utilizacao dos seguintes materiais a seguir, por dia:

Material	**Uso 0.Nao 1. Sim**	**Quantidade para cozinhar**	**Quantidade para aquecer**	**Quantidade para outros fins (especificar)**	**Custo (em metical ou em horas de coleta p/ dia)**
Carvao					
Lenha					
Gas					

AGUA

E.2 Quanta água a sua unidade familiar consume por dia? _____baldes (ou especificar a unidade _____)

E.3 Desta quantidade acima, quanto e: colectado _____ e comprado _____

E.4 Você practica alguma forma de irrigacao? (*marque*)

0. Não	1. Sim

E.5 Especificar a sua fonte normal (ou regular) de agua: (*marque*)

	Periodo das chuvas (Oct. - Jan.)			**Periodo da seca (Abril – Jun)**		
	Normal	**Enchente**	**Seca**	**Normal**	**Enchente**	**Seca**
Poco comunitario						
Bomba comunitaria						
Agua canalizada						
Rio						
Outros (especificar)						

PARTE F: USO DE RECURSOS NATURAIS

F.1 Voce tem acesso aos seguintes recursos?

Recurso	**Recolhe /cata recurso? 0. Não 1. Sim**	**Consume o Recurso? 0.Não 1. Sim**	**Meses do ano em que se colhe/recolhe?** (*marque*)												**Vende Recurso 0.Não 1.Sim**	**Rendimento do recurso por mes (Mtn)**				
																0 – 250	251 - 500	501 - 750	751 - 1000	> 1001
			j	f	m	a	m	j	j	a	s	o	n	d						
Vegetais não cultivados																				
Frutas não cultivados																				
Madeira																				
Lenha																				
Carvão																				
Mel																				
Carne de caca																				
Passaros selvagems																				
Plantas medicinais																				
Outros (e*specificar*)																				

MUITO OBRIGADO POR SEU TEMPO!

Appendix 3.3: Wildlife & Tourism Checklist

Wildlife and Tourism

- Area of block
- Trends in stock of wildlife – species and numbers. Trends for the whole hunting area and the Buffalo Reserve?
- Mortality rates, birth rates and poaching. What are the differences between these variables between normal and above or below normal rainfall seasons?
- Cost of anti-poaching (ie what portion of your wage bill is devoted to fighting poaching)
- Allocated and actual trophy hunts by types over years
- Fees to government for permits
- Number of visitors over years
- Source of visits (%) (local(province),Southern and East Africa, North Africa, West Africa, Europe, ASIA, North America, South America)
- Distribution of visits during the year
- Average duration for each visit
- Accommodation capacity
- Accommodation cost per night by season (peak/off-peak)
- Average amount spent by the visitor in the block
- Purpose of visit (hunting only, hunting + ecotourism, eco-tourism only) in what proportions
- Prices and average number of game viewing rides by non-hunting visitors
- Price of trophy hunts by species over time
- Cost of preparing stuffed trophies and freight charges
- Sales trends for production wildlife. Where? What costs are incurred by the game park operator in preparing animals for dislocation?
- Effects of flooding on productivity
- Culling trends – type and number of animals
- How many employees are employed and what is the wage bill?
- In what way do neighbouring communities benefit from the coutada operations?

Appendix 3.4: Agriculture Checklist

Agriculture

- What are the commercial agricultural activities done in the Marromeu complex? Number of farmers, crop types (sugar etc), hectares, output, numbers of animals etc over time?
- What are the smallholder agricultural activities are done in the Marromeu complex? Number of farmers, crop types, hectares, output, numbers of animals etc over time.
- Are there reports of these?
- Irrigation activities and plans for the area
- Perceptions on DRIFT(proposed changes in Zambezi flow rates)
- Any information on how productivities change due to flooding? Any studies?
- Who are the representatives of the agriculture ministry in the delta area?
- Maps(GIS the better) eg for soil type, land suitability(etc)

Appendix 3.5: Environment Checklist

Environment

- Information on changes in animal(land and water based) and plant species over time in the delta area
- Magnitude of charcoal production in the DELTA
- Harvesting and trade in mangrove products in the delta area including crab
- Projections of future climate patterns in the Zambezi basin
- Effect of floods on populations of animal and plant species
- Meteorological data
- Any plans for the Zambezi Basin
- Biodiversity reports on the Delta
- Representatives of Environment department in the Delta

Appendix 3.6: Commercial Timber Checklist

Commercial Timber

- Log timber value = Sum over species[cubic meters of commercially saleable timber*(price of the species of log timber per cu.m in Beira – transport cost per cu.m to Beira)}] + estimated cu.m of trimmings*(price of fuelwood in nearest community market – transport cost to nearest community market) – (cost per cubic metre of harvesting timber)
- What companies are involved in the transportation of logs? From where?
- Benefits accruing to employees = wage bill
- Value added in sawing in Beira= Sum over species and non-TCT Delta producers(price per cu.m of sawn timber – cost per cu.m of log timber*(cu.m of log timber required to produce a cu.m of sawn timber) - costs of sawing per cu.m of sawn timber)
- Value added in sawing realised in Delta = Sum over species for TCT (&&&)

Appendix 3.7: Commercial Fisheries Checklist

Commercial Fisheries

Data needed

- Total investment in the delta shrimp business
- What is needed to set up a shrimp business? How much would it cost?
- Total employment in the delta shrimp catching. Wage bill
- Volume of shrimp from the delta over the years.
- Price per tonne of catch in the delta
- Cost of transporting shrimp to processing units per tonne
- Cost of processing a tonne of shrimp
- Whole/export price per tonne of processed shrimp
- Employment in the processing industry
- Wage bill of the processing industry

Appendix 3.8: Commercial Sugar Checklist

Commercial Sugar Production

- Area, yields and production trends over the years
- Cost of production per tonne. How does it compare to those for production elsewhere in Mozambique, other Southern African countries eg. Zimbabwe, RSA, Malawi
- Tonnes of what fertilisers, agrochemicals used in production
- Processing capacity established.
- Current capacity utilisation
- Planned expansion/potential sugar area
- Cost of expansion (land clearance, dyke construction, extension of irrigation)
- What products are produced by the delta plant?(raw sugar, molassis, alcohol etc) what quantities? Sold to whom? For what purposes(eg is there a livestock fattening enterprise utilising molassis and other by-products)?
- What is the benefits per tonne of the various products produced by the plant
- Do you produce energy from by-products of processing? What form? What is the equivalent electricity or fossil fuel served by using this alternative energy source? What is the potential of energy produced using current levels of production?
- How much water is used in irrigating sugarcane under current levels? Is water enough drought periods? What impacts on area/productivity do these entail?
- How many workers are employed by the company (seasonal(how long)/permanent)? What population is supported? Wage bill of the company.
- Are they involved in small agriculture, fishing etc and to what level (type of crops, hectares, output, species of fish)?
- Flooding episodes – how do they affect productivity of sugar cane?
- Environmental effects of Dykes
- What value addition activities occur when sugar and products leave the Delta? Transport, packing and retailing activities