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:

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

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

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

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

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

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

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

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:

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

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:

$$D(t) = V_{t+1} - V_t \quad (10)$$

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

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

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:

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

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).

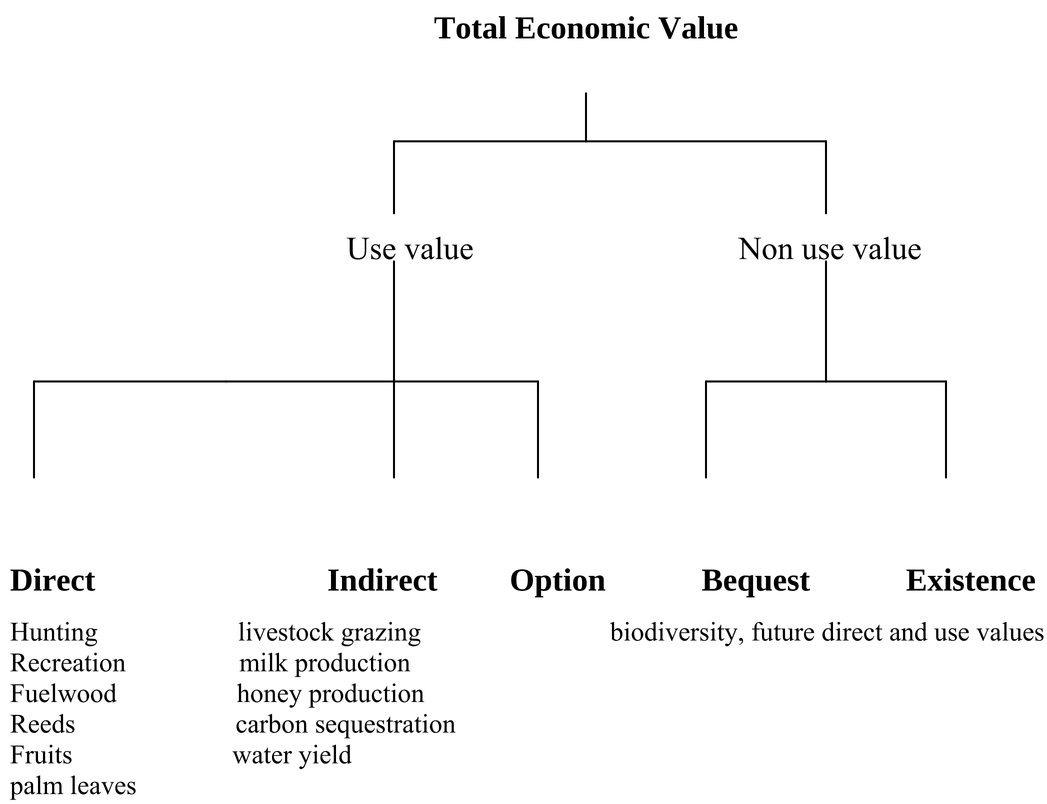

Figure 4: **Components of total economic value**
Source: Barbier (1991)

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.