The value of the Okavango delta: A natural resource accounting approach

by

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ABSTRACT

Economic valuation of the Okavango Delta can support decision making in a complex socio-economic environment in which economic development depends on a deep understanding of the value of biodiversity. The use of a natural resource accounting framework in determining the value of goods and services is crucial. The total economic value of the Okavango Delta was estimated by using primary (household valuation) and secondary data. A natural resource accounting framework was used. The components of the total economic value were the composition of wild herbivores and vegetation, and the functional values, which comprised direct use values of wild herbivores, river reed, thatching grass, wild fruits, fuelwood and palm leaves, indirect consumptive values of honey production, carbon sequestration, livestock grazing, milk production, non-consumptive use of tourism, and existence and bequest values. The values of the composition and function are expressed in per/ha values. The value of the composition of wild herbivores was estimated at P1 444 992 400 (US$ 294 850 699.2) or US$ 27.4/ha, while the functional value was estimated at P185 913 117.4 (US$ 37 527 840.96 or US$ 619.77/ha. Of the estimated direct use values of vegetation, river reed had the highest value of US$ 29.0/ha, while the highest value among indirect use values was that of milk production (US$ 8.5/ha). These values of selected resources reflect the contribution of the value of biodiversity of the Okavango Delta to the overall economy of the country and represent initial estimates of costs to society if these resources are lost. The estimated values can be used to raise awareness among decision makers of the economic benefits of conserving the Okavango Delta. Overall, the findings showed that the various components of the total economic value of the Okavango Delta were comparable to other wetlands in the region.

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CHAPTER 1

INTRODUCTION

This chapter gives the background of the study in terms of the world-wide problems that wetlands, including Botswana's Okavango Delta wetland, face today. The chapter also gives the motivations of the study, objectives of the study and a short overview of the methodology. The structure of the thesis is presented at the end of the chapter.

1.1 Background

Botswana is well endowed with a variety of natural resources that include the Okavango Delta wetland, the world's largest known Ramsar site in the north, which supports a rich biodiversity of wild biota. Despite the importance of wetland ecosystems in the social and economic development in the countries in which they occur, they are among the most threatened of all environmental resources (Brouwer et al., 2001). Their loss and degradation may be considered at two levels, which are the direct loss and degradation of the wetland itself, and the indirect loss and degradation, which occur outside the wetland (Brouwer et al., 2001). The loss and degradation of wetlands reduces their future capacity to provide the goods and services to mankind and life on earth. The major causes of wetland loss and degradation include conversion to agriculture, commercial and residential or settlement development, resource extraction, dredging and channelization, diking and damming and discharge of waste material (Stuip et al., 2002).

According to Winpeny (1991), the reason that wetland ecosystems are prone to loss and degradation is that their values (especially functional values) are not understood, or where these values are understood, are simply not appreciated. Wetland ecosystems are often considered wastelands, unproductive and without value (Turner et al., 2000; Silvius, 2000). Their products are also not marketed. This makes them appear to have a low economic value which in turn leads to inefficient resource allocation. Wetlands also have characteristics of public goods, which means that the services they provide are not paid for by the users (Barbier et al., 1997). Further, wetlands are in many cases open access resources where no rules apply to their use, hence are often subjected to over-exploitation. This market failure is considered one of the most important causes of wetland conversion and loss (Turner et al., 2000; Barbier et al., 1997).

1.2 Motivation

While international conventions such as the UN Non-Navigational Uses of International Watercourses and Protocol on Shared Watercourse Systems advocate equitable sharing of water and sufficient conservation of scarce resources, any development in the form of wetland utilization such as water abstraction or hydropower generation, is bound to have an opportunity cost associated with such impacts. The Botswana's Okavango Delta provides an example of a continually threatened wetland. Firstly, in 1985 the government of Botswana issued terms of reference for the Southern Okavango Water Development Project to undertake feasibility studies on possible uses of the delta water with minimal environmental impacts. The aim of the project was to improve the utilization of land and water resources, increase food production and increase employment opportunities and raise the standard of living of people in the southern part of the peripheries of Okavango (Scudder et al., 1993). Some of the proposed development structures in this project included construction of river control structures: construction of dams and bunding of river channels (Scudder et al., 1993). The project met a lot of criticism from among local and international communities due to its perceived negative impacts on the environment. As a result, the government engaged the World Conservation Union (IUCN) to carry out an independent assessment of the project, the recommendations of which led to the abandonment of the project (Schudder et al., 1993).

Secondly, in 1996 the government of Namibia proposed to construct a 240 km pipeline for abstracting 17 million cubic metres annually from the Okavango River, which is the source of the Okavango Delta in Botswana (Ashton et al., 2003; Rothert, 1999). The abstracted water was to be distributed to central Namibia through this pipeline. While Namibia, Botswana and Angola had formed the Permanent Okavango River Basin Water Commission (OKACOM) in 1994 to co-ordinate and collaborate the sharing of the basin's water resources, Namibia's proposal to abstract water from the Okavango Rivers was developed outside the framework of OKACOM (Hitchcock, 2001). The government of Botswana protested to the Namibian government for failing to consult other stakeholder countries about the project (Hitchcock, 2001). The government of Namibia had also recommended the undertaking of environmental impacts of the project within Namibia only. Due to lack of consideration of the impact of the project on neighbouring states, the government of Botswana and other environmental organizations called for an investigation of the downstream impacts of the project within Botswana as well. The water abstraction scheme was temporarily suspended due to good rains in Namibia (Gumbricht et al., 2004). While the Government of Namibia's studies on environmental impact assessment revealed that the anticipated impacts were more likely to be seen in the Okavango Delta than in the Okavango River and the information available was insufficient to provide the extent of and significance of these impacts there were not any significant negative impacts that would prevent the proposed water abstraction scheme from proceeding as the anticipated ecological impacts were within the natural variability of the Okavango Delta system (Republic of Namibia, 1997).

1.3 Statement of the problem

While water development projects (for example, water extraction) in the Okavango Delta may be pursued for social and economic benefits, there may be negative impacts on the ecological integrity of the ecosystem that result in the impairment of the Delta's ability to provide ecosystem goods and services. Although the fraction of the total economic value that may be lost or reduced due to the implementation of such projects cannot be estimated precisely, there is need to generate basic information about the economic values that are provided by the Okavango Delta to allow for more informed decision-making by all stakeholders in the context of total economic value.

Past research in the Okavango Delta has concentrated on many aspects of natural resources including socio-economic and environmental impact of tourism development, (e.g. Mbaiwa, 2002), and the economic, social and environmental sustainability of enclave tourism and its economic impact on the Okavango Delta (e.g. Mbaiwa, 2005). Attempts have also been made to estimate direct economic values of some utilised resources. These studies include economic analysis of craft based resources (e.g. Terry, 1999); financial and economic viability of commercial fishing in Shakawe, Okavango

Delta (e.g. Mmopelwa et al., 2005a); the economic contribution of safari hunting to rural livelihoods (e.g. Thakadu et al., 2005); and the willingness of households to pay for improved water supply and quality in the village of Maun (e.g. Mmopelwa et al., 2005b). Economic analysis of some land uses (including commercial wildlife viewing) has been undertaken by Barnes et al. (2001). Barnes (1998) applied the contingent valuation method (CVM) as part of a larger study on determining direct use values in the wildlife sector in Botswana. In this study the CVM was used to determine the proportion of tourists' expenditures consisting of the consumer surplus, the willingness of tourists to contribute to a conservation fund and the willingness of tourists to pay increased park entry. The study revealed that visitors had a consumer surplus ranging between 17 and 20 percent of the total trip costs, and were willing to donate money for the conservation of wildlife resource of Botswana.

Much of the existing research on valuation of resources has focussed on particular sites within the Okavango Delta, and did not give indications of aggregate estimates of economic value for the whole area. It appears also that none of the past studies used a natural resource accounting framework in their valuation. In addition, the national accounts of Botswana have missing values. These include wildlife and livestock values, the inclusion of which have been hampered by lack of data (Lange and Wright, 2004), subsistence resources harvested by communities from the wild (e.g. forest and fishery resources, traditional medicinal plants, wild fruits, fuelwood, basket making resources) and indirect goods and services (e.g. livestock grazing, honey production carbon sequestration) which do not normally enter the trade and market sphere.

The motivation of natural resources accounting is about proper measurement of income derived from resources (El Serafy, 1989). There has been a preoccupation with links between measures of income and measure of human well-being or welfare (Hamilton et al., 1994). The standard measures of income such as Gross National Product (GNP) provide a comprehensive view of a nation's economy in terms of total income and output (Sėve, 2002). However, it is common knowledge that GNP or GDP are fairly poor indicators of welfare because they were designed to measure the level of economic activity and not welfare (Hamilton and Lutz, 1996; Hamilton et al., 1994). According to Hamilton et al. (1994), the inability of these indicators to measure welfare stems mainly from their lack of consideration of non-market activities because the system of national accounts measures the performance of the economy based on market transactions, ignoring the value of non-market goods provided by the environment. Another important shortfall of the conventional accounting is that important considerations such as the degradation and depletion of resources are not accounted for in spite of the fact that resource degradation and depletion result in reduction in social welfare (Seregeldin, 1996; Hartwick, 1990).

Environmental concerns about degradation and depletion of resources and sustainability of economic activities have contributed to the development of natural resource accounting (Hamilton et al., 1994). The concept of sustainable income forms the foundations of natural resource accounting (El Serafy, 1989). A proper measurement of sustainable income will guide a person or a nation on how much to spend on consumption for any particular period in order to maintain a constant level of income (Santos and Zaratan, 1997). A proper estimate of sustainable income requires capital, including natural capital, to be kept constant, which means that a reduction in one form of capital must be offset by the acquisition of any other form of capital so that the society does not suffer deterioration in the future (El Serafy, 1997; Santos and Zaratan, 1997).

Since conventional measures of macroeconomic performance disregard depletion of natural assets, and are inappropriate for evaluating long-term welfare aspects, natural resource accounting generates accurate indicators of well-being and macroeconomic performance which gives correct signal about the environment impacts of economic activities (Hassan et al., 1998; Hamilton and Lutz, 1996). Thus, in as far as produced and natural capital are concerned, the primary motive of natural resource accounting is to correct or adjust existing conventional measures of income, wealth and social welfare so that a more accurate overall picture of a nation's income and wealth is obtained (Hassan et al., 1998; Hamilton and Lutz, 1996). Such adjustments are therefore important for policy- making decisions tradeoff between economic activities and environmental degradation (Hassan et al., 1998).

This thesis therefore aims at estimating the value of selected ecosystem goods and services of the Okavango Delta using a resource accounting framework.

1.4 Research objectives

The general objectives of the study are:

(i) To compile physical resource accounts for Okavango Delta Region for 2003

(ii) To construct a monetary valuation of the physical assets where possible and to estimate the per hectare values.

(iii) To formulate policy scenarios resulting from an understanding of the value of ecosystem goods and services derived from the Okavango Delta.

The specific objectives are:

(i) To determine compositional and functional resource accounts of wild herbivores, vegetation and water use

(ii) To determine the direct non-consumptive use value of tourism in Moremi game reserve.

(iii) To determine indirect use value for livestock grazing, milk production, honey production and carbon sequestration.

(iv) To determine the non-use or existence value of the Okavango Delta from households and tourists.

The Okavango Delta wetland in Botswana has been chosen for the case study. The choice of the Okavango Delta was based on two reasons. Firstly, although the Okavango Delta can be considered to be a relatively undisturbed ecosystem, it has been threatened from time to time because of its great water utilization potential as has been shown by threats from Namibia and Botswana. The second reason why the Okavango Delta wetland was chosen for the case study is that it is a unique ecosystem, which contributes to the economy of Botswana, particularly through tourism. For instance, tourists spend roughly about US$5000.00 to US$6000.00 in a 6-10 days visit to the Okavango Delta (Mbaiwa, 2002). The Okavango Delta also supports thousands of communities through provision of many direct and indirect services such as water supply and collection of various veld products.

1.5 Overview of methodology

The total economic value of the ecosystem goods and services provided by the Okavango Delta during 2003 was estimated and presented in a natural resource accounting framework. The following accounts have been constructed using data from secondary information sources and surveys of households and tourists: composition of and ecological functions provided by wildlife; the composition of and ecological services provided by vegetation; direct consumptive use of tourism; indirect consumptive use value of livestock grazing, milk production, honey production, carbon sequestration, water supply and use and non-use values (preservation values). The physical accounts were valued using market prices where possible.

1.6 Structure of the thesis

The first chapter gives the motivation of the study, defines the research problem and spells out the objectives and hypothesis. Chapter Two presents the background on Botswana and a description of the Okavango Delta including its hydrology, threats, economic significance and conservation and management in the overall context of the Botswana government policies on natural resources management and utilization. A review of the relevant literature about capital theory and natural resource accounting and valuation in general is presented in Chapter Three 3. Theoretical framework, sources of the data, study areas and sampling are discussed in Chapter Four. Chapter Five presents an analysis of physical and monetary accounts of different resources. Discussions of results, policy implications and conclusions are presented in Chapter Six.

CHAPTER 2

BOTSWANA AND THE OKAVANGO DELTA

2.1 Introduction

This chapter gives background on the general physical, demographic and socio economic characteristics of Botswana and the Okavango Delta. The chapter also discusses the significance of the Okavango Delta to the general economy of Botswana in relation to other natural resources. The chapter concludes with a brief review of natural resources management policies as they relate to the management of resources in the Okavango Delta.

2.2 General characteristics of the country

2.2.1 Physical characteristics

Botswana is a land locked country found in the southern part of Africa with an area of 582 000 square kilometers between latitudes $17^0$30 north-west and 28^0 south of Equator and longitudes 20^0 and 29^0 East of Greenwich Meridian (Government of Botswana, 2001). The country is boardered by Namibia to the west and north, South Africa to the south and south-east, and Zimbabwe to the north east (Figure 1). Botswana's topography is mostly flat, with gentle undulations and occasional rock outcrops. There are no major mountain features. However, in the eastern and south-eastern parts elevations vary between 1491 metres for Otse Hill to less than 800 metres in the Limpopo basin (Government of Botswana, 2001).

The country is characterized by four drainage basins, which are the Okavango-Makgadikgadi, Zambezi, Limpopo and Orange basins. The Okavango-Makgadikgadi basin in the west of the country occupies 60% of the total basin area.

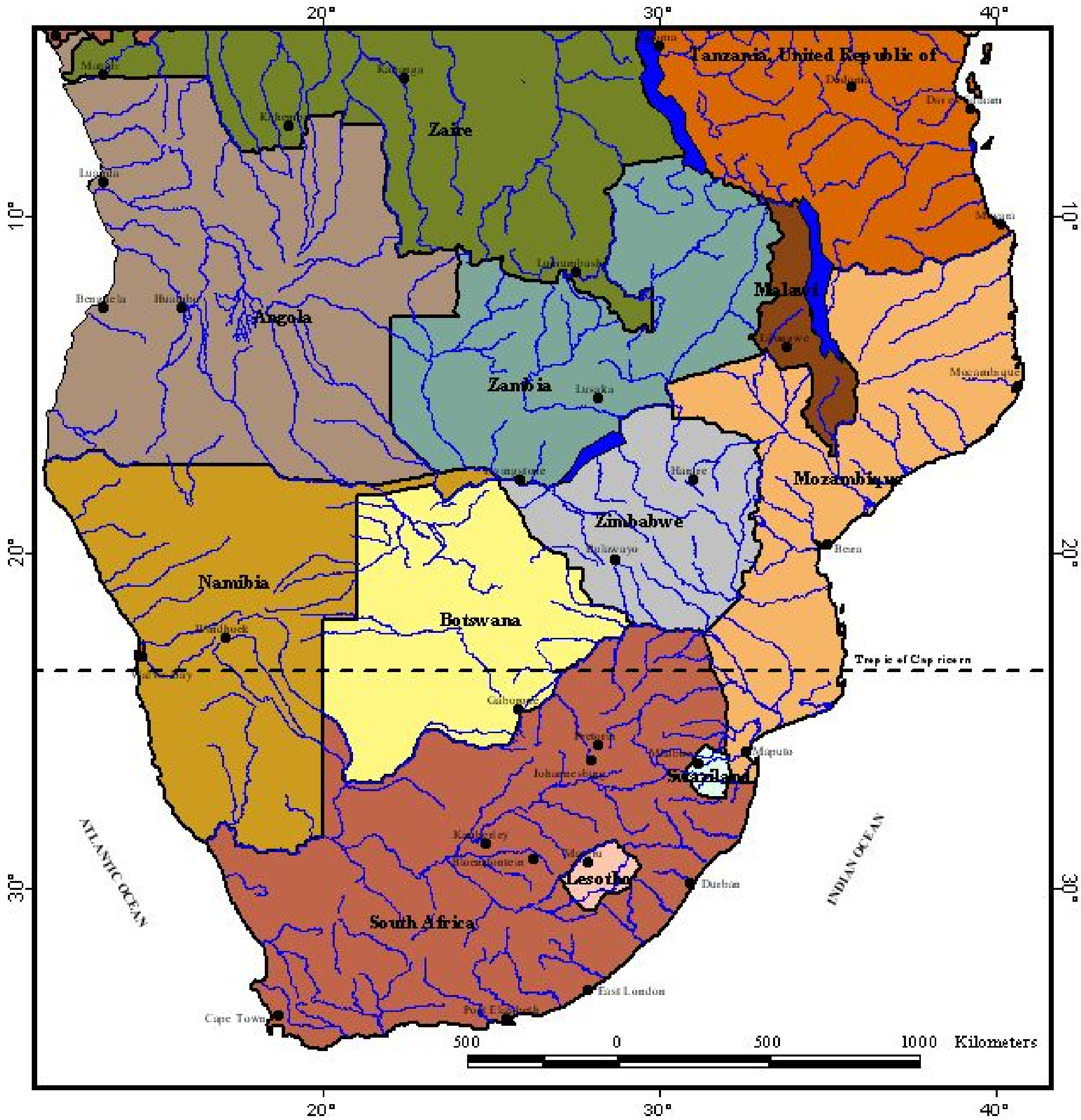

Figure 1: **Location of Botswana**

The Okavango River drains inland from the country of Angola forming the Okavango Delta and the Chobe/Linyanti rivers. The two river systems form the major perennial surface water and constitute 95% of the country's water (Government of Botswana, 2001). The Limpopo basin in the eastern fringe of the country covers 20% of the total basin area. The head waters of the Limpopo basin are in South Africa. All ephemeral sources found in the east drain towards this basin and the Marco River in South Africa. The Orange basin in the southern fringe of the country covers about 20% of the total basin area. The Orange River basin has a minor tributary, the Molopo River, at the South African and Botswana border and receives its water flows from northern part of South Africa. The Zambezi basin in the northern extremity of the country covers less than 5% of the total basin area. The Zambezi River originates in Zambia and forms the border between Botswana and Zambia.

Approximately two thirds of the country is covered by aelion Kalahari sands known as the sandveld, which are generally known to be infertile, while the remainder of the country has a more diverse and harder geological base, known as the hardveld (Government of Botswana, 2001). The major soil group of the sandveld is the Arenosols, which are generally deep, fine textured soils with a low nutrient and water holding capacity. The hardveld is characterized by more than one soil grouping.

Botswana's annual rainfall is low, and has a high spatial and temporal variability, with the mean annual rainfall ranging from about 650 mm in the north to less than 250 mm in the south-western part of the country (Government of Botswana, 2001). The rainfall occurs in the summer months of October to April and usually falls as localized showers and thunderstorms. The dominant features of Botswana's climate are its dryness and high temperatures which cause annual evaporation to be three to four times the annual amounts of rainfall in most parts of the country (Government of Botswana, 2001). The mean annual temperatures vary from 20^0 C in the south west to 23^0 C in the north. The average daily maximum temperature ranges from 18^0C in July in the north and east to 21^0 C in west and south-west, while the average daily minimum temperature in January ranges from 12^0 C in the north and east to 15^0 C in the west and south west (Government of Botswana, 2001).

Most of Botswana's natural vegetation can be classified as savanna grassland with a more or less developed tree layer. The major specific vegetation types are bush savanna, which cover most of the northern part of the country, tree and bush savanna, which cover a broad area trending north west to south east in the centre of the country, mopane woodland, which is found in the belt to the north of tree and bush savanna, arid shrub savanna in the extreme south west, dry deciduous forest in the extreme north and small area of grassland around the Okavango Delta and the Makgadikgadi pans (Government of Botswana, 2001).

2.2.2 The economy of Botswana

At independence in 1966, agriculture was the dominant economic activity, contributing 40% of the Gross Domestic Product (Government of Botswana, 2001). However, since the discovery of minerals in 1967 and in the subsequent years, the composition of GDP changed significantly (Table 1). The other contributing sectors to total GDP are manufacturing, water and electricity, construction, trade hotels and restaurants, transport and communication, banks, insurance and business services, social, personal services and general government.

Agricultural contribution to GDP has been declining. For instance, in 2001/2002, the agricultural contribution to GDP declined to 2.5 % (Republic of Botswana, 2003a). Much of the decline has been attributed to low and erratic rainfall, recurrent droughts and uneven distribution of land resources. Despite the poor economic performance of agricultural sector lately, it still remains an important source of food, income, employment and capital formation for the majority of the rural population. For instance, agriculture provides about 20% of employment generated within the country, and about half of the population depends on arable farming for its income (Republic of Botswana, 2000a).

Table 1 Sectoral shares of GDP (%) (Current prices)

Sector	1992 / 1993	1993 / 1994	1994/ 1995	1995/ 1996	1996/ 1997	1997/ 1998	1998 / 1999	1999/ 2000	2000 / 2001	2001/ 2002	2002/ 2003	2003/ 2004
Agriculture	4.9	5.1	3.9	4.1	3.4	3.4	3.0	2.7	2.6	2.5	2.4	2.6
Mining	33.8	43.4	33.8	33.8	38.9	38.0	31.1	33.6	35.2	35.1	34.8	30.7
Manufacturing	4.8	4.7	5.0	5.1	5.0	5.0	5.2	5.0	4.7	4.4	4.3	4.2
Water & Electricity	2.3	2.6	2.2	1.9	1.8	1.8	2.1	2.3	2.4	2.3	2.6	2.5
Construction	6.5	7.8	6.3	6.2	5.7	5.7	6.3	5.7	5.5	5.4	5.4	5.8
Trade, Hotels & restaurant	5.3	9.7	9.6	10.1	10.1	10.0	10.9	11.0	11.1	11.4	11.5	11.4
Transport	3.7	4.5	3.8	3.6	3.2	3.3	3.8	3.8	3.8	3.8	3.5	3.4
Banks, Ins &Buss. Servs.	9.7	12.5	11.0	11.4	10	10.3	11.2	11.1	11.2	11.4	11.3	11.6
General Government	15.7	18.7	15.4	14.9	14.0	14.5	17.4	16.5	15.9	16.5	16.6	17.5
Social & Pers. Services	4.4	5.2	4.4	4.3	3.8	3.7	4.0	4.0	3.9	3.9	3.8	3.9
Total value added	91.0	94.3	95.4	95.5	96.0	95.8	95.1	95.5	96.3	96.7	95.6	93.4

Source: Republic of Botswana (2004a)

The mining sector has for a long time been the largest contributor to total GDP **(**Republic of Botswana, 2004a; Table 1). During 1991 to 1997, the mining sector contributed over 30% of the GDP. In 1993/94 prices, GDP grew marginally from P16.254 billion in 2000/2001 to P16.911 billion in 2001/2002 (Central Statistics Office, 2001).

The growth rate of the non-mining sector output increased from 4.0% during 2000/2001 to 5.5% in 2001/2002 with the manufacturing sector registering a very low output growth of –0.4% in 2000/2001 and 0.2% in 2001/2002 (Central Statistics Office, 2001). Trade, hotels, and restaurant sector registered a growth rate of 8.2% during 200/2001 as compared to 6.5% recorded in 2001/2002, while Social and Personal Services sector registered a growth rate of 6.2% during 2001/2001 as compared to 2.8% recorded in 2000/2001 (Republic of Botswana, 2003a).

In terms of trade, diamond exports reached P10 billion in 1999, compared to P6 billion in 1998 (Republic of Botswana, 2000b). This represented more than 70% of the total exports (Table 2). Other principal commodities are meat and meat products, live animals, hides and skins, copper nickel matte, textiles, soda ash, vehicle parts and other goods. Botswana remains an importer of a number of export commodities. The principal import commodities include food, beverages and tobacco, fuels, chemicals and rubber products, wood and paper products, textiles and footwear, metals and metal products, machinery and electrical equipment and vehicles and transport equipment. The share of manufacturing and electrical equipment to total imports was highest (22.2%) during 2000, followed by food beverages and tobacco (14.1%) during the same year (Table 2). During 2002, the shares of these import commodities were 14% and 21.6%, respectively.

Table 2: **Percentage contribution to total export and import by most important items (1994-2002).**

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002
Exports									
Meat & meat products	3.7	3.0	2.5	2.2	3.4	1.8	1.9	2.6	0.83
Diamonds	74.9	67.0	70.4	73.8	69.5	79.4	82.3	84.5	87.1
Vehicle and parts	6.1	16.1	14.1	11.4	11.1	5.5	2.0	2.01	2.6
Imports									
Food beverages & tobacco	17.7	15.9	16.9	13.1	13.1	13.9	14.1	14	14
Machinery & electrical equipment	17.6	15.7	16.1	17.6	21.2	21.1	22.2	19.7	21.6
Vehicle and transport equipment	12.0	18.6	14.1	20.0	16.3	13.5	12.4	12.2	13.3

Source: Republic of Botswana (2004a)

The tourism sector is one of the most important activities in Botswana's economy and is currently the fastest growing sector in the economy (Government of Botswana, 2001). The contribution of tourism to GDP has increased from 2.5% in 1996/97 to 3.6% in 2000/2001 and to 3.8% in 2001/2002 (Republic of Botswana, 2003a). In view of government policy on economic diversification, the tourism industry is regarded as having the greatest potential of all other sectors in the economy. For the year 2003, tourism expenditures was estimated at 1.8 million Pula (US$356 million) which represents an average annual growth rate of 15.3% over the past five years (Tourism

Statistics, 2003). Tourism revenues are due to a high number of tourists visiting the country (Table 3).

Table 3: **Tourist arrivals from the top 10 countries**

Country/Year	1999	2000	2001	2002	2003
RSA	393 528	507 610	478 044	407 247	438 605
Zimbabwe	245 630	311 452	319 174	401 424	432 334
Zambia	28 888	40 343	36 681	44 644	48 082
Namibia	39 952	40 429	36 681	34 814	37 495
USA	9 871	23 967	21 971	15 238	16 411
UK	15 519	22 868	19 283	18 077	19 464
Germany	8 209	13 317	8 875	8 640	9 305
Netherlands	4 460	7 038	6 030	5 161	5 558
Australia	5 577	8 217	5 756	5 488	5 911
France	3 219	4 562	4 358	3 679	3 962
Other countries	88 461	123 993	11 992	92 146	99 241
Totals	***843314***	***1103796***	***1048845***	***1036558***	***1116373***

Source: Tourism Statistics, 2003

Tourism is predominantly wildlife based. The wildlife resources of Botswana are concentrated in national parks and game reserves, which cover over 17% of Botswana's land area. Payments of various taxes and fees related to the use of tourism resources are among the most important income earners for government (Table 4). Some of these payments include corporate taxes, airport tax, social tax, personal/individual tax, sales tax, park fees, entry fees, vehicle license fees, lease rentals, trophy fees and resources royalties (Mothoagae,1997).

Table 4 Revenue by type of fee from national parks (1999- 2001) (Botswana Pula)

Type of fee	1999	2000	2001	2003
Entry	7 856 191	12 927 576	15 687 296	1 3693 546
Camping	1 697 323	1211535	1 589 556	988 432
Vehicle	540 622	1 238 267	1 550 044	1 072 555
Boat	5 700	2 620	5 490	5 860
Aircraft	10 690	26 994	80 252	46 900
PARRO[1]	11 67 731	864956	1 173 152	66 500
Other	5 226	552	1 000	835 215.5
Total	**11 283 483**	**16 272 500**	**20 086 790**	**1 670 9008.5**

1 PARRO: Parks and Reserve Reservation Office

Source: Annual Reports for Parks and Reserve Reservation Office 1999-2003

Although Botswana has maintained one of the world's highest economic growth rates since independence, the distribution of income in the country remains highly unequal and poverty affects a wide spectrum of people. According to Republic of Botswana (2000b), income inequalities are mainly due to uneven availability of income-generating activities and gender differences. The 1993/1994 Household and Income Survey estimated that the richest 20% of the households received 61.2% of the total national income, while the poorest 40% of households received only 9.4% (Republic of Botswana, 2000b). In 1995/96, the Household and Income Expenditure Survey estimated the Gini Coefficient to be 0.556 for all income and 0.703 for cash income. The extent of the income inequality is still very high when evaluated by world standards (Central Statistics Office, 2001). The government of Botswana has therefore adopted a National Strategy for Poverty Reduction of 2003 (Republic of Botswana, 2004b).The strategy is to guide all initiatives which are aimed at eradiating poverty.

While the problem of unemployment is still widespread, Republic of Botswana (2004b) indicates that about 15000 formal sector jobs have been created from 2001 to 2003, and this represents 2.7% of employment growth per annum. When compared to growth of 5%, of formal employment between September 1998 and September 1999, this shows some growth improvement (Central Statistics Office, 2001). Through the Citizen Entrepreneurial Development Agency (CEDA) which was incepted in 2001, the government expects to create more jobs throughout the country (Republic of Botswana, 2004b).

The Population and Housing Census of 1991 estimated the population of Botswana at 1 327 million, with a growth rate of 3.5%. The 2001 Population and Housing Census estimated the population of Botswana at 1,680 863. The annual growth between 1991 and 2001 is 2.38% compared with 3.5% between 1981 and 1991 (Central Statistics Office, 2001). The main features of the Botswana's population are that it is small in relation to the size of the country, it grows very rapidly as a result of high fertility rates and its age structure is youthful (Republic of Botswana, 2004b) and is characterized by a high rate of urbanization. HIV/AIDS has had a significant impact on the population growth**.** During 2000, the national prevalence rate of HIV/AIDS was estimated at 38.5% (UNDP, 2002).

2.2.3 The relevance of the study to the economy of Botswana

Although not reflected in the GDP, the economic values of some goods and services provided by the Okavango Delta are important for the well-being of the society. As indicated in chapter 1, if the Okavango Delta is adversely affected by human use, it may no longer be an important destination for a large number of tourists who are a source of foreign earnings. At the local level, the Okavango Delta is important for the creation and realization of employment benefits and local business opportunities through tourism (Hitchcock, 2002; Schudder, et al., 1993; Republic of Botswana, 2001). Due to a likely reduction of income generated from tourism activities as a result of external impacts, there will be concomitant reductions in employment opportunities for the local population which in turn will result resulting in increased unemployment and poverty. Thus, there will be reduction in the standard of living of the people.

2.3 The Okavango Delta

The Okavango Delta is a relatively undisturbed ecosystem that supports both terrestrial and aquatic forms of lives. The delta occupies a significant place in the economy of Botswana as it supports the tourism industry and subsistence activities of the communities living around it (Rothert, 1997).

2.3.1 Location and resources

The Okavango Delta is found in the North West District of Botswana, with coordinates: $18^{0}\ 29^{1} - 20^{0}\ 12^{1} S$ and $22^{0}\ 12^{1} - 23^{0}\ 45^{1}\ E$ (Government of Botswana, 2001; Figure 2). It is the largest inland wetland known in Africa for its large quantities of fresh water spreading over lagoons and channels (Ashton et al., 2003) and not flowing to the sea. The delta's maximum extent is approximately 22 000 square kilometres (Monna, 1999).

Based on flooding frequencies, the delta can be partitioned into five main regions, which are perennially flooded swamps (4887 sq. km), seasonally flooded swamps (3855 sq. km), seasonally flooded grassland (2760 sq. km), intermittently flooded areas (2502 sq. km) and dry land (1842 sq. km) (Ashton et al., 2003). The Okavango Delta fluctuates in area from 6000-8000 sq. km during the dry season to over 15000 sq. km during the flood season (Ashton et al., 2003) (Figure 3 and 4).

The source of the Okavango Delta waters is the Okavango River, whose headwaters are in the highlands of Angola, where it is called Cubango River. The Cubango River enters Botswana as the Okavango River at a place called Mohembo (Ashton et al., 2003). After entering Botswana, the Okavango River flows through a narrow swamp called the Panhandle, and disperses its water into the delta shaped systems of swamps and distributary channel consisting of three major channels of Thaoge, Jao/Boro and Nqogha/Maunachira (McCarthy et al., 1998; Ashton et al., 2003; Republic of Namibia, 1997).

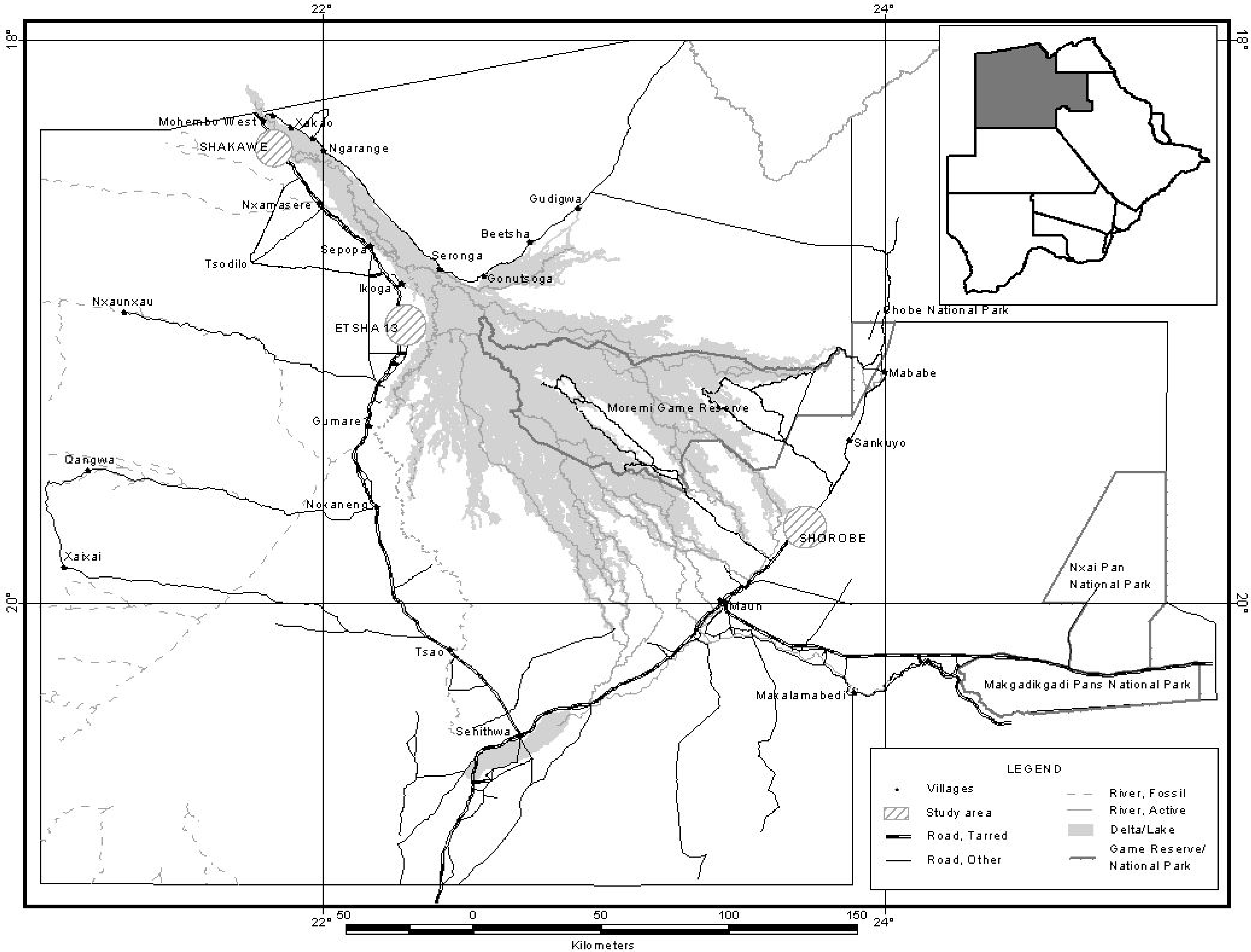

Figure 2: **Map of the Okavango Delta**

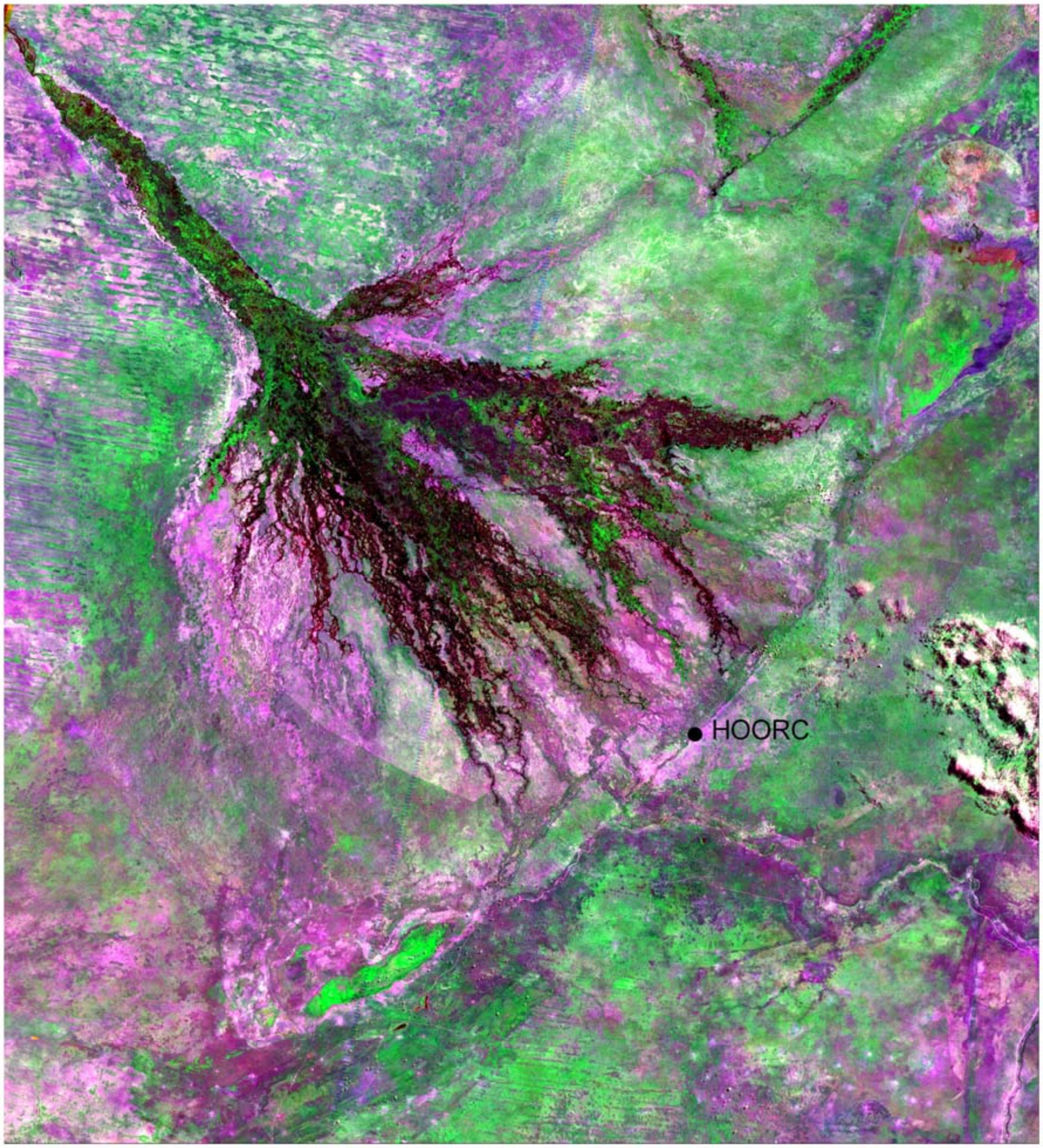

Figure 3: **A Satellite image of the of the Okavango Delta during the wet season.**

The Thaoge channel carries water to the western delta; Jao/Boro to the central delta and Nqoga to the eastern delta (Republic of Namibia, 1997). Of the water entering the Panhandle, the Thaoge, Jao/Boro and Nqoga/Maunachira account for 60% of the discharge, the remaining 40% is lost by leakage channel margins (Republic of Namibia, 1997). The annual inflow at Mohembo varies from 6 000 million cubic metres to 16 000 million cubic metres with an average of 10 000 million cubic metres (Republic of Namibia, 1997). The annual flow is very seasonal. Rainfall contributes 2000 million cubic metres to 8000 million cubic metres per year. The peak flow is normally recorded in April and has an average of 650 m^3/s, and the lowest flow is recorded in November with an average of $150m^3/s$ (Republic of Namibia, 1997). The majority (97%) or 2172 mm of this inflow is lost mainly by evaporation while groundwater seepage contributes a very small amount to this total loss (McCarthy et al., 1998; Gumbricht et al., 2004).

The climate of the Okavango Delta region may be described as dry, semi-arid with very high temperatures and a pronounced dry winter season (Masundire et al., 1998). Minimum temperatures occasionally fall to around zero during winter. The mean annual rainfall over the Okavango Delta is 513 mm. The rainfall is very variable and ranges from a low of 288.3 mm to a high of about 800 mm (Republic of Namibia, 1997). Rainfall is usually in the form of thunderstorms of short duration, and occurs during the months of October to March (Masundire et al., 1998). The rate of evapotranspiration is high due to high temperatures. The winters are dry and mild. The driest months are June and July, and the mean monthly temperature during these months is about 16^0 C (Government of Botswana, 2001). The summers are hot, and the hottest month is October.

The vegetation types found in the Okavango Delta region are determined by the flood water regimes of the perennially flooded area, seasonally flooded areas and intermittently flooded areas and the dryland area (Hudson-Murray and Parry, 1997)**.** The vegetation in the region can be described as dry savanna. In the perennial swamps, the dominant vegetation (tall emergents) is papyrus species, *Miscanthus junceus and Phragmites australis* while the emergent communities are dominated by a variety of grasses and sedges (Government of Botswana, 2001). The dryland is characterized by mixed stands of trees, grasses, shrubs and forbs. In the small islands the vegetation includes *Ficus verruculosa, Syzygium cordatum*, tall broad leaved evergreen trees such as *Ficus natalensis, Diospyros mespiliformis, Garcinia livingstonei and Phoenix reclinata,* while the vegetation in the large islands and the sandveld tongues can be described as open shrublands and woodlands (Ellery and Ellery, 1997).

2.3.2 Social and Economic Significance of the Okavango Delta

The Okavango River, which is the source of the Okavango Delta, holds the largest wetland and freshwater reserves of the country and supports the livelihood of many communities (Gumbricht et al., 2004; Ashton et al., 2003; Silvius et al., 2000; Rothert, 1997; Neme, 1997). According to Rothert (1997) 'over 70 percent of the riparian community households collect water directly from the Delta in the dry season; 75 percent of the households collect fish, edible or medicinal plants from the Delta, and nearly 20 percent of households conduct farming in the Delta flood plains.'

The Okavango Delta is particularly important as one of the largest remaining inland wetland ecosystems in the world today because it is a habitat for a variety of species of plants and animals. It is believed that the Okavango Delta is a habitat for between 2000 and 3000 species of plants, more than 65 species of fish, over 162 arachid species, more than 20 species of large herbivores and over 450 species of birds (Monna, 1999).

The Delta also supports a large tourism industry as is evident from the build-up of more lodges and increasing tourist visitors from all over the world (Table 5). The Delta's main tourism attractions relate to its complex mosaic of dryland, island frindge and wetland habitat and associated wildlife including big game, birds, fishes, reptiles and amphibians (Masundire et al., 1998; Ashton et al., 2003). Over 400 species of birds have been recorded and the opportunity to observe rare species and/or large numbers of particular birds is an integral part of the Delta's visitor's experience (Masundire et al., 1998). One of the game reserves, Moremi (3880 sq. km), located in the northern eastern part of the Okavango Delta, is an area of considerable ecological diversity and scenic beauty particularly with its wilderness combinations of water, riverine woodland and wildlife (Barnes, 1998). Thus, the principal attraction is the opportunity to view animals in their natural environment.

The Okavango Delta has become a major attraction for recreation, (Gumbricht et al., 2004). It provides appealing scenery and novel recreational activities that include canoe rides, site-seeing, motor boat cruises, and game fishing (Rothert, 1997; Mbaiwa, 2002). The river system provides a medium for traditional transport and communication, primarily through the use of boats. The dug–out canoe has been adopted by the tourist industry as a way for tourist to experience the Delta (Cassidy, 1997). Opportunities exist for short duration of two to four day-camping trips by boats.

Although tourism contributes significantly to the country's GDP, it is reported that tourism links with other economic sectors are not clearly defined in the traditional categorization of economic activity shown in the national accounts (Republic of Botswana, 1999). As a result, services such as inland water transport by boat operators are not included in the national accounts. Notwithstanding this situation, it has been shown by Republic of Botswana (1999) that tourism has strong links with certain sectors of the economy as shown in Table 5.

Table 5: Tourism related share of GDP at market prices 1996/1997

Economic Activity	Tourism related output	
	P million	**Percentage of total**
Agriculture	3.1	0.5
Mining	0.5	-
Manufacturing	17.1	3.0
Water and electricity	1.6	0.3
Construction	4.9	0.8
Trade, Hotels and Restaurants	331.1	57.3
Hotels and Restaurants	248.5	43.0
Wholesale trade	52.6	9.1
Retail and other trade	30.0	5.2
Transport	51.7	8.9
Banks, Insurance and Business services	49.5	8.6
General Government	48.5	8.4
Social and Personal services	70.4	12.2
Tourism related GDP	578.4	100

Source: Republic of Botswana (1999)

The Okavango Delta is also economically important as a source of water for north central Botswana (Government of Botswana, 2001) and water availability has greatly influenced settlement patterns in the region. However, the open access use of water in the Okavango Delta makes it difficult to record water consumption by economic sectors such as agriculture, tourism or mining (Zambo, personal communication, 2003).

Direct use of the water from the delta depends on whether or not there is a water reticulation system in a village community and the extent to which such reticulation functions (Applied Research Development Consultants, 2001). Riparian communities are more likely to use more water directly from the river than non-riparian communities. Based on North West District Council's manual on estimations of daily water needs of the population in the area, 787m^3 of treated surface water is extracted daily from the Okavango Delta to meet the needs of 18 villages in the area. A total of 1229m^3/day is supplied through 36 boreholes to meet the needs of some other 26 villages. It is assumed that since all boreholes are situated along the Delta, they are recharged by the Delta.

Much of the surface water from the Okavango Delta is not priced, and as such, the GDP fails to account for the non-marketed value of surface water. Only water that is supplied by the Water Utilities Corporation by metering and that which is provided through private connections by the Department of Water Affairs is reflected in national accounts. The latter is very common in major villages such as Maun, which is currently the largest village in the country, and capital of the North West district. Maun village water supply is dependent on the flood outflows from the Delta to recharge the aquifer.

The Delta also indirectly supports arable and livestock agricultural activities. Two systems of arable farming are practiced: dryland and floodplain agriculture. In dryland agriculture, the source of moisture is rainfall. In floodplain agriculture, crops are planted on the fringes of the Delta to make use of residual moisture in the soil and then sustained by summer rains (Bendsen, 2002). According to Kgathi (2002), there were a total of 11 200 dryland cultivated farms and 2118 floodplain agricultural farms in the region in 1998. The average size of these farms is 2.2 hectares, while the national average is 4.4 hectares. Irrigated agriculture in the area is limited to two commercial farms that are located near the Panhandle area, and the size of the land under cultivation is approximated at 137 hectares. The amount of water used for irrigation purposes is, however, unknown (Tawana Land Board, 2001).

The primary means by which the Delta supports livestock is through provision of grazing grounds and water. Most of the aquatic habitats have vegetation which comprise grass and herb species which are highly palatable to livestock (Kwerepe, 1995). Before the outbreak of cattle lung disease in 1995/96 that led to the killing of all livestock (cattle mainly) in the region, the Delta waters supported an estimated head of 318 000 cattle. Restocking by an estimated 100 000 cattle was done after complete eradication of the disease (Alberton, 1997). In 1998, there was a total of 192 540 cattle, 1487 sheep, 5869 goats and 5122 donkeys in the area (Central Statistics Office, 2001). Using the North West District Council's water consumption estimates of 50 litres per head of cattle, 5 litres per sheep per day, 5 litres per goat per day and 20 litres per donkey per day), the estimated livestock's consumption of water converts to a rough estimate of 4 746 920 litres per day. Considering the average annual discharge of $1.64x10^{10}m^3$ (Gumbricht et al., 2004), the percentage of livestock water use to total water supply would be about 10.6. When considering that 97% of surface water is lost through evapotranspiration (Hichcock, 2002; Gumbricht et al., 2004), the percentage of livestock water use to total water usage is expected to be higher.

The Okavango Delta also supports the well-being of many people through the provision of various veld products, fish and wildlife hunting. Veld products collected include craft products, such as palm leaves (*Hyphaene petersian)* grapple plant (*Harpagophytum procumbens),* thatching grass (*Eragrostis pallens, Aristida stipitata, Cymbopogon excavatus* and *Eragrostis pallens),* reeds, floristic materials, various fruits and firewood. In 1999, P22 million (US$4.75 million) worth of crafts from Botswana was sold (Terry, 2000).

Fish is exploited at three levels: subsistence fishing, commercial and sport fishing. According to Mosepele (2001), 65% of Ngamiland north population depends on fishing and that the total annual economic turnover in the Okavango fishery is approximately P1.5 million. There are several safari camps and mobile operators offering fishing as part of their tourist package in many areas of the Delta. According to Merron (1995), the value of recreational fishing generated through tourist fishing activities is in excess of P750 000.00.

2.3.3 Property right regimes in the Delta

The use of resources by different entities such as government or communities, results in different management regimes for those resources. Four property rights regimes are recognised in Botswana: open access, common property, state property and private property (Kgathi, 2002). State property regime refers to situations where resource use is controlled by the state. Wildlife resources in national parks and game reserves, which are abundant in the Okavango Delta region, are owned and controlled by the state government through the Department of Wildlife and National Parks (DWNP). The Department's responsibility is to ensure the conservation of indigenous wildlife and habitat in national parks and game reserves through minimal interference, ensure conservation of biodiversity throughout Botswana in the interest of present and future generations, promote research in all areas related to management of wildlife resources in Botswana, raise public awareness and appreciation of Botswana's unique wildlife resource, and involve communities, NGOs, and the private sector in the realization of the full economic potential of wildlife resources outside the protected areas through sustainable utilization.

Open access resource regime refers to a situation where there are no restrictions or regulations on resource use as the resource is not owned by any person or institution (Pearce and Turner, 1990; Prato, 1998). It is generally argued that under open access regime, there is a market failure that ensues from the inability to adopt the right measures to conserve and sustain resources (e.g. Perman et al., 2003). As a result of this inability, the negative effect of greater harvesting pressure on the resource results in a falling population of the harvested biological species which eventually leads to lower levels of the supply of the resource (Barbier et al., 1997). The use of resources such as grazing on flood plains, fishing, surface water for domestic and livestock purposes, and veld products (thatching grass, reeds, basket weaving resources) is theoretically controlled by the state, but it is in practice on an open access basis (Hasler, 2001; Rozemeijer and van der jagta, 2000). Contrary to open access use of water resources, the rights to use boreholes are essentially determined by de facto rights as boreholes are owned by individuals or organizations that have invested substantial amount of labour and capital resources in having them (Hitchcock, 2001).

Common property resource regimes are those regimes whereby resources are owned and controlled by a defined group of people such as a community for the benefit of that group (Pearce and Turner, 1990). The management regime under common property is often considered to be a sustainable system of resource management in the sense that group members have secure expectation that they can gain access to future use, which is ensured by the existing guidelines for resource use and enforcement mechanisms for punishing deviant behaviour (Tietenberg, 2000).

The Botswana Government's recent efforts to implement community based natural resources management programs has resulted in some changes in the previous resources management regimes, particularly in the management of wildlife resources in controlled hunting areas. The management responsibilities of wildlife resources in these areas has been decentralised to the communities who have organized themselves into legally registered entities such as trusts so that they can better realize the benefits from such resources (Rozemeijer and van der jagta, 2000). Communities wanting to have access to wildlife resources in controlled hunting areas are bound to have a constitution and bylaws that define the natural resources management functions and accountability and responsibility towards the community members as well as land-use management plans that conform to Wildlife Management Areas regulations as approved by the land authority (Rozemeijer and van der jagta, 2000). Community Based Organisations (CBO) assist the communities in the drafting of these documents. Following the approval of a community application by the Department of Wildlife and National Parks, a community is given a 15 year lease for the area, which is reviewed after every five years. The lease essentially entitles the community to exclusive access to wildlife resources in the area. However, the lease is not for the land but for governing the use of natural resources in that area. The community will now be in a position to invite private companies to tender for the area. The company that wins the tender will then sign a sublease with the community that outlines the responsibilities of each party. The company that has won the tender and signed a sub-lease agreement with community will then have exclusive rights to operate in the designated controlled area. While the company has exclusive right of use during the sublease period, it pays annual fees, such as hunting fees to the community as agreed in the lease arrangements (Rozemeijer and van der jagta, 2000). At the end of the sublease period, the community may opt to tender the area again or renew the sub lease agreement with the previous partner.

2.4 Overview of Natural Resources Management Policies, Programs and Acts

The Government of Botswana recognizes that its natural resources need to be used in a sustainable manner in order to meet some of its social, economic and environmental goals. Motivated by this concern, the government has formulated a number of policies and programs to achieve these goals. This section gives a review of these programs and policies, particularly as they pertain to the management of natural resources in the Okavango Delta.

2.4.1 Water Resources

Water is an important development constraint in Botswana. According to the Water Act of 1968 (Cap. 34:01), no person has a right of ownership of public water, including groundwater, water in any natural streams, rivers, lakes, pans or swamps. The use of water, including that of pumping from a river and building a dam near a river, requires application and approval from the Water Appointment Board. The Act also controls pollution of public water and requires the permission of the Water Registrar for the introduction of any poison in public water to which a member of the public may have access. Okavango Delta waters are open access resources, and any person using the water for domestic and livestock watering purposes does not have the right to exclude other people from using the water (Hitchcock, 2002). However, in the case of using water for irrigation purposes, the user is required to make an application to a Water Appointment Board for approval

2.4.2 Tribal Land

The Tribal Land Act (Cap. 32:02) was established with a view to effectively control the use of land resources in the country (Republic of Botswana, 1968). Under this act, the Land Boards, which are the land custodians, can grant land under customary law and common law. User rights can only be given under customary law. These rights pertain to arable agriculture, residential, business, and to a small extent, grazing (Hitchcock, 2002). Under common law, grants can only be given in the form of written agreement between the Land Board and the applicant (Cassidy, 2000). The Panhandle area is an important but little known component of the Okavango Delta, with unique flora and fauna. In an effort to maintain the ecological integrity of the panhandle area, the Land Board has taken an important step of not allocating land for any purposes within 100 metres of the water mark. Further, a study aimed at developing a management plan for the Okavango Delta and developing management recommendations for areas within and on the periphery of the panhandle, has been commissioned (Tawana Land Board, 2001).

2.4.3 Agricultural Resources

The Agricultural Resources Board (ARB), the custodian of agricultural resources in the country, was established by the Agricultural Resource Conservation Act of 1972 (Cap. 35:06). The aim of the act is to achieve sustainable utilisation of natural resources, most of which are veld and agricultural resources. In some areas, the ARB is working closely with Village Conservation Committees, who act as law enforcing agents. However, not all villages have conservation committees. In the village of Etsha, in the Okavango Delta, the Village Conservation Committee is actively involved in regulating the exploitation of palm tree, *Hyphaene ventricosa*, which is used for basket making (Hitchcock, 2001).

2.4.4 Fish resources

Fish protection is under the control of the Ministry of Agriculture. The Fish Protection Act of 1975 (Cap. 38:05) empowers the Minister of Agriculture to regulate the species and quantities of fish harvested and the methods of harvesting of fish. The act also prohibits the use of explosives, poisonous or noxious substances as a means of catching fish easily. Fishing activities in the Okavango Delta are controlled by the Fisheries Division of the Ministry of Agriculture. The government provides support for fishing activities in the form of fishing equipment such as gillnets, boats and assisting in fish marketing (Hitchcock, 2001). By virtue of its position, the Fisheries Division controls the sizes of fishing nets in order to avoid over-exploitation of fish resources of the Okavango Delta.

2.4.5 Conservation and utilization of wildlife

According to Republic of Botswana (1986), the government position is that wildlife resources must be seen in terms of their potential contribution to the economic well-being of the nation and in terms of their heritage and aesthetic value. Accordingly, the government formulated the Wildlife Conservation Policy of 1986 with the objectives of realising the full potential of the wildlife resources; developing commercial wildlife industries (such as ostrich farming) in order to create economic opportunities, jobs and incomes for rural populations and to enable more rural dwellers to enter the modern economy; and increasing the supply of game meat as a consequence of the further development of wildlife commercial utilization.

As a practical strategy towards the implementation of the Wildlife Conservation Policy, the Ministry of Local Government and the Department of Wildlife and National Parks re-zoned controlled hunting areas, which are administrative blocks for allocating hunting quotas, in order to establish areas in which better management of wildlife resources would be undertaken. (Rozemeijer, 2001). Most of these areas are found in the Okavango Delta region, and include commercial multipurpose areas, commercial photographic areas, community managed wildlife utilization areas, community photographic areas and community managed wildlife utilization in livestock areas (Republic of Botswana, 1997; Rozermeijer, 2000). The Government of Botswana assumes that communities living in the vicinity of areas with wildlife will manage these resources better when they are given security of tenure and can realise the benefits of management. According to Republic of Botswana (2003b), the Wildlife Policy of 1986 is being reviewed to keep pace with other national development policies and other international agreements.

2.4.6 Tourism

Wildlife and wilderness represent the principal tourist attractions (Republic of Botswana, 1990). The Government of Botswana has established a national tourism policy in 1990 to guide the operationalisation of tourism in the country (Hachileka, 2003). The objectives of the policy are: to increase foreign exchange earnings and government revenues; to generate employment, particularly in rural areas; to raise incomes in rural areas in order to reduce urban drift; to promote rural development and to stimulate the provision of other services in remote areas of the country; to improve the quality of national life by providing educational and recreational opportunities and to project a favorable national image to the outside world. Hotel business has been increasing in the Okavango Delta. Tourism in Botswana is 'described under the policy as 'low volume-high value' which means that to protect the fragility of the ecosystem from high number of tourists, higher entry fees have been introduced (Rozemeijer, 2000). According to Republic of Botswana (2003b), tourism policy is being reviewed to bring it in line with the latest international development on tourism. This entails improvements such as development of infrastructure in wildlife protected areas to enable Botswana's tourist destinations to compete with other international destinations.

2.4.7 The conservation and management of elephants

Botswana has one of the highest elephant populations in the world. The central government has committed itself to ensuring that elephants are used in manner that also benefits communities. One of the greatest threats to elephants is poaching, which is driven by the lucrative ivory trade. The government is committed to conserving elephant population and ensuring that there is a legal and clean trade in elephant products. The

Republic of Botswana (1991) established an act on the Conservation and Management of Elephants in Botswana. The objectives of the acts are: to manage elephants on a sustainable multiple use basis in accordance with the Wildlife Conservation Policy and the Tourism policy; to maintain elephant populations at a level that is not beyond the carrying capacity of the land resources; to maintain elephant populations through research and monitoring; to maintain biodiversity and essential life support systems in the national parks and game reserves; to reduce conflict between elephants and humans and to support and undertake elephant population habitat research and monitoring programs.

In 1989, the Convention on International Trade on Endangered Species (CITES) banned the ivory trade and decided to place elephants in Appendix 1 of the convention (Barnes, 1998). Botswana was among the list of countries that were protesting against this ban because of the huge population of elephants which was threatening to destroy the environment on which they depended. The high population of elephants was also causing land use conflicts in the communities, and government felt that allowing international trade in elephant products would redeem the Okavango Delta and other areas, particularly Chobe, from degradation.

2.4.8 National parks and wildlife conservation

The Wildlife Conservation and National Parks Act of 1992 replaced two previous acts: the Fauna Conservation Act and the National Parks Act. The act describes how wild animals can be used in all areas of Botswana. A number of controlled hunting areas (CHA) have been established. For these areas, permitted activities are listed in the act. Management of CHA depends on certain conditions, such as whether the area is a commercial or a private operator area, or a community area, whether the area is a multi-purpose area or photographic area, whether the area is inside or outside a Wildlife Management Area and whether the area is within state land or tribal land. In Moremi Game Reserve, in the north eastern part of the Okavango Delta, certain areas are designated as community use zones for communities living in or adjacent to the game reserve. Communities are allowed to conduct only commercial tourism activities and to make sustainable use of veld products in the game reserve.

2.4.9 Ramsar Convention on Wetlands

Recognising the Delta's importance and threats, the Government of Botswana ratified the Ramsar Convention and officially registered the Okavango Delta as a Ramsar Wetland of International Importance on 4th April 1997 (Monna, 1999; Rothert, 1997). The Okavango Delta is currently the largest wetland in the Ramsar List of Wetlands of International Importance. The mission of the Ramsar Convention is the conservation and wise use of wetlands by national action and international cooperation as a means of achieving sustainable development throughout the world (Barbier et al., 1997). The benefit of the Okavango Delta being a Ramsar site is that the Government of Botswana is committed to developing management plans and policies guiding its use (Hachileka, 2003; Barbier et al., 1997).

2.4.10 Community Based Natural Resource Management (CBNRM)

The Government of Botswana Community Based Natural Resource Management Policy of 1998 was formulated as an extension of other existing policies and acts such as the Wildlife Conservation Policy of 1986, the Tourism Policy of 1990, Wildlife Conservation and National Parks Act of 1992 and the Agricultural Resources Conservation Act of 1972 (Republic of Botswana, 1997). The aim of Community Based Natural Resource Management (CBNRM) is to provide a means of combining natural resource conservation with social and economic development. CBNRM involves initiatives that are owned by one or more defined communities, or run as a joint venture partnership with the private sector with equitable community participation, as a means of using the natural resources in a sustainable manner to improve their standard of living in an economically viable way (Rozemeijer, 2001). Communities apply to the Department of Wildlife and National Parks (DWNP) to be granted rights over control of wildlife with the aim of deriving benefits from them (Hitchcock, 2002; Republic of Botswana, 1997). The government expects that the benefits derived from the use of natural resources such as wildlife will prompt the community to use the resources in a sustainable way (Rozemeijer, 2001). Several communities in the Okavango Delta such as the Sankuyo community have formed community trusts and undertaken to participate in joint venture projects in the management of wildlife resources after the DWNP has allocated land to the communities.

2.4.11 Conservation and utilization of wetlands

The Government of Botswana has already undertaken some steps towards the development of a wetland policy (Monna, 1999). These include execution and completion of a national wetland inventory, the formulation of issues pertaining to wetlands, stakeholder consultations and consultation with policy bodies of government and drafting of the policy and the strategy. The main goal of the Draft Policy of 2000 is to promote the conservation of Botswana's wetlands in order to sustain their ecological and socio-economic functions as well as providing benefits for the present and future wellbeing of the people living in and near wetlands. The draft policy recognizes the following threats to the wetland of Botswana: changes in land use, invasive plant species, sedimentation due to upstream habitat loss and destruction, uncontrolled exploitation of water resources through commercial exploitation of communal resources such as river sand, alienation of communities living in or near wetlands due to reduced rights of access of resources, and international threats such as global worming and trans-boundary activities (Government of Botswana, 2001).

On-going policy work in the Okavango Delta region includes development of an Okavango Delta management plan under the auspices of the Tawana Land Board. Since the Delta is also a trans-boundary natural resource, the Permanent Okavango Commission (OKACOM) has been formed with membership from Botswana, Namibia and Angola, whose responsibilities include facilitating cooperation in the development and implementation of an integrated management plan of the Okavango Delta.

2.5 Chapter Conclusion

This chapter has given the general physical characteristics of Botswana and those of the Okavango Delta, the large alluvial fan that lies in the northern part of the country (Government of Botswana, 2001). The general physical characteristics are, to a large extent, determinants of the functioning of any natural system and the consequent goods and services that are a product of that ecosystem (Novitzki et al., 1997). As has been shown in the chapter, the sources of the Okavango Delta waters are the Okavango River whose tributaries are in Angola. Together, the Okavango River and the Chobe/Linyanti river systems form the major perennial surface and constitute 95% of Botswana's surface water.

The chapter has also given an overall picture of the economy of Botswana, and the economic and social role played by the Okavango Delta in the total economy of the country. As Rothert (1999) and Gumbricht et al. (2004) have shown, the Okavango Delta contributes significantly through tourism to the economy of Botswana, as well as sustaining the livelihood of riparian communities through the harvesting of water, veld products and other resources such as fish. The Okavango Delta is also source of moisture for flood plain agriculture.

The chapter has also presented a general policy framework and property regime within which resources of the Okavango Delta are utilized and regulated. Some of these policies include Wildlife Conservation Policy of 1986, Tourism Policy of 1990, and Ramsar Convention of Wetlands and Community Based Natural Resources Management Policy of 1998.

CHAPTER 3

REVIEW OF LITERATURE ON NATURAL RESOURCE ACCOUNTING

3.1 Introduction

The purpose of this chapter is two-fold. First, literature is reviewed on capital theory and sustainable development and the state of the art of natural resource accounting and how it has been applied in the management of renewable and non-renewable resources. Second, literature is reviewed on how information related to biodiversity (e.g. ecological monitoring) may be used within the context of natural resource accounting for the conservation and management of biodiversity.

3.2 The concept of sustainable development and capital theory

Development is a process by which the well-being or welfare of a society is improved over some period of time (Pearce and Perrings, 1995). The motivation of environmental accounting has been the adoption by governments of the notion of sustainable development coupled with the understanding that economic activities play a central role in determining whether development is sustainable or not (Lange, 2003b). The World Commission on Environment and Development (1987) defined sustainable development as ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs.’ In terms of resource use, sustainable development does not imply that renewable resources are prevented from being depleted, or even kept at the current or some other level (van Kooten and Bulte, 2000). Rather, it implies that environmental assets should not be depleted, and if they are used, they should not be depleted beyond some limits (Serageldin, 1996). As defined by the World Commission on Environment and Development (1987), sustainable development is an ethical principle because it entails aspects of equity or fair division of access to global resources (Blignaut, 2004; Moffat et al., 2001). Equity therefore appeals to the concepts of freedom and justice (Holmberg and Sandbrook, 1992). Society or individuals should have equal rights of resource access to satisfy their human wants (Blignaut, 2004).

According to this definition, a country can attain a maximum level of development (non-declining human welfare or per capita consumption) without running down its capital assets. While the definition of sustainable development emphasizes non-declining welfare there are challenges to measuring welfare directly. The concept of capital basis for sustainable development has been suggested to overcome this problem as capital stock indicates the ability of an economy to produce output to generate well-being (Alisjahbana et al., 2004). Thus, non-declining welfare per capita is guaranteed by non-declining stock of capital (United Nations, 2003).

The literature on economic growth and exhaustible resources forms the origin of capital theory approach, which is based on the idea of maintaining a constant capital stock as a necessary condition for sustainable development (Stern, 1995). In neoclassical theory, the economic notion of capital stock includes man-made or produced capital (Alisjahbana et al., 2004). However, what constitutes capital is not only man-made capital but also other forms of capital which are human capital, natural capital and social capital/organizational (Turner, 1992; Alisjahbana et al., 2004).). Manufactured or man-made capital comprises goods such as machines, buildings and other infrastructure; human capital refers to the individual capacities for work (Ekins et al., 2003; Perman et al., 2003). Social/organizational capital includes the networks or relationships among individuals or institutions/organizations (Pearce and Atkinson, 1998). Natural capital refers to environmental or ecological resources that provide resources of production and absorb waste material from production. Natural capital comprises basic life support functions and contributes to human welfare through amenity services (Ekins et al., 2003).

Economists worldwide do not ascribe to one single theory of capital growth (Victor, 1991). There are two main components of sustainability differing in their treatment of the substitutability relationship between manufactured and natural capital: weak and strong sustainability. (De Groot et al., 2003; Chiesura and De Groot, 2003; Prugh et al., 1995 Weak sustainability is based on the view of the main stream neoclassical school on capital, that the aggregate stock of capital assets should remain constant over time to ensure that there is no decline in per capita well-being over that time horizon (Pearce and Atkinson, 1998; Cairns, 2000). Since the emphasis of weak sustainability is on aggregate stock of capital stock (Kosz, 1998) it is not necessary to calculate components of total economic value or ecological capital or economic capital to determine if a country is on a sustainable development path. The rule requires that some suitably defined value of services of these stocks should be maintained over time (Hediger, 1999). The implication of aggregating capital is that the degradation of certain types of capital such as natural capital is not given due regard in the quest for attaining overall constant or non-declining capital stock. According to this view, the elasticity of substitution between natural capital and man-made capital is one, and if any of the total assets is reduced, its reduction will be offset by an increase in the value of other assets in order that the unit's income may be sustained (Stern, 1995; El Serafy, 1997; Turner, 1992). This compensation or intergenerational equity is achieved by investing rents from depleted capital into other forms of capital (Lange and Wright, 2004; Collados and Duane, 1999). Thus, the change in the aggregate value of assets at any point in time must be at least zero in the aggregate (Pearce and Atkinson, 1998). This rule has come be known as the Hartwick and Solow rule or the constant capital rule (Pearce and Atkinson, 1998; Lange et al., 2003; Hediger, 1999).

The rule assumes substitution between different reproducible capital and natural capital to ensure that economic growth can be sustained while generating a continuous decline in resource stocks (van Kooten and Bulte, 2000; Prugh et al., 1995; Lange, 2003b; Serageldin, 1996). Substitutability also assumes that it is possible to lump natural capital and manufactured capital and measure then using one common yardstick, which is money (De Groot and Chiesura, 2003). Because of the possibilities of substitution, the proponents of this view do not see any difference between different forms of capital or between the different kinds of welfare which the different forms of capital generate (Ekins et al., 2003). However, there are limits to substitution between natural and man-made capital based on non-utilitarian reasons (Stern, 1995). For instance, if people are asked about their willingness to pay for protection (existence value) they are those who would refuse to do because of moral reasons. Such people are said to be having lexicographic preferences (Kosz, 1998). As a result of this refusal, the valuation founded on neoclassical theory becomes flawed. Thus, the existence of lexicographic preferences does not fit in the assumed model of substitution between natural and man-made capital (Stern, 1995; Kosz, 1998).

The weak sustainability rule also emphasizes technological change and population change. According to this rule, positive technological change can lead to increased output and consumption thereby leading to increased present discounted value of current and future utility from consumption (Arrow et al., 2004; Pearce and Atkinson, 1998). Consequently, declining capital stock is not perceived as a major concern because technological growth will compensate for the decline. In the context of population growth, weak sustainability assumes that the growth in population can improve the well-being of the society by stimulating technological change (Pearce and Atkinson, 1998). However, population growth is also more likely to deplete natural capital as pressure is put on it.

The second view is that of strong sustainability which asserts that is not enough to protect the overall level of capital because some capital is not substitutable (Turner, 1992; Victor, 1991). In other words, minimum amounts of different forms of capital should be maintained independently or separately which therefore assumes that reproducible capital and natural capital are complements rather than substitutes (Prato, 1998, El Serafy, 1997; Serageldin, 1996; van Kooten and Bulte, 2000). The strong sustainability rule is perceived by some environmental economists as a modified view of the weak sustainability rule because in addition to maintaining the *overall value* of capital, the stocks of individual natural capital should not decline (Pearce and Atkinson, 1998; Turner, 1992).

According to this view, the possibility of substitution as assumed by weak sustainability is seriously limited by environmental characteristics such as irreversibility in the context of environmental degradation or loss, scientific uncertainty and the existence of critical components of natural capital (Pearce and Turner, 1990; Ekins et al., 2003; Perman et al., 2003). Proponents of strong sustainability argue that substitutability declines as resources stocks are depleted, and that there are no substitutes for many natural resources such as wilderness, implying that the elasticity of substitution between natural capital and reproducible capital becomes zero (van Kooten and Bulte, 2000).

It is argued that destruction of capital is very rarely irreversible and therefore not always possible to substitute manufactured capital for natural capital (Victor, 1991). This is because natural capital provides some life support functions which cannot be provided by man-made capital (De Groot et al., 2003: Pearce and Turner, 1990). For example, the scale effects of phenomenon such as climate change cannot be compensated for by manufactured capital even in the presence of high level of human knowledge or technology (Ekins et al., 2003). The resources for which substitution between natural capital and manufactured capital is not possible are called critical capital and they are responsible for important environmental functions (Ekins et al., 2003; Prug, 1995; England, 1999; Collados and Duane, 1999). Capital can also become critical because it is threatened or vulnerable (De Groot et al., 2003). However, quantifying the degree of threat to natural systems is not an easy task because a large number of different pressures-state impacts factors should be taken into account (De Groot et al., 2003).The proponents of this school also argue that standard economic valuation techniques can not be used to place a monetary value on this critical capital. Consequently, when there is depletion of critical non-substitutable capital, development becomes unsustainable.

It is also argued under this school of thought that there is scientific uncertainty about how natural processes such as climate regulation operate and how environmental capital, productivity and sustainability relate among themselves (Pearce and Turner, 1990). If it is assumed that natural capital can be given up for man-made capital, without fully understanding how ecological processes operate, it will only be realized that the consequences of such an assumption cannot be reversed once resource degradation has occurred. For example, effects such as species extinction occur once and cannot be reversed (Ekins et al, 2003). Based on limited substitution between manufactured and natural capital, strong sustainability calls for the *precautionary principle* which cautions against the use of renewable resources in excess of their regenerative capacity, imprudent and inefficient use of non-renewable resources that leads to essential functions being unavailable to future generations and using sink functions beyond their assimilative capacity (United Nations, 2003).

3.2.1 Some indicators of sustainability

Literature indicates that there are three indicators of weak sustainability, namely genuine savings, changes in net national product (NNP) and change in welfare per capita (Alisjahbana et al., 2004). Genuine savings is a measure of the true rate of saving in an economy after accounting for depreciation and depletion of capital assets (World Bank, 1997). Hamilton et al., (1997) defined genuine savings as "the sum of net investment in produced assets and human capital and the changes in various stocks of natural resources and pollutants, (valued at the shadow price), marginal changes in pollutants" Thus, the measure of genuine savings is a measure of net increase or decrease in the nation's wealth.

Persistently negative genuine savings indicates that development is not on a sustainable path and the well-being of the nation will decline in the future (World Bank, 1997). On the other hand, if genuine savings is positive, it is an indication that the society is refraining from current consumption, which this leads to an addition to the capital base (Alisjahbana et al., 2004). Pearce and Atkinson (1993) showed that a country will not be on a sustainable path (fails sustainability test) if it is not saving enough to offset depreciation of its capital assets by using the following formula:

$$Z > 0 \text{ iff } S > (\delta_M + \delta_N) \qquad (1)$$

where Z is a sustainability index, S is saving, δ_M is value of depreciation of man-made capital and δ_N is value of depreciation of natural capital.

However, genuine savings does not give an indication as to whether or not the total well-being is declining, and a new measure called change in wealth per capita has been proposed (Alisjahbana et al., 2004):

$$\dot{k} = \frac{d}{dt} = \left(\frac{K}{N}\right) = \frac{K}{N}\left(\frac{\dot{K}}{N} - \frac{\dot{N}}{N}\right) = \frac{K}{N}\left(\frac{\dot{K}}{K} - n\right) \qquad (2)$$

where $\dot{k}$ is growth of capital per capita, K is broadly-defined capital, N is population, n is the rate of population growth, and $\dot{K}$ is genuine savings i.e. net addition to total wealth. From this expression it can be seen that if growth of genuine savings ($\dot{K}$/K) is less than growth of population (n), then the change in welfare per capita ($\dot{k}$) will be negative, implying that the economy is not on a sustainable path (Alisjahbana et al., 2004).

Another measure of sustainability is net national product. Traditionally, net national product (NNP) is the difference between gross national product and depreciation of produced capital. Clearly, NNP does not include natural resource depletion and environmental degradation in the national accounts (Asheim, 2003). This is primarily because it is easier to net out economic depreciation from GNP for those assets which can be priced but not so for resources whose flows cannot be valued using market price (Hartwick, 1990). As a result of this situation, the unadjusted NNP is a misleading sustainability indicator because social welfare may decrease in the long term. According to Hartwick (1990) appropriate scarcity or shadow prices should be used to value flows for natural capital which does not have market prices in order to derive green NNP which takes into account depreciation of natural capital. According to Dasgupta and Mäller (2002), green NNP is not only an important quantitative measure of making welfare comparisons but also a measure of social well-being. Green NNP represents the maximum amount of produced output that can be consumed at a point in time while leaving this measure of wealth constant (World Bank, 1997).

On strong sustainability, the London School thought indicates that the maintenance of different forms of capital means that (i) the physical quantity of natural resources must not change, (ii) the unit value of the natural capital must not change and (iii) the value of the resource flows from natural capital must not change (Pearce and Turner, 1990). Kosz (1998) emphasizes the framework of total economic value as the basis for capturing all the economic values for a natural resource. In the absence of market prices for environmental resources, attaching monetary value to these resources using the willingness to pay (WTP) principle ensures that a common unit of value can be used in maintenance of constant stock of capital (Pearce and Turner, 1990).

While techniques such as WTP can be applied to value natural capital, Özkaynak et al. (2004) question such methodologies on three grounds: firstly, they argue that a single common unit of measurement (money) cannot be used to value complex and interrelated attributes of the ecosystem because of the moral aspects of the environment. Secondly, the measure of the WTP depends on the distribution of income/wealth and preference. Thus, the values are misleading as indicators of sustainability as they have no relationship to the biophysical condition of the ecosystem. Thirdly, the preferences of respondents in WTP surveys are not exogenously determined as assumed by the neoclassical model but are determined by the hypothetical situation as presented to them by the interviewer. Notwithstanding the criticism of putting a monetary value on natural capital, Pearce and Turner (1990) indicate that it remains a useful yardstick.

Proponents of strong sustainability also argue that operationalising strong sustainability cannot be analyzed solely in terms of economic tools since ecological sustainability is a prerequisite for strong sustainability (Perman et al., 2003; Turner, 1992). They argue that physical indicators for sustainability are better measures than economic indicators because they indicate threshold levels of critical capital. An example of such a measure is the change in the level of species which could reflect resilience of an ecosystem (see Perman et al., 2003). However, these indicators have been criticized because they are taken in abstraction and do not become useful for decision making processes (Özkaynak et al., 2004).

3.3 National Income Accounting and its deficiencies

The conventional measures of national income such as Gross Domestic Production (GDP), Gross National Product (GNP) and Net National Product (NNP) and other national income accounts were designed to monitor temporal changes in aggregate economic activities (Prato, 1998; Peskin, 1991). GDP for instance, is a measure of total economic activity, and mostly valuable for indicating the short- to medium-term changes in the level of economic activity in a country (El Serafy and Lutz, 1989). The measures were never intended to be measures of wealth and societal welfare because they do not account for the value of natural resources and changes in environmental and resource conditions upon which all production ultimately depends (Hassan et al., 1998; Peskin, 1991; Turner and Tschirhart, 1999). This is an unfortunate weakness because the natural environment provides the context within which all human action takes place and sustains life-support systems. Not only is the natural environment a life supporting system, it is also the source of raw materials and energy and the ultimate recipient assimilator of wastes of production and consumption (El Serafy, 1997).

The conventional measures of income treat gradual wear of physical capital (machines and equipment) as depletion rather than income, but respond poorly to depletion of natural resources (Peskin, 1991; Prato, 1998). For instance, El Serafy (1997) argues that 'the production of a mineral for a particular year registers an increase in gross national product equivalent to its monetary value and inflates the GDP just as it inflates the gross profits of an enterprise'. However, the resultant depletion of the country's natural wealth due to such production is not recorded in the system of national accounts (Santos and Zaratan, 1997; Hartwick, 1990; El Serafy, 1997; Ryan et al., 2001). Winter-Nelson (1995) also argues that while export expansion has been associated with growth in GDP in most countries, it has often been based on extraction of natural capital without commensurate investment to maintain total capital stock or generate increased production. According to Ryan et al. (2001), depletion in an economic sense results because the value of the resource has been lowered through its use in a productive activity, and the use has reduced the asset's ability to produce in the future. Thus, in the absence of discoveries of fixed resources such as minerals, their extraction and consequent decline will lead to their reduced capacity to generate sustainable income and employment for future generations (Blignaut and Hassan, 2001; Prato, 1998; Ryan et al., 2001; Minnitt et al., 2002; El Serafy, 1989; Winter-Nelson, 1995). It therefore follows that if depletion of a country's mineral assets are not accounted for in the system of national accounts, the national wealth and social welfare in the economy of that country is over- estimated (Blignaut and Hassan, 2001; Hassan et al., 1998; Lange, 2003b). Thus, countries such as Botswana, with mineral dependent economies should strive for economic diversification. The more diversified the economy is, the more resilient it will be in times of economic disturbances (Lange, 2003b).

El Serafy (1989) argues that the basic problem of not taking depletion of natural resources into account is because the true or sustainable income is not accurately calculated by economies based on natural resources. As El Serafy (1997) puts it 'if economists accept the measurement of conventional accounts as valid, and set out to analyze the economic problems of a country that is selling its natural assets on an appreciable scale while counting this as value added, their analysis is likely to be wrong, and the policy measures they prescribe are likely to be unsuitable or even harmful.'
Hicks (1946) quoted by El Serafy (1989) noted that:

> the purpose of income calculation in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves. Following out this idea, we ought to define a man's income as the maximum value which he can consume during a week, and still expect to be well off at the end of the week as he was at the beginning. Thus, when a person saves he plans to be better off in the future; when he lives beyond his income, he plans to be worse off.

> Remembering that the practical propose of income is to serve as a guide to prudent conduct, I think it is fairly clear that this is what the central meaning must be.

Thus, proper measurement of income will guide the person or nation on how much to spend on consumption, hence investment for any particular period in order to maintain a constant or increasing level of income (Santos and Zaratan, 1997). According to Minnitt et al. (2002), any resource based economy in which gross investment is less than resource depletion means that the asset base is being run down rather than being built up. Furthermore, natural resource endowment is being used to fund current consumption. The component of the revenue which is known as the user cost must be deducted from the GDP to arrive at a socially sustainable gross domestic product (Santos and Zarantan, 1997; Winter-Nelson, 1995; Bartelmus, 1999, El Serafy, 1989). To compensate future generations with future stocks as a result of consumption of the natural asset, the deducted component must be re-invested in other forms of capital assets that can provide the same stream of benefits in the future (Blignaut and Hassan, 2001; Kellenberg, 1996). Thus, when the finite flow of user cost is re-invested, it is transformed into infinite income flow which will ensure that the society is not worse-off in the future as result of depletion of its resource base (Santos and Zaratan, 1997). In other words, income will not be a declining asset, which is an essential condition for the maintenance and well-being of the society (Blignaut and Hassan, 2001; El Serafy, 1997).

Conventional measures of national income also poorly reflect efforts to defend against environmental expenditures made to reduce adverse welfare effects of resource depletion and environmental degradation (Peskin, 1991). Prato (1998) proposes that expenditures made by governments as well as medical and relocation expenses incurred by households to reduce the adverse effects of environmental pollution should be subtracted from, and not added to aggregate measures of economic welfare because these expenditures do not increase economic welfare.

Many resource costs are also excluded from national income accounts because they are not priced (Prato, 1998). These costs include user fees for grazing on public rangelands and water subsidies (Prato, 1998; Lange, 1998). For instance, Prato (1998) argues that if the grazing fee for public rangelands is set below the true resource costs of grazing, resource users would have the incentive to shift from private to public grazing lands leading to overgrazing. As a result, the retail price of meat product would be lower, and consumption of the meat product would be higher than would be if grazing fee reflected the full cost of grazing. Since the costs of reduced capacity of the grazing land on public grazing land are not reflected in retail meat price and consumption, national income accounts are overstated.

National Income Accounts also neglect subsistence economic activities because they focus on production of market goods and services (Hassan et al., 1998; Peskin, 1989). As a result of this, benefits derived from the use of tangible and intangible non-market goods and services are missing. These benefits include the value of firewood collected directly by many households, the carbon sink function of standing forests and watershed protection and other indirect services offered by various ecosystems (Hassan et al., 1998). Peskin (1989) cautions that it should be clear that if non-market activity is widespread in an economy, and if such activity is ignored in national data system, then these systems will not be able to support accurate analysis of economic behaviour. Lack of data on non-market activities, especially those that lead to negative externalities such as pollution, may produce a distorted view of the likely benefits of actual and proposed development projects (Peskin, 1989). Such a view is likely to result in sub-optimal allocation and unsustainable extraction and use of natural resources (Hassan et al., 1998; Winter-Nelson, 1995; El Serafy, 1997).

3.4 What is Natural Resource Accounting?

Natural resource accounts, also known as green accounts, are an accounting framework designed to provide information that tracks important changes in economic use of environmental resources (Statistics New Zealand, 2002). The natural resource accounting framework consists of physical and monetary accounts (Blignaut and Hassan, 2004). The physical accounts consist of stock accounts and flow accounts. The stock accounts show opening and closing stock level of a resource and changes that occurred during the period that is usually a year (Statistics New Zealand, 2002). Thus, stock accounts can reveal the extent to which a resource has been depleted. The monetary valuation of the natural asset or changes in use of that asset should be fully integrated into economic accounting (Bartelmus, 1999).

The flow accounts show how the natural resources have been supplied and used within the economy (Blignaut and Hassan, 2004). Depending on the type of material and energy and the nature of the origins of physical flows, the flows can be categorized according to natural resources (for example, timber from saw mills), products (for example, wood products from saw mills to furniture) or residuals (for example, timber treatment chemicals (Statistics New Zealand, 2002). Flow accounts can also be measured in monetary terms, though there is a need to aggregate the accounts into a condensed form called 'economy wide material flow accounts' (Statistics New Zealand, 2002).
As discussed in the following sections, many of the ecosystem goods and services provided by natural systems such as the Okavango Delta are not included in the calculation of GDP because the market system fails to capture such services (Blignaut, 2004). The use of natural resource accounting in determining the value of goods and services is crucial for policy decisions affecting the use of such resources.

Since the standard measures of economic performance such as GDP do not fully account for unsustainable use of natural resources, natural resources accounts complement these measures to provide a more complete picture of a country's economic and environmental performance (Statistics New Zealand, 2002). Natural resource accounts achieve this goal by adjusting conventional measures for the missing environmental values, and establishing the link between economic activities and use of natural resources and impacts on the environment (Hassan et al., 1998). Natural resource accounts provide information that can improve resource management and help determine whether natural resources are being utilized efficiently on a national basis (Statistics New Zealand, 2002).

Natural resource accounting can also be used to assess the physical and monetary extent of environmental depletions of natural resources that can threaten living standards, the food chain, ecological stability, and economic productivity. Natural resource accounting can also be used to assess the extent of environmental protection expenditures; and measure health and welfare costs associated with degradation of the environment (Statistics New Zealand, 2002). Hassan et al. (1998) also point that natural resource accounting can, and has, been linked to economic planning and policy analysis models for evaluating alternative development strategies in terms of their environmental impacts.

3.5 Application of natural resource accounting in resource management

Although natural resource accounting as a field of study is relatively young, most studies undertaken in natural resource accounting have had an element of sustainable management of natural resources. El Serafy and Lutz (1989) emphasize the need to collect data on renewable and non-renewable resources for long-run planning of resource exploitation in order to achieve sustainable economic activity.

3.5.1 Mineral Resources

In the management of non-renewable resources such as minerals, the objective and application of natural resource accounting has been to find out how the system of national accounts may be corrected for resource extraction so that industries dependent on these resources can be managed to contribute to sustainable economic growth.

In the Philippines, Santos and Zaratan (1997) used El Serafy (1989) user cost method to estimate mineral depletion during the 1980-1990 period in the copper and gold industry. The El Serafy (1989) formula for partitioning the revenue from mineral extraction between income and user costs is as follows:

$$X/R = [1-1/ (1+r)^{n+1}] \qquad (3)$$

where *X* is true income, *R* is total revenue (net of extraction costs), *r* is the rate of discount and *n*, the number of periods during which the resource is to be liquidated. *R-X* would be the user cost or depletion factor. According to van Kooten and Bulte (2000), the user cost of removing ore from the mine today is actually the benefit that one obtains from the same ore at some future date, appropriately discounted.

The application of the user cost method in Santon and Zaratan (1997) was important in the following three respects: firstly, it gave an idea of how much the GDP must be reduced for any given time to arrive at a socially sustainable value. Secondly, such an estimate can also be used to test how well the decision makers in the industry have used the mining revenue. Finally, since the difference between the industry's revenue and user cost is sustainable income, estimate of the latter can give an idea of how much disposable income the industry can provide without adversely affecting the economic welfare of future generations. The authors found the user cost in the copper and gold mining industries to be relatively smaller than true income, and attributed the low depletion rate and user cost to the maintenance of high levels of reserves relative to production. They concluded that the small proportion of the user cost in revenue very likely led the mining industry to invest at least as much as the value of depleted minerals.

Kellenberg (1996) examined natural capital depletion in Ecuador from 1971-1990, a period that corresponded with an oil boom. The depreciation method and the user cost method were utilised to measure the economic value of natural capital depletion in the production of petroleum. The value of natural capital depletion derived using the depreciation method equaled 4.3 percent of GDP while that derived using the user cost method was 8.9 percent of GDP. Kellenberg (1996) attributed the unsustainable development path to the failure by Ecuador government to reinvest oil revenues in other capital assets, but used oil reserves to sustain consumption which was equal to 6 percent of GDP and a reduction of taxes equal to 2 percent of GDP.

In South Africa, where mining has been an important economic activity during the country's early stages of economic growth, Blignaut and Hassan (2001) analyzed the change in the state of and value of the mineral resources (mainly gold and coal), and how they have been managed to support sustainable development. Resource accounting indicators and measures of sustainable management of the mineral resources sector were derived, and the components of the resource rent that needed to be reinvested and true income were calculated using the El Serafy (1989) formula. Mineral rent is defined as the difference between total revenue generated from extraction of natural resources and all costs incurred during the extraction process including the costs of produced capital (Minnitti et al, 2002). According to Lange and Wright (2004) capturing maximum rent generated from natural resources and investing it in other alternative assets that will generate as much income once the natural resource have been exhausted, is key to sustainable economic development. Thus it creates a permanent source of income. This is essentially the operationalisation of the Hartwick-Solow rule. Blignaut and Hassan (2001) found that the royalties captured were a very small percentage of total resource rent and were approximately a third of what should be captured according to El Serafy (1989). The lower rent captured was attributed to the nature of property rights related to the resource and the system of royalties and levies in place for its exploitation.

Contrary to the situation in South Africa, Lange and Motinga (1997) found that in Namibia and Botswana, where the central governments own the mineral resources, governments have been successful in recovering resource rents from mining to the extent that this reflects the longer-term rent generating capacity of the mining industry. In Botswana for instance, recovery of mineral rents in Botswana has been achieved through the levying taxes and royalties on minerals (Lange and Hassan, 2003; Lange and Wright, 2004). Lange (2003a) reported that Botswana receives about 50 percent of its revenues from taxes in the mining sector. The Government of Botswana has also constructed the Sustainable Budget Index (SBI) to monitor whether minerals are used in a manner that will promote development (Lange and Wright, 2004). SBI measures the extent to which annual consumption by the public sector is financed out of mineral revenues which are considered to be non-recurrent revenues. i.e. $SBI = \frac{Spending_{non-investment}}{\mathrm{Re}venue_{recurrent}}$ Essentially, an SBI value of 1.0 or less indicates that consumption is sustainable because it is financed entirely out of revenues other than from minerals, and that mineral revenue is used for public investment, while an SBI value of greater than 1.0 means that consumption relies on mineral revenues which is unsustainable in the long run (Lange and Wright, 2004).

In many African states, especially those whose economies are dependent on extractive industries, there is a substantial discrepancy between growth in production and growth in Gross Domestic Production (Winter-Nelson, 1995). Revenues from activities that reduce the stock of capital are treated as income without considering the impact of lost stock on future consumption opportunities. Given this state of affairs, Winter-Nelson (1995) adjusted the national income accounts of 18 African countries for mineral and petroleum depletion using the El Serafy method. For the countries with large extractive sectors (Botswana, Gabon and Nigeria), the El Serafy adjustment lowered the income levels by 5-10 percent relative to the conventional GDP estimates. For other countries, Winter-Nelson (1995) did not find the accounting correction to have any significant impact on income. Thus, the adjusted measures indicated that rates of income growth were very different from those suggested in conventional analysis.

There is, thus, a tendency among mineral dependent economies to ignore the contribution of exhaustible resources to national income and account for it in some way that is reflected in national income. Minnitt et al. (2002) undertook a study in which they examined the performance of the South African gold mining industry since its inception in terms of the capture of resource rents and capital component. Resource rent arising from the gold mining during 1910-1917 and 1970-2000, as calculated using the El Serafy (1989) method indicated that the exploitation of South Africa's gold deposits has not been undertaken in a fashion that was consistent with sustainable development. The surplus rents have flowed to investors at the expense of income and employment opportunities of future generations. Although the capture of a large proportion of rents (47 percent) may be justified by the risky nature of the mining industry and the fact that resource rents serve as the main stimulant of investment, Santos and Zaratan (1997) argue that decision makers in the mining industry, whether in the private or public sector, must ensure that the capital portion of the revenues from minerals or any extractive resource are regularly invested in the most rewarding and socially beneficial projects.

3.5.2 Forest resources

The application of natural resource accounting in the management of forestry resources has also revealed substantial weaknesses in the system of national accounts of many countries. In China, where the main natural forests and timber stocks have been greatly reduced by deforestation ensuing from agricultural conversion and the high demand for timber consumption, Liu (1998) estimated the economic damage of forest resources in national accounts from 1976 to 1992. Both El Serafy (1989) method and the net price method were applied to reach forest-adjusted income accounts. Economic depreciation, which was calculated as a reduction of timber volume multiplied by the stumpage value, was found to be 2.02 to 8.31 billion Yuan from 1976 to 1992. Although the two methods gave different results of depreciation, they both showed that depreciation accounted for a high percentage of gross output. Both approaches also reflected the real scarcity of forest resources.

In their study of the contribution of natural woodland and forests for national income and economic welfare, Schakleton et al. (2002) established the value of natural woodlands and forests in South Africa, and used the estimated values to correct measures of national income and wealth and to derive better indices of economic performance and welfare change. The study revealed that woodlands and forest contributed up to R3.6 billion value added in direct use values in 1998 prices. This value, which is typically missing from the current income accounting, was found to be equivalent to three-fold the total contribution of forestry to the country's GDP reported in 1996. The study also found the total value of standing asset stocks and carbon externality to be more than R7 billion in 1998 prices, a value which was found to be more than five-fold the reported contribution of forestry to GDP in 1996. The study concluded that as a result of omissions of the values of woodlands and forests, the measures of the country's genuine savings or wealth formation (NNP) in 1996 was underestimated by about 2%.

Hassan (2003) found that the national income accounts estimate of the value added in agriculture, forestry and fishery combined was an underestimate of the contribution of cultivated forests to national income wealth in South Africa. In this study, changes in the value of standing stock of trees (for example, economic appreciation or depreciation due to natural growth and harvesting) were not captured in conventional measures of income and capital formation. The study further revealed that the value of other non-timber products and environmental amenities and expenditures were missing. In a related study, Hassan (1999) corrected the measures of national income for the missing water abstraction and carbon sink externalities in the South African industrial plantations. The loss value to agriculture of water abstraction amounted to 1.43 percent and 23.53 percent of value added in agriculture and forestry, respectively, while the net economic benefit from carbon storage functions was found to be about half of the economic costs of water reduction by plantation.

In Maharashtra, India, Haripriya (2003) undertook a study in the forestry sector to adjust the value added to include non-timber forest production of timber, fuel wood and non-timber forest products that are usually left out in the calculation of the GDP. In this study, the net state domestic product was adjusted for the depletion and degradation of forest assets to yield the environmentally adjusted net state domestic product. Results showed that the value added of forest was 3.5 percent of the net state domestic product and the value for depletion was 19.8 percent of the estimated value added. The environmentally adjusted net state domestic product was found to be 99.3 percent of the estimated net state domestic product.

In Ghana, where more than 60% of the forest has been destroyed in search of agricultural land, firewood, and logging, Baytas and Rezvani (1993) attempted to set up physical and monetary accounts for the timber resources between 1970 and 1987. When adjusting the GDP to net basis to reflect depreciation, the authors found that the GDP was reduced by 2.2%. This was in spite of the fact that the constructed accounts did not represent the total value of the country’s forest resources which yield many important non-timber products such ad resins, oils, foodstuff and other forest services.

3.5.3 Water and fish resources

In Namibia, where water supplies are not being used sustainably Lange (1998) applied natural resource accounting to examine water policy as an example of the kind of analytical perspective that natural resource can provide to policy makers. Despite the scarcity of water in Namibia, Lange (1998) reported a number of factors that explain the unsustainable management of water resources. Firstly, groundwater resources are increasingly being depleted, there is increased harvesting pressure of ephemeral surface water and water is wasted through losses in the distribution network due to poor maintenance. Secondly, no user of government-provided water pays the full financial cost (operational and capital costs), a situation that represents an inefficient use of society's scarce water resources. Lange (1998) argued that the full social costs of using water must reflect the opportunity cost that measures the lost revenues from alternative uses, and that omission of capital costs can distort decision making regarding alternative water supply strategies. She concluded that a reallocation of resources from such activities that can generate income sufficient to pay the full cost of water or any other input needed for production, would bring about an economic improvement.

In the fishing industry, application of natural resource accounting in Namibia indicated that the major commercial fishes (hake, pilchard and mackerel) generated significant resource rent (Lange and Motinga, 1997; Lange, 2003b). However, rent recovery in the fishing industry was sub-optimal mainly because the government has been cautious in introducing high taxes to capture rents because the industry is still relatively new and government regards it as source of potential employment.

3.6 The status of natural resource accounting in Botswana

The first attempts to construct natural resource accounts at national level in Botswana were carried out by Perrings et al. (1989). The objectives of the study were to determine how national accounts might be extended to accommodate non-market resource based activities and to develop estimates of value of such activities; to recommend an appropriate system of natural resource accounts for Botswana and to develop a methodological data guide for the construction of the accounts; and to indicate how the extended national accounts and the natural resource accounts might be incorporated in the planning process in the country's development plans and in the national conservation strategy. According to Lange (2000), there was no follow-up to this work until in 1997 when a small pilot project involving the Central Statistics Office (CSO) and the National Conservation Strategy Agency (NCSA) led to the development of the current natural resource accounts that enabled the government to participate in regional initiatives to establish natural resource accounts in Southern Africa. Construction of natural resource accounts in Botswana is still at an early stage. Natural resource accounts have been constructed for minerals and water. In the mineral accounts, only proven reserves as opposed to both proven and probable reserves have been included (Lange, 2000). Natural resource accounts for water consist of stock and use accounts, with stock accounts including information about quantities of water stored in dams, annual runoff to rivers, and estimated ground water (Republic of Botswana, 2001).

Though the values of asserts and services in this thesis are those of the Okavango Delta region only, some of the corresponding values are missing in the national accounts of Botswana. For instance attempts to construct accounts for wildlife and livestock have been hampered by lack of data (Lange and Wright, 2004). In addition, natural resource accounts for products harvested and used for subsistence by communities from the wild (e.g. forest and fishery resources, traditional medicinal plants, wild fruits, fuel wood, basket making resources) and indirect goods and services (e.g. livestock grazing, honey production carbon sequestration) are also missing from the national accounts primarily because these products do not normally enter the trade and market sphere. Further, in the national accounts, tourism is not a clearly defined sector because its activities and output are assumed to form part of the Trade, Hotels, and Restaurant sectors (Republic of Botswana, 1999). This is in spite of the fact that tourism has become the second most important economic activity after mining.

3.7 Biodiversity conservation and resource accounting

This section outlines the nature of biodiversity, the problems threatening it, and its place in the construction of natural resource accounts.

3.7.1 Definitions, value and loss of biodiversity

According to UNEP (1992), biological diversity or biodiversity is "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems". Biological diversity is usually considered at three different levels: genetic, species and ecosystem diversity. Genetic diversity refers to the variety of genetic information contained in all of the individual plants, animals and microorganisms, while species diversity refers to the variety among living things. Ecosystem diversity relates to the variety of ecosystems, biotic communities and ecological processes, as well as the tremendous diversity present within ecosystems in terms of habitat differences.

Biological diversity provides many important benefits for mankind (Balmford, 2002; Myers, 1996). In spite of the significance of biodiversity in maintaining the integrity of life-supporting ecosystems and support for human life, the past century has seen a strikingly high rate of species loss as a result of anthropogenic and natural factors. Market and policy failures have been reported as some of the underlying causes of loss of biodiversity (see Kahn, 1997; Perrings et al., 1995). The failure of the market stems from the fact that significant external effects in resource systems and public good features of biodiversity are not accurately valued and included in current decision making, while policy failure stems from the fact that government's decision to promote inefficient conversion of natural capital into other assets (van Kooten and Bulte, 2000; Barbier and Bugas, 2003). The proximate causes of loss of biodiversity are many and include habitat change by humans caused directly through land use change, urbanization, infrastructure development and industrialization (Perrings et al., 1995). Many species are found in specific habitats, and when these habitats are destroyed by conversion into other land uses the species may become extinct (Kahn, 1997). Conversion alters the structure, composition and function of natural ecosystems by modifying their basic physical properties (hydrology, topography, soil structure) and their predominant vegetation (World Resource Institute, 2000). In freshwater ecosystems Braga et al. (1998) reported that between 20 to 35 percent of fresh water fishes are vulnerable, endangered or extinct, mostly because of habitat alteration. Pagiola et al. (1997) identified agriculture as one of the most important causes of loss of habitat and species diversity. Barbier and Bugas (2003) found that data on stratified random sampling of the 10 percent of the world's tropical forests indicated that direct conversion by large-scale agriculture was the main source of deforestation, accounting for around 32 percent of total forest cover change, followed by conversion to small scale agriculture, which accounted for 26%.

The second major cause of biodiversity loss is the introduction of invasive and alien species, that may subsequently out-compete native species and lead to their extinction (Miani and Fajardo, 2001; World Resources Institute, 2000). Exotic species may be introduced into other environments by accident or through deliberate release. Brag et al. (1998) pointed out that freshwater ecosystems or other aquatic ecosystems are particularly vulnerable to these introductions because of the impact of activities beyond their boundaries such as forest clearance or industrial effluence. In North American freshwaters the freshwater zebra mussel, which was introduced from Russia in the 1980s through ship ballast water, has invaded Canada and the Great Lakes and has expanded into the inland waters at an alarming rate (World Resources Institute, 2000). The introduction of the Leidy comb jellyfish proliferated in the Baltic Sea after its introduction from the Western Atlantic in 1982 and led to the devastation of the natural zooplankton stocks (World Resource Institute, 2000). In East Africa's Lake Victoria, which is characterised by high species endemism of over 200 species, the introduction of the Nile perch into this lake in 1960 to improve local fishing for sport fishing and food was responsible for the extinction of 60% of the fish fauna (Braga et al., 1998).

The introduction of pollutants contributes to loss of biodiversity because pollutants alter ecosystem primary productivity, nutrient availability and hydrological cycle and other essential processes, leading to changes in the conditions and composition of the organisms (Perrings et al., 1995). Multiple pollutants can create a toxic synergy that weakens the organism and gradually reduce ecosystem productivity and resilience (World Resources Institute, 2000). In Lake Victoria, Lake Malawi and Lake Tanganyika, excessive suspended sediments from soil erosion caused by deforestation and over grazing and pollution from domestic and industrial wastes are causing eutrophication which has resulted in a serious reduction of fish populations in these lakes (Braga et al., 1998). D'Eposito and Feiler (2000) cited in the World Resources Institute (2000) reported that in the year 2000, an amount of 99 000 cm^3 of cyanide-laden wastes escaped the Romanian gold mine when the earthen tailings dam collapsed, and found its way into the Danabe floodplains and tributaries, wiping out virtually all aquatic life along the 400 kilometre stretch of the Danube.

Another important factor that leads to loss of biodiversity is open access harvesting which is associated with over-harvesting (Kahn, 1997). Around Lake Victoria, which is source of water and food for millions of people and their livestock, the lake's biodiversity and fisheries productivity have been depleted by over-harvesting and other factors (Braga et al., 1998). One reason why over-harvesting occurs is because no one owns the resources and that biological resources are harvested at a rate faster that they can regenerate naturally.

3.7.2 The structure, composition, and function of an ecosystem

3.7.2.1 Structure of ecosystems

It has become customary to define the structure and the operation of an ecological community largely with regard to feeding relationships, dividing the member species in terms of the trophic role (Shugart, 1998). Feeding relationships are by far the most common route of interaction between different organisms of the community. Such relationships may be *commensal* (one organism deriving benefits from the other while the other neither gains nor loses) *mutualistic* (both organisms gaining from the association), *parasitic* (one organism feeding upon the other to the benefit of itself but at the expense of its host) or *holozoic* (animals feeding directly one upon the other or on plants) (Kimmins, 2004). Thus, a forest, lake or pasture ecosystem is bound to be characterized by definite trophic structures determined by the interaction of the food chains and the metabolism relationship among its organisms. Communities having a high number of different species usually have complex trophic structures (Shugart, 1998).

Each step in the food chain represents a trophic level, with the first trophic level belonging to producers, the second to herbivores, the third to carnivores and the fourth to decomposers (Kimmins, 2004; Molles, 2002). Trophic structures may be measured and described as standing crop per unit area or in terms of energy fixed per unit area or per unit time at successive trophic levels (Odum, 1971; Molles, 2002). Each trophic level contains at any one time a certain amount of living material composed of a number of kinds of organisms and since some energy is lost between successive trophic levels, the total mass supported at each level is limited by the rate at which energy is being stored below (Shugart, 1998). Thus**,** the biomass of the producers must be greater than that of herbivores that they support, and the biomass of herbivores must be greater than that of carnivores, and so on. The pyramid of biomass would thus indicate that the total numbers of organisms in each trophic class decrease as we ascend the trophic scale because each organism relies on more than one organism in the previous level to support it (Molles, 2002). While this is true for most of ecosystems, exceptions occur in aquatic ecosystems where phytoplankton has small smaller biomass than zooplankton (Dajoz, 1977).

Not all organisms in communities are equally important in determining the nature and function of the whole community. For instance, out of hundreds of thousands of kinds of organisms that might be present in a community, a relatively few species or species groups generally exert a major controlling influence by virtue of their numbers, size, distribution over a large area, largest contribution to energy flow or mineral cycling or by some other means that can influence the rest of the community (Odum, 1971). These are driver species. The removal of dominant species would result in important changes, not only in the biotic community, but also in the physical environment, whereas removal of non-driver species would produce much less change (Odum, 1971; Kimmins, 2004). This however, does not necessarily mean that the non-dominant communities do not have important roles in the community.

The structure of a community is not only affected by the actual relationship among species, but also by the relative number of organisms in those different species (Molles, 2002; Magguran, 1988). The diversity of species within a community reflects in part the diversity in the physical environment in which the organism is found. Species diversity can be defined on the basis of the number of species in a community (species richness) or on the basis of the relative abundance of species (species evenness) (Molles, 2002). In general, species diversity increases with environmental complexity of heterogeneity (Molles, 2002). Accordingly, the greater the variation in the physical environment, the more numerous are species because there are more microhabitats available. A more diverse plant community is expected to support a more diverse animal community because food for a variety of herbivores will be abundant (Chapman and Reiss, 2003).

According to Magguran (1988), relative abundance is a better measure of species diversity than species richness because a community spread over a large area does not necessarily imply that it is species richer than one which is geographically restricted. The relative abundance of individuals in a particular species may have a marked influence on the nature and function of the community, the distribution of individual species between species within the community, and ultimately on its stability (Chapman and Reiss, 2003).

3.7.2.2 Composition of an ecosystem

Living organisms and their non-living environment are inseparably interrelated and interact upon each other. Odum (1971) defines an ecological system or an ecosystem as 'any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles within the system.' An ecosystem is composed of populations (groups of interbreeding organisms of the same kind occupying a particular space), that assemble into communities (naturally occurring assemblage of plants and animals that live in the same environment) (Chapman and Reiss, 2003). A population can be considered in different ways: it is a demographic unit; it is characterised by density (number of organisms occupying a definite unit of space); it possesses a certain age structure and a death rate; it experiences the movement of new individuals into itself (immigration) and loses others through emigration (Chapman and Reiss, 2003).

Biotic communities have definite functional unity within feeding structures and patterns of energy flow as well as compositional unity in that there is a certain probability that certain species will occur together (Odum, 1971). According to Chapman and Reiss (2003), a key quality of communities is that the organisms making up communities somehow interact as a society does. As Clapham (1983) puts it ' communities have a structure at all times and in all situations that is reflected in the roles played by the constituent populations, their ranges and types of areas they inhabit, the diversity of species in the community and the spectrum of interactions among them and the precise flow patterns of energy and nutrients through the community'. Thus, the interactions that occur among individuals in their habitats define their exact role in the community.

All ecosystems, whether terrestrial or aquatic, have four basic components: producers (autotrophs or green plants), the primary consumers (herbivores), secondary consumers (carnivores) and the decomposers (mainly microorganisms) (Kimmins, 2004). Producers are the only group within the community that can actually synthesize organic compounds and thus produce food for the community, while primary consumers such as ungulates, feed on producers for their energy needs (Osborne, 2000). In terrestrial ecosystems, the synthesis of organic compounds is carried out by higher plants, while in the sea, it is executed by microscopic plankton algae (Dajoz, 1977). In general, secondary consumers (carnivores), such as lions, are larger organisms that kill and eat smaller prey. Decomposers are mainly microorganisms such as bacteria or saprophytic fungi which may attack plant and animal material, slowly breaking them down and releasing energy.

3.7.2.3 Energy flow and material cycles in ecosystems

Energy flow through the ecosystem starts with the process of photosynthesis in which solar energy is used to produce simple organic carbon compounds from water and carbon dioxide (Townsend et al., 2003). According to Smith and Smith (2001), energy stored in the chemical bonds of organic carbon-based compounds forms the basis of energy flow in the ecosystem. The fixation of energy by plants is called primary productivity while all the energy that is assimilated in photosynthesis is called gross primary production (Molles, 2002; Smith and Smith, 2001).

Plants require energy for metabolic processes which they acquire through the oxidation of organic compounds during the process of respiration (Smith and Smith, 2001). The energy remaining after respiration is stored as organic matter and is called net primary production (Molles, 2002). Thus, net primary production equals gross primary production minus respiration. Net primary production is allocated to plant growth, the buildup of components such as stems and leaves and storage (Smith and Smith, 2001). Storage involves accumulation (increase of compounds that do not directly support plant growth), reserve formation (the synthesis of storage compounds from resources that otherwise would be allocated directly to promote growth) and recycling (retaining compounds that otherwise would be lost to litter) (Smith and Smith, 2001).

According to Molles (2002), the importance of nutrients, their relative scarcity and their influence on primary productivity makes nutrient cycling one of the most significant ecosystem processes. Biogeochemical cycles are the means through which nutrients move through the ecosystem, and the cycles involve chemical exchange of elements in the atmosphere rocks, water and living organisms (Smith and Smith, 2002). Some of the important elements such as carbon, phosphorus and nitrogen are made available to plants through the carbon cycle, phosphorus cycle and nitrogen cycle, respectively. While carbon and nitrogen enter the ecosystem through the atmosphere, phosphorus does not because it occurs in mineral deposits (Molles, 2002). The rate at which nutrients such as nitrogen and phosphorus are made available to primary producers (plants) in terrestrial ecosystem depends on the rate at which nutrients supplies are converted from organic to inorganic forms during the mineralization process which takes place through decomposition (Molles, 2002).

3.7.2.4 Ecosystem goods and services

Ecosystem functions are the capacity of natural processes and components to provide goods and services. The provision of environmental goods and services of ecosystems is a result of complex interaction between biotic and abiotic components of the ecosystem through the universal forces of matter and energy (de Groot et al., 2002; Norberg, 1999).

3.7.2.4.1 Direct consumptive use values

Food and raw material: Natural ecosystems are a source for local people of edible plants and animals, ranging from non-timber forest products such as raisins, to game and bush meat (de Groot et al., 2002). They are also a source of energy (for example, fuel wood) and building materials.

Genetic resources: A varying but often substantial proportion of the benefits of biodiversity accrue to agriculture through the provision of genes for the development of improved varieties in terms of productivity and disease resistance (Pagiola et al., 1997;

Field, 2000). Many important crops could not maintain commercial status without the genetic support of their wild relatives (de Groot et al., 2002).

Medicinal resources: Nature provides chemicals that can be used as drugs and pharmaceuticals, or which may be used as models to synthesize drugs (de Groot et al., 2002). According to WHO (2004) 80% of the population in Africa depends on traditional medicine for primary health care while in China, herbal medicines account for 30-35% of total medicinal consumption.

3.7.2.4.2 Direct non-consumptive use value

Recreation and ecotourism: Natural ecosystems have an important value as a place where people can come for rest, relaxation, refreshment and recreation. Recreational use may be consumptive, such as through hunting (Field, 2000). Through aesthetic qualities and almost limitless variety of landscapes, the natural environment provides many opportunities for recreational activities, such as walking, hiking, camping, fishing swimming and nature study (de Groot et al., 2002). In 1994, whale watching in 65 countries and dependent territories attracted 5.4 million views and generated tourism revenues of $504 million (Myers, 1996).

3.7.2.4.3 Indirect-consumptive use value

Environmental services comprise the main indirect values of biodiversity as opposed to direct use values in the form of material goods such timber, fish, plant based pharmaceuticals and germ-plasm for agricultural crops. They include generating and maintaining soils, converting solar energy into plant tissue, sustaining hydrological cycles, storing and recycling essential nutrients, supplying clean air and water, absorbing and detoxifying pollutants, decomposing wastes, pollinating crops and other plants, controlling pests, running biogeochemical cycles of such vital elements such as nitrogen, phosphorus and sulphur, controlling the gaseous mixture of the atmosphere and regulating climate and weather at both macro and micro levels (Myers, 1996).

Water supply: Lakes, stream, rivers and aquifer perform the function of filtering, retaining and storing water through the surrounding vegetation and soil biota (de Groot et al., 2002). The thick and diverse vegetation in some natural ecosystems allow a slower and more regulated runoff, allowing water supply to make a sturdy and more substantive contribution to the ecosystem, instead of quickly running off (Myers, 1996).

Crop pollination: Wild bees and honey bees pollinate $30 billion worth of 90 US crops annually, plus many more natural plant species (Myers, 1996). Without pollination many plant species would go extinct and cultivation of most modern crops would be impossible (de Groot et al., 2002). Thus, pollination is a service for which there is no substitute technology.

Carbon sequestration: Carbon sequestration service values are potentially of great interest for domestic and international policies because they involve local and global externalities (Kundhlende et al., 2000). Vegetation can serve as a source of sink for carbon dioxide. According to Myers (1996) evidence abound that species rich ecosystems can consume carbon dioxide (carbon sequestration) at a faster rate than less diverse ecosystem, which indicates that biodiversity loss or decline may promote the build up of carbon dioxide in the atmosphere.

Climate regulation: Local weather and climate are determined by the complex interaction of regional and global circulation patterns with local topography, vegetation, albedo as well as the configuration of lakes, rivers and bays (de Groot et al., 2002). The Amazonian region, which contains two-thirds of all above-ground freshwater on earth, has at least half of its moisture retained within the forest ecosystem, which is constantly being transpired by plants before being precipitated back onto the forest (Myers, 1996).

Waste assimilation: Natural ecosystems are able to store and recycle certain amounts of organic and inorganic wastes through dilution, assimilation and chemical re-composition (de Groot et al., 2002). A number of tree species such as beech, elm oak and sycamore willow and wilder have been found to serve to clean up sulphur dioxide pollution (Myers, 1996). Forests filter dust particles from the air, and wetlands and other aquatic ecosystems can treat relatively large amounts of organic wastes from human activities acting as free water purification plants (de Groot et al., 2002).

Soil protection/stabilization: While soil erosion is a major problem in certain environments, leading to declines in production in croplands and pastures, plant root systems hold the soil. Plants foliage also intercepts storm impacts, thus preventing compaction and erosion of soil as well as prolonging water discharge (Norberg, 1999; de Groot et al., 2002).

Nutrient cycling: The existence of the living world depends on the flow of energy and the circulation of material through the ecosystem (Smith and Smith 2001). Many structural and functional aspects of natural ecosystems facilitate nutrient cycling at local and global levels. Soil organisms decompose organic matter thereby releasing nutrients to both local plant growth, but also to the atmosphere (de Groot et al., 2002).

3.7.2.4.4 Basic information requirement to account for biodiversity

Most of managed biodiversity is found in protected areas. Protected areas are designated natural areas aimed at keeping natural areas relatively intact and restricting commercial development (van Kooten and Bulte, 2000). The World Conservation Union has defined ten categories of protected areas with different objectives (Dixon and Sherman, 1990). These are *scientific reserve/strict nature reserve* (to protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment for scientific, monitoring educational purposes); *national parks* (to protect large and scenic areas of national and international significance); *natural nature reserve/natural landmark* (to protect and preserve nationally significant natural features because of their special interests or unique characteristics); *managed nature reserve* (to ensure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities or physical features of the environment requiring human intervention for their perpetuation); *protected landscape* (to maintain nationally significant landscapes characteristics); *resource reserves* (to protect the natural resources of the area for future use and curb development that can affect the area); *natural biotic area/anthropological reserve* (to allow societies living in harmony with the environment to continue their way of life undisturbed by modern technology); *multiple-use management area/managed resource area* (to provide for the sustained production of water, timber, wildlife, pasture, and outdoor recreation).

Although the initial intention for establishing parks was to protect scenic and recreational resources, and not to conserve biological diversity per se, protected areas, to a large extent constitute in situ protection of biodiversity and other environmental value (Dixon and Sherman, 1990; van Kooten and Bulte, 2000). The Keystone Centre Report (1991) as cited in Stohlgren et al. (1994) argues that the national parks system provides both fully protected habitats for the long term maintenance of biological diversity and a baseline against which to measure change. In the Kwazulu Natal Province of South Africa, game ranching has significantly enhanced the species status of large herbivore and predator species (elephant, white rhino, black rhino, lion, leopard, wild dog) and the survival prospects of wider ranging species, whose populations are not entirely secured in the formal protected areas (Goodman et al., 2002). Jones (1996) is of the view that protected biodiversity should be listed, described and monitored so that the basic requirement for conservation and management of these resources is met. Common and Norton (1995) view ecological monitoring as an essential component of any viable strategy to conserve biological diversity because it provides a basis to track the status of various components of biodiversity over time in the context of different management regimes. As Stohlgren et al. (1994) puts it 'these assessments are essential to form natural resource management policies, manage the natural diversity within existing national parks, and identify potential new or expanded reserves to encompass biotic diversity not now effectively protected within the park system.' According to the World Resources Institute (2000), the condition of forest diversity in forest reserves can be directly measured by changes in the number of species found in the forest, including the extinction of native species or introduction of non-native species. Accordingly, any change in the number or relative abundance of different species represents ecosystem degradation from the standpoint of biodiversity. In many situations, however, data on biodiversity accounts is not available and most of what is known about the condition of forest species is only inferred from various measures (for example, habitat fragmentation, logging and loss of habitat) of pressures on forest diversity (World Resources Institute, 2000).

In the Cosmeston Lakes Country Park in Wales, UK, Jones (1996) compiled physical resource accounts for wildlife habitats, flora and fauna using a natural inventory model which comprised six broad levels of hierarchical criticality moving from critical (irreplaceable) natural capital to non-critical natural capital. Since the park was a community asset, and not in the commercial domain, there was no open market valuation. A best estimate of the amenity value of the different managed natural habitats was made to accompany the ecological grading in which a habitat with a great ecological worth was assigned grade 1, and a habitat with little ecological worth was assigned grade 5. According to Jones (1996), the fauna accounts suggested that the increase in bee orchids was sustainable as it was aided by good conservation work.

Similarly, because wildlife habitats form a major focus of nature conservation policies, Scott (2001) reports that, in the UK, habitat accounts have been produced using results of a country survey for the period 1990 to 1998. The accounts, which take the form of a simple balance sheet, present the opening stock of habitats, the major transfers of land between habitats, and the closing stock and net change. In addition to habitat accounts, a number of habitat condition measures have been developed based on the plants observed in vegetation plots, which include direct measures of species diversity such as mean species richness and measures of ecological status such as nutrient level or acidity. The constructed habitat accounts showed that there were high rates of exchange of land between intensive agriculture habitats and semi-natural habitats, leading to a net loss of 60,000 hectares of semi-natural habitats, apparently due to agricultural intensification. The gains in agricultural intensification were however offset elsewhere by losses from agriculture to woodland and developed land habitats. With regard to habitat conditions, results showed a significant loss in species richness in grassland vegetation types over the period 1990 to 1998, and increased fertility in semi-natural grasslands which resulted from agricultural intensification.

3.8 Chapter conclusion

In this chapter, the concept of sustainable development has been discussed, particularly in the context of capital theory and the paradigms of weak and strong sustainability. According to El Serafy, (1997) weak sustainability calls for keeping capital intact, meaning that a reduction in the form of capital must be offset by acquisition of other forms of capital in order that the unit's income may be sustained. Proponents of strong sustainability argue that substitutability declines as resources stocks are depleted, and that there are no substitutes for many natural resources such as wilderness, implying that the elasticity of substitution between natural capital and reproducible capital becomes zero (van Kooten and Bulte, 2000). The concept of sustainable development also entails ethical and social limits to growth (Blignaut, 2004). The society or individuals must have equal rights of resource access to satisfy their human wants. The social limit to growth is that high incidences of poverty, unemployment and inequality still occur during high economic growth periods.

The chapter has also given an overview of what resource accounting is, the deficiency of conventional national income accounting, and how natural resource accounting can be used to augment these measures. Case studies where natural resource accounting has been used have been reviewed. Natural resource accounting has been applied in the management of non-renewable resources such as minerals, and renewable resources such as forests in many areas of the world. The chapter has also reviewed the literature on how natural resource accounting can be used in the conservation of biodiversity at structural, compositional and functional levels.

CHAPTER 4

CONCEPTUAL FRAMEWORK AND GENERAL METHODOLOGY

4.1 Introduction

The purpose of the chapter is two-fold. First, the chapter outlines the conceptual framework for the analysis of the Okavango Delta data. Second, the methods of data collection and analysis are described in detail. The methodology describes how the different economic values were obtained and presented using a natural resource accounting approach.

4.2 Conceptual framework

As discussed in chapter 2 of the thesis, the physical characteristics of an ecosystem determine the ability of that ecosystem to yield various goods and services for human well-being. By supplying the goods and services, the ecosystem contributes positively to the overall economy of a country. In chapter 3, it has been pointed out that natural resource accounting can be used to provide information that can improve resource management and to determine whether natural resources are utilized efficiently or not. This chapter explains how the total economic value of the Okavango Delta can be estimated using a natural resource accounting framework.

The natural environment provides resources for the economic system. However, the economic system (System of National Accounts) does not take into account the value of goods and services provided by this environment and whether there are stock level changes due to extraction of resources. For instance, receipts from extracted oil add to the value of GDP, but the calculation of GDP does not take into account the depletion costs of extraction (El Serafy, 1997; Hassan et al., 1998). Since the calculation of GDP does not take into account depletion costs of extraction, it is not a suitable indicator for measuring environmental sustainability (Perrings and Vincent, 2003; Statistics New Zealand, 2002). Natural resource accounting seeks to correct deficiencies found within the System of National Accounts. There is considerable literature on work that has been done to correct some of the deficiencies (for example, see Hassan, 2003; Hassan, 2002; Shackleton et al., 2002; Haripriya, 2003; Blignaut and Hassan, 2004; El Serafy, 1997; Santos and Zaratan, 1997; Lange, 2003; Peskin, 1991; and many others).

4.2.1 Physical accounts

Natural resource accounts consist of two types of assets, namely, stock and flow (Statistics New Zealand, 2002). The United Nations (2003) defined an asset as 'an entity over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners from holding them or by using them for a specified period'. The definition includes cultivated biological resources and non-cultivated biological resources, such as fish and forest resources. The System of Integrated Environmental and Economic Accounting (SEEA) identifies three types of assets, namely produced assets, non-produced economic assets, and environmental assets. Produced assets are those assets whose growth is controlled by man through the process of cultivation. One example of produced assets is plantation forests. Non-produced economic assets are those assets which can be exploited for economic purposes and for which there could be ownership or no ownership, but which have a price (Statistic New Zealand, 2002; Haripriya, 2003). An example of non-produced economic assets is fish. Non-produced environmental assets are those assets for which neither ownership rights are enforced nor direct monetary benefits are derived from their use (Haripriya, 2003). Examples include environmental services by forests or wetlands such as climate change or water purification**.**

4.2.1.1 Stock accounts

A stock account measures the absolute level of a natural stock at a point in time, and also shows the change in stock levels over a certain period of time (United Nations, 2002; Hassan 2002). Thus, the stock of any asset at the end of a year should be equal to the stock at the beginning of the year adjusted for the changes that have taken place during that year. Accordingly, the changes may be due to man made or natural factors. For biological resources such as wild animals, the natural increase may be due to birth, while natural decrease may be due to death. Man-made changes are brought about by the direct economic use or exploitation of the asset. Economic uses or activities include extraction of minerals, logging, fish catch, water abstraction etc (United Nations, 2003). Stock levels, such as the volume of fish or forest biomass, help to determine sustainable yield and appropriate harvesting policies, while stock levels for minerals provide the needed information to plan extraction path and to indicate ho long a country can rely on its minerals (Lange et al 2003). Perrings et al. (1989) showed that stock balances for single resources, such as wildlife, may be represented by the following equation:

$$S_0 + N + I = C + S_1 \qquad (4)$$

Where

S_0 = stock at the beginning of time period;
N = net natural increase;
I = net imports
C = extraction by the resource user and
S_1 = stock at the end of the period

$$\Delta S = S_1 - S_0 = N + I - C \qquad (5)$$

ΔS = net change in stocks

For fauna and flora, stock accounts represent the biological diversity of these resources. Fauna refers to 'wild animals and birds living naturally in a certain area (Collins, 2001). In this thesis, fauna refers to the wildlife animal species in the Okavango Delta. Flora refers to a list of taxonomic plant entities found within an area (Mueller-Dombois and

Ellenberg, 1974). This concept is often differentiated from the vegetation, which generally refers to plant communities which can be described in terms of their structure, life form, spatial patterns, species compositions, successional stages, biomass and functional processes (Kimmins, 2004). Both flora and fauna constitute the composition of which an account could be defined as the number of animal or plant species and the associated standing values in a given area at a given time.

The standing stock of fauna therefore forms a compositional account of animal species. The composition of the standing stock may be categorized further according to feeding behaviour or trophic levels, (for example, herbivores, carnivores), sex, breeding population as well as whether animals are trophy or not (see Blignaut and Moolman, 2004). For floral resources, the composition of the standing stock includes the volume of individual vegetation species (biomass) in a given area, such as a forest. The total biomass of flora for individual species comprises the different plant parts which include branches, roots leaves, stem, and bark, all of which constitute a percentage component of the total biomass (see Blignaut and Moolman, 2004).

4.2.1.2 Flow accounts

The interaction between the environment and the economy results in three types of physical flows: natural resource flows, ecosystem input flows, product flows and residual flows. Natural and ecosystem input flows originate in the environment and flow to the economic system; product flows originate in and circulate within the economic system, while residual flows originate from the economy to the environment (United Nations, 2002). If a resource is harvested for use, it generates one of the flow services. In the case of many resources, the stock flows occur when the natural resources enter the economic sphere and/or are transformed into other products by economic entities, such as households. For example, households transform construction material into other products

(Statistics New Zealand, 2002). For resources such as fish, the physical flow account is linked to the physical stock account through the use of commercially caught volume of fish from the physical account.

Product flows are a result of production, while residuals include physical output discharged from the economic sphere, and back into the environment sphere (Statistics New Zealand, 2002). The purpose of flow accounts is therefore to describe how material and energy are used as inputs in the economy, how commodities are produced and used, and how residuals and wastes are the results of economic activities by industries and households (Statistics New Zealand, 2002). Physical flow accounts indicate the origin (supply) and destination (use) of the resources (United Nations, 2003; Blignaut and Hassan, 2004).

4.2.1.3 Valuation of natural assets

To estimate the market price of stock or depletable natural resources and changes in the value of stocks, such as minerals, timber and fuelwood, the net price method and the user cost method may be used (see Blignaut and Hassan, 2001; Santos and Zaratan, 1997; Haripriya, 2003). Under the net price method, the value of a resource at the beginning of period t, V_t, is the volume of the resource Q = ΣQ (annual extractions over the lifetime of the resource) multiplied by the difference between the average market value per unit of the resource p_t and the per unit production costs, c_t (United Nations, 2002). Thus,

$$V_t = (p_t - c_t)Q = N_tQ. \tag{6}$$

The user cost on the other hand, is the difference between the finite net returns R (= N_tQ) from the sales of exhaustible reserve during the accounting period, t (expected annually during the lifetime of the resource, T) and perpetual income stream X, resulting from the investment of the user cost at a rate of interest, r. Thus

$$R\text{-}X = R/[1+r]^{T+1} \quad (7)$$

The basic link between stock accounts and flow accounts is that the flow accounts further describe the changes occurring in stock accounts particularly in the economic use or harvesting or extraction of resources (Statistics New Zealand, 2002). The extraction of resources from the standing stocks yields the flow of goods and services during economic transactions, and hence, changes in flows can be measured in monetary terms using available market prices. Changes in environmental assets are not easily measured in monetary terms because they involve changes in the capacity of those environmental assets to provide services (Statistics New Zealand, 2002).

The value of a natural resource (whether renewable or non-renewable) is the expected net present discounted value of streams of services (rents) that it will provide over its useful life, plus the salvage value it has at the end of its life (Lange, 2004). For a non-renewable resource such as minerals, Vincent and Hartwick (1998) show that the asset value at time t is given by

$$Vt = \sum \{(1+i)^{t-s}[pq(s) - C(q(s))]\} \quad (8)$$

where p is the price of one unit of the extracted resource, $q(s)$ is the quantity of resource extracted in period s, $C(q(s)$ is the total extraction costs, i is the discount rate. The expression $pq(s) - C(q(s)$ is the current resource rent. The resource rent may be defined the return to any production input over the minimum amount required to retain it in its present use (Lange, 2000). The undiscounted rent in period t can be separated and expressed as follows:

$$V(t) = pq(t) - C(q(t) + V(t+1)/(1+i) \quad (9)$$

For renewable resources such as forests, the change in asset value is a result of natural growth, harvesting and other damages such as fire and movements or transfer of timber (Hassan, 2000). Thus, net accumulation (the change in asset value from one period to the next) can be negative or positive. Net accumulation (*D(t)*) can be expressed as follows:

$$D(t) = Vt+1 - Vt \qquad (10)$$

Inserting equation (9) into (10) we get:

$$D(t) = iV(t+1)/(1+i) - [pq(t) - C(q(t))] \qquad (11)$$

Equation (11) is the fundamental asset equilibrium condition. It indicates that net accumulation is the difference between two opposing forces. Firstly, the shifting of the discounted streams of future rents towards the present, which increases the asset value, and secondly, the realization of current resources rent which decreases the asset value.

Under continuous time (11) simplifies to the negative of the amount of a resource extracted and the marginal net price of the resource:

$$D(t) = -[p - C'(q(t))]\, q(t) \qquad (12)$$

where $C'(q(t)$ is the marginal cost of extraction. The expression [p – $C'(q(t)$] is the marginal rent associated with resource extraction. According to Vincent (1999), this result requires prices, the cost of extraction schedule and the discount rate to be constant over time and the extraction time to be optimal. The product of the marginal rent and quantity extracted is known as Hotelling rent. According to Vincent and Hartwick (1998), (12) is the correct equation to use even though there is a difficulty of finding data on marginal costs. Because of the difficulty in finding marginal cost data, average costs has been used in place of marginal costs as a measure of resource rent. However, the use of average cost is said to lead to an overestimation of the resource rent and the value of the asset (Vincent and Hartwick, 1998; Lange and Wright, 2004; Mabugu et al., 1998; Davis and Moore 2000). This bias is mainly due to the fact that average cost is usually lower than marginal cost (Lange, 2000; Davis and Moore, 2000).

If data on average cost and the elasticity of marginal cost curve are available, net accumulation can be calculated by applying the net price method as follows:

$D(t) = -[p - (1+\beta)C(q(t)/q(t)]\ q(t)$: (13)

where $C(q(t)/q(t)$ is the average extraction costs and β is the elasticity of marginal cost curve.

To derive net accumulation, the negative of the current resource rent is multiplied by a conversion factor involving the discount rate, the number of years until the resource is exhausted (T-t) and the elasticity:

$D(t) = -[pq(t) - C'(q(t))]\ \{1 + \beta)/[1 + i)^{T-t}]\}$ (14)

Equation (14) may be regarded as the generalized form of the El Serafy method (Vincent and Hartwick, 1998)

The application of the net price method in valuation of timber resources has been described as the net depletion method (Vincent and Hartwick, 1998). The net depletion method of a resource such as timber is calculated by subtracting growth and other additions from harvest (and other subtractions) and then the negative of the result is multiplied by the net price as follows:

$D(t) = -[p - C'(q(t)]\ [q(t) - g(S(t))]$ (15)

where g(S(t) is growth of resource in period *t.* The net depletion method is however suited to renewable resources which can be harvested immediately. Forestry resources grow over a length of time before they can mature and become ready for harvest (Hassan, 2003). Thus, at any point in time, there is a mixed stand of forest consist of different age groups. To allow for age differences in forests, Vincent and Hartwick (1998) derived a method based on the present value criterion to calculate changes in asset values and distinguished between mature and immature forest as follows:

$D(T) = -[p - C'(q(T))]\, q'(T)\, [1 - (1 + i)^{t-T}]/i$ mature forest (16)

$D(T) = [p - C'(q(T))]\, q'(T)\, (1 + i)^{t-T}]$ immature forest (17)

This is often called the net price variation (Vincent and Hartwick, 1998)

where *T* is optimal rotation length in years, *t* is age of forest, *C'* is the marginal cost.

If harvest interval is not necessarily optimal under the net price method, the change in the asset value/ha can be determined by the El Serafy method for forest as follows:

$D(T) = -[pq(T) - C'(q(T))][1 - (1 + i)^{-T}]$ Mature forest (18)

$D(t) = [pq(T) - C'(q(T))]\, i\, (1 + i)^{t-T} / [1 - (1 + i)^{-T}]$ Immature forest (19)

were *p* is the price of harvested timber, per m^3, *c* is average cost of harvesting, *D* is the volume of timber harvested in m^3/ha, *i* is the discount rate, *t* is the age of the forest (years), *T* is rotation age which is not necessarily optimal. Two main differences between El Serafy's method for non-renewable resources (e.g. minerals) and El Serafy's method for renewable resources (e.g. forest) is that in the latter the marginal cost of elasticity does not appear and that the discount terms are more complex (Vincent and Hartwick, 1998). The complexity of the discount rate is a reflection of the delay between regeneration and harvest as well as the economic condition for selecting the optimal rotation period (Vincent, 1999).

Because of lack of data (including time series data), it was not possible, in this thesis, to compute the value added generated by various resource activities in the Okavango Delta. Ideally, the appropriate measure of value should be the marginal contributions of wetland asserts and services. The marginal value of a resource is the change in economic value that results from a small increase of decrease in the service being valued (Gowdy, 2000). In the context of wetlands, the marginal contributions would be economic value of the services gained or lost from an alteration of an incrementally small wetland area (EEDP, 1989). Because of human dependence on wetlands, the changes in quality and quantity of wetlands ecosystem goods and services results in change in human welfare. The valuation of ecosystem services and goods at the margin would therefore entail determining the difference that relatively small changes in these services make to human welfare (Costanza et al., 1997). The changes in quality and quantity of ecosystem services, essentially lead to changes in the benefits or costs associated with human activities thorough established market or through non market activities (Costanza et al., 1997).

In this thesis, the measure of value is total value and not marginal value because data on marginal and average values is lacking. The value of the Okavango Delta assets and services were determined using the 'total economic value' framework which is based on three main components: direct use values, indirect use values and non-use values (Tietenberg 2000; Pearce and Moran, 1994; Hanley and Splash, 1993; Munasinghe, 1992; Kahn, 1997).

Use value comprises direct and indirect use values (Figure 4). Direct use values are those benefits that arise from people's direct use of the resource, such as wetlands (Turner et al., 2000; Oglethorpe and Milaidou, 2000). Many species are economically useful and can be directly harvested or serve as inputs to a production process, giving rise to extractive or direct use values. In the context of a forest, extractive use value would be derived from timber, harvest of minor forest products such as fruits, honey, herbs, or mushrooms, firewood, and from hunting and fishing (Environmental Assessment Source Book Update, 1998). Another category of use value is the option value, value that arises from the fact that an individual may be uncertain about his or her future demand for a resource and its availability in the future (Barbier et. al., 1997). Economic valuation techniques such as market analysis, travel cost, contingent valuation, replacement cost method can be used to determine direct use value (Barbier, 1994).

The combination of organisms and their role in sustaining biophysical cycles within the framework of a hierarchy of ecosystem also give rise to indirect use values (Perrings et al., 1995). Indirect use values, also known as non-extractive use values, are derived from the services that the environment provides, and do not require any good to be harvested, nor do they enter a market at all (Environmental Assessment Source Book Update, 1998). In the context of wetland resources, examples of indirect use values include floodwater retention, groundwater recharge and nutrient abatement (Achrya, 2000). These values may be determined by techniques such as damage cost avoided, preventative expenditure and replacement cost method (Barbier, 1994).

Non-use values, (passive values) on the other hand, are intangible values that people derive from preservation of the environmental assets such as wetlands (Oglethorpe and Miliadou, 2000). Two categories of non-use values are recognized. These are existence and bequest values. Existence value is value that is attached to knowing that an environmental asset exists even though the value attributer may not be interested in consuming that resource (Barbier et al., 1997; Oglethorpe and Miliadou, 2000; Turner et al., 2000). The concept of existence value is fundamentally related to the deep ecologists' view that resources should have the right to exist. According to Chopra (1993) existence value is related to the extent to which the loss of a resource is irreversible and irreplaceable. Bequest value is the value that an individual derives from ensuring that the resources will be available in the future (Turner et al., 2000; Oglethorpe and Miliadou, 2000). Another category of non-use value is option value which refers to the fact that an individual values an environmental resource because he/she has the option to use that resource in the future (Kahn, 1997; Pearce and Turner, 1990).

Contingent valuation method is the most popular method used in determination of non-use values (Folmer, 1997; Oglethorpe and Miliadou, 2000; Pate and Loomis, 1997; Sutherland and Walsh, 1985; Blomquist and Whitehead, 1998). While direct and indirect use values are important, van Kooten and Bulte (2000) think that perhaps the largest economic value that biodiversity provides is the existence value, which is a category of a non-use value often considered as the sum of what individuals are willing to pay for knowing that certain species exist. In spite of their view, some of the benefits of ecosystems have proved to be difficult to measure because they are mostly not captured by conventional market based economic activity and analysis (Balmford et al., 2002).

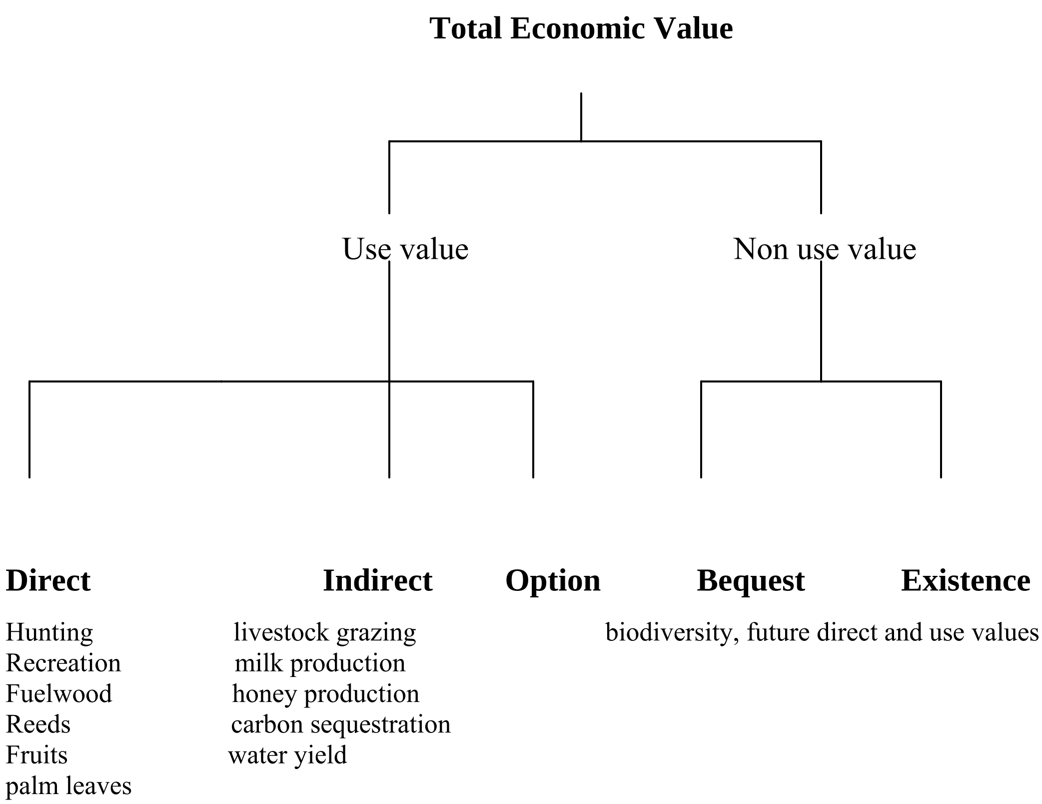

Figure 4: **Components of total economic value**
Source: Barbier (1991)

4.3 General methodology

The present study uses the Okavango Delta as an example to identify some of the important uses of resources that can be included in natural resource accounts at national level, as well as their estimated economic values. The Okavango Delta is one of the most economically important areas in Botswana but until now there has not been any economic data such as Gross Regional Product or forest reserve collected or used which can be adjusted by using some of the results from this study. Hence this study does not make any attempt to adjust any accounts. It is expected that ongoing work of the Okavango Delta Management Project (ODMP) will contribute to efforts to generate data that will be used in the construction of natural resource accounts.

4.3.1 Direct consumptive use

4.3.1.1 Accounting for the composition of traded herbivore species

A compositional table for traded herbivore species at the end of 2003 was compiled using data from a report of DWNP (2003) on aerial census of animals in Botswana. The aerial census accounts do not show the population of males and females separately. For valuation of the standing stocks (composition), the department's schedule of prices for single game hunting licenses for non-citizens was used. Botswana, unlike, South Africa, does not have auction market prices for traded animals. The single game hunting license fees paid by non-citizens are the closest values to the market values since they reflect the average auction prices of South Africa, Namibia and Zimbabwe (Kaisara personal communication, 2004). However, these single game hunting license fees do not differentiate between males and females. However, it is generally understood that the hunting license fees reflect prices of male animals since they are the ones to be hunted. To determine the value of a species, the single game hunting license fees paid by non-citizens was multiplied by the number (population) of the species. This value was then translated into per hectare values. A conservative estimate for herbivores was calculated using single game hunting license fees paid by citizens.

4.3.1.2 Accounting for ecological functions provided by wild herbivores

When a portion of standing stock of animals is used, the size of the standing stock changes. The number of animals traded yields flow values. The annual hunting quota specifies the total allowable off-take of animals from citizen hunting areas, community managed areas and concession areas. In citizen hunting areas, hunting quotas are allocated using a raffle system. In community managed areas and concession areas, quotas are allocated only after expected demands have been submitted to Department of Wildlife and National Parks. A functional table was compiled using allowable wildlife off-take from hunting areas during 2003. The value of hunting was determined by multiplying the number of traded animals from all hunting areas by their associated prices (single game hunting license fees for paid by non-citizens). Some wild herbivores such as the rhino, giraffe and waterbuck are not traded because they are protected. Conservative estimates were derived by multiplying the annual hunting quota by the single game hunting license fees paid by citizens.

4.3.1.3 Accounting for the composition of vegetation

Plant species of the Okavango Delta are very diverse. Growth of different species or forms in certain environments is determined principally by the soil and moisture conditions. Because of lack of data on specimen density and biomass, a compositional table for flora that is similar to that for wild animal species could not be constructed. However, a compositional table for the number of species and their growth forms in 2003 was constructed. A plant growth form is a type of growth which displays features of plants in a given environment (Mueller-Dombois and Ellenberg, 1974; Odum, 1971). Plants may be tall or short, evergreen or deciduous, herbaceous or woody (Smith and Smith, 2001). Thus, evergreen tall trees, broadleaved evergreens, broadleaved deciduous, thorn tree, dwarf trees, and hydrophytes are different types (Smith and Smith, 2001; Mueller-Dombois and Ellenberg, 1974).

The stock accounts of the number of plant species were for the closing date of the end of 2003. The stock accounts show an inventory of diversity and how much of it is there. Different growth forms included aquatic creeper, aquatic emergent, free floating aquatic plants, floating leaved aquatic plants, floating stemmed aquatic plants, aquatic shrub, submerged aquatic plants, epiphyte, ground creeper, geophyte, graminoid plants, herbaceous plants, shrublet, tree and woody climber. Data sources for this compilation of compositional table were the report of aquatic species of the Okavango Delta (Rapid Biological Assessment of the Aquatic Ecosystem of the Okavango Delta, Ecological Zoning of the Okavango Delta, and the report of the Feasibility study on the Okavango River to Grootfontein link of the eastern national water carrier.

4.3.1.4 Accounting for ecological functions provided by vegetation

Vegetation provides a number of products that include fuelwood, building materials (poles, thatching grass, river reed), medicines, palm leaves for basket weaving, and a range of wild fruits that are directly consumed or used in other production activities such as beer brewing.

A functional value table for river reed, fuelwood, wild fruits, palm leaves and thatching grass from the Okavango Delta was compiled using information from household surveys. Thus, the values or functions were not derived from standing stock of vegetation biomass, but from people’s responses about the use of these resources. Due to the lack of data on vegetation biomass and productivity, estimation of the rate of extraction of vegetation resources was not possible. While vegetation has great medicinal values, no valuation was done for medicinal plants because of the difficulty in estimating the quantities of traditional medicines used during a year. Only plant part’s used as medicines were indicated. This information was based on the household survey, group discussion and existing literature.

The data for the household surveys was collected by administering a semi-structured questionnaire in the villages of Shakawe (located in the Panhandle area of the Okavango Delta), Etsha-13 (located in the eastern side of the Delta), and Shorobe (located in the southern part of the Delta) (Figure 1).

Sampling of households was undertaken using enumeration maps from the Botswana Population Census for 2001. All household dwellings had a dwelling and enumeration area number. This made it possible to consider the list of households as an appropriate sampling frame. Household dwellings were randomly selected from the list of each village. There were a total of 1096 household dwellings in Shakawe, 345 in Etsha-13 and 242 in Shorobe. One hundred and fifty five (155) households were randomly selected from Shakawe, 55 households from Etsha-13, and 45 households from Shorobe, making a total of 255 households.

Information about natural resources included species of plants or plant products harvested, frequency of harvesting, quantity harvested, and whether plant resources were harvested for sale or home consumption. Information about price was collected for resources that were marketed. Information from the survey, group discussions and existing literature on plant use was used to estimate annual quantities of plant resources consumed or harvested, as well as the annual labour time spent in collecting these resources. In some instances the weight and diameter of the bundles of resources were measured. Estimating and valuing the quantities (kg) of wild fruits collected was problematic for a number of reasons. Firstly, wild fruits are harvested in different volumes or weights. Secondly, harvesters may collect wild fruits and consume them directly without any known quantity or volume. Thirdly, some of the wild fruits are not usually sold in the local market or never exchanged with any goods. Some traditional fruits may have substitute fruits that are sold in local shops but which are of higher quality. This means that the use of the price of the substitute fruits may not truly reflect the value of the wild fruit. Respondents were asked to estimate the equivalent quantities of their regular harvest. Attempts were made to convert the reported harvested quantities into weight by multiplying the harvesting period (weeks) by the frequencies of collection and the estimated quantities (weight).

To estimate the total quantities of plant resources in the riparian communities, the average household's harvest and the percentage of households harvesting different products in the villages of Shakawe, Etsha-13 and Shorobe, were used. According to Applied Research Development Consultants (2001), these plant resources are harvested in 21 riparian villages. The direct use value of each plant resource was determined by multiplying the price of the resource by the annual quantities harvested by households and by the estimated percentage number of household that harvest the resources. Conservative estimates were derived by assuming that the values of these plant resources were 30% of the total estimate. Experience and group discussions show that about 70% of the plant resources harvested are not actually used at household level because some of these resources are stored until they rot. This happens either because household lacks the labour to do construction work or there is no market for which the household had planned to sell the product.

4.3.2 Direct non-consumptive use values

Direct non-consumptive use value in this study was based on tourism in the Moremi Game Reserve. Moremi Game Reserve is the only game reserve found within the Okavango Delta visited by a high number of tourists. Wildlife viewing is the basic form of land use inside Moremi game reserve. The game reserve provides access to the Okavango Delta's wide variety of attractions, which range from wilderness scenery of wildlife viewing to fishing and it is arguably one of southern Africa's most popular safari destination as it is hugely populated with impressive wildlife and wilderness areas (Barnes, 1998).

The value of tourism includes traveling expenditure by tourists to the Okavango Delta (using air or road transport), revenues from accommodation (hotel and camping fees), entry fees, vehicle fees, boat fees, aircraft landing fees and other fees (filming and permit renewals for guides). Data used for computation of direct non-consumptive use value of tourism were obtained from a report of the *Northern Parks and Reserve Visitor Statistics for 2003* which is compiled by the Department of Wildlife and National Parks.

While expenditure on international travel is a very significant component of the value of tourism, there is often a difficulty in estimating this value due to multiple visits. The difficulty arises because the value of travel expenditure to a particular destination cannot be isolated from other destinations that were visited. To resolve this problem, only air travel expenditure from international airports in the region and road travel expenditure within Botswana were estimated. Data on camping nights (accommodation), entry fees, vehicle fees, boat fees and aircraft landing were compiled by the DWNP.

4.3.2.1 Citizen and resident tourists

A citizen tourist is a visitor who visits a particular destination point within his country. The citizen tourists may be given some special treatment as compared to other types of tourists. For instance, citizen tourists may pay a lower park entry fee than a non- citizen. A resident tourist is a non- citizen individual who lives in the country for a particular reason. When such an individual visits a tourist destination he or she may also receive special treatment compared to non-citizen tourists.

To estimate the travel expenditure, it is important to know the origin of tourists. Though the origins of tourists from within Botswana were not indicated in the statistical report, a very small percentage of tourists have Maun and the surrounding areas as their origin (Mbaiwa personal communication, 2004; Gojamang, personal communication, 2004). It was therefore assumed that among citizen and resident tourists, only 2% of the visitors had Maun and the surrounding areas as their origin, while the rest (98%) had their origins in urban centers and villages such as Gaborone, Francistown, Lobatse, Selibe Pikwe, Sua town, Kasane, Orapa, Jwaneng, Ghantsi, Kang Serowe, Palapye, Ramotswa, Kanye, Mahalapye. In addition, it was assumed that all citizen and resident tourists drove to Maun and to Moremi Game Reserve. The distance from Maun to Moremi Game Reserve and back is approximately 40 kilometres of tarred road and 80 kilometres of sandy road. The expenditure on travel for citizen and resident tourists was estimated by multiplying the total number of vehicles, the distance covered and the cost per kilometer. Each vehicle was estimated to have a seating capacity of five people. To determine the number of vehicles, the total number of tourists was divided by the average seating capacity of each vehicle (5). The government of Botswana's official rate for mileage cost was used as the cost of travel per kilometer. The official rates are P2.90/km for sandy road, P2.10/km for gravel road, and P1.30/km for tarred road.

It was assumed that 98% of citizen and resident tourists used road transport and covered an average distance of 698 kilometres between 15 urban centers and Maun. Their travel expenditure was estimated in the same way as that for citizen and resident tourists. The expenditure for this category of tourists also included entry and vehicle fees.

4.3.2.2 South African tourists

Of the tourists who came from South Africa, it was assumed that about 95% of them drove to Maun, while only 5% used air transport (Gojamang personal communication, 2004). Those who used road transport drove through the border gates of Tlokweng, Martin's Drift or Lobatse. The average distance between the three border gates to Maun was estimated to be 925 kilometres. The expenditure on travel for this category of tourists was estimated in the same way as that of citizen residents. Other expenditure for these tourists included accommodation, entry fees and vehicle fees.

For South African tourists who used air travel, the travel expenditure was estimated from the cost of a return air ticket (P2211.00) between Maun and Johannesburg multiplied by the number of tourists.

4.3.2.3 Other international tourists

An international tourist is a visitor who stays at least one night (24 hours) in a collective or private accommodation in the country visited (Mowforth and Munt, 1998). International tourists, including those who came from other African countries, generally use air transport from Windhoek (Namibia), Johannesburg (South Africa) or Victoria Falls (Zimbabwe) and then used road transport to travel from Maun to Moremi Game Reserve. Their expenditure on travel was estimated by multiplying the average price of a return air ticket (P2115.00) from each of the three departure points and the number of tourists. Data on the prices of air tickets between Maun and different places (Johannesburg, Windhoek, Gaborone and Victoria Falls) were obtained from Air Botswana's schedule of fares in the region. The expenditure on road transport for these three groups of tourists were estimated in the same way as other tourists who used road transport.

Estimates of the value of tourism were derived based on the assumptions that there were few local visitors who had Maun and the surrounding areas as their origin. This assumption is based on the fact that locals are used to seeing animals in their area. The second assumption was that all South African visitors drove from the major border gates between Botswana and South Africa to the Moremi Game Reserve as they wanted to have a full experience of other places.

4.3.3 Indirect consumptive use values

4.3.3.1 Livestock grazing

The value of livestock grazing was computed using data from a report of the Department of Animal Health and Production (2003) on livestock census for Ngamiland district during 2003. The different types of livestock considered were cattle (bulls, cows, oxen, tollies, heifers, and calves), goats, sheep, donkeys and horses. Based on the existing relationships that a livestock unit (LSU) weighs about 450 kg, the following livestock equivalents were derived to estimate the total number of livestock units: *1 bull = 1.2 LSU*, *1 cow = 1* ox *= 1 LSU, 1 heifer = 1 tolly =0.1 = 1 LSU*. The value of grazing was calculated based on the information that (i) a Tswana LSU grows at a rate of 0.4kg per day, while a cross breed between Tswana cattle and Brahman breed grows at a rate of 0.5kg per day (Raditedu personal communication, 2004) (ii) the protein conversion efficiency of a livestock unit is about 55% (King, 1983). (iii) beef biomass is priced at P272 per 1000kg of biomass. The price of beef was obtained from the Botswana Meat Commission's schedule of prices for 2002/2003. The grazing value was calculated from the number of large stock units x growth of LSU x price of livestock unit. This value was then converted into per hectare basis. In the first scenario, it was assumed that 95% of the LSU were of the pure Tswana breed and 5% were of a cross breed between Tswana and Brahman breed.

4.3.3.2 Milk production

The value of milk production was calculated using information on the number of births, as a proxy for lactating cows. However, data on the number of births during 2003 was not available. Therefore, the number of births for 2003 was estimated by projecting the number of births for 2002 into 2003 using an annual birth rate of 3%. The value of milk production was then calculated by multiplying the number of births, the average period of lactation during the year, the average production of milk per cow (kg) and the price of milk (Pula/kg). The value was then converted into per hectare basis. In the first scenario, all breeds were assumed to be of pure Tswana cattle. In the second scenario, 50% of the breeds were assumed to be pure Tswana, while 50% were cross-breed between Tswana and Jersey. The sources of data for the valuation of milk production were the Central Statistics Office (2002), Mahabile personal communication (2004) and Bendsen (2002).

4.3.3.3 Honey production

The estimated value of honey production was calculated from the product of the number of hives or reared colonies, the average production per hive, the period of harvesting and the price per kilogram of honey (Pula/kg). The total production and total value were then converted into the value per hectare. Data on honey production and prices of honey per kg was obtained from annual reports of the Bee-keeping Section of Regional Agricultural Office in Maun. Conservative estimates of the value of honey were derived based on the assumption that in most cases the environmental conditions for honey production were not favourable or optimal. For instance, drought can lead to low production levels of honey.

4.3.3.4 Carbon sequestration

Plants absorb carbon dioxide from the atmosphere through the process of photosynthesis and store carbon in woody tissues. When the plant dies and decays, the carbon dioxide is released into the soil which is ultimately released to the atmosphere through the process of decomposition. The value of storage function of plants is in delaying the release of carbon into the atmosphere that causes global warming.

In this study, the monetary value of carbon sequestrated was estimated by using information from a study of Veenendaal et al. (2004) in which the seasonal variation in carbon dioxide, water vapour and energy fluxes in a broad leaved semi arid savanna (Mopane woodland) was determined using eddy covariance technique. Since there is no carbon trading in Botswana, the price of US$5.4/ton as used by Hassan (2002) in South Africa was used in the computation of the value of carbon sequestration.

4.3.3.5 Water supply and use

The use of water from the Okavango Delta was estimated from information on the supply of boreholes distributed throughout the Delta as well as the amount of surface water pumped out from the Delta to supply villages that are surrounding the Delta. Estimates for the supply of either surface or groundwater were done for Okavango sub-district, Ngami sub-district and the urban village of Maun. The amount of water supplied by boreholes was the output of water that was pumped from each borehole for 10 hours per day.

The estimated economic value of water supplied was obtained by multiplying the total volume of the water in m^3 by the average consumption tariff of P4.95/m^3. Conservative estimates were made by using minimum water consumption tariff of P3.75/m^3 The sources of information for water supply were the annual reports for the Department of Water Affairs (2003), Republic of Botswana (2003c) and Republic of Botswana (2003d)

4.3.4 Non–use values (Preservation values)

Estimates of indirect non-consumptive values (existence and bequest values), also known as preservation values, were determined from surveys of households and tourists. The results derived from households and tourists were extrapolated to derive the non-use value for the whole area for 2003.

4.3.4.1 Household survey

The respondents in the household survey on preservation values of the Okavango Delta were the same respondents who provided information on the direct use values of vegetation as described in section 4.3.1.4. A total of 250 household heads were interviewed face to face about their willingness to pay for the preservation of the Okavango Delta. The contingent scenario for the willingness to pay is discussed in section 4.3.4.3. In the first scenario, estimates were made on the assumption that households were quite aware of the possibility of upstream water abstraction by the Namibian Government. In the second scenario, it was assumed that there was no possibility of water abstraction and hence the willingness to pay for the preservation of the Okavango Delta would only be 1/3 of the maximum that would be paid under a threat of water abstraction.

4.3.4.2 Tourist survey

In the tourist survey, no systematic sampling was done. The aim was to get as many responses as possible. The questionnaire (see annex) was handed out to tourist respondents by research assistants, at various arrival points (Maun Airport, hotels, lodges and various camping sites). A total of 500 questionnaires were handed out to tourists. The need and purpose of the survey was explained to tourists in the covering letter. Tourists were assured in the covering letter that the information they were going to reveal would be used for academic purposes only. Tourists were requested to mail the completed questionnaire using an already addressed envelope, or leave the questionnaire at the reception at hotels, lodges, or at the airport when they departed. The completed questionnaires were collected regularly at these points. A total of 132 questionnaires were returned which represented a response rate of 26.4%. The formulated scenarios for tourists were similar to that of households, except that tourists were assumed to pay 50% under the scenario of no possibility of Namibian water abstraction.

4.3.4.3 The contingent valuation scenario

No questions were asked about the different categories of non-use values such as existence or bequest values. An open-ended question was directed to households and tourists (see annex). The following contingent valuation scenario was presented to households, tourists and non-users**:**

> The Okavango River is increasingly being viewed as a source of water for development by the governments of Namibia, Botswana and Angola. In 1996 the Namibian government proposed to abstract about 17 million cubic metres of water annually from the Okavango River. Hydrological simulations indicate that as a result of water abstraction, the maximum loss of inundated area would be approximately 7.5 square kilometres. This loss is equivalent to 0.1% of the total inundated area of the delta. Assume that the Permanent Okavango River Basin Commission (OKACOM) wishes to establish an Okavango River Conservation fund (ORCOF) with the main aim of supporting activities that will help in conservation of the Delta. Assume also that the funds will be used in the best possible way you can think of. Would you be willing to contribute to this fund?

Since it was anticipated that the heads of households in the household survey would have difficulty in stating their monetary contribution, they were given the option of expressing their willingness to pay by giving other forms of contribution such as livestock (cows, goat, sheep or chicken) and crop amounts (bags of sorghum, maize, beans or groundnuts). These contributions were then converted to monetary values using the prevailing market prices during 2003.

CHAPTER 5

TOTAL ECONOMIC VALAUE OF THE OKAVANGO DELTA

5.1 Introduction

In this chapter, the total estimated economic value of the Okavango Delta is presented under different scenarios and assumptions. In most cases two scenarios have been developed. Actual estimates are made, while conservative estimates are made under various assumptions. Estimates are made of compositional accounts of selected herbivores, functional or direct use value of herbivores and plants, water supply, indirect use values of livestock grazing, milk production, honey production and carbon sequestration. Estimates of non-use values are made for tourists and households. All estimates are also presented on per hectare basis.

5.2 Accounting for stock of wild herbivores and vegetation of the Okavango Delta region: Composition values

5.2.1 Wild herbivores

The wildlife resources of Botswana are found within protected areas and wildlife management areas (WMAs). Protected areas refer to game reserves and national parks that are managed by the DWNP for the conservation of wild habitats, biological diversity and wildlife. Only non-consumptive uses such as wildlife viewing is allowed within protected areas. WMAs on the other hand, are areas that surround and connect protected areas, providing migratory corridors and buffer zones. Consumptive and non-consumptive exploitation of wildlife is carried out within WMAs (Government of Botswana, 2003c). To facilitate the administration of hunting in the country, the government established controlled hunting areas (CHAs) within the WMAs.

The annual wildlife census compiled by the Department of Wildlife and National Parks provided the data base for the construction of the compositional accounts for selected herbivore species. Two scenarios were developed based on hunting license fees for various animal species. In the first scenario, the valuation of the composition of selected herbivores was carried out using hunting license fees paid by non citizens, while in the second scenario the valuation was carried out using hunting license fees paid by citizens. The hunting fees paid by citizens are lower than hunting fees paid by non-citizens. In both scenarios, the estimated values were for traded species only. In a perfect market system, the price of a given animal species would reflect its total economic value or the sum of direct use value, indirect use value and non-use value. Accordingly, an animal species such as an elephant has direct use values (meat, hides, ivory, live animals, tourism, recreation), indirect use values (for example, contribution to biodiversity or nutrient cycling), option values (all future values) and non-use values (existence, bequest and spiritual values). The hunting license fees should reflect the scarcity values of the traded animal species. However, since the prices are controlled by the Government of Botswana, they are subject to change depending on management situations as seen by government of Botswana. For instance, hunting license fees paid by citizens and non citizens have been very lower for a long time when compared to the new schedule of prices introduced in 2001 (Arntzen, 1998). The new schedule of hunting license fees is a result of a recent review of old fees by the government of Botswana. The current prices are comparable to prevailing prices in the region, particularly those in Zimbabwe, South Africa and Namibia.

Scenario 1: compositional values of wild herbivores using citizen prices

Table 6 shows the compositional accounts for different herbivore wildlife species during 2003. The change in the population of wildlife species is expected to be brought about by natural increase (birth) and decrease (death) and man-made increase (introductions) or decrease (hunting and poaching). Table 6 also shows the values of each species during the same year.

Table 6: Estimates of stocks of traded wild herbivores using non-citizen prices

Species name	Common name	Number of animals	Area size (ha)	Density (animal/ha)	Market price (Pula)	Value (Pula)	Value (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)	Species status
Loxodonta Africana	Elephant	57 381	10 822 000	0.00530	20 000	114 762 000	23 417 186.1	106.05	21.64	CITES appendix 1
Equus burchelli	Zebra	17 447	10 822 000	0.00161	5 000	87 235 000	17 800 301.75	80.61	16.45	Abundant
Phacochoerus aethiopicus	Warthog	1 148	10 822 000	0.00011	500	5 740 000	1 171 247	0.53	0.12	Abundant
Taurotragus oryx	Eland	360	10 822 000	0.00003	2 500	90 000	18 364.5	0.0083	0.0017	Abundant
Tragelaphus strepsiceros	Kudu	3 693	10 822 000	0.00034	1 000	3 693 000	753 556.65	0.34	0.069	Abundant
Tragelaphus spekei	Sitatunga	167	10 822 000	0.00002	5 000	985 000	200 989.25	0.099	0.020	Abundant
Oryx gazelle	Gemsbok	7 191	10 822 000	0.00066	2 500	17 977 500	3 668 308.88	1.66	0.34	Abundant
Hippotrugus niger	Sable	949	10 822 000	0.00009	5 000	4 745 000	968 217.25	0.44	0.090	Partially protected
Kobus leche	Lechwe	48 628	10 822 000	0.00449	1 000	48 628 000	9 922 543.4	4.49	0.92	CITES appendix II
Redunca arundinum	Reedbuck	67	10 822 000	0.00001	1500	100 500	20 507.025	0.0093	0.0019	Protected
Damaliscus lunatus	Tsessebe	4 560	10 822 000	0.00042	3 000	13 680 000	2 791404	1.26	0.26	CITES appendix II
Alcelaphus buselaphus	Hartebeest	414	10 822 000	0.00004	1 000	414 000	84 474.7	0.038	0.0078	Abundant
Connochaetes taurinus	Wildebeest	5 765	10 822 000	0.00053	2 500	14 412 500	2 940 870.63	1.33	0.27	Abundant
Aepyceros melampus	Impala	26 419	10 822 000	0.00224	500	132 095 00	2 695 398.48	1.22	0.24	Abundant
Antidorcas marsupialis	Springbok	1 417	10 822 000	0.00013	400	566 800	115 655.54	0.052	0.011	Abundant
Sylvicapra grimmia	Duiker	973	10 822 000	0.0009	300	291 900	59 562.20	0.027	0.0055	Abundant
Raphicerus campestris	Steenbok	3 391	10 822 000	0.00031	300	1 017 300	207 580.065	0.094	0.019	Abundant
Syncerus caffer	Buffalo	17 697	10 822 000	0.00164	5 000	88 485 000	1 8 055 364.25	8.18	1.67	Abundant
Papio ursinus	Baboon	3 037	10 822 000	0.00028	200	607 400	123 939.97	0.056	0.011	Abundant
Total		**200 704**	10 822 000			**1 444 992 400**	**294 850 699.2**	**133.5236**	**42.14**	

Source: Own calculations based on Aerial Census of Animals in Botswana (2003), Single Game License Hunting Fees

Using the license fees paid by non-citizens, the total value of the standing stock of selected wildlife herbivore species was estimated at P1 444 992 400[1] (US$294 850 699.2) (Table 6). The total value is an underestimation because some of protected herbivore species such as the rhino and giraffe are not traded. The total value per hectare was estimated to be P133.5/ha (US$27.24/ha). The value of wildlife herbivores per hectare for individual herbivore species ranged from P106.05/ha (US$21.64/ha) for elephant (*Loxodonta africana*), to P0.093/ha (US$0.018/ha) for reedbuck (*Redunca arundinum*). The low value per hectare for *Redunca arundinum* is a result of the low population of these animal species. Currently, *Redunca arundinum* is a protected animal species.

Scenario 2: Compositional value of wild herbivores using non-citizen prices

In the second scenario, the compositional value was estimated at P535 881700 (US$109 000000), while the values per hectare was estimated at P49.5/ha (Table 7). The corresponding values in the first scenario are more than two times the size of the values in the first scenario. Considering that hunting license fees paid by non citizens are closer to market values of animals (Kaisara personal communication, 2004), the valuation of wild herbivores using hunting license fees paid by citizens leads to a gross undervaluation of these resources which may lead to unsustainable utilization of wildlife resources.

[1] 1Botswana Pula = 0.204050US$ (5/7/2004)

Table 7: **Estimates of compositional values of selected wild herbivores using citizen prices**

Species name	Common name	Number of animals	Area size (ha)	Density (animal/ha)	Market price (Pula)	Value (Pula)	Value (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)	Status
Loxodonta Africana	Elephant	57 381	10 822 000	0.00530	8 000	459 048 000	93 668 744	42.42	8.66	CITES appendix 1
Equus burchelli	Zebra	17 447	10 822 000	0.00161	1 000	17 447 000	3 560 060	1.61	0.33	Abundant
Phacochoerus aethiopicus	Warthog	1 148	10 822 000	0.00011	150	172 200	35 137.41	0.012	0.0024	Abundant
Taurotragus oryx	Eland	360	10 822 000	0.00003	700	252 000	51 420.6	0.023	0.0047	Abundant
Tragelaphus strepsiceros	Kudu	3 693	10 822 000	0.00034	300	1 107 900	226 067	0.10	0.020	Abundant
Tragelaphus spekei	Sitatunga	167	10 822 000	0.00002	1 500	250 500	51 114.53	0.023	0.0047	Abundant
Oryx gazelle	Gemsbok	7 191	10 822 000	0.00066	700	5 033 700	1 027 126	0.47	0.096	Abundant
Hippotrugus niger	Sable	949	10 822 000	0.00009	1 500	1 423 500	290 465.2	0.13	0.027	Partially protected
Kobus leche	Lechwe	48 628	10 822 000	0.00449	300	14 588 400	2 976 763	1.35	0.28	CITES appendix II
Redunca arundinum	Reedbuck	67	10 822 000	0.00001	500	33 500	6 835.68	0.0030	0.00061	Protected
Damaliscus lunatus	Tsessebe	4 560	10 822 000	0.00042	500	2 280 000	4 65 234	0.21	0.043	CITES appendix II
Alselaphus buselaphus	Hartebeest	414	10 822 000	0.00004	300	124 200	25 343.01	0.011	0.0022	Abundant
Connochaetes taurinus	Wildebeest	5 765	10 822 000	0.00053	500	2 882 500	5 88 174.1	0.27	0.055	Abundant
Aepyceros melampus	Impala	26 419	10 822 000	0.00224	150	3 962 850	808 619.5	0.37	0.075	Abundant
Antidorcas marsupialis	Springbok	1 417	10 822 000	0.00013	100	141 700	28 913.89	0.013	0.0027	Abundant
Sylvicapra grimmia	Duiker	973	10 822 000	0.00009	100	97 300	19 854.07	0.009	0.0018	Abundant
Raphicerus campestris	Steenbok	3 391	10 822 000	0.00031	100	339 100	69 193.36	0.031	0.0063	Abundant
Syncerus caffer	Buffalo	17 697	10 822 000	0.00164	1 500	26 545 500	5 416 609	2.45	0.50	Abundant
Papio ursinus	Baboon	3 037	10 822 000	0.00028	50	151 850	30 984.99	0.014	0.0029	Abundant
Total		**200 704**	10 822 000			**535 881 700**	**109 000 000**	**49.5**	**10.10**	

Source: Own calculations based on Aerial Census of Animals in Botswana (2003)

5.2.2 Vegetation

The Okavango Delta is characterized by high floristic diversity. Floristic species diversity can be measured in terms of species richness and evenness (*alpha* diversity), or in terms of habitat diversity (*beta* diversity) (Ellery and Tacheba, 2003). The species richness of the Okavango Delta is due to a number of factors including the range of habitats (perennial swamps, seasonal swamps, seasonal grasslands, intermittent flooded areas, and the dryland) the gradient in soil and water chemistry, which ranges from freshwater swamps to saline pan and the dynamic water flow patterns that occur over time scales (Ellery and Tacheba, 2003). Plant diversity of the Okavango Delta is made up of 134 families, 530 genera, 1256 species and 1299 taxa (Ellery and Tacheba, 2003). Gibbs-Russell (1987) cited in Ellery and Tacheba (2003) indicated that the density of species in the Delta is between 0.029 and 0.039 taxa.km^{-2} which is greater than for most of the Southern African biomes such as savannah, nama karroo and desert, and is similar to the grassland and succulents karoo biomes, but less than that for the fynbos. Gibbs-Russell (1987) cited also in SMEC (1989) indicated that species area ratio of the Okavango Delta is greater than even some of the world larger biomes such as Europe, Sudan, Eastern Northern America, Tropical Africa, West Tropical Africa, Australia, Tropical Asia, Brazil and Southern Africa. The plant growth forms of the Okavango Delta and number of recorded species are shown in Table 8.

Table 8: Identified growth forms and number of species in the Okavango Delta

Growth form	**Number of species**	**% of known total species (1259)**	**Status[a]**		
			Vulnerable	Low risk- nearly threatened	Low risk- least concern
Aquatic creepers	6	0.48	-	-	-
Emergent aquatic	82	6.5	*Eulophia angolensis, Eulophia latilabris*	-	-
Free floating aquatic	17	1.4	-	-	-
Floating leaved aquatic	12	0.95	-	-	-
Floating stemmed aquatic	5	0.4	-	-	-
Aquatic shrub	7	0.6	-		
Emergent & submerged aquatic	2	0.2	-	-	-
Submerged aquatic	27	2.1		-	-
Epiphyte	1	0.08	*Ansellia Africana*	-	-
Geophyte	2	0.2	-	-	-
Ground creeper	14	1.1	*Herpagophytum procumbens*	-	-
Graminoid	331	26.4	-	-	*Pycreus okavangensis*
Herb	383	30.5	-	-	-
Herbacious wetland plant	15	1.2	-	-	-
Herbaceous creeper	76	6.05	-	-	-
Herbaceous geophyte	30	2.4	-	-	-
Woody herb	4	0.3	-	-	-
Tree	67	5.3	*Acacia hebaclada*	-	-
Shrub/tree	33	2.6	-	*Boscia foetida*	-
Shrub/wood climber	4	0.3	-	-	-
Shrub	57	4.5	-	-	
Shrublet	36	2.9	-	-	-
Aquatic tree	3	0.2	-	-	-
Wood climber	4	0.3	-	-	-
Woody ground creeper	1	0.08	-	-	-
Herbaceous root parasite	2	0.2	-	-	-
Tolerance of salinity/alkalinity	1	0.08	-	-	-
Total	221				

Sources: Compiled from Ellery and Tacheba (2003, SMEC (1989), Golding (2002)

a = the species indicated does not occur in the Okavango Delta, but is either vulnerable , endangered or nearly threatened in other parts of Botswana: *Adenum boehmianum* (endangered), *Adenium oleifolium* (vulnerable), *Hoodia lugardi* (vulnerable), *Huernia levyi* (vulnerable), *Orbeopsis knobelii* (vulnerable), *Euphobia venteri* (endangered), *Naaea minima* (vulnerable), *Anacampeeros rhodesiaca* (vulnerable), *Erythrophysa transvaalensis* (vulnerable), *Harpagophytum zeyheri* (nearly threatened).

Of the known floral growth forms, herbs contributed the highest numbers in species diversity, while epiphytes and woody ground creepers were the least diverse. In terms of species conservation status, two emergent aquatic plants, one epiphyte species, one ground creeper and one tree species, are vulnerable. One shrub/tree species is nearly threatened.

The vegetation composition was not valued because the number of individual plant species was not known. Only growth forms of plants occurring in the Okavango Delta are recorded. For instance, it is known that *Sclerocarya birrea,* a tree, or *Cyperus papyrus,* a graminoid, occur in the Okavango Delta, but data showing the number of specimens of *Sclerocarya birrea* or *Cyperus papyrus* plants in the Okavango Delta does not exist. Further, no data exists showing the density of plant species which could be used to compute the number of specimen of species.

5.3 Direct use values from the Okavango Delta

5.3.1 Wild herbivores

The determination of direct use values of wild herbivores was based on hunting license fees paid by citizen and non-citizens. The value of extraction in the first scenario was determined using hunting license fees paid by non-citizens, while values in the second scenario were determined using hunting license fees paid by citizens.

Scenario 1: Direct use value of wild herbivores using citizen prices

Individual animal species showed a range of extraction values and the value of extraction per hectare during 2003 as shown in Table 9. The extraction value was determined by multiplying the number wild herbivores in the hunting quota for 2003 by the hunting license fee for the particular animal species. The duiker (*Sylvicapra grimmia)*, the warthog (*Phacochoerus aethiopicus*) and the Steenbok (*Raphicerus campestris*) had the highest rates of extraction, which were 26.8%, 21.35% and 18.35%, respectively. The rate of extraction was calculated by dividing the number of wild herbivores in the hunting quota for 2003 by the total standing stock for that particular species in 2003. In terms of the value per hectare, elephants had the highest value of P0.29/ha. Species such as the sable (*Hippotragus niger*), the Roan antelope (*Hippotragus equines*) are not extracted because they are partially or fully protected.

Table 9: Estimates of direct consumptive use values of selected wild herbivores during using non-citizen prices

	Common Name	Area (ha)	Total animals	Animals off-take	Extraction (%)	Price (Pula)	Total value (Pula)	Total value (US$)	Value/ha Pula/ha	Value/ha (US$)
Loxodonta Africana	Elephant	10 822 000	57 381	156	0.27	20 000	3120 000	6 36636	0.29	0.059
Equus burchelli	Zebra	10 822 000	17 447	106	0.61	5 000	530 000	108 146.5	0.049	0.010
Phacochoerus aethiopicus	Warthog	10 822 000	1 148	245	21.3	500	122 500	24 996.125	0.011	0.0022
Taurotragus oryx	Eland	10 822 000	360	29	8.1	2 500	72 500	14 793.625	0.0067	0.0014
Tragelaphus strepsiceros	Kudu	10 822 000	3 693	180	4.9	1 000	180 000	366 729	0.017	0.0035
Tragelaphus spekei	Sitatunga	10 822 000	167	0	0	5 000.	0	0	0	0
Oryx gazella	Gemsbok	10 822 000	7 191	38	0.53	2 500	95 000	19 384.75	0.0088	0.0018
Hippotrugus niger	Sable	10 822 000	949	0	0	5000	0	0	0	0
Kobus leche	Lechwe	10 822 000	48 628	296	0.61	10 00	296 000	60 398	0.0056	0.0011
Redunca arundinum	Reedbuck	10 822 000	67	0	0	1 500	0	0	0	0
Damaliscus lunatus	Tsessebe	10 822 000	4 560	398	8.7	3 000.	1 194 000	243 635.7	0.11	0.022
Alselaphus buselaphus	Hartebeest	10 822 000	414	40	9.7	1 000	40 000	8 162	0.0037	0.00076
Connochaetes taurinus	Wildebeest	10 822 000	5 765	132	2.3	2 500	330 000	67 336.5	0.030	0.0061
Aepyceros melampus	Impala	10 822 000	26 419	860	3.3	500	430 000	87 741.5	0.040	0.0082
Antidorcas marsupialis	Springbok	10 822 000	1 417	41	2.9	400	16 400	3 346.42	0.0015	0.00031
Sylvicapra grimmia	Duiker	10 822 000	973	261	26.8	300	78 300	15 977.115	0.0072	0.0015
Raphicerus campestris	Steenbok	10 822 000	3 391	622	18.3	300	18 600	3 795.33	0.0017	0.00035
Syncerus caffer	Buffalo	10 822 000	19 697	138	0.78	5 000	690 000	140 794.5	0.064	0.013
Papio ursinus	Baboon	10 822 000	3 037	265	8.7	200	53 000	10 814.65	0.0049	0.001
Total		10 822 000	**200 704**	**3807**	**1.90**		**7 266300**	**1 484 688.52**	**0.65**	**0.13**

Source: Own calculations based on Wildlife Hunting Quota for 2003

The total extraction rate for all species was 1.9%, while the total value (flow) of this extraction was estimated at P7 266 300 (US$1 482 688.52). On per hectare basis, this is translated into P0.69/ha (US$0.14/ha). The flow values may be considered true estimates of the extraction value because the values were derived from the actual number of animals allocated in hunting quotas.

Scenario 2: Direct use values of wild herbivores using non-citizen prices

In the second scenario, the total direct use value of extraction was estimated at P2 299 100 (US$469 131.4), and the direct use value per hectare was estimated at P0.21/ha (US$0.043/ha). The total direct use value, which represents a conservative estimate, is one third of the estimated value in the first scenario.

Table 10: **Estimates of direct use values using citizen prices**.

Species name	Common Name	Area (ha)	Total animals	Off-take of animal stock per annum	Rate of extraction per annum (%)	Price (Pula)	Total value (Pula)	Total value (US$)	Value/ha (P/ha)	(Value/ha) (US$/ha)
Loxodonta Africana	Elephant	10 822 000	57 381	156	0.27	8 000	1248 00	254 654.4	0.12	0.024
Equus burchelli	Zebra	10 822 000	17 447	106	0.61	1000	106 000	21 629.3	0.0098	0.0020
Phacochoerus aethiopicus	Warthog	10 822 000	1 148	245	21.3	150	36 750	7 498.84	0.0034	0.00070
Taurotragus oryx	Eland	10 822 000	360	29	8.1	700	20 300	4 142.22	0.0019	0.00038
Tragelaphus strepsiceros	Kudu	10 822 000	3 693	180	4.9	300	54 000	11 018.7	0.0050	0.0010
Tragelaphus spekei	Sitatunga	10 822 000	167	0	0	1500	0	0	0	0
Oryx gazelle	Gemsbok	10 822 000	7 191	38	0.53	700	26 600	5 427.73	0.0025	0.00050
Hippotrugus niger	Sable	10 822 000	949	0	0	1500	0	0	0	0
Kobus leche	Lechwe	10 822 000	48 628	296	0.61	300	88 800	18 119.64	0.0082	0.0017
Redunca arundinum	Reedbuck	10 822 000	67	0	0	500	0	0	0	0
Damaliscus lunatus	Tsessebe	10 822 000	4 560	398	8.7	500	199 000	40 605.95	0.018	0.0038
Alselaphus buselaphus	Hartebeest	10 822 000	414	40	9.7	300	12 000	2 448.6	0.0011	0.00023
Connochaetes taurinus	Wildebeest	10 822 000	5 765	132	2.3	500	66 000	13 467.3	0.0061	0.0012
Aepyceros melampus	Impala	10 822 000	26 419	860	3.3	150	129 000	26 322.45	0.012	0.0024
Antidorcas marsupialis	Springbok	10 822 000	1 417	41	2.9	100	4 100	836.61	0.00038	0.000077
Sylvicapra grimmia	Duiker	10 822 000	973	261	26.8	100	26 100	5 325.71	0.0024	0.00049
Raphicerus campestris	Steenbok	10 822 000	3 391	622	18.3	100	62 200	1 2691.91	0.0057	0.0012
Syncerus caffer	Buffalo	10 822 000	19 697	138	0.78	1500	207 000	42 238.35	0.019	0.0039
Papio ursinus	Baboon	10 822 000	3 037	265	8.7	50	13 250	2 703.66	0.0012	0.00025
Total		10 822 000	**200 704**	**3807**	**1.90**		**2 299 100**	**469 131.4**	**0.021**	**0.0043**

Source: Own calculations based on Wildlife Hunting Quota for 2003 and Single Game License Hunting Fees

5.3.2 Vegetation

Two scenarios were developed based on the estimated direct use values and the conservative estimates. In the first scenario, it was assumed that households sold all of their harvest in the market. This scenario represents the value of the total quantities of vegetation resources. In the second scenario households were assumed to sell part of their harvest because the market was not well developed. In addition, households used part of the resource collected at home. It was assumed that households sold only 30% of the harvest or collection while prices remained unchanged. The second scenario represents the value of what households actually use.

Scenario 1: Households sell all their harvest

The household survey in the villages of Shakawe, Etsha-13 and Shorobe revealed that households harvest a number of products of vegetation (Table 11).

Table 11: Percentage of households harvesting vegetation resources in the Okavango Delta

Resource	Village			Average %
	Shakawe	Etsha-13	Shorobe	
River reed	81	67	24	57
Thatching grass	81	49	16	49
Wild fruits	45	25	4	27
Fuelwood	92	98	87	92
Palm leaves	27	42	33	34
Medicinal plants	8	20	9	12

Source: Compiled from the household survey in 2003 conducted by the author, and household survey conducted by Applied Development Research Consultants in 2001

5.3.2.1 River reed

Two species of reeds, *Phragmites australis* and *Phragmites mauritianus,* are harvested in the area. *Phragmites mauritianus*, also known as the common reed, is more spiny, taller and more productive than *Phragmites australis.*

At Shakawe, river reed is harvested from August to December when the Okavango Delta flood levels have receded. Reeds are harvested using a sickle and then made into bundles. An average reed bundle measures approximately 800 mm in diameter and weighs 10 kg. Information from the household survey and discussion groups revealed that on average, 3 bundles are harvested by an individual in 8 hours per day. The average frequency of harvesting was about twice a week. Based on the frequency and the seasonality of harvesting, the annual labour hours of harvesting were calculated to be 336 hours. The total number of bundles harvested annually was therefore 126. Bundles are then carried by head to the household yard. A bundle of reed was worth P20.00 (US$4.08) in 2003.

At Etsha-13, the harvesting of river reed commences in December and ends in mid February when the flood levels have peaked. A reed harvester in Etsha-13 spends 8 hours a day to harvest 2 bundles. More time is spent walking an approximate distance of 5 kilometres to the harvesting site. On average, the frequency of harvesting was reported to be 2 times a week. The total labour hours for harvesting were therefore 171.2 hours. On this basis, fourty three (43) bundles were harvested annually from Etsha-13. All harvesters reported that they carry the reeds on their heads. As in Shakawe, a bundle of reed was worth P20.00 (US$4.08) in 2003.

At Shorobe, the harvesting of river reed starts in August and ends in January. The bundles of reeds are made smaller than those at Shakawe and Etsha-13, and measure about 400 mm in diameter. While harvesters at Shakawe are closer to the river, those in Shorobe are about 25 kilometres away from the harvesting site. Harvesters hired transport for transporting them to the harvesting site where they stay for about two and half months. At the site, an average harvester spends about 10 hours to harvest 10 bundles per day. The reported frequency of harvesting was 6 days a week. The total estimated labour hours are thus 516 hours and the total number of bundles harvested was 516 bundles. Each bundle was sold for P10.00 (US$2.04) in 2003.

Using reported prices of reeds from the household survey and group discussions, the total estimated annual use value of reed in the riparian communities was estimated at P25 588 400.00 (US$5 221 313.02) in 2003, while the value of river reed per hectare was estimated at P142.16 (US$29.00).

5.3.2.2 Thatching grass

At Shakawe, *Miscanthus junceus* is the main thatching grass. The harvesting season is from August to December. Eighty-one percent of the households at Shakawe were involved in the harvesting of *Miscanthus junceus*. Approximately 4 bundles of grass are harvested in 8 hours per day by one harvester twice a week. It has also been reported that it takes less time to harvest a bundle of grass than river reed. The total labour hours for grass harvesting was 336 hours. Annually, a household therefore harvests about 168 bundles. A bundle of *Miscanthus junceus* measures about 850mm in diameters and weighs almost the same as a bundle of river reed. A bundle of grass was worth P20.00 (US$4.08) in 2003.

Miscanthus junceus is also the main thatching grass at Etsha-13. The harvesting period is from December to mid-February. It takes an average harvester 10 hours per day to harvest 3 bundles of grass per day. The harvesting site is approximately 7 kilometres away. The harvesting frequency was twice a week. The total labour hours for harvesting were estimated at 214 hours per year. Annually, a household therefore harvests 64 bundles of grass. Despite the fact that the village is located some kilometers away from the harvesting site, none of the households reported to be using any other means of transport other than carrying the bundles one by one on their heads. The local price of the grass was P20.00 (US$4.08) in 2003.

At Shorobe, the main thatching grass species is *Cymbopogon excavatus* which is harvested between July and October. Harvesters pay for transporting their bundles by sharing the total bundles equally between themselves and owner of transport. On average, 8 bundles are harvested in 10 hours per day. The average frequency of harvesting was six (6) days in a week. The total labour hours for harvesting was estimated at 642 hours. The annual number of bundles harvested was 514. A bundle for *Cymbopogon excavatus,* which has a diameter of 500mm, and an average weight of 4.5 kg, was worth P10.00 (US$2.04) in 2003. The annual direct use values of thatching grass in the riparian communities was estimated to be P706 208 (US$144 101.74) in 2003 (table 12) which translates to P3.92/ha (US$0.80/ha).

5.3.2.3 Palm leaves (Hyphaene petersiana)

The leaves of the palm tree (Hyphaene petersiana) and the roots and/or bark of bird plum (Berchemia discolor) and diamond leaved euclea (Euclea divinorum) are used in the making of baskets. The roots/and or bark of Berchemia discolor are used to produce red dye, while Euclea divinorum is used to produce brownish dye. Hyphaene petersiana can be harvested year round. According to group discussions, the majority of basket makers harvest the palm tree leaves for own production of baskets. The average harvesting frequency was once a month. The harvested leaves are cooked and dried and tied into small bundles. From the initial harvest, about 5 small saleable bundles can be made. An average dry bundle weighs about 37 grams (0.037kg). Thus, the total amount of palm leaves harvested per household per year was 2.2kg. Each bundle was sold for P2.00 (US$0.41) in the local market during 2003. Thus, a kilogram of dry palm leaves would cost about P54.00 (US$11.02). The annual direct use values of harvesting palm leaves from all riparian communities in the area was estimated at P638 431.20 (US$130 271.89) (table 12) during 2003. This value translates to P1.53/ha (US$0.31/ha).

5.3.2.4 Wild fruits

Fifteen wild fruits were reportedly harvested by respondents in all the three villages. The reported harvested wild fruits were corky bark monkey orange *(Strychnos cocculoides),* spiny leaved monkey orange *(Strychnos pungens),* kalahari pobery *(Dialium engleranum),* false brandybush *(Grewia bicolor),* brandybush *(Grewia flava*), large sour plum *(Ximenia caffra),* rough-leaved raisin bush *(Grewia flavascens*), rough-leaved raisin bush *(Grewia retinervis*), makettii tree *(Recinidendron rautenenii*), African mongostein *(Garcinia livingstonei),* bird plum *(Berchemia discolor),* water lily *(Nymphaea caerula)* and African ebony *(Diospyros mespiliformis)*

In this study, the main wild fruits which are often sold in the market were *Strychnos cocculoides*, *Strychnos pungens*, *Grewia bicolor, Grewia flava, Garcinia livingstonei Berchemia discolor* and *Nymphaea caerula.* An average household harvests about 10 fruits of *Strychnos cocculoides*, 10 fruits of *Strychnos pungens*, twice a month during the harvesting period. A single fruit of each plant weighs about 200 grams and was sold for P1.00 (US$0.20) in 2003. For the water lily (*Nymphaea caerula)*, a household harvests about 2 kilograms at a frequency of four times during the harvesting season. A bulb of *Nymphaea caerula,* which weighs about 150 grams, was sold for P0.50 (US$0.10) during

2003. For *Grewia bicolor, Grewia flava, Garcinia livingstonie* and *Berchemia discolor*, the group discussions indicated that the harvesting frequency of an average household was about twice during the harvesting period. A harvester therefore harvests about 2 kilograms of each fruit. A cup full of each fruit was sold for about P1.00 in the local market in 2003.

Using 4 months as an average harvesting period and the different collection frequencies for different wild fruits, the total amount of fruits collected by an average household was estimated at 128 kg. When an average market price of P4.4/kg was used for all saleable fruits, the average annual household value for fruit collection was calculated to be P563.20 or US$114.92. Table 10 shows that the total estimated amount of fruit collected by riparian communities in the Okavango Delta was P2 225 766.40 (US$454 167.63) during 2003, which translates to P5.33/ha (US$1.09/ha).

5.3.2.5 Fuelwood

A large number of households depend on fuelwood as a source of energy. The most preferred tree species of fuelwood are *Diospyros mespiliformis*, *Terminalia sericea*, *Acacia erubescens*, *Combretum collinum*, *Acacia negrescens*, *Combretum imberbe*, *Baikiaea plurijuga*, *Dichrostachys cenerea*, *Guiboutia coleosperma*, *Colophospermum mopane*, *Acacia tortilis*, *Erythrophleum africanum*, *Euclea undulata*, *Ximenia caffra*, *Ziziphus mucronata*, *Pterocarpus angolensis*, *Lonchocarpus capassa*, *Garcinia livingstonei*, *Croton megalobotrys* and *Bocia albitrunca*. Only dead wood was reported to be collected in all the three villages. The majority of the households collected fuelwood in bundles which they carry on their heads. A few households use donkey carts to carry fuelwood. A bundle of fuelwood weighs about 12 kilograms, while a one-axle load on a donkey cart weighs about 350 kilograms. About 29 bundles of fuelwood can fill up a one-axle donkey cart (350 kg). Group discussions revealed that on average, a bundle of fuelwood can last 3 days. Thus, fuelwood requirements for a week were estimated at 28 kg. On an annual basis, a household fuelwood requirement would be 1 456 kg (1.456 tones). Based on the price of a one-axle donkey cart load of fuelwood of P45.00

(US$9.18) during 2003, the annual revenue for a household would be about P187.00 (US$38.16). The annual direct use value of fuelwood collection in 2003 is shown in Table 12. The total annual direct use value in the riparian communities was estimated at P2 752 509.70 (US$561 649.60) during 2003. On per hectare basis, this was P6.6/ha (US$1.35/ha).

The overall total direct use value of vegetation resources (river reed, thatching grass, fuel wood, wild fruits and palm leaves) was estimated at P29 908 315.74 (US$66 102 791.74) (Table 12), which translates to P159.53/ha (US$ 32.55/ha). The total direct use value is considered an underestimate because it includes only plant products that are marketed.

Table 12: **Estimated direct use value of vegetation in 2003**

Resource	Area (ha)	Average annual household harvest (kg)	Estimated number of Household harvesting	Estimated total harvest (kg)	Price (Pula/kg)	Value per household (Pula)	Total estimated value (Pula)	Total estimated value (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)
River reed	180 000	1 420	9 010	12 794 200	2.00	2 840.00	25 588 400	5 221 313.02	142.16	29.0
Grass	180 000	116	3 044	353 104	2.00	232.00	706 208	144 101.74	3.92	0.80
Fuelwood	417 500	1 456	1 4542	21 173 152	0.13	189.28	2 752 509.70	561 649.60	6.60	1.35
Wild fruits	417 500	128	3 952	5 05 856	4.4	563.20	2 225 766.40	45 455.48	5.33	1.09
Palm leaves	417 500	2.2	5 374	11 822.8	54.00	118.8	638 431.20	130 271.89	1.53	0.31
Total			**35 922**	**34 838 134.8**		**3 583.28**	**29 908 315.74**	**6102 791.74**	**159.53**	**32.55**

Source: Compiled by author from the household survey in 2003

Table 13: **Conservative estimate of the value of vegetation in 2003**

Resource	Area (ha)	Average annual household harvest (kg)	Estimated number of Household harvesting	Estimated saleable harvest (kg)	Price (Pula/kg)	Total value (Pula)	Total value (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)
River reed	180000[a]	1420	9010	3838260	2.00	7676520	1566394	42.6	8.7
Grass	180000	116	3044	105931.2	2.00	211862.4	43230.52	1.17	0.24
Fuelwood	417500[b]	1456	14542	6351945.6	0.13	825752.93	168494.90	1.98	0.40
Wild fruits	417500	128	3952	151756.8	4.4	667729.92	136250.3	1.60	0.33
Palm leaves	417500	2.2	5374	3546.84	54.00	191529.36	39081.57	0.46	0.094
Total			**35 922**	**10 451 440**		**9 573 24.61**	**1 953 396.08**	**48.81**	**9.76**

Source:Table12

Scenario 2

In the second scenario, the total estimated direct use value of river reed, thatching grass, fuel wood, wild fruits and palm leaves were P9 573 124 (US$1 953 396.07) and the per hectare value was estimated at P48.81/ha (Table 13). Values under this scenario can be considered to represent the real situation.

5.3.2.6 Traditional medicinal plants

Plants reported to be used as traditional medicines *were Diospyros lycioides, Bauhinia variagata, Terminalia serecea, Combretum collinumn, Recinidendron rautenenii, Acacia erioloba, Acacia tortilis, Adansonia digitata, combretum imberbe, Bocia albitrunca, Acacia galpinii, Rhus tenuinervis, Clerodendrum ternatum, Ximenia americana, Melhania griquensis, Enicostema ascillare, Combretum hereroense, Pterocarpus capasa, Ficus sycomorus, Gardenia spatulifolia, Croton megalobotrys, Albizia anthelmentica Colophospermum mopane, Ficus thonningii, Euclea divinorum and Harpagophytum procumbens.* Plant parts used for various ailments are shown in Table 14.

Table 14: **Plants parts used as traditional medicine**

Plant	Ailment	Part used
Dispyros lyciocoides	gonorrhea	roots
Terminale serecea	diarrhea, pneumonia, schistomiasis	roots, barks, leaves
Acacia eriolaba	ear infections, headache, stops bleeding	bark, roots leaves
Acacia tortilis	stops vomiting	leaves
Adansonia digitata	diarrhea, fever	leaves, bark
Combretum imberbe	cough	flowers
Bocia albitrunca	epilepsy	unripe fruit
Enicostema ascillare	general pain killer	leaves
Acacia nibrownii	tuberculosis	roots
Clerodendrum ternatum	wound healing	roots
Ximenia americana	pain killer	roots
Melhenia griquensis	improves blood circulation	roots
Combretum hereroense	general pain killer, stomach disorder	roots
Perocarpus capasa	stops bleeding common cold, snake bite	bark
Ficus sycomorus	chest ailments, sore throat	bark and latex
Gardenia spatulifonia	sore throat	roots
Croton megalobytrys	fever (malaria)	bark, seeds
Albiza anthelmentica	body sores	bark and roots
Colophospemum mopane	would healing	gum from wood
Ficus thonningii	snake bite, influenza, syphilis, diarrhea	bark roots
Eulea divinorum	relieves constipation	roots
Harpogiphytum procumbens	painful joints	tubers

Source: compiled by author from the household survey of 2003, Roodt (undated), Hedberg and Staugard (1989)

The valuation of traditional medicinal plants is beset with problems. First, it is very difficult to estimate the quantities or volumes of plants components (roots, bark, leaves or herbs) that are used as traditional medicine. Thus, respondents could not state how much roots or leaves they chewed or how many tea-spoons of powdered materials they used. Second, people use traditional medicine only when they fall sick. This creates the problem of estimating the quantities of medicines used during the year.

It is also difficult to establish the price of traditional medicine because some people harvest traditional medicines from the wild in order to treat themselves without having to buy the medicine elsewhere. Many people visit traditional doctors not to buy traditional medicine but to consult and get treatment. A minimal consultation fee ranging from P10-20 is paid. Thereafter, a larger fee, which includes the whole treatment service, is paid after the patient and the traditional doctor have agreed on the prescribed treatment and the cost thereof. The service may also include performance of rituals. The treatment usually involves more than one type of traditional medicine.

Second, asking people about traditional medicine is a sensitive issue, particularly when the medicine is used to treat sexually transmitted diseases (STD). Traditional medicine is also regarded as inferior to western medicine. These two aspects lead to a people's unwillingness to reveal all the information that is related to the use of traditional medicine.

Third, whether or not traditional medicine treats reported ailments is subject to scientific investigation or tests. Most traditional medicines have not been subjected to laboratory tests. Given this situation, it appears incorrect to use substitute prices of conventional medicines for the cases that traditional medicines were reported to cure. On the basis of these problems, the value of traditional medicine was not estimated.

5.3.3 Water supply and use

The main source of water for the Ngamiland district is the Okavango Delta which has its sources in Angola. Summer rainfall contributes significantly to the flow of the Okavango River which discharges into the Panhandle at Mohembo where the Okavango River enters Botswana. Annual input of rainfall in the Okavango Delta amounts to about 6 144 million cubic metres (Republic of Namibia, 1997), while annual evaporation is estimated at 2 172 mm (Gumbricht et al., 2004).

The Water Unit of the Ngamiland District Council is responsible for supplying water to the rural population in the two sub-districts of Ngami and the Okavango. In the Ngami sub-district where most villages are located far from the Okavango River channel, water is pumped from boreholes into storage tanks and then supplied via stand-pipes. In other smaller rural villages, water is supplied directly from the boreholes. In the Okavango sub-district, groundwater is supplied from boreholes while surface water is supplied from treatment plants to the neighbouring villages.

In the village of Maun, the Department of Water Affairs is responsible for the supply of water to the village. Groundwater is supplied from a wellfield which depends on recharge from seasonal swamps floods in the Shashe River. Water is consumed by the following sub-sectors: domestic (house, yard, stand pipes), institutional (boarding schools, hospitals, force, administration offices), commercial (shops, workshops, banks, restaurant, hotels, irrigation and others), industrial (abattoirs, brick moulding) agriculture (irrigation and livestock). Table 15 shows the quantities and values of water yielded by boreholes (groundwater) and treatment plants (surface water) during 2003.

The source of water for the village of Maun and Ngami sub-district is groundwater, while that for the Okavango sub-district is surface water. The water consumption charges are determined based on the quantities of water supplied to the consumer. Each unit charge corresponds to a water use band. The minimum tariff charge is P3.75/m^3. Using a water consumption tariff of P4.95/m^3, the value of groundwater for the village of Maun and the Ngami sub-district were estimated at P6 413 130.90 (US$1 308 599.36) and P2 477 054.25 (US$505 442.92), respectively, while the value of surface water for the Okavango sub district was estimated at P5 342 559.75 (US$1 090 149.32) (Table 15). The total value of water used during 2003 was estimated at P14 232 744.9 (US$2 904 191.60), and the total value per hectare was estimated at P130.58/ha (US$26.6/ha). This value does not include the value of water used by wildlife and tourist camps situated along the Okavango Delta, as no record of these is made.

Table 15: Estimates of direct use value of water in the Okavango Delta

Surface area (ha) 109 000	Village District	Groundwater water (m^3)	Surface water (m^3)	Total annual yield (m^3)	Water tariff (P/m^3)	Value of water (Pula)	Value of water (US$)	Value per hectare (Pula/ha)	Value per hectare (US$/ha)
	Maun	1 295 582	0	1 295 582	4.95	6 413 130.90	1 308 599.36	58.84	12
	Okavango Sub-district	586 555	492 750	1 079 305	4.95	5 342 559.75	1 090 149.32	49.01	10
	Ngami Sub district	500 415	0	500415	4.95	2 477 054.25	505 442.92	22.73	4.6
	Total	**283 647**	**492 750**	**2 876 397**	**4.953.45**	**14 232 744.9**	**2 904 191.60**	**130.58**	**26.6**

Sources: Own calculations based on report of Waste Water Department and Republic of Botswana (2003c).

Using the minimum water consumption tariff of $P3.75/m^3$, which can be considered a conservative estimate, the value of water was estimated at P10 782 382.5 (US$2 200 143.31). The total estimate of the direct value of water obtained using a tariff of $P4.95/m^3$ was about 1.3 times the value of water obtained under a minimum value of $P3.73/m^3$ as shown in Table 16.

Table 16: Direct use value of water using minimum tariff

Surface area (ha) 109 000	Area	groundwater water (m^3)	Surface water (m^3)	Total annual yield (m^3)	Water tariff (P/m^3)	Value of water (Pula)	Value of water (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)
	Maun	1 295 582	0	1 295 582	3.75	4 858 432.5	991 361.32	44.57	9.09
	Okavango Sub-district	586 555	492 750	1 079 305	3.75	4 047 393.75	825 870.69	37.13	7.38
	Ngami Sub district	500 415	0	500 415	3.75	1 876 556.25	382 911.30	17.22	3.51
	Total	**283 647**	**492 750**	**2 876 397**	**3.75**	**1 078 2382.5**	**2 200 143.31**	**98.92**	**19.98**

Source: Table 15

5.4 Indirect use values

5.4.1 Honey production

Bee-keeping is an income generating activity for individual farmers or groups of farmers, communities or clubs. The production of honey depends on a number of environmental factors, such as rainfall that influence flowering in vegetation that is the source of nectar. Under optimal environmental conditions in Botswana, a hive produces about 12 kg of honey per harvest (Madisa personal communication, 2004). However, because of the variation in environmental conditions, production levels can be as low as 9-10 kg per hive. There were a total of 58 hives during 2003 and the total production was estimated at 1392 kg. At a market price of P30/kg of honey, the value of honey was estimated at P41 760.00 (US$8 531.13), which translates to P0.1/ha (US$0.02/ha) (Table 17).

Table 17: Honey production under optimal environmental conditions

Surface area	No. of hives	Average production per hive (kg)	Period of honey flow	Total honey production (kg)	Market price of honey (P/kg)	Value of honey (Pula)	Value of honey (USD)	Value per hectare (Pula/ha)	Value per hectare (US$/ha)
417500	58	12	2	1 392	30	41 760	8 521.13	0.1	0.02

Source: Own calculations based on Madisa and Keaja (2003), Madisa Personal communication (2004), Annual Beekeeping Report for Ngamiland (2003/2004)

At a production level of 9 kg per hive the total value of honey was estimated at P3 1320 (US$6 390.85) or P 0.075/kg (Table 18). The value of production under the first scenario was about 1.3 times that under this scenario.

Table 18: Honey production under sub-optimal environmental conditions

Surface area (ha)	No. of hives	Average production per hive (kg)	Period of honey flow	Total honey production (kg)	Market price of honey (P/kg)	Value of honey (Pula)	Value of honey (USD)	Value/ha (Pula/ha)	Value/ha (US$/ha)
417500	58	9	2	1 044	30	31 320	6 390.85	0.075	0.015

Source: Table 17

5.4.2 Carbon sequestration

In their study, Veenendaal et al. (2004) estimated the net uptake of carbon dioxide to be 1 mol Cm^{-2} yr^{-1} during a 12 months period. The annual net photosynthesis (gross primary production) was estimated to be 32.2 mol m^{-2} yr^{-1} which translates to 0.322 tonnes per hectare (*1 mole C = 1 gram C*). Since there are no markets for determination of the value of carbon in Botswana, this study used carbon value estimates from other studies. In South Africa, where carbon dioxide contributes 60% of the total greenhouse gas emissions Hassan (2002) estimated the value of carbon to be US$5.4/ton in 1995 prices. Applying carbon price of US$5.4/ton to Botswana, the total value of carbon sequestrated by Mopane woodlands was estimated at P1 533 859.0 (US$312 984.00) or P1.74/ha (US$0.35/ha) (table 19).

Table 19: **The Value of carbon sequestration**

Surface area (ha)	Carbon sequestrated per tone	Carbon sequestrated per total area (tones)	Price of carbon (Pula/t)	Price of carbon (US$/t)	Value of carbon (Pula)	Value of carbon (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)
180 000	0.322	57 960	24.5	5.4	1 533 859.3	312 984	1.74	0.35

Sources: Own calculations based on Hassan (2002), Veenendaal et al. (2004)

5.4.3 Livestock grazing

Information on the statistics of livestock does not show figures for livestock according to the types of breed of cattle. However, the Tswana breed (the local breed), is the most common in the country, and is expected to constitute the highest number of livestock. Two scenarios were formulated based on a number of assumptions and information from various sources. In the first scenario, it was assumed that:

(i) Ninety percent (90%) of the cattle LSU that grazed in the Okavango Delta during 2003 were of the pure Tswana breed as most local farmers prefer to keep the local breed because of its local adaptation for factors such as diseases, parasite and drought. Ten percent (10%) of the cattle LSU the cross breed between Tswana and Brahman because some of the farmers take advantage of genetic traits from different animal breeds.

(ii) Carl Bro (1982) cited in Duraiappah and Perkins (1999) found that in Botswana, livestock units (LSU) (450kg) values vary from 1.2 LSU for a bull to 0.1 LUS for a calf, with a cow or ox that is 4 years old and older being 1.0 LSU.

(iii) The pure Tswana breed LSU grows at a rate of 0.4kg per day or 146 kg per year, while the cross breed between Tswana and Brahman LSU grows at a rate of 0.5kg per day or 183 kg per year (Raditedu Personal Communication, 2004).

(iv) Fifty five percent (55%) of the grazing intake is converted into animal biomass (King, 1983).

(v) The 'All Animal Grade' price of P272 per 1000kg (P0.272/kg) for Botswana Meat Commission (BMC) was used to determine the value of grazing for both pure Tswana breed cattle and the composite breed (Tswana x Brahman)

In the second scenario, it was assumed that one hundred percent (100%) of the cattle LSU that grazed in the Okavango Delta during 2003 were of pure Tswana breed. The growth rate of the LSU units, the feed conversion rate and the grade price for BMC were as stated in the first scenario.

Scenario 1: Grazing values for a cross breed

Using information on the livestock statistics and the livestock unit equivalents, there were a total of 75 096 LSU. Ninety percent (67 586) of these were Tswana breed LSU, while the remaining 10% or 7510 were a cross breed of Brahman and Tswana LSU. Taking 55% to be protein conversion efficiency, the total grazing uptake (kg/LSU) for Tswana breed LSU was therefore 146kg x 100/55 =265 kg, while that for the cross breed was 183 kg x 100/55 = 333kg. The value of grazing was estimated from LSU biomass production (kg) x total number of LSU x the price of beef (P/kg). Using the price of P0.272/kg, the total grazing value was estimated at P3 057 792. 99 (US$623 942.660), while the value of grazing per hectare was estimated at P7.33/ha (US$1.54) (Table 20).

Table 20: **The value of grazing for a Tswana breed and a cross breed between Tswana and Brahman cattle**

Surface area (ha)	Total no. of LSU	LSU biomass production per year (Kg)	(% contribute -on to LSU biomass production	Grazing uptake (kg/LSU)	Total equivalent biomass production (kg)	Price of beef (Pula/kg)	Value of grazing (Pula)	Value of grazing (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)
417 500	67 586	146	55	265	9 867 556	0.272	2 683 975.23	547 665.15	6.43	1.31
417 500	7 510	183	55	333	1 374 330	0.272	373 817.76	76 277.51	0.90	0.23
Total	75 096	329	55	698	11 241 886	0.272	3 057 792.99	623 942.66	7.33	1.54

Source: Own calculations based on Raditedu personal communication (2004), Botswana Meat Commission (2003), Animal Stock Census for Ngamiland in 2003, King (1983), Bendsen (2002)

Scenario 2: Grazing value for a Tswana breed

A lower estimate of the value of grazing was that of the Tswana cattle, which was P 2 982 212.35 (US$ 608 520.43). The value of grazing per hectare was calculated to be P7.14/ha (US$1.46/ha (Table 21). The value of grazing for a cross breed was about 1.3 times the value of grazing for a pure breed of Tswana cattle.

Table 21: Estimated grazing value for pure Tswana cattle breed.

Surface area	Total no. of LSU	LSU biomass production- per year (Kg)	(% contribution to LSU biomass production	Grazing uptake (kg/LSU)	Total equivalent biomass production (kg)	Price of beef (P/kg)	Value of grazing (Pula)	Value of grazing (US$)	Value/ha (Pula/ha)	Value/ha (US$)
417 500	75 096	146	55	265	10 964 016	0.272	2 982 212.35	608 520.43	7.14	1.46

Sources: Own calculations based on Raditedu, personal communication (2004), Botswana Meat Commission (2003), Animal Stock Census for Ngamiland in 2003, King (1983), Bendsen (2002)

5.4.4 Milk production

The value of milk produced can be estimated as the product of the number of births (a proxy for lactating cows), the average production of milk per cow and the price of milk per kg. Data for livestock population and the number of births for 2003 was not available. Therefore, the number of births for 2003 was estimated by projecting births for 2002 using a national average birth rate increase of 3% which was computed for 12 years (1979-1993). Using 3% as the average birth rate increase, the number of births or lactating cows was estimated at 34 138.

As with the value of livestock grazing, the production of milk is a function of breed of cattle. A pure dairy breed such as the jersey, produces more milk per cow than a non-dairy breed of cattle such as Tswana. The average annual milk production of a pure Tswana cow breed, a pure dairy breed cow and a cross breed between Tswana x Jersey is 300 kg, 2000 kg and 800 kg, respectively (Mahabile personal communication, 2004). Since statistics on livestock do not categorize animals according to the type of breed, the valuation of milk production was based on two scenarios and assumptions.

In the first scenario, it was assumed that 50% of the lactating cows were of Tswana breed, while the other 50 percent were of a pure dairy breed. In the analysis, the average annual milk production of 800kg for a cross breed was used. In the second scenario, it was assumed that all the lactating cows were of the Tswana breed.

Scenario 1: Value of milk production for a mixed breed

The total annual milk produced was estimated at P18 770 400 (18 770.4 tones). When valued at P1.70/kg, the total value was P31 909 680 (US$6 512 190.45). On per hectare basis this translates into P76.39/ha (US$17.62/ha) (Table 22).

Table 22: Milk production for Tswana breed and Jersey breed during 2003

Surface area (ha)	No. of lactating cows	Average production per cow (kg)	Total milk produced (kg)	Price of milk (P/kg)	Value of milk (Pula)	Value of milk (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)
417500	17 064	300	51 192 00	1.70	8 702 640	1 776 793.94	20.84	4.25
417500	17 064	800	13 651 200	1.70	23 207 040	4 735 396.51	55.59	13.37
Total	34 128	1100	18 770 400		31 909 680	6 512 190.45	76.39	17.62

Sources: Own calculations based on Central Statistics Office (2002), Mahabile, personal communication (2004)

Scenario 2: Value of milk production for a Tswana breed

All animals under this scenario were of the Tswana breed which had an average annual milk production of 300 kg. Using the market price of milk of P1.70/kg, the annual value of milk production was estimated at P17 405 280 (US$3 551 547.38) (Table 23). Taking the size of communal area of 417500 hectares, the value of milk per hectare was estimated at P41.69/ha (US$8.5/ha) (Table 23).

Table 23: **Milk production for a pure Tswana cattle breed during 2003**

Surface area (ha)	No. of lactating cows	Average production per cow (kg)	Total milk produced (kg)	Price of milk (P/kg)	Value of milk (Pula)	Value of milk (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)
417500	34 128	300	10 238 400	1.70	17 405 280	3 551 547.38	41.69	8.5

Source: Own calculations based on Central Statistics Office (2002), Mahabile, personal communication (2004)

5.5 Non-consumptive use values

A total of 37 378 tourists visited the Moremi Game Reserve during 2003. Twenty-nine percent (29%) of the visitors were private visitors, 23% were clients from mobile operators, 23% were clients from fixed camps/lodges inside Moremi game reserve, and 25% were visitors from fixed camps/lodges outside Moremi Game Reserve. The category of visitors were citizens (4 282), residents (2 435), South Africans (6 114), other African countries (615), North Americans (6 059), South Americans (532), United Kingdom (3 148), Europeans (12 529), Australians/New Zealand (1 300), Asia (281) and (other countries (81). Residents are not citizens of Botswana but stay in the country for various reasons such as diplomatic assignments. Europeans constituted the highest percentage of visitors (33.5 %), while tourists from South Africa constituted the second highest percentage (16%). The smallest percentage was constituted by visitors from other countries.

Two scenarios were developed using various assumptions and information from guidelines set by the Department of Wildlife and National Parks. In the first scenario it was assumed that:

(i) 2% of the citizen and resident visitors (134) had Maun and the surrounding areas as their origin. The remaining (6 583) traveled from the urban towns and villages to Maun covering an average return trip of 1396 km by road. No visitor used public transport. The number of vehicles was derived from: No of visitors/Average sitting capacity of each vehicle which was 5 people. Visitors covered a distance of 20 km of tarred road (Maun to Shorobe), and 80 kilometres of sandy road (Shorobe to Moremi game reserve). Thus, for a return trip, they also covered a distance of 40 km of tarred road and 160 kilometres of sandy road. The total cost of road travel was calculated from: Number of vehicles x Distance covered by each vehicle x Cost per kilometre.

(ii) Ninety-five percent (95%) of South African tourist visitors (5 808) used road transport from South Africa to Maun and passed through the boarder gates of Tlokweng, Martin Drift and Lobatse. No tourists used public transport. The expenditure on road transport was determined as in the first assumption.

(iii) Five percent (306) South Africans used air transport from South Africa to Maun. The cost of air travel was estimated from: the cost of a return ticket x the number of tourists

(iv) All international tourist visitors, comprising visitors from the U.K, Europe, North America, South America, other African countries, Asia and other countries, used air transport from either Johannesburg (South Africa), Victoria Falls (Zimbabwe) or Windhoek (Namibia). The expenditure on air travel was estimated as in the third assumption.

(v) The cost of accommodation (camping) was calculated from: Total number of people who spent nights in the park x Number of nights spent x Average camping fees per person per night. The camping fees are P5.00, P15.00 and P20.00 for citizens, residents and non-resident, respectively. Entry fees are P10.00, P20.00 and P30.00 for citizens, residents and non-resident, respectively. Other costs of tourists include vehicle, boat, aircraft and Parks and Reserve Reservation Office (PARRO).

(vi) Vehicle fees are determined based on weight of a vehicle and whether the vehicle is registered in Botswana or not. The revenue from vehicles was obtained from: Number of vehicles x Number of vehicle per day x Charge according to vehicle weight. Vehicles registered in Botswana weighing under 3 500 kg, between 3 500 and 7 000kg and over 7 000kg, are charged P10.00, P500.00 and P800.00, respectively. Vehicles that are not registered in Botswana weighing under 3 500 kg, between 3 500 and 7 000kg and over 7 000kg, are charged P50.00, P1 000.00 and P1 500.00, respectively.

In the second scenario, it was assumed that none of the citizen residents had Maun and the surrounding areas as their origin because the people from Maun and the surrounding areas are accustomed to seeing animals in their area, particularly in the local game reserve (Maun game reserve). It was also assumed that all South African visitors drove from South Africa to Botswana because they wanted to have a full experience of other places as they were driving to the Okavango Delta. The rest of the information and assumptions were as stated in the first scenario.

Scenario 1: Value (cost) of road travel by citizen in Maun and surrounding areas

The total average distance driven by citizen tourist visitors from urban towns and villages to Maun was estimated to be 698 km or 1 396 km per return trip. These visitors also drove a distance of 40 kilometres using tarred road and 160 kilometres using sandy road between Maun and Moremi game reserve. South African tourist visitors drove a distance of 925 km or 1 850 km for a return trip. As with citizen tourists, the South African tourist visitors drove a distance of 40 kilometres using tarred road and 160 kilometres using sandy road between Maun and Moremi game reserve. Using the calculated number of vehicles and the respective cost per kilometre, the total road travel costs were estimated at P13 932 (US$2 842.83) for visitors from Maun and the surrounding areas, P3 069 663.6 (US$626 364.86 for citizens not coming from Maun, P28 625 678 (US$5 841 669.1) for South African tourists and P3 164 628 (US$645 736.34) for international tourist. The total expenditure on travel was estimated at P9 673 903.6 (US$1 973 960.03) (Table 24).

Table 24: Road travel cost of tourists

Type of tourists	Number of tourists	Number of Vehicles	Distance traveled (km)	Rate used (Pula/km)	Cost of travel (Pula)	Cost of travel (US$)
Local (Maun)	134 134	27 27	40 160	1.3 2.90	1 404 12 528	286.49 2 556.34
Residents & other local tourists	6 583 6 583	1 317 1 317	1 436 160	1.3 2.90	2 458 575.6 611 088	501 672.35 124 692.51
South Africans	5 808 5 808 306 306	1 162 1 162 61 61	1 890 160 40 160	1.3 2.9 1.3 2.9	2 855 034 539 168 3 172 28 304	5 82569.69 110 617.23 647.25 5 775.43
International Overseas	30 664 30 664	6 133 6 133	40 160	1.3 2.9	318 916 2 845 712	65 074.81 580 667.53
Total	-	-	-	-	**9 673 903.6**	**1 973 960.03**

Source: Own calculations based on Northern Parks and Reserves Visitor Statistics Annual Report, 2003

Using P2 211.00 as the price of a return air ticket on Air Botswana travel schedule, and the number of tourists, the air travel expenditure for South African tourists was estimated at P676 566.00 (US$138 053.29) (Table 25).

Using the average price of an air ticket between Maun and Windhoek, Maun and Victoria Falls, and Maun and Johannesburg of P2 115.00, and the total number of tourists (30 664), the total expenditure on air travel for international tourists was estimated to be P64 854 360.00 (US$13 233 532.16). The total air travel for South African tourist and international tourists was therefore estimated at P65 530 926 (US$13 371 585.45) (Table 25).

Table 25: **Air travel costs of tourists**

Type of tourist	Number of tourists	Cost of return air ticket (Pula)	Travel cost (Pula)	Travel cost (US$)
South Africa	306	2211	676 566	138 053.29
International	30 664	2115	64 854 360	13 233 532.16
Total	**30 970**		**65 530 926**	**13 371 585.45**

Source: compiled from Northern Parks and Reserves Visitor Statistics Annual Report (2003)

The revenue generated from accommodation was P539 774.50 (US$110 140.99). Revenue generated from entry, vehicle, boat and aircraft fees are shown in Table 26. The highest of these revenues (78.26%) was constituted by entry fees.

Table 26: **Revenue by type of fees**

Type of fee	Revenue generated (Pula)	Revenue generated (US$)	% contribution
Entry	5 495 723.50	1 121 402.38	78.26
Camping	539 774.50	110 140.99	7.69
Vehicle	488 110	99 598.85	6.95
Boat	240	48.97	0.0034
Aircraft	34 050	6 947.90	0.48
PARRO	464 730	94 828.16	7.62
Total	**7 022 628.00**	**1 432 967**	**100**

Source: Northern Parks and Reserves Visitor Statistics Annual Report 2003

Scenario 2: No tourists from Maun and surrounding area, all South African tourists drive

The assumptions made under this scenario implied that resident visitors, citizen visitors and South African visitors would use more vehicles. Expenditure on road travel will increase as more vehicles would be used. The total expenditure under this scenario was estimated at P9 930 871.4 (US$2 026 394.31) (Table 27).

Table 27: Road travel cost of tourists under scenario 2

Type of tourists	Number of tourists	Number of Vehicles	Distance traveled (km)	Rate used (Pula/km)	Cost of travel (Pula)	Cost of travel (US$)
Residents & other local tourists	6 717 6 717	1 343 1 343	1 436 160	1.3 2.90	2 507 112.4 623 152	511 576.29 127 154.17
South Africans	6 114 6 114	1 223 1 223	1 930 160	1.3 2.9	3 068 507 567 472	626 128.85 115 792.66
International Overseas	30 664 30 664	6 133 6 133	40 160	1.3 2.9	318 916 2 845 712	65 074.81 580 661.53
Total					**9 930 871.4**	**2 026 394.31**

Source: Own calculations based on Northern Parks and Reserves Visitor Statistics Annual Report, 2003 and assumptions

Clearly, travel expenditure formed a significant part of the value of tourism (91.5%) as compared to accommodation (0.6%) and other costs (7.9%) in the first scenario (Table 28). However, in the second scenario, the road travel cost accounted for only 12%, while air travel constituted the largest percentage cost of 79%.

Table 28: **Overall direct non-consumptive use value for tourism in 2003**

Area (ha)	Number of tourists	Accommodation (Pula)[a]	Cost of road travel (Pula)	Cost of air travel (Pula)	Other costs[a]	Total value of tourism (Pula)	Expenditure per person	Value/ha (Pula/ha)	Value/ha US$/ha
Scenario 1									
491 400	37 378	539 774.50	9 673 903.6	6 553 0926	6 482 853.50	82 227 457.6	2 199.89	167.33	34.14
Scenario 2									
491 400	37378	539 774.50	9 930 871.4	6 553 0926	6 482 853.50	82 484 425.4	2 206.76	167.86	34.33

Source: Own calculations based on Northern Parks and Reserves Visitor Statistics Annual Report (2003)

The total value of tourism may be considered an underestimation because the air travel outside Botswana for some of the international tourist was not included in the analysis.

5.6 Non-use values

Estimates of total non-use values for households and tourists were derived by adding all the stated figures for willingness to pay for the preservation of the Okavango Delta. The figures were then converted to Pula or US$ using the prevailing exchange rate. The willingness to pay per person was estimated from: Total willingness to pay for all the respondents/Number of respondents with a positive willingness to pay.

5.6.1 Households' willingness to pay

In the first scenario households were assumed to be aware of the possibility of upstream abstraction of water, which might impact negatively on the benefits that households derived from the Okavango Delta. Consequently, it was assumed that the willingness to pay for the preservation of the Okavango Delta would be a maximum value that household would have decided to contribute. In the second scenario, it was assumed that there was no possibility of water abstraction and households would be willing to pay only a minimum. The minimum value would be equivalent to 1/3 of the maximum that households were willing to pay in the first scenario.

Scenario 1

The household survey revealed that 70% of the households were willing to pay for the preservation of the Okavango Delta. The rest of the households (30%) offered zero bids because they indicated that they did not have any contributions to offer. Respondents could be offering zero values because they believed that others will pay for action to take place. When excluding zero bids, the total willingness to pay for the preservation of the Okavango Delta was estimated to be P8 634.80 (US$1 761.93). The average willingness to pay was therefore P48.24 (US$9.84).

The total population of the head of households staying around and depending on the Okavango Delta was estimated at 15 806 (Population and Housing Census, 2001).

Extrapolating the sample survey results to the total population, the total number of households willing to pay was estimated at 11064, and the total willingness to pay was P533 727.6 (US$108 907.07) (Table 29). The willingness to pay per hectare was therefore P2.97/ha (US$0.6/ha).

Table 29: Maximum households' willingness to pay for the preservation of the Okavango Delta

Area (ha)	Number of household WTP	WTP per person (Pula)	WTP per person (US$	Total WTP (Pula)	Total WTP (US$)	WTP per hectare Pula/ha	WTP per hectare US$/ha
180 000	1 1064	P48.24	9.84	P533 727.60	108 907.07	2.97	0.6

Source: Own calculations based on household survey conducted by author in 2003

Scenario 2

Without the possibility of water abstraction, the total households' willingness to pay for the preservation of the Okavango Delta was estimated at P177 909.12 (US$36 302.36) which translates to P0.99/ha (Table 30).

Table 30: Minimum households' willingness to pay for the preservation of the Okavango Delta

Area (ha)	Number of household WTP	WTP per person (Pula)	WTP per person (US$	Total WTP (Pula)	Total WTP (US$)	WTP per hectare Pula/ha	WTP per hectare US$/ha
180 000	1 1064	P16.08	9.84	177 909.12	36 302.36	0.99	0.20

Source: Table 29

5.6.2 Tourists' willingness to pay

Two scenarios were formulated under the willingness of tourists to pay for the preservation of the Okavango Delta. In the first scenario it was assumed that because tourists have had an experience of the Okavango Delta, they held bequest and existence values, and were willing to pay for the preservation of the Okavango Delta to prevent any water abstraction from upstream of the Okavango Delta. In the second scenario it was assumed that there was no possibility of water abstraction and tourists would be willing to pay a minimum amount for the preservation of the Okavango Delta. The minimum amount was assumed to be 50% of that which they were willing to pay under the possibility of water abstraction in the first scenario.

Scenario 1

In the tourist sample survey, 33.3% of the respondents were willing to pay for the preservation of the Okavango Delta. 51.5% were not willing to pay, while 15.2% protested. Respondents who were not willing to pay were identified by having indicated a 'no' response to the willingness to pay question and then indicating their reason(s) for not willing to pay. Those protesting were identified by not responding to the willingness question, as well as not giving the reasons for not willing to pay. When considering only those who were willing to pay and contributing a value greater than zero, the total willingness to pay was estimated at P46 163.34 (US$9 419.63). The willingness to pay per person was estimated at P1 049.17 (US$214.08) (Table 31). The reasons given by those not willing to pay were responses such as: "I am already contributing to other conservation organizations"; "The Okavango Delta should not be disturbed so that there should be no need to finance its conservation"; "I have insufficient funds to contribute to the conservation of the Okavango Delta"; "The Okavango Delta should generate its own funds through tourism for its conservation"; "Even if I can contribute towards the conservation of the Okavango Delta, it is unlikely that my contribution will be channeled to the conservation of the Okavango Delta"; "The conservation of the Okavango Delta should be the responsibility of Botswana government"; "The conservation of the Okavango Delta should be the responsibility of international conservation organizations"; "There are more international pressing issues than the conservation of the Okavango Delta."

Considering that the total number of tourists who visited Moremi Game Reserve during 2003 was 37 378 (Northern Parks and Game Reserve Statistics, 2003), it can then be inferred from the survey that 12 335 (33% *37 378) of the tourists were willing to pay for the preservation of the Okavango Delta. The total willingness to pay was estimated to be P99 236.00 (US$202 261.71). On per hectare basis this value converts to P5.5 (US$1.12/ha).

Table 31: **Maximum tourists' willingness to pay for the preservation of the Okavango Delta**

Area (ha)	Total number of individuals	Number of individuals WTP	Total WTP (Pula)	Total WTP (US$)	WTP per person (Pula)	WTP per person (US$)	WTP/ha (Pula/ha)	WTP/ha (US$/ha)
180 000	37 378	12 335	12 941 511.95	2 640 676.8	1 049.17	214.08	71.90	14.67

Source: Own calculations based on tourist survey conducted by author in 2003

Scenario 2

The minimum amount that tourists would be willing to pay under no possibility of water abstraction was estimated to be P6 470 755.98 (US$1 320 357.76), while the willingness to pay per hectare was estimates at P35.95/ha (Table 32).

Table 32:Minimum tourists' willingness to pay for the preservation of the Okavango Delta

Area (ha)	Total number of individuals	Number of individuals WTP	Total WTP (Pula)	Total WTP (US$)	WTP per person (Pula)	WTP per person (US$)	WTP/ha (Pula/ha)	WTP/ha (USD/ha)
180000	37 378	12 335	6 470 755.98	1320 357.76	173.12	35.33	35.95	7.34

Source: Table 31

5.7 Chapter conclusion

An effort has been made in this chapter to estimate the economic value of Okavango Delta for selected resources during 2003 using a total economic value framework (Table 33). The various components of total economic value were: composition of herbivores, direct consumptive use of herbivores, vegetation, water supply, direct non-consumptive use of tourism, indirect consumptive use of milk production, livestock grazing, carbon sequestration, honey production and existence value of the Okavango Delta.

The value of composition of wild herbivores was estimated at US$294 850 699.20 under a scenario where hunting license fees paid by non-citizens were used. In the second scenario, a conservative estimate value of composition was derived using hunting license fees paid by citizens. Similarly, the direct use value of wild herbivores of US$1 462 688.22 was derived using hunting license fees paid by non-citizens, while conservative estimates of wild herbivores were derived using hunting license fees paid by citizens. Conservative estimates of both compositional value and direct consumptive use value were underestimated values because they consider values derived using citizen prices which are lower than market prices of wild herbivores. Non- citizen prices, on the other hand are closer to the market values of wild herbivores.

The value of vegetation was estimated at US$6102791.74 under a scenario that assumed that all the harvested vegetation resources were marketed. Conservative estimates of

US$1 953 396.08 were derived under the second scenario that assumed that only 30% of the harvested plants were marketed. The second scenario represents a common situation because households are either not able to sell all their harvest due to lack of market or they are unable to use the plant material due to household labour constraints. Both of these factors lead to non-use of the resource and ultimately loss due to rotting during storage.

The value of water was estimated at US$2 904 191.60 using an average water consumption tariff. A conservative estimate of US$2 200 143.31 was derived based on the scenario that a minimum tariff was used. The minimum tariff leads to an underestimate.

The direct non-consumptive use of tourism was estimated at US$16 778 512.72 under the scenario that assumed that 2% of the local tourists had Maun and the surrounding areas as their origin. The second scenario, which assumed that there were no tourists visitors coming from Maun and the surrounding areas, led to an US$16 830 947. In this case value of the first scenario were conservative estimates

The value of livestock grazing was estimated at US$623 942.66 under the scenario that there were only Tswana and Brahman breeds, while a conservative estimate of US$608 520.43 was derived using the scenario that assumed that the Tswana breed of cattle were the only breed in the Okavango Delta. The value in the second scenario is a conservative estimate as it excludes the value of imported breeds of certain desirable characteristics.

The value of milk production was estimated at US$6 512 190.45 under the scenario that cattle breeds used in the production of milk were Tswana and Jersey. A conservative estimate of milk production of US$3 551 547.38 was derived under the scenario that assumed that only pure Tswana breed of cattle was used for milk production. The second scenario yields conservative estimates because it excludes the value of milk production from other breeds. However, Tswana breeds constitute the highest number of breeds in the country.

The existence value of the Okavango Delta was estimated by households to be $108 907.07 and tourists to be $2 640 676 under the scenario that there was a possibility of water abstraction by the Namibian Government. Conservative estimates were derived based on the scenario that there was no water abstraction. Estimates by households were $36302.36 while those of tourists were $1 320 357.76.

Table 33: **Summary of various economic values of the Okavango Delta**

	Area	Estimated value (Pula)	Estimates value (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha)	Conservative estimate (Pula)	Conservative estimate (US$)	Value/ha (Pula/ha)	Value/ha (US$/ha
COMPOSITION									
Herbivores	10 822 000	1 444 992 400	294 850 699.22	133.52	27.24	535881700	109 000 000	49.5	10.10
Total value		**1 444 992 400**	**294 850 699.2**	**133.52**	**27.4**	**535 881 700**	**109 000 000**	**49.5**	**10.10**
FUNCTION									
Direct consumptive									
Herbivores	10 822 000	7 266 300	1 482 688.52	0.65	0.13	2 299 100	469 131.4	0.021	0.0043
River reed	180 000	25 588 400	5 221 313.02	142.16	29	7 676 520	1 566 394	42.6	8.7
Thatching grass	180 000	706 208	144 101.74	3.92	0.80	211 862.4	43 230.52	1.17	0.24
Wild fruits	417 500	2 225 766.40	45 455.48	5.33	1.09	667 729.92	13 6250.3	1.6	0.33
Fuelwood	417 500	2 752 509.70	561 649.60	6.6	1.35	825 752.93	168 494.90	1.98	0.4
Palm leaves	417 500	638 431.20	130 271.89	1.53	0.31	191 529.36	39 081.57	0.46	0.094
Water	109 000	14 232 744.9	2 904 191.60	130.58	26.6	10 782 382.5	2 200 143.31	98.92	19.98
Total direct consumpt.		**53 410 360.2**	**10 489 671.85**	**291.46**	**59.28**	**22 654 877.11**	**4 422 726**	**146.75**	**27.75**
Indirect consumptive									
Honey	417 500	41 760	8 521.13	0.1	0.02	31 320	6 390.85	0.075	0.015
Carbon sequestration	417 500	1 533 859.30	312 984	1.74	0.35	-	-	-	-
Livestock grazing	417 500	3 057 792. 99	623 942. 660	7.33	1.54	2 982 212.35	608 520. 430	7.14	1.46
Milk production	417 500	31 909 680	6 512 190.45	76.39	17.62	17 405 280	3 551 547.38	41.69	8.5
Total indirect use value		**36 543 092.29**	**7 457 638.24**	**85.56**	**19.43**	**20 418 812.35**	**970 458.66**	**53.91**	**9.96**
Non -consumptive use									
Tourism	491 400	82 484 425.4	16 83 0 947.0	167.86	34.33	82 227 457.6	16 778 512.72	167.33	34.14
Total non-consumptive	**491 400**	**82 484 425.4**	**16 830 947.0**	**167.86**	**34.33**	**82 227 457.6**	**16 778 512.72**	**167.33**	**34.14**
Existence & bequest									
Household Tourists	491400 491 400	533 727.60 12 941 511..95	108 907.07 2 640 676.8	2.97 71.90	0.6 16.67	177 909.12 6 470 755.98	36 302.36 1 320 357.76	0.99 35.95	0.20 7.34
Total existence & bequest	491 400	**13 475 239.55**	**2 749 583.87**	**74.87**	**17.27**	**6 648 665.10**	**1 356 660.12**	**36.95**	**7.54**
Function: Grand total		**185 913 117.4**	**37 527 840.96**	**619.77**	**130.31**	**131 949 812.20**	**23 528 357.50**	**404.94**	**79.39**

CHAPTER 6

DISCUSSION AND CONCLUSIONS

6.1 Introduction

In this chapter, a brief summary of results is given. Secondly, a comparative analysis of the results with other findings in Botswana and elsewhere is made. The policy implications of the findings are also given. Finally, conclusions and recommendations are made at the end of the chapter.

6.2 Summary of results

The composition of wild herbivores varied significantly with elephant constituting the highest population during 2003. Due to their high numbers they had the highest composition value which was estimated at US$19.38/ha. Similarly, the direct use value of elephants was the highest (US$0.059/ha) of all the wild herbivores. However, this does not imply that elephants were the most hunted animals or had the highest hunting quota allocation during 2003. The high direct use value is attributed to the highest market price placed on them. Herbivores with the highest hunting allocation were the duiker, the steenbok and warthog. Such animals have faster reproductive cycles and can replace their population within a short time. The functional value of wild herbivores may be considered a true estimate of the use value since these values were derived from the actual number of animals that were allocated for hunting.

The Okavango Delta ecosystem is characterized by high floral diversity, which is a function of the diversity of its habitats. The floristic diversity is greater than some of the world greatest biomes. The compositional values of the vegetation of the Okavango Delta were not computed. However, given the high plant species diversity, these values are expected to be significant.

Of the estimated direct use values of vegetation (river reed, thatching grass, wild fruits, fuelwood and palm tree leaves), river reed had the highest direct use value of US$29.0/ha, while palm leaves had the lowest direct use value of US$0.31/ha. Considering all the direct use values in the study, which are inclusive of water, the highest direct use value was that of water which was estimated at US$19.98/ha.

Among the estimated indirect use values of the Okavango Delta (honey production, carbon sequestration, livestock grazing and milk production), the greatest value was derived from milk production (US$8.5/ha), and the smallest was derived from honey production (US$0.015/ha).

The willingness to pay towards the conservation of the Okavango Delta as stated by households indicates the monetary sacrifices people would make to have the Okavango Delta preserved from possible ecosystem change as a result of water abstraction. The value per hectare for households and tourists were estimated at US$0.06 and US$16.67, respectively.

6.3 Discussion

6.3.1 Composition value for wild herbivores

The value of the composition of wild herbivores was estimated at over P1.4 billion (US$294.8 million) or P133.5 (US$27.24) on per hectare basis during 2003. The estimated value of the composition of wild herbivore species during 2003 was higher than estimates made on some similar studies in the southern Africa region. In the Rooibos Bushveld area of the Kruger National Park, South Africa, Blignaut and Moolman (2004) estimated the total value of tradable mammals of wildlife species at R167 million (US$2 6475 483). Though the value of the tradable mammalian wildlife species estimated by Blignaut and Moolnam (2004) was lower, the value per hectare of R1024.7 (US$ 153.28) was greater than the value from this study. The differences in the value per hectare may be due to three factors. Firstly, the differences in per hectare values may be due to differences in the sizes of the two areas and the distribution of animals (density). The size of area of the Okavango Delta is almost 10 times the size of the Roibos Bushveld area, and because of the smaller area of the Rooibos Bushveld area, the average densities of animals are higher than the average densities in the Okavango Delta area. Secondly, the differences could be due to the variation in the market price of individual animals. However, these differences are expected to be smaller as the market prices of animals in Botswana are derived based on the average prices of South Africa, Zimbabwe and Namibia. The third factor could be the differences in the compositional structure of animals in the two areas. In South Africa, animals with a higher market price, such as the rhino are auctioned, while they are not traded in Botswana because they are protected.

The compositional value represents the revenue that the country would gain if all the selected wild herbivores were traded at the prevailing prices. The value, however, is a partial value of the total value of wild herbivores as there are also non-consumptive and existence values. The sustainability of production of the compositional value depends on the management of the wild herbivores. The compositional value provides the resource management basis for the following year. That is, it is the value of the standing stock at a given time. Since this value is known, decisions regarding the future utilization of wildlife can be made based on full information of the stock value. Part of the compositional value can be allocated for consumptive use such a safari hunting, while the other part can be allocated to non-consumptive use such as wildlife viewing. This does not however, imply that biologically determined harvestable levels should not be used for hunting quota allocation, but rather, each allocation would be accompanied by its economic value.

The value per hectare of wild herbivores also has important policy implications in the conservation and sustainable utilization of wildlife resources. The value per hectare is a function of the density and the market price of the herbivores. Lower returns per unit of land may be due to low densities suggesting that the stocks of animals may be increased to achieve optimal utilization of resources. However, the carrying capacity of the land should not be exceeded.

6.3.2 Direct use value of herbivores

The direct use value of wild herbivores represents a flow service (hunting), valued at P7 266 300 (US$1 484 688.52) using hunting license fees paid by non-citizens. Though the number of elephants in the hunting quota for 2003 was not necessarily high, their contribution to direct use value was highest. Their high contribution was mainly due to the high price paid for each animal. Sustainable derivation of direct use value of wild herbivores will be determined by harvesting only the surplus or growth, and not the resource base. Harvestable surplus should be from each animal species because each species plays a role in the animal community. Thus, the value derived from elephant can not compensate for lost value of other species.

Sustainable direct use value will also depend on whether or not the habitat for these species is degraded. Thus, conservation and sustainable use are key to sustained utilization of these resources for the current and future generations.

6.3.3 Direct use value of vegetation

Results have shown that vegetation (reed, thatching grass, fuelwood, fruit trees and palm leaves) provide subsistence and income values to households in the Okavango Delta. The average annual household income of US$47.34 for river reed was much higher than the average annual household income of river reed of some wetlands in the region. For instance, Turpie et al. (1999) estimated the annual income of river reed for a household in Barotse Floodplain and Chobe Caprivi Wetlands at US$0.22 and US$29.00/ha, respectively.

The average household direct use value of wild fruits estimated at US$114.92 (USD$5.33) compared well with that found by Twine et al. (2003) in Mametja area in

Limpopo Province in South Africa, which was estimated at R1 026 (US$153.5). The household average direct use value of fruit collection was also higher than the values obtained in the Chobe Caprivi wetlands. Turpie et al. (1999) estimated the annual direct use value of wild fruits per household in these wetlands at US$9.64, while the total value for all households was estimated at US$30 196. On per hectare basis, the value of Chobe Caprivi wetlands were US$0.0099/ha.

The average direct use value of fuelwood per household was estimated at US$38.62 during 2003. This value was smaller than the value of fruit collection and reed collection in this study, but greater than the household value of R 8.7 (US$1.30) obtained by Twine et al. (2003) in Mametja area in Limpopo Province of South Africa. The total direct use value of fuelwood was estimated at more than US$5 million, with a value per hectare of US$1.35/ha.

Thatching grass in the Okavango Delta provided an average annual household direct use value of P232 (US$47.34) during 2003. This value was higher than the direct use value of thatching grass of US$0.023 in the Barotse flooplain, and US$20.79 in the Chobe Caprivi wetlands (Turpie et al., 1999). It was also higher than the direct use value of US$1.30 obtained by Twine et al. (2003) in Mametja area in Limpopo province of South Africa. The per hectare value of US$0.8 from this study was also greater than the per hectare value of US$0.099 in the Barotse floodplain and the per hectare value of US$0.24 in the Chobe Caprivi wetlands (Turpie et al., 1999).

Palm leaves provided an annual average household direct use value of P118.8 (US$24.24) from this study. This value was more than the corresponding value of US$1.36 in the Barotse floodplain wetlands and the value of US$2.27 in the Chobe Caprivi wetlands (Turpie et al, 1999). Similarly, the direct use value per hectare of US$0.31 from this study was higher than the corresponding values of US$0.025/ha in Chobe Caprivi wetlands, and US$0039/ha in the Barotse floodplain (Turpie et al., 1999).

Although the direct use value per hectare of vegetation reported in this study makes it possible to compare these values with the values obtained from studies undertaken in other parts of the world, variations still exist. Firstly, it is not possible to estimate the exact size of the area used and the amount of plant product extracted. Secondly, the use of plant products is not always separated according to the rights of use among the villagers, as people from other places, even urban areas, sometimes visit the areas to extract plant products (see Gram, 2000). Thus, the values per hectare in this study should be considered 'rough estimates' because of the difficulty in estimating the extent and the amount of floral products extracted. Not withstanding these methodological limitations, these values show the revenue from saleable products from the wild. The values show that people, especially the poor, depend on the services of nature, even though the products from which these services are derived outside the realm of market system.

These values provide an important source of information where policy makers are faced with several land use options. For instance, if the government of Botswana supported commercial maize production in the same area where these resources also grow, the values could be compared to the values of commercial maize production per hectare in the same area. If respective values for each resource or the aggregated value is higher than the value of commercial maize production, the decision to convert land into commercial maize production should be abandoned, and the land should be conserved to support the growth of these resources.

6.3.4 Direct use value of water

The direct use value of water from this study was estimated at more than US$2 million. However, this value does not represent the true value of the benefit of water because some use value of water is not accounted for. Secondly, while the structure of the water consumption tariff is designed to encourage water conservation by emphasizing the minimum basic water requirements and thereafter paying more for every extra cubic metre of water consumed (Government of Botswana, 2001), it does not take into account all the costs of supplying water to the consumers. The price of water delivered (water consumption tariff) is lower than what the market price should be, and therefore does not provide the true potential revenue of this resource. The lack of information on the stocks of groundwater adds to this undervaluation problem because if depletion of groundwater is occurring, it is not being accounted for in the structure of water consumption tariffs. The total price of water should reflect the investment cost, operation and maintenance cost as well as external costs of depletion. There is need for policy on correct water pricing, given the scarcity and limited options for augmenting water supply, to meet the needs of the growing rural population. The water pricing policy should aim at bringing water consumption tariffs closer to market prices. It is only through correct resource allocation that sustainable utilization can be achieved.

6.3.5 Non-consumptive use value of tourism

In this study, the value of tourism in Moremi Game Reserve, which included expenditure on travel, was estimated at over P82 million (over US$16 million) during 2003. The aggregate cost per visitor was estimated at US$167.86. The value in the current study was higher than the aggregate recreational value of some of the well known tourist destinations in Africa such as Lake Nakuru National Park in Kenya. Navrud and Mungatana (1994) estimated the recreational value of 88 528 non-resident visitors and 52 803 resident visitors of Lake Nakuru National Park in 1991. The aggregate recreational value for non-resident and residents visitors was estimated at US$13.7-US$15.1 million, while that for non-resident visitors and residents was estimated at US$10.1-US$10.6 million and US$3.6-US$4.5 million, respectively. While the total recreational value for this study was greater, its value per hectare of US$34.33 was smaller than that for Lake Nakuru National Park of US$76.1-US$83.9. Similarly, the value of tourism per hectare in Moremi Game Reserve was lower than the corresponding value for the Rooibos Bushveld area of Kruger National Park in South Africa which was estimated at US$96.66/ha (see Blignaut and Moolman, 2004). The value of tourism per hectare from this study compares well with the value of tourism in the Olango Islands in the Philippines, where the value of on-site expenditure was estimated at US$40-US$50/year (White et al., 2000).

Given the importance of tourism in export earning, employment creation and overall contribution to economic development, the Government of Botswana should continue conserving wildlife resources which are the key resources driving tourism in the Okavango Delta. For sustainable tourism development, part of the returns from tourism should be re-invested in the management of tourism resources as well as in the improvement of delivering tourism services. Thus, the tourism product should be of high quality so that Moremi Game Reserve remains a preferred tourism destination. It should, however, be ensured that the tourism carrying capacity is not exceeded as this may lead to environmental degradation. Customers paying for a tourist experience expect a high standard of environmental quality, but in the face of a declining environmental quality, it is expected that tourists would visit other places of interest with better environmental quality. Thus, an important lesson for policy is that tourism should not solely be driven by the realization of high revenues from the large number of tourists, but must be sustainable in the sense that high revenues are obtainable with little or no environmental damage.

6.3.6 Indirect use values

6.3.6.1 Honey production

Honey production provides additional income and source of food for farmers. The average production of 12 kg per hive was within the production range of 10-15 kg per hive of the Bas Congo Region of the Democratic Republic of Congo (Lathan, undated). The value of honey production during 2003 was estimated at P41 760 (US$8 521.13) or P0.1/ha (US$0.02/ha) which was the smallest of all the indirect use values from this study. The production of honey depends, to a large extent on the sources of pollen and nectar for maintaining the bee colony throughout the rainy season. Whenever there is a shortage of suitable forage during the rainy season, the production of honey should be expected to decline, leading to a decline in economic value.

Under unfavourable environmental conditions, the value of honey production was estimated at US$6 390.35. Since production levels of honey depend on the condition of the vegetation, it follows that the loss of plant biodiversity or the occurrence of unfavourable environmental conditions will inevitably lead to a reduction in the production of honey, and the standard of living of those who depend on honey as a source of food and income. Forest policies should therefore emphasize the conservation of vegetation species which are important sources of pollen and nectar so that not only does income derived from beekeeping becomes sustainable, but also that the functioning of bees as natural pollinators is not affected.

6.3.6.2 Livestock grazing

Based on the number of livestock units, the growth of livestock units and the prices of beef biomass (Pula/kg), the value of a grazing for Tswana cattle breed and a cross breed between the Tswana and Brahman was estimated at just over P3 million (US$623 942.66), while that for a pure Tswana breed only was estimated at P2.9 million (US$608 520). The results seem to indicate that the returns from a cross breed are slightly higher than those for keeping a pure breed only. The per hectare values of a cross breed and pure Tswana breed were estimated at US$1.54 and US$1.46, respectively. Both of the values of grazing per hectare were greater than values for cattle grazing in the Chobe Caprivi wetlands of US$0.84/ha (see Turpie et al., 1999). This is in spite of the fact that the values for the Chobe Caprivi wetlands included the value of milk.

Grazing value provides essential information in the management of grazing resources. High grazing values in open grazing lands may be associated with the high productivity of a range. A high ratio of number of livestock units to the size of the grazing land, may lead to overgrazing, low productivity of the range, poor condition of the animals and low economic values. Thus, if the carrying capacity has been exceeded, the quality of the product (for example, beef) is also expected to decline. One of the predisposing factors to poor productivity of the range is drought. Policies on grazing should therefore address the correct distribution of cattle within grazing resources while considering the limits imposed by adverse environmental conditions.

6.3.6.3 Milk production

A assuming that there were 17 064 lactating Tswana breed of cattle and the same number of Jersey breed of cattle, the total value of milk production was estimated at P31.9 million (US$6.5 million). Assuming also that all breeds of cattle (34128) were of the pure Tswana breed only, the value of milk was estimated at P17.4 million (US$3.5 million). Though milk is generally considered to be a secondary product of livestock and consumed mostly during the wet season in Botswana (Arntzen, 1998), it appears that the returns to milk production in both scenarios are higher than returns from beef production. However, it is common knowledge that beef production is highly subsidised by government. Given that most of the households in the Okavango Delta have to diversify their livelihood strategies due to the multi stranded income strategies and the subsistence orientation production activities (Schudder et al., 1993), it would appear rational for households to keep both beef and dairy breeds of cattle.

6.3.6.4 Carbon sequestration

The value of carbon storage per hectare (US$0.34/ha/year) from this study is much smaller than that found in other species-rich ecosystems. For instance, in the tropical forest, Pearce and Moran (1995) cited in Myers (1996) reported higher values of carbon storage to the value of US$1 000 to US$3 500/ha/year, and those of the Brazilian Amazonia to the value of US$46 billion.

Since vegetation converts carbon dioxide from the atmosphere into carbon in plant tissues (leaves roots, stems) during the process of photosynthesis, it therefore follows that a reduction in the vegetation density would lead to the buildup of carbon dioxide in the atmosphere. It Botswana, tree species such *Colophaspermun mopane* provide good fuelwood and building materials, and the high demand of such species predispose them to over-exploitation. If exploitation of resources leads to a reduction in the density of vegetation, thene carbon storage value is expected to decrease, leading to increases in the concentration of carbon dioxide in the atmosphere. The policy implication of reduced value of carbon sequestration is that government intervention in the form of improving the management and utilization of vegetation resources is necessary. This is because the carbon sequestration service values are of great interest for domestic and international policies. Conservation strategies that would contribute towards the reduction of the buildup of carbon dioxide in the atmosphere should be supported or introduced. These include among others, the introduction of licenses on the cutting of certain tree species or a tax associated with the quantities and/or volumes of trees cut.

6.3.7 Non-use values

Non-use values are un-marketed in nature. In this study, they were solicited by the willingness to pay for the preservation of the Okavango Delta to prevent or mitigate water abstraction. The average willingness of households to pay was estimated at US$9.84, while that for tourists was estimated at US$214.08. On per hectare basis, the willingness of households to pay was US$0.6/ha, and that for tourists was estimated at US$1.12/ha. Minimum estimates for willingness to pay were also derived based on the scenario that there was no threat of water abstraction, and the values were US$36 302.36 for households, and US$2 640 676.8 for tourists.

The sample results obtained in the first scenario were comparable to values obtained in other studies where wetland resources are also facing human threat similar to the Okavango Delta. In Morocco, where the Merja Zerga lagoon is facing threat of over-exploitation, Benessaiah (1998) estimated non-use values of the lagoon by asking 250 visitors how much they were willing to contribute to a state project to avert the threat to the lagoon. The average willingness to pay was a one-time contribution of US$19 per person, which is more than the one-time average households' contributions from this study, but less than the average contribution for tourists. However, Benessaiah (1998) indicated that his findings should be considered a minimum value because the willingness to pay for the population living outside the area (national and international) was not taken into account.

In Kenya, Navrud and Mungatana (1994) also solicited the willingness of residents and non-residents to pay to prevent pollution of Lake Nakuru. The contingent valuation scenario indicated that lake pollution would harm the flamingo birds that were the centre of tourist attraction. The average annual willingness to pay per person was estimated at US$73 for residents and US$20 for non-residents. These results show that the average willingness to pay to prevent pollution was more than the average willingness to pay by households to prevent water abstraction, and slightly higher than that for tourists in this study. In a similar study in Namibia, Barnes et al. (1997) estimated the willingness of tourists to contribute to a wildlife conservation fund and obtained a value of N$144 (US$21.56) which was less than the willingness of tourists to pay in this study. The willingness of households to pay for the conservation of Zambezi wetlands of US$35.06 (see Turpie et al., 1999) was more than that for households in this study.

The willingness of households to pay reflects local people's preference for having the Okavango Delta undisturbed. If the Okavango Delta is left undisturbed, it will continue to provide goods and services to the people. If disturbed, and depending on the nature of disturbance, the Okavango Delta may not provide all or some of the goods and services that it provided before. Simply put, the willingness to pay shows the people's monetary sacrifice to have the Okavango Delta free from disturbance.

The expressions of the willingness to pay for the preservation of the Okavango Delta also imply bequest value held by value attributers. The current generations using resources of the Okavango Delta may not only be attaching a monetary value on the current utilization of the Okavango Delta, but also on its use by the future generations. Thus, they would like to see their way of life and culture that has co-evolved with the wetland to continue from present to future generations. This is the concept of intergenerational equity.

The expression of the willingness to pay by households to avert water abstraction from the Okavango Delta may also be an indication that they did not approve of the proposed move to extract water upstream of the Okavango Delta. It may also suggest that they were not involved in the project consultation process from the beginning. That is, the value of the Okavango Delta to local people was not considered in the proposal to abstract water. Local resource users should therefore be involved in order to understand their perception of how the intended project(s) would impact on resources that sustain their livelihood. It is also equally important to note that the conservation of a resource represents an essential link between indigenous culture (including livelihood strategies) and the value that riparian communities place on the resource (Turpie et al, 1999). Thus, it is not only the economic values that matters but also the social and cultural values of the people. However, these values are difficult to quantify.

The non-use values for the conservation of an ecosystem also imply that biodiversity should be conserved. If disturbed, part of the biodiversity may be lost, and may in turn lead to reduction in the provision of ecosystem services such as recreation and other direct use values. One of the main reasons that biodiversity should be conserved is because its future value is not known, and therefore, its conservation implies that it has a quasi option value. Though difficult to value and appreciate, non-use values represent an important value of a wetland resource. Lack of the estimation of non-use values for resources such as wetlands can lead to their conversion to provide more direct use values. Policy planners should therefore start appreciating the existence value of resources, especially that current generations should not compromise the future generation ability to meet their own needs.

6.3.8 Comparison of the value of Okavango Delta with some specific land uses in Botswana

The value per hectare of certain components of total economic values can be compared to the value per hectare of other land uses in the country. For example, Barnes et al. (2001) evaluated the economic viability of certain land use in some parts of Ngamiland District in Botswana. Some of the evaluated agricultural based land uses were traditional livestock production (the rearing of livestock, mainly cattle and goats, on a small scale for the production of milk, meat, draft power, manure and as a store of value), cattle post livestock production (keeping of cattle as a store of value and to produce meat and milk), and commercial livestock production (the keeping of cattle in commercial ranches mainly for meat production).

The estimated value per hectare for milk production of US$8.5/ha from this study was less than the gross financial income/ha of US$17.55 for traditional livestock production, but greater than the gross financial income/ha of cattle post livestock production (US$5.51/ha), and commercial livestock production (US$7.55/ha). Traditional livestock is characterized by lower production costs of inputs. The cost of labour, the main production input, is usually very low. The value of livestock grazing per hectare (US$1.46) was smaller than the values of all the three agricultural land use types.

The value of milk production per hectare and livestock grazing per hectare can also be compared to wildlife based land utilization types. These are community wildlife use in low quality areas, community wildlife use in high quality areas and commercial tourism (Barnes et al., 2001). The value of milk production per hectare was less than the financial gross income/ha for commercial tourism of US$33.87/ha, but greater than the gross financial income/ha for community wildlife use in low quality areas (US$0.19/ha), and community wildlife use in high quality areas (US$2.38/ha) (Barnes et al, 2001). While livestock keeping and wildlife based tourism have comparative advantages in Botswana, the comparison of results of this study to those of other studies seem to indicate that livestock production does not yield as much returns as tourism in the Okavango Delta. The results therefore provide a basis for evaluation of land use related policy where livestock would compete for resources with other land uses.

6.3.9 The expected impact of water abstraction on total economic value

As had been shown in the previous chapter, the value of the Okavango Delta is over P1.4 billion (US$294.8 million) worth of composition values and over P185.5 million (US$37.5 million) worth of goods and services (functional values). The estimated economic values from this study could be considered to represent the total economic value of selected resources in the Okavango Delta in the absence of a water abstraction project (without project scenario). The ecological impacts of water abstraction were anticipated by project planners to be small in spatial extent and localized, and therefore, would not have stopped the project from proceeding (Republic of Namibia, 1997). It was also argued that the anticipated impacts would be lessened as they would be spread across the whole aerial extent of the Okavango Delta. It is expected however, that, through ecological processes, the value of certain resources would be reduced by some magnitudes if the project was implemented (with project scenario). The quantified marginal economic changes resulting from water abstraction would reflect the economic impact of the project in the first year. The estimated economic values might drop further due to cumulative effects of the anticipated water abstraction project. If the flood extent reduction could lead to a reduction in the density of a water-dependent resource such as reeds, the value per hectare could decrease with the cumulative yearly water abstraction.

The anticipated water abstraction might also have a greater economic impact in terms of the loss of biodiversity. Since the willingness to pay for the preservation of the Okavango Delta also implies the conservation of biodiversity, an environmental impact assessment that does not take into account the non-use values would not reflect the real situation in terms of the economic losses to be expected. For instance, a loss in one vegetation or animal species might have significant effects on the future economic value of biodiversity. If the future economic value of such an animal or plant species could be determined, it may as well be found that its value would be significantly greater than the total non-use values.

6.4 Conclusions

The purpose of this study was to attempt to quantify economic values of some selected resources in the Okavango Delta by using the framework of total economic value (TEV). Based on these findings, this study found that there is over P1.46 billion (US$294.8 million) worth of the composition values of herbivores and over P185 million (US$37.5 million) worth of goods and services of selected resources in the Okavango Delta. These values represent initial estimates of costs to society if these resources are lost. The estimated values can be used to raise awareness among decision makers of the economic benefits of conserving and sustainably managing the Okavango Delta. Thus, the estimated values provide a strong argument for policy makers to preserve the Okavango Delta because it provides goods and services upon which many communities and economies depend**.** If this interdependence is not fully recognised in the sustainable management of the Okavango Delta, those who depend on the Okavango Delta for a living will be disadvantaged.

The composition values of wild herbivores were comparable to other areas in the region, but with some variation. Composition values can be used in management decisions in allocating the different uses of wildlife. Together with other values of wildlife, this information can be very vital where decisions are to be made between converting the ecosystem into other land use types or conserving it. The values of wildlife help to prioritise pricing policy for the sustainable utilisation of wildlife. With appropriate pricing, the economic returns from wildlife utilisation should be compared to other land uses, such as livestock farming. Improper pricing leads to inefficient resource allocation and therefore, a proper pricing policy in the management of these resources is crucial for their conservation and sustainable utilisation.

The productivity of the Okavango Delta as well as the economic values derived from harvestable vegetation resources was comparable to other wetlands in the region, such as the Chobe Caprivi Wetlands and Barotse Wetlands. The per hectare values of river reeds, wild fruits, thatching grass and palm leaves in the Okavango Delta were slightly higher than the corresponding values in these wetlands. However, these differences should be interpreted with caution as they may be due to the methods used to estimate the values. For instance, there are difficulties associated with estimating the exact size of the area over which the resource was measured, as well as in measuring the quantities of resources harvested. On this basis, comparative analysis on productivity, which leads to economic valuation using market prices, should be backed by field experiments.

Better estimates of resource values can be achieved if full natural resource inventories are undertaken at national level. Resource inventories should be undertaken periodically to monitor stock level changes as well as the underlying causes of these changes. Information from resource inventories can assist in identifying which resources are under increasing threat through their use. If indications are that resource levels are declining due to over-exploitation, appropriate measures can then be taken to reverse the current trend. For instance, if over-harvesting leads to scarcity of some of the resources, it may be appropriate for the resource management authority to introduce harvesting permits to control over-exploitation.

The value of carbon sequestration obtained was lower than that estimated in species-rich ecosystems, such as tropical forests. While the carbon sequestration value does not have direct implications on households, it has implications for global policies on climate change. The value of carbon sequestration should be compared to other benefits of other woodlands, such as timber production or clearing land for agricultural production (see Kundhlande *et al*., 2000). The government will have to strike a balance between meeting the increasing food needs from agriculture**,** and forests.

Milk production yielded the greatest value of all indirect use values in this study. The value in this study was found to be higher than the value of livestock grazing. It was also higher than the estimated values from other wetlands in the southern African region, such as the Chobe Caprivi wetlands. Though the value of livestock grazing is smaller than those for milk, it provided important information for decision making in the management of grazing resources, seeing that livestock provides important foreign earnings for the country. Owners of livestock should ensure that range deterioration does not occur, lest the standard of living of those who depend on cattle may fall. As put by Bhatia *et al.* (1998) 'strategies for range management should aim to maintain rangeland productivity, protect and improve biodiversity, promote livestock production and improve the standard of living of the people.'

Water is an extremely scarce resource in Botswana, so much so that it has become a serious development constraint in many parts of the country. The value of water obtained in this study does not include the cost of water supply and groundwater depletion. These costs are not reflected in the structure of the water consumption tariff. The emphasis of a water pricing policy in Botswana is on meeting the minimum basic water requirements of humans. However, there is a need for financial cost recovery in this policy of water demand management. The policy should recognise that the supply of water (though being subsidised by government) and the environmental cost of water abstraction from aquifers are important parameters in water pricing.

The total value of tourism in the present study was comparable to most tourist destinations. However, the values of resources per hectare were, in most cases, smaller. The values for tourism provide essential information in comparing the performance of the tourism sector in 2003 and in other years. There is a need to determine the tourism carrying capacity of the Moremi Game Reserve, and the cost thereof. This will help establish a relationship between ecological limits of the Moremi Game Reserve and sustainable economic benefits from tourism. For example, the Government of Botswana's position that tourism should operate under the deliberate '*low volume high value'* is not based on any information on environmental costs of tourism.

The existence of the Okavango Delta is highly valued by local households and tourists. The stated non-use values of the Okavango Delta represent the people's monetary sacrifice to have the Okavango Delta free of disturbance. This is in light of the potential water development projects that possibly threaten the ecological integrity of the Okavango Delta. If the resources of the Okavango Delta are used sustainably, they will be available to future generations.

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ANNEX

Household Questionnaire

1. Households characteristics

Age _____ Sex ____ Occupation_____ Years of schooling ____ Family size _____

2. Are you employed?

01Yes ☐ 02 No ☐

3.If yes how?

____

4. What is your source of income?__________

Income: 01 < 100 ☐

02 100-200 ☐

03 200-300 ☐

04 400-500 ☐

05 500-600 ☐

06 >600 ☐

5. Which of the following resources do you harvest?

Resources	Yes	No
Reeds		
Grass		
Palm leaves		
Wild fruits		
Fuelwood		

A REEDS

A1. Which species of reeds do you harvest and how often do you harvest?

Species harvested	Where harvested	Frequency of harvesting	Comments
1.			
2.			
3.			

B2. What quantities do you harvest per day?

Species	Quantities harvested (bundles)	Comments
1.		
2.		
3		

A3. Who harvests the reeds in this household?

01Women ☐ 02 Men ☐ 03 children ☐

04 Other (specify)____________

A4. What equipment/ material do you use in the harvesting of reeds?

01 ________________________

02 ________________________

03________________________

A5. How long does it take you in hours or days to complete one harvest trip?

____________ hours

A6. How far away do you harvest?

____

A7. How do transport the harvested reeds to your home?

01Own transport ☐ 02 Hired transport ☐

03 shared transport ☐ 04Other (specify)_________

A8. If you use own transport, what means?

____

A9. If you use hired transport how much do you usually pay per load?

____________ Pula/ load

A10. Of the amount of reeds that you harvest, do you sell any?

01 Yes ☐ (>>A11) 02 No ☐ (>> A12)

A11. If yes, please complete the table below:

Reeds species	Where sold	Price	Quantity sold	When sold
1.				
2				
3				

A12. Other than selling, what do you use the reeds for?

01 Fence ☐
02 House construction ☐
03 Fish baskets ☐
04 Fish wall traps ☐
05 Fish spears ☐
06 Fishing rods ☐
07 Handicrafts ☐

B. GRASS

B1 . Which species of grass do you harvest and how often do you harvest?

Species	Where harvested	Frequency of harvest	Comments
1.			
2.			
3.			

B2. What quantities do you harvest per day?

Species	Quantities harvested	Comments
1.		
2.		
3.		

B3. Who harvests the grass in this household?

01 Women ☐ 02 Men ☐ 03 Children ☐

04 Other (specify)____________

B4. What equipment do you use in the harvesting of grass?

01 ______________________

02 ______________________

03______________________

B5. How long does it take you in hours or days to complete one harvest trip?

____

B6. How far away do you harvest?

____

B7. How do you bring the harvested grass to your home?

01 use own transport ☐ 02 hired transport ☐

03 Shared transport ☐ 04 Other (specify)__________

B8. If you use own transport, what means?

____

B9. If you hire transport, how much do you usually pay per load?

_____________Pula/load

B10. Of the amount of grass that you harvest, do you sell any?

01 Yes ☐ (>>B11) 02 No ☐ (>>C12)

B11. If yes, please complete the table below:

Reeds species	Where sold	Price	Quantity sold	Date last sold
1.				
2				
3				

B12. Other than selling, what do you use the grass for?

01 thatching ☐

02 weaving ☐

03 Other (specify)_________________

B13. How much of this is used in your own household?

____

C. PALM LEAVES

C1. Where do you harvest and how often do you harvest palm leaves?

Where harvested	Frequency of harvesting	Comments

C2. What quantities do you harvest per day?

Quantity harvested	Comments

C3. Who harvests palm leaves in this household?

01 Women ☐ 02Men ☐ 03 Children ☐

04 Other (specify)________

C4. How many hours or days does it take you to complete one harvest trip?

____________ hours

C5. How far away do you harvest?

____

C6. Of the amount that you harvest, do you sell any of them?

01 Yes ☐ (>>C7) 02 No ☐

C7. If yes, please complete the table below:

Where sold	Price	Quantity sold	Date last sold

D. WILD FRUITS

D1. Which wild fruits do you harvest and what is the frequency of harvesting?

Species	Where harvested	Frequency of harvesting	Comments
1			
2			
3.			

D2. What quantities do you harvest per day?

Species	Quantities harvested	Comments
1		
2		
3		

D3. Who harvests the plants in this household?

01 Women ☐ 02 Men ☐ 03 Children ☐

04 Other________

D4. How many hours or days does it take you to complete one harvest trip?

____

D5. How far do you harvest?

____

D6. Of the amount that you harvest, do you sell any?

01 Yes ☐ (>>next) 02 No ☐ (>>E12)

D7. If yes, please complete the table below:

Plant	Where sold	Price	Quantity sold	Date last sold
1.				
2				
3				

D11. Of the amount that you harvest do you use some at home?

01 Yes ☐ (>>next) 02 No ☐ (>>E14)

D12. How much is used at home?

____

E. MEDICINAL PLANTS

E1. Which species of medicinal plants do you harvest and how often do you harvest?

Species	Where harvested	Quantity sold	Comments
1			
2			
3			

E2. What quantities do you harvest per day?

Species	Quantities harvested	Comments
1		
2		
3		

E3. Who harvests the plants in this household?

01 Women ☐ 02 Men ☐ 03Children ☐

F4. What equipment do you use in the harvesting of medicinal plants?

01 ______________________

02 ______________________

03______________________

E5. How long does it take you in days or hours to complete one harvest trip?

____

E6. How far away do you harvest?

____

E7. Of the plants that you harvest, do you sell any?

01 Yes ☐ (>> E8) 02 No ☐ (>>E9)

E8. If yes, please complete the table below:

Plant	Where sold	Priced	Quantity sold	Date last sold
1.				
2				
3				

E9. Have you consulted a traditional doctor in the past three months?

01 Yes ☐ (>>E10) 02 No ☐ (>>E11)

E10. For what purposes did you consult doctor?

____

____

E11. Did he/she give you medicinal plants?

01 Yes ☐ (>>next) 02 No ☐ (>>F18)

E12. What plant medicine did he/she give?

____

____

E13. How much did you pay for consulting?

____

E14. How much did you pay for the medicine?

____

E15. How often do you see a traditional doctor in a month?

____________________ times

F FUELWOOD

F1. Which species of fuelwood do you harvest and how often do you harvest/collect?

Species harvested	Where harvested	Frequency of harvesting	Comments
1			
2			
3			

F2. What quantities do you harvest/collect per day?

Species harvested	Quantities harvested	Comments
1		
2		
3		

F3. Who harvests/collects fuelwood in this household?

01 Women ☐ 02 Men ☐ 03Children ☐

04 other specify ______________

F4. How is fuelwood harvested/collected?

01 Picking up dead wood ☐

02 Cutting dead trees ☐

03 Cutting live trees ☐

04 Other (specify)____________

F5. What equipment do you use in the harvesting of fuelwood?

01 ________________________

02 ________________________

03________________________

F6. How long does it take you in hours or days to complete one harvest trip?

____

F7. How far away do you harvest?

____

F8. How do you bring the fuelwood to your home?

01 use own transport ☐

02 shared transport ☐

03 hire transport ☐

04 other (specify) ____________

F9. If you use own transport, what means?

____

F10. If you use hired transport, how much do you usually pay per load?

____

F11. Of the amount of fuelwood you harvest/collect, do you sell any?

01 Yes ☐ (>>F12) 02 No ☐ (>> F13)

F12 If yes, complete the following information:

Species	Where sold	Price	Quantity sold	When sold
1				
2				
3				

F13. Of the fuelwood that you harvest do you use some for cooking and heating?

01 Yes ☐ (>>F14) 02 No ☐ (>>H15)

F14. How much of a day's harvest is usually reserved for this purpose?

____

G. Preservation of the Okavango Delta.

1. Please keep in mind that the following question is a hypothetical experiment intended to provide an economic measure of how strongly you value the preservation of the Okavango delta.

Question: The Okavango River is increasingly being viewed as a source of water for development by the governments of Namibia, Botswana and Angola. In 1996 the Namibian government proposed to abstract about 17 million cubic metres of water annually from the Okavango River. Hydrological simulations indicate that as a result of water abstraction, the maximum loss of inundated area would be approximately 7.5 square kilometres. This loss is equivalent to 0.1% of the total inundated area of the delta. Assume that the Permanent Okavango River Basin Commission (OKACOM) wishes to establish an Okavango River Conservation fund (ORCOF) with the main aim of supporting activities that will help in conservation of the Delta. Assume also that the funds will be used in the best possible way you can think of. Would you be willing to contribute to this fund?

Would you be willing to contribute to such a fund?

01Yes ☐ 02No ☐

2. If you would be willing to contribute, how much would you be willing to contribute as one time payment to such a fund? Pula____________________

3. If you would not be willing to contribute to such a fund, please state the reason(s) for not being willing.

1_________________________________

2_________________________________

3_________________________________-

4_________________________________

4. Thank you very much for your time Do you have any comments or questions in relation to what we were asking you?

____

Tourists Questionnaire

1. Background

Country traveling from_____________________ Nationality__________________

Sex:_______ Age__________ Family size________ Profession____________
Years of schooling___________

2. Where are you currently a resident?

Place ______________ Country____________

3. How long will you be (or have you been) away from home?

_______________ days

4. Which other destinations in Botswana/elsewhere have you visited?

01________________ 02_______________ 03________________

5. What mode of transport did you use to come to the delta?

01 Air ☐ 02 Road ☐ 03 Other specify_____________________

6. Have you visited the delta before?

01 Yes ☐ 02 No ☐

7. If yes, how many times during the past 10 years?

___________________times

8. What is/has been the purpose of your trip?

01 Wildlife viewing ☐
02 Photographing ☐
03 Hunting ☐
04 Visiting historical sites ☐
05 Sport and recreational fishing ☐
06 Bird watching ☐
07 Horseback safaris ☐
08 Elephant back safaris ☐
09 Other (Please specify)_____________

9. How much of your time have you allocated to recreation related activities in the delta?

__________ days

10. In what accommodation are you staying?

01 Hotels ☐ 02 Game lodges ☐ 03Hunting camps ☐ 04 campsites ☐

05 Other specify_____________

11. What is the total cost of your holiday? (Please specify the currency)

____

12. How much of these costs have you spent in visiting the delta in Botswana?

________________________Pula

13. Please indicate, if possible, a break-down of all your costs including park entry fees, vehicle fees and camping fees, and whether these were paid separately or as an accommodation package

Cost item	Cost (Pula)
1.	
2.	
3.	
4.	

14. Please approximate your annual income

_____________________ Currency___________

15. What is the most important aspect of the delta that you have valued most and why?

____

____

16. Do you consider your trip worth the money spent?

01 Yes ☐ (Q>>>18) 02 No ☐ (>>17)

17. If not, and assuming you were to return on the same trip, please suggest a value in relation to your present costs by which you think your costs should be reduced to induce you to return?

The present costs should be reduced by

01 10 % ☐ 02 20% ☐ 03 30%☐ 04 40% ☐ 05 50% ☐ 06 >50% ☐

18. If yes, please suggest a value in relation to the present cost level that you will consider high enough to have prevented you from coming.

I would not have come if the present costs level were higher by:

01 10 % ☐ 02 20% ☐ 03 30% ☐ 04 40% ☐ 05 50% ☐ 06 >50% ☐

19. How much of the Okavango delta do you think should be preserved?

01 all of it ☐ 02 half ☐ 03 only one quarter ☐ 04 none ☐

20. Please keep in mind that the following question is a hypothetical experiment intended to provide an economic measure of how strongly you value the preservation of the Okavango delta**.**

Question: The Okavango delta is increasingly being viewed as a source of water for development by the governments of Namibia, Botswana and Angola. In 1996 the government of Namibia proposed to abstract 17 million cubic metres annually from the Okavango River**.** Hydrological simulations indicate that as a result of water abstraction, the maximum loss of inundated area would be approximately 7.5 square kilometres. This loss is equivalent to 0.1% of the total inundated area of the delta.

Assume that the Permanent Okavango River Basin Commission (OKACOM) wishes to establish an Okavango River Conservation Fund (ORCOF) with the aim of supporting activities that would help in the conservation of the Okavango Delta. Assume also that the funds will be used in the best possible way you can think of. Would you be willing to contribute to this fund?

01 Yes ☐ (>>next) ☐ 02 No (>>> Q23)

21. If yes, and given your annual income and other regular expenses, how much would you be willing to contribute as a one - time payment to this fund? : Pula_______ or any other currencies________

22. If no, kindly indicate the reason(s) for not being willing to contribute?

i)____

ii)____

iii)____

We thank you very much for your assistance in this important study. We would be grateful if you could mail the questionnaire to us using the self addressed envelop or leave the questionnaire at the reception of the hotel /lodge, or leave it with Air Botswana personnel at Maun Airport.