CHAPTER 1

INTRODUCTION

1.1 Background and Statement of the Problem

It is now widely recognised that rural communities with livelihood strategies that combine subsistence agriculture with the utilisation of wetland[1] resources constitute a significant proportion of the population in developing countries (Silvius *et al*., 2000; Dixon and Wood, 2003; Adams, 1993). The report by the Millennium Ecosystem Assessment (MEA) (2005) to the Ramsar Convention entitled 'Ecosystems and Human Well-being: Wetlands and Water synthesis' extensively documents the importance of ecosystem services provided by wetlands for human well-being.

In southern Africa, wetlands play a significant role in the livelihoods of rural communities (Taylor *et al*., 1995; Breen *et al*., 1997; Frenken and Mharapara, 2002). The ability of wetlands to store water during the wet season and release it during the dry season provides farmers, who live in semi-arid areas, with opportunities to grow crops all-year round thereby improving their food security and incomes. Besides crop production, wetlands provide other services that support people's livelihoods such as: dry season livestock grazing and watering; domestic water supply; fishing; and natural products (Matiza and Chabwela, 1992; Mmopelwa, 2006).

However, wetlands are sensitive ecosystems that are threatened by human interventions. Altering the wetland environment through conversion to croplands and other uses has the potential to degrade the wetland and undermine its capacity to provide services in the future. As in many other parts of the world, wetlands in southern Africa are being increasingly degraded and lost through conversion to croplands (Taylor *et al*., 1995; Matiza and Chabwela, 1992; Breen *et al*., 1997; Biggs *et al*., 2004). This has been primarily driven by population growth and the increasing

[1] Wetland ecosystems are generally defined as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres'(Barbier *et al*. 1997; MEA 2005).

frequency of droughts. Given the importance of the direct and ecological services wetlands provide to human society, it is important that they are sustainably managed[2] so that they continue to provide services in the future.

Two major limitations to sustainable management of wetlands in Africa have been identified in the literature. The first limitation is that wetland users and decision-makers have insufficient understanding of the true values of wetlands and the consequences of alternative management and policy regimes on wetland functioning, ecosystem services and human well-being (Barbier, 1994; Schuyt, 2002; Schuyt, 2005).

The second limitation is the lack of understanding of the factors that influence people's decisions on the use of wetland resources. This aspect is critical, because while the use of wetlands is common in Africa, the extent to which households incorporate wetland activities into their livelihood strategies varies considerably due to significant socio-economic differentiation across households (McCartney and Van Koppen, 2004). Understanding how such differentiation influences the dependence on wetland resources is important when considering possible interventions for supporting rural livelihoods and promoting the sustainable use of wetlands.

In general, very little work has been done on the two constraints articulated above, particularly in southern Africa (Frenken and Mharapara, 2002). To the best of the author's knowledge: there is very little empirical knowledge of the impacts of alternative wetland management and policy regimes on wetland functioning, ecosystem services and economic well-being are currently available in southern Africa. This is particularly the case with modelling multiple benefits from an ecosystem to enable the evaluation of trade-offs between the provision of multiple

[2] Sustainable use or management of an ecosystem refers to human use of the ecosystem so that it yields continuous benefits to the present generation without compromising its potential to meet the needs of future generations (MEA 2003). The concept implies that people use and derive benefits from an ecosystem in a manner that does not exceed its carrying capacity and compromise the long-term productivity of the ecosystem. In contrast, ecosystem conservation implies non-use (strict protection) or maintenance of an ecosystem in its pristine state. It can be total (where the entire ecosystem is under protection) or partial conservation (where only parts of the ecosystem are under protection). Except in cases where a resource is non-renewable or its use has irreversible effects, strict conservation is seldom an optimal strategy especially in rural populations in Africa where the natural resource base is key to people's well-being.

services. Similarly, empirical knowledge on the factors that influence people's decisions on the use of wetland resources for wetland systems in the region is limited. Against this background, this study seeks to make two important contributions. The first is the analysis of the factors that influence household decisions on the use of wetland products using an agricultural household modelling framework. The framework takes into consideration the fact that rural households are both producers and consumers and that they allocate their scarce resources among competing livelihood activities.

The second contribution is the evaluation of trade-offs between provisions of various components of a bundle of multiple wetland services using a dynamic ecological-economic model to simulate the impacts of alternative policy and management regimes on wetland functioning, ecosystem services supply and human well-being. The results of this study should generate useful insights for improving policy and management interventions to promote the sustainable management of wetlands in southern Africa. The Ga-Mampa wetland, which is located in the Limpopo basin (on the South African part) of southern Africa, has been selected as the case study area.

1.2 Objectives of the Study

The primary objective of this study is to: analyse rural households' resource allocations and decisions among competing livelihood activities including wetland activities; and evaluate the impacts of alternative policy and management regimes on wetland ecosystem functions and human well-being. The specific objectives are to:

1. Identify the factors that influence rural household labour allocation and product supply decisions among competing livelihood activities, including wetland activities.
2. Develop an ecological-economic model establishing the linkages between ecological and economic systems in a wetland system and apply the model to evaluate the impacts of alternative policy and management regimes on wetland functioning, ecosystem services supply and economic well-being.
3. Draw relevant policy recommendations for the sustainable management of wetlands based on the findings of the study.

1.3 Hypotheses of the study

Based on findings in the literature on rural household labour allocation and supply decisions and also on the interactions between ecological and economic systems in developing countries, the following hypotheses are made:

1. Higher education, wealth and access to off-farm income contribute to the reduced participation in on-farm and wetland activities, which have positive impacts on wetland conservation.
2. Policy interventions that promote diversification out of agriculture, such as improving access for the poor to off-farm income and employment opportunities, can simultaneously enhance people's economic well-being and wetland conservation.

1.4 Approaches and methods of the study

Two main analytical approaches are employed to achieve the aforesaid study objectives. To pursue the first objective the agricultural household model is employed. The agricultural household model considers rural households to make joint production and consumption decisions to maximise utility. The model is used to derive a system of reduced form labour use as well as grain and wetland products supply equations, which are estimated jointly using a seemingly unrelated regression approach.

To achieve the second objective, an ecological-economic model, based on the system dynamics framework, is developed and applied. The system dynamics framework takes into consideration feedback effects between ecological and economic systems as well as involved trade-offs in the supply of individual constituents of multiple services provided by wetlands. This framework also captures the intertemporal effects of interventions on ecosystem dynamics. This model uses labour use with grain and wetland products supply functions' parameters estimated in the first part of the study.

1.5 Organisation of the thesis

The following chapter presents background information on the biophysical and socio-economic characteristics of the study area. It also briefly discusses: the characteristics of wetland ecosystems in southern Africa in terms of the main types of wetland ecosystems and their distribution; wetland services and their link to human well-being; and major threats to wetlands. Chapter 3 presents the analytical framework for analysing household labour allocation and supply decisions for alternative livelihood activities including wetland activities. The empirical model and results on the determinants of household labour allocation and supply decisions for wetland products and grain are presented and discussed in Chapter 4. Chapter 5 reviews analytical approaches used in analysing the linkages between ecological and economic systems and evaluating: the impacts of alternative management and policy scenarios on ecosystems and the supply of ecosystem services and economic well-being. Chapter 6 develops an empirical ecological-economic model establishing the linkages between the ecological and economic systems in the studied wetland and applies the model in simulating impacts of alternative management and policy regimes. Finally, Chapter 7 presents a general summary and conclusion and also derives policy implications based on the findings of the study.

CHAPTER 2

WETLAND ECOSYSTEMS IN SOUTHERN AFRICA AND THEIR IMPORTANCE FOR HUMAN WELL-BEING

2.1 Introduction

This chapter provides an overview of wetland ecosystems in southern Africa and demonstrates their significance for the well-being of people. The first section presents background information on the biophysical and socio-economic features of the study area. Section two characterises wetland ecosystems in the region in terms of the main types of wetland ecosystems and their distribution. The third section discusses the link between wetland ecosystem services and human well-being. The main threats to wetlands in southern Africa are discussed in section four and section five then concludes the chapter.

2.2 Biophysical and socio-economic characteristics of the study area

2.2.1 Climate and major ecosystems

The Limpopo Basin is situated in the eastern part of southern Africa and is one of the largest river basins in the region (Figure 2.1). The riparian countries are Botswana, Mozambique, South Africa and Zimbabwe. The drainage area of the river basin is estimated at 413 000 km^2 (FAO, 2004). Approximately 45% of the land area is located in South Africa (Table 2.1).

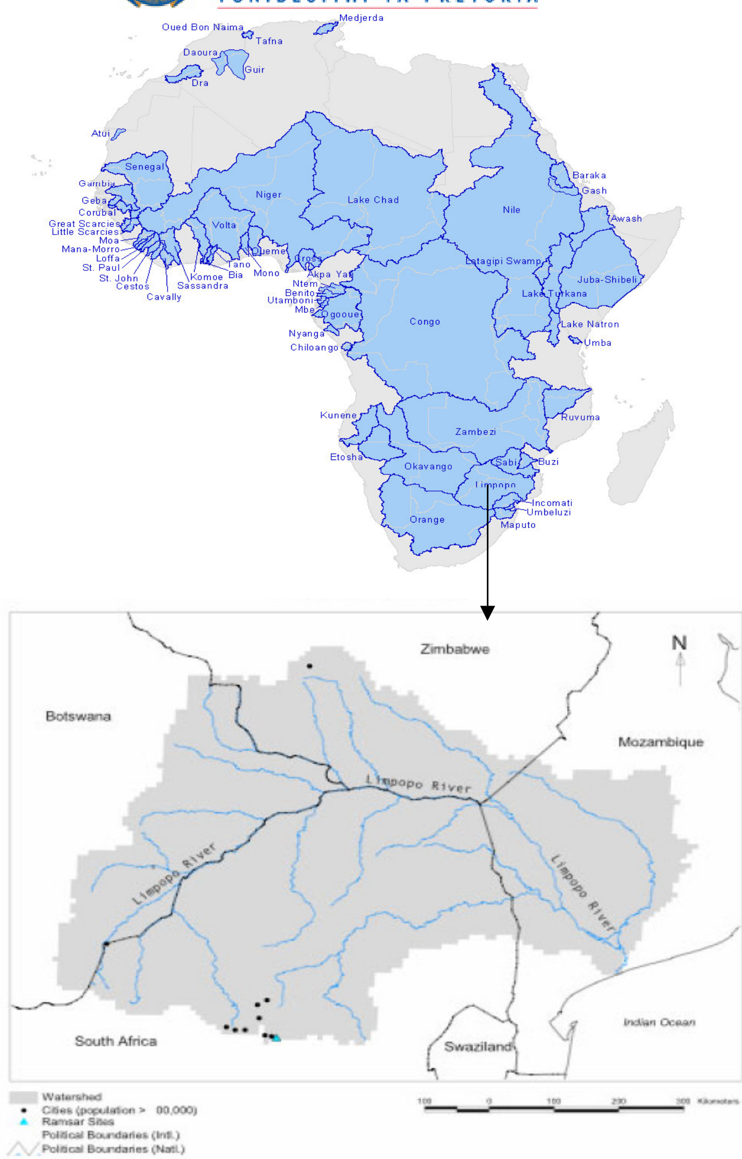

Figure 2.1: Map showing (a) African river basins and (b) the Limpopo river basin riparian countries (World Resources Institute, 2003)

Table 2.1: Area under the Limpopo river basin by riparian country

Riparian country	Area of country in basin (km^2)	Percentage of total area of basin
South Africa	183,500	45
Mozambique	87, 200	21
Botswana	81, 500	20
Zimbabwe	62,600	15

Source: FAO (2004)

The climate of the Limpopo basin is predominantly semi-arid. Rainfall is very low and varies from approximately 300mm in the hot dry western parts in Botswana to

1000 mm in the high rainfall areas in the South African part of the basin (Rosenberg, 1999).

Rainfall in the Limpopo basin is highly seasonal with 95% of it occurring between October and April, often with mid-season dry spells occurring during the critical stages of crop growth. With the exception of small areas on the outer limits of the basin, the rainfall season is very short (FAO, 2004). Despite the periodic occurrence of short and intense storms, rainfall is generally erratic and unreliable, and droughts are frequent. The seasonal nature of rainfall is reflected in the highly seasonal water flows with some surface water bodies completely drying up during the dry season.

Evaporation rates are higher than rainfall, ranging from 800mm to 2400mm per year, with an average of 1970mm per year (FAO, 2004). These high evaporation rates reduce effective rainfall and soil infiltration thereby increasing chances of crop failure in rainfed cropping systems.

Southern Africa has diverse ecosystems. Scholes and Biggs (2004) identified seven main ecosystems (biomes) in the region, the savanna being the dominant ecosystem (Table 2.2).

Table 2.2: The main ecosystems of southern Africa

Ecosystem (biome)	Sub-biome	Soil/geology	Area ($1000km^2$)		
			Pre-colonial	Area remaining untransformed by cultivation by year 2000	Percentage (%) remaining untransformed by cultivation by year 2000
Forest	Lowland forest	Generally infertile	1815	1693	93
	Montane forest	Fertile, but steep	190	149	78
Savanna	Miombo	Infertile, sandy	3558	3217	90
	Mopane	Fertile and loamy	605	469	77
	Acacia	Fertile, loamy & clayey	1785	1504	84
Grassland	Montane grasslands	Fertile or infertile	434	298	69
Arid shrubland	Non-succulent	Fertile often calcareous	671	663	99
	Succulent	Often very stony	103	102	100
Desert	Namib	Sandy or gravelly	126	126	100
Fynbos	*Fynbos*	Generally infertile	78	68	87
Wetland	Permanent wetland	Organic (peaty)	172	153	89
	Seasonal (dambo, *vlei*)	Often cracking clays (turf)	990	885	89
	Estuaries & mangroves	Saline, mangroves	23	22	95
	Salt pans		40	38	95
	Inland water and coastal waterways		197	197	100

Source: Scholes and Biggs (2004)

2.2.2 Demographic and socio-economic characteristics

Approximately 14 million people reside in the Limpopo basin. The basin is predominantly rural, with almost 57% (8 million) of its population residing in rural areas. Although South Africa has the highest number of people living in the basin, in comparison Botswana has the highest proportion of its population residing in the basin. The population density, over much of the basin, is less than five people per km^2 (Mgonja *et al.*, 2006). Population density is highest in high rainfall areas and in large urban and industrial areas.

Table 2.3: Selected population statistics for the Limpopo basin

Riparian country	Total population of country in 1998 (million)	Population residing in basin (million)	Percentage of country's population in basin
South Africa	42.1	10.7	25
Mozambique	16.5	1.3	8
Botswana	1.6	1.0	63
Zimbabwe	11.4	1.0	9
Total	71.6	14.0	

Source: FAO (2004)

Most of the people living in the basin rely mainly on agriculture (i.e. crop and livestock production) for their livelihood. Non-farm sectors such as mining are also important sources of livelihood, particularly in areas with significant industrial and urban developments. However, low levels of education and skills among the majority of the rural population limit their opportunities for employment in non-farm sectors.

Agricultural production in the Limpopo basin is predominantly rainfed. Maize, which is the staple crop in the basin countries, is produced largely under rainfed conditions. Consequently, production varies from year to year due to annual rainfall variability. Although there is surplus maize available at the basin level, household food insecurity is a major problem in most rural areas in the basin due to low agricultural productivity, which is a result of several factors: frequent droughts; land degradation; low use of fertilisers and improved crop varieties; limited access to markets; limited irrigation; and limited agricultural knowledge (FAO, 2004; Mgonja *et al.*, 2006).

In terms of the standard of human well-being, the Human Development Index (a composite index of human welfare, which includes health, education and income dimensions of human welfare) for the basin countries ranges from 0.35-0.7, which indicates that the level of human well-being in the basin is quite low (UNDP, 2003). It is estimated that 57% of the basin's population is below the poverty line (Amaral and Sommerhalder, 2004). The increasing level of poverty is partly due to declining supply of ecosystem services (Scholes and Biggs, 2004).

2.3 Characterisation of wetland ecosystems

2.3.1 Definition of wetlands

The term 'wetland' has been defined in many ways. The difficulty in defining wetlands arises partly because of their highly dynamic character and the difficulties in defining their boundaries (Turner *et al*., 2000).

The Environmental Protection Agency (EPA) of USA defines wetlands as 'areas where water covers the soil and is present either at or near the surface of the soil all year or for varying periods of time during the year'. They define two broad categories of wetlands: coastal and inland wetlands (EPA, 2004).

The United States Fish and Wildlife Service (USFWS) defines wetlands as 'lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water' (Cowardin *et al*., 1979). According to this definition wetlands must have one or more of the following three attributes:

(i) at least periodically, the land must predominantly support hydrophytes;
(ii) the substrate must consist of predominantly undrained soil; and
(iii) the substrate must be non-soil and be saturated with water or covered by shallow water at some time of the growing season each year.

In southern Africa, wetlands are defined differently across the region, thus showing the different perceptions people have of wetlands in this region. For instance, in South Africa wetlands are loosely defined as places where marine, aquatic and terrestrial ecosystems meet and interact. Whereas in Zimbabwe wetlands are understood to be lands that are subjected to permanent or seasonal flooding or areas of subsurface water accumulation through seepage such as *vleis* or dambos (Hirji *et al*., 2000).

The most widely accepted definition is that proposed under the Ramsar Convention (1971) which defines wetlands as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceed six meters' (Ramsar Convention, Article 1.1) (Ramsar Convention Secretariat, 1971).

What is evident from the above definitions is that the term 'wetland' covers a wide range of habitats that share a number of common features, the most important of which is continuous, seasonal or periodic standing of water or saturated soils with characteristic fauna and flora (Finlayson and Van der Valk, 1995).

2.3.2 Types of wetland ecosystems

Wetlands vary in type and size. Southern Africa's wetlands are among the most diverse, both physically and biologically, of any other in the world (Taylor *et al*., 1995). Wetlands differ in habitat or in their physical features, such as depth of water, perennial flow and types of vegetation. However, very little work has been done to systematically characterise and classify wetland ecosystems in the region. Yet, this kind of information is necessary for wetland conservation and management (Finlayson and Van der Valk, 1995).

A number of wetland classifications exist in literature. Just as some disagreements exist on the definition of wetlands so too is there no universally agreed classification system of wetlands. This is partly attributed to the fact that wetlands occupy an intermediate position between truly terrestrial and aquatic ecosystems and therefore encompass a diverse array of habitats (Finlayson and Van der Valk, 1995). One classification system categorises wetlands by their: geographical location; water quality; and mode of formation. This has given rise to classifications such as: inter-tidal and sub-tidal marine systems; lakes (artificial and natural); riverine systems;

floodplains; swamps; marshes; and dambos. Dugan (1990) classified wetland systems into three main categories, based on the quality of water and the mode of formation, namely: saltwater wetlands; freshwater wetlands; and artificial wetlands.

Roggeri (1995) classified wetlands according to geomorphological units (the main sources of water and nutrients) and ecological units (in particular vegetation). The geomorphological units distinguish four parts: alluvial lowlands; small valleys; lakeshores; and depressions. In addition to this, three ecological units were specified: periodically flooded ecosystems; swamps and marshes; and permanent shallow lakes and water bodies.

The most comprehensive and widely applauded wetland classification system is that developed by Cowardin *et al*. (1979). This classification is hierarchical and includes several layers of detail for wetlands including: a subsystem of water flow; classes of substrate types; subclasses of vegetation types; and dominant species. It classifies wetlands into five major categories based on hydrologic, geomorphic, chemical and biological features, which are: marine; estuarine; lacustrine; riverine and palustrine.

Breen *et al*. (1997) classified the main wetland systems in southern Africa based on the Cowardin *et al*. (1979) classification system and identified six main wetland classes: marine; estuarine; lacustrine; riverine; palustrine; and endorheic systems. The main features of these wetland classes are discussed below.

2.3.2.1 Marine systems

Marine systems consist of the open ocean overlying the continental shelf and its associated coastline. They are exposed to the waves and currents of the open ocean and their water regimes are determined primarily by the ebb and flow of oceanic currents. In southern Africa, the marine system also includes the coastline of the Indian and Atlantic oceans that is characterised by coral reefs, seagrass beds and intertidal areas. These systems are poorly understood and their potential has not been fully investigated (Breen *et al*., 1997).

2.3.2.2 Estuarine systems

These systems include tidal wetlands which are usually semi-enclosed by land but have open, partially obstructed or sporadic access to the open ocean and in which water is at least occasionally diluted by freshwater run-off from the land. Estuarine systems are subdivided into sub-tidal areas, which are continually submerged, and intertidal areas, which are exposed and flooded by tides. The intertidal zone may include a variety of habitats such as lagoons, mud flats, marshes and mangroves. These systems are regarded as some of the most productive ecosystems in the world and are major breeding and feeding sites for fish and invertebrates.

2.3.2.3 Lacustrine systems

These systems are areas of permanent water with little flow. Their main characteristic features are that: they are situated in topographic depressions or dammed river channels; they lack trees, shrubs, persistent emergent mosses or lichens with more than 30% area coverage; their total area exceeds eight hectares (Cowardin *et al.*, 1979). These systems include natural or constructed dams and lakes. Pans, which are categorised under lakes by other scholars, are sometimes classified under lacustrine systems (Cowan and Van Riet 1998). However, pans are slightly different from lakes in that pans have a water depth of less than three metres and dry up during the dry season, whereas lakes are more permanent in nature, larger in size, have a greater water depth and support a wider variety of fauna and flora (Richards, 2001). In southern Africa, lacustrine systems are mostly used for hydroelectric power and irrigated agriculture. However, they are threatened by pollution due to the disposal of industrial pollutants and siltation.

2.3.2.4 Palustrine systems

Palustrine systems can be described as transition zones between terrestrial and aquatic systems. These systems include freshwater habitats with a wide range of physical, water regime and vegetation characteristics. These include: permanent or seasonal marshes and swamps; peatlands and fens; springs; and headwater wetlands. These systems are the most widespread wetland systems in southern Africa (see Table 2.2). Of the different types of palustrine systems seasonal wetlands or dambos (*vleis*) are the most widespread. These wetland systems are extensively used for crop production and livestock grazing. Palustrine systems also include marshes and swamps which are typically dominated by reeds (*Phragmites sp*.) and papyrus (*Cyperus papyrus*) which are of importance to the livelihoods of many rural communities in southern Africa. Floodplain wetlands, which are areas of periodic flooding, situated between the river channel and valley sides, fall under this category. They are extensively used for agriculture, fisheries and wildlife.

2.3.2.5 Riverine systems

Riverine wetlands are composed of small, localised floodplains and swamps, which occur along river channels. These wetland systems are valuable sources of fish and are also used for agriculture. Riverine systems also play a key role in hydrological regulation (Dini *et al*., 1998).

2.3.2.6 Endorheic systems

These are commonly referred to as pans in South Africa and as small closed basins or playas in geomorphological literature. The endorheic system has been added to Cowardin's original five categories of wetland systems in recognition of the significant ecological role played by pan ecosystems in southern Africa (Hirji *et al*., 2000). Being located largely in dry regions, pans display characteristic patterns of ephemeral and irregular inundation.

Table 2.4 presents examples of wetland systems in the southern Africa region under each wetland category.

Table 2.4: Examples of major wetland types in southern Africa and the main services they provide

Wetland type	Major examples of wetlands in the region	Country	Main services it provides
Palustine wetlands (Floodplains)	Barotse floodplain	Zambia	Wildlife, fisheries, livestock grazing, water supply and cultural heritage
	Okavango delta	Botswana	Wildlife, agriculture, grazing, water extraction, fisheries and tourism
Riverine wetlands	Zambezi river	Angola, Botswana, Namibia, Malawi, Tanzania, Zambia and Zimbabwe	Wildlife, fisheries, hydropower, water supply, navigation and tourism
	Limpopo river	Botswana, South Africa, Zimbabwe and Mozambique	Wildlife, water supply, agriculture and irrigation
Lacustrine wetlands	Lake Kariba	Zambia and Zimbabwe	Hydroelectric power, wildlife, agriculture, fisheries and tourism
	Lake Chilwa	Malawi and Mozambique	Fisheries
Estuarine delta	Zambezi delta	Mozambique	Fisheries, agriculture, wildlife and waterfowl habitat
	Limpopo/Inkomati	Mozambique	Wildlife, fisheries, agriculture, tourism and forestry
Endorheic wetlands(Pans)	Cahora Bassa lake	Mozambique	Hydroelectric power and fisheries
	Makgadikgadi Pan	Botswana	Mining, wildlife, tourism and grazing

Source: Breen *et al*. (1997); Hirji *et al*. (2000)

2.3.3 The distribution of wetlands

It is estimated that 6% of the world's land area consists of wetlands (Mitsch and Gosselink, 2000). The MEA (2005) estimated the global extent of wetlands to be in excess of 1,280 million hectares, although it is well-known that this is underestimated. However, the estimates of the extent of wetlands globally and in Africa differ significantly across studies due to the different definitions of wetlands and methods used for delineating wetlands (Finlayson *et al*., 1999). Table 2.5 presents estimates of wetland areas by Ramsar region.

Table 2.5: Estimates of global wetland areas by Ramsar region

Region	1999 Global Review of Wetland resources (million hectares)	2004 Global Lakes and Wetlands Database (million hectares) (Lehner and Doll, 2004)
Africa	121-125	131
Asia	204	286
Europe	258	26
Neotropics	415	159
North America	242	287
Oceania	36	28
Total area	1276-1280	917

Source: MEA (2005)

Despite the widespread distribution of wetlands across Africa, knowledge on the extent of African wetlands is far from complete and is inadequate to support management needs (Taylor *et al*., 1995; Finlayson *et al*.,1999). Due to lack of scientific investigation and a single classification system, as well as inconsistent mapping policies, an exact estimate of the total extent of wetlands in Africa is unknown (Schuyt, 2005). However, it is estimated that 1% of the land surface in Africa is covered by wetlands (Schuyt, 2002). In sub-Saharan Africa, wetlands constitute approximately 4.7% of the land surface and this figure increases to 6% with the inclusion of lakes, rivers and reservoirs (Rebelo *et al*., 2009). Most of the wetlands occur within the major river basins in the region (Figure 2.2). Swamps and floodplains are the most widespread type of wetlands in Africa occurring mostly in central, eastern and southern Africa.

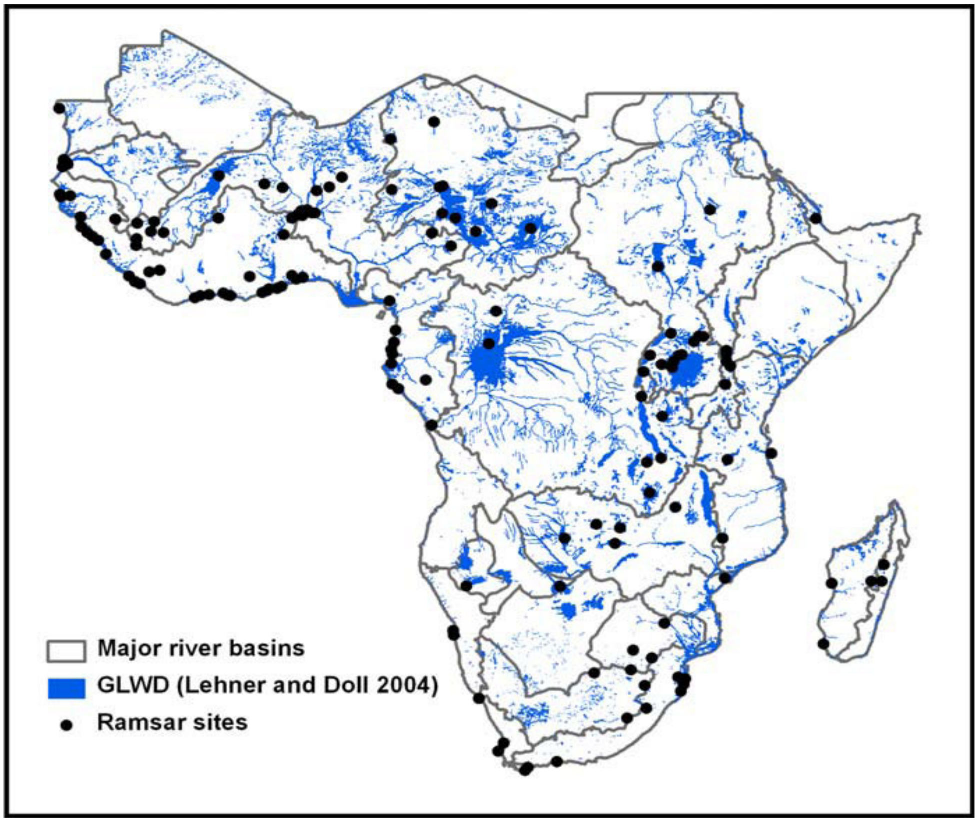

Figure 2.2: Wetland distribution and location of Ramsar sites across major river basins in Sub-Saharan Africa (Rebelo *et al*., 2009)

In southern Africa, wetland ecosystems were identified as one of the eight main ecosystems in the region (Scholes and Biggs, 2004). However, quantitative data on the extent of wetlands in the region is limited due to lack comprehensive national wetland inventories characterising and classifying wetlands in a systematic manner (Taylor *et al*., 1995; Frenken and Mharapara, 2002). In addition, as is the case at the global and continental levels, the figures on the total extent of wetlands in the region also differ significantly across studies due to different definitions of wetlands and delineation methods.

Within the Limpopo basin, it is estimated that 3% of the total land area is made up of wetlands (World Resources Institute, 2003). Table 2.6 presents estimates of area under wetlands in each of the riparian countries of the Limpopo basin from different sources.

Table 2.6: Estimates of wetland area (in km^2) in Limpopo basin countries

Country	Taylor *et al.* (1995)	Stevenson and Frazier (1999)	Country area	Percentage of wetland
Botswana	28,310	-	569,582	5
Mozambique	24,122	25, 632	799,380	3
South Africa	4,600	7,545	1,219,090	<1
Zimbabwe	12,800	16,832	390,310	3-4

Some of the wetland systems in the region are listed as being of international importance under the Ramsar Convention on Wetlands (Ramsar Convention, 1971). The Ramsar Convention is an intergovernmental treaty that provides a framework for national action and international cooperation for the wise use of wetlands. Six of the countries in southern Africa are parties to the Ramsar Convention: Botswana; Malawi; Namibia; South Africa; Tanzania; and Zambia. Some of the obligations of the parties to the Convention are to designate some wetland sites to the Ramsar list of wetlands of international importance and to promote the conservation and wise use of wetlands (Ramsar Convention Secretariat, 2004). The criteria for designating wetlands to the Ramsar list include: the uniqueness of the wetland system; its role in supporting populations of endangered species; and its role in supporting waterfowl populations.

Several wetland sites in southern Africa are designated Ramsar sites. Examples include the Okavango delta (Botswana), Lake Chilwa (Malawi), the St Lucia system (South Africa) and the Kafue Flats (Zambia). These wetland systems have socio-economic importance to the communities living around them and the countries in which they are found. Although some of the region's most significant wetland systems are not listed as Ramsar sites, this does not mean that they are not important. Indeed in many arid areas in the region, any wetland system of any size is of significant socio-economic importance to the local people (Hirji *et al*., 2000).

2.4 The importance of wetlands for human well-being

The fact that wetlands support human well-being through its provision of services is well-known. This was confirmed in the MEA (2005) to the Ramsar Convention, entitled: 'Ecosystems and Human Well-being: Wetlands and Water synthesis.' The linkages between wetland services and human well-being are shown in Figure 2.3. In southern Africa, the linkages between ecosystems and human well-being are stronger in poor rural communities, whose lives are directly affected by the availability of ecosystem products such as food, medicinal plants and firewood (Scholes and Biggs, 2004).

The services that wetlands provide can be classified into: provisioning; regulating; cultural; and supporting services (Turner *et al*., 2000; De Groot *et al*., 2002; Hein *et al*., 2006; MEA, 2005). Provisioning services are tangible products people obtain from wetlands such as: food; fibre; water; and genetic resources. Regulating services are benefits obtained through the role of wetlands in the regulation of ecosystem processes such as: water purification; climate regulation; and erosion control. Cultural services are non-material benefits people derive from wetlands through: spiritual enrichment; cognitive development; and recreational, educational and aesthetic values. Supporting services are those services that are necessary for the production of all other ecosystem services such as: soil formation; nutrient cycling; and biodiversity. Table 2.7 shows examples of services provided by wetlands under each of these categories.

It is worth noting that a wetland system may not provide the full range of services listed in the table. This is because the services that a particular wetland provides are determined by its characteristics and most fundamentally by specific factors such as size, climate, geology and topography. The services provided by wetlands contribute to human well-being in many ways (Barbier *et al*., 1997; MEA, 2005). It is well-known that the provisioning services from wetlands are strongly linked to the access of basic materials for the 'good life' dimension of human well-being (MEA, 2005). The regulating functions of wetlands also affect human well-being in multiple ways. For instance, water purification, flood attenuation and climate regulation functions affect the health, security and other components of human well-being. Supporting services are critical for sustaining vital ecosystem functions that deliver many benefits to people. In addition to these services, wetlands have significant aesthetic, educational, cultural and spiritual values and provide invaluable opportunities for recreation and tourism, thereby influencing the social relations aspect of human well-being.

Table 2.7: Ecosystem services provided by or derived from wetlands

Service	Examples
Provisioning	
Food	Production of fish, wild game, fruits and crops
Fibre and fuel	Production of fuelwood, fodder, building and craft materials
Fresh water	Storage and retention of water for domestic, industrial and agricultural use
Biochemical	Extraction of medicines and other materials from biota
Genetic materials	Genes for resistance to plant pathogens, ornamental species
Regulating	
Climate regulation	Source of and sink for greenhouse gases, influence local and regional temperatures and precipitation
Water regulation	Groundwater recharge and discharge
Water purification	Retention, recovery and removal of pollutants
Erosion control	Retention of soils and sediments
Natural hazard regulation	Flood control and storm protection
Pollination	Habitat for pollinators
Cultural	
Spiritual and inspirational	Source of inspiration, spiritual and religious value
Recreational	Opportunities for recreational activities
Aesthetic	Many people find beauty and aesthetic value in wetland ecosystems
Educational	Opportunities for formal education and training
Supporting	
Soil formation	Sediment retention and accumulation of organic matter
Nutrient cycling	Storage, recycling and processing of nutrients

Source: MEA (2005)

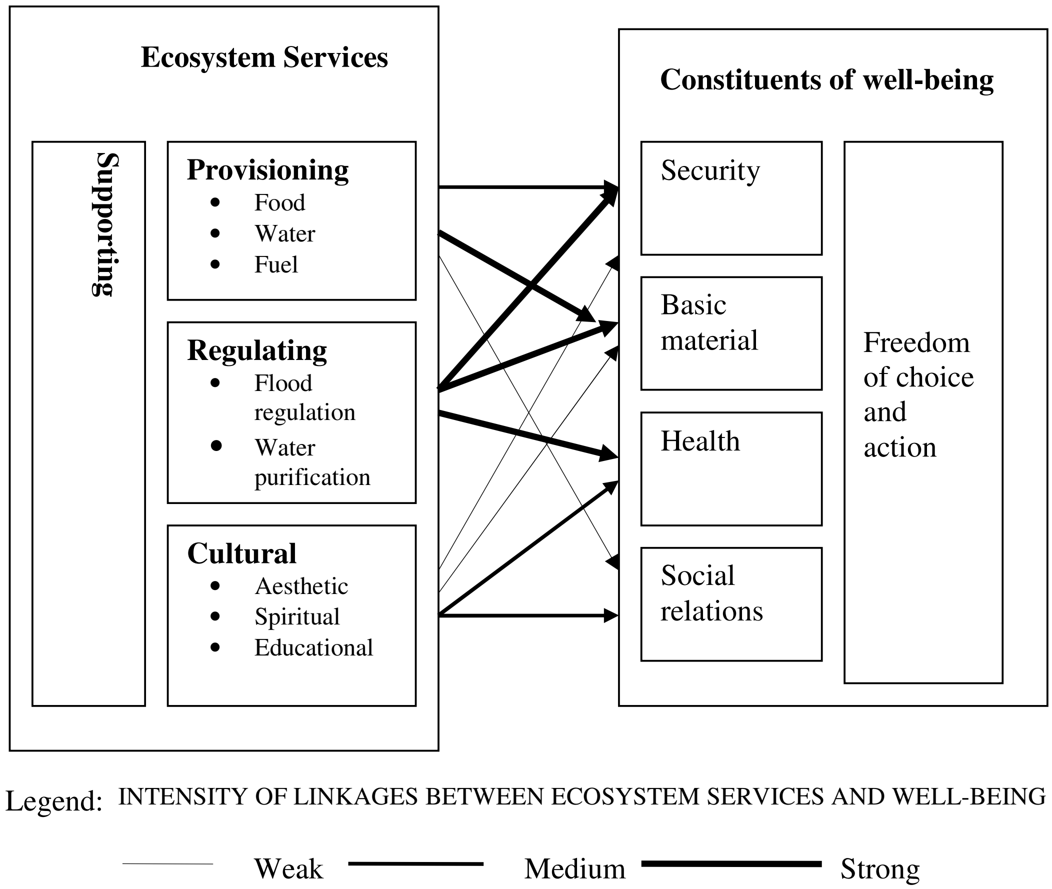

Figure 2.3: Linkages between wetland services and human well-being (MEA, 2005)

In southern Africa, many communities depend on wetlands for multiple values, including social, economic, ecological and aesthetic values (Breen *et al*., 1997; Hirji *et al*., 2000). As much of the region experiences semi-arid to arid climate conditions, many people rely on wetlands for agricultural production due to their ability to retain water throughout the year and for their fertile soils (Chabwela, 1991; Frenken and Mharapara, 2002; Breen *et al*., 1997). Wetland cultivation provides a coping mechanism by which communities mitigate crop yield losses that are associated with low rainfall and frequent droughts.

Besides agriculture, wetlands provide other provisioning services upon which a significant proportion of the rural population in the region depends. These include: dry season livestock grazing and watering; fisheries; wildlife; wetland plants (papyrus, reeds, sedges, edible plants, medicinal plants and thatching grass); clay for pottery; as well as water supply for domestic, irrigation and industrial uses (Breen *et al*., 1997).

Several studies quantified the economic contribution of wetland systems in southern Africa to human welfare. However, it is worth noting that most of these studies were carried out at local scales rather than at national and regional scales due to limited data on the actual extent of wetlands at national and regional levels. In addition, most of the valuation studies focused on quantifying a few key services due to the difficulty in quantifying some of the wetland services given the data and resource limitations. For example, Seyam *et al*. (2001) used a simple approach that takes into account the common problems with data limitations and estimated that the total use value of approximately 3 million hectares of wetlands in the Zambezi basin was about $145 million (USD) per year, which was equivalent to 4.7% of Zambia's GDP in 1990. Adekola (2007) estimated that the direct use value of the main provisioning services of the Ga-Mampa wetland, which covers an area of 120 hectares, is $90 000 (USD) per year (2005/2006 values).

Table 2.8 shows the net financial values per user household for selected wetland services in selected wetland systems in the region, including the study area. These net financial values deduct variable costs, but do not take into account labour costs. As most of the rural households rely on family labour for most wetland activities, deducting the opportunity costs of labour in environments of mostly low earning skills and limited labour opportunities is perhaps not a good idea.

The figures presented show that the net financial value per user household for wetland services varies from one wetland system to another, which confirms that the extent to which wetlands provide services and the contribution of wetland services to human well-being vary depending on the characteristics of the wetland. In some cases a service (or services) that is provided by one wetland system is absent in another wetland system.

Table 2.8: Net financial values per user household of selected services for selected wetland systems in southern Africa

Wetland service	Chobe and Caprivi wetlands, Namibia US$/user household/year	Barotse Floodplain, Zambia US$/user household/year	Lower Shire wetlands, Malawi US$/ user household/year	Ga-Mampa wetland, South Africa US$/user household/year
Crop production	205	85	310	1072
Livestock grazing	485	256	169	-
Fish production	299	325	56	12
Reeds collection	39	6	7	93
Sedge and papyrus collection	42	5	32	88

Source: Turpie *et al.* (1999); Adekola (2007)

Some wetland systems in the region have important recreational, aesthetic and spiritual values. Aesthetic value is reflected, for example, in the tradition of some tribes to have initiation rites in wetland areas. The abundant wildlife and scenic beauty offered by wetland ecosystems form the backbone of the tourism industry in the region (Hirji *et al*., 2000). Examples of wetlands in southern Africa that are important for tourism are the Okavango delta, Etosha pans and St Lucia to name a few. Apart from supporting nature-based tourism, some wetlands are used for a variety of recreational activities such as: sport hunting; fishing; bird watching; swimming; and sailing.

2.5 Major threats to wetland ecosystems in southern Africa

Globally, wetlands continue to be degraded and lost at an increasing rate (Moser *et al*., 1996; MEA, 2005; Ramsar Conservation Bureau, 1997). It is estimated that more than half of the wetlands in the world may have been lost since the start of the 20th century, with the greatest loss found in developed countries, while dramatic losses have occurred over a short space of time in developing countries (Barbier, 1993).

Southern Africa is no exception to this global trend (Taylor *et al*., 1995; Breen *et al*., 1997). However, data on wetland losses and conversion rates for the region are scanty and hard to compare as different sources provide very different estimates of wetland areas. In some cases the data is not available due to the lack of capacity in many countries to undertake wetland inventory studies (Taylor *et al*., 1995).

The few studies, which were conducted in the region, show that the rate of wetland degradation and loss is quite high. For example, in South Africa, Kotze *et al*. (1995) estimated that more than 50% of the wetland area had been lost countrywide. In a review of wetland inventories in southern Africa, Taylor *et al*. (1995) reported wetland losses in two areas in Natal, South Africa: the Tugela basin, where over 90% of the wetland area has been lost in parts of the basin; and the Mfolozi catchment, where 58% of the original wetland area had been lost.

The loss of wetlands disproportionately affects the well-being of poor people who depend on wetland services for their livelihoods. It is therefore important that wetlands are sustainably managed so that they continue to provide services in future. This is in line with the call by the Ramsar Convention (1971) on the 'wise use' and 'sustainable development' of wetlands. They define wise use as the sustainable utilisation of wetlands for the benefit of mankind in a way compatible with maintenance of the wetland ecological security.

The major threats to wetlands can be classified into direct and indirect drivers (MEA, 2005). Direct drivers are factors that directly affect wetland ecosystem processes. Indirect drivers are those factors that trigger one or more direct drivers. Moser *et al*. (1996) refer to direct drivers as proximate causes of wetland loss and degradation and the indirect drivers as underlying causes. Furthermore, the analysis of the threats to wetlands can be considered at two levels: the direct loss and degradation that occurs to the wetland itself; and the indirect loss and degradation which occur as a result of changes outside (upstream) of the wetland system.

The primary direct drivers of wetland degradation and loss are: infrastructure development (dams, dykes, irrigation, canals and mining); land use or cover due to conversion to agriculture or other uses; wetland drainage and filling; introduction of invasive alien species; overharvesting and overexploitation of wetland products (fish, wildlife and wild plants); water abstraction; water pollution (from sewage discharge, pesticides and sediments); and more recently, climate change (MEA, 2005). Conversion of wetlands to agriculture is the principal cause of wetland loss worldwide. It is estimated that by 1985, 2% of the wetlands in Africa had been converted to agriculture (MEA, 2005).

Socio-economic and political factors are the principal indirect drivers to the loss of wetlands (Kotze *et al*., 1995; Moser *et al*., 1996). These include: population growth; rising poverty and economic inequality; food insecurity; and other socio-economic factors including policy intervention failures, due to inconsistencies among government policies in different departments and institutional failures, related to institutions that govern wetland resources management (MEA, 2005). For example, in the studied wetland system, access and use of wetland resources for both agriculture and natural products is influenced by the interplay between:

- local level institutions (traditional leaders, the wetland committee and the Community Development Forum);
- civil society organisations (non-governmental organisations working on wetlands such as the Mondi Wetlands Project); and
- national level institutions (Department of Agriculture, Department of Water Affairs and Forestry, Department of Land Affairs and the Department of Environmental Affairs and Tourism) (Tinguery, 2006).

In southern Africa, the main underlying factors causing the loss of wetlands are: population growth; rising poverty; severe economic stress; and frequent droughts (Matiza and Chabwela, 1992). Barbier *et al*. (1997), Turner *et al*. (2000) and Schuyt (2005) noted that the underlying causes of wetland degradation and loss are:

(i) lack of understanding of wetland values and the impact of human activities on wetland functioning;
(ii) market failures associated with the character of externalities of many wetland services and the uneven distribution of their benefits across stakeholder groups; and
(iii) policy intervention failures.

Table 2.9 shows the main threats to wetlands in southern Africa.

Table 2.9: Major threats to wetlands in southern Africa ranked according to extent of occurrence

Threat	Rank	Areas at risk
Dams	1	All dam areas especially the Lower Zambezi
Irrigation	1	Most river basins and floodplains in the region
Vegetation clearing (conversion to agriculture)	1	Most parts of southern Africa
Overgrazing	1	Most parts of southern Africa
Over-hunting (Poaching)	1	Largely in Zambia, Angola, Tanzania and Mozambique
Overfishing	1	Most rivers, small lakes and floodplains
Over- extraction of water resource	1	Potentially Zambezi river and Okavango Delta
Population growth and human settlements	2	Coastal zone of Mozambique and dambos of Zimbabwe
Siltation (infilling)	2	Luangwa and Save rivers
Pollution (pesticides)	2	Common in all parts of the region
Pollution (agro-chemicals)	2	Common in all parts
Pollution (industrial)	3	Urban areas and mining sites
Eutrophication	3	Lake Chivero (Zimbabwe) and Kafubu (Zambia)

Legend: 1=A widespread problem seriously disrupting ecological and hydrological processes; 2=Causing serious damage, but is not yet widespread; 3=Present, but not yet widespread

Source: Breen *et al*. (1997)

2.6 Concluding Summary

This chapter briefly presented the biophysical and socio-economic characteristics of the region under study. The chapter also reviewed the major ecosystems in southern Africa and showed that wetlands are one of the eight major ecosystem types occurring in the region. Wetlands provide multiple services, which are important to the livelihoods of many rural communities in the region. The services range from agricultural production, natural products, dry season livestock grazing, water supply, fisheries and other aesthetic and cultural values. The services wetlands provide vary from one wetland to another depending on the biophysical characteristics of each wetland.

Despite their role in supporting people's livelihoods wetlands continue to be degraded and lost at an increasing rate. The major threats to wetlands in the region are conversion to agriculture and overexploitation of wetland products driven primarily by the increasing demand for wetland services due to population growth, increasing poverty levels and other socio-economic factors. Given the key role wetlands play in supporting the welfare of the rural poor in the region it is critical that they are sustainably managed so that they continue to provide services in future.