UNIVERSITY OF ZIMBABWE

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING


MEASURING THE ECONOMIC VALUE OF WETLAND ECOSYSTEM SERVICES IN MALAWI: A CASE STUDY OF LAKE CHIUTA WETLAND

STEARNER ZUZE

MSc. THESIS IN IWRM

HARARE, NOVEMBER 2013

UNIVERSITY OF ZIMBABWE

FACULTY OF ENGINEERING

DEPARTMENT OF CIVILENGINEERING

University of Zimbabwe **IN COLLABORATION WITH** **Waternet**

MEASURING THE ECONOMIC VALUE OF WETLAND ECOSYSTEM SERVICES IN MALAWI: A CASE STUDY OF LAKE CHIUTA WETLAND

By

STEARNER ZUZE

Supervisors

Prof. Isla GRUNDY

Prof. Theresa MKANDAWIRE

Mr. Fanuel HAZVINA

A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science in Integrated Water Resources Management at the University of Zimbabwe

November 2013

DECLARATION

I Stearner Zuze, herewith declare that I am the sole author of this master thesis: **Measuring the economic value of wetland ecosystem services in Malawi: A case study of Lake Chiuta wetland** and that I have conducted all works connected with the master thesis on my own. It is being submitted for the degree of Master of Science in Integrated Water Resources Management (IWRM) at the University of Zimbabwe. This master thesis has not been presented to any other examination authority.

Date: ___________________________

Signature: ________________________

.

The findings, interpretations and conclusions expressed in this study do neither reflect the views of the University of Zimbabwe, Department of Civil Engineering nor of the individual members of the MSc. Examination Committee, nor of their respective employers.

ABSTRACT

Economic valuation of wetland ecosystem goods and services aims to investigate public preferences for wetlands and the natural resources in monetary terms and it aids in quantifying the direct and indirect benefits that people derive from wetlands. Lake Chiuta wetland is the only second wetland to be valued in Malawi for ecosystem goods and services through this research. Valuation of Lake Chiuta wetland is an important step forward towards the economic valuation and conservation of wetlands in Malawi. The objectives for this study were to identify the current ecosystem services provided by the wetland, quantify the values of wetland resources (goods and services) and to determine the economic dependency on the wetland of the people living in the surrounding areas. In this study, the Total Economic Valuation approach was used which concentrated on direct and indirect use values of the wetland ecosystem services with more emphasis on direct use values. The Market Price technique was used to estimate the direct use value of wetland ecosystem goods and services and Contingent Valuation Method was used to solicit the willingness to pay for the conservation for biodiversity. The data were collected through focus group discussion, key informant interviews and the household survey as well as field investigations. The value of Lake Chiuta wetland was assessed in terms of Gross financial value (GFV), Net financial value (NFV) and cash income. The research findings have revealed that the contribution of the wetland to the surrounding communities has an estimated annual value of US$17.2M, which translate to US$554 per ha (GFV), and an annual per capita value of wetland economic benefits of US$248. The results show that fishing and crop production each contributes 75% and 23% respectively to the cash income of the households. Willingness to pay for the conservation of biodiversity was estimated at an annual aggregate of US$11M, which is lower than the GFV. The households living around Lake Chiuta depend on the wetland for socio economic livelihoods. The results indicate that the annual mean income per household is US$223 which is accrued through farming, fishing and harvests of wetland goods. There are no active community and government institutions in resource use and management of the wetland in Lake Chiuta, which make the wetland susceptible to over exploitation of the resources, thus putting at risk the availability of wetland resources for future generation and existence of the wetland. In view of the high value of economic benefits, the wetland provides to the communities living in the surrounding areas. It is important that the government, through key ministry (Ministry of Natural Resources & Climate Change) should set up the government institutions and facilitate the formation of a Community Based Natural Resource Management (CBNRM) programme and the institution to manage resource use and management in the wetland.

Keywords: Wetland, Ecosystem services, Economic valuation, GFV, market price

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BVC	Beach Village Committee
CI	Cash Income
CST	Total Cost of hasting or production of wetland goods
CVM	Contingent Valuation Method
DAES	Department of Agriculture and Extension Services
DES	Demand for Ecosystem Services
DOF	Department of Fisheries
EAD	Environmental Affairs Department
EPA	Extension Planning Area
ES	Ecosystem
ESMIN	Minimum Ecosystems
ESOPT	Option Ecosystems
ESV	Ecosystem Value
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GFV	Gross Financial Value
HH	Household
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
MADD	Machinga Agricultural Division Development
MDC	Machinga District Council

Met. Dept.	Metrological Department
Mk	Malawi Kwacha
MNM	Minimum
MPM	Market Price Method
MVU	Maximum Use Value
NSO	National Statistics Office
NUV	Non Use Value
QHT	Quantity Harvested
QSD	Quantity Sold
SCBD	Secretary for Conservation of Biodiversity
SMS	Safe Minimum Standards
TA	Traditional Authority
TCM	Travel Cost Method
TEV	Total Economical Value
UNEP	United Nation Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US$	United States Dollar
USGS	United States Geological Survey
UV	Use Value
WTP	Willingness to Pay

DEDICATION

To my dear wife Jacqueline and son Caleb

ACKNOWLEDGEMENT

My greatest appreciation goes to **The God Almighty** for being with me throughout the entire research. My sincere appreciation goes to WaterNet and University of Zimbabwe for giving me an opportunity to enroll in their Programme.

This study would not have been possible without the ongoing support of Prof. Isla Grundy, Prof. Theresa Mkandawire and Mr. Fanuel Hazvina. To them I am extremely grateful for their step-to- step supervision and distinctive contribution on each chapter of my thesis. Thanks also to the Department of Civil Engineering staff for personal and professional support provided. I would also like to thank the District Commissioner for Machinga for granting me permission to carry out fieldwork and for supplying me with the information I needed. I would like to extend my gratitude to Mr. Msango Pikini, Titani Kantondo, and Mr. Khosa for being supportive during my fieldwork. Lastly, I would like to thank Traditional Authorities Ngokwe and Chikweo as well as the communities of Lake Chiuta wetland for being so welcoming and for their generosity with their time and for all the efforts made to assist me during data collection period.

God bless you!

CHAPTER ONE: INTRODUCTION

1.0 Background

Biological diversity has been regarded as essential for human survival (Collings 2009; Edwards *et al.*, 1998) and is argued to be of infinite value to economies (Costanza *et al.*, 1998). However, despite these infinite values, population increase coupled with intense anthropogenic activities and unplanned developmental activities have altered or impaired the biodiversity and is affecting the ecosystems functions (Collings, 2009).

Since the very beginning of human life on earth, wetlands have provided valuable resources and refuge for human populations and many other life forms (RCB, 2002). Through their ecological complexity, wetland areas perform many functions, which in turn provide the goods and services that are important for human well-being (De Groot *et al.*, 2006). In Southern Africa, wetlands have been identified to support the livelihoods of many rural and often poor households (Cartney *et al.*, 2004; Masiyandima *et al.*, 2004; Turpie, 2000; Turpie *et al.*, 1999).

Wetlands occupy a transitional region between terrestrial and aquatic habitats, and are influenced by both and they differ broadly in character as a result of differences in climate, soils, topography, hydrology, water chemistry, vegetation, and other factors at both regional and local level (Schuyt, 2004). A key defining force; the depth and duration of inundation can differ significantly between types of wetlands and also can vary from year to year within a single wetland type (Schuyt, 2004). Wetland as defined by Ramsar Convention (1971), are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing; fresh, brackish, or salty, including areas of marine water the depth of which at low tide does not exceed six meters (Ramsar Convention, 1996).

In spite of their importance in sustaining human well-being, many wetlands remain threatened. It has been observed that lack of readily available data and information about the values of wetlands is a major reason why their conversion and development have been viewed generally as a more attractive option, most especially in developing countries (Balmford, 2002; Mmopelwa *et al.*, 2006). The wetlands' ecosystems provide humanity with a wide range of benefits known as ecosystem goods and services. These goods produced by ecosystems include food (meat, fish, vegetables etc.), water, fuels, and timber, while services include water supply and air purification, natural recycling of waste, soil formation, pollination, and the regulatory mechanisms that nature, left to itself, use to control climatic conditions and populations of animals, insects and other organism (MEA, 2005).

An ecological-economic analysis framework distinguishes between characteristics, structure, processes and functions of ecosystems (Turner *et al.*, 2000a) including wetlands. De Groot (2002) classified ecosystem function into four categories:

1. **Regulation Functions**: ecosystems regulate ecological processes that contribute to a healthy environment – examples are recycling of nutrients and human waste, and watershed protection.
2. **Carrier Functions**: ecosystems provide space for activities like human settlement, cultivation and energy conversion.
3. **Production Functions**: ecosystems provide resources for humans like food, water, raw materials for production of goods and services.
4. **Information Functions**: ecosystems contribute to mental health by providing scientific, aesthetic and spiritual information. These functions (goods and services) have an economic value provided by the ecosystem that directly or indirectly contributes to the economic growth in countries.

The economic value of some environmental goods and services is measured by the summation of many individuals' willingness-to-pay for it, as one way of measuring it (Ramachandra *et al.*, 2004). In turn, this willingness-to-pay (WTP) reflects individuals' choice for the goods in question. Therefore, economic valuation in the environment context is about measuring the preferences/choices' of people for an environmental benefit or against environmental degradation (Ghermandi *et al.*, 2008) as well as for conservation of biodiversity for future generations. The economic valuation of wetlands helps us to understand the constituents' functions as well benefits and this exercise could act as a catalyst for wetlands conservations (Korsgaard *et al.*, 2010; Barbier *et al.*, 1997). Emerton (1998) lists reasons for wetlands valuation, which include: to review the high value associated with the conservation of wetlands and the quantifiable economic benefits that can be realised by stakeholders across board. She believes that showing the costs incurred due to wetland degradation and loss substantiates the reasons for wetland conservation as an economically beneficial investment. She further argued that wetlands valuation enhances the conservation of wetlands through the integration of business and economic concerns into conservation strategies and policies.

Monetary valuation of ecosystem services provides traction in the decision-making process particularly with policy agents and scientists (Fisher *et al.*, 2008). For example, economic analyses coupled with scenario-based planning provided a method relevant to stakeholders in determining the consequences (the costs and benefits) of potential land use changes or development options (Turpie *et al.*, 2007). Prior to the concept of environmental valuation or in cases where valuation has not occurred, environmental systems are deemed unimportant to policy and decision makers (Edwards *et al.*, 1998) which results in degradation and destruction of these environmental goods and services.
The benefits derived from natural resources have been identified and critically examined since the mid-1960s (De Groot *et al.*, 2002). Classifications of these wetland ecosystem goods and services (from this point forward referred to as ecosystem services) are highlighted in the literature (see De Groot *et al.*, 2002; MEA, 2003) as are numerous studies calculating the economic values of these services (Costanza *et al.*, 1998; Edwards *et al.*, 1998; Hanemann, 1994; Kroeger, 2005; Turpie *et al.*, 1999).

A number of environmental economic studies address the total economic value (TEV) of a system (De Groot *et al.*, 2002). This value can be determined from the summation of a system's use values and non-use values. Use values include direct use such as harvesting of resources, indirect or ecological function values such as flood control, and option value such as future drugs (Collings, 2009). Non-use values include existence values, which place importance based purely on the presence of a system, and bequest value. There are a number of valuation methods that are applied in this area of study: contingent valuation, group valuation, indirect market valuation and direct market valuation are broad categories of these methods (De Groot *et al.*, 2002).

1.1 Problem Statement

Wetlands perform a number of functions that provide services, which people value. In recent years, decision-makers have placed increasing focus on valuing ecosystem services in order to capture as complete an accounting as possible of the costs and benefits of land and resource management programs and policies, such as wetland conservation and restoration (Stuip *et al.*, 2002a).

Malawi recently made an inventory of its wetlands to be recommended as Ramsar site for their conservation. Ramsar sites are wetlands of international importance, designated under the Ramsar Convention (Defra, 2006). There are eleven known wetlands in Malawi of which only one wetland, Lake Chilwa, is valued and is under conservation as a Ramsar site. The rest are unprotected despite the wide range of goods and services, which they provide. Lake Chiuta wetland does not have a protected status and as a result, there is uncontrolled exploitation of the wetland and its resources, which risk the wetland of being lost.

Thomson, (2006) found that all levels of society in the area unanimously agree that Lake Chiuta wetland is important and that life without it would be more difficult; however, he observed that there is unsustainability utilisation of wetland resources. He noticed that there is a reduction in the lake level due to water abstraction within the catchment and degradation of the catchment by the local population. Over-trapping and shooting of resident and migratory birds is an additional problem. The potential threats for the future include poverty, population increase due to drying of nearby wetland (Lake Chilwa), soil erosion and siltation, destruction of breeding grounds and sanctuaries for fish (Thomson, 2006).

A major reason for excessive depletion and conversion of wetland resources is often the failure to account adequately for their non-market environmental values in development decisions (Barbier *et al.*, 1997). By providing a means for measuring and comparing the various benefits of wetlands, economic valuation can be a powerful tool to aid and improve wise use and management of wetland resources (Barbier *et al.*, 1997). In light of the issues raised above, it is therefore important to quantify the value of wetland resources for the communities living around the wetland as well as the nation, to realise the valuable benefits the wetlands provides in order to improve wise use and management of its resources.

1.2 Objectives

1.2.1 Main Objective

The overall objective of this research is to measure the economic value of Lake Chiuta wetland ecosystem services in order to guide in decision making for its future conservation as well as to sustain its ecological and socio-economical functions.

1.2.2 Specific Objectives

The specific objectives of this research were to:

1. Identify current ecosystem services provided by Lake Chiuta wetland.
2. Quantify the values of wetland resources (goods and services) identified.

3. . Determine the economic dependency on the wetland of the people living in the surrounding areas.

1.3 Research Questions

Considering the purpose and objectives of the study, the following guiding questions were addressed in this research:

Wetland Resources

What are the current ecosystem services provided by Lake Chiuta wetland?

Economic Value of Wetland Resource

1. What is the value of Lake Chiuta wetland resources (goods and services) in its present status?
2. How much are the communities living around Lake Chiuta wetland willing to pay for the conservation of the wetland?

Socio-economic Value of Wetland

How do the people living in the surrounding areas depend on the wetland for their livelihoods?

1.4 Justification of the Study

Economic valuation is but one of the many ways to define and measure values of wetland ecosystem services. Other types of values (religious, social, cultural, global, intrinsic etc.) are also important but the economic value is the most important in most countries when decision makers have to make difficult choices about allocation of scarce government resources (Lambert, 2003). Information on the economic values of policy changes (with regard to the environment) can greatly assist in identifying the policy and sectoral priorities. Economic valuation incorporating environmental aspects helps in evaluating developmental projects, programmes and policies (Setlhogile, 2010; Emerton, 1998).

The MEA (2003) states that a country could cut its forests and deplete its fisheries and this would show in the short term only as a positive gain to GDP despite the loss of the capital asset. The lost asset could only be reflected in the income of the community if its economic value is measured. By applying various resource valuation techniques, this research attempts to determine economic value of particular ecosystem services that constitute a part of Malawi's natural capital. Measuring the value of Lake Chiuta wetland ecosystem services will bring to light the significance of Lake Chiuta wetland in a language more familiar to key decision makers. It is acknowledged that the development of Machinga District (which Lake Chiuta wetland is located) rests on its natural resources, e.g. land, water, fish and wild life (MDC, 2007). Therefore an economic valuation will guide in decision making for the conservation of Lake Chiuta wetland, promote sustainable utilisation and management of wetland resources by the community. In addition, few studies have been conducted in the field of wetlands valuation in Malawi. Only one study on wetlands valuation had been conducted; 'the valuation of Lake Chilwa wetland', which was estimated at an annual value of US$ 21M (Stuip, *et al.*, 2002). Therefore, the study will contribute to the availability of literature on wetlands valuation in Malawi and will be a benchmark for future studies on wetlands valuation in Malawi; hence, it will contribute to the growing field of wetland resource economics in the World.

1.5 Scope and Limitations of Study

It is acknowledged that an effective method for valuing cultural, artistic or spiritual, social, intrinsic and global value is to conduct intensive contingent valuation (Collings, 2009; De Groot, 1992), as in the cultural study by Impey (2002). However, due to limited time and resources, this study was limited to economic valuation of wetland ecosystem services particularly goods and services that are traded on the market. The research did not consider the other types of values such as religious, social, cultural, global, intrinsic etc.

1.6 Structure of the Thesis

The thesis is organised in five chapters. Chapter One (Introduction) contains the background of the study, research problems, objectives, research questions and justification of the research as well as scope and limitation of this study. Chapter Two is literature review of wetlands, specifically the roles and values of wetland, including wetland losses and their causes. The chapter also covers the relationship between wetland ecology and economics as well as the link between the ecosystem and human welfare. Classification of ecosystem services values, the framework for valuing ecosystem services, the valuation of wetland ecosystem services at global level and methods used in wetland ecosystem services valuation are also discussed in this chapter. The overview of study area in relation to its location, climate, natural resources and socio-economic characteristics is provided in Chapter Three. The Chapter also includes a discussion of methods used in this study and data analysis of the results. The findings of the research and discussions for the findings as per the specific objectives are presented in Chapter Four. Finally, Chapter Five provides conclusions and recommendations from the study.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

The world community is concerned with the fate of world wetlands, considering the valuable resources wetlands provide and the functions they perform in sustaining human life. The literature shows a growing focus in the field of wetlands resource economics, on wetland uses and benefits as well as various factors and activities that lead to their degradation and loss. This Chapter gives an overview of literature on wetlands, in terms of their roles, values as well as loss. The chapter also covers the relationship between wetland ecology and economics, the link between ecosystem and human welfare, classification of wetland goods and services, valuation of ecosystem services and the methods for valuing wetlands ecosystem services. Some empirical studies on wetland valuation, both at international and regional as well as national experiences are also provided in this chapter.

2.1 Roles and Values of wetland

Efforts to preserve and create wetland ecosystems depend on the recognition of their ecological as well as their economic values. From an ecological perspective, wetlands are valuable as they are the among world's most productive ecosystems and host a large amount of biological diversity (Ghermandi *et al.*, 2008). The economic rationale for conserving and creating wetland ecosystems is thus linked to the services and goods they provide, which have been recognised to be extremely valuable welfare constituents to many people worldwide (MEA, 2005).

A widely agreed, precise definition of what constitutes a wetland is not available (Lannas *et al.*, 2009). However, The Convention on Wetlands, a UNESCO (United Nations Educational, Scientific and Cultural Organization) based intergovernmental treaty on wetlands provides a broad characterisation (SCBD, 2001). Wetlands, as defined by the Ramsar Convention, cover a wide range of habitat types such as rivers, lakes, coastal lagoons, mangroves, peat-lands and coral reefs and are considered as a homeland of a variety of flora and fauna and provide tremendous economic benefits (Brander *et al.*, 2006). Wetlands are considered as hot spots of biodiversity (RCS, 2004) which provides goods and services for human well being. This research adopts the definition by the Ramsar Convention since it is widely used and accepted for conservations of wetlands and water resources.

Wetlands are important sources of natural resources upon which many rural economies and entire societies depend (RCS, 2006). Wetlands provide a range of goods and services and possess a variety of attributes of value to society (Barber, 1993). They offer provisioning, regulating, cultural, and supporting services (MEA, 2005). Wetlands also perform important functions that have economic value. The total economic value of world's wetlands is estimated at US$3.4 billion per year and the value of wetlands in Africa is estimated at US$544 million per year. However this value is low as it only calculated from 89 case studies (Schuyt, 2004). In Malawi, only one wetland has been valued and in 2002 had an estimated annual value of US$21million in benefits to the surrounding communities (Stuip *et al.,* 2002).

2.2 Wetland loss

The Millennium Ecosystem Assessment (Smith *et al*., 2007) has identified wetlands as the most threatened of all ecosystem types. Faced with the reality of global climate change, implications for wetlands pertain largely to the hydrology of these systems (Erwin., 2009). Wetlands are valuable ecosystems that occupy 6% of the worlds surface (Schuyt, 2004) and in Malawi wetlands cover approximately 58 000 km^2 (Kambewa, 2005). Since 1900 more than half of world's wetlands have disappeared (Barber, 1993). These losses are caused by the fact that many wetlands' products and services are public goods and do not have clear property rights and also their loss is partly because of lack of understanding of their ecological and socio-economic importance, which leads to distorted policy and decision making regarding their use and management (Adaya *et al.*, 1997). Barbier (1993) indicated that wetland losses are mainly caused by external costs that are imposed on the stakeholders of wetlands and policy intervention failures due to a lack of consistency among government policies in different areas. Despite legislation designed to protect them, wetlands continue to be degraded and lost at an alarming rate (Turner *et al.*, 2000b).

In southern Africa, many wetlands have been lost or degraded due to increasing demands for land and water as a result of growing population (Lannas *et al.*, 2009). An understanding of the socio-economic value of wetlands is crucial when deciding on conservation and development priorities related to land use and the allocation of scarce resources. Therefore, the value of the natural resources that wetlands provide to poor communities is a critical consideration (Schuijt, 2002). These resources include rich, moist soils (for cultivation), grazing land, fisheries, reeds, sedges, grasses, timber; and water (for domestic use and livestock as well as for irrigation) (Kotze *et al.*, 1994).

2.3 The Relationship between wetland Ecology and Economics

Lambert (2003) highlighted that the social, economic and environmental hardships that human populations suffer today is a result of destruction and mismanagement of natural resources, which includes wetlands and water resources. He further observed that continuing destruction of natural resources is contributing to poverty, scarcity of water supply and food. Understanding the concept of wetland ecosystem services is useful for landscape management, sustainable business practice and decision making (Costanza *et al.*, 2006). The wetland ecosystem concept helps to synthesise essential ecological and economic concepts, which allows researchers and managers to link human and ecological systems and this is an essential tool to evaluate economic and other tradeoffs between landscape development and conservation alternative (Lynam, 2007).

Although wetlands are amongst the richest life-supporting ecosystems on earth, they are amongst the most threatened and destroyed (Smith *et al.*, 2007). Lambert (2003) argued that the reason people destroy wetlands is because they do not value wetland goods and services. However, the sacred wetlands are an exception and are often well conserved because their religious value is recognised by local people.

2.4 Relating Ecosystem Services and Human welfare

Economics is essentially the study of how humanity provides for itself (Heilbroner 1968) and humanity largely provides for itself by standing on the shoulders of natural systems (Fisher *et al.*, 2008). Bockstael *et al.*, (2000, p1384-1389) states: “In economics valuation concepts relate to human welfare” that the economic value of an ecosystem function or service relates only to the contribution it makes to human welfare, where human welfare is measured in terms of each individual’s own assessment of his or her well-being. And MEA (2005, p155) states that ‘‘ecosystem services are the benefits people obtain from ecosystems”. Given humanity’s demand for natural resources, Fisher *et al.* (2008) link ecosystem services to human welfare with a supply and demand relationship as proposed by Pearce (2007) (Figure 1).

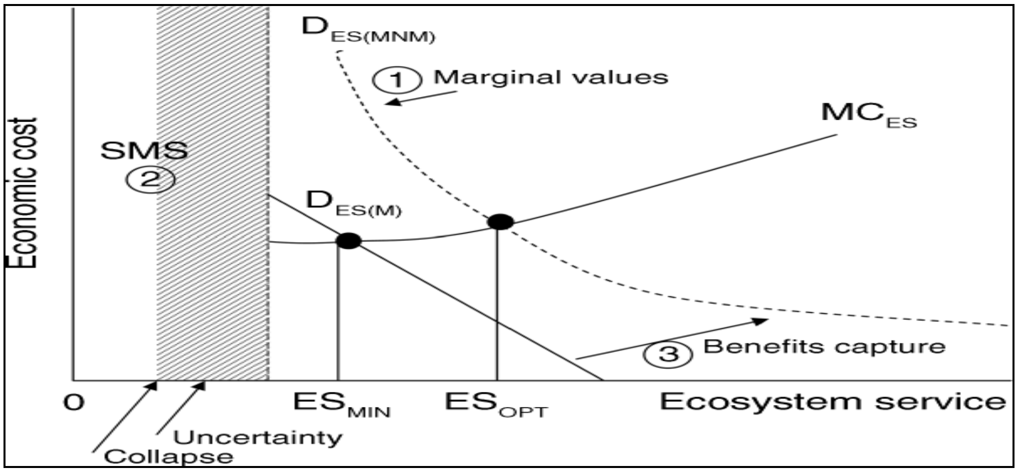


Figure 1: Stylised costs and benefits of Ecosystem Service (ES) provision Source: Collings, (2009); Fisher *et al.*, (2008).

DES (MNM): Demand for all ES benefits (market and non-market goods). DES (M): Demand for ES benefits from market goods only. MCES: Supply curve or the marginal cost of managing ES or acquiring additional units of ES benefits. ESMIN: The point where only marketed ES are provided/ demanded and ESOPT: the optimal level of ES provision. SMS: Safe minimum standard or quantity of ES below which the system may collapse.

The demand curve (DES (M)) represents the demand for marketed services from an ecosystem, or products such as fuel wood or fish. DES (MNM) is the demand for both marketed and non-marketed services including goods such as scientific knowledge or watershed protection (Pearce, 2007). As every potential non-marketed good is unknown, DES (MNM) represents an ideal scenario that includes all of these unknown services. MCES illustrates the marginal cost curve or supply curve for ecosystem services. The interaction of supply and demand curves denotes the economic cost of the supply or, in this case, the cost incurred to gain an additional unit of the ecosystem service. ESMIN indicates the cost associated for marketed services whilst ESOPT relates to the potential trading of all ecosystem services both marketed and non-marketed. This relationship describes an optimal diversity services level where marginal costs meet the demand for all ecosystem service benefits (Lambert, 2003). A Safe Minimum Standard (SMS) of services that an ecosystem may offer was thus introduced to account for uncertainty regarding initial quantities of ecosystem services. Pearce (2007) mentions limitations of this model and acknowledges its simplicity (Box 1). However, it provides a helpful economic basis to approaching ecosystem services trading and valuation (Collings, 2009; Costanza *et al.*, 2006)

Box 1: Simplicity and limitations of cost & benefit of ecosystem service provision model proposed by Pearce (2007)

- the model assumes that ES are best secured by conserving the ecosystems that generate them. This is not consistent with using the ecosystem for some other purpose, e.g. agriculture.
- it ignores the possibility that ES might be largely maintained while serving some development function.
- it ignores the possibility, realistic in practice, that the conversion process may be very inefficient. Ecosystems may be converted only for the development option not be realised because of mismanagement of the conversion process or of the subsequent development.

Source: Pearce, (2007)

2.5 Classification of wetland Ecosystem goods and Services values

Ecosystem goods and services emanate from a functioning ecosystem and are of direct value to humans (Brown, *et al.*, 2006). Ecosystems goods are generally tangible material products that result from ecosystem processes, whereas ecosystem services are in most cases improvements in the condition or location of things of value (Brown *et al.*, 2006). Experts have identified four different kinds of ecosystem services, all vital to human health and well-being (MEA, 2005). Table 1 below presents these four kinds of services provided by the wetland ecosystems.

Table 1: Types of services provided by ecosystem services Source: (MEA, 2005)

Kinds of Ecosystem services	Example
Regulating services	Benefits obtained from the regulation of ecosystem processes. This governs climate and rainfall, water (e.g. flooding), waste, and the spread of disease.
Provisioning services	Products obtained from ecosystems. This supply the goods themselves, such as food, water, timber and fibre etc.
Cultural services	Includes the beauty, inspiration and recreation that contribute to our spiritual welfare.
Supporting services	Ecosystem services that is necessary for the production of all other ecosystem services. Includes soil formation, photosynthesis and nutrient cycling

Although in the current literature the term ecosystem services aggregate a variety of benefits, economics normally classifies these benefits into three different categories: (i) goods (e.g. products obtained from ecosystems, such as resource harvests, water and genetic material). (ii) Services (e.g. recreational and tourism benefits or certain ecological regulatory functions, such as water purification, climate regulation, erosion control etc.), and (iii) cultural benefits (e.g. spiritual and religious, heritage, etc) (MEA, 2003).

The definition of the total value of environmental resources differs from the concept commonly used in environmental economics (Schuyt *et al.,* 2004). In an ecosystems perspective, the total values of wetland ecosystems are classified into primary and secondary values (Gren, 1992). The primary values are the values of wetland for its own development and maintenance, which includes the dynamic changes of the ecosystem over time as well as its resilience. The secondary values are the value that the wetland exports to other ecosystems and humanity (Gren, 1992).

The second classification of total value of wetland ecosystem has usually been divided into use and non-use values derived from individual preferences (Krutilla *et al.*, 1975) also called direct use and indirect use values respectively. Gren (1992) argued that in the economic literature, the commonly used classification of values into use and non-use values is not fully satisfactory since does not fully distinguish between alternative life support functions of an environmental resources. However, he further argues that the measurement of values according to either of the two classification systems, primary and secondary versus use and non-use values would provide the same results.

Table 2: Classification of total economic value of wetland ecosystem:Use and non-use values Source: Barbier *et al.*, (1993)

Direct Use Value	Indirect Use Value	Option Value	Existence
- Fish harvest - Agriculture - Fuel wood collection - Recreation - Transport - Wildlife harvesting - Peat/Energy	- Nutrient retention - Flood control - Storm protection - Ground water recharge - External ecosystem support - Micro-climatic stabilisation - Shoreline stabilisation, etc.	- Potential future uses (as per direct and indirect uses) - Future value of information	- Biodiversity - Culture heritage - Bequest values

2.6 Framework for Ecosystem Services Valuation

Figure 2 below shows an integrated framework developed for ecosystem services valuation (Costanza *et al.*, 2006; De Groot *et al.*, 2002). It shows how ecosystem goods and services form a pivotal link between human and ecological systems. The Framework (Figure 2) shows the ecosystems structure and processes being transformed into ecosystem functions which then provide goods and services people valued (De Groot *et al.*, 2002). These values include the ecological value which is the capacity of the ecosystem to provide good and service based on sustainable use. The social-cultural value, which is the perception of human being in determining the importance of ecosystems in terms of the function of ecosystem to human society and the economic value (De Groot, *et al.*, 2002). The framework shows that a total value of ecosystem services is a summation of ecological, social-cultural and economic values.

In addition, the framework incorporates the decision-making process, which determines the policies options and the management measures that directly modify the ecosystems' structures and processes.

The framework also shows inter-linkages between values, ecological functions and ecosystem services. De Droot *et al.,* (2002) highlighted that the overlapping of ecosystem services as well as the functions can lead to double counting when valuing ecosystems, hence care must be taken when conducting valuation process.

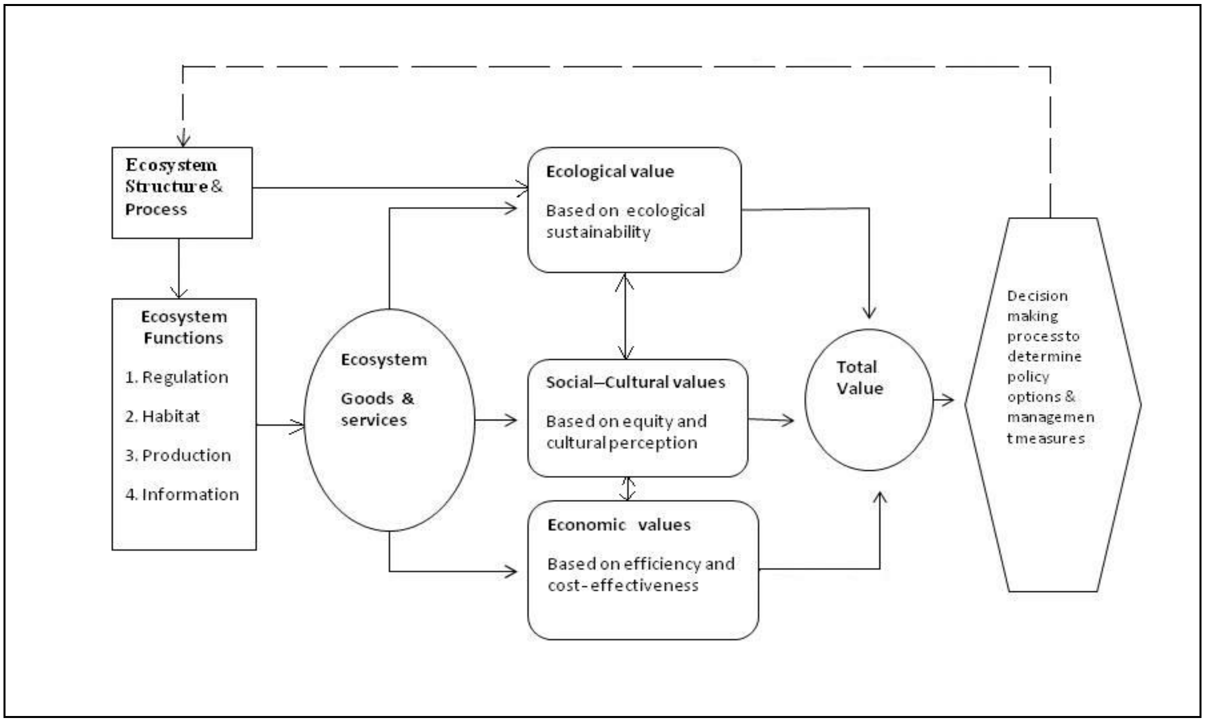


Figure 2: Framework for integrated and Valuation of Ecosystem functions, goods and services Source: De Groot *et al.*, (2002).

2.7 Valuation of wetland Ecosystem Services

The literature has shown to be extremely diverse in terms of values estimated, wetland types considered and valuation methods used (Korsgaard, 2010). Economic valuation can be defined as the attempt to assign quantitative and monetary values to goods and services provided by environmental resources or systems, irrespective of the availability of market prices to assist us (Balmford, 2002). When market prices are not available (e.g. for flood control services, for disaster mitigation services, or erosion avoidance), the value is established by the willingness to pay for the good or service whether the actual payment is made or not (Phouphet, 2011).

A major problem in assessing the value of ecosystems is when the services provided by the ecosystems (e.g. climate change regulation or biodiversity conservation), benefit the global community (Costanza *et al.*, 2006; Leschine *et al.*, 1997). Ecosystem Service Valuation is thus the process of assessing the contribution of ecosystem services to meeting a particular goal or goals (Turner *et al.*, 2000). Usually the goal is to allocate the scarce ecosystem services among competing uses such as development and conservation (Costanza *et al*., 2006).

Economic valuation can provide useful information for wetland management (Lannas *et al.*, 2009; Schuyt *et al.*, 2004). This information can be on the rate of harvest of wetland resources and methods used for harvesting the resources. Such information can assist to determine the level of wetland resource exploitation and overall status of wetland resources (Lannas *et al.*, 2009; Schuyt *et al.*, 2004). In addition, having such information can help to devise appropriate measures to control the use of wetland resources and the methods used for harvesting wetland resources.

The economic values of wetland goods and services are important in cost benefit analysis of development activities whereby the decision has to be made between the development and the alternative use of wetland. In such the case economic values of wetland goods and services can help decision makers to make the best choice. Furthermore, the information on direct economic value of wetland, provides evidence of monetary benefits of wetlands to community living around (Kopp and Smith, 1993). Therefore, economic value of wetland resources can highlight the significance of wetlands for people and can be used as arguments for conservation of wetlands (Schuyt, 2004).

Korsgaard (2010) asserts that, although economic valuation does have an important benefit, economic valuation must be done with care. In general, one can say economic valuation of wetlands is important as it highlights significance of economic activities that depend on wetland functions (Smith *et al.*, 2007). In this way, it can be helpful to management plans of wetlands. It may also be useful in supporting the arguments on wetland conservation. Monetary valuation is an important complementary assessment to other qualitative assessments on wetland functions that cannot be monetarised (Cartney, 2004).

Due to inconsistencies, the field of Ecological Economics has received much resistance, with some viewing the valuation of natural resources as subjective or a ‘guessing game’ (Carson *et al.*, 2001). Many researchers argue that the environmental goods and services have intrinsic value, which cannot be valued in conventional economic terms (MEA, 2003), sometimes, even peoples’ willingness to pay for a certain service simply cannot be directly observed or measured (ibid). While literature emphasises on importance of valuation of environmental goods and services and put forward valuation methodologies, Carson *et al.,* (2001) highlighted that there is no standard method for valuation that can be compared, to ensure accurate measurement of environmental goods and services. Schuyt, (2004) agrees with Carson *et al.,* (2001) and he suggested that the high variability in valuation techniques and the site-specific ecosystem characteristics that do not allow for a standardised method of environmental valuation are the reasons for failure to have a standard method for valuation.

De Groot *et al.,* (2002) suggested that the complex ecosystems should be categorised or segregated into their products or functions when conducting valuation in order to determine isolated monetary values. He however, states that this option has its disadvantages since certain ecosystem functions may overlap which can lead to double counting of economic values. He gives an example of valuing river water whereby can be valued for its provision thus for irrigation but could also be valued as a supporting function i.e. for boating or habitat for aquatic biodiversity (De Groot *et al*., 2002; Hein *et al*., 2006).

Ecosystem Service Valuation (ESV) has also been criticised on methodological and technical grounds. Some arguing that ESV can only be used to evaluate changes in ecosystem service value (Ghermandi *et al.,* 2008). While others said, assessing the total value of ecosystem services at global, national, or state level is pointless because it does not relate to changes in services and one would not really consider the possibility of getting rid of the entire ecosystem at these scales (Bockstael, 2000). Furthermore (Gren, 1992) observed that, although ESV is widely used in micro-level studies, so far the contribution of ESV to ecosystem management has not been as large as anticipated or as clear as imagined. However Hermans *et al.,* (2006) argued that in practice, it is better to reach a consensus based on imperfect value estimates rather than continuing theoretical argument over the actual value of environmental goods and services.

2.8 Wetland Ecosystem Valuation Methods

According to Ghermandi *et al.,* (2008), there are three approaches or issues most important to the economic analysis of wetlands. The first approach is the *Impact analysis,* which is applied if the problem is specifically external, for example effluent from industries polluting a wetland, oil spills on a coastal wetland etc. The second approach is the *partial valuation* which is suitable if a choice is to be made between wetland use options, for example whether to convert wetland to agriculture land or divert water from the wetlands for other uses or to develop part of the wetlands at the expense of other uses. The third and last approach is the *Total valuation*, which is suitable if the problem is more general for example; to develop a conservation/restoration plan requires estimation of the total benefits provided by the wetland.

Several methods are described in the literature for valuation of wetlands ecosystems services. However, following Smith and Krutilla's (1975) classification, two classes of methods are identified: the biophysical and technological methods and secondly behavioural models. Gren, (1992) states that some biophysical models relate their measurements to human activities, but not directly to human economic well-being. Based on behavioural models, Mitchel *et al.,* (1989) further divided the methods for estimating values of environmental benefits into direct and indirect methods. The direct methods involve the demand for environmental goods and services measured by means of a constructed or hypothetical market (Mitchell *et al.*, 1989).

Mäler (1992) suggests another classification of methods for measuring environmental goods and services values. He distinguishes between values that are revealed on the markets and those not revealed on the markets. The values revealed on the market correspond to the values derived from observed market behaviour (Mäler, 1992) and the values not revealed on the market refers to the all values that are attributable to environmental goods and services which cannot be revealed from observed markets (ibid)

Most of the empirical studies carried out in Africa on wetland valuation uses classification suggested by (Mäler, 1992). The studies focus on values revealed on the markets when valuing wetland ecosystem services. However Gren, (1992) had reservations on the use of values revealed on the market as they refer only to human consumption and exclude the values exported to ecosystems outside the wetland in question, hence often resulted in under estimating the wetlands values.
Table 3 lists the valuation methods commonly used to value wetland goods and services. It must be noted that these valuation methods differ considerably in terms of the welfare measures that they estimate (Carson *et al.*, 1996; Kopp *et al.*, 1993).

2.8.1 Total Economic Value

The conceptual model put forward by Pearce *et al.*, (1994), categorise Total Economic Value (TEV) of wetland resources into use value (UV) and non-use value (NUV). A use value is a value arising from actual use made of a given resource. Use value can be derived from people's direct or indirect uses of wetlands through wetland goods and services. Direct uses of wetlands could involve both commercial and non-commercial activities such as harvesting of fish, collection of fuel wood and use of wetland for transportation services. Indirect use values refer to values provided by wetlands that maintain and protect nature and human systems through services such as maintenance of water quality and flow, flood control and storm protection as well as the production and consumption activities they support.

Total Economic Value (TEV) = Use Value [*Direct-use value + Indirect-use value +Option value*] + Non-use Value [*Existence value + Bequest value + Philanthropy value*]. (Hegg, 2006; Pearce, 1993)

2.8.2 Market Value Methods

There are three main valuation methods that are based on market values: the observed market and related goods approach; the productivity approach; and cost-based methods (Lambert, 2003). Where ecosystem goods and services are directly traded on markets, value can be observed through market prices. These market prices are usually the best estimate of willingness to pay (WTP) as they reflect decision-making reality (UNEP, 1998). Other non-market goods, such as the products arising from subsistence production, can be derived using the market price of a similar good or the value of the next best alternative. These goods must be comparable, with a high degree of substitution between them. If they are perfect substitutes, their economic value should be equal (Akadola, 2006). For example, the value of fuel wood collected for consumption at home, can be inferred through market prices of sold fuelwood, or alternatives such as charcoal or kerosene (Turpie and Barnes, 2003).

Table 3: Principal goods and services provided by wetlands and valuation methods commonly used to estimate their value. HP = hedonic pricing; CVM = contingent valuation method; TCM = travel cost method; NFI = net factor income Source: Barbier (1997)

Ecological Function	Wetland service	Valuation methods
Cultural	Amenity and aesthetics	CVM , HP , TCM
	Non-consumptive recreational activities	CVM , TCM
	Appreciation of uniqueness to culture/heritage	-
	Educational	-
	Recreational hunting	TCM, CVM
	Recreational fishing	CVM , TCM
Supporting	Biodiversity	CVM , choice experiment , market prices
	Support of pollinators	
	Commercial fishing and hunting	Market prices , NFI , production function
Provisioning	Harvesting of natural materials	Market prices , NFI
	Fuel wood	Market prices , NFI
	Surface and groundwater supply	Replacement cost , NFI
	Flood control and storm buffering	Replacement cost, CVM
Regulating	Sediment retention	
	Water quality improvement	Replacement cost , CVM
	Micro-climate stabilisation	
	Regulation of greenhouse gases	Replacement cost , CVM

2.8.3 Market Price Method (MPM)

Market price is a straightforward method to estimate the value of wetland goods and services. Market prices reflect what people are willing to pay for wetland products and the value they place on them. The direct values can be calculated from their main resource-based economic activities in the area, which include agriculture, hunting, fishing and honey collection. When these products are sold in the market, market prices are used to calculate the generated gross income and the opportunity cost of time and labour spent in collecting and producing these wetland products (Barbier, 1991).

Using the market prices methods, we assume that the market is efficient. Where this is the case the market price is the equilibrium between demand and supply and marks the point where the consumer's WTP is equal to the costs of production. This means the price reflects the full opportunity cost of inputs such as transport, marketing, labour and processing costs of products (Bishop, 1999). The costs of these inputs need to be accounted for in order to extract the true value of a market good and in cases where markets are known to be imperfect and price distortions exist, they must be adjusted for. Corrections for market failures and inputs will make application of this method more complex, though overall the use of market values is a widely accepted method as WTP is directly measured (Loomis *et al*., 2000).

Even though some authors express reservation on market price methods, but Barbier, (1991) recommended this method because it reflects an individual's willingness to pay for costs and benefits of goods that are bought and sold in markets, such as fish, timber, or fuel wood. Thus, people's values are likely to be well defined. Price, quantity and cost data are relatively easy to obtain for established markets and the method uses observed data of actual consumer preferences. It also uses standard accepted economic techniques (Mardle, *et al*., 2004).

2.8.4 Contingent Valuation Method

The contingent valuation method involves using a survey to directly ask people how much they would be willing to pay for specific environmental services. Contingent valuation is one of the only ways to assign dollar values to non-use values of the environment- values that do not involve market purchases and may not involve direct participation (Brander *et al*., 2006). The method has great flexibility, allowing valuation of a wider variety of non-market goods and services than is possible with any other non-market valuation technique. It can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. It circumvents the absence of markets for environmental goods by presenting consumers with hypothetical markets in which they have the opportunity to pay for the good in question (Venkatachalam, 2004).

In addition to the above methods, the Production Function approach is also one of the methods which are described in the literature to value the non-market use value of wetlands (Boscolo *et al.*, 2003). The method is used to estimates the value of a non-marketed resource or ecological function in terms of changes in economic activity by modeling the physical contribution of the resource or function to economic output. It is widely used to estimate the impact of wetlands and reef destruction, deforestation, water pollution, etc., on productive activities such as fishing, hunting and farming (Carson, 1996). Barbier (2007) summarised the different studies in which production function methods were applied in valuing Ecosystem goods and services (Table 4).

Table 4: Valuation of ecosystem services using production function Source: Barbier, (2007)

Author & year	**Study**
Ricketts *et al.*, 2004	Pollination service of tropical forests for coffee production in Costa Rica
Kaiser and Roumass *et al*., 2002	Tropical watershed protection services
Acharya *et al.*, 2000	Groundwater recharge supporting irrigation farming in Nigeria
Rodwell *et al.*, 2002	Coral reef habitat support of marine fisheries in Kenya
Mardle *et al.*, 2004	Marine reserves acting to enhance the 'insurance value' of protecting commercial fish species in Sicily

2.9 Integration with GIS and Remote Sensing

Geographical Information Systems (GIS) is a growing popular tool used in Valuation of wetland ecosystem goods and services, the GIS tool is used to increase the context specific of value transfer[i] (e.g. Eade and Moran 1996; Wilson *et al*., 2004). Apart from being used in value transfer, GIS is a potent tool that enables to present and standardise economic valuation data in map form offers a powerful means for expressing environmental and economic information attributed with ecosystem service values to stakeholders (Tejuoso, 2006). In simplified terms as described by Lomba, (2004) the technique involves combination of different land cover layers which represent the geographical location by which ecosystem services are aggregated. The ecosystem Service Value (ESV) is clearly made spatially by disintegrating the landscape into their constituent land cover elements and ecosystem service types (Wilson *et al.*, 2004). The process increases the possible management applications for ecosystem service valuation by allowing users to see clearly the location with important ecological landscape elements and overlay them with other relevant themes for analysis (Lomba *et al.*, 2004).

2.10 The Empirics of Wetland Valuation

Studies on valuation of wetland ecosystem services show variation in their use of valuation techniques, the actual products and services being valued as well as the type and geographical location of the wetlands being considered (Brander, *et al.*, 2006). In addition the value estimates produced by different valuation methods are not necessarily directly comparable (Brander *et al.*, 2006). By 1997, there had already been over 385 estimates of the economic value of 181 natural and man-made wetlands from 167 studies worldwide. The economic value of wetlands worldwide is estimated at US$3.4 billion per year, from the economic assessment of 63 million hectares of wetlands and the highest benefits are obtained from wetlands in Asia with an economic value of US$1.8 billion per year (Brander and Schuyt, 2010).

Lannas, *et al.*, (2009) used the Market Price method to estimate the value of provisioning services of Letseng-la-Letsie wetland in rural areas of Lesotho. It was found that the annual value of US$220 per ha is being provided by Letseng-la-Letsie wetland. This value was found to fall within the range of most estimated values from rural wetlands conducted by other researchers elsewhere (Barbier *et al.*, 1997). For example, The Hadejia-Nguru wetland in Nigeria where by the annual value derived from agriculture, fishing, and firewood provision was approximately US$34–54/ha (Barbier *et al.*, 1997) and The Nakivubo wetland in Uganda, generate approximately US$500/ha annually from agriculture (Emerton *et al.*, 1999).

Adekola *et al.*, (2009) conducted the economic and livelihood value of provisioning services of the Ga-Mampa wetland in South Africa. The main provisioning services valued in the study were the collection of edible plants, crop production, livestock grazing, fishing, hunting, fuel-wood, reeds and sedge collection. In his study, the Market price method was also applied. The value of Ga-Mampa wetland was estimated at an annual net financial value of $211 per household which was found to be far exceeds its annual cash income of $35 per household (Adekola, 2009). However, he found that siege collection contributed highest to the value of Ga Mampa wetland, which is contrary to the empirical findings in Turpie, (2000) where fish and crop production were found to be the main contributors to the value of wetlands.

The 2005, IUCN Integrated report on the Institutional and legal requirements for acceding and Implementing the Ramsar Convention, and associated costs and benefits in Laos, reviewed that the total economic value of wetlands in the Lao PDR is at US$945,000 per ha/year while the average economic value of the world's wetlands has been estimated as US$2,393/ha/year. It was indicated in this report that, by applying the global average economic value of wetlands, the total economic value of wetlands in the Lao PDR is estimated at US$ 2.3 billion per year (IUCN, 2005). However, it was pointed out that while the estimate were crude and based on a range of assumptions, but it serves to illustrate the fact that wetland ecosystems in the Lao PDR are valuable and deliver many services to people (IUCN, 2005).

Lake Chilwa wetland is the only wetland that has been valued in Malawi. The wetland has an area of 2,400 km^2 and it has been designated as Malawi's first Ramsar site in 1996 (Stuip, 2002). Stuip, (2002) carried out a study on economic valuation of Lake Chilwa wetland. In his study, five wetland resources (Agriculture, fish, grass, open water and vegetation) were valued using Market Price method. An annual value of US$21M was estimated in this study (Table 5). It was found that fish contributed highest value followed by agriculture production. However, the indirect use values of Lake Chilwa wetland were not estimated in the study. Later, the study conducted by IUCN, (2005) found out that the economic value of Lake Chilwa wetland was US$20.4 million which was lower than the previous estimate. The reason for such difference could be attributed to economic crisis (devaluation of Kwacha) which the country was experienced during this period. However, comparing the individual services or goods, again fish and agricultural production were found to contribute highest to the value of Lake Chilwa wetland which in agreement with the previous study conducted by Stuip, (2002).

Table 5: Economic value of Lake Chilwa wetland in Malawi Source: Shuyt, (2005)

Wetland benefits	Economic values (US$/year, 2002)
Agricultural grounds	1.2 million
Fish	18.7 million
Vegetation and clay	14,000
Water transport	436,000
Grasslands	638,000

Mmopelwa, (2006) carried out a study in Okavango Delta to estimate the total value of tourism. Two methods were used in this study, the Travel Cost method which was used to estimate the direct use value and CVM which were used to estimate the non use value, by estimating the willingness to pay by the tourists for the conservation of Okavango Delta wetland. The consumptive value estimated from this study was US$816,659.9 per annum and a total direct non-use value was estimated at US$14M per annum. The total non-use value, solicited through WTP for the conservation of the Okavango delta was estimated at US$9419.63 which is lower than the value of direct use.

Conclusion

Although the literature emphasises on the importance of valuation of ecosystem services but the fields has been facing criticism on both the products and services being valued and the methodologies used, with some people labeled the process of valuation of ecosystem goods and services as a guessing game (Carson *et al*., 2001). The field shows the variations in the methods used in valuation of ecosystem services. Even though the valuation of ecosystem services started longtime ago still up to date there is no standardised methods to compare (Carson *et al*., 2001) however some argued that its better agree on the imperfect value other than theoretical arguing over the actual value of environmental goods and services (Hermans *et al*.,2006). From the existing empirical studies, it is shown that Market price method is the most widespread method used for valuing marketed ecosystem services, (Korsgaard, 2010) and it has also been seen that where ecosystem services are non marketed then the travel cost was often applied (Shuyt, 2005). It is observed that most of the dominant values in valuation studies are the use value and the reason is that the use values are relatively straight forward when it comes to valuation (Shuyt, 2002). On the other hand, non-use values can be estimated through shadow pricing techniques, like the Contingent Valuation method and these, often require a relatively long time and involve high costs (Shuyt, 2005). The results obtained by Mmopelwa, (2006), showed that the value estimated by Market price method yield more value than CVM (i.e. people's willingness to pay is less than the value of actual goods and services derived from the wetland).

CHAPTER THREE: RESEARCH METHODS

3.0 Introduction

This chapter is organised in Four Sections. Section 3.1 gives a description of the study area in relation to its location, climate, natural resources and socio-economic characteristics of the area. Section 3.2 outlines the methodological approaches that were used in the research to achieve the objectives of this study and finally Sections 3.3 provides the sampling methods for data collection and the approaches to analysis of data is provided in Section 3.4.

3.1 Description of the Study Area

The study area is located in Machinga district. It covers the two agricultural Extension-Planning Areas (EPA) of Chikweo and Nampeya, which are found in two traditional authorities (TA): Ngokwe and Chikweo.

3.1.1 Location and Characteristics

Lake Chiuta (14°42'-14°53'S/35°47'-35°55'E) wetland is situated on the border between Malawi and Mozambique. The wetland ecosystem comprises a permanent lake, which has an area of 2,500 to 13, 000ha (according to season and rainfall), permanent swamps & marshes and sedge marshes**:** These occur where inundation is neither very deep nor permanent, in sites where the surface dries for a short period each year (EAD, 2010). The wetland is located at an altitude of 620m in the southern part of Malawi and the open waters have a maximum depth of 4m (FAO, 1994). The wetland covers a total area of 31,000ha, thus the open water plus the surrounding marshes.

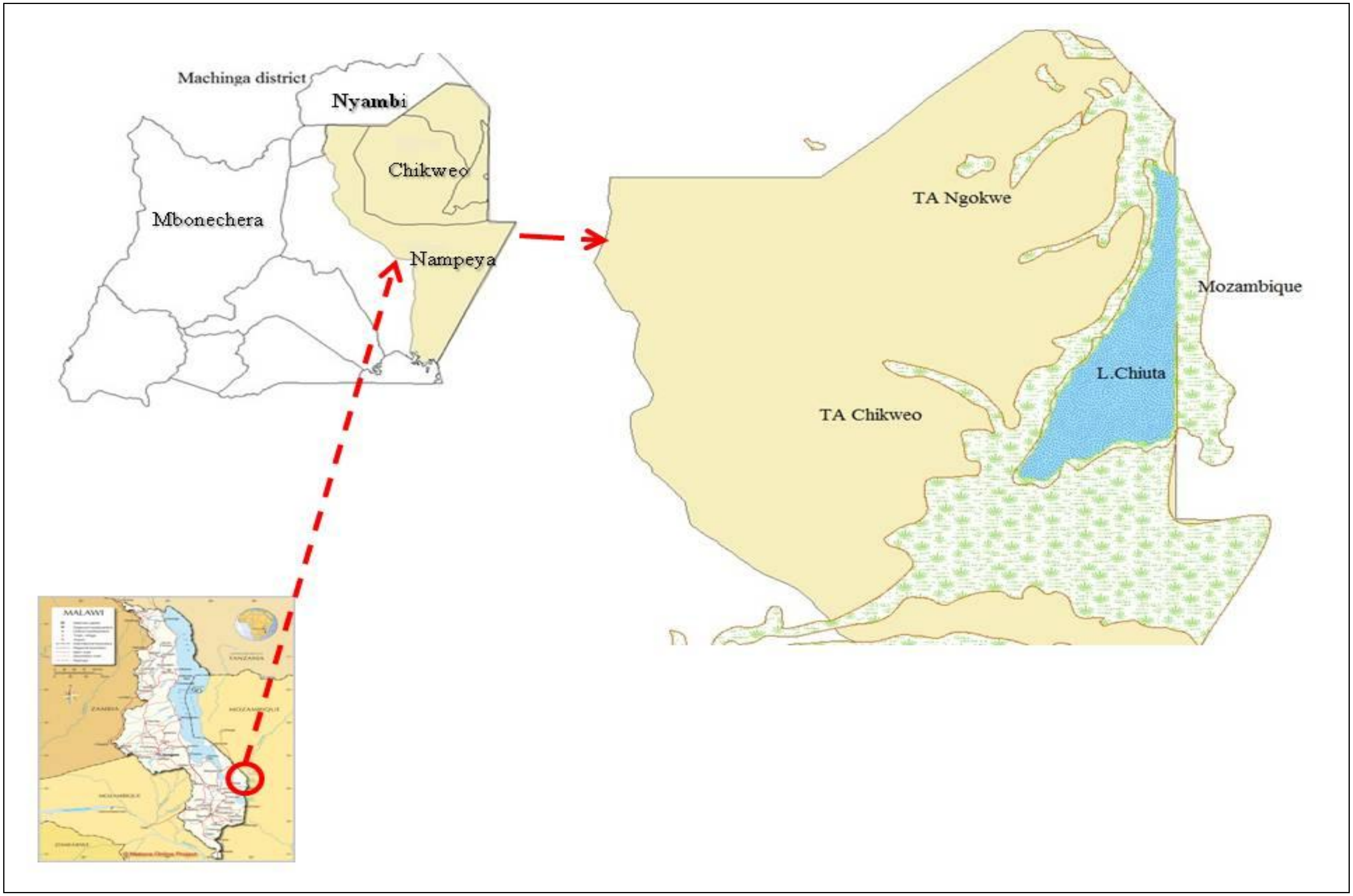
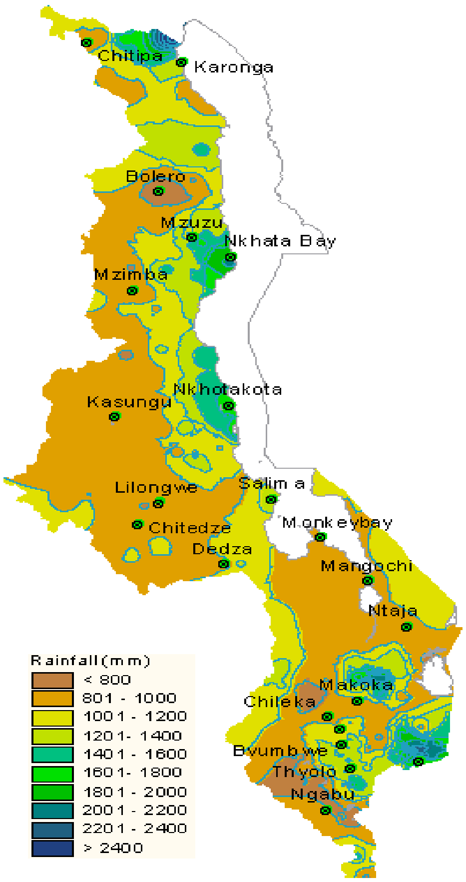


Figure 3: Malawi, showing the Study area.



3.1.2 Climate (Rainfall and Temperature)

Machinga District experiences an average mean annual temperature of about 23.2°C and the low-lying areas of Lake Chiuta wetland experience hot to very hot temperatures throughout the year. The mean minimum temperature in June is 13.5 °C and the mean maximum temperature in November is 31.6 °C. The Lake Chiuta wetland receives mean annual rainfall of below 800mm (Met. Department, 2010) and the wetland is drained by the Mpiri, Lifune, Mikoko and Sankhwi rivers.

Figure 4: Malawi's rainfall distribution
Source: Metrological Dept., (2011).

3.1.3 Land use/land cover Pattern

Generally, there are five categories of land use patterns observed in the Chiuta area (MADD, 2001), including the water body with hills in the lake, swamps & marshes, shrubs, agricultural land, grassland, grazing land and settlement. The greater part of the wetland is being used for agricultural purposes, fishing and grazing. The dominant soils in the wetland are alluvial sandy clay soils which is fertile for crop production (MADD, 2001).

3.1.4 Vegetation

Lake Chiuta wetland contains a diversity of flora (EAD, 2010). The phytoplankton comprises species of Chlorophyceae, Conjugatophyceae, Cyanophyta and Chrysophyta. In the open lake the only emergent macrophytes are found around Chiuta Island, but the substratum is covered by a dense mat of *Utricularia* spp. The permanent swamps are dominated by *Phragmites mauritianus* and *Typha domingensis*, or by *Cyperus papyrus* in permanent water with seasonally fluctuating levels. The southern area of the wetland supports a diverse community of emergent vegetation. The wetland has wet grassland while open canopy woodlands and shrubs are mostly located on the Kawinga plains (EAD, 2010).

3.1.5 Wildlife Resources

Lake Chiuta wetland, like other wetlands is an important habitat for migratory as well as local water birds. A 2004 survey (MWD, 2004) recorded 207 species of birds of which 112 species are migratory. Twelve mammals and 19 reptiles were also recorded. The most abundant mammals are the hippopotamus and baboon. Among the reptiles found in Lake Chiuta wetland are snakes and crocodiles.

3.1.6 Socio- economic Characteristics

The population of the surrounding villages comes predominantly from the Yao tribe, the politically dominant ethnic group in the area (MDC, 2007-12). The area has an estimated population of 128,456, from 174 surrounding villages, which makes up about 26 % of the District's population, with an estimated population growth rate of about 4.1 % and a fertility rate of 6.0 children per woman (NSO, 2008). Total number of households that earn their livelihood in the wetland is 10,084 (60,504 people) (MADD, 2013).

Machinga is one of the districts that offers limited employment opportunities so that development of the District rests on natural resources, e.g. land, water, fish and wild life (MDC, 2007-12). The area consists of poor, low-income households most of which have no formal income at all. Most people, particularly in the rural areas are in the informal sectors (NFRA, 2010). It is estimated that 90 % of the population earn their living through farming, fishing, carpentry, bricklaying, water transportation and small business (NFRA, 2010).

Portable water is one of the challenges faced by the community in the wetland. The households depend on boreholes, shallow wells and in the dry season they draw water directly from the wetland for their multiple uses.

3.1.7 Fisheries

An annual fish production from the Lake between 1953 and 1960 has been estimated at 200 tonnes (Fisheries Department, 1971) However, from 1976 to 1996, fish catches from Lake Chiuta averaged around 2000 tonnes per year (Njaya *et al.*, 1998) while the current fish catch is 5,040 tonnes per year (DOF, 2010). Thirteen species were recorded and the dominant fish species include *Oreochromis* *shiranus*, *Tillapia rendalli*, *Clarias gariepinus* and *Barbus paludinosus* (DOF, 2012). There are 3,800 registered fishermen in the wetland (DOF 2012). The lake part of the wetland has more than 31 beaches, out of which the 11 beach village committees (BVC) that were formed fall under the umbrella of the Chiuta Fisheries Association (DOF, 2012).

3.1.8 Agriculture

The local population depends on the wetlands of Lake Chiuta for rice production and cattle grazing. Apart from, rice and livestock, Chiuta communities also produce maize, peas and sorghum (Thomson, 2006). To promote rice farming in the area, the Ministry of Agriculture established a commercial rice irrigation scheme. In his report , Thomson, (2006) highlighted that the sustainability of agricultural production depends on the availability of water in the flood plain. He indicated that during dry spells the yields are low.

3.1.9 Water Transport

The lake borders with Mozambique and there are four harbours where water transport takes place, i.e. Njerwa, Mpakaka, Nafisi and Mbagalira harbours. Some households use boats and canoes for transport to either side of the lake. On average, a boat can carry 30 people per trip. The average income per household engaged in water transport is K3000 ($9) per day.

Figure 5: Water transport services on Lake Chiuta wetland - Njerwa harbour.

3.2 Methods for Valuation of Wetland Goods and Services

A range of valuation techniques exists for assessing the economic value of goods and services provided by wetlands (Pushpam, 2001). In this study, direct market valuation and contingent valuation techniques were chosen from the different environmental valuation methodologies discussed in the literature. The Market Value Method (MVM) was used to estimate use values and Contingent Valuation Method (CVM) was used to estimate the non-use values (see Ramachandra, 2004).

The Market value method was chosen because the market prices exist for most goods and services provided by wetlands (or close substitutes) and the use of direct market value is able to give a realistic value estimate. It also makes the outcome comparable to other sources of income for the local population (Schuijt, 2002). In addition, to capture the non-use value and to complement the market value method, a contingent valuation method was used since the market price based method captures the use value only.

3.2.1 Market Value Methods

Among the approaches described under the market value methods, the observed market and related goods approach was used in this study and Market price method was chosen under this approach.

3.2.2 Market Price Method

The values of ecosystem goods and services were assessed through the market prices. The actual prices of traded goods/ services were used to value the goods and services identified in the wetland. For the goods which were not traded on market, their values were inferred to the market prices of similar goods sold on the market (indirect substitute cost) (Adekola, 2006). These prices were used to calculated gross financial value, net financial value and cash income (ibid). Assumption made was that the market was efficient that is the market price was the equilibrium between demand and supply and this point is where the consumers' WTP is equal to the costs of production (Bishop, 1999).

3.2.3 Contingent Valuation Method

In this study, the CVM was used to quantify the non-use value through soliciting the willingness to pay for conservation of biodiversity. The households were asked to state the amount they would be willing to pay for conservation of biodiversity in the Lake Chiuta wetland (Brander *et al*., 2006).

3.3 Data collection: Sample Size and Sampling techniques

3.3.1 Sampling and Data Collection

Qualitative and quantitative research methods were applied to primary data collection in this study through focus group discussions (FGD), a structured & unstructured household questionnaire and key informant interviews (see Watson, 2007). In addition, field observations & measurements, market pricing and the Pebble Distribution Methods were used to complement and supplement data, following Lynam, (2007). In order to offset some expected limitations, some values provided by households were cross-checked with the government extension officers.

3.3.2 Determination of the Sample Population

Identification and determination of the population of the study area is an important prerequisite for research sample design (Farolfi, 2011). The target population of this study is defined as the households that stay around and use Lake Chiuta wetland.

3.3.3 Sample Selection Methods

Bartlett, (2001) provides techniques for selecting representative sample from the population. These techniques include simple random sampling, systematic sampling, stratified sampling, clustered sampling and multistage sampling. However, the selection of the sampling method depends on the objective of the study, the information available before the survey and the size of the population in the studied area (Farolfi, 2011).

In this study a clustered sampling and simple random sampling methods were used to generate data. The clustered sampling method was chosen to avoid biasness when selecting households for interviews (see Bartlett, 2001). In addition, the random sampling was applied to avoid systematically excluding certain types of respondents, so that each household should have an equal chance of being surveyed (Bartlett, 2001). The households were grouped according to the Traditional Authority (TA) of the area, then within each TA's area simple random sampling was applied to select households from villages surrounding the wetland.

3.3.4 Sample Size

To determine the required sample a confidence interval of 95%, was used, with a standard error of 6% and sample fractions of 60%. The required sample (of 256 households) was calculated using the following formula:

$$n = \frac{\mathbf{Z^2} \prod(\mathbf{1} - \prod)}{[\mathbf{S.E.}(\boldsymbol{p})]}\mathbf{2}$$ (Adapted from Cochran, 1979)

S.E (p) is the standard error of a proportion

n is the sample size

Π is the proportion of the population size

Z is the coefficient corresponding to the chosen confidence interval (1.96 for c.i. = 95%)

3.3.5 Data Collection Methods

For the primary data collection, a questionnaire was design (Appendix 1), to be used by five enumerators. The questionnaires were designed to collect quantitative data on income as well as qualitative data on socio-economic characteristics, general information about access and use of the wetland, wetland products, detailed information about each provisioning service (quantity of goods & service harvested, costs and prices), community perspectives of wetland use and conservation, etc. Both quantitative and qualitative methods were used to ensure a through and meaningful analysis of the data and information.

Three focus group discussions were conducted, two from TA Ngokwe and one from TA Chikweo. The FGDs were aimed to collect quantitative economic data and qualitative data about wetland products extracted their prices, marketing chain as well as the seasonal variability of different products. The discussions was also aimed at obtaining background information, identifying main uses and users of wetland resources, institutions & organisations involved, common property, access, regulation and constraints, among others. A pilot survey was conducted in order to test the appropriateness of the questionnaires and whether it achieved its objectives. Respondents were asked to answer questions as best they could, as well as commenting on the content and time taken to complete them. The questionnaires were revised when the questions found to be vague.

Fifteen key informant interviews were conducted with key informants from the main government ministries involved: Ministry of Agriculture (Department of Agriculture Extension Service and Department of Fisheries), Ministry of Environment Affairs; Traditional leaders (two senior Group Village Headmen), influential people in the area; Chiuta Fisheries Association and Beach village Club leaders.

Secondary data was taken from the last national demographic census (NSO, 2008), research papers, maps, satellite images and reports from relevant government ministries. To estimate the current extent of the wetland and its predicted future extent and also to estimate the changes in land use and cover over the past 20 years, satellite images from Landsat TM 4-5 sensor were downloaded from the United States Geological Survey (USGS) website[ii]. A spatial resolution of 30m by 30m – for its bands 3, 4, 5, since it shows details enough to give clear resolution of land use and land cover and bands 3, 4, and 5 gives natural composite colour which helps to distinguish different features.

3.4 Data Analysis

3.4.1 Descriptive Statistics

The data collected from the survey were first entered into a Microsoft Excel spreadsheet (Ms Excel, 2007) and then the basic descriptive statistical analysis was performed on average income, levels of education, household sizes, economic activities, quantity of goods harvested annually etc., using SPSS (SPSS, 2007).

3.4.2 Economic values of wetland Ecosystem goods and services

Three indicators were used to express the monetary value of goods and services of each wetland provisioning service: the Gross Financial Value (GFV), the Net Financial Value (NFV) and Cash Income (CI), after Adekola, (2006). Values were expressed by respondents in Malawian Kwacha, and were then converted into US Dollars (US$) based on an average exchange rate of July 2013 of Mk358 = $1. These values were computed as follows (adapted from Adekola, 2006):

GFV = TQH × P ……………………………………………………………………………(1)

Where

TQH - is the total annual quantity harvested (or produced) and P is the average price per unit of product at which a resource/commodity was sold at the market.

TQH was computed from the average annual quantity collected per household multiplied by the percentage of households participating in the activity (PPH) and by the total number of households in the population

TQH was calculated as follows:

TQH = $\frac{\sum_{i=1}^{m} HCi}{n}$ × PPH…………………………………………………………………..(2)

Where *HCi* is the quantity of product collected by household *i*.

Where PHH = $\frac{m}{n}$ x N……………………………………………………………………(3)

PHH = percentage of households participating in the activity

m = number of households in the sample participating in the activity

n = total number of sampled households (256)

N = total number of households in the population (N=10,084)

NFV = GFV – CST…………………………………………………………………………(4)

Where **CST** = total costs of collection / production. Costs were estimated based on all monetary inputs going into the harvesting and use of each good/service of the wetland.

CI = QSD × **P** ……………………………………………………………………………… (5)

Where QSD is the total quantity of product sold. This was estimated using the same method as for TQH.

The total economic value of the direct benefits of a wetland was calculated by summing up the individual goods and services, calculated from equation 1 above.

3.4.3 Estimating non-use value using Willingness to Pay

The WTP method is most suited to valuing those benefits that do not have a market value, in particular for intrinsic worth benefits such as biodiversity, cultural heritage etc. (Phouphet, 2011).

Twtp = Mean WTP* Population

Twtp: Total of WTP in the community/population

Mean WTP: mean of sample WTP in the community

Population: No. of people in community

3.4.4 Land use/ land cover Changes

Land use map classification for the study area at different times (1992, 1996, 2000, 2006, 2008 and 2011) was done within the ENVI software (ENVI 4.2, 2005). Analyses, in the form of area extent of the wetland, were derived from the Attribute Table section of the Arc-GIS software, (Arc-GIS 9.3, 2008) to estimate the changes in land uses and cover over this period as result of agricultural activities, settlement and other activities.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the major findings and a discussion of the results that were obtained from the research. The results linked to the third objective are presented in Section 4.1 of this chapter and the findings linked to the first objective are presented in Section 4.2. In Section 4.3, the findings from the second objective, which sought to quantify the wetland resources (goods and services), are presented using tables and graphical presentations. The detailed analyses are attached in the Appendices. Land use/cover changes that occurred in the wetland as well as Lake Chiuta wetland resources in terms of access, regulations and constraints are also discussed in this chapter.

4.1 Socio - economic dependence on the wetland

As discussed in the literature, wetlands are important sources of natural resources upon which many rural economies and entire societies depend (RCS, 2006). The descriptive results show the level of dependence on Lake Chiuta wetland of the people living in the surrounding areas. The socio economic dependence was estimated in terms of the percentage of overall household incomes accrued from wetland as a result of use of wetland resources.

4.1.1 Household Characteristics

Households living in the areas surrounding Lake Chiuta wetland are relatively large. The households have a mean family size of six people (+/-2), often consisting of extended families with 5 to 7 children. The literacy level in the area is low. Of the households interviewed, 68% had completed primary school, 28% had not attended any formal education at all while 3% had completed secondary school and 1% attended tertiary education. The householders around Lake Chiuta wetland live in traditional houses, 85 % of the houses had thatched roofs while 15% of the houses had iron sheets for roofs.

4.1.2 Main occupation of households Surveyed

The main occupation of households living around Lake Chiuta wetland is agriculture in terms of both food and income. This closely followed by fishing which is main income earner for these households. Only 8% of the households surveyed are engaged in other income generating activities and these included manual labourer, small business and formal employment. Two percent of the households are engaged in both farming and fishing. Apart from fishing and agriculture, the households also keep livestock and poultry for food and income. Forty five percent of the surveyed households indicated that they keep poultry, 12% of the households keep goats, and 7% keep cattle. The figures 6 and 7 below illustrate the main occupation and the percentage of livestock kept by households living around Lake Chiuta wetland.

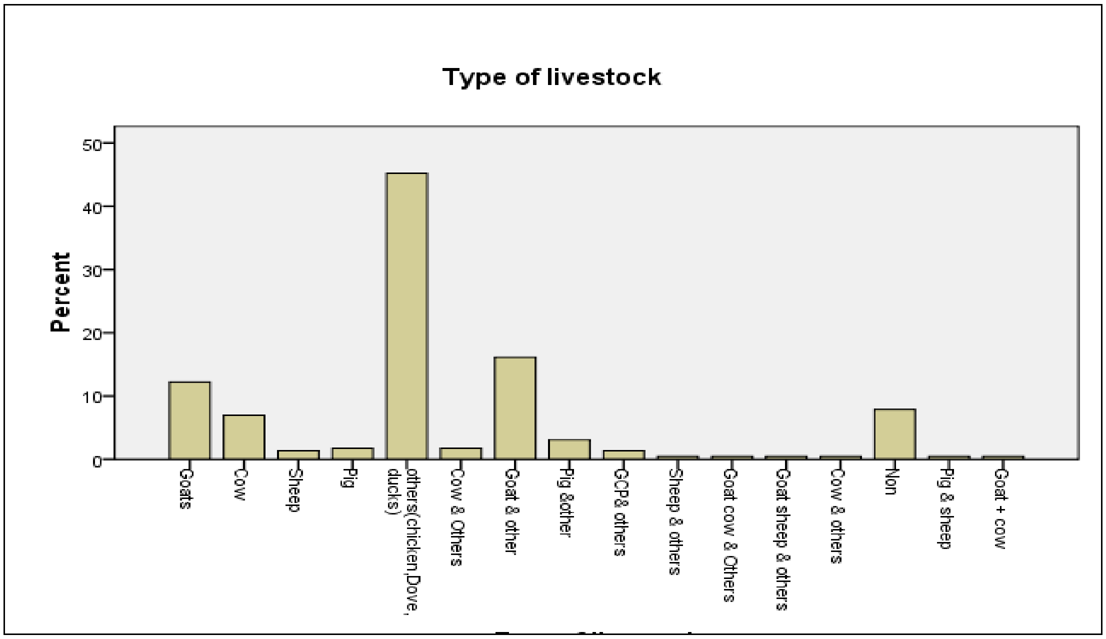


Figure 6: Percent of Livestock owned by Surveyed Household in Lake Chiuta wetland.

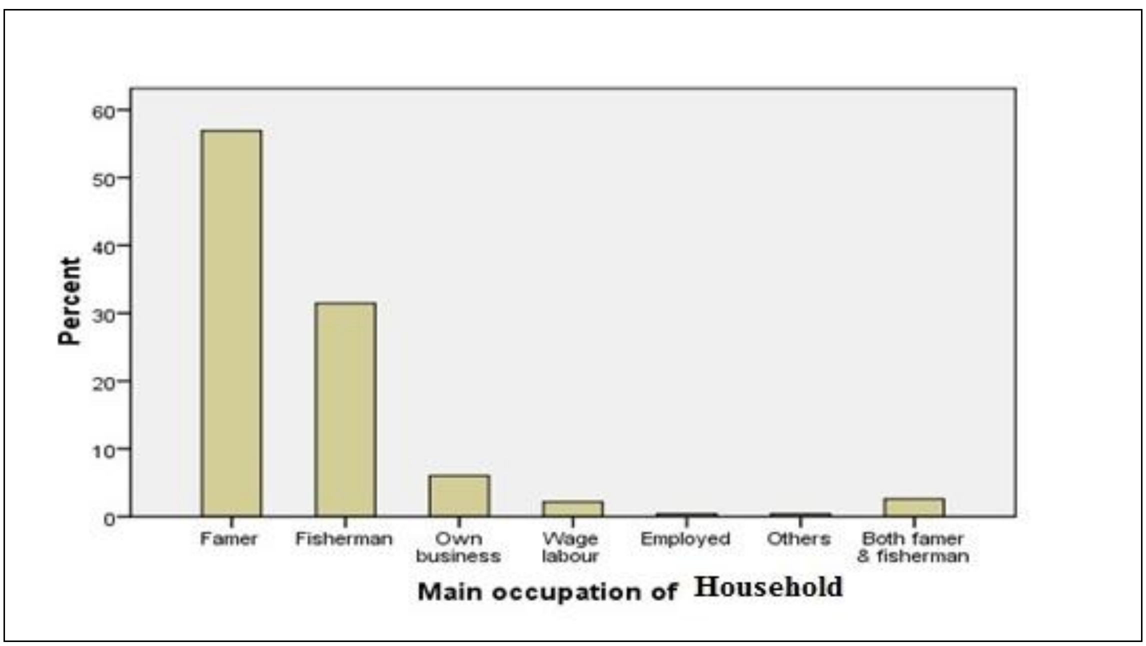


Figure 7: Main occupation of Household in the wetland.

4.1.3 Annual income of Households Surveyed

The majority of households obtain their income from crops grown in the wetland which reflect the dependency of the household on Lake Chiuta for crop production. The next important source of income is fishing. However, another source of income for the Chiuta community is from selling the products harvested from wetland e.g. grass, birds, crabs and firewood as well as services from water transport. The average annual household income around Lake Chiuta wetland was US$213 (+/- US$ 154) with 35% of the surveyed household earning less than Mk50,000.00 (US$140). The wetland contributes an estimated annual cash income of US$10.9M to the communities living around the wetland.

Table 6: Income level of the household in Lake Chiuta wetland

	N	Minimum	Maximum	Mean	Std. Deviation
Income level of HH	253	50.00	3.00E5	7.6367E4	55278.03299
Valid N (listwise)	253				

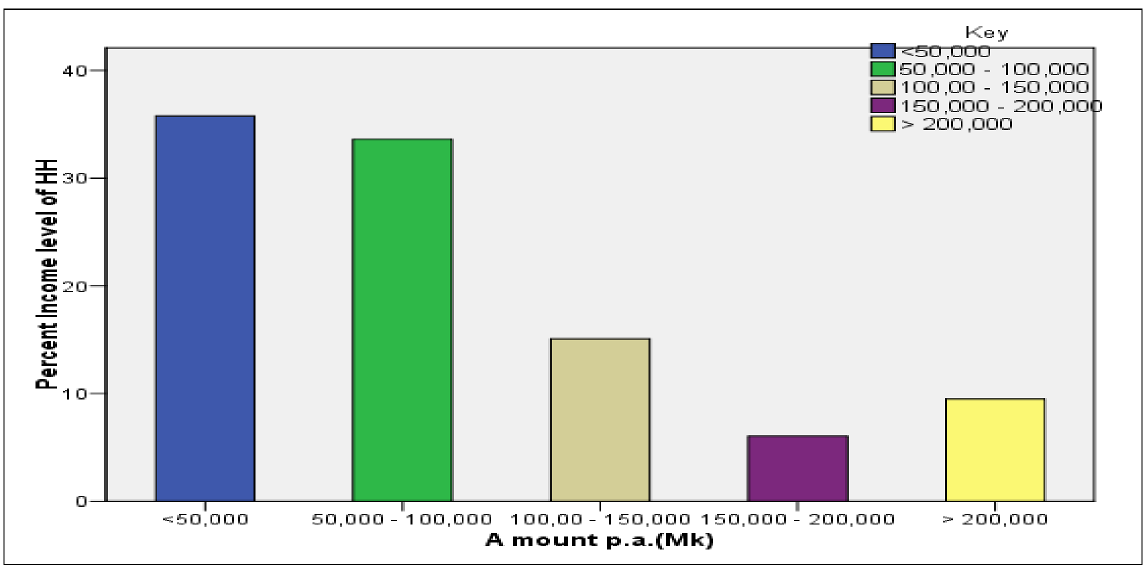


Figure 8: Income levels of Households Surveyed.

The majority of the households living around Lake Chiuta depends on the wetlands resources for their survival. Higher average income was earned by households through agriculture and fishing (31%, 64% respectively) which are the most important activities for livelihoods of households living around the wetland. Despite the district having the limited job opportunities, the majority of the households have low literacy levels which limit them to look for formal jobs, hence they rely on the wetland for their living.

4.2 Ecosystem goods and services provided by Lake Chiuta wetland

Wetland ecosystem goods and services from Lake Chiuta were assessed for four services based upon the collected data during field surveys. The goods and services that are provided by Lake Chiuta wetland, which were considered in the quantitative estimation for values for the wetland, are summarised in Table 7 below.

Table 7: Ecosystem goods and services provided by Lake Chiuta wetland

Ecosystem goods and Services	**goods/services**
Provisioning services	• Food e.g. fish, birds, fruits, mice, crabs, • Raw material e.g. grass, string/ropes , poles, firewood • Water • Forage/pastures • Crop production, • Fish nursery, • Livestock grazing • Clay for moulding bricks • Surface to allow water transport
Regulating services	• Water regulation e.g. water table recharge and discharge • flood control
Supporting services	• Nutrient cycle, • Crop pollination, • Photosynthesis
Cultural services	• Education e.g. research • Spiritual e.g. Baptism • Aesthetic e.g. Habitat for biodiversity

4.2.1 Provisioning services

The provisioning services of Lake Chiuta wetland are one of the most important services, which the wetland performs. The communities of the surrounding villages depend on various goods and services from the wetland. There is a variety of goods (listed in Table 7) that are obtained from the wetland.

Fish and crop production are the main goods which contribute to the livelihoods of the Chiuta population. The main crop types which are grown in the wetland are rice and maize for both home consumption and income. Other crops include groundnuts, sorghum, beans, pigeon peas, sweet potatoes and cassava, which are grown on a small scale. The wetland is also important for keeping livestock.

Fish forms the main sources of income for Chiuta communities and the dominant fish species found in the wetland include *Oreochromis shiranus*, *Tillapia rendalli*, *Clarias gariepinus* and *Barbus paludinosus* (DOF 2012). The marshes of the wetland provide the breeding habitat for fish.

Table 8: Production levels for major crops in Lake Chiuta wetland (metric tonnes) Source: MADD, (2013)

Season	Maize	Rice	G/nuts	Sorghum	Pigeon peas	Cassava	Sweet potato	beans
2012-2013	2071	4018	825	7126	2045	8667	16399	4
2011-2012	1921	3087	1208	1684	2875	13017	89103	1
2010-2011	2384	3760	1440	1054	1506	16300	9681	1.16
2009-2010	2102	3407	1191	1528	2773	12764	14333	0
2008-2009	1304	2797	723	974	1312	5299	4406	1
2007-2008	1408	2066	658	918	1102	5382	3964	1
2006-2007	242	2624	750	824	1375	5262	4619	3
2005-2006	2136	2389	777	922	1351	3283	4447	4
2004-2005	1294	623	371	432	690	3203	6412	3
2003-2004	1127	1387	561	1417	991	3957	5663	28
2002-2003	1070	3423	751	1505	794	2901	6519	25

Table 9: Annual fish production in Lake Chiuta wetland Source: DOF, (2012)

YEAR	QUANTITY (ton)
2011 - 2012	5,040
2010 - 2011	6,552
2009 - 2010	8,518
2008 - 2009	7,595
2007 - 2008	6,179
2006 - 2007	6,894
2005- 2006	5,385

The community also obtains building materials such as grass, ropes and poles for their housing, 85% of the community have grass-thatched houses. Grass in large quantities is among non-food goods that are harvested from the wetland. Most of the grass is used for roofing (e.g. *Hyparrhenia filipendula*) and for making mats (e.g. papyrus reeds). Other raw materials like ropes/strings, poles or planks and firewood are harvested in smaller quantities because of deforestation.

The wetland also provides grazing for livestock. The wetland is mostly used for livestock grazing during the dry season in designated places. During the rainy season, the communities collect fodder from the wetland for their livestock, or they take their livestock to the dry areas. Normally they do not use the wetland for grazing during the rainy season because of diseases, mud and also to avoid crop damage by the animals. Cattle, goats and sheep are among the livestock that are found in surrounding villages of the wetland.

Table 10: Animal production on Lake Chiuta wetland Source: MADD, (2013)

YEAR	CATTLE	GOATS	SHEEP	PIGS
2007 - 2008	6135	60490	9288	2864
2008 - 2009	6340	59522	9345	3946
2009 - 2010	6675	62944	9972	3749
2010 - 2011	7135	68333	9910	3847
2011-2012	7817	60043	10333	3069
2011 - 2013	10571	67431	16280	3852

The wetland provides water for both domestic use and irrigated agriculture as well for livestock. The community of Lake Chiuta wetland depends on shallow wells and boreholes for the water supply; in dry months, (i.e. October and November) they obtain water directly from the lake. The lake is also used for water transport between Malawi and Mozambique.

4.2.2 Regulating services

The only benefit that was easily identified in the wetland under this service is the water regulation service - water table recharge and discharge, which is the source of water supply from the swallow wells and boreholes for the Chiuta communities. The wetland also provides water for winter farming.
Lake Chiuta wetland regulates the flood-water drained by inflow streams that flow into the wetlands. This reduces the risk of floods in the surrounding villages and crop fields. However, there are more

benefits from this service (e.g. waste treatment, climate and rainfall regulation, reduction in the spread of diseases etc.) which are beyond the scope of this research as this study focused on direct use benefits accruing to the Lake Chiuta households from ecosystem goods and services.

4.2.3 Supporting services

Among the benefits that are accrued from the wetland are the nutrient cycling, soil formation and crop pollination, which is important for crop, fish and livestock production. Photosynthesis is another indirect service that the wetland provides as primary production for biodiversity in the wetland ecosystems.

5.2.4 Cultural services

Along with providing other services, wetlands have great cultural significance to local people in the vicinity. (De Groot *et al.*, 2002). These non-material benefits contribute to human well-being via the direct economic benefits of their exploitation (e.g. tourism), and their psychosocial value (e.g. spiritual) (MEA, 2005).The benefits that are provided by this service in Lake Chiuta wetland are the educational value for scientific research. Currently most of the research conducted in the wetland is in the fisheries field. Apart from educational services, the other service is spiritual, where the Christians use the wetland for baptism. The wetland also supports a wide range of the biodiversity which is potential for eco-tourism.

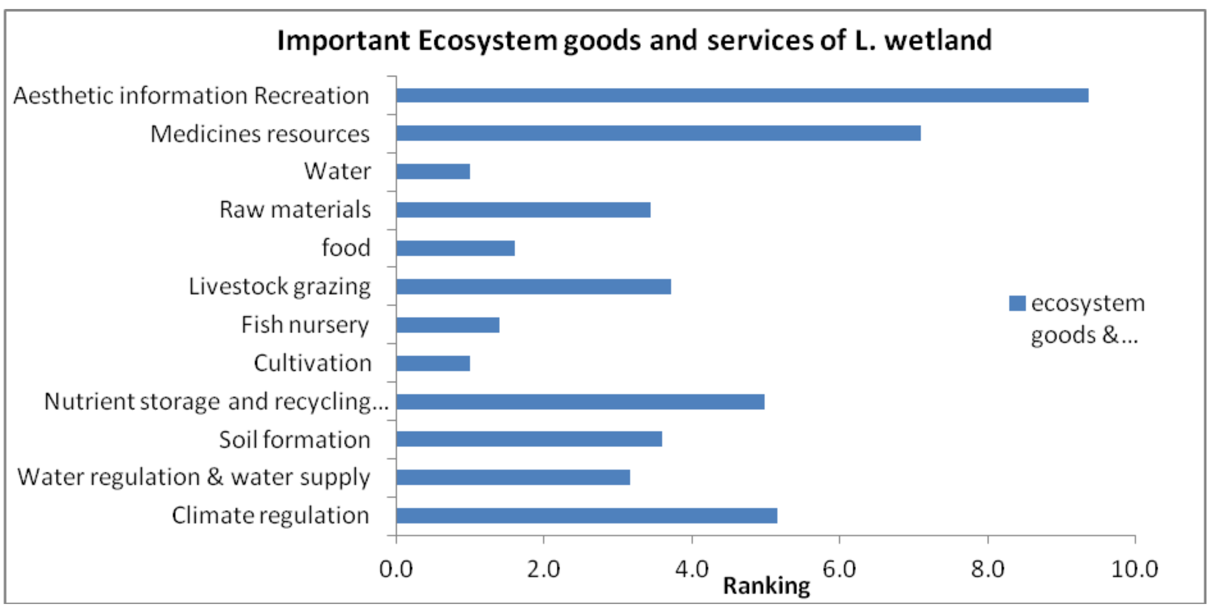


Figure 9: Ranking of Ecosystem Services in order of their benefit to Chiuta Community.

Ranking; 1 = most important service; 10 = least important

The households were asked to rank the most valuable wetland services on a scale of 1 to 10. From Figure 9 above, water, food, and farming are the most important goods and services that the households benefit for their livelihoods according to Lake Chiuta community as these services ranked the lowest.

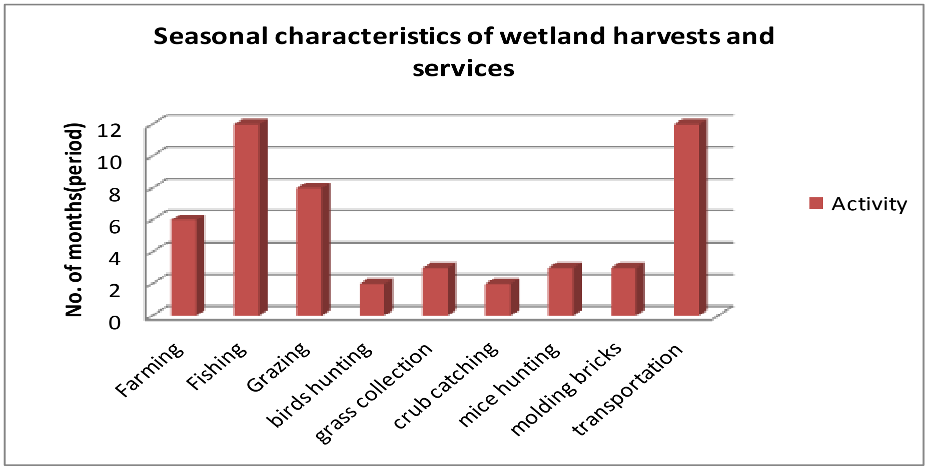


Figure 10: Seasonal characteristics of wetland harvests and use.

Fish and water transport are the only activities that takes place through the year in the wetland, others are seasonal, i.e. birds hunting and crab harvesting are done during rainy seasonal between December and February.

4.3 Economic value of ecosystem services (goods and services) of Lake Chiuta wetland

Economic valuation is but one of the many ways to define and measure values of wetland ecosystem services. Other types of Values (religious, social, cultural, global, intrinsic etc.) are also important but the economic value is the most important in most countries when decision makers have to make difficult choices about allocation of scarce government resources (Lambert, 2003). The following sub section will discuss the economic values provided by the wetland in terms of direct and indirect use of wetland ecosystem goods and services.

4.3.1 Quantity of goods and services harvested/produced from Lake Chiuta wetland

The households of Lake Chiuta wetland depend on the wetland for their livelihood. Annually large quantities of goods are being harvested and produced from wetland. The wetland is the back-borne for the Chiuta communities in terms of food security and income. Table 11 below details the quantities of harvests and produce obtained from wetland.

Table 11: Annual quantity of goods harvested/produced from Lake Chiuta wetland

WETLAND GOODS/SERVICE	UNIT OF MEASURE	ANNUAL HARVESTS/PRODUCE	QUANTITY SOLD
Ropes	bundle	55,773	34,858
Poles	No.	66,895	56,603
Crabs	kg	20,541	19,172
Bricks	ton	9,960	9,960
Mice	kg	1,328	830
Birds	No.	138,850	104,138
Papyrus	bundle	206,909	206,908
Grass harvest	bundle	3,231,860	1,040,768
Firewood	bundle	102,251	40,170
Crop production	kg	18,340,140	8,996,297
Fishing	ton	5,040	4,284
Water transport	trips	420	[iii]
Pasture	kg	32,333,026	[iv]
Water supply	m^3	50,436	[iv]

Pasture

The scarcity of high-quality grazing is one of the greatest limiting factors affecting livestock production in Africa (Lannas, 2009; Meltzer 1995). Wetlands are preferentially grazed by both small and large stock (Grab and Morris 1997), and grazing is a common use of wetlands in the region (Palmer *et al*., 2002, Bisaro 2007). Lake Chiuta wetland is important for livestock grazing particularly during the dry season.

The quantity of pasture was estimated from the total number of livestock grazing in the wetland based on their dairy requirements for the period of seven months (dry season), as it was reported that during rainy season the animals graze upland to prevent them from diseases and also to avoid the animals stuck in the mud. The data for livestock used in the determination of quantity of pasture is a 2013 Agriculture Production Estimates Survey (APES).

Crop production

Farming is one of the main occupations for Chiuta households, 57% of the households are farmers and the main two important crops are Maize and rice. Almost 90% of the rice is sold for household's income. Rice is grown without fertilizer while maize fields; fertilizer is applied, since the maize is grown in high grounds areas within the wetland.

Poles

Apart from using poles for building purposes, households also harvest poles for sale to the fishermen and those engaged in brick moulding. Poles are collected from the wetland's islands. In 1998, many trees were cut from Nafisi hill and large Chiuta Island by the fishermen who came from Lake Chilwa, which lead to deforestation of wetland forests.

Birds hunting

According to the respondents, the annual birds caught between December and March is 138,850. Seventy five percent of the catch is sold to the lodges at Liwonde town. The common birds caught are fulvous whistling duck, black headed heron, grey head gull and white winged black tern. The hunters' use guns for hunting. It was reviewed during discussions that the birds' population is decreasing in the wetland. Unlike Lake Chilwa, in Lake Chiuta wetland there is no hunters' organisation to control unsustainability of birds hunting. Most hunters are not the residence of the area.

Figure 11: A hunter carrying birds from Lake Chiuta wetland.

Water

The wetland is an important source of water supply for domestic use, watering domestic animals and building purpose for local communities living adjacent. Annually, a total of 50,436m^3 is being drawn from the wetland (Table 11) of which 7.2% is used for watering livestock. The monthly mean water usage per household is 2.4m^3. The watering sources are in form of borehole, shallow wells and the lake. Most households obtain water from shallow wells and few obtain water from the borehole. However, during the driest months of October and November, the households obtain water directly from the wetland. Two formal irrigation schemes are present in the area, which draws water from the inflow streams of the wetland for such reason water use for irrigation, were not quantified in this study. It was difficult to determine the quantity of water used by the informal irrigation schemes; since the farmers use watering canes and some practice recession farming.

The open water[v] of the wetland (lake) is used for water transport for the people of Malawi and Mozambique. There are three harbours in Lake Chiuta and the main harbour is at Njerwa. Although there is no immigration offices, but people from these two countries frequently cross through these harbours. Eighteen boats are used in water transport service, which are owned by local residents. The quantification of water transport services was based on the number of trips per week and on average ten trips are made per week for all three harbours in dry season while in rainy season, only five trips per week are made because of weather. On average, 420 trips per year are made (see Appendix 2: Table g).

Grass collection

As in many other wetlands in Africa, Chiuta communities collect grass (*Hyparrhenia filipendula*) for roofing their houses. Most respondents expressed concern on the availability of grass in the wetland due to a tendency of bushfire set by the mice hunters. This situation has given rise to the grass selling business, since grass is burnt before all the households collect. Approximately, 85% of buildings in Lake Chiuta wetland are roofed with grass collected from wetland. Annual grass harvest is estimated at 3,231,860 bundles (see Table 10). Of this 72% is used directly by households for roofing their own houses.

Papyrus collection

Papyrus is an important wetland resource in Lake Chiuta. Papyrus is used for making mats and an annual estimated of 206,909 bundles of papyrus are harvested from the wetland. One hundred percent of the quantity harvested is used for making mats, which are then sold at the market. Four bundles are used to make one mat. A household makes two mats per week and one mat is sold at K1, 000 ($3)

Firewood

Fuel wood remains the main source of energy for domestic cooking, heating and lighting in the wetland. Firewood collection in the wetland is done in the shrub areas and Nafisi hill. Fuel wood collection is done only in the dry season. Firewood is collected in bundles, and estimates of 102,251 bundles are harvested annually. Because of deforestation, the fuel wood collection is limited to shrubs and is a growing business in the wetland. The standard price for firewood, reviewed during fieldwork was K1200 ($3.4) per bundle.

Fishing

Fish are the most important vertebrates associated with wetlands. Worldwide, over 1,800 species of fish are resident for all or part of their life cycles in wetlands (Akwetaireho, 2009). Lake Chiuta wetland acts as a breeding and nursery ground for fish species where by later in adult stages are trapped by fishermen. Lake Chiuta wetland is one of the productive lakes in Malawi (DOF, 2011) and fishing is probably the main source of income for Lake Chiuta wetland residents. Estimates reveal that a total annual harvest of 5040 tons is harvested (DOF, 2012) and 85% of the catch is sold. Fish is sold direct to the fish mongers at the landing site and fish is sold per kg irrespective of the catch composition.

Figure 12: Fisherman fishing and fishmongers preparing the fish for preservation.

Mice, crabs and bricks

Mice hunting is not a common activity in the wetland since the area is predominantly inhabited by Muslim people and their religious belief do not allow them to eat or associate with mice, for this reason it has affected the quantity of mice catch annually. The mice hunting is done in the grasses and rice fields after harvest. It was revealed during discussions that mice hunting is discouraged in the area since in the process rice plots are destroyed and also grass is burnt. An estimate of 1,328kg is caught per annum.

Crabs are also caught in small quantities and it is only done in the southern part of wetlands where crabs are harvested during rainy season. About 20,541kg of crabs are caught annually and 93% of the catch is sold to the lodges in Liwonde.

Brick moulding business is practised by the residents in the southern part of the wetland in Nayuchi. The soil in Nayuchi is sandy and the communities rely on wetland's soil for bricks for their houses and for business in the nearby trading centre of Ntaja. The activity is also contributing to the deforestation of the wetland's forests, though it is not done at a large scale. Over 9,960 tones of burnt bricks are made annually for sale. The quantification of the bricks was only restricted to burnt bricks, which are sold.

4.3.2 Economic value of the direct use goods and services in Lake Chiuta wetland

The use value of Lake Chiuta wetland is for hunting (birds, mice), fishing, cultivation, harvesting (grass, poles, papyrus), collection (firewood, ropes/strings), catching crabs, moulding bricks, grazing (pasture) and water transport. As mentioned in the methods section, the monetary value of goods and services were expressed as Gross Financial Value (GFV), the Net Financial Value (NFV) and Cash Income. Table 12 below provides a detailed economic value for each goods/service provided by Lake Chiuta.

Table 12: Economic value of goods harvested and produced in Lake Chiuta wetland (US$)

Wetland goods/services	Gross Financial Value(GFV)	Cash Income(CI)	Net Financial Value(NFV)
Ropes	4,674	2,921	3,764
Timber	9,343	7,905	4,175
Crabs	17,214	16,066	16,141
Bricks	97,369	97,369	57,356
Mice	1,484	927	1,223
Birds	116,635	87,476	64,612
Papyrus	28,898	28,898	19,538
Grass harvest	270,826	29,072	237,456
Firewood	28,562	11,221	(11,480)[vi]
Crop production	4,685,562	2,427,038	4,682,344
Fishing	9,573,184	8,137,207	7,421,432
Water transport	17,934	17,934	16,251
Pasture	135,474		80,865
Water supply	2,204,547		

Fishing and farming contribute the highest economic value; each has a GFV of $9.6M and $4.7M respectively (Table 12). The NFV for crop production is approximately equal to its GFV (GFV = NFV), this is because the input costs for crop production are low, labour cost is almost negligible since family labour is abundant. In terms of cash income, fish contribute greater cash income to the Chiuta households than crop production. This is because among the crops grown rice is the only crop that contributes higher percentage to the cash income. Only 20% of the maize harvest is sold. For fishing 85% of the catch is sold, hence high CI from fishing.

The NFV for fishing is also relatively high because of the low input costs. The only input cost for fishing is the cost of fishing gears (traps, nets, hooks, canoe etc.) whose costs are relatively low. Eighty percent of the fishermen use fish traps which are locally made, the cost of one trap is approximately Mk600 ($1.6) and on average one fisherman has 25 traps. The cost for one gill net is around Mk550 ($1.4).

The only expensive fishing equipment is the canoe, which cost Mk18, 000 ($37), however, most of the canoes, on average last for more than 20 years, hence overall the cost for fishing is also low. The opportunity costs for time spent in fishing is negligible since the catch/effort ratio is very small especially during the peak months. This is probably because of abundant fish available in the wetland.

There is no price for folders in the wetland; however, the price was calculated from wages for looking after cattle while grazing which was Mk3500 per ten cattle per month. The wages was calculated per day to estimate the price for pasture, this method is known as indirect substitute cost method (Pushpam, 2001). The GFV for pasture, as result of grazing is US$135,474 for seven months, which gives the GFV of (US$0.005/kg). The input costs was calculated from the opportunity cost for time spent looking after cattle while grazing. Normally livestock graze for an average of 8 hours and the minimum wage of a labourer per day is Mk317 (US$0.9) (Livingstone, 2012),which translates to $0.2/hour that gives the NFV of US$80,865 after subtracting input cost (CST).

Water transport services yield an estimated annual gross value of US$18,328 and the NFV of US$16,518. It was observed that the cash income from water service is approximately equal to its GFV (refer Table 12). To estimate the value of water for domestic use, the cost of providing an alternative source of water was used, should the current supplies of water be made unavailable through the loss or degradation of the current source that sustains community (Akwateiraho, 2009). One option proposed was to provide clean water by sinking a borehole, which has a market cost (Bush *et al*, 2005; Akwateiraho, 2009). Bush *et al*, 2005 observes that while a borehole may not be appropriate in all cases; boreholes are perhaps one of the most common methods to obtain a regular supply of clean domestic water in rural area.

Based on the above method, the economic value of water in Lake Chiuta wetland was estimated by considering the cost of sinking a borehole in the wetland (replacing the source of water in the wetland) to the surrounding community, assuming the wetland ceases to exist. The cost of drilling one borehole in Malawi is US$10,000 and the annual maintenance cost for one borehole is Mk48, 000 (US$134) (MDC, 2010). Therefore the cost of providing a borehole to the community is US$10,134. One borehole serves 50 households (MDC, 2010). Therefore the unit cost of water was estimated at US$43.71 per m^3, (see Appendix 2: Table f) which gives the value of water supply in Lake Chiuta wetland of US$2.2M (Table 11**)**.

The estimated gross value of grass is US$270,826 and has a net value of US$237,456 which is close to its GFV. This is because; the input cost for grass collection is low as the only cost is the cutting implement, which is relatively cheap (US$1.3). The input cost as opportunity cost in terms of time spent in collection of grass was negligible because the households spent few hours to collect grass because of its proximity and abundance. Grass collection contribute cash income of US$ 11,221 per year.

Mice's hunting has the lowest GFV among the goods collected /produced from the wetland. The NFV for fire wood collection is negative, this is because of the high input costs as opportunity cost in terms of time spent in collection of fire wood. The other reason is because of deforestation in the wetland's forest hence the households spent several hours in looking for fire wood.

Figures 13 and 14 below are the graphical presentations of the information in Table 12 above; figure 13 shows the comparison between the GFV, IC and NFV for each good/ services and again, fishing has the highest GFV, IC and NFV. The cash income from fish is greater than its net financial value. Farming has low cash income because of the low selling prices and not all the harvested quantities are sold, some quantities are kept for home consumption, hence resulted in low IC. As explained above, the GFV for farming is equal to its NFV because of low input costs. The other goods that contribute significantly to the value of the wetland are grass, pasture and birds.

Fishing contributes 64 % (Figure 14) of the economic value of Lake Chiuta wetland (GFV) and farming contributes 31% while the rest of the goods and services contribute 5%. In terms of cash income fishing contributes 75%, farming contributes 23% and the rest of the goods /services contribute 2% of cash income to the Chiuta community.

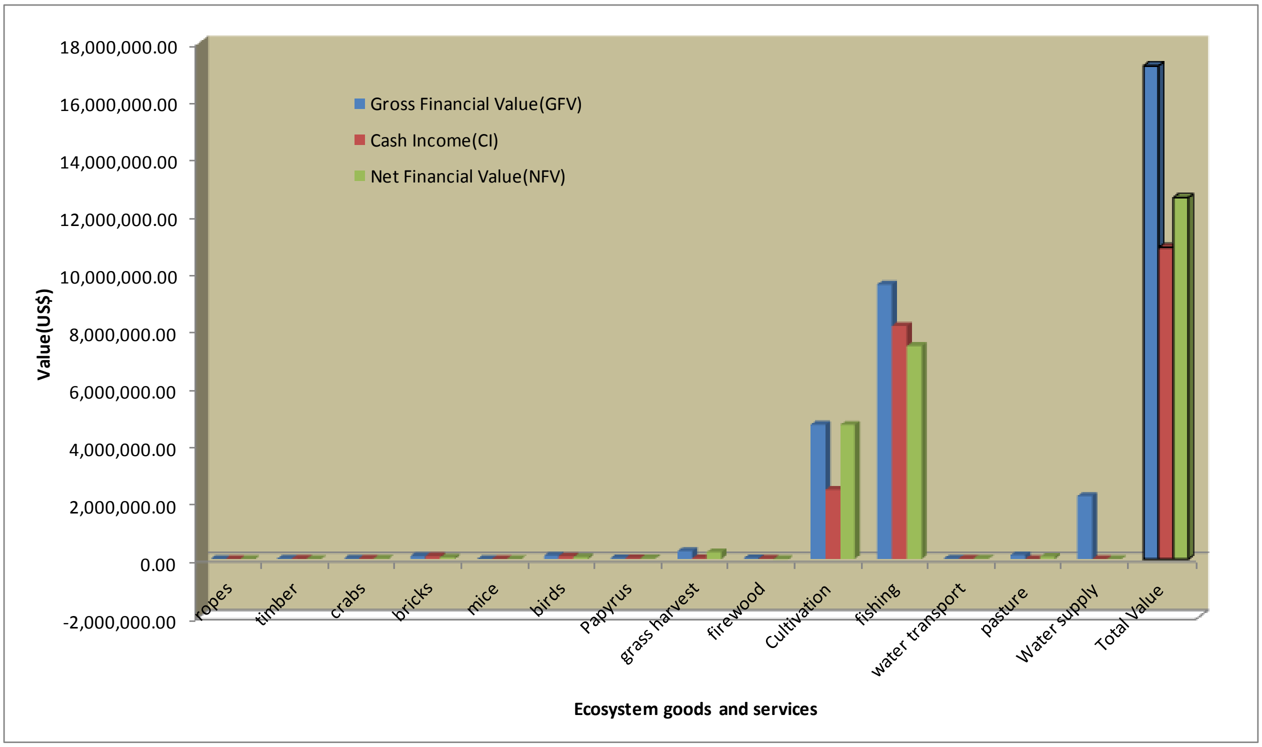


Figure 13: Comparing the Gross Financial Value, Net Financial Value and Cash income for each goods/services of Lake Chiuta wetland.

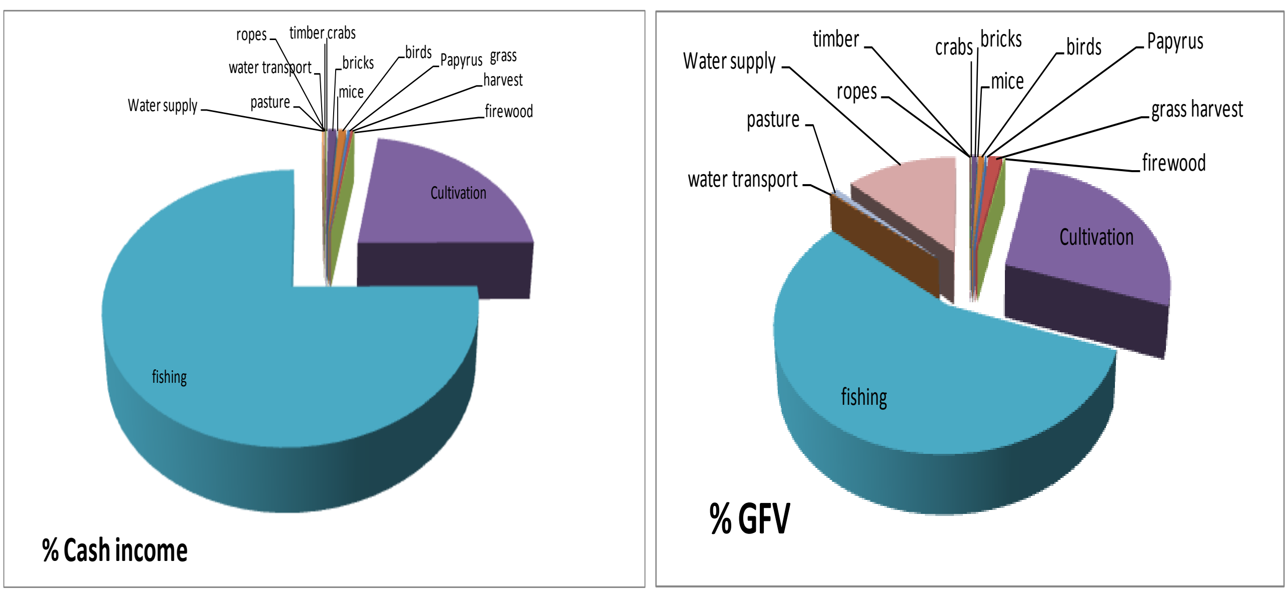


Figure 14: Economic Value Contribution for each goods/services in Lake Chiuta wetland.

4.3.3 Economic value of non-use value of Lake Chiuta wetland

Non-use values of wetland are estimated by reveal preference such as Contingent Valuation Method (CVM) which can also be referred to as Willingness to Pay (WTP) (Kouphet, 2011). In order to capture the value of non-use value and other indirect use value of Lake Chiuta wetland (i.e. water, nutrient recycling, conservation for biodiversity etc), which were not quantified in this research using market value, WTP was used to quantity monetary value which the households are willing to pay for the conservation of biodiversity in the wetland.

Table 13: Statistical results for estimation of willingness to pay

		WTP	Support to Environmental. Programmes	Achieving better environment requires to pay for it	Who should pay for conservation of WL	Amount/month
N	Valid	252	251	253	250	252
	Missing	1	2	0	3	1
Mean		.0991	.0736	.0388	1.6288	325.8621
Range		6.00	2.00	1.00	5.00	800.00
Sum		23.00	17.00	9.00	373.00	75600.00

The monthly mean household WTP to conserve the wetland's biodiversity was estimated at Mk325.86 ($0.91) where as the monthly aggregate WTP was Mk3.3M ($9,178.69) with annual aggregate WTP of $11.0M.

4.3.4 Overall economic value of Lake Chiuta wetland

In reality, it is extremely difficult to estimate an exact economic value for wetland services due to uncertainties on many data. However, using minimum average and maximum values for prices and quantities of each service, it is possible to estimate range of values (Akwetaireho, 2009). Based on calculations of each individual goods/service of Lake Chiuta wetland (Table 12), the economic value of all the direct use goods and services provided by Lake Chiuta wetland was estimated at US$ 17.2M (Gross financial value) per year. The annual economic value per hectare of direct use, was estimated at $554.84 and annual per capita value of wetland economic benefits of US$247.71 (total population=60,504).

Fishing was found to contribute the highest economic value to household income, which is in agreement with empirical findings in Turpie, (2000), Turpie *et al.*, (1999) and Schuyt, (1999), Adekola, (2006) in which fishing was the most significant wetland service contributor to household income ($224 per household). The value for cropping service (US$151/ha/yr) fall well within the range of suggested values in De Groot *et al.*, (2002) and Adekola (2006) (i.e. food provision can range between $6-2761 per ha/ year).

4.3.5 Comparing the results of this study with the Empirical Studies

The economic valuations tend to vary widely because of the varied techniques employed and the underlying assumptions (Collings, 2009). Likewise, the economic value of Lake Chiuta wetland tends to be different from those of other studies (Table 14). The economic value per ha for Lake Chiuta is lower than that of compared studies (Figure15) but higher than that of Kamfozi wetland in South Africa. Apart from differences in variation methods, the value for Lake Chiuta wetland is for direct use services only. Collings, (2009) indicated that the variations in wetland values might result from the differences in the number and socio-economic characteristics of beneficiaries of ecosystem services, the variability in ecosystem properties and characteristics from one site to another.

For Example, the socio-economic characteristics, which affect the value of wetlands include income of the households, education, occupation, family size and ethinicity. The wetlands whose beneficiaries are educated and have high income, wetland values are higher since there is sustainable use of resources. Wetlands located in areas where there is few employment opportunities yield low value because of over dependence on wetland resources, which is the case in Lake Chiuta wetland. Ethnicity of the household living around the wetland also affect the utilisation of goods and services; example in Lake Chiuta, the value of mice is low due to religious belief of the people; hence, such differences affect the overall value of wetland in question.

However comparing individual services, the economic values of fishing and agriculture production are higher than the rest of the services, which is true with the findings of all other compared valuation studies where fish and agriculture production are the highest contributor to economic values of wetlands (see Table 14).

The WTP for the conservation of wetland was lower (US$11M) than the value obtained from direct use of goods and services (US$17.2M). This similar to the findings in the study conducted by

Mmopelwa (2006) in Okavango Delta, in which the value obtained from direct use service was higher than the WPT for conservation of the wetland. This suggests that the value estimated from the direct use (through market price) give a rather realistic value estimate (De Droot *et al.*, 2002).

Table 14: Comparative summary of ecosystem services values from other case studies A: IUCN, 2009; B: Collings, 2009.

Type	**Lake Chiuta,Malawi**	**Lake Chilwa wetland, Malawi (A)**	**That Luang wetland, Laos(A)**	**Muthurajawela wetland, Sri Lanka (A)**	**Mfolozi flood plain,South Africa (B)**
Size (Ha)	**31,000**	**240,000**	**2,000**	**6,000**	**20,886**
Direct use total (US$/year)	**14,833,949.40**	**19,969,703.64**	**2,030,570.00**	**433,696.00**	**336,891.18**
leisure and recreation		423.64		54,743.00	167,505.72
garden cultivation			55,017.00		
agriculture production	4,685,561.65	1,293,802.00	529,352.00	314,049.00	
fishing	9,573,184.36	18,675,478.00	1,092,092.00	64,904.00	149,543.76
birds	116,634.72	250,000.00			
crabs	17,213.53				
mice	1,483.73				
non-fisheries products			354,106.00		
vegetation[iv]	439,871.41	13,457.00			19,841.70
Indirect use total	**148,933.28**	**435,668.00**	**2,912,088.00**	**6,843,961.00**	**1,034,483.58**
open water[ii]	18,328.37	435,668.00			50544.12(Sediment retention)
flood protection			2,842,000.00	5,033,800.00	504,605.76
wastewater purification			70,088.00	1,682,841.00	14,620.20
domestic sewage treatment				44,790.00	464713.5(water provision)
firewood	28,561.71			82,530.00	
timber	4,673.73				
brick	97,369.47				
Non use value					**844,003.26**
Existence					40,518.84
Cultural &					803,484.42
Education& Education					

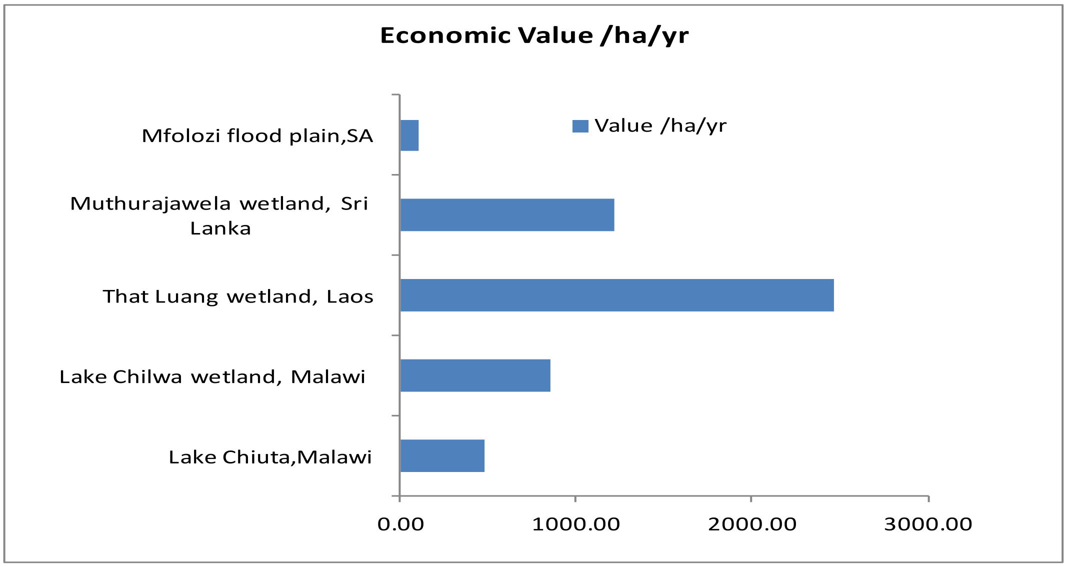


Figure 15: Comparative Summary of Economic Values from other Studies.

In conclusion, the total economic value of wetland ecosystem services is given by:

Total Economic Value (TEV) = *Use Value [Direct-use value + Indirect-use value +Option value] + Non-use Value [Existence value + Bequest value + Philanthropy value*] (Hegg, 2006; Pearce, 1993)

However, in this study the economic value estimated was from the direct use goods and services. This is because these goods/services have the direct market value and market prices exist (or close substitutes) for most of these goods /services in this study area. De Droot *et al.*, (2002) highlighted that the use of direct market value is able to give a rather realistic value estimate. The goods and services identified are the major services in the wetland that contribute to socio- economic activities for the communities of Chiuta wetland, hence this study focused on the economic value of direct use services. However to capture other types of value (i.e. non market goods and service), WTP was used whereby the household were asked to state the amount they are willing to pay per month in order to conserve Lake Chiuta wetland. In this way the study was able to estimate the value of indirect and non market services which were not valued using the market price methods. In view of this, it is probable that the total economic value (TEV) of Lake Chiuta will be higher than estimated in this study**.**

4.4 Land use/ land cover Changes

There have been significant changes in land cover and land use since 1992. Figure 16 shows that the bare land increased from 1996 to 2011, which is probably because of agricultural activities and deforestation taking place in the wetland's catchment. However, it was beyond the scope of this study to quantify the amount and rates of change in land use and land cover. Figure 17 shows the areal extent of the wetland between rainy and dry seasons.

4.5 Access, Regulation and Constraints in resource use in the wetland

Wetlands are considered as a means of revenue earning in the formal systems (reserved or conserved schemes) (Khan, 2012). The management of wetland resources worldwide is complicated and related to access, property rights, and the socio-economic condition of stakeholders, as well as resource-poverty relationship and institutional variables (Khan, 2012; Ahmed 1991; Ahmed *et al.*, 1997; Charles 1988; Hanna 1994). Sustainable management of wetlands as a common pool resource is linked to institutions that govern the interactions between the individuals and their physical environment (Neil *et al.*, 2000). Lack of effective institutions to manage wetland resources results in unsustainable use of the resources. Lake Chiuta, as an important wetland for both local communities and the nation, lacks important aspect of wetland management in terms of property rights in the form of access, use and control by different stakeholders. The only stakeholders that are currently involved in resource use and management are the farmers, fishermen, hunters and the Department of Fisheries.

In this study it was revealed that there are limited or no regulations or property rights in access to, use and control over Lake Chiuta wetland resources. People obtain the permission to use wetland resources from the Chiefs who control and manage the use of resources in the wetland. Once a permission is obtained for a token of Mk5000 (US$14), the person is free to use the wetland in any way he/she wants. It was further discovered that only in fisheries resources are there rules relating to the use of specified fishing equipment. Apart from the Dept Fisheries, there is no other government or non-governmental institution that is managing the use of resources. This has attributed to the unsustainable use of wetland resources. During the field investigations it was learnt that there is;

- over trapping of birds by visitors (from Liwonde and Lake Chilwa).
- deforestation of wetland forests (in Nafisi and on one of small and big Chiuta hills).
- uncontrolled burning due to bush fires set by mice hunters.

- encroachment of the habitat for biodiversity by communities through agriculture (rice farming), which has lead to departure of most animals to Mozambique.

Unlike other wetlands in Malawi where there is closure of the lake for fish breeding season, Lake Chiuta wetland fishermen fish all year round and use destructive fishing equipments (mosquito nets) despite rules and regulations which were laid down to control this. It was also learnt that some fish species no longer exist.

Constraints

Lake Chiuta is a trans-boundary wetland, which is shared between Malawi and Mozambique, and these two countries manage the wetland separately. On the Malawian side, some effort have been made to control wetland resources but on the Mozambican side there has been none. As a result it is becoming a challenge to manage the resources in isolation, since most of fishermen can move to the Mozambique side where there are no regulations at all. In addition, there are often conflicts between the communities of these two countries. On the Malawian side, there are often conflicts between fishermen and farmers, as the latter are accused of destroying fish traps when sourcing water for irrigation.

Lack of active community and government institutions involved in resource use and management in the wetland makes the wetland susceptible to over-exploitation of the resources. Lake Chiuta wetland has potential for ecotourism and scientific research but the road infrastructure is poor and limits the access to the wetland.

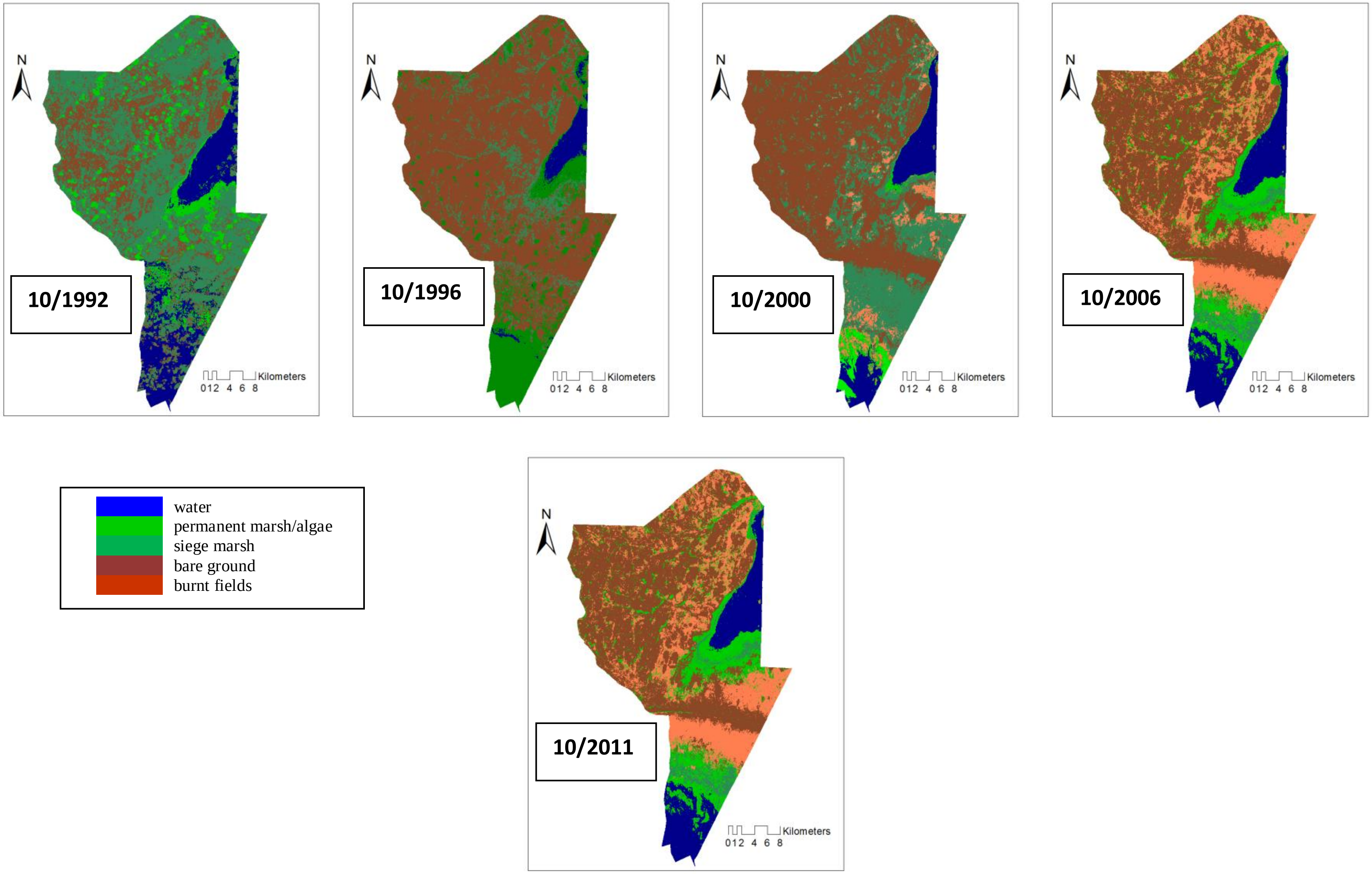


Figure 16: Land use map for Lake Chiuta wetland showing Land cover Changes from 1992 to 2011.

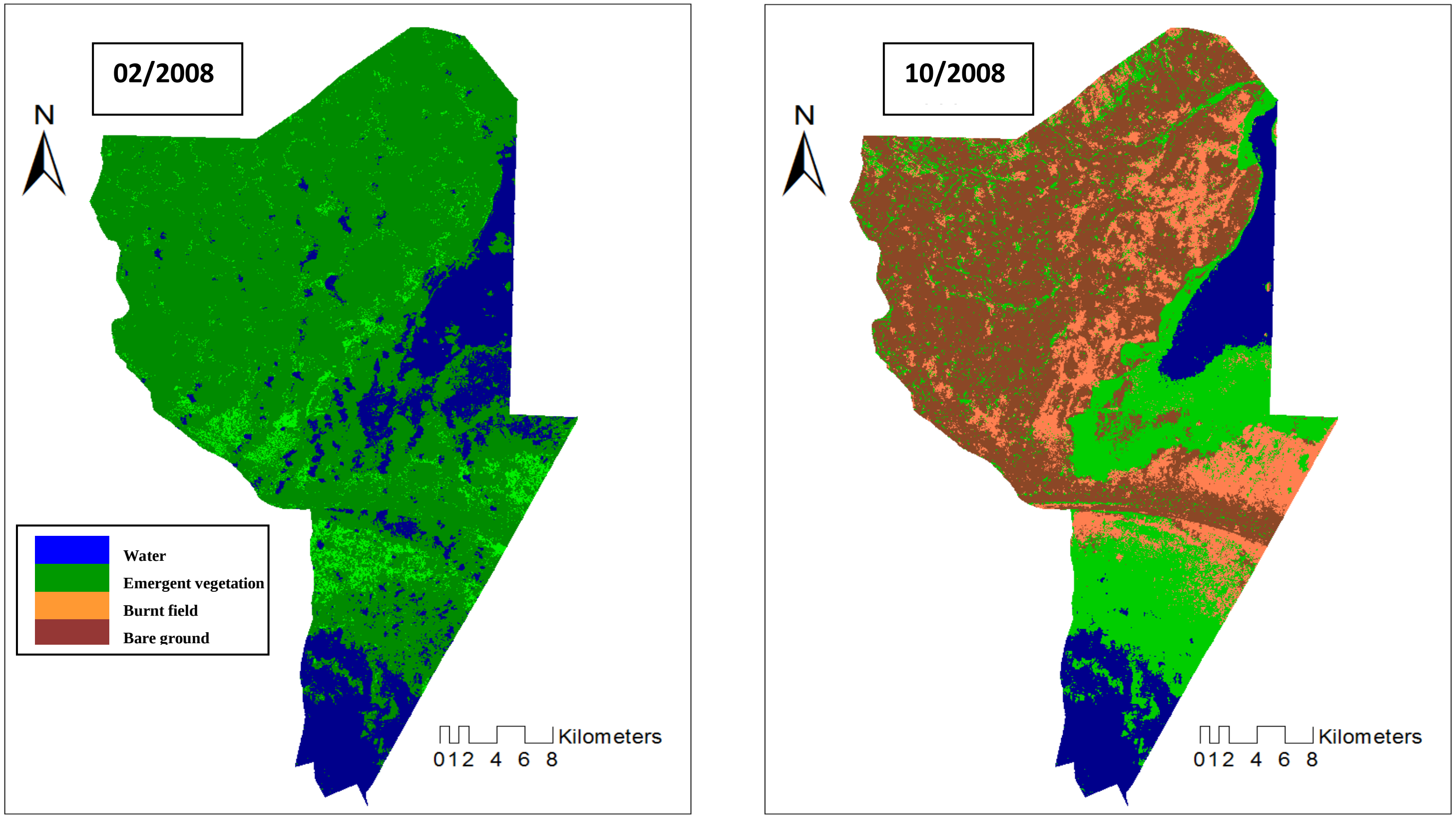


Figure 17: Land use map for Lake Chiuta wetland showing area extent of the wetland during rain and dry Seasons.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

The conclusions of this study presented in this chapter are linked to the specific objectives and the recommendations are drawn from the conclusions. The overall objective of this study was to measure the economic value of Lake Chiuta wetland.

5.1 Main Conclusions

Based on the findings of this study it can be concluded that;

1. Lake Chiuta wetland provides provisioning, regulatory, supportive and cultural services to the surrounding households. The householders reap more benefits from the provisioning services (i.e. food, raw material, water, cultivation, fish nurseries etc) and significantly contributing to socio-economic livelihoods for the Chiuta community. Other services are also important since the ecosystem services are linked and they enhance the socio economic development for the area.

2. The economic valuation of ecosystem services goods and services provided by Lake Chiuta wetland in its present condition contribute a total annual economic value of US$17.2M to the surrounding communities, representing an annual value of US$554 per hectare (GFV) and an annual per capita value of wetland economic benefits of US$248. This value is accrued from the direct and indirect goods provided by the wetland. In addition, the households living around the wetland said they were willing to pay an annual aggregated value of US$11.0M for the conservation of biodiversity, which is lower than value of benefits, obtained from the wetland. This suggests that the value estimated using market prices method gives a realistic value for wetland goods and services than the value estimated using stated preference methods (e.g. CVM). It also suggests that the villagers do not realise the true value of the services.

3. Lake Chiuta wetland is an important source of income for the communities living around the wetland, obtained through fishing, crop production, water services and harvests of wetland resources, providing a mean annual income per household of US$223.

4. There has been a tremendous change in land use and land cover over the years through agricultural activities. The land use map shows an increase in bare land from 1992 to 211, hence a decrease in wetland extent area.

5.2 Recommendations

Drawing from the conclusions of this study, it is therefore recommended that;

1. An economic analysis of non-use value and indirect use value for Lake Chiuta in order to estimate the total economic value of ecosystem goods and services of Lake Chiuta wetland is urgently required. It was not within the scope of this research to undertake this work. This would help to convince policy makers about the significance of the ecosystem services provided by the wetland, encourage the sustainable use of these resources, as well as promoting the development of a policy option for conservation of the Lake Chiuta wetland. Without this there is unlikely to be future support to the local wetland community, nor protection of the biodiversity.

2. Lake Chiuta wetland provides a high economic value (US$17.2M) to the surrounding communities however, in its current state the sustainability of the wetland is questionable as there are no institutions on the ground to control the use and management of the wetland resources. It is therefore recommended that the government, through key ministries (Environment Affairs and the Ministry of Natural Resources) should set up the government institutions and facilitate the formation of a Community Based Natural Resource Management (CBNRM) programme and the institution to manage resource use and management in the wetlands.

3. Lake Chiuta is a trans- boundary wetland, which needs to be managed by both Malawi and Mozambique (based on the problems discussed in section 5.4). The communities of the either side of the wetland need to form a trans-boundary committee to coordinate the management of the wetland.

4. Similar research should be performed on other remaining wetlands in Malawi to account for the economic contributions of wetlands to rural development.

REFERENCE

ACHARYA, G. and BARBIER, E. B. (2000) Valuing groundwater recharge through agricultural production in the Hadejia-Jama'are wetlands in northern Nigeria. *Agricultural Economics*, 22,247–59.

ADAYA, A. L. H., LIYA, H., BITRUS, M., BANJAJI, D., EATON, M. B., GAMBO, M., GOGGOBE, A., MAKINTA, D., OKALI, A. D., OMOLUABI, G., POLET, M., SANUSI, S. S. S., SARCH, T. M. and SHUAIBU, M. (1997) Local-level assessment of the economic importance of wild resources in the Hadejia-Nguru Wetlands, Nigeria. Hidden Harvest Project, Research Series Volume 3, No. 3. International. *Institute for Environment and Development*, London, UK

ADEKOLA, O., SYLVIE M, DE GROOT, R. and GRELOT, F. (2006) The economic and livelihood value of provisioning services of the Ga-Mampa wetland, South Africa**,** Environmental Systems Analysis Group, Wageningen UR.

AHMED, M. **(**1991) A model to determine benefits obtainable from the management of riverine fisheries of Bangladesh. *ICLARM Technical Reports* 28, 133pp

AHMED, M., CAPISTRANO, A. D. and HOSSAIN, M. (1997) Experience of partnership models for the co-management of Bangladesh fisheries. *Fisheries Management and Ecology* 4:233-248.

AKWETAIREHO, S. (2009) Economic valuation of Mabamba Bay wetland system of International importance, Wakiso District, Uganda. Alps-Adriatic University of Klagenfurt, Austria Authority, Kampala, Uganda. (http://albertinerift.org/arift-home/ariftpublications/

BALMFORD, A. (2002) Economic Reasons for Conserving Wild Nature. *Science* 297, 950.

BARBER, E. B. (1993) Sustainable use of wetlands, Valuing tropical Benefits; Economic Methodologies and application. *The geographic journal* 159, 22 - 32.

BARBIER, E. B. (1997) Valuing ecosystem services as productive inputs *Economic Policy January 2007* pp. 177–229, London Great Britain.

BARBIER, E. B. (2007) Valuing ecosystem services as productive inputs Economic Policy pp. 177–229.

BARBIER, E. B., ACREMAN, M. and KNOWLER, D. (1997) Economic valuation of wetlands*:* A guide for policy makers and planners, Gland, Ramsar Convention Bureau, Gland, Switzerland.

BARBIER, E.B. (1991) Economic Valuation of Wetland Benefits – The Hadejia-Jama're Floodplain, Nigeria, IIED/LEEC Paper, DP 91-02.

BARTTLET, J. E., KOTRLIK, J. W. and HIGINS, C. C. (2001) Organizational Research: Determining Appropriate Sample Size in Survey Research, *Information Technology, Learning, and Performance Journal*, Vol. 19, No. 1.

BISARO, S. (2007) Formal and informal institutions in the wetlands of the Lesotho Highlands, in C. Pahl-Wostl, P. Kabat, and J. Moltgen, Editors.

BISHOP, R. C. and HEBERLEIN, T. A. (1999) Measuring values of extra-market goods: are indirect measures biased?American Journal of Agricultural Economics 1979;61:926– 30

BOCKSTAEL, N. E., FREEMAN, A. M., KOPP, R. J., PORTNEY, P. R. and SMITH, V. K. (2000) On measuring economic values for nature. *Environmental Science and Technology* 34:1384–1389.

BOSCOLO, M. and VINCENT, J. R. (2003) Non-convexities in the production of timber, biodiversity, and carbon sequestration. *Journal of Environmental Economics and Management*, 46, 251–68.

BRANDER, L. and SCHUYT, K. (2010) The economic value of the world's wetlands available at: TEEBweb.org.

BRANDER, L. M., FLORAX, R. J. and VERMAAT, J. E. (2006) The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature. *Environmental & Resource Economics:* 223–250, Vrije Universiteit, Amsterdam, Netherlands.

BROWN, T.C., BERGSTROM, J. C., LOOMIS, J. B. and COLLINS, F. T. (2006) Ecosystem Goods and Services: Definition, Valuation and Provision, Rocky Mountain Research Station, U.S. Forest Service, Fort Collins, Colorado.

CARSON, R. T., FLORES, N. E. and MEADE, N. F. (2001) Contingent Valuation: Controversies and Evidence, *Environmental and Resource Economics,* 19: 173-210.

CARSON, R., FLORES, N., MARTIN, K. and WRIGHT, J. (1996) Contingent valuation and revealed preference methodologies: comparing estimates for quasi-public goods. *Land Economy*. 72 (1), 80–99.

CARTNEY, M. P. and KOPPEN, B. V. (2004) Wetland contributions to livelihoods in United Republic of Tanzania. Netherlands Partnership Programme*: Sustainable Development and Management of Wetlands.* Rome: FAO.

CHARLES, A.T. (1988) Fishery socio-economics: a survey. *Land Economics* 64:276-295.

COCHRAN, W. G. (1977) Sampling techniques (3rd ed.). New York: John Wiley & Sons.

COLLINGS, S. L. (2009) Economic Consequences of Ecological Change: Restoration options for the Mfolozi Floodplain and implications for Lake St Lucia. Rhodes University, South Africa.

COSTANZA, R., D'ARGE, R., De GROOT, R., FARBER, S., GRASSO, M., HANNON, B., LIMBURG, K., SHAHID, N., O'NEILL, R. V., PARUELO, J., RASKIN, R. G., SUTTONN, P. and BELT, M. V. D. (2007) Forum on valuation of ecosystem services. The value of ecosystem services: *putting the issues in perspective.*

COSTANZA, R., D'ARGE, R., De GROOT, R., FARBER, S., GRASSO, M., HANNON, B., LIMBURG, K., NAEEM, S., O'NEILL, R. V., PARUELO, J., RASKIN, R. G. J., SUTTONN, P. and BEL, M. P. V. D. (1998) The value of the world's ecosystem services and natural capital. *Ecological Economics*,25:3-15.

COSTANZA, R., WILSON, M., TROY, A., VOINOV, A., LIU, S. and D'AGOSTINO, J. (2006) The Value of New Jersey's Ecosystem Services and Natural Capital, Gund Institute for Ecological Economics, University of Vermont Burlington.

DAILY, G. C. (1997) Nature Services, Societal Dural systems dependency on nature, Island press, Washington DC.

De GROOT, R. S. (1992) Functions of Nature: Evaluation of Nature in Environmental Planning, Management and Decision Making. Wolters- Noordhoff, Groningen.

De GROOT, R. S., WILSON, M. A. and BOUMANS, R. M. J. (2002) A typology for the classification, description and valuation of ecosystem functions, goods and services. *Elsevier,* 41**,** 393-408.

De GROOT, STUIP, FINLAYSON and DAVIDSON (2006) Guidance for valuing the benefits derived from wetland ecosystem services. *CBD Technical Series No. 27, Secretariat of the Convention on Biological Diversity.* Gland, Netherland.

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (2006) Ramsar sites in England – A policy statement, England.

DEPARTMENT OF FISHERIES (2010) Annual report, Ministry of Agriculture, Lilongwe, Malawi.

DEPARTMENT OF FISHERIES (2012) Frame fishery survey report, Ministry of Agriculture, Lilongwe, Malawi.

DEPARTMENT OF WILD LIFE (2004) Wildlife frame survey report, Lilongwe, Malawi.

EDWARDS, P. J. and ABIVARDI, C. (1998) The value of biodiversity: Where ecology and economy blend. *Biological Conservation,* 83: 239-246.

EMERTON, L. (1998) Economic Tools for Valuing Wetlands in Eastern Africa. IUCN, Economics and Biodiversity programme for East Africa.

ENVIRONMENTAL AFFAIRS DEPARTMENT (2010) Annual report, Ministry of environmental affairs, Lilongwe, Malawi.

ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (2008) Arc-GIS desktop, version 9.3. USA.

ERWIN, K. L. (2009) Wetlands and global climate change: the role of wetland restoration in a changing world. *Wetlands Ecology and Management,* 17:71-84.

FAO (1994) Fisheries characteristics of the shared lakes of the Eastern African Rift. *CIFA Technical Paper,* No. 24, Rome. pp 27-28.

FAROLFI, S. (2011) Primary data collection and processing for applied research in water economics eliciting Willingness to pay for water in a rural area of South Africa, Universidad Eduardo Mondlane, Maputo.

FIGUEROA, B. E. and PASTEN, C. R. (2010) Improving benefit transfer for wetland valuation: Income adjustment and economic values of ecosystem goods and services, Department of Economics and Domeyko research project in Biodiversity (PDBD), Universidad de Chile.

FISHER, B., TURNER, K., ZYLSTRA, M., BROUWER R., De GROOT, R., FARBER, S., FERRARO, P., GREEN, R., HADLEY, D., HARLOW, J., JEFFERISS, P., KIRKBY, C., MORLING, P., MOWATT, S., NAIDOO, R., PAAVOLA, J., STRASSBURG, B., YU, D. and BALMFORD, A. (2008) Ecosystem Services and Economic Theory: Integration for Policy-Relevant Research. *Ecological Applications,* 18: 2050-63.

FISHER, B., TURNER, K., ZYLSTRA, M., BROUWER, R., De GROOT, R., FARBER, S., FERRARO, P., GREEN, R., HADLEY, D., HARLOW, J., JEFFERISS, P., CHRIS KIRKBY, MORLING, P., MOWATT, S., NAIDOO, R., PAAVOLA, J., STRASSBURG, B., YU, D. and BALMFORD, A. (2008) Ecosystem services and economic theory: integration for policy-relevant research. *Ecological Applications,* 18(8), 2008, pp. 2050–2067_ 2008 by the Ecological Society of America.

FISHERIES DEPARTMENT (1971) Annual frame survey results, Monkey Bay, Malawi

GHERMANDI, A., BERGH, J. C., BRANDER, L. M., De GROOT, R. S. and NUNES, P. A. (2008) The Economic Value Of Wetland Conservation and Creation: A Meta-Analysis. *Research in agriculture and Applied science,* VU Amsterdam.

GREN, I. M. (1992) Benefits from Restoring wetland for nitrogen abatement; A case study of Gotland, Beijer discussion paper series No.14. The Beijer international. *Ecological Economics,* Stockholm.

GRAB, S., and MORRIS**, C. (**1997) A threatened resource: Lesotho's alpine wetlands, unique in many ways, are facing a complexity of threats. *African Wildlife* 51(3):14-16.

HANEMANN, W. M. (1994) Valuing the Environment through contingent valuation. *The Journal of Economic Perspectives,* 8: 19-43.

HANNA, S**. (**1994) Property rights and performances of natural resource systems, *The Common Property Resource Digest* 29:1-3.

HEGG, D. A. (2006) Valuing ecological services and community design - Implications for the private market and Local Government, Faculty of Geography, University of Victoria.

HEIN, L., KOPPEN, K. V., De GROOT, R. S. and IERLAND, E. C. V. (2006) Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics,* 57: 209-228.

IBM Corporation (2007) Statistical package for social sciences, version 16. USA.

IMPEY, A. (2002) Culture, Conservation and Community Reconstruction: Explorations in Participatory Action Research and Advocacy Ethnomusicology in the Dukuduku Forests, Northern KwaZulu Natal (South Africa). *Yearbook for Traditional Music*, 34:9-24.

IUCN (2005), Can Lao PDR afford not to invest in conserving its biodiversity; Exploring the need for innovative financial mechanisms, Vientiane, Laos: The World Conservation Union (IUCN).

KAISER, B. and ROUMASSET, J. (2002) 'valuing indirect ecosystem services: The case of tropical watersheds', *Environment and Development Economics*, 7, 701–14.

KAMBEWA, D. (2005) Access to and monopoly over wetlands in Malawi. International workshop on 'African Water Laws*: Plural Legislative Frameworks for Rural Water Management in Africa'.* 26-28 January 2005, Johannesburg, South Africa.

KHAN, H. M. M. S. (2012) Participatory wetland resource governance in Bangladesh: An analysis of community-based experiments in *hakaluki haor* , Faculty of Environment, Earth, and Natural Resources, Institute University of Manitoba

KOPP, R. J. and SMITH, V. K. (1993) Valuing Natural Assets*:* The Economics of Natural Resources Damage Assessment, Resources for the future, Washington DC, USA.

KORSGAARD, L. and SCHOU, J. S. (2010) Economic valuation of aquatic ecosystem services in developing countries. p20-31,Technical University of Denmark, Demark.

KOTZE, D. & BREEN, C. (1994) Agricultural land-use impacts on wetland functional values. Water Research Commission, Pretoria, Report No 501/3/94.

KROEGER, T. (2005) The economic value of ecosystem services in four counties in North eastern Florida; a companion report to the study economic benefits of natural land conservation: Case study of North-eastern Florida, commissioned by Defenders of Wildlife.

KRUTILLA, J. V. and FISHER, A. C. (1975) The economics of natural resources. Baltimore, MD: Resources for the Future, Inc.

KRUTILLA, J. V. (1967) Conservation reconsidered, *American Economic review* 57,777 – 786

LAMBERT, A. (2003) Economic valuation of wetlands: an important component of wetland management strategies at the River Basin Scale.

LANNAS, L. S. M. and TURPIE, J. K. (2009) Valuing the provisioning services of wetlands: contrasting a rural wetland in Lesotho with a peri-urban wetland in South Africa. *Ecology and Society* 14(2): 18. *[online] URL: http://www.ecologyandsociety.org/vol14/iss2/art18/*

LESCHINE, T. M., WELLMAN, K. F. and GREEN, T. H. (1997) The Economic value of wetlands: wetlands' Role in Flood Protection in Western Washington. Washington, Washington State, Department of Ecology USA.

LIVINGSTONE, I. (2012) Minimum wage policy, rural development and poverty alleviation in Malawi. Issue, Volume 26, Issue 4 pp729-752.

LOMBA, Â., TORRES, J., ALVES, H. and HONRADO, J. (2004) GIS applied to landscape valuation and management in coastal areas, Universidade do Porto, Portugal.

LOOMIS, J., KENT, P., STRANGE, L., FAUSCH, K., and COVICH, A. (2000) Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey, *Ecological Economics* 33(1): 103-117.

LYNAM, W. D. JONG, D., SHEIL, KUSUMANTO, T. and EVANS, K. (2007) A review of tools for incorporating community knowledge, preferences, and values into decision making in natural resources management,**:** *Ecology and Society* 12(1).

MACHINGA AGRICULTURAL DEVELOPMENT DIVISION (2001) Annual report, Ministry of Agriculture, Machinga, Malawi.

MACHINGA AGRICULTURAL DEVELOPMENT DIVISION (2013) Agriculture production estimate survey report, Machinga, Malawi.

MACHINGA DISTRICT COUNCIL (2007-2012) Machinga district social economic profile report, Machinga, Malawi.

MACHINGA DISTRICT COUNCIL (2010) Public works annual report, Machinga, Malawi.

MACHINGA DISTRICT COUNCIL (2012) Annual report, District water development sector Machinga, Malawi.

MALER, K. G. (1992) Multiple use of Environment Resources: Household Production function approach, *Beijer discussion paper series No.* 4. *The Beijer internation institute of Ecology Economics*, Stockholm.

MARDLE, S, JAMES, C., PIPITONE, C. and KIENZLE, M. (2004) Bioeconomic interactions in an established fishing exclusion zone: The Gulf of Castellammare, NW Sicily. *Natural Resource Modeling*, 17(4), 393–447.

MASIYANDIMA, M, MCCARTNEY, M. and KOPPEN, B. (2004) Sustainable Development and Management of Wetlands: Wetlands Contributions to Livelihoods in Zambia. Rome: IUCN.

MELTZER, M. I. **(**1995) Livestock in Africa: the economics of ownership and production, and the potential for improvement. *Agriculture and Human Values* 12 (2):4-18.

Microsoft corporation (2007) Microsoft office professional Edition. USA

MILLENIUM ECOSYSTEM ASSESSMENT (2003) Ecosystems and human well-being*: a* framework for assessment, Millennium Ecosystem Assessment. Island Press, Washington D.C. (www.millenniumassessment.org).

MILLENNIUM ECOSYSTEM ASSESSMEN (2005) Ecosystems and Human Well-Being: Synthesis, Washington. 155pp.

MILLENNIUM ECOSYSTEMS ASSESSMENT (2005) Ecosystems and Human Wellbeing, Island Press, Washington.

MITCHELL, R. C. and CARSON, R. T. (1989) Using surveys to value public goods. The Contingent Valuation methods, Resources for the future, John Hopkins University press, Washington.USA.
MMOPELWA, G. and BLIGNAUT, J. (2006) Okavango Delta: The Value of Tourism. SAJEMS NS, University of Pretoria, RSA, No.9**,** 113-126.

NATIONAL FOOD RESEVESE AGENCY (2010) Household food security survey, Zomba. Malawi.

NATIONAL STATISTICS OFFICE (2008) National demographic survey report, Zomba, Malawi.

NEIL, A. W and LUTTRELL, C. (2000) "Property rights and the utilisation of wetlands."*Ecological Economics* 35.1: 75-89.

NJAYA, F. J., DONDA, S. J. and HARA, M. M. (1998) Fisheries co-management in Malawi: lake Chiuta re-visit case study. Centre for African Studies. Bellville, University of Western Cape.

PALMER, R. W., TURPIE, J., MARNEWICK, G. C. and BATCHELOR, A .L**. (** 2002) Ecological and economic evaluation of wetlands in the Upper Olifants River Catchment, South Africa. WRC Report Number 1162/02. Water Research Commission, Pretoria.

PEARCE, D. (2007) Do we really care about biodiversity? *Environmental and Resource Economics* 37:313–333.

PEARCE, D. and MORAN, D. (1994) The Economics of Biodiversity, IUCN, Gland, Switzerland and Earth scan, London.

PHOUPHET K. (2011) Simple manual for estimating economic value of wetland for Lao policymakers**,** Faculty of Economics and Business Management, National University of Laos.

PUSHPAM K. (2001) Cost of wetland conversion: a case study of Floodplain wetland ecsystems along the Yamuna river corridors of Delhi-region, *Global Environmental Change Research Community, Rio de Janeiro, October 6-8, 2001*

RAMACHANDRA,T. V., and RAJINIKANTH, R. (2001) Economic Valuation of Wetlands Energy & Wetlands Research Group, Center for Ecological Sciences, Indian Institute of Science, Bangalore.

RAMSAR BUREAU, (1971). 'Convention on Wetlands of International Importance'. Gland, Switzerland.

RAMSAR CONVENTION BUREAU (2002) Cultural aspects of wetland. 8th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands, (Ramsar, Iran, 1971), Vale.

RAMSAR CONVENTION, (1996) Strategic plan 1997-2002. , Ramsar Convention Bureau, Gland, Switzerland.

RAMSAR, CONVENTION SECRETARIATE. (2006) Ramsar handbooks for the wise use of wetlands, Convention Secretariat, Gland, Switzerland. htt p://www.ramsar.org/lib/lib_handbooks2006_e.htm.reports

RESEARCH SYSTEMS Inc. (2005) Environmental for Visualizing Images, version 4.2 USA.

RICKETTS, T. H., DAILY, G. C., EHRLICH and, P. R., MICHENER, C. D. (2004) 'Economic value of tropical forest to coffee production', *Proceedings of the National Academy of Science*, 101(304), 12579–82.

RODWELL, L. D., BARBIER, E. B., ROBERTS, C.M. and MC CLANAHAN, T. R. (2002) 'A model of tropical marine reserve-fishery linkages', *Natural Resource Modeling*, 15(4), 453–86.

SCHUIJT, K (2002) Land and water use of wetlands in Africa: Economic values of African wetlands, international institute for applied system analysis, Laxenburg Austria.

SCHUYT, K. & JANSEN, J. (1999) Economic Valuation of the Lake Chilwa Wetland. Danida, Copenhagen, Denmark.

SCHUYT, K. (2004) Economic values of global wetlands. *WWF International. Ecological Economics* 33:1–6, Gland, Switzerland.

SCHUYT, K. (2004) Economic values of the world's wetlands, WWF-International, Gland, Switzerland.

SECRETARIAT OF CONVENTION ON BIODIVERSITY (2001). The value of forest ecosystems, Secretariat of the Convention on Biological Diversity, Montreal, Canada.

SETLHOGILE, T. (2010**)** Economic valuation of selected direct and indirect use values of the Makgadikgadi wetland system, Botswana**,** Department of civil engineering, University of Zimbabwe, Harare, Zimbabwe.

SMITH, L. (2006) Stakeholder-oriented valuation to support water resources management processes. Confronting concepts with local practice. FAO Water Reports No. 30, FAO, Land and Water Development Division, The World Conservation Union, International Water. Management Institute, Imperial College London, Roma, Italy.

SMITH, M. J., E. SABINE, G. SCHREIBER, M. KOHOUT, K. OUGH, R LENNIE, D. TURNBULL, C. and JIN, T. (2007). Wetlands as landscape units: spatial patterns in salinity and water chemistry. *Wetlands Ecology and Management*, 15: 95–103, Integration for Policy-Relevant Research. *Ecological Applications,* 18: 2050-2067. South Africa.

STUIP, M. A. M., BAKER, C. J. and OOSTERBERG, W. (2002a) The socio-economics of wetlands Wageningen. *Wetlands International and RIZA*, The Netherlands. 35pp.

STUIP, M. A. M., BAKER, C. J. and OOSTERBERG, W. (2002) The Socio-economics of Wetlands, Wetlands International, Lelystad, Wetlands International and RIZA. Tanzania. IUCN East Africa Regional Office, Nairobi, Kenya.

TEJUOSO, O. J. (2006**)** Wetland uses/dynamics for agricultural purposes and its health implications in lower Ogun river basin, Lagos, Nigeria, *a technical report* , IDRC, Nigeria.

THOMSON, J. T. (2006) Malawi's Lake Chiuta fisheries: intelligent burden shedding that favours renewable resources stewardship. Chancillor College, Zomba, Malawi.

TURNER, R. K. (1991) Economics and wetland Management, *Ambio* 20, 59 – 63.

TURNER, R. K., BERGH, T. V., SÖDERQVIST, D. T., BARENDREGT, A., STRAATEN, J. V. D., MALTBY, E. and IERLAND, E. C. V. (2000b) Ecological-economic analysis of wetlands: scientific integration for management and policy. *Ecological Economics* 35:7–23.

TURNER, R. K., BERGH, T. V., SÖDERQVIST, D. T., BARENDREGT, A., STRAATEN, J. V. D., MALTBY, E. and IERLAND, E. C. V. (2000a) Ecological-economic analysis of wetlands: scientific integration for management and policy. *Ecological Economics*, 35: 7-23.

TURPIE, J. K. (2000.) The use and value of natural resources of the Rufiji Floodplain and Delta. Tanzania, Rufiji Environmental Management Project; IUCN - Eastern Africa Regional Office; Fitzpatrick Institute, University of Capetown, Cape Town, South Africa.

TURPIE, J. K. and LANNAS, K. (2007) Wetland valuation and recommendations for its practice in South Africa; a scoping study for the Wetland Health and Integrity Research Programme. WRC Project No. K5/1584. 83pp.

TURPIE, J., SMITH, B., EMERTON, L. and BARNES, J. (1999) Economic value of the Zambezi Basin Wetlands, IUCN The World Conservation Union Regional Office for Southern Africa. 346pp.

TURPIE, J. K and BARNES, J. I. (2003) Balancing Ecology and Economics in the Multiple Use of Wetlands on Communal lands. Proceedings of the 7th International Rangelands Congress, Durban, South Africa, 26 July – 1 August 2003. 1932-1941.

UNEP (1998) Environmental Valuation: A worldwide compendium of case studies. *Environmental Economics Series.* Number: 26.

WATSON, C. (2007) Direct consumptive use valuation of Ecosystem goods and services in the Bale mountains Ethiopia eco-region, faculty of natural sciences, Imperial College London.

APENDICES

APENDIX 1: HOUSEHOLD QUESTIONNAIRE

UNIVERSITY OF ZIMBABWE

CIVIL ENGINEERING DEPARTMENT IWRM 2012/13

MEASURING THE ECONOMIC VALUE OF WETLAND ECOSYSTEM SERVICES IN MALAWI

(A Case study of Lake Chiuta Wetland by Stearner Zuze)

This research is a socio economic study of the value of Lake Chiuta wetland which is one of the important wetlands in Malawi that supports many people in the area. The purpose of this research is to measure the total economic value of Lake Chiuta wetland ecosystem services both to Malawi and to the local inhabitants. Such information will be valuable in decision making for the conservation of Lake Chiuta wetland and to improve wise use & management of wetland resources by the Malawian community. Improved management will help to assure a continuous flow of goods and services to the present and future generations, as well as contributing to the sustainable development of the local economy. The study is part of the requirements for the Master of Science Degree in Integrated Water Resources Management at the University of Zimbabwe In this survey I will be asking for your opinions and ideas about the Lake Chiuta wetland. Your answers will be kept strictly confidential and used only for scientific purposes; your name will not be attached to the form. I appreciate for taking your time to assist me and help me to complete it.

1.0 General Information (*Demographics and socio-economic*)

Interviewer:		**Date:** **Time:**	
Checked by		**Respondent : (i) Name**	
Village		**(ii) Age**	
T/A		**(iii) Sex**	
District			

i) What is the size of your family (number of family members)?

ii) Educational level of the household head

(a) None (b)Primary (c) Secondary (d) Diploma (e) Degree (g) High degree

i) What type livestock do your household have?

(a) Goats (b) Cow (c) Pigs (d) Sheep (e) Other-specify(and add below)

ii) Type of housing

(a) Iron sheet roofed (b) Grass thatched house (c) Tiled roofed house
(b) Plastic sheeting
(c) Other (**specify**)____

iii) What is your main occupation?

(a) Farmer (b)Fisherman (c) Own business (d) Wage labour (e) Employed

(f) Unemployed (g) Other – specify

iv) What is your annual income?
(a) <K50,000 (b) K50,000-100,000 (c) K100,000-150,000 (d) K150,000-200,000
(e) >K200, 000

2.0 General Knowledge about the wetland

***i.* Are you familiar with the Lake Chiuta Wetland?**
(a) Have worked with this area already (b) Have detailed information about the area
(c) Have heard about the area before (d) Never heard about this area

iii) What is the main activity for which your household uses Lake Chiuta wetland?

3. Lake Chiuta wetland ecosystem is considered to perform many important functions, which fall into 4 main groups: Regulation, Carrier function, Production, and Information functions. Table 2 presents the major functions of Lake Chiuta Wetland according to this classification

i) What are the most valuable functions of Lake Chiuta wetland, to your mind? Could you rank them, please *(1 is the most important, 10– the least)*

Table 2: Classification of functions for Lake Chiuta wetlands

No.	**Wetland functions**	Ranking (1,2……10)
	Regulation	
1	Climate regulation	
2	Water regulation & water supply	
3	Soil formation	
4	Nutrient storage and recycling & waste treatment	
	Carrier Functions	
5	Cultivation	
6	Fish nursery	
7	Livestock grazing	
	Production Function	
8	food	
9	Raw materials	
10	Water	
11	Medicines resources	
	Information Functions	
13	Aesthetic, information & Recreation	

ii) Do you think any change in the functions mentioned above can impact the total value of the Lake Chiuta wetland ecosystem?
(a) Yes (b) No

4.1 Accessibility to and use of Lake Chiuta wetland

i) From which part of the wetland do you obtain goods e.g. fuels, plants, timber, fish, fodder etc?

(a) Forest (b)Open waters (c) Swamp (d) Shores

(e) Others.______________________________

ii) Which means of transport do you use to reach the wetland?

(a) By foot (b) By bicycle (c) By car (d) By Bus (e) By boat

iii) How long does it take you to reach there?
(a) < 15min (b) 15min (c) 30min (d) 45min (e) 1hr (f) 2hrs
(g)> 2hrs

iv) Which months of the year do you most often use the wetland?
Month: JAN FEB MAR APR MA JU JUL AUG SEP OCT NOV DEC

4.2 Livestock

ii) Do you obtain forage/pasture and water for the livestock from Lake Chiuta wetland?
(a) Yes (b) No

iii) If **YES**, may you provide explanation on the following aspects in the table below?

Livestock	**Time of the year**	**Quantity of forage/pasture (bundles)**	**Price per unit of forage**	**Quantity of water (jerry cans)**
Goats				
Cows				
Pigs				
Sheep				

4.3 Water resources

i) From what sources do you get your water supply?
(a) Private tap (b) Collective tap (c) Wetland (d)Borehole (e) River

ii) How is water carried home from the sources?

iii) Type of container:
(a) Bucket (b) 25l water container
(b) Other - specify)________________________________

iv) How many jerry cans of water do you use each day? ________________________

4.4 Building Materials

ii) Where do you get you the building material for your house?
(a) Wetland (b) Forest (c) Mountain (d) Other (**specify**)

ii) What type of building materials do you get from the wetland?
(a) Grass (b) Timbers/poles (c) Strings and ropes (d) Bricks
(b) Other **(specify)**________________________________

4.5. Which goods do you collect from the wetland?

Wetland goods	**Local unit**	**Quantity harvested annually**	**Quantity sold**	**Quantity consumed**	**Unit price**

5.0 Detailed information on each provisioning service under study

5.1 Agriculture Production

i) Area and crop productivity for different crops

Crop type	area	Local unit	Quantity	% Quantity sold	Quantity consumed	Unit price
maize						
rice						
cassava						
sugarcane						
Sweet potatoes						
Others specify						

ii) Itemised cost of production per hectare by crop (fixed and variable costs)

Crop	Fixed cost	Variable cost	Output prices by type of crop	
			on-stand price	market price

5.2.1 Fisheries

i) In which part of the wetland do you fish?

(a) Marsh (b) Open water (c) Both

ii) Size of the fishing fleet (including the number of fishermen),

iii)

Size of fishing fleet	Number of fishermen

v) Cost of fishing (wages and fuel costs),

Wages
How much do you pay the fishermen?
(a) <Mk1000 (b) Mk1000 (c) Mk2000 (d) Mk3000 (e) Mk4000
(b) > Mk4000

Fuel
How much fuel do you use per trip?
(a) < 5*l* *(b)* .10*l* *(c)* 15*l* *(d)* 20*l* *(e)* >20*l*

viii) What is the composition of the catch? (Fish Species and sizes) ______________________________

xi). Prices of fish by species (ex-vessel),

Fish species	Unit price

x) What is the type of fishing gear and its cost?

Type of fishing gear	Unit price

xi) Boat capacity and type,

Boat type	capacity

6.0 Access and availability of ES

i) What changes have you seen in terms of goods and services in from the wetland over the past 10 years?

(a) Less (b) Same (c) More ES available

ii). How do you see access and supply of goods and services changing in the next 10 years – and if so how will it change? (Small, medium much)

iii) What is this change due to?

vi) As a community (resource user) you should know that if you wait for the government to do something, it often takes time or doesn't happen and if you want change you will have to do something yourselves as a community.

What can you yourself do about it improve the situation, and give examples?

v) What can you as a community does about it to improve the situation, and give examples

vi) Do you think other members of the community would join you in the utilisation of wetland?

(a) Yes (b) No

vi. How reliant are you on the wetland for your livelihoods? Do you get goods and services from elsewhere as well? What proportion do the ES from the wetland make up?

7.0 Lake Chiuta wetland valuation based on a concept of Willingness to Pay (WTP)

The following section is designed to establish a value of Lake Chiuta Wetlands, based on the WTP for conservation of this area. The questions are asked hypothetically. Your responses will be used in NO WAY, but for the MSc research ONLY**.**

Reasons for valuing	Not important	Moderately important	Very important	Extreme important	No opinion
Protecting rare wild life					
Protecting wild life living area					

Providing flood control and storm buffering					
Providing food					
Providing water for agriculture, domestic purpose and livestock					
Proving building material					
Providing livestock folder					
Providing water purification					
Knowing that the future generation will also need it					
Other - specify					

7.0 Would your household support an environment programme that seeks to conserve Lake Chiuta wetland, if it doesn't cost your household anything?

(a) Yes because (b) No because (c) Not sure because

The conservation of Lake Chiuta wetland for its future state depends on the quality of different environmental elements (i.e. Vegetation, water, Insects, Fish, Mammals and birds). **T**he Lake Chiuta wetland ecosystem improvement due to the undertaken conservation measures. These measures, of course, have costs which somebody has to pay for.

Do you agree with this statement: '*If we want to achieve a better environment, we will all have to pay for it'*?

(a) Yes (b) No

Who should pay for the Lake Chiuta conservation? *(Please, choose not more than three options)*

(a) Government (b) People who get benefit from it

(b) Others ______________________________________

Lake Chiuta is a wetland an important wetland, which is heavily used by the local community surrounding this area. However due to unsustainable utilisation, the wetland has deteriorated, and it is questionable whether the wetland will be able to provide many benefits to residents also in the future. Suppose therefore, that a management plan will be set up to protect, secure and conserve the wetland so that the wetland will be beneficial to residents and the wildlife also in the future. In order to secure this, suppose that the wetland will be strictly managed with restrictions of access and use of resources. In order to implement the programmes that lead to conservation of Lake Chiuta wetland, would you pay for such programmes?

(a) Yes (b) No

How much would you be willing to pay as a contribution (paid by all residents) devoted solely to a funding scheme for securing the success of wetland management (per month?)

(a) Nothing (b) <K200 (c) K200 (d)K400 (e) K500 (f)K650

(b) K800 (h)>K800

Thank you very much for the information

APENDIX 2: ESTIMATION OF VALUE OF GOODS AND SERVICES IN LAKE CHIUTA WETLAND

(a) Calculation of GFV and NFV

Wetland goods /service	Number of HH participating in collection /production of wetland resources	Total Quantity harvested /produced	unit of measure	Unit price(MK)	GFV(Mk)	GFV(US$)	CST	NFV(Mk)	NFV(US$)
ropes	187	55,773.46	bundles	30	1,673,197.04	4,673.73	910.00	1,347,417.04	3,763.73
timber	277	66,895.00	No.	50	3,344,734.16	9,342.83	5,167.60	1,494,734.16	4,175.24
crabs	147	20,541.48	kg	300	6,162,444.44	17,213.53	1,072.50	5,778,489.44	16,141.03
bricks	71	9,960	ton	3500	34,858,271.60	97,369.47	40,013.97	20,533,271.60	57,355.51
mice	18	1,328	kg	300	531,173.66	1,483.73	260.36	437,963.66	1,223.36
birds	116	138,850	No.	400	41,755,229.63	116,634.72	52,022.35	23,131,229.63	64,612.37
Papyrus	80	206,909	bundles	50	10,345,437.04	28,897.87	9,360.00	6,994,557.04	19,537.87
grass harvest	981	3,231,860	bundles	30	96,955,792.59	270,826.24	33,370.06	85,009,312.59	237,456.18
firewood	393	102,251	bundles	100	10,225,093.00	28,561.71	40,042.54	(4,109,997.00)	(11,480.44)
Cultivation	981	18,340,140.13	Kg	*	1,677,431,072.10	4,685,561.65	3,217.52	1,676,279,202.15	4,682,344.14
fishing	393	5,040.00	ton	680	3,427,200,000.00	9,573,184.36	2,151,751.40	2,656,873,000.00	7,421,432.96
water transport	232	360.00	trips	150	6,561,555.00	18,328.37	1,809.93	5,913,600.00	16,518.44
pasture	232	32,333,025.60	kg	1.5	48,499,538.40	135,473.57	54,609.07	28,949,491.36	80,864.50
Water supply	1,084	50,35.76	cum	*	2,204,547.07				

GFV = TQH × P

NFV = GFV – CST

(b) Calculation of cash income for harvests

Activity	HCI	PHH	QSD	unit of measure	(Mk)	CI(Mk)	CI(US$)
ropes	20	1,743	34,858.27	bundles	30	1,045,748.15	2,921.08
timber	22	2,573	56,603.19	No.	50	2,830,159.67	7,905.47
crabs	14	1,369	19,172.05	kg	300	5,751,614.81	16,065.96
bricks	15	664	9,959.51	ton	3500	34,858,271.60	97,369.47
mice	5	166	829.96	kg	400	331,983.54	927.33
birds	97	1,079	104,138.00	No.	300	3,339,446.91	9,328.06
Papyrus	277	747	206,908.74	bundles	50	10,345,437.04	28,897.87
grass harvest	114	9,130	1,040,768.40	bundles	30	10,407,683.95	29,071.74
firewood	11	3,652	40,170.01	bundles	100	4,017,000.82	11,220.67
Cultivation	[a]		8,996,297.43	Kg		868,879,767.90	2,427,038.46
fishing	[b]		4,284.00	ton	680	2,913,120,000.00	8,137,206.70

CI = QSD × P

(c) Estimation of GFV for crop production

ACTIVITY	TQH(kg)	Price (Mk)	GFV(Mk)	$
maize	7,879,421.81	80	630,353,744.86	1,760,764.65
rice	9,746,663.23	100	974,666,322.63	2,722,531.63
cassava	346,466.32	90	31,181,968.89	87,100.47
sweet potato	829.96	50	41,497.94	115.92
pigion peas	143,416.89	70	10,039,182.22	28,042.41
finger millet	18,591.08	35	650,687.74	1,817.56
Groundnuts	63,574.85	80	5,085,987.82	14,206.67
Tobacco	141,176.00	180	25,411,680.00	70,982.35
farming activity	18,340,140.13		1,677,431,072.10	4,685,561.65

GFV = TQH × P

(d) Estimation of cash income for crop production

Activity	HCI	PHH	QSD(kg)	price(Mk)	CI(Mk)	US$
maize	205	9,005	1,846,035.97	80	147,682,877.37	
rice	800	8,424	6,739,265.84	100	673,926,584.36	
cassava	176	954	167,983.67	90	15,118,530.37	
sweet potato	2	207	414.98	50	20,748.97	
pigeon peas	65	996	64,736.79	70	4,531,575.31	
finger millet	100	166	16,599.18	35	580,971.19	
Groundnuts	121	166	20,085.00	80	1,606,800.33	
Tobacco	486	290	141,176.00	180	25,411,680.00	
			8,996,297.43		**868,879,767.90**	2,427,038.46

CI = QSD × P

(e) Estimation of percentage household

Goods/services	M	n	N	PHH
ropes	42	256	1084	**187**
timber	62	256	1084	**277**
crabs	33	256	1084	**147**
bricks	16	256	1084	**71**
mice	4	256	1084	**18**
birds	26	256	1084	**116**
Papyrus	18	256	1084	**80**
water	243	256	1084	**1,084**
grass harvest	220	256	1084	**981**
firewood	88	256	1084	**393**
pastures	52	256	1084	**232**

PHH = $\frac{m}{n} X N$

(f) Estimation of the value of water

Number HH per BH	number BH required	providing one BH(US$)	Total cost BHs(US$)	Estimated Consumption per a.n*	Unit Cost per m^3
50	202	10,134.00	2,043,825.12	46,763.76	43.71
2,204,547.07					

(g) Estimation of water transport services

number of participating HH	number of harbour	average number of trip round	average capacity	unit price	Total number of trip p .a	Sub Total(Mk)	US$
18	3	4	12	130	340	6364800	
	3	1	15	130	80	468000	
						6,832,800.00	17,933.86
Input cost						648,000.00	1,683.12

(h) Estimation of the forage (Livestock grazing)

Type of livestock	Total number of livestock in the wetland	Daily consumption of Forage (Kg.)	Quantity (Q.) of Forage Required		Amount (Mk) (calculated from wages for labour)		
			Daily	Annual	Daily	Annual	
CATTLE	6,135.00	16.5	101,227.50	24,294,600.00	151,841.25	36,441,900.00	
GOATS	60,490.00	0.48	29,035.20	6,968,448.00	43,552.80	10,452,672.00	
SHEEP	9,288.00	0.48	4,458.24	1,069,977.60	6,687.36	1,604,966.40	
Total	75913	17.46	134,720.94	32,333,025.60	202,081.41	48,499,538.40	135,473.57

(i) Estimation of input cost of harvests and pasture

Wetland goods/services	Average time	cost of input	cost per unit	PPH	COST(Mk)	US$
ropes	2		65	2506	325,780.00	910
timber		500		3700	1,850,000.00	5,167.60
crubs	3		65	1969	383,955.00	1,072.50
bricks		15000		955	14,325,000.00	40,013.97
mice	6		65	239	93,210.00	260.36
birds		12000		1552	18,624,000.00	52,022.35
Papyrus	48		65	1074	3,350,880.00	9,360.00
firewood	42		65	5251	14,335,230.00	40,042.54
grass harvest	14		65	13128	11,946,480.00	33,370.06
pasture	1920		65	232	28,949,491.36	80,864.50

[i] Value transfer is the method used to estimate ecosystem economic values by transferring available information from a site where a study was realised to a place where the valuation has to be performed under the assumption that characteristics in both sites are similar (Figueroa and Pasten, 2010).

[ii] http://glovis.usgs.gov.

[iii] Water transport is a business service hence quantified in terms of number of trips per year

[iv] Water and pasture are not sold

[v] The lake side where water transport is conducted

[vi] The NFV of firewood is negative due to high input cost as opportunity of time spent in collecting firewood

[vii] Vegetation value = grass collection, pasture and papyrus reeds`