Nile Ecosystems Valuation for Wise Use

"Nile Eco-VWU"

RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR

Guidelines for Wetlands Ecosystems Valuation in the Nile Basin

2016

NILE BASIN CAPACITY BUILDING NETWORK

NBCBN-RE

Project: Nile Ecosystems Valuation for Wise-Use (Nile-Eco-VWU)

Wp6: Application of the economic methods and tools for ecosystems valuation on the selected case studies ad developing tradeoffs scenarios

Deliverable 6b: An Introductory Guidelines to Valuing Wetland Ecosystem Services Within the Nile Basin for Wise Use

Project Funded by:

CGIAR | RESEARCH PROGRAM ON Water, Land and Ecosystems

Summary

Economic valuation of wetland ecosystem services enhances informed public decision making concerning sustainable utilization of the ecosystem. The valuation is particularly crucial where the economic values of wetlands need to be compared directly against the monetary value of alternative public investments.

Burullus lake is one of the most vulnerable areas along the delta's, it is the second largest of the Egyptian northern lakes along the Mediterranean coast declared by Prime ministerial decree 1444 in the year 1998, a protected area. In 1998 Burullus Lake was approved as a RAMSAR site in Egypt, this report aim to clarify the main terms and methodology used by several guidelines to valuate use and non use ecosystem services, two questionnaires were prepared to conduct a new field work for further information about local communities satisfaction toward the fish capture as a market price method and bird watching as a travel cost method.

In Mara wetland, Tanzania, economic valuation of ES derived from the wetland remains limited despite the fact that the wetland has been expanding landward over the last five decades. This study reviewed different economic valuation tools used in estimating economic values of wetlands, their limitations and selected the appropriate methods applicable in the case of the Mara wetland. In this case, market price-based methods were used to estimate their values. Other provisioning ES such as water and pasture for livestock however, are not for sale. The monetary values of water and livestock's pasture were estimated by group valuation method through an FGD consisting of 23 people utilizing the services. Water purification ES of the wetland though assessed in this study was not valued directly to avoid double counting of the service. The willingness to pay for the water provision captures both water quality and quantity. The current (2015/2016) annual total economic value of Mara wetland in terms of provisioning and water purification ES is TZS 39,877,804.22 (USD18, 453.40) of which crop production contributes the highest (47%) value of the TEV while thatching grass contributes the lowest (0.1%).

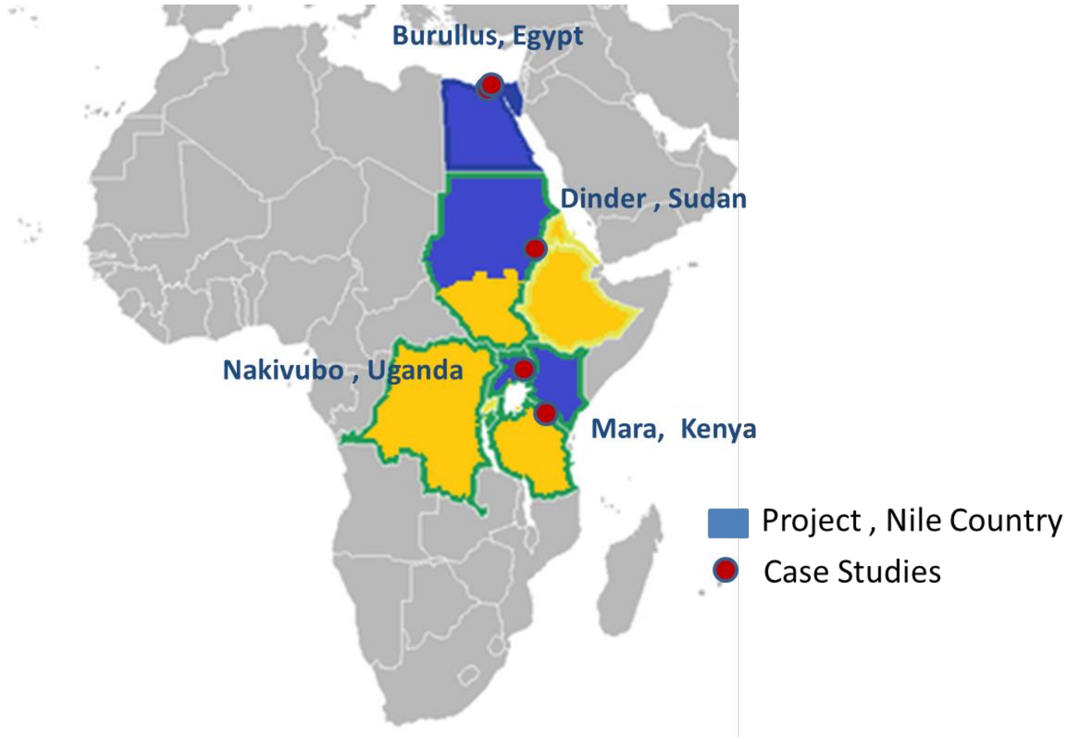
The dinder park of Sudan was declared a National Park at 1935, as Biosphere reserve at 1979 and was designated as Wetland of International Importance (Ramsar site) in 2005. The economic evaluation methods are mainly by direct use and market prices. The Total Economic Value (TEV) produced as result is (92944.22 USD) The economic importance of the wetlands is definite and this TEV is still limited if compared to the real benefits from the different Dinder wetland' ecosystems.

In Nakivubo wetland, Uganda the direct use value of the main provisioning services of the Nakivubo wetland Local Communities (one household per hectare per year) is worth about 8,951,809.11Uganda Shillings ($14,833.88).

Acknowledgment

NBCBN as the Nile-ECO-VWU project coordinator organised the closing workshop and final working meeting for the project partners in the period from 20th to 21st December 2016, Cairo, Egypt.

During this event the project partners and research groups presented and discussed the project results of the four case studies and the two important deliverables: the guidelines report and the gender report. Trade-off scenarios of the different ecosystems services in the four pilot areas were also presented and discussed for ecosystems wise use recommendations in the Nile basin. The project teams also had a discussion on the dissemination of the project communication developed tools and the future extended research questions and the possible future research activities and capacity building events that can be based on the project outputs.



Forward

The articles and pictures in this magazine came from the Nile Eco-VWU Project which focused on developing and testing integrated tools for wetland ecosystem services, valuation, and assessment that can be applied at local and regional scales within the Nile Basin.

It was guided by the methodology of the Economics of Ecosystems and Biodiversity Reports (http://www.teebweb.org/areas-of-work/biome-studies/teeb-for- water-and-wetlands), and those of the Wet-Health (www.wrc.org.za) and TESSA toolkit for rapid assessment of wetlands of biodiversity conservation importance.

The project reviewed and apply appropriate ecosystem assessment and economic methods to support local and regional understanding and decision making for wetland management. This provided a more evidence-based policy and management method to evaluate tradeoffs of different ecosystems services in relation to agricultural, urban and infrastructural development.

Better understanding of the consequences of decisions related to ecosystem services will help optimize wetland use for Total Economic Value (TEV), to ultimately contribute to better livelihoods of local communities dependent on wetlands, as well as local and regional policy making and implementation.

Case studies will play a major role in the project implementation by providing direct interaction with stakeholders and next users, highlighting the needs for improvement of the existing management tools, and challenging the application of the economic valuation of wetland services for better livelihoods.

Each of the selected case studies represented a specific type of wetland and specific climatic, hydrological and environmental characteristics, and has a specific contribution to the project based on the different existing ecosystem services, but all the pilot areas shared common objectives to allow comparison across current existing services, challenges and applied economic tools for better decision making. Four case studies were considered in this project:

- Burullus Lake, Egypt ;
- Dinder Wetland, Sudan
- Mara Wetland, Kenya-Tanzania;
- Nakivubo Wetland, Uganda.

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1. Introduction

Wetlands are known to be one of the most productive and biologically rich Ecosystems (Richardson, 1995), they work as natural infrastructure and networks of natural ecosystems that deliver a range of important ecosystem services (Krchnak et al., 2011), some wetlands might have many direct values/benefits such as wild fish and other aquatic animals and plants while other wetlands might have significant indirect values/benifits such as flood control, water purification and biodiversity, providing many non-marketed and marketed benefits to people (MA).

A Convention on Wetlands of International Importance (1977), called the Ramsar Convention, has a mission of "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world", the Convention has recognized the importance of applying wetland valuation in ensuring appropriate decision-making in relation to Environmental Impact Assessment, thus it aims to clarify the importance of wetlands as their values are often not taken into account properly or fully in decision making, or are only partially valued, often leading to degradation or even destruction of a wetland. (M. S. Rudolf de Groot).

The wetlands ecosystem services was identified in alleviation four broad categories of ecosystem services: provisioning services, regulating services, cultural services, supporting services (MA), and some guidelines have been adopted for identification the concept of wetlands valuation and the methodology for calculation of the use and non-use value of their ecosystem services.

The methodologies of economic valuation such as travel costs, hedonic prices, stated preferences, contingent valuation, etc. use information on related goods that do have markets or that is obtained from specially designed surveys applied directly to those from whom we are interested in revealing or determining their valuations. The technique to be used in each case depends on the type of ecosystem good or service we want to valuate and the type of contribution it makes to the wellbeing of individuals or society. Examples of applications of these methodologies have been growing in the last decades both in developed and developing countries (Bateman, 1999; Bateman and Willis, 1999).

This research aims to raising the national stakeholder's awareness of economic value of ecosystem activities in Burullus Lake as one of Ramsar sites that have international important for migratory water birds breeding, the research followed a guideline steps toward valuation of the lake ecosystem services. First, an overview of the main definitions and indicators that clarify the concept of valuation of wetlands. Second, a brief summery on the methodology used for assisting the valuation of wetlands ecosystem services. Third, assessing the case study of ecosystem services of Burullus lake. Finally, recommendations was stated to be taken into consideration by stakeholder for better assessment of ecosystem services.

2. Definitions and Indicators

Ramsar Convention, aims to develop national wetland policies, to include wetland conservation considerations within their national land-use planning, to develop integrated catchment management plans and, in particular, to adopt and apply the guidelines for implementation of the Wise Use Concept, which is the sustainable utilisation of wetlands for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem, through which several definations and methedologies were introduced by numbers of guide lines for indentification of the wet land value, the main guide lines can be identified as shown in .

Table 2 A Brief Review of the Wetland Valution Guideline

Guideline	Year /Author	Purpose
A guide to policy makers and planners on the potential for economic valuation of wetlands and how such valuation studies should be conducted	1997 Edward B Barbier, Mike Acreman and Duncan Knowler, Gland, Switzerland	promote the economic valuation of wetland benefits and functions through dissemination of valuation methods
A guide for incorporating biodiversity-related issues into environmental impact assessment legislation and/or processes and in strategic environmental assessment'	2001 Convention on Biological Diversity (CBD)	support defining and reporting on the ecological character of wetlands
Millennium Ecosystem Assessment Panel (MA)	2003 C. Max Finlayson, Rebecca D'Cruz, Nick Davidson	Conduct the maintenance and delivery of ecosystem services to human well-being and poverty reduction through maintenance of the ecological character of wetlands
A guidance on "evaluating the values and functions, goods and services provided by wetlands"	2006 Rudolf de Groot and Mishka Stuip of Wageningen University and the Foundation for Sustainable Development (FSD) in the Netherlands.	Stress the importance of fully involving the various different types of stake holders throughout wetland valuations
TEEB Ecological and Economic Foundations	2010 Rudolf de Groot, Brendan Fisher, Mike Christie	Link economics and ecology, to highlight the relationship between biodiversity and ecosystem services to show their importance for human well-being, as to quantify the costs of inaction and examine the macroeconomic dimension of ecosystem services loss

2.1 Definitions

A number of different definitions for valuation of ecosystem services of wetlands have been developed and adopted through number of initiatives including the following:

Wetlands: areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres" Ramsar Convention (Article 1.1).

The components: of the system are the biotic and non-biotic features which include the soil, water, plants and animals. The interactions between the components express themselves as **functions**, including nutrient cycling and exchange of water between the surface and the groundwater and the surface and the atmosphere. The system also has attributes, such as the diversity of species. (Edward B Barbier, 1997)

An ecosystem: can be defined at the most basic level as a natural unit of living things (animals, plants and micro-organisms) and their physical environment, see Figure 1. The living and non-living elements function together as an interdependent system – if one part is damaged it can have an impact on the whole system. Ecosystems can be terrestrial or marine, inland or coastal, rural or urban. They can also vary in scale from the global to the local. At the continental level examples include rainforests, deserts and coral reefs. Closer to home we might think more in terms of different types of habitats (e.g. woodlands, grassland, marshes, heathland, rivers, peat bogs) though this can also extend to the urban environment (e.g. parks and gardens, rivers and streams). In many cases, ecosystems overlap and interact.

Ecosystem services: is defined as "the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits." (As defined by the MA, 2005), another definition of the ecosystem functions is 'the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly' (De Groot, 1992).

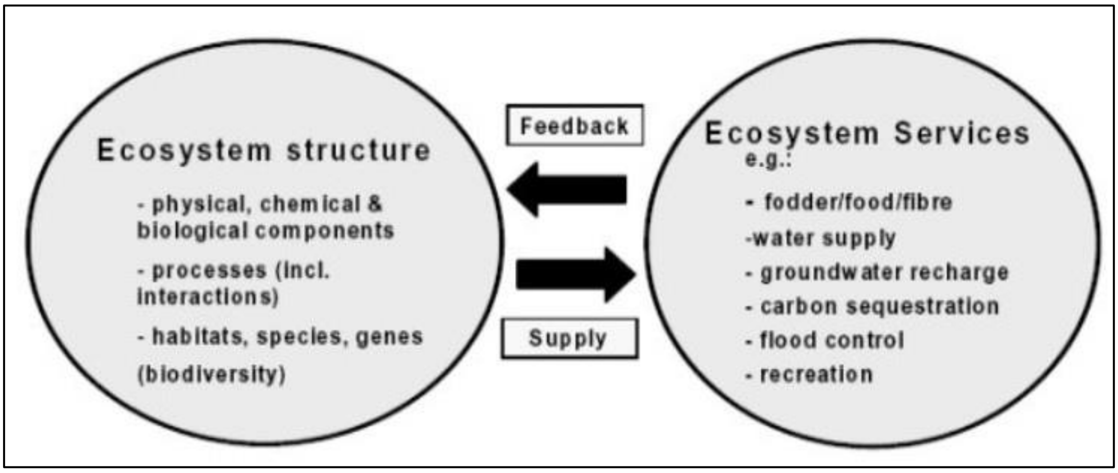


Figure 1 Millennium Ecosystem Assessment's description of "ecosystems”

Ecological character: is the combination of the ecosystem components, processes and services that characterise the wetland at a given point in time.

Wise use of wetlands: is the maintenance of their ecological character within the context of sustainable development, achieved through the implementation of ecosystem approaches.

Value: is defined by the Millennium Ecosystem Assessment (2003) as “The contribution of an action or object to user-specified goals, objectives, or conditions”.

Three definitions of value roughly coincide with the interpretation of the term value by the three main scientific disciplines involved in ecosystem valuation mentioned in (M. S. Rudolf de Groot).

a) **Economics**, which is mainly concerned with measuring the exchange value or price to maintain a system or its attributes (Bingham et al. 1995)
b) **Ecology**, which measures the role (importance) of attributes or functions of a system to maintain ecosystem resilience and health (Bingham et al. 1995)
c) **Sociology**, which tries to find measures for moral assessments (Barry & Oelschlaeger 1996).

Direct use values: are derived from ecosystem services that are used directly by humans. They include the value of consumptive uses such as harvesting of food products, timber for fuel or construction, medicinal products, and hunting of animals for consumption as well as the value of non-consumptive uses such as the enjoyment of recreational and cultural amenities like wildlife and bird watching, water sports, and spiritual and social services that do not require harvesting of products. Direct use values correspond broadly to the MA’s definition of provisioning and cultural services. They are typically enjoyed by people located in the ecosystem itself.

Indirect use values: are derived from ecosystem services that provide benefits outside the ecosystem itself. Examples include the natural water filtration function of wetlands, which often benefits people far downstream; the storm protection function of coastal mangrove forests, which benefits coastal properties and infrastructure; and carbon sequestration, which benefits the entire global community by reducing climate change. This category of benefits corresponds broadly to the MA's notion of regulating and supporting services.

Option values are derived from preserving the option to use in the future services that may not be used at present, either by oneself (option value) or by others or heirs (bequest value). Provisioning, regulating, and cultural services may all form part of option value to the extent that they are not used now but may be used in the future.

Non-use values refer to the value people may place on knowing that a resource exists even if they never use that resource directly. This kind of value is usually known as existence value (or, sometimes, passive use value). This is one area of partial overlap with non-utilitarian sources of value as shown in Table 3.

Table 3 The Wetland Total Valuation Components

Use values	Direct use value (DV)	Refers to values associated with direct consumption (physical use of resources) or the values related to the production of market goods, such as wood used for fuel and building purposes, fish capture, timber and recreation.
	Indirect use value (ID)	Refers to values provided by the underlying functions of the ecosystem (e.g., flood prevention, water purification, climate regulation or maintenance of biodiversity carbon sequestration, water quality attenuation and supply).
Non-use values	Existence value (EV)	Refer to intrinsic worth, regardless of use such as biodiversity, landscape, aesthetic, heritage, bequest and culture (IUCN, 2006). Thus can be found when people are willing to make economic sacrifices to preserve a healthy environment regardless of whether they themselves are using or visiting this particular environment (e.g., biodiversity, landscape, aesthetic, heritage, bequest and culture) (IUCN, 2006).
	Passive use	Value can be found when people are willing to make economic sacrifices to preserve an environment that they may consider using or visiting in the future.
	Bequest value	Refers to the values associated with preserving a healthy Environment for Future generations for all services (including Supporting services).
Total Economic Value (TEV) = DV + IV+ OV + EV		

Economic Value of Wetlands

The economic value of wetland eco-systems can be divided into four categories based on the benefits/functions/services provided by the ecosystem: direct (DV), indirect (IV), option (OV) and existence (EV) values, where the Total Economic Value (TEV) = DV + IV+ OV + EV

However, most policy makers/planners consider only the direct value of ecosystems and neglect the other values which leads to an underestimation of the true economic value of the wetland. This is one of the factors that has the lead to the loss of wetlands in many developing countries, (MA).

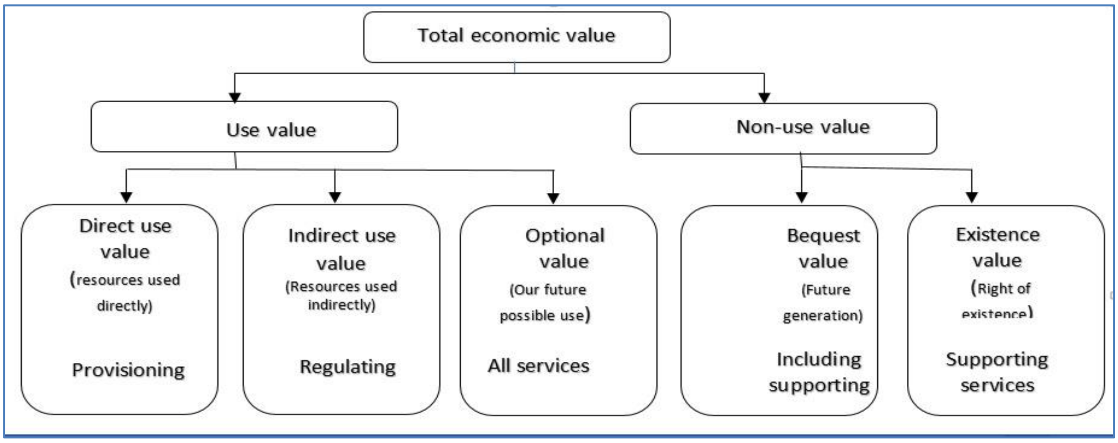


Figure 2: Total Economic Value Framework (MA)

Clearly delineating between ecological phenomena (functions), their direct and indirect contribution to human welfare (services), and the welfare gains they generate (benefits) is useful in avoiding the problem of double counting that may arise due to the fact that some services (in particular supporting and regulating services) are inputs to the production of others (Boyd and Banzhaf 2007; Wallace 2008; Fisher and Turner 2008; Balmford et al. 2008), Such differentiation is also crucial to provide a clear understanding of the spatial distribution of where the function occurs, where the provision of the service can be assessed, and ultimately where the benefits are appreciated. Although the distinction between functions, services and benefits is important, especially for economic valuation, it often is not possible to make a fully consistent classification, especially for regulating services (B. F. Rudolf de Groot).

2.2 Indicators

Indicators are “easily observed characteristics that are correlated with quantitative or qualitative observations of a function” and “reflect the capacity and opportunity that a wetland has to perform functions” (Hruby, 2006) mentioned in (Galbraith, 2010), but it is difficult (and sometimes impossible) to actually measure the exact degree to which a given wetland performs functions and services, so the level of functions and services provided is approximated by indicators., A guidance on “evaluating the values and functions, goods and services provided by wetlands” Ramsar convention 2006 set the following Table 4 The Advantages and Disadvantages of Market Price Methiod shows the indicators for determining (sustainable) use of wetland services (Rudolf de Groot M. S., 2006).

Table 4 The Advantages and Disadvantages of Market Price Methiod

Services	Ecological process	Indicator	Performance indicator
Provisioning			
Food: production of fish, algae and invertebrates	Presence of edible plants and animals	Total or average stock in kg	Net productivity (in Kcal/ year or other unit)
Fresh water: storage and retention of water; provision of water for irrigation and for drinking	-Precipitation or surface water inflow. -biotic and abiotic processes that influence water quality (see water purification)	-Water quantity (in m^3) -Water quality related to the use (conc. of nutrients, metals, etc.)	Net water inflow (m^3/year) (i.e., water inflow minus water used by the ecosystem and other water needs)
Fiber & fuel & other raw materials: production of timber, fuel wood, peat, fodder, aggregates	Presence of species or abiotic components with potential use for fuel or raw material	Total biomass (kg/ha)	Net productivity (kg/year)
Biochemical products and medicinal resources	Presence of species or abiotic components with potentially useful chemicals and/or medicinal use	Total amount of useful substances that can be extracted (kg/ha)	Maximum sustainable harvest
Genetic materials: genes for resistance to plant pathogens	Presence of species with (potential) useful genetic material	Total “gene bank” value (e.g., number of species & subspecies)	Maximum sustainable harvest
Ornamental species: e.g., aquarium fish and plants	Presence of species or abiotic resources with ornamental use	Total biomass (kg/ha)	Maximum sustainable harvest
Regulating			
Air quality regulation: e.g., capturing dust particles	Capacity of ecosystems to extract aerosols & chemicals from the atmosphere	Leaf area index, NOx-fixation, etc.	Amount of aerosols or chemicals “extracted” - effect on air quality
Climate	Influence of	Greenhouse gas-	Quantity of

Services	Ecological process	Indicator	Performance indicator
regulation: regulation of greenhouse gases, temperature, precipitation, and other climatic processes	ecosystems on local and global climate through land-cover and biologically-mediated processes	balance (esp. C-fix), DMS production, Land cover characteristics, etc.	greenhouse gases, etc., fixed and/or emitted - effect on climate parameters
Hydrological regimes: groundwater recharge/ discharge; storage of water for agriculture or industry	Role of ecosystems (especially forests and wetlands) in capturing and gradual release of water	Water storage capacity in vegetation, soil, etc., or at the surface	Quantity of water stored and influence of hydrological regime (e.g., irrigation)
Pollution control & detoxification: retention, recovery and removal of excess nutrients/ pollutants	Role of biota and abiotic processes in removal or breakdown of organic matter xenic nutrients and compounds	Denitrification (kg N/ha/y), Accumulation in plants, - Kg –BOD /ha/y, chelation (metal binding)	Maximum amount of waste that can be recycled or immobilized on a sustainable basis; influence on water or soil quality
Erosion protection: retention of soils	Role of vegetation and biota in soil retention	Vegetation cover, root matrix, etc.	Amount of soil retained or sediment captured
Natural hazard mitigation: flood control, storm & coastal protection	Role of ecosystems in dampening extreme events (e.g., protection by mangroves and coral reefs against damage from hurricanes)	Water storage (buffer) capacity in m^3; ecosystem structure characteristics	Reduction of flood danger and prevented damage to infrastructure
Biological Regulation: e.g., control of pest species and pollination	Population control through trophic relation; role of biota in distribution, abundance and effectiveness of pollinators	Number & impact of pest control species; number & impact of pollinating species	Reduction of human diseases, livestock pests, etc.; dependence of crops on natural pollination
Cultural & amenity			
Cultural heritage and identity: sense of place	Culturally important landscape features	Presence of culturally important landscape features	Number of people “using” ecosystems for cultural heritage

Services	Ecological process	Indicator	Performance indicator
and belonging	or species	or species (e.g., No. of WHS)	and identity
Spiritual & artistic inspiration: nature as a source of inspiration for art and religion	Landscape features or species with inspirational value to human arts and religious expressions	Presence of landscape features or species with inspirational value	Number of people who attach religious significance to ecosystems; number of books, paintings, etc., using ecosystems as inspiration
Recreational: opportunities for tourism and recreational activities	Landscape features; attractive wildlife	Presence of landscape & wildlife features with stated recreational value	Maximum sustainable number of people & facilities; actual use
Aesthetic: appreciation of natural scenery (other than through deliberate recreational activities)	Aesthetic quality of the landscape, based on e.g. structural diversity, "greenness", tranquillity	Presence of landscape features with stated appreciation	Expressed aesthetic value, e.g., number of houses bordering natural areas; number of users of "scenic routes"
Educational: opportunities for formal, informal education/training	Features with special educational and scientific value/ interest	Presence of features with special educational and scientific value/ interest	Number of classes visiting; number of scientific studies, etc.
Supporting			
Biodiversity & nursery: Habitats for resident or transient species	Importance of ecosystems to provide breeding, feeding or resting habitat to resident or migratory species (maintain certain ecological balance, evolutionary processes)	Number of resident, endemic species, habitat integrity, minimum critical surface area, etc.	"Ecological Value" (i.e., difference between actual and potential biodiversity value); dependence of species or other ecosystems on the study area
Soil formation: sediment retention, accumulation of	Role of species or ecosystem in soil formation	Amount of top soil formed (ha/year)	These services cannot be used directly but provide the basis for most

Services	Ecological process	Indicator	Performance indicator
organic matter			other services, especially erosion protection and waste treatment
Nutrient cycling: storage, recycling, processing and acquisition of nutrients	Role of species, ecosystem or landscape in biogeochemical cycles	Amount of nutrients (re-cycled (ha/year)	

3. A Review of Ecosystem Valuation Methods

There are several methods for valuating ecosystems. Each one has strengths and weaknesses, and certain methods are most appropriate for specific situations depending on the type of information that is desired. There are different methodologies to economically valuing goods and services provided by ecosystems in general and wetland's ecosystems in particular. All of them differ in its validity for the case at hand, their theoretical underpinning and their informational requirements and feasibility (Bishop, 1999), choosing an appropriate methodology for wetland valuation should be based on three factors as follows (Kyophilavong, march 2011).

- Time and cost for study
- Capacity and experiences of those carrying out the study
- Information and characteristics of wetland

Number of different methods were developed for Economic valuation of ecosystems undertaking different aspects and purposes of wetland valuation. In order to assist Contracting Parties in having economic valuation information better available for decision-making on wetlands, Monetary or financial valuation methods fall into three basic types, each with its own repertoire of associated measurement issues (M. S. Rudolf de Groot):

- Direct market valuation
- Indirect market valuation
- Survey-based valuation (i.e., contingent valuation and group valuation)

Revealed and Stated preference Approaches

For both revealed and stated preference methods of ecosystem valuation it is essential to understand the differences between **willingness to pay** and **willingness to accept**. The difference is that willingness to pay is how much a person is willing to pay for a small improvement in environmental quality, and willingness to accept is how much a person is willing to accept for a small reduction in environmental quality (Field, 2002). A major difference is that willingness to pay is limited by income, but willingness to accept has no limitations as shown in Table 5**.**

Table 5 The Differnces between Revealed and Staed Prefernces Approaches

Revealed preference approaches	Stated preference approaches
Extrapolate the individual's willingness to pay or except by examining the choices that he or she makes within a market. The choices are distinguishable only the quality of the environment or by the goods and services that the ecosystem provides, hence the different choices reveal the value of those attributes.	survey individuals to find out what they state as their value of the ecosystem attributes, good, and services. The most common measures of value in the stated preference approach are willingness to pay and willingness to accept.
Market price method Productivity methods Hedonic pricing method Cost method (Travel cost method, Substitute cost method, Replacement cost method, and Damage cost avoidance method).	Contingent Valuation Method Conjoint Analysis Contingent choice method

A summary of each method from Revealed and Stated Preference approaches is necessary to be well understood for choosing the suitable method in evaluating the lake ecosystem services.

3.1. Ecosystem Approaches

3.1.1. Value contribution based approach

Value contribution based approach measures economic value of a good/service based on its contribution in terms of increased profits or reduced cost, with available market information. The approach mainly includes market based methods such as price-based, cost-based and production-based. The main advantage of using market based approaches is that they use data from actual markets, and thus reflect actual preferences or costs to individuals (Pascual *et al.*, 2010). In addition, such data i.e. prices, quantities and costs exist and thus are relatively easy to obtain.

3.1.2. Preference based approach

It measures economic value by people's willingness To Pay for goods/services (or willingness To Accept for bad usage/dis-services). This approach entails two methods: revealed preference methods (e.g. hedonic pricing and travel cost), and stated preference methods (e.g. contingent valuation and choice modelling).

3.1.3. Benefit transfer

It refers to the practice of using values estimated for an alternative policy context or site as a basis for estimating a value for the policy context or site in question (Brouwer, 2000). In some cases, it may be possible to apply the findings of other studies of similar areas to the area under consideration for which primary valuation estimates are unavailable (Johnston and Rosenberger, 2010). This method is only applicable if a study already exists that valued an ES similar to the one in question (Turpie*et al.*, 2010). The assumption is that the existing or adjusted estimate of economic value may be used as an approximation of the economic value of the ES in question. The advantages of the benefits transfer approach include: economic benefits which can be obtained more quickly by undertaking primary research, it is noticeably cheaper, flexible and estimate both use and non-use value of non-market ES if similar studies are available (Turpie*et al.*, 2010).

The benefit transfer method constitute 3 approaches; transferring mean unit values, transferring adjusted unit values and transferring the demand function (Georgiou *et al.*, 1997). Transferring mean unit values approach assumes that well-being experienced due to an ES at one site is the same in the next one. However, the problem is that at the new site, individuals may not have the same preferences. In the case of transferring adjusted unit values, the mean unit values obtained at a different site are adjusted to meet the needs of the new site. Potential differences that may be considered include variability in socio-economic characteristics of individuals, environmental change, and availability of substitute ES. Generally, the unit value transfer method is most suitable when the context of the study is similar or is in close proximity to the policy sites. This ensures that the economic value from one study site can be easily projected unit by unit to a policy site (Rusche, 2013). When the context of the study site varies from the one of the policy site, function transfer may increase the reliability of the benefit transfer. Depending on the specific features of the new site, the economic value of the ES in the study site may be altered particularly when the factors affecting the WTP e.g. socio-economic characteristics are known. The entire demand function estimated at existing sites could then be transferred to the new site. The general consensus in literature is that function transfers are typically more accurate than unit value transfers (Johnston and Rosenberger, 2010) despite the fact that inconclusive or contrary findings have been reported (Brouwer, 2000). However, both unit and value transfer methods are subject to two categories of errors: measurements errors; generated from the original study, and generalization or transfer errors which occur when estimates from study sites are adapted to policy sites especially, when the two sites are not similar in features (Rosenberger and Phipps, 2007).

3.2. Ecosystem Valuation Methods (Applications, Advantages and Limitations)

3.2.1. Contingent Valuation Method

The contingent valuation method (CVM) is a survey technique using direct questioning of individuals to generate estimates of individuals' willingness to pay for something they value ((Edward B Barbier, 1997), in some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services as it is based on asking people questions, as opposed to observing their actual behaviour, is the source of enormous controversy. The conceptual, empirical, and practical problems associated with developing dollar estimates of economic value on the basis of how people respond to hypothetical questions about hypothetical market situations are debated constantly in the economics literature.

Contingent Valuation Method (CVM) is one of the most popular non-market based approaches to valuation. Implementation of the CVM requires the construction of hypothetical market that contains a description of the proposed policy/development that will be effected the wetland resource.

It directly obtains consumers' Willingness To Pay (or Willingness To Accept) for a change in the level of an environmental good, based on a hypothetical market. The most common means of estimating economic value of an ES using CVM is to state a hypothetical market for an environmental good, and ask consumers (through surveys, questionnaires or experimental techniques) to state their maximum willingness to pay to realize an improvement or maintenance in the quality of that environmental good, or their minimum willingness to accept compensation for deterioration in the quality or loss of the ES. The method has mostly been used to value cultural ES, recreation, in temperate wetlands (Barbier *et al.*, 1997). Though CVM can be used for both use and non-use values of a wide range of non-market goods and services including changes yet to be experienced, it remains partly a controversial technique (Turpie *et al.*, 2010). This is attributed to the biases that arise as a result of relying on direct questioning rather than observing people's actual behaviour. The limitations of this method include;

- Controversy over whether people would actually pay the amounts they state in the interviews.
- The outcome of the exercise based on the CVM may be susceptible to biases:
  - Biases due to divergence between the intended import (of the evaluator) and received import (by the respondents) of the hypothetical scenario put up in the survey.
  - Biases due to association of different scenarios with the one put up by theevaluator before the respondents, once the evaluator puts up a scenariobefore the respondent, it may invoke other scenarios in the minds of therespondents inhibiting or promoting/boosting up the

appreciation of the evaluator's scenario. This may lead to biased responses.

- Evaluator's scenario may invoke 'warm glow' effect – feeling good to pay for the public good, or it may dampen the actual response due to political biases evoked by the scenario.
- Biases due to casual dealing of the respondents with the whole exercise of the survey
- If people are first asked for their Willingness ToPay for one part of the environmental asset and then asked to value the whole asset, the amounts stated may be similar. This is referred to as the "embedding effect." Due to this effect, the responses are biased.
- Strategic bias -when the respondent provides a biased answer in order to influence a particular outcome.
- Information bias which arises when people have to express their opinion of something which they do not know properly.

In order to minimize the biases in CVM, guidelines for its application were formulated by an American National Oceanic and Atmosphere Administration (NOAA) panel (Arrow *et al.*, 1993).Thus, if used properly in such a way that itminimises bias, it is deemed an acceptable method of measuring economic value of ES. The guidelines includedto implement it are:

1. For a single dichotomous choice question (yes-no type) format, a total sample size of at least 1000 respondents is required.
2. High non-response rates would render the survey unreliable.
3. Face-to-face interviewing is likely to yield the most reliable results.
4. Full reporting of data and questionnaires is required for good practice.
5. Pilot surveying and pretesting are essential elements in any CVM study.
6. A conservative design is more likely to underestimate Willingness To Pay is preferred than one likely to overestimate it.
7. A Willingness To Pay (WTP) format is preferred to Willingness To Accept (WTA).
8. The valuation question should be specific and posed as a referendum-type (yes-no) question, rather than open ended.
9. Accurate information on the valuation situation must be presented to respondents, with particular care needed over the use of photographs.
10. Respondents must be reminded of the status of any undamaged possible substitute commodities.
11. Time-dependent measurement noise should be reduced by averaging across independently-drawn samples taken at different points in time.
12. A 'no-answer' option should be explicitly allowed in addition to the 'yes' and 'no' vote options on the main valuation question.
13. Yes and no responses should be followed up by the open-ended question: 'why did you vote yes or no?'
14. On cross-tabulations, the survey should include a variety of other questions that help to interpret the responses to the primary valuation question, i.e. income, distance to the site, prior knowledge of the site, etc.

15. Respondents must be reminded of alternative expenditure possibilities, especially when ‘warm glow’ effects are likely to be present.

Applications

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. These values are sometimes referred to as “passive use” values. They include everything from the basic life support functions associated with ecosystem health or biodiversity, to the enjoyment of a scenic vista or a wilderness experience, to appreciating the option to fish or bird watch in the future. So, it is the most widely used method for estimating non-use values. It is also the most controversial of the non-market valuation methods, shows the advantages and disadvantages of this method.

Table 6 Advantages and disadvantages of Contingent Valuation Method (CVM)

Advantages	Disadvantages
▪ **Do not rely on markets and can be used for any situation, good or service** ▪ **Places value on non-market goods and services.** ▪ **Estimate both use and non-use values.** ▪ **Used to estimate economic values for all kind of ecosystem and environmental services.**	▪ Large and costly surveys ▪ Large data sets ▪ Sophisticated analysis techniques ▪ Based on hypothetical situation ▪ Many economists, psychologists and sociologists, for many different reasons, do not believe the dollar estimates that result from CV are valid. ▪ Many jurists and policy-makers will not accept the results of CV.

3.2.2. Conjoint Analysis

Determine specific preferences between different levels of characteristics of an ecosystem attribute. It allows individuals to choose between two hypothetical environments, plots of land, or houses, etc. based on a list of characteristics that distinguish them from each other based on a ranking system of each attribute. This method allows for the researchers to see which of the two choices teach respondent prefers, and it shows which characteristics they value the most. An example of this could be two different pieces on land for sale on a lake. A list of characteristics of the properties could include differences in water quality, air quality, and soil fertility, animals that inhabit the area, the different types of trees, and so forth. The respondent would choose which piece of property he or she preferred along with a ranking of the attributes that led to the decision of preference.

Conjoint analysis will also allow policy makers to see a ranked order of which environmental issues the community believes to be the most imminent. This would be an excellent guide to the order that the issues should be addressed. It will give government officials an itinerary of environmental issues, and it will let them know what the community values most.

3.2.3. Market Price-based Methods

The market price method uses the prices of goods and services that are bought and sold in commercial markets to determine the value of an ecosystem service. This method values changes in either quantity or quality of a good or service. By measuring the change in producer and consumer surplus after the application of a change in production or price, the value can be determined.

This method uses questionnaires to collect data about the market price of buying and selling wetland goods, the standard method for measuring the use value of resources traded in the market place is the estimation of consumer surplus (The difference between the price actually paid for a good, and the maximum amount that an individual is willing to pay for it) and producer surplus (The difference between the total amount earned from a good - price times quantity sold - and the production cost), thus consumer surplus is measured by the maximum amount that people are willing to pay for a good, minus what they actually pay. Similarly, producer surplus is measured by the difference between the total revenues earned from a good, and the total variable costs of producing it.

The total net economic benefit, or economic surplus, is the sum of consumer surplus and producer surplus, a demand function must be estimated to determine a producer and consumer surplus, and then the standard market price must be subtracted from the level demanded.

Applications of the Market Price Method

The market price method uses prevailing prices for goods and services traded in markets, such as fish, timber, or fuel wood or fish sold commercially, this method only takes into account use-values and marketed goods or services that have an actual price. (Kahn, 1998), as it represents the value of an additional unit of that good or service, assuming the good is sold through a perfectly competitive market (that is, a market where there is full information, identical products being sold and no taxes or subsidies), Table 7 The Advantages and Disadvantages of Market Price Method shows the advantages and disadvantages of this method.

Table 7 The Advantages and Disadvantages of Market Price Method

Advantages	Disadvantages
▪ **Simplest and most straight forward way of finding out the value of wetland goods.** ▪ **Reflects an individual's willingness to pay for costs and benefits of goods that are bought and sold in markets. Thus, people's values**	▪ May only be available for a limited number of goods and services provided by an ecological resource and may not reflect the value of all productive uses of a resource. ▪ The true economic value of goods or services may not be fully reflected in market transactions, due

Advantages	Disadvantages
are likely to be well-defined. ▪ **Price, quantity and cost data are relatively easy to obtain for established markets.** ▪ **Uses observed data of actual consumer preferences.** ▪ **Uses standard, accepted economic techniques.**	to market imperfections and/or policy failures. ▪ Seasonal variations and other effects on price must be considered. ▪ Cannot be easily used to measure the value of larger scale changes that are likely to affect the supply of or demand for a good or service. ▪ Usually, do not deduct the market value of other resources used to bring ecosystem products to market, and thus may overstate benefits.

3.2.4. Cost-based Methods

The methods are based on estimations of the costs that would be incurred if the ES needed are to be recreated through artificial means or replaced with man-made infrastructure. Costs related to the provision of the goods or services directly observed in actual markets can be used as a measure of the value of the ES. The method entails: (a) the avoided damage cost method, which relates to the costs that would have been incurred in the absence of ES, (b) replacement cost method, which estimates the costs incurred by replacing ES with artificial technologies, and (c) mitigation or restoration cost method, which refers to the cost of mitigating the effects caused by to the loss of ES or the cost of getting those services restored (Pascual et al., 2010). According to Brander et al. (2013) the most common method used to estimate the value of regulating ES such as flood attenuation and water purification has been the estimate to cost of replacing the service with man-made infrastructure. For instance, the flood attenuation ES by a wetland may be valued as the cost of constructing flood control measures that provide the same level of protection. The ES can also be valued by estimating the flooding damage cost as the value of wetland for preventing/mitigating floods. However, the avoided damage cost method has been used in a small number of cases (Brander et al., 2013). Water purification ES by a wetland may be estimated as the cost of equivalent water treatment methods such as replacement cost method, or avoided damage cost method through estimating the people's health costs (De Groot et al., 2006). The replacement cost however as noted by Anderson and Rockel (1991) is an upper bound on the true value since the stakeholders may not choose to actually use that alternative considered. In addition, Brander et al., 2013 noted that the cost-based valuation methods used to estimate the value of wetland regulating ES do not all have sound basis on economic welfare theory. For example, using replacement or avoided damage costs methods, implies that the costs are reasonable approximation of the benefits that society attributes to the resources in question. The underlying assumption, which may not always be reasonable, is that the benefits are at least as great as the costs involved in repairing, avoiding or compensating for damage. These methods are widely applied due to the relative ease of estimation, relatively short timeframe requirement and availability of data, but it is important to be aware of the limitations in terms of the information they convey with respect to economic benefits. The limitations of the cost-based methods include:

- Being applicable only where wetland-related ES can be replaced or restored by market goods or damage loss can be estimated with market information.

- Non-use value cannot be estimated using the method.
- Provide a lower bound estimate of the TEV.

3.2.5. Production Function (PF) or Net Factor Income (NFI) Method

This method estimates how much a given ES (e.g., regulating service) contributes to the delivery of another service which is traded on an existing market.The value of an ES is reflected by its contribution to enhanced income or productivity of marketed goods (Barbier, 2007). A production function indicates the contribution of these inputs to the output and from this information one may deduce the benefit due to these inputs. This method has mainly been used for valuing water supply as an input to agriculture (Brander et al., 2013). In some instances, PF was used to value fisheries improvement as a result of water quality enhancement (De Groot, 2006). The PF method consists of two-step procedure (Barbier, 1994).The first step is to determine the impacts of changes in ES on an economic activity. In the second step, the effect of these changes is valued in terms of the corresponding change in marketed output of the traded activity. A distinction should then be made between the gross value of output and the value of the marginal product of the input. Therefore, the PF approach generally uses cause-effect relationships between the ES being valued and the output level of marketed goods. As Barbier et al. (2009) noted, the PF function approach is applicable where there is sufficient scientific knowledge of how the ES link to enhanced economic activities. The limitations of the method include;

- Not all environmental goods/services are related to the production of marketed goods.
- Difficulty in assessing the production-service (or cause-effect) relationship, due to scientific uncertainty and lack of data.
- Difficult to apply if the changes in the availability, quantity and quality of environmental goods/services affect the market price of the final good, or the prices of any other inputs.
- Difficulty in specifying and estimating production function.
- The concept of production function presumes optimal utilization of inputs, which, in the real life is not always feasible.
- Considerable data requirement on market price, output, demand and production inputs
- Double counting of benefits is a common pitfall

3.2.6. Group Valuation Method

The group valuation method is the same as CVM but involves group deliberation (De Groot *et al*., 2006). The group CVM is based on the assumption that the valuation of ES should be as a product of an open public deliberation process, not from the assemblage of separately measured individual preferences. In this approach, small groups of people utilizing the ES are brought together in a less rigorous forum with an explicit intention of deriving a monetary value of the ES in question through discussions and consensus building. The end result is a deliberative "group" CVM process. According to De Groot *et al*. (2006) the bias in a group CVM is thought to be less than in individual CVM.

3.2.7. Choice Modelling Method (CM)

Questionnaire-based approach to infer individual WTP or WTA indirectly from their stated choices among options related to change or provision of non-market ES.The method is used to estimate both use and non-use value of non-market goods and services including changes yet to be experienced. Although CM is quite similar in its application to CVM, the difference is that in CM the respondents are asked to rank or score their preferred options within a range of scenarios which differ in the state of their traits, one of which is either a price or subsidy, while in CVM only one option is presented to respondents (Pascual *et al.*, 2010; Turpie, 2010; Rusche, 2013). Both methods nevertheless maybe used to assess Total Economic Value (TEV) from a change in the quantity of ES (Pascual *et al.*, 2010). Turpie *et al.* (2010) state that CM may be used to establish how different characteristics of a wetland, contribute to its overall value, and how this overall value varies when certain attributes change. For example, the method may be used to assess the contribution of management efforts to the value of the wetland, and the impact of a change in management input on the overall value of the wetland. This method is therefore particularly important for the analysis of multiple scenarios but requires careful design to ensure choice options and attributes are manageable.

In CM applications the major characteristics of the ES in question are identified through focus group discussion (FGD) to define the features of the ES that are likely to be affected by a specified policy action (Stewart and Kahn, 2006). It is generally important that the chosen attributes for instance, water quality, wetland area, etc. have monetary value, especially if economic values of the ES are to be estimated. The chosen features may be changed by responsible authority or experts in the field of study. The attributes are given certain levels which should be realistic, feasible and cover the variation of respondents` preferences. One of the attribute levels is generally the “status quo” (Pearce et al., 2006). The varying levels or scenarios of the attributes are afterwards used in an experimental design to create choice sets that present respondents with investment alternatives. The limitations of CM include;

- Complexity of choice questions versus response consistency
- Requires high level of expertise to implement
- Relatively lengthy timeframe (e.g., 3-12 months) is needed

3.2.8. The Travel Cost Method (TCM)

This is a survey based technique using the cost incurred by individuals to travel and gain access to a recreational site as a proxy for the recreational use value of ecosystems such as fishing, boating, and swimming. TCM method is based on the rationale that there are both direct expenses and opportunity costs of time associated with recreational value of a site (Pascual et al., 2010). In most cases TCM is used where visitor fees are low or non-existent (Turpie et al., 2010). Data requirements for TCM include travel costs, number of visits per individual or household, number of visitors to the site, their origin, socio-economic characteristics, the duration of the journey and time spent at the site, values placed on time by the respondent, and the purposes of the journey other than visiting the site (Turpieet al., 2010; Rusche, 2013). The cost of time for visiting a site is usually estimated as a third of the wage rate (Pearce et al., 2006). The limitations of the TCM as reported by Turpieet al., 2010 and Rusche, 2013 include;

- Can only be used for recreational use value of non-market goods and services and not non-use values.
- Difficulty in isolating the value of the site in question from that of other destinations on the journey. Hence, the method works best where it is a single destination trip.
- The method does not allow monetary quantification of single ES.

3.2.9. Hedonic Pricing Method (HPM)

The HPM is based on the rationale that the price difference of similar market goods may be attributed to their different attributes such as brand, quality, design, or environmental conditions. The method utilizes available information on the demand for an environmental feature to identify the implicit price for the market commodities (Pascual et al., 2010). For instance, price of houses or property may be dependent on the beauty of the landscape or/and proximity to water bodies or forests. Hence, the value change of an ES will be reflected in the change in the value of property. This implies that HPM uses the statistical techniques, such as multiple regressions, to isolate the price effect of ecosystem-related goods and services. The method therefore attempts to (i) identify how much of a property differential is due to a particular environmental difference between two properties, and; (ii) infer how much people are Willing To Pay for an improvement in environmental quality (Turner et al., 1994). The method is the most suitable to assess the value of local environmental attributes. In addition, it is used to estimate economic benefits or costs associated with environmental quality such as air pollution, water pollution, noise and environmental amenities such as proximity to recreational sites. The limitations of HPM include;

- Limited to direct or indirect use values of non-market goods and services
- Applicable only to valuation of those ES that are tied to marketed services and the prices of the latter respond to changes in the quality/quantity and attributes of the former.
- Limited to environmental features observable by individuals
- Require large amounts of data on prices, characteristics of the market goods, and population demographics.
- Assuming that nothing else modifies the relationship between the ES and the property.

3.2.10. Benefit Transfer Method

In some cases, it may be possible to apply the findings of other studies of similar areas to the area under consideration, of which primary valuation estimates are unavailable (Johnston and Rosenberger, 2010). This method is only applicable if there is a study already exists that valued ES similar to the one in question (Turpie et al., 2010). The assumption is that the existing or adjusted estimate of economic value may be used as an approximate to the economic value of the ES in question. The advantages of the benefits transfer approach is that economic benefits can be obtained more quickly than undertaking primary research, it is noticeably cheaper, flexible and estimate both use and non-use value of non-market ES (Turpie et al., 2010).

The benefit transfer method constitute 3 approaches; transferring mean unit values, transferring adjusted unit values and transferring the demand function (Georgiou et al., 1997). Transferring mean unit values approach assumes that well-being experienced due to an ES at one site is the same in the next one. However, the problem is that at the new site, individuals may not have the same preferences. In the case of transferring adjusted unit values, the mean unit values obtained at a different site are adjusted to meet the needs of the new site. Potential differences that may be considered include variability in socio-economic characteristics of individuals, environmental change, and availability of substitute ES. Generally, the unit value transfer method is most suitable when the context of the study is similar or is in close proximity to the policy sites. This ensures that the economic value from one study site can be easily projected unit by unit to a policy site (Rusche, 2013).

When the context of the study site varies from the one of the policy site, function transfer may increase the reliability of the benefit transfer. Depending on the specific features of the new site, the economic value of the ES in the study site may be altered particularly when the factors affecting the WTP e.g. socio-economic characteristics are known. The entire demand function estimated at existing sites could then be transferred to the new site. The general consensus in literature is that function transfers are typically more accurate than unit value transfers (Johnston and Rosenberger, 2010) despite the fact that inconclusive or contrary findings have been reported (Brouwer, 2000). However, both unit and value transfer methods are subject to two categories of errors: measurements errors; generated from the original study, and generalization or transfer errors which occur when estimates from study sites are adapted to policy sites especially, when the two sites are not similar in features (Rosenberger and Phipps, 2007).

3.2.11. Productivity methods

Estimates economic values for ecosystem products or services that contribute to the production of commercially marketed by measuring the contribution that a non-market ecosystem service has on a marketed commodity, this method is most useful in cases where a resource is a perfect substitute for another input for production and in cases where the producers are the only ones to benefit from changes in quantity or quality of the resource, and consumers are not affected goods.

Applications

It is applied in cases where the products or services of an ecosystem are used, along with other inputs, to produce a marketed good. For example, water quality affects the productivity of irrigated agricultural crops, or the costs of purifying municipal drinking water. Thus, the economic benefits of improved water quality can be measured by the increased revenues from greater agricultural productivity, or the decreased costs of providing clean drinking water, Table 8 shows the advantages and disadvantages of this method.

Table 8 The Advantages and Disadvantages of Productivity Method

Advantages	Disadvantages
▪ Applicable to a wide range of ecosystem goods and services. ▪ Straight forward method where environmental quality directly affects the cost of producing a marketed good municipal drinking water.	▪ Difficult to quantify the relationship between change in ecosystem goods and services and production. ▪ Large number of other variables that influence product markets.

3.2.12. Replacement Cost/Damage Cost Avoided

The damage cost avoided, replacement Cost/Damage Cost Avoided cost, and substitute cost methods are related methods that estimate values of ecosystem services based on either the costs of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services.

The methods are based on estimations of the costs that would be incurred if the ES needed are to be recreated through artificial means or replaced with man-made infrastructure. Costs related to the provision of the goods or services directly observed in actual markets can be used as a measure of the value of the ES. The method entails: (a) the avoided damage cost method, which relates to the costs that would have been incurred in the absence of ES, (b) replacement cost method, which estimates the costs incurred by replacing ES with artificial technologies, and (c) mitigation or restoration cost method, which refers to the cost of mitigating the effects caused by to the loss of ES or the cost of getting those services restored (Pascual *et al.*, 2010). According to Brander *et al.* (2013) the most common method used to estimate the value of regulating ES such as flood attenuation and water purification has been the estimate to cost of replacing the service with man-made infrastructure. For instance, the flood attenuation ES by a wetland may be valued as the cost of constructing flood control measures that provide the same level of protection. The ES can also be valued by estimating the flooding damage cost as the value of wetland for preventing/mitigating floods. However, the avoided damage cost method has been used in a small number of cases (Brander *et al.*, 2013). Water purification ES by a wetland may be estimated as the cost of equivalent water treatment methods such as replacement cost method, or avoided damage cost method through estimating the people's health costs (De Groot *et al.*, 2006). The replacement cost however as noted by Anderson and Rockel (1991) is an upper bound on the true value since the stakeholders may not choose to actually use that alternative considered. In addition, Brander *et al.*, 2013 noted that the cost-based valuation methods used to estimate the value of wetland regulating ES do not all have sound basis on economic welfare theory. For example, using replacement or avoided damage costs methods, implies that the costs are reasonable approximation of the benefits that society attributes to the resources in question. The underlying assumption, which may not always be reasonable, is that the benefits are at least as great as the costs involved in repairing, avoiding or compensating for damage. These methods are widely applied due to the relative ease of estimation, relatively short timeframe requirement and availability of data, but it is important to be aware of the limitations in terms of the information they convey with respect to economic benefits.
The limitations of the cost-based methods include:

- Being applicable only where wetland-related ES can be replaced or restored by market goods or damage loss can be estimated with market information.
- Non-use value cannot be estimated using the method.
- Provide a lower bound estimate of the TEV.

Applications

The costs of avoiding damages or replacing natural assets or their services provide useful estimates of the value of these assets or services.

For example: Loss of wetland flood attenuation may lead to increased, downstream flooding and destruction of infrastructure and property, Table 9 Advantages and disadvantages of Damage Cost Avoided shows the advantages and disadvantages of this method.

Table 9 Advantages and disadvantages of Damage Cost Avoided

Advantages	Disadvantages
▪ Less data and resource intensive that other methods ▪ Provide surrogate measures of value for services that are difficult to measure by any other means ▪ Simple to apply and analyze ▪ The methods may provide a rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods. ▪ It is easier to measure the costs of producing benefits than the benefits themselves, when goods, services, and benefits are non-marketed. Thus, these approaches are less data and resource-intensive. ▪ Data or resource limitations may rule out valuation methods that estimate willingness to pay. ▪ Provide surrogate measures of value that are as consistent as possible with the economic concept of use value, for services which may be difficult to value by other means.	▪ Difficult to find perfect replacements for ecosystem goods and services ▪ May lead to over or under valuation ▪ Based on predicted/hypothetical situations ▪ These approaches assume that expenditures to repair damages or to replace ecosystem services are valid measures of the benefits provided. ▪ Costs are usually not an accurate measure of benefits. ▪ Do not consider social preferences for ecosystem services, or individuals' behavior in the absence of those services. ▪ May be inconsistent because few environmental actions and regulations are based solely on benefit-cost comparisons, particularly at the national level. ▪ Requires information on the degree of substitution between the market good and the natural resource. ▪ The goods or services being replaced probably represent only a portion of the full range of services provided by the natural resource.

4. Selection of Economic Valuation Methods

The selection of the type/types of economic valuation methods vary depending on the site of interest, type of service, availability of resources, time, objectives of the study and data collection methods (Barbier, Acreman and Knowler , 1997; Stelk and Christie, 2014). Application of economic valuation method necessitates an understanding of WTP concept. In competitive markets where there are no distortions of prices for ES, market price method may be used under the assumption that it reflects the WTP for the goods and services. Market price method may be applied in valuing the direct use values of an ecosystem particularly involving harvesting of resources i.e. provisioning ES (Barbier, Acreman and Knowler, 1997; Naruševičius and Matiukas 2011). Nevertheless, in cases where market prices are distorted, shadow prices are often recommended but should be used cautiously. Shadow prices are actual prices adjusted to minimize any distortions from policies or imperfect competitions in order to reflect the actual WTP.

When there are no clear markets for an ES, indirect means of attaching monetary values may be employed (De Groot, Stuip, Finlayson and Davidson, 2006). The non-market valuation methods include revealed and stated preference methods. The methods are applicable for valuing some provisioning ES particularly those harvested for household use only, cultural services and non-use values. In cases where site specific data cannot be obtained as a result of financial or time constraints, benefit transfer method may be applied (De Groot, Stuip, Finlayson and Davidson, 2006).

Ramsar Convention has stressed that the true value of wetlands and the services they provide to people should be recognized, as well as their importance to the maintenance of biological diversity. In particular, the preamble to the Convention's text adopted in 1971 recognized "that wetlands constitute a resource of great economic, cultural, scientific, and recreational value, the loss of which would be irreparable".

Ramsar Convention has recognized the importance of applying wetland valuation in ensuring appropriate decision-making in relation to Environmental Impact Assessment.

The MA defines ecosystem services as "the benefits that people receive from ecosystems" (Millennium Ecosystem Assessment 2005), Ramsar Contracting Parties at COP9 in 2005 updated the definitions of wise use and ecological character, using the term "ecosystem benefits/services".

The release of the Millennium Ecosystem Assessment (MA 2005a) helped foster use of the concept of ecosystem services by policy makers and the business community. However, progress in its practical application in land use planning and decision making has been slow (e.g., Daily et al. 2009, Naidoo et al. 2008) beside it did not pay much attention to the economics of ecosystem change. (Rudolf de Groot B. F., 2010)

TEEB guide line was adopted in 2010, to give due attention to the underlying changes in ecological „values" (ecosystem integrity and life-support functions) and sociocultural implications as emphasis is on the economic, notably monetary, effects of the loss of ecosystem services, (Rudolf de Groot B. F., 2010), although the TEEB study focuses primarily on the measurement of economic values and the assessment of costs and benefits in a welfare economics approach, it includes equity considerations in particular for the aggregation of benefits over time and over groups of people. It specifically analyses the relationships between ecosystems and poverty (GDP of the poor), because of the higher dependence of the poor on ecosystem services for their livelihood (TEEB 2008) mentioned in (Rudolf de Groot B. F., 2010),

Table 10 shows the main different between each guide line.

Table 10 The Main Differences Between Guidelines

	MA	RAMSAR	TEEB
Aim	Introduces the linkages between the ecosystem provided by wetlands and their contribution to human well-being or quality of life.	Identify and determine the value of the ecosystem services (ecological, socio-cultural, and economic) provided by wetlands.	Provide more and better data and understanding of the (economic) significance of these losses and the consequences of policy inaction on halting biodiversity loss at various scales (global, regional and local).
Terms	Provisioning and cultural services	Direct use value	Provisioning, cultural and amenity services
	Regulating and supporting services (e.g: nutrient cycling and food-chain dynamics)	Indirect use value	Regulating services (e.g: a subset of ecological processes)
	Biological, physical, and chemical components	Attributes/ features	Habitat services,
	Processes	Interactions	Processes
	Ecosystem services: the benefits that people receive from ecosystems	Ecosystem functions "the capacity of ecosystem process and components to provide goods and services that satisfy human needs, directly or indirectly"	**Ecosystem services**"the direct and indirect contributions of ecosystems to human well-being"
	Ecosystem Components: physical; chemical; biological (habitats, species, genes)	"components", "features", "attributes", "properties"	Biological components (genetic, species and community scale elements)
	Ecological Processes within and between ecosystems	Processes", "interactions", "properties"; "functions"	Makes a distinction between ecological, socio-cultural and economic benefits and values
	Services	Values, functions, and products	Links between biodiversity, ecosystem functions and specific ecosystem services
Ecosystem	Identifies four broad categories of	Guide line 1997 three	Proposes a typology of 22 ecosystem services divided in

	MA	RAMSAR	TEEB
services	ecosystem services: • **Provisioning services** - Food - Fresh water - Fiber - Genetic resources - Biochemical - Ornamental resource • **Regulating services** - Air purification - Climate regulation - Water regulation - Erosion regulation - Soil formation - Pollination • **Supporting services** - e.g. Photosynthesis, primary production, nutrient cycling • **Cultural services** - Aesthetic values - Knowledge systems Educational values - Recreation & eco-tourism - Spirit. & religious - Cultural diversity	categories: - Components/assets - Functions/services - Diversity/attributes Guide line 2006 uses MA categories	4 main categories; (mainly following MA) • **Provisioning services** - Food - Water - Raw materials - Medicinal resources - Genetic resources - Ornamental resource •**Regulating services** - Air purification - Climate regulation ((incl. C-sequestration) - Disturbance prevention or moderation - Regulation of water flows - Waste treatment - Erosion prevention - Maintaining soil fertility - Pollination - Biological control • **Habitat** - Lifecycle maintenance - Gene pool protection • **Cultural and amenity** - Aesthetic information - Recreation & tourism - Inspiration for culture, art and design - Spiritual experience - Information for cognitive development
Valuation	Value as “The contribution of an action or object to user-specified goals, objectives, or conditions” (after Farber et al. 2002	Guide line 1997 The attempt to assign quantitative values to the goods and services provided by environmental resources, whether or not market prices are available to assist us. Guide line 2006 adopt	Focus on the economic, notably monetary, consequences of the loss of biodiversity

	MA	RAMSAR	TEEB
		MA definition	
Concept	Drivers of loss and degradation of wetlands	Reflect the Values of Ecosystems and Biodiversity in Policy-making	Inform decision makers of the welfare gains and losses of alternative possible futures and different associated policy packages by comparing the outputs under several scenarios
Objectives	Represent the relationship between ecosystem services and human well-being	Draw attention to the benefits provided by biodiversity (encompassing ecosystems, species and genes).	To develop a global study of economic of biodiversity losses

5. Case studies

5.1. Egypt, Burullus Lake

Geographic location

The Burullus Wetland is one of the five northern lakes in Egypt. It is bordered from the north by Mediterranean Sea and from south by the agricultural lands of the northern parts of the Nile Delta. This wetland is a Ramsar site and has been declared as a natural protectorate in 1998. The protectorate includes the entire area of Burullus Lake with numerous islets inside it, as well as the sand bar separating the lake from the Mediterranean Sea, with a shoreline of about 65 km. It has an oblong shape extending for a distance of 47 km along NE-SW axis. Its width in the west does not exceed 5 km, then it increases in the middle to reach about 11 km. It is clear that the Burullus Lake had lost about 62.5% of its size during the last two centuries (1092 km^2 in 1801 to 410 km^2 nowadays). Its depth varies between a few centimetres near the shores and 200 cm near the sea outlet, increasing from east to west and from south to north (Maiyza et al., 1991).as shown in Figure 3

Figure 3: Location of Burullus Lake

Burullus Lake is situated at the northern part of the Nile Delta, between the two main Nile branches. It extends between latitudes 31° 22' N and 31° 35' N (Maiyza, 1989), and longitudes 30° 30' E and 31° 10' E, 60 km east of Rosetta branch and 70 km west of Damietta branch (Beltagy, 1985). The lake is roughly rectangular in shape, about 60 km in length, the width is ranging from 6 to 16 km with an average width of 11 km and its surface area is 350 km^2. The length of its shoreline is about 150 km (Said, 1992).

The lake is separated from the sea by a stripe of land covered with sandbars and sand dunes of different width and height (Beltagy, 1985). The barrier tapers from about 4 km width in the west to about 1 km in the east, near the lake outlet at El-Burg (Sestini, 1992).

Burullus Lake is connected to the Mediterranean Sea through an opening in its northeastern corner known as Boughaz El-Burullus. This outlet is about 200 m in with whereas its maximum depth is only 2.8 m (Maiyza, 1989). The outlet of Burullus has always been unstable, but before the 1940's, its tendency to migrate eastward, due to littoral drift, was balanced by the strong in and out flows between sea and lagoon .The bottom of the lake consists of sands, calcarious material of sea origins (shells of Cardium and other Mollusks) and silt.

Climate and hydrology

Lake Burullus water is of brackish nature. A drain and sea water are the two main sources to the lake. Seepage from the cultivated lands and rainfall in winter are secondary sources. Human activity wastes are also discharged to the lake. Generally, the southern part of the lake and its southern basin are more affected by the drainage water. Northern parts and the eastern basin are more affected by the sea water.

Rainfall

The mean annual rainfall over the area is 187 mm, providing the lake with a volume of about 77.4 million m^3 (El-Shinnawy, 2003). Most rainfall takes place during the winter season (October – March), with no rainfall during summer months. The maximum depth of rainfall is received in December and January.

Drainage discharges

The lake serves as reservoir for drainage waters, which are contaminated, with anthropogenic materials (El-Sammak and El-Sabrouti, 1995a). It receives drainage waters from agricultural areas through seven drains in addition to the fresh water from Brembal Canal situated in the western part of the lake. The lake receives drainage water which fluctuated between 78×10^6 and 272×10^6 m^3 $month^{-1}$ in January and July 2002, respectively (Ministry of Irrigation).

The drainage system provides the lake with about four million cubic meters of agricultural drainage water annually. However, according to the result of Samaan *et al.* (1989), the amount of the drainage water discharged annually into the lake fluctuates from one year to the other, with the average of about 2.5 billion m^3 $year^{-1}$. During the winter period, seawater may also enter the lake, increasing the salinity of the water. El-Shinnawy (2003), showed that the monthly inflow of the drainage water through each of the drains joining the lake at its southern margin.

Tidal effect

Fanos (1990) found that the tidal fluctuation in the Burullus Lake, i.e. the difference between the mean high water level (33 cm) and the mean low water level (18 cm) is 15.0 cm. Accordingly, the tide effect is too small and may be neglected during the spring, summer and autumn and considered only in winter when the action of wind contributes in the invasion of sea water into the lake.

Domestic discharge

The social studies in the area surrounding Burullus Lake indicated that about 185 thousand people live in the area. Water consumption of that population can be estimated as 27,750 m^3 day^{-1}. This volume of water is discharged to the lake.

Groundwater flow

The ground water inflow to Burullus Lake was estimated by El-Shinnawy (2003) as follows:

Interface	Ground water inflow (m^3 day^{-1})
Bottom	63,141
Boundaries	25,761
Total	88,902

Evaporation

The mean annual evaporation is 1583 mm. This value approximates about 646.5 million m^3 of water loss from Burullus Lake. Maximum evaporation takes place in May – September, while the minimum occurs in December – February.

Outflow to the sea

Simulation of the outflow from the lake to the sea was implemented for two different cases (El-Shinnawy 2002). The first case represented the flow from the drainage system over the last four years when the High Dam releases continued without any winter closure. In this case, results indicate that the water table was always above the mean sea level. The second case represented the usual case of the irrigation system in Egypt that includes an annual winter closure. In this case, simulation was made by allowing no discharges from the drainage system to the lake during the winter closure (in January). Results indicate that water level falls below the sea water level by about 26 cm. This case allowed a volume of 110.7 million m^3 of sea water to move into the lake as a result of the winter closure.

Land cover and land use

Many forms of human activites, including construction, open-cast mining, agriculture, and forestry involve disturbing or removing vegetation cover in and around Lake Burullus. These disturbances generate further environmental and economic problems.

In accordance with the standard land use classification system implemented by the World Land Use Commission (WLUC), several land use categories can be identified in Egypt, especially in the delta. The different land use types can be summarized as follow:

- Settlements and non-agricultural territories. This includes public land and urban areas like the land along the coastal sandbar and the communities of the two main towns Burge El-Burullus and Baltim.
- Horticulture (that covers about 1.1 % of the total crops area in the deltas) but this area is widely spread and diffused inside the Burullus protected area.
- Tree crops represented mainly by groves of palm trees. These groves are widespread along the delta. There are mainly groves of palm trees along the eastern shore of the lake between Burg El-Burullus and Baltim which are standing close to the lake.
- Permanent cultivated cropland is the dominant land use type, in major parts of the delta, especially along the southern and southwestern border of the Burullus protected area. The crops are predominantly irrigated by Nile water. There are seasonal or yearly agricultural vegetation, e.g. the cotton bush is planted every year.

5.2. Sudan, Dinder Park

➢ **Description of the Dinder Wetland:**

- **Geographic location**

The Blue Nile River originates from the steep mountains of the Ethiopian Plateau and has a total length of 1,450 kilometres (900 mi), of which 800 km is in Sudan. On its way to north, the Blue Nile is joined by 2 tributaries (Rahad River and Dinder River), at the Dinder National Park (DNP), adjacent to the border between Sudan and Ethiopia Figure 4: Location Map of Dinder Wetland, Sudan. DNP declared at 1935 and was designated as Wetland of International Importance (Ramsar site) in 2005.

Dinder wetland boundaries follow the Rahad river at latitude 12^o 26’ N and longitude 35^o 02’ E, continuing in a north-western direction up to latitude 12^o 42’ N and 34^o 48’ E along the River Dinder. It further continues up to latitude 12^o 32’ N and longitude 34^o 32’ E along Khor Kenana. It then diverts slightly to the South East, to latitude 11^o 55’ N and longitude 34^o 44’ E, to be enclosed by the Sudanese-Ethiopian border.

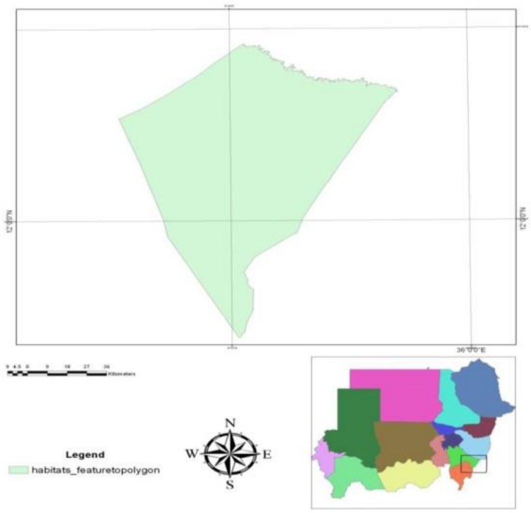


Figure 4: Location Map of Dinder Wetland, Sudan

Elevation: At the Ethiopian plateau, the relief is topping 3133 m a.s.l. The lower parts range from 515 m a.s.l. at the south-east to 100 m a.s.l. at the north-eastern reaches of the park in the Sudan.

The Dinder wetland covers an area of 1.084.600 hectares (10.291Km2). It lies along the transition ecotone zone between two floristic regions; the Ethiopian high plateau and the arid Saharan-Sudanian biomes. It also lays along the boundary of two major faunal realms of the world i.e. the paleoartic and Ethiopian region, with high diversity of the floral and faunal communities.

- **Climate**

The climate of Sudan is characterized by two seasons: the hot and humid rainy season (June- October) and the cool dry season (November-May). It was found, that the rainfall of the central Sudan is associated with the West African System, which is derived from South Atlantic and Congo air masses, with little or no Indian Ocean influence. The isohyets run from west to east until they turn first to northeast and then east and southeast, around the Ethiopian highlands. Dinder wetland, therefore, lies in the zone of northeasterly winds, in which rainfall decreases to the northeast. Consequently, the decrease in the mean annual total is of the order of 30 mm for every 20 km and this decrease in rainfall is the main reason for the marked zonation of the vegetation of the wetland. The northeastern part of the Dinder has the least rainfall (600-800 mm), which gradually increases with distance towards the southeast of the area (800-1000 mm).

The most effective rains in the Dinder area start in May in the southeast and in June in the northeast part. The normal rainy season is from May to November with the peak in August. During the rainy season, the maximum temperature is approximately 30 ^{o}C and the minimum is approximately 20 ^{o}C. As the rains gradually subside, the temperature gradually rises until it reaches a maximum of 36 ^{o}C. On the other hand, the relatively cool months of December, January and February are followed by a general rise in temperature that averages 38 oC in March, with an average humidity of 60-65 %. The maximum temperature sometimes exceeds 40 ^{o}C in April and May and then drops suddenly by the first rain of the new season. Average temperature in the Dinder wetland during May 2014 is 33 oC and the average humidity is 39 % (source: Dinder Weather Station).

- **Hydrology**

The Rahad and Dinder rivers are the largest tributaries of the Blue Nile. They both originate from the Ethiopian Highlands. River Rahad flows along the northern boundary of Dinder wetland, while the Dinder River flows through the centre of the Dinder wetland (Figure 5 : Drainage system, Mayas and water bodies.

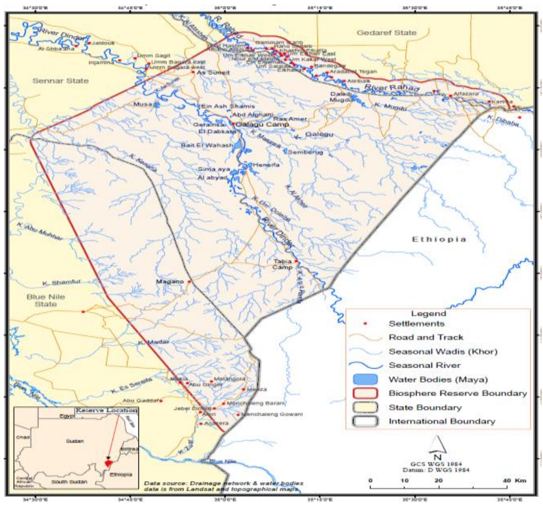


Figure 5 : Drainage system, Mayas and water bodies

The catchment area of the Dinder River is around 16,000 km^2 and it has an average annual discharge of about four billion cubic meters. The channel traversing the DNP ranges from 150 to 400 m in width and is 1 to 9 meters in depth.

The river has a seasonal character. It starts surging in June, peaking around the middle of August each year. It ceases flowing sometime in January. The sandy riverbed, thereafter, is left with numerous pools, some of which may retain water throughout the dry season.

Wetlands are important components of the drainage systems in whole Sudan. Moghraby (2001) stated that the routing effect of the wetlands on the seasonal flows of the tributaries of the Nile is the factor that brings about the steady and even flow of the main streams.

Meadows – back swamps – locally named as Mayas, are found along the flood plains of the Dinder and Rahad rivers. They have been formed due to the meandering character of the river course and the nature of flow of its waters. They occupy low-lying basins, meanders and oxbows. They are generally crescent shaped with slight and/or not clear banks.

Mayas vary in area from less than 200 m2 up to 4.5 km2. They have been classified as productive and non-productive habitats, based on their carrying capacities and water retention potential (Abdel Hameed, 1983, Hakim 1987).

Runoff is a function of rainfall. It is suspected by many that Global Warming might induce a decrease in rainfall over Ethiopia, by the magnitude of 15%. That would result in a 30 % decrease of river discharge. It should be remembered that the Ethiopian highlands contribute as much as 84 % to the total annual discharge of the Nile system (Moghraby, 2001). As it stands today, the Dinder River is going through a trend of decreasing volume of annual discharge. The trend seems to have persisted throughout the past 20 years. In the 1970’s the annual discharge was around 3 billion cubic meters. It has declined to around 2 bcm. In 1985 it was down to 0.6 bcm (Abdel Hameed et al 1996).

- **Land cover**

Several descriptions of the vegetation of the Dinder have been given by different authors, Smith (1949); Harrison and Jackson (1958); Holsworth (1968); Abdel Hameed (1983) and HCENR-WRC (2001). (Figure 6 : Land cover Map of Dinder Wetland below shows the land cover map of the Dinder Wetland.

a. Flora

According to Smith (1949) the distribution of the tree species is influenced by the combined effects of rainfall; soil texture and topography. Harrison and Jackson (1958) gave a general classification of Sudan’s vegetation and reported that the Dinder as National Park is situated in the Acacia – Balinites Savannah alternating with grass area zones. Dasmann (1972) classified the vegetation into four categories: Wooded grassland; Open grassland; Woodland and Riverine forest.

Abdel Hameed et al (1995) produced a zonation to the most dominated plant species of the Dinder using remote sensing technique. Hakim et al (1978) and Abdel Hameed et al (1996) recognized three types of ecosystems:

1- Acacia seyal – Balinites ecosystem
2- Riverine ecosystem
3- Mayas (Meadows-back swamps) ecosystem

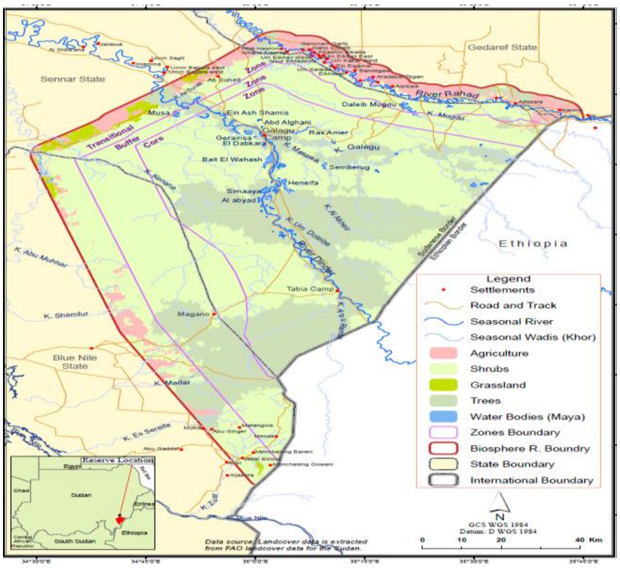


Figure 6 : Land cover Map of Dinder Wetland

b. Fauna

The Dinder wetland holds a large variety of wildlife species. The most important herbivores are tiang (*Damaliscus lunatus tiang)*, reedbuck (*Redunca redunca*), waterbuck (*Kobus ellipsipry mnusdefasa*) roan antelope (*Hippotragus equines*), oribi (*Ourebi aourebia*), warthog (*Phacochoerus aethiopicu*) and Cape buffalo (*Syncerus caffer caffer*). Other animals such as baboon (*Papio anubis*) and husser monkey (*Cercopithecus aethiops)* are frequent. Greater Kudu (*Tragelap husstrepsiceros*) and red-fronted gazelle (*Gazella rufifrons)* are restricted to certain locations (Abdel Hameed, 1986, HCENR-WRC, 2001).

Dinder wetland hosted large varieties of birds like ostrich (*Struthio camelus*), greater bustard (*Ardeotis kori*), leaser bustard (*Eupodotis senegalensis),* crown crane *(Balearica pavonina),* Egyptian goose *(Atopochen aegyptiacus),* guinea fowl *(Numara meliagris),* marabou stork *(Leptoplilo scrumeneferus) and grey heron (*Arden cinerea) (HCENR-WRC,2001).The Guinea fowl is the most common game bird. Dinder also hosts abundant colourful starlings (*Spreo spp*), bee-eaters (*Merops spp*), sunbirds (*Nectarinia spp*), herons (*Ardea spp*), egrets (*Casmerodius spp*), rollers (*Coracias spp.)* and many others. Herons, egrets, marabou storks and pelicans are commonly seen near the ponds. The endangered Arabian bustard (*Ardeotis arabs*) and greater bustard (*Ardeotis kori*) also visit the Dinder. The ponds' counts and the Strip Transect Count of Wild Animals in Dinder at June 2002 showed that reedbuck, warthog, waterbuck and baboon were the most abundant ones (HCENR-WRC, 2002).

During the recent field survey many spp's were seen especially in Abdel Gani Maya which is the closest one to the Dinder Camp, including reedbuck, buffalo, warthog, waterbuck, baboon and many birds and water fowls.

➢ Land use

Village land, under all different uses including cultivation, is under communal tenure. Local communities settled in about 30 villages in and around the Dinder wetland. The ten villages at Rahad river's banks are inhibited by a total of 7750 individuals (CWSP, 2014 census). Agricultural lands on the flood plains, near the villages and towns are owned by local tribal leaders who assume the responsibility of land distribution.

Traditional farming and gerif cultivation are practiced by the villagers along River Rahad banks. Crops are produced under shifting cultivation practices, whereby a land holding is cultivated for a number of years, after which it is left to rest. Meanwhile, a new plot of land adjacent to the old one is put under cultivation, which is usually done by felling of trees and clearance of land by burning. These practices are in the areas adjacent to the Dinder. Huge Agriculture Schemes (e.g.African Company Scheme) are occupying the lands east of the Rahad River's Villages.

The socio-economic survey carried out recently documented the main crops cultivated in this area such as sorghum (Dura), sesame, beans, pumpkins, okra and cucumber. Other crops include maize and groundnuts. Farmers care more for securing their stable food crop, so that sorghum ranks as their staple crop. After harvesting the Gerif, land is usually rented for nomads to graze the crop residues. The permanent residents keep limited numbers of domestic animals (goats, sheep, donkeys, chickens and sometimes cattle). Animals graze first on the natural pasture around the villages, and then they move into the traditional and mechanized rain-fed farms to feed on crop residues and sometimes they move inside the wetland..Some of nomadic tribes (eg UmBararow) camp near Dinder Wetlands for grazing and watering their livestock.

Gerif cultivation and fishing are important economic practices by the local communities, in the rivers and Mayas. There are other activities that include tree felling, rope making, straw mats and bed (local name Angaree) making and bird capturing in ponds. Brick making for buildings is an introduced practice to the area. It is practiced along the banks of the rivers where sediments deposit usually replenished by the annual floods.

5.2.1. Principal Wetland Ecosystem, Benefits, Services and Functions.

Dinder wetland with its three ecosystems (Woodland, Riverine and Mayas ecosystems) provides tremendous ecosystem services and values. Dinder provisioning Services include Fresh Water, Timber, non-wood forest products, Genetic Resources, etc. The Regulating Services include Air quality regulation, Water purification and treatment, Water regulation, Climate regulation, Erosion regulation, Soil formation, Pollination, Pest regulation, Disease regulation, Primary production and Nutrient cycling. The Cultural Services include Spiritual and religious values, Aesthetic diversity, Cultural diversity, Recreation and ecotourism and Knowledge system and educational values. Biodiversity conservation, recreation and tourism opportunities are considered as important issues in the sustainable management of the Dinder wetland as a protected area.

The Mayas (natural depressions which store rainfall water and covered with a meadow) in Dinder wetland act as tools for water regulation in the drainage pattern. The forested ecosystems regulate the climate in the whole Dinder area. Dinder wetland is a watershed area, control water erosion and nutrient cycling and is protecting the most influential feeders of the Blue Nile and their tributaries. They deposit fertile soils in the banks of the rivers for plant regeneration and crop production. These wetlands minimize the damage during floods, especially during high floods. Thus, the flood-plain has a high rate of water retention and natural hazard regulation. The forests regulate erosion, air quality and climate locally and regionally.

The habitats of the flood plain, depression, lakes, Mayas and pools are rich in their ichthyofauna and they are a major breeding ground for the fishes, amphibians, water dwelling insects and micro fauna which greatly enhance the biodiversity of these wetlands. They offer refuge and protection to fish after the flood season and therefore are valuable reserve for reactive net when the next flood starts and joins the pools and Mayas to the main channel of Dinder and the Blue Nile rivers. They are the most important features of the Dinder in terms of availing water and green grasses for the wildlife species during the dry season as well as to different fish eating species.

Dinder wetland, as protected area, is an island of a diverse array of fauna and flora of the region which support biodiversity and a large population of wild animals such as the tiang, roan antelope, red-fronted gazelle, reedbuck, oribi, warthog, waterbuck, lion and ostrich. This species are not found elsewhere in the region. Some of these species are endangered (classified conservation dependent by IUCN), Vulnerable in the IUCN Red List), and cited on CITES Appendix II. With regard to lion and the elephant, it is the only area in the region where such species still exist. The wetlands also protect endemic species which live in the region or are permanent settlers of the Dinder, numerous kinds of fishes and insects species such as bees which are of economic importance to the local communities living around and within the Dinder wetland.

Dinder lies on the migration route of African wintering birds during their pass to the eastern African Rift valley lakes or southward. The wetlands provide a refuge for a large number of migratory birds (about 250 species). It is also special area for recreation and ecotourism. It has educational values to university students and researchers.

The Dinder wetland is the very source of lives and wellbeing of wildlife and humans. The ecosystems provide food, fruits, fuel, fiber, timber, fuel wood and medicinal plants to the local communities in and around Dinder. The water of the pools are used for all household uses. The pools are rich in fish and waterfowl. The pools are of pivotal importance as a source of water for birds, wildlife, trespassing livestock, poachers, honey collectors and so forth.

Gerif land is the land which stretches along the river banks and from which river water receded after flood time. Most Rahad villages inside the Dinder possess Gerif land. Crops produced here are mostly high-value vegetables and fruits (Mango, guava and papaya) and beans. After harvest the Gerif land is usually rented for nomads to graze the crop residues. Nomadic pastoralists, during the dry seasons, move to the area to utilize the available water and grazing resources. Hence the wetland provide valuable pastures for pastoralists.

Dinder wetland provides historical cultural services. It has spiritual, religious and aesthetic values. The Dinder Archaeological finds revealed the considerable geographical extent of the Meroitic Kingdom and showed possible relationship with the kingdom of Axum. Additional sites of the Fung period are highly likely to turn up along the Dinder River. The population of Magano Mountain village was known to exist at the south-western boundaries of the reserve before the Dinder park was established. They trace back their history to 1912. The Magano community has built its own system of belief. This manifested itself around certain taboos and prohibitions. The wetlands social services improve e.g. education, scientific and recreational activities to the local areas and the region as a whole.

5.2.2. Principle Beneficiaries and Stakeholders for each ecosystem service and function:

Dinder Wetland ecosystems are currently maintaining their regulation, provision, and supporting functions effectively. Most of the local communities are poor and depend on the socio-economic values and function of the Dinder ecosystems.

The woodland ecosystem constitutes most of the area of the Dinder. It is dominated by many valuable trees, grasses and herbaceous vegetation. The grasses and herbaceous cover in this ecosystem are distributed according to the relative amounts of rainfall and topography. The dominant tree species are Talih (*Acacia seyal*), Habeel (*Combretum spp.*) and Higleig (*Balanities aegyptiaca*). They appear in a pure or mixed stands. The common annual grasses are Addar (*Sorghum purpurea-sercum*) Um Sarha (*Hyparrheria pseudocymbaria*), El Gowou (*Aristida plumosa*) and Danab El Bashoum (*Pennisetumr amosum*). This ecosystem provides the local community poles of trees and grasses which are used for building the huts, and the branches that are not within reach of camels and goats are cut for browsing. Trees (all species of Acacia and Balanites) are also cut- down for the production of charcoal which is used as a source of fuel.

Riverine ecosystem occurs on silt, clay loam and sand soils along the banks of the rivers Dinder and Rahad as well as the large seasonal streams. This ecosystem is composed of multi-layered forest which varies in depth according to local conditions of soils and relief. Currently, the regulation function of this ecosystem works efficiently. The dominant trees are Dom (*Hyphaene thebaica*), Abu Gawi (*Gardenia lutea),* Kuk *(Acacia sieberiana),* Aradieb *(Tamarindus indica),* Jomez *(Ficus spp.)* and Sidir *(Ziziphus spina-christi)* and *(Ziziphus abyssinica).* Most of the flora in this ecosystem is source of food, fruits, and medicinal plants.

The wild fruits that are eaten include the dome palm, “Nabag” (*Ziziphus spp.*), “Lalob” (*Balanites*) and “Tebeldi” (*Adansonia digitata*). Some are sold in the local markets. “Saaf” which are young leaves of the dome palm are used for making mats, baskets, honey pots and handicrafts. Some of the manufactured items are for household use and others are for sale. Other non-wood product is the "japaly" which is the root of some plant species.

One of the reserve products; 'the Saaf' as stated above are the leaves of the palm trees, has also social functions and is of symbolic significance being weaved and tied around the hand and leg. It is perceived as a protection for spouses and circumcised girls against evil eyes. It is also used to protect the corpse from decaying until it is buried.

Both woodland and riverine ecosystems provide good habitat and shelter for the wild animals. They currently maintain the supporting function of the wetland.

Mayas are being filled during floods in the rainy seasons. They store water sometimes up to the following rainy season. Dinder has more than 40 Mayas varying in size and duration of storing water from few months after the rainy season to almost year around. Some of the Mayas contain quantities of fish throughout the dry season. Fishing is still a usual practice in the Mayas and pools.

The communities practice cultivation along the banks of the Rahad River known locally as Gerif in which they grow fruits, vegetables and grains. They grow sorghum and millet in small plots within five kilometres of their villages in rain fed fields. There are lots of **beneficiaries and users**:

- Use of wetlands as sources of drinking water, agricultural irrigation, directly used by water abstractors and agricultural producers as users of gerif lands along Rahad and Dinder Rivers. The human settlement is expanded along the boundaries' of Dinder wetland because of the benefits they gain from the ecosystem goods and services.
- Collection of sediments, and clay by direct exploiters such as brick makers and houses builders.
- Indirect users benefit from indirect wetland services, such as storm abatement and flood mitigation.
- Conservation, tourists and amenity groups conserve nature and some groups enjoy the presence of biodiversity (plants and animals)
- Researchers and students from different national Universities and Research Institutes.

5.3. Uganda, Nakivubo Wetlands

5.3.1. Geographical location

Nakivubo wetland is situated between latitudes 00° 17' and 00° 19' N and longitudes 32°37' and 32°39' E, at an altitude of 1135 m above mean sea level. This tropical and perennial wetland lies about 5 km south-east of Uganda's capital city, Kampala, and connects the city to the Murchison Bay of Lake Victoria (Figure 7 A map showing location of Nakivubo wetland. The wetland is approximately 2.5 km2 of which 56% is modified by agricultural and industrial activities. It is bordered by residential areas both in the west and the East, an industrial area in the north and Lake Victoria in the south. The wetland is located both in Nakawa and Makindye divisions in Kampala city. It covers Kisugu and Bukasa wards in Makindye division and Bugolobi, Luzira Prisons and Luzira wards in Nakawa division . The wetland receives run-off, untreated and partially treated waste water carried by Nakibubo Channel on its way from the City Centre, before discharge into Lake Victoria and the Inner Murchison Bay. The water supply for Kampala is obtained from the same bay at Ggaba, just 4 km from the discharge point.

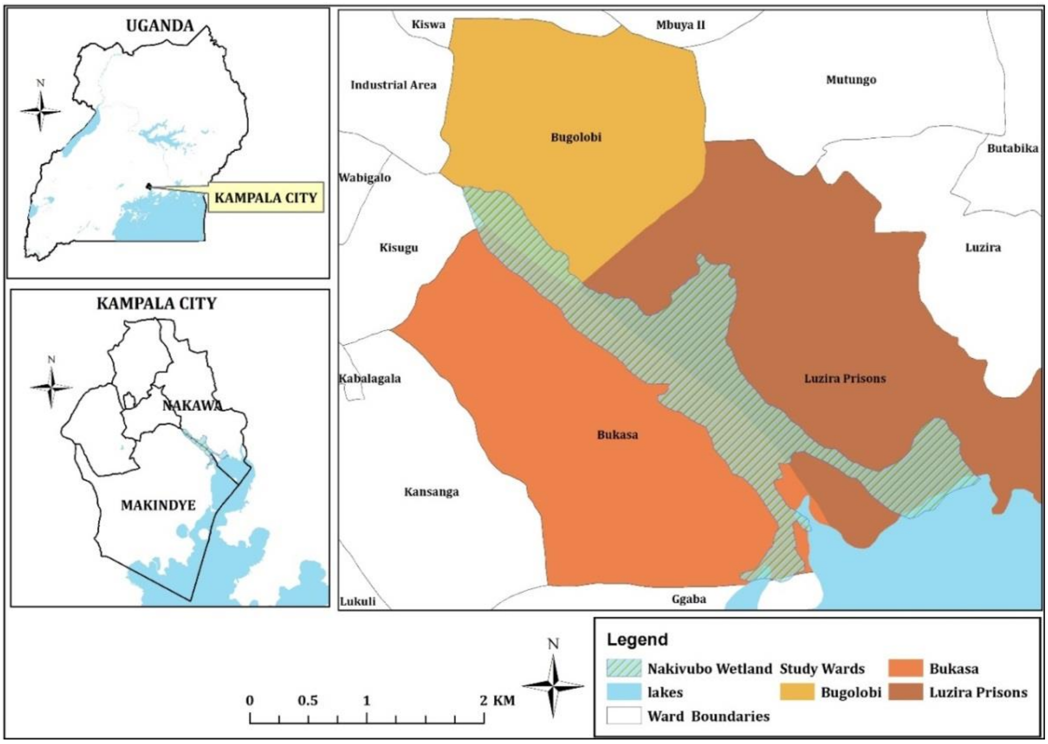


Figure 7 A map showing location of Nakivubo wetland

5.3.2. Climate

The Nakivubo wetland is within the equatorial belt, and has a moist sub-humid climate with a mean annual temperature of 23^{o}C. It receives a bi-seasonal rainfall in the periods of March to May and September to November. The rainfall is linked to the Inter Tropical Convergence Zone (ITCZ), the altitude, local topography and the lake. This rainfall frequency and reliability favour the formation of peat lands and wetlands. The presence of a large adjacent water body also ensures a both reliable and fairly stable hydrological regime (always humid, annual water level variations about 0.5 m).

5.3.3. Land cover and land use

The wetland is divided into two by a railway line running from Port Bell in Luzira to Kampala City Center; Upper and Lower Nakivubo wetland. It covers Namuwongo and Bukasa ward in Makindye Division and Bugolobi and Luzira ward in Nakawa Division Kampala. Upper Nakivubo wetland is the most modified with agriculture as the major cause for the modification. Crops such as bananas, maize, sugar canes and coco yams are among the major crops that are grown in Upper Nakivubo. There are small portions that are covered with wetland vegetation especially in the Northern and eastern part of this section of the wetland. These areas are predominantly wet with Echnocloapyrimidaris and Vossiacuspidata as the major wetland vegetation type/ land cover.

In the lower Nakivubo wetland, agriculture is carried out in the South east and south west of this section of the wetland with coco yams and sugar canes being the major crops grown. Other crops like vegetables, bananas, maize and cassava are also grown but not on a large scale. A large area of this section was filled with murram (planned industrial development) and this significantly modified the wetland as the papyrus vegetation has been lost and a small portion remaining at the lake-wetland interface. A part of the wetland which was in between the area covered by murram and Lake Victoria broke off in 2015 and went afloat in Lake Victoria. The break-off was attributed to the encroachment on the wetland vegetation, pouring of murram and the increasing levels of water in the Lake.

5.4. Kenya- Tanzania, Mara Wetlands

5.4.1. Geographic location

Mara wetland is a reparian papyrus wetland situated in the Mara River Basin which is a transboundary basin shared between Kenya and Tanzania. The basin covers an area of approximately 13,750 km^2 of which 65 % is located in Kenya and 35 % in Tanzania (Mayo *et al.*, 2013). The wetlands' source of water is mainly the Mara River which originates from Enapuiyapui swamp in the Kenyan Mau Escarpment. The Mara River meanders through large and small scale agricultural farms before entering the Masai Mara Game Reserve and the Serengeti National Park in Kenya and Tanzania respectively, and finally ending its 395 km journey by discharging into Lake Victoria through the Mara wetland near Musoma town, Tanzania (Global Water for Sustainability Program, 2007).as shown in Figure 8

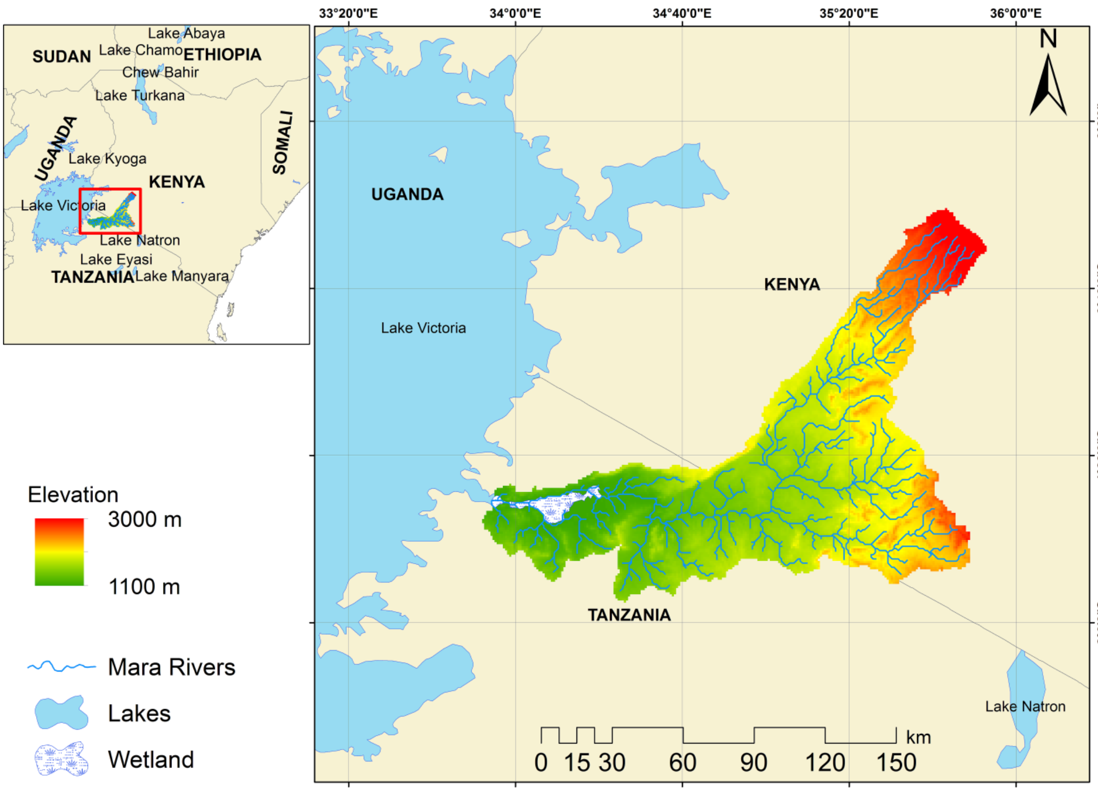


Figure 8 Map of Mara River Basin showing drainage network and Mara wetland

The Mara wetland covers a total area of approximately 204.46 km^2 with a length of 36.8 km and a maximum width of 12.9 km. The wetland is located at longitudes of 34º00´E and 34º25´E, and between latitudes of 1º08´S and1º39´S. Administratively, the wetland lies between Tarime and Musoma (Butiama) rural districts of the Mara region in Tanzania (Ng'umbi, 2009; Mayo *et al.*, 2013).

5.4.2. Climate and hydrology

The amount of rainfall in the Mara River Basin varies with altitudes. The Mau Escarpment which has an altitude of 2,932 m receives annual rainfall ranging from 1,400 to 1,800 mm; the middle savannah grasslands receive an average rainfall between 900 and 1,000 mm, while the lower regions (altitude of 1,134 m) including the shores of Lake Victoria, experience approximately 500 to 800 mm (Bogers, 2007; Mayo et al., 2013). The Mara region experiences a bimodal rainfall pattern. The long rains start in mid-March and last to June with a peak in April; while the short rainy period occurs between September and December (Mutie et al., 2006). The Mara wetland is fed by the Mara River from the upstream catchment before the water flows into Lake Victoria.

The river contributes about 37.5 m^3/s water input to Lake Victoria, which is about 4.8 % of the total discharge into the lake. The tributaries feeding into the Mara river include the Nyangores, Amala, Talek, Sand and Engare rivers, located on the Kenyan side and Bologonja river on the Tanzanian side (Mango et al., 2011). The perennial nature of the Mara river is attributed to the larger rivers, such as Nyangores and Amala, which feed it. The two rivers constitute 60 and 40 %, respectively, from the Mau catchment (Gereta et al., 2002).

5.4.3. Land cover and land use

The Mara River Basin receives rainfall of approximately 1400 mm/yr on the upper catchment located at the Mau forest complex and 600 mm/yr on the plains. This well distributed rainfall and fertile soil is favorable for agriculture, wildlife and livestock activities (Mutie *et al.*, 2006; NBI, 2008). Consequently, human population growth rate of 2.7 % has been experienced in the basin as a result of immigration (NBI, 2008). The growing population is increasing pressure on the limited land and water resources, and thus, causing changes in land use/cover.

The basin is highly affected by human activities, mainly deforestation followed by crop farming. Mutie et al. (2006) reports a decline of 31 % in closed forests between 1973 and 2000 due to deforestation for timber, tea plantation and human settlement. The clearing of forests resulted in an increase of open forests and tea plantations by +214 %, as shown in **Figure** 9 and Table 11 . Savannah, grasslands and shrub land (rangelands) on the other hand had decreased by 35 % due to the expansion of agricultural land by 203 %. These trends on the decline of range lands has increased based on data obtained from MODIS MCD12Q1 product available at 500 m resolution from 2001 and 2012 as shown Figure 11 and Table 11. The grasslands have been reduced by 32 %, woody savanna 42 % while croplands and permanent wetlands have increased by 36 % and 32 % respectively between 2001 and 2012.as

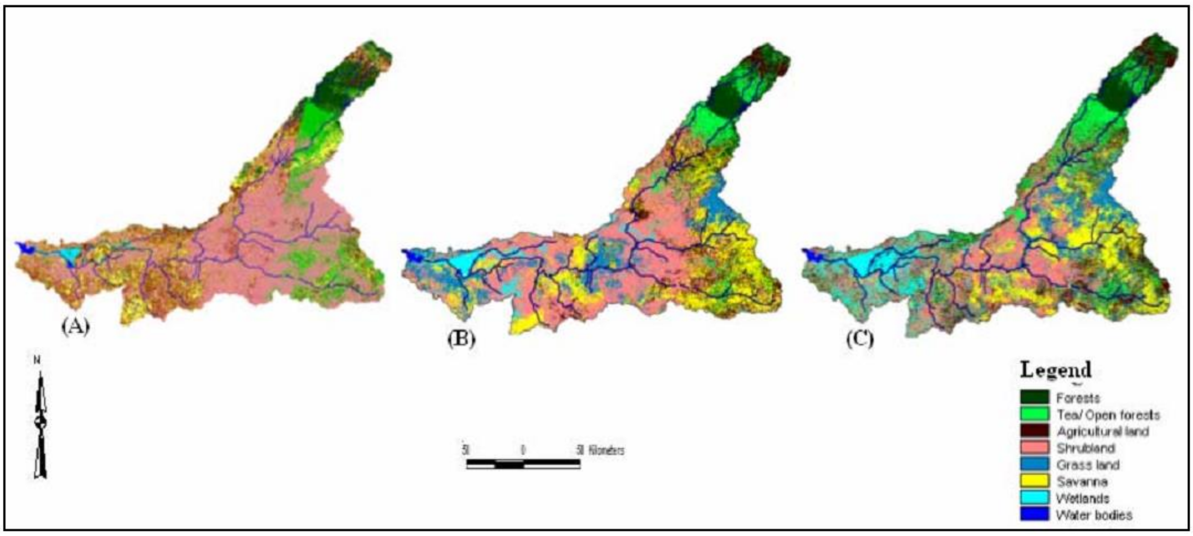


Figure 9 Land use/land cover maps of (A) 1973, (B) 1986 and (C) 2000 for the transboundary Mara River Basin (Source: Mutie et al. (2006))

Table 11 Extent of land use and land cover changes in the Mara River Basin, 1973-2000 adapted from Mutie et al. (2006)

Land cover type	1973 (km^2)	1986 (km^2)	2000 (km^2)	Change (1973-2000)	
				km^2	%
Forest	1008	893	689	-319	-32
Tea/open forest	621	1073	1948	+1327	+214
Agricultural	826	1617	2504	+1678	+203
Shrub land	5361	5105	3546	-1815	-34
Grassland	2465	1621	1345	-1120	-45
Savannah	3163	2867	2354	-809	-26
Wetland	286	604	1394	+1109	+387
Water bodies	104	54	55	-49	-47

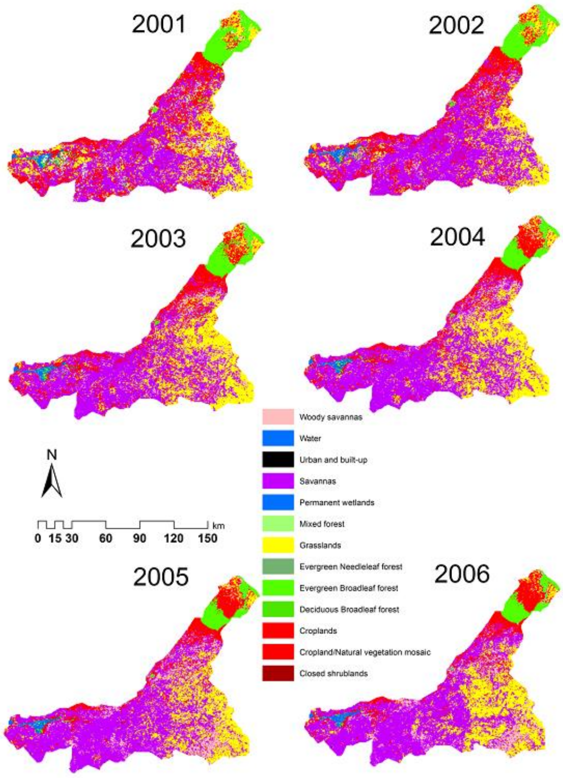


Figure 10 Land use/cover changes from year 2001 to 2006 in the Mara River Basin (developed from MODIS MCD12Q1 product available at 500 m resolution)

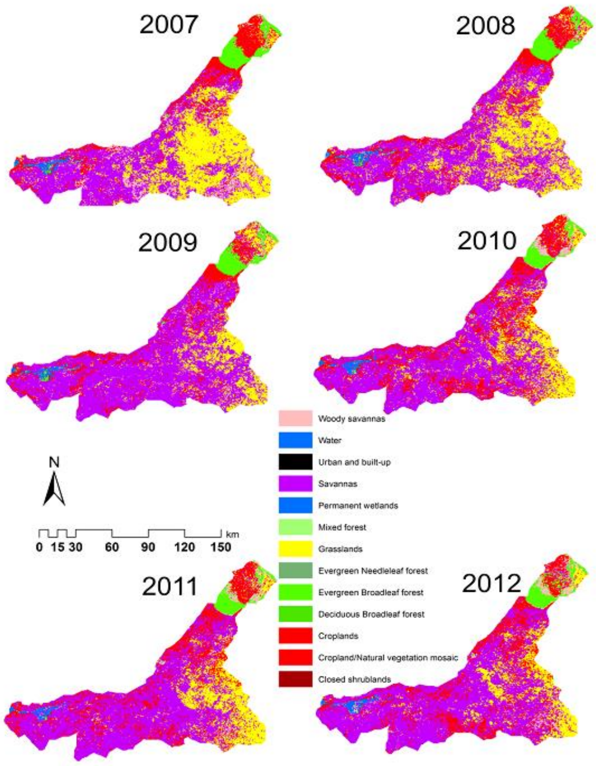


Figure 11 Land use/cover changes from year 2007 to 2012 in the Mara River Basin (developed from MODIS MCD12Q1 product available at 500 m resolution)

The reduction in natural vegetation cover caused by deforestation and increase in agriculture coupled with poor management of cultivated land and overgrazing has resulted in severe soil erosion in the basin (Mutie *et al.*, 2006; Defersha and Melesse, 2012). Subsequently, sediment deposition in the water bodies has increased, resulting in 47 % reduction of their aerial extent (Mutie *et al.*, 2006). Moreover, the basin wetlands, specifically the Mara wetland, has increased by 387 % from 1973-2000, due to sediment deposition at the river mouth causing backflow during rainy season.as shown in **Figure** 9

5.4.4. Existing Ecosystems Services in the study area

Mara wetland is a riparian papyrus wetland located in the transboundary Mara River Basin, shared between Kenya and Tanzania. The basin covers an area of approximately 13,750 km^2, of which 65 % is located in Kenya and 35 % in Tanzania (Mayo et al., 2013). The wetland's source of water is mainly the Mara River which originates from Enapuiyapui swamp in Kenyan Mau Escarpment. Administratively, the wetland lies between Tarime and Butiama districts of Mara region in Tanzania (EEAA, 2000) (Ng'umbi, 2009; Mayo et al., 2013). The wetland covers an area of approximately 164 km^2 with a variation from 135 km^2 in the dry season to 186 km^2 in the rainy season.

The Mara wetland supports the livelihoods of the local communities both directly and indirectly by providing a wide array of Ecosystem Services (ES) (Kema, 2010). The ES include provisioning services (fish, fresh water, crops, firewood, papyrus mats, charcoal, bricks, pasture for livestock, thatching grass and milk), regulatory services (water purification), cultural services (recreation, spiritual and religious uses, aesthetics, education and research) and supporting services (nutrient cycling) (Ng'umbi, 2009; Kema, 2010). In relation to water purification ES, the wetland is a recipient of accumulated effects of all the upstream activities such as agriculture, gold mining and soil erosion among others (Ng'umbi, 2009; Mayo et al., 2013).Thus, its capability to retain nutrients, heavy metals and sediments before water is discharged into Lake Victoria is highly valuable in enhancing water quality of the lake. However, quantitative information on the ES remains scanty. Moreover, unlike the common occurrence of wetland loss reported in many parts of the world, Mara wetland has been expanding landward over the past five decades (Mutie et al., 2006; Bogers, 2007). This has been due to land degradation upstream of the wetland resulting in faster run-off, siltation and prolonged flooding downstream (Mutie et al., 2006). Therefore, quantification and economic valuation of ES derived from the Mara wetland is important for decision making regarding the sustainable management of the wetland.

6. Conceptual Framework for wetland Valuation Case Studies

A frame work containing number of steps have been developed as a guide line to be followed that lead toward identifying the ecosystem services for the different case studies representing different types.

6.1. Egypt, Burullus Case Study

6.1.1. Step 1: Define the scope of the wetland to be valued

Lake Burullus is one of Egypt’s most important wetlands offering a wide range of ecosystem services, located in Kafr El Sheikh Governorate, one of the largest Governorates in Nile Delta. The Lake is located within five districts of Kafr El Sheikh Governorate. These districts are from the East to the West: Baltim, El-Hamoul, El-Riad, Sidi Salem and Metobes, Figure 12.

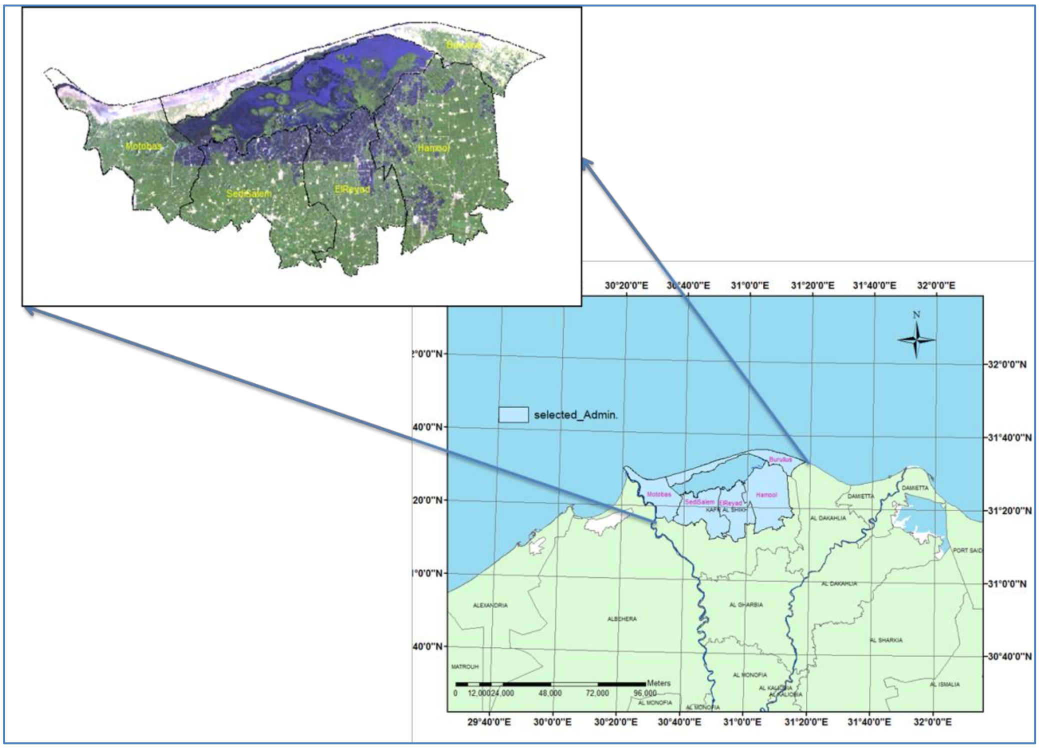


Figure 12: Location of Lake Burullus Wetland Boundary

The local communities living around the lake depend mainly on the lake ecosystem services to earn their livings mainly through exploiting the fishery resources which is the leading activity in the lake; the agriculture comes in the second most important economic activity. The main other activities in and around the lake are: reed cutting, grazing, bird hunting, gathering medicinal plants and salt extraction with only a small minority working in industries such as boat building and repair, mechanics or in various services.

Recently with the rapid increase of the population around the lake with absence of environmental laws enforcement several illegal activities losing parts of the lake for urban development or more profitable activates as agricultural activities and illegal fish farms, thus stressing the lake resources and the sustainability of ecosystem services offered by the lake.

A serious action has to be done by the stakeholders for restoration of the lake size and ecosystem services, this study offer the decision maker a good guide for the current ecosystem services offered by the lake, and a simple and easy evaluation of its economic participation in the local communities' livelihood to be able to take more effective and timely decisions.

6.1.2. Step 2: Identify the principle wetland benefits/functions and services

The main provisional services of the districts around Burullus lake can be summerized as followed:

- Agriculture and livestock

Kafr El Sheikh is an agricultural governorate. As of 2002, there are only 7,590 ha under cultivation within the boundaries of the Protectorate. The average yield of rice and cotton of about 60% - 40% respectively of the national average.

The only profitable crops are guava, berseem and dates intensively cultivated on the eastern side of the inlet, near Baltim. Other crops are tomatoes, grapes, clover, cabbage, cauliflower, watermelons, broad beans, wheat, rice, and maize.

Livestock is considered a part of agricultural activities in lake shore, villagers keep herds of buffaloes, cows, sheep, goats and camels inside the Protected Area, making little contribution in the overall economic input.

- Fishing and fish farms

Fishing is considered the main activity in the protected areas, providing the principal life-support system for the local communities; fishermen, fish merchants, fish brokers, ships and fishing tools manufactory.

Annual fish catch in the lake has decreased from ٥٣,٩٠٩ tons in 2005 to ٤٩,٧٠٤ tons in 2013, while fish farms reached 155,000 tons/year. The fishery performance of the Lake become weak and the fishermen complain from disappearance of high value fish due to decrease of lake fertility.

- Economic plants

The economic plants are classified into six major categories: grazing, fuel, medicinal use, human food, timber, reed harvesting and other uses, e.g. making mats, baskets, ropes, chairs, ornamental uses, beach bed, sand binder, soap manufacture and oil and dye extraction.

- Local and migratory birds

Although all forms of hunting are illegal after the declaration of Burullus as a protectorate, the bird hunting is largely concentrated in the autumn; quail: Coturnix and winter; water birds. Still bird catching is not an economically significant or stable activity in the Burullus area.

- Salt marshes

Salt marshes extend along the lowlands of the Lake marine bar, with an area about 40% of the total area of the bar; 6% only found in the eastern part, and 34% in the western part due to the relative low level of its surface. Tidal action is considered among the principal factors responsible for the formation and development of salt marshes.

6.1.3. Step 3: Identify wetland beneficiaries and stakeholders

The main beneficiaries of Burullus Lake are the local communities of the five districts surrounding the lake; Baltim, Sidi Salem, El- Hamool, El Reyad, Motobas, as shown in Table 12. The main activities of these districts are fishing, reed harvesting, salt extraction, boat industry, agriculture activities which mainly depend on the available ecosystem services in each district as shown in

Table 13 social fishing organization have been established to serve the fishing activities, as there are around six fishermen cooperatives in areas around Lake Burullus intended to serve the needs of the fishermen. Each cooperative has a board of around 11 members including a chairperson (who may be the fishermen Chief), a treasurer, a secretary and a deputy chairperson. All fishermen are expected to be members in one of these cooperatives. (Local food and security, 2013).

Table 12 Beneficiaries and Stakeholders of Lake Burullus Wetland

Ecosystem services	Beneficiaries of ES	Stakeholder
Fish harvesting	Fishermen, fish sellers, fish farm owners, related industries	EEAA, General authority of fishery development, Kafr El-Sheikh Governorate, Ministry of health , Coast Guards, NGOs
Agricultural crops	Farmers, market sellers, food industries	Ministry of Irrigation and Water Resources, Kafr El-Sheikh Governorate, Ministry of Agriculture and land reclamation
Salt extraction	Local communities – salt industries	Kafr El-Sheikh Governorate, NGOs
Live stock	Farmers – local communities	Kafr El-Sheikh Governorate, Ministry of Agriculture and land reclamation
Bird hunting	Local communities	EEAA, Kafr El-Sheikh Governorate, NGOs
Economic plants	Medical industry – local communities	EEAA, Ministry of Agriculture and land reclamation, Kafr El-Sheikh Governorate, NGOs
Carbon sequestration	Global society	EEAA, NGOs

Table 13 Major Activities at Lake Burullus wetland Surrounding Area

Markaz (Markaz)	Population (Pop./km$^{2)}$	Major Activities
Baltim (Burullus)	734	Fishing Reed Harvesting Salt Extraction Boating industry Agriculture
Sidi Salem	444	Fishing Fishing net Agriculture
El-Hamool	266	Fishing Fish farms
El-Reyad	345	Fishing Agriculture Grazing
Motobas	618	Fish Farms Fishing Fishing net Agriculture

The main stakeholders relevant to lake management and their main responsibilities shown in Table 14.

Table 14 The Main Stackholders and Their Resposibilities

Institution	Rule
EEAA	Nature Conservation Sector (NCS) and central department of integrated coastal zone management (ICZM) in EEAA has the ultimate legal responsibility for the proper management of the Burullus Protected Area and its resources.
Kafr El-Sheikh Governorate	It is the most influential stakeholder at the local level. It has its own Environment Office, Local Administration Councils and Investment Council. It plays an important role in the approval and allocation of land for development projects.
Ministry of Agriculture and land	The General Authority for the Development of Fisheries Resources (GADFR)- Ministry of Agriculture, is responsible for the management of the Lake’s fisheries.

Institution	Rule
Reclamation	It also issues permits for the establishment of fish farms in the vicinity of the Protectorate. The Ministry of Agriculture determines the distribution and area of rice cultivation in Nile Delta and fines farmers violating the instructions by exceeding the limits of areas allowed for this crop.
Ministry of Water Resources and **Irrigation**	This Ministry is responsible for water resource management and the maintenance of all water courses in the country. It is also concerned with the volume of water in the Lake as it dams the likely sea water intrusion into the Delta
Ministry of Defence	Coast Guard, which comes under the jurisdiction of the Ministry of Defense, is responsible for security and controls all illegal smuggling activities along the coast (which forms the northern border of the lake).
Ministry of Interior	Police of water surfaces enforces fisheries and environmental regulations, such as restrictions concerning hunting, fishing and quail netting within the lake. Currently, there are two police stations on the Lake shores and a third is under construction.
Ministry of Housing and New Communities	This Ministry has constructed an international coastal highway between Sallum (on the border with Libya) and Rafah (on the border with Palestinian Authority), which traverses the area from east to west. Part of the highway is a bridge over the Bughaz and the rest cuts through the entire sand bar lengthways. This highway is rapidly attracting new populations and settlements to the area. The impact of the increased human activities along the both sides of the highway is yet to be properly assessed
Ministry of Health	Directorate of Public Health in Kafr El-Sheikh Governorate is responsible for health issues affecting inhabitants of the Burullus Protected Area
A number of (NGOs) in the Kafr El-Sheikh Governorate	Play a key role affecting land and resource use in the area. Four of these are mainly concerned with local community development and a further seven are fishermen's societies

6.1.4. Step 4: Identify the Constraints under Which the Valuation Will Be Carried Out

Choosing an appropriate methodology for wetland valuation should be based on three factors, these constrains are considered in selecting the valuation methods applied.

- Time and cost for study
- Capacity and experiences of those carrying out the study
- Information and characteristics of wetland

6.1.5. Step 5: Choosing a Valuation Method for (LBW)

There are various methods of estimating economic values of wetlands which depend on the type of value (direct use values, indirect use values and non-use values) being estimated. , additional field work is needed for filling two proposed questionnaires for valuation of fish consumer and producers surplus by the market price method (Annex 1) and bird watching intitives in burullus lake by travel cost methods (Annex 2). The selected LBW services and its valuation method are represented in Table 15.

Table 15 Lake Burullus Wetland (LBW) Serviecies and Valuation Approach

Services	Functions associated with services	Direct/ indirect value	Valuation approach
Provisional (commercial products)	Fish catch *	Direct	Market price value *
	Reed harvesting		
	Salt extraction		Productivity methods
	Agriculture crops		
	Livestock		Travel cost method
	Bird hunting		
	Economic plants		
Supporting/ Regulating	Carbon sequestration *	Indirect	Market price value
	Erosion Protection		
	Climate change and SLR protection		Avoided (damage) cost *
	Nutrient Cycle		
	Shore line management		Mitigation or restoration cost
	Water purifiction		
Recreational /Atheistic	Water bird watching *	Direct	Travel cost *
	Touristic opportunities		
	simple nautical activities		Mitigation or restoration cost
	Sand dunes		

6.1.5.1. Fish catch

Fishing plays an important role in Egyptian economy, Kafr el Sheikh governorate ranked the first governorate in fish production by that reached 559.8 thousand tons about 41.1% of the total Egyptian production according to the 2011, mainly concentrated in the districts around Burullus Protected Areas providing the principal life-support system for the local inhabitant, Most of the population consists of fishermen, farmers, fish merchants and fish brokers, few years ago, consumers preferred fresh products from capture fishery (with relative higher price in market), but recently they cannot differentiate between products from different sources. As aquaculture products are sold fresh and sometimes alive. Fish are sold in the markets without label or processing. Some large supermarkets sell fresh fish without labels or packing. (Stefano Cataudella, 2015)

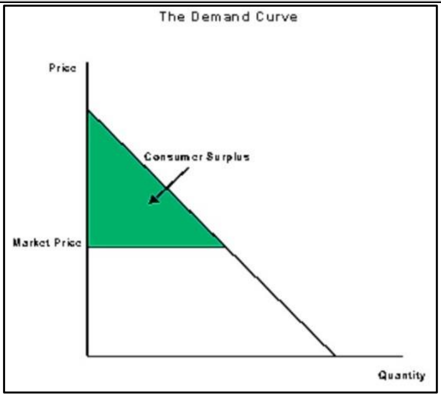
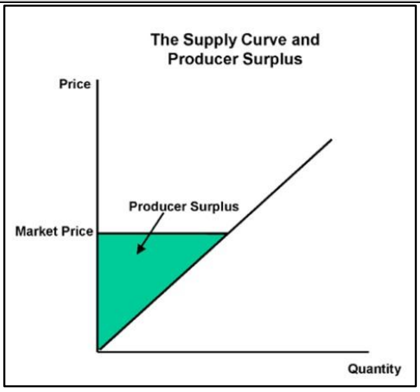
The mean price of the fish production has increased from 7.6 LE / kilo in 2002 to 12.3 LE in 2011 by 61.8%, Flocculation in the amount of fish production in Burullus Lake, the max. production was in 59.8 thousand ton that represent 34.8% from the total fish production of the northern lakes in 2002, the min. production was 45.5 thousand ton that represent 27.9% from the total fish production of the northern lakes in 2011, market price was used valuate fish production as a market product. (Source: annual report of fishery production 2013 – GAFRD)

Market Price method

Market price approach was selected in this case study, as the simplest and most straight forward way of finding out the value of wetland goods because we can find out directly the consumption and sale value of wetland goods. This method uses questionnaires to collect data about the market price of buying and selling wetland goods, measuring the satisfaction of market price of fish from the consumer as well as the producer point of view, the market price only translate the minimum amount that consumers who buy the good are willing to pay for it and also the maximum amount that sellers who sell fish are willing to earn from it, Table 16 The Difference between Consumer and Producer Surplus shows the different between consumer and producer surplus .

Table 16 The Difference between Consumer and Producer Surplus

Consumer surplus	Producer surplus
The difference between the prices actually paid for a good, and the maximum amount that an individual is willing to pay for it	The difference between the total amounts earned from a good (price times quantity sold) and the production costs.

<table>
<tr><th>Consumer surplus</th><th>Producer surplus</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>“The law of demand”: the consumer will purchase less for a specific good/service, if the price of this good/service increases.as people demand less of something when it is more expensive (assuming prices of other goods and peoples’ incomes have not changed)

The demand function for a commodity can be estimated by relating the quantity demanded and the price of the commodity (Steven, 2003).</td><td>Economic values are affected by the changes in price or quality of substitute goods (Goods that you might purchase instead of a particular good) or complementary goods(Goods that are often purchased together, such as bread and butter).</td></tr>
<tr><td colspan="2">Requires the development of empirical models for the demand and supply relationships describing market outcomes</td></tr>
<tr><td colspan="2">Depending on each application this can be difficult due to lack of data at the level of resolution required to describe how economic policies affect each of these relationships.</td></tr>
</table>

Compensating variation (Compensating variation is the amount of money that leaves a person as well off as they were before a change. Thus, it measures the amount of money required to maintain a person’s satisfaction, or economic welfare, at the level it was at before the change).

Equivalent variation. (Equivalent variation is the amount of money that leaves a person as well off as they would be after a change. Thus, it measures the amount of money required to maintain a person’s satisfaction, or economic welfare, at the level it would be at after a change.)

In order to make resource allocation decisions based on economic values, what we really want to measure is **the net economic benefit** from a good or service, the economic benefit to individuals, or consumer surplus, received from a good will change if its price or quality changes (Kyophilavong).

For the simple market price the following equation can be used for calculating the net price of fishery activity neglecting the compensation rate of consumer and producer for giving an annual use value of fishery production.

$$\textbf{Annual use value} = Q \times (p-c)$$

Where: Q= total catch
P= market price
C= cost of harvesting the resource

A questionnaire was prepared by the project team as shown in annex (1) for evaluating the consumers and producers surplus in selected districts around Burullus lake to calculate the direct benefit of fish capture using the following equation:

$$D_{benefit} = \textbf{Mean} \times \textbf{Population}$$

Where:
$D_{benefit}$= Total of direct benefit (fish capture)
Mean= Mean of direct benefit (fish capture) from all the questionnaires in the sample
= The total number of fish caught/ No. of households samples
Population= Total population use or collect in the fish capture

6.1.5.2. Bird Watching

Considering the geographical position and the present habitat types, Burullus Lake is most likely of major importance for water birds, especially herons, ducks, waders, gulls and terns (Goodman *et al*. 1989, Tharwat 1997, Baha El-Din 1999). There is virtually no data on the function of Burullus Lake as a staging area for birds during spring and autumn migration. Apart from the winter surveys, the only reasonably complete census of water birds was made on November 1981 (Bennett *et al.* 1982). Since that census was carried out after the main autumn migration period of most water birds between Eurasia and sub-saharan Africa, and before the main winter influx of ducks and coot, numbers of most species observed were lower than in winter, 93 kind of birds was recorded through last two decade in Burullus area, data obtained by EEAA in 2010 showed that about 112 bird species and subspecies were recorded in Lake Burullus. These species were divided into 46 residents, 80winter visitors, 23 spring visitors, and 72 both summer and autumn passers. The Islets and marshy areas are undoubtedly of importance for enormous number of passerines during migration.

Bird watchers visit the lake are only few visitors to the area due to lack of organizations and facilities as a few unqualified number of hotels were built in the districts around the lake as shown in Table 17, the main visitors are from local community as school visits and some visitors from other governorates, travel cost method is used for this section as recreational non use service.

Table 17 Availiable Hotels in Districts around the Lake

District	Hotel numbers	Hotel names
Baltem	6	Kelopatra- Isis – Medan el Zahra – Nefertiti – Nefertari – Dahab
Modobas	1	El Salam
Sedi salem	1	Sport club

Travelling cost method

The travel cost method is used to estimate economic use values associated with ecosystems or sites that are used for recreation, The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site represent the "price" of access to the site. Thus, peoples' willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs. This is analogous to estimating peoples' willingness to pay for a marketed good based on the quantity demanded at different prices, then graph in Figure 13 The overall trend between travel costs and visit rates at a particular asset or site is drawn in order to estimate the no. of visits to the lake for bird watching per year a with the price of a visit.

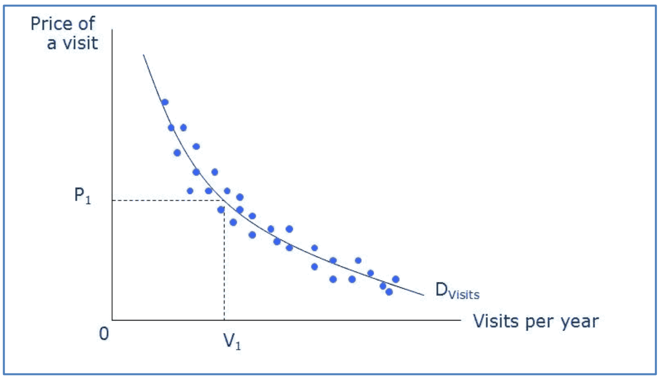


Figure 13 The overall trend between travel costs and visit rates at a particular asset or site

A questionnaire was prepared by the project team to evaluate the economic benefits or costs resulting from traveling of local and foreign visitors to the lake area for bird watching purposes, estimating the will to pay to visit this site for its scenic quality and characteristics. The number of visitors per year and the money that the visitor pays for visiting this site was considered (this includes the price of the plane ticket, price of local transportation and the lodging cost) as shown in annex (2) to calculate the following equation:

TVC = average number of visitors × [ticket price + prices of local transportation + (rate of hotel charge per night× number of days)]

Zonal travel cost method

The zonal travel cost method is the simplest and least expensive approach. It will estimate a value for recreational services of the site as a whole. It cannot easily be used to value a change in quality of recreation for a site, and may not consider some of the factors that may be important determinants of value.

The zonal travel cost method is applied by collecting information on the number of visits to the site from different distances. Because the travel and time costs will increase with distance, this information allows the researcher to calculate the number of visits "purchased" at different "prices." This information is used to construct the demand function for the site, and estimate the consumer surplus , or economic benefits, for the recreational services of the site.

To calculate the value of the asset (V) for a single visit the researcher now uses the simple equation as follows:

$$\mathbf{V = ((T \times \mathit{w}) + (D \times \mathit{v}) + Ca) \times Va}$$

Where,
T= travel time (in hours)
W= average wage rate (EGP/hour)
D= distance (in km)
V= marginal vehicle operating costs (EGP)
Ca= cost of Admission to asset (EGP)
Va = average number of visits per year

6.1.5.3. Carbon Sequestration

Terrestrial carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide (CO_2) by forests, grasslands, wetlands and other terrestrial ecosystems; it is an important ecosystem service that has been a primary focus of climate change mitigation efforts as with CO_2 increase, there is growing public and scientific concern about the carbon sequestration potential (CSP) of various terrestrial ecosystems especially wetlands (Ebrahim M. Eid).

The major greenhouse gas (CO_2) is absorbed directly by water and indirectly (through photosynthesis) by vegetation, leading to storage in biomass and in soils as organic matter; the ability of soils to store carbon is a major regulator of climate. Other greenhouse gases, notably methane (CH_4) and nitrous oxide (N_2O) are regulated by soil microbes. Organisms in the marine environment play a significant role in climate control through their regulation of carbon fluxes, by acting as a reserve or sink for CO_2 in living tissue and by facilitating burial of carbon in sea bed sediments (Beaumont et al. 2007). The capacity of the marine environment to act as gas and climate regulator is very dependent on its biodiversity. (B. F. Rudolf de Groot).

In order to place a monetary value on carbon sequestration by habitats, most studies use either carbon market prices or an estimate of the marginal value for the social damages from emissions (Ferraro et al, 2012).

A study was conducted for “Evaluation of carbon sequestration potential of lake Burullus, Egypt to mitigate climate change” in 2013 to assess the distribution of soil organic carbon in vegetated and un-vegetated sites in Lake Burullus, to give accurate estimation of soil organic carbon stock in this lake in order to meet the requirements of the Kyoto Protocol; and to provide estimates of its carbon sequestration potential.

One of the main importance of the vegetation in Lake Burullus is carbon sequestration (e.g. Phragmites australis, Typha domingensis, Eichhornia crassipes, Potamogeton pectinatus), Lake Burullus could be instrumental in formulating efficient strategies related to carbon sequestration and reduction of greenhouse gas emissions in Mediterranean wetlands, as reed beds (Phragmites australis) of the lake represent one of the most important reed beds in the Mediterranean region, where this type of habitat is becoming rare and threatened.

The reed beds in the lake represents one of important nature habitat; its area reached to about 40% of the lake total area, the lake include about 30 islets, those near the lake- sea connection are sandy nature, while those far from the inlet have clayey bottom, some of the small islets are covered with water during high water periods. Heavy growth of reed plants (Eid) may lead to merger of adjacent islets. (Ebrahim M. Eid), although the wetlands in warm regions (e.g. south Mediterranean) have greater carbon production than the wetlands in temperate climates, they have also greater decomposition due to high temperature (Eid).

TEEB, 2010 defined carbon sequestration(indirect use value) as regulating service for climate regulation that can be measured by several methodologies as Revealed Preference method (market value) or Cost based method (Avoided cost, Damage Cost, Mitigation Cost) or benefit transfer method (benefit transfer), plan blue on going project proposed the following methods for calculating carbon sequestration potential in lake Burulus, the main methods for evaluating carbon sequestration are applied at this project represents in **Table 18**.

Table 18 Methods for evaluating Carbon Sequestration

Method	Description	Limits
Mandatory market price	Markets for emissions permits are compulsory for some activities in certain countries/regions (eg. EU-ETS)	Egypt is not part of a mandatory carbon market
Voluntary market price	Emitters buy credits from clean investments in developing countries on Voluntary Carbon Markets	Egypt receives credits from VCM but does not compensate for its own emissions through this channel
Carbon tax	Pigouvian tax on GHG emissions	Does not exist in Egypt
Replacement cost	Cost estimate of artificial infrastructures that would provide an equivalent service	No existing reference project
Social cost of carbon (preferred option)	Estimate of the damage induced by an additional emission of 1 tCO_2	Global cost

6.2. Sudan, Dinder Park Case Study

Fifteen (15) villages in and around the Dinder wetland, were selected. Target communities were selected including; Farmers, pastoralists, fishermen, honey collectors, brick makers, charcoal makers, market traders, non-wood forest products' collectors, tourism investor and other users

Beside the related data from available documents, the socio-economic and ecological data which is collected by the field team during the field surveys. The procedures used for ecosystem services data collection and information include beside others:

- Direct contacts with village traders and villages 'shops were carried on.
- Market prices of the wetland resources were collected and listed.
- Informal discussion with members of communities (Village leaders, pastoralists, farmers, fishermen, members of tourist companies, other users and beneficiaries) and management authorities in Dinder wetland was performed.

6.2.1. Step 1: Define the scope of the wetland to be valued

Dinder wetland is located in North-Eastern Sudan between latitudes 11-13 N and longitudes 34-36 E, adjacent to the Sudanese border with Ethiopia. It covers an area of 1.084.600 hectares (10.291Km2).

6.2.2. Step 2: Identify the principle wetland benefits/functions and services

Dinder wetland with its three ecosystems (Woodland, Riverine and Mayas ecosystems) provides tremendous ecosystem services and values. Dinder provisioning Services include Fresh Water, Timber, non-wood forest products, Genetic Resources, etc. The Regulating Services include Air quality regulation, Water purification and treatment, Water regulation, Climate regulation, Erosion regulation, Soil formation, Pollination, Pest regulation, Disease regulation, Primary production and Nutrient cycling. The Cultural Services include Spiritual and religious values, Aesthetic diversity, Cultural diversity, Recreation and ecotourism and Knowledge system and educational values. Biodiversity conservation, recreation and tourism opportunities are considered as important issues in the sustainable management of the Dinder wetland as a protected area.

The Mayas (natural depressions which store rainfall water and covered with a meadow) in Dinder wetland act as tools for water regulation in the drainage pattern. The forested ecosystems regulate the climate in the whole Dinder area. Dinder wetland is a watershed area, control water erosion and nutrient cycling and is protecting the most influential feeders of the Blue Nile and their tributaries. They deposit fertile soils in the banks of the rivers for plant regeneration and crop production. These wetlands minimize the damage during floods, especially during high floods. Thus, the flood-plain has a high rate of water retention and natural hazard regulation. The forests regulate erosion, air quality and climate locally and regionally.

The habitats of the flood plain, depression, lakes, Mayas and pools are rich in their ichthyofauna and they are a major breeding ground for the fishes, amphibians, water dwelling insects and micro fauna which greatly enhance the biodiversity of these wetlands. They offer refuge and protection to fish after the flood season and therefore are valuable reserve for reactive net when the next flood starts and joins the pools and Mayas to the main channel of Dinder and the Blue Nile rivers. They are the most important features of the Dinder in terms of availing water and green grasses for the wildlife species during the dry season as well as to different fish eating species.

Dinder wetland, as protected area, is an island of a diverse array of fauna and flora of the region which support biodiversity and a large population of wild animals such as the tiang, roan antelope, red-fronted gazelle, reedbuck, oribi, warthog, waterbuck, lion and ostrich. This species are not found elsewhere in the region. Some of these species are endangered (classified conservation dependent by IUCN), Vulnerable in the IUCN Red List), and cited on CITES Appendix II. With regard to lion and the elephant, it is the only area in the region where such species still exist. The wetlands also protect endemic species which live in the region or are permanent settlers of the Dinder, numerous kinds of fishes and insects species such as bees which are of economic importance to the local communities living around and within the Dinder wetland.

Dinder lies on the migration route of African wintering birds during their pass to the eastern African Rift valley lakes or southward. The wetlands provide a refuge for a large number of migratory birds (about 250 species). It is also special area for recreation and ecotourism. It has educational values to university students and researchers.

The Dinder wetland is the very source of lives and wellbeing of wildlife and humans. The ecosystems provide food, fruits, fuel, fiber, timber, fuel wood and medicinal plants to the local communities in and around Dinder. The water of the pools are used for all household uses. The pools are rich in fish and waterfowl. The pools are of pivotal importance as a source of water for birds, wildlife, trespassing livestock, poachers, honey collectors and so forth.

Gerif land is the land which stretches along the river banks and from which river water receded after flood time. Most Rahad villages inside the Dinder possess Gerif land. Crops produced here are mostly high-value vegetables and fruits (Mango, guava and papaya) and beans. After harvest the Gerif land is usually rented for nomads to graze the crop residues. Nomadic pastoralists, during the dry seasons, move to the area to utilize the available water and grazing resources. Hence the wetland provide valuable pastures for pastoralists.

Dinder wetland provides historical cultural services. It has spiritual, religious and aesthetic values. The Dinder Archaeological finds revealed the considerable geographical extent of the Meroitic Kingdom and showed possible relationship with the kingdom of Axum. Additional sites of the Fung period are highly likely to turn up along the Dinder River. The population of Magano Mountain village was known to exist at the south-western boundaries of the reserve before the Dinderpark was established. They trace back their history to 1912. The Magano community has built its own system of belief. This manifested itself around certain taboos and prohibitions. The wetlands social services improve e.g. education, scientific and recreational activities to the local areas and the region as a whole.

6.2.3. Step 3: Identify wetland beneficiaries and stakeholders

There are lots of beneficiaries and users:

- Use of wetlands as sources of drinking water, agricultural irrigation, directly used by water abstractors and agricultural producers as users of gerif lands along Rahad and Dinder Rivers. The human settlement is expanded along the boundaries' of Dinder wetland because of the benefits they gain from the ecosystem goods and services.
- Collection of sediments, and clay by direct exploiters such as brick makers and houses builders.
- Indirect users benefit from indirect wetland services, such as storm abatement and flood mitigation.
- Conservation, tourists and amenity groups conserve nature and some groups enjoy the presence of biodiversity (plants and animals)
- Researchers and students from different national Universities and Research Institutes at Local, National and International levels.

6.2.4. Step 4: Identify the Constraints under Which the Valuation Will Be Carried Out

Among the procedures used for data collection was the literature review including previous reports, scientific papers and office documents. Previous historical reports and published scientific papers on Dinder wetland. Data used for comparison, includes studies and activities of the ongoing projects such as the socio-economic study which was conducted in 10 Rahad villages inside Dinder National Park (DNP). by Community Watershed Management Project (CWMP)(2012-2015). The different monitoring studies which was conducted by the UNESCO Project (Zonation of Dinder Biosphere Reserve) during (2014-2015), concerning range and pastures status, fishing practices, honey production and inventory of research, MSc and PhD studies conducted in the Dinder were reviewed.

Beside the related data from available documents, the socio-economic and ecological data which was collected by the field team during the visits and survey conducted during the course of this study (May, 20- 10 June, 2015 and Jan-Feb 2016), are used. The procedures used for data collection and information include:

- Locations of selected visited villages(15 out of 30 villages) are documented using GPS
- Meetings with stakeholders (WCGA, WRC, CWMP, Nile Basin Discourse, National Man and Biosphere Committee (MAB)) are conducted.
- Training for Field team members on Field data collection templates and guidelines is achieved.
- Field data collection templates and guidelines for Field survey, Household survey, questionnaires and interviews are translated to Arabic Language and used.
- Assessing the land use patterns around the wetland (direct observation, informal discussions and reports reviewed) was performed.
- Direct contacts with village traders and villages 'shops were carried on.
- Market prices of the wetland resources were collected and listed.
- Informal discussion with members of communities (Village leaders, pastoralists, farmers, fishermen, traders,++ members of tourist companies) and management authorities in Dinder wetland was performed.
- Interviews, meetings, and villages' views were documented by photos and locations of villages using GPS.
- The data was analyzed statistically using SPSS and Chi-square methods.

Samples of water were collected from different Mayas (Ras Amir, Abdelgani, Musa, Gerierrisa, BeitElwahash, BerkatElTmsiah and Samiyaa) and pools along Dinder and Rahad rivers and KhorGalaguo and additional economic and hydrological data collected during the field visit from 15 to 20 Feb. 2016.

- Lab analysis were done for the samples collected from the field.
- Economic valuation data sheets using certain valuation methods were used to assess the economic values for different wetland resources and benefits. Several parameters are used for data collection. Most of the related stakeholders and institutions(5) are involved.

There are certain factors that affect the productivity of the wetland such as the natural hazards, disasters and difficult time to produce food. The difficult months for fish and crops production, is before crop harvesting (66.7%), and in summer (33.3%). Most of the interviewers (71.0 %) reported that no improvement in wetland production during the last 10 year. Most of the interviewed people are worried from the decreasing of soil fertility (51.4%). Drought, insect (14.3%) and floods (29.5%) are other problems that affect their production levels.

Main constraint to better income are the regulations of Wildlife Conservation General Administration (WCGA) as reported by 62% and to 37.5% the constraints are flood and drought. Difficulties in production (37.5%) and difficulties in transportation (62.5%) are major problems.

The majority of people (87.6%) need permission from WCGA to conduct certain activity. Some of the interviewers (43%) reported that permissions are needed for wood cutting and charcoal production, while 57% see that Gum Arabic collection is the only activity which need permission. There are regulations for wetland production to 52.4% of the interviewers. There are Federal, State and Local regulations. All of them (100%) reported that they do not break the regulation or change any regulation. About 63.0% mentioned that there are conflicts because of breaking the regulations.

When the communities face problems in income due to any disaster, most of them (37.1%) either shift to other jobs and honey collection, or they may migrate to nearby towns searching for work. Honey production is a good opportunity for gaining income. They sometimes sell their livestock (25.7%). The change of the prices according to the market (32.7%), change according to the production (61.5%) and the change according to the season (5.8%).

There are different users from outside the area using the wetland as mentioned by 62.3%. According to 33.3% there are good wetland production periods during 1988, 1999, 2003, 2011 and 2013, but others (66.7%) considered 2009, 2010, and 2014 are bad years. Therefore the seasonal condition of the wetland is the factor that related to human benefits from the wetland ecosystem products.

6.2.5. Step 5: Choosing a Valuation Method for (LBW)

The economic value for some of the functions could be estimated using Benefit Transfer Method (BTM), assuming the limit as presented in Table 18 below:

Table 19 Benefit Transfer Method (BTM)

Wetland benefit	Economic value Sudanese pounds		
		Total value in USD	USD
Water purification	6600= 970,5	970,5+00	970.5
Water recharge and supply	80292= 11807.6 USD	11807.6 +5000 USD(34000)	16807.6
Flood attenuation	12130= 1783.82	1783.82+00	1783.82
Habitat and breeding	159000=23382.3 USD	23382.3+ 50000 USD	73382.3
Total in USD			92944.22

*At the time of valuation 1 USD is equivalent to 6.8 Sudanese pounds.

Market Price Approach (MPA)

Market Prices for Wetland products are collected by direct communication with traders and beneficiaries. The market prices (in Sudanese currencies) of some crops, fruits, vegetables are presented in Table 19 . Economic Valuation of products table (20-21) is estimated using MPA.

Estimated Economic Values for Wetland products:

Wetland products:

Fish product:

The result of the field work showed that fishing is usually practiced in the Mayas and pools during December up to July for about 8-9 months a year. The fishermen usually use monofilament nets without using other equipment or additives. The fish species collected are: "gormut" (*Clariaslazera*), "noak" (*Heterotisniloticus*), "bulti" (*Tilapia niloticus*), "gurgur" (*Synobipe*sspps) and the agel -Nile borch.

The net weight collected per day is 63 kg. They sold the fresh fish in the towns. Sometimes are locally sold as dried fish (called locally Kajek) at the local markets of the villages. Most of this dried fish is bought by rich merchants and farmers for feeding the laborers during the rainy season

There is an investment fish project started, in 2012, by the Wildlife Management Authority using fishermen from different villages as partners. The fishermen use monofilament nets with small mesh size nets, Jago and hooks with different sizes. They produce 8 tons of fish every 10 days. The fish usually transported by car to towns and the hired fishermen paid their share which is 50 % of the income. The price of fish varies in Dinder area according to the fishing season range between 10-20 SDG/Kg.

Wood Forest products:

- “**Saaf**” which are young leaves of the dome palm (*Hyphenethebica*) are used for making mats, baskets, honey pots and handicrafts. Some of the manufactured items are for household use and others are for sale. Saaf can be sold as raw material or manufactured as **Mat- *Berish* and broom**. The quantity collected by women is 3 bundles per woman per day. The saaf could be collected throughout the whole year. Saaf could be harvested by women themselves but sometimes by the men and then sold to the women. The price of the bundle is 4 SDG/bundle(1 USD = 6.0 SDG).

Photo 1: Palm (Hyphenethebica)

For manufacturing a ***berish,*** a woman usually spent about 4 hours per day during harvesting and 8 hours per day for the processing. They use colour powder to colour the saaf before processing. The price of the mat-berish differ depend on its size and its colour. Calculation was done for manufacturing 8 Mats- Berish per day, 4 Mats-Berish per day, 12 Mats- Berish per day or selling 12 bundle per day

Photo 2: Broom

Saaf also used to manufacture baskets and brooms. They can produce 6 brooms per day. Like the berish, the same time is spent for manufacturing a ***Broom.*** Calculation was done for manufacturing 6 brooms per day, and 12 bundles per day.

Photo3: Huts

Straw- grasses of *Sorgumsudanensis* and other types of grasses are also used for building the huts.It is used to make mat- Bresh (local name) (Mat- 30 SDG / mat-Bresh)

Photo 4: Mfareek

Trees may be cut for poles which are used for building the huts, and the branches that are not within reach of camels and goats are cut for browsing. *Balanitesegyptiaca is* the tree usually used for this purpose.Also the branches of *Balanitesegyptiaca or Entada Africana* are usually used for production of **wood-blender called locally"Mfareek**".

About 70 branches are harvested per day by a man. He uses chopper, knife and rope. He usually spend about 4 hours per day during harvesting and 7 hours per day for manufacturing *7-10 Mfareek*. (sell price is 4SDG/Mofraka).

Charcoal production: Trees (all species of *Acacia* and *Balanites*) are cut- down for the production of charcoal which is used as a source of fuel and income. Any charcoal dome is made up of 10 tons of wood – or 5 m3 of steams of trees- to produce about 100-150 sacks of charcoal. Charcoal now is very expensive in the towns (1 sack cost 100-400 SDG). About 4-6 persons work together in the whole process; from managing the woods, covering it with mud and using fire wood to burn it. The process will take about 10-15 days as said by charcoal maker. 100 Sacks will be produced by 4 men every 15 days for 6 months (Net cost is 3560 SDG, Net income is 288000 SDG). Villagers collect the dead wood which mostly used as a source of energy (fuelwood). The most preferred trees for fuel fire wood in order of preference are: *Acacia seyal, Combretum sp. and Anogeissus sp.*

Non-wood forest products:

The non-wood products which are collected, harvested and utilized by the communities around and within the wetland include the wild fruits and other special parts of both plants and animals.The **wild fruits** that are eaten include the dome palm, “Nabag” (Ziziphus spp.), “Lalob” (Balanites) and “Tebeldi” (*Adansoniadigitata*).

Photo 5 :“Lalob” (Balanites)

Photo 6: “Nabag” (Ziziphus spp.),

Photo 7: “Tebeld (Adansoniadigitata).

Some are sold in the local markets. Beside these forest fruits "Okra" a wild plant is collected. The field data collected showed that these products usually collected by women and girls. A full sack will be collected within a month. They sold these products in the local village market with low prices (5-20 SDG/Ib).

Medicine (wild plants and animals)

Many plants are used for medication such as fruits of Tamarindusindica and Acacia nilotica, A. Complycanth, Balanitiesaegyptiaca, Nauroeasp roots, and bark of Acaciaseyal trees and roots, (the price is 10-30 SDG /Bundle).

Photo 8: Tamarindusindica **Photo 9: Medicinal plants**

Fruits

Honey collection Honey collection from natural bee hives found in the woodland and riverine ecosystems, starts in the dry season, usually in the months of Feb to June. There are many tree spp where natural bee hives are found. Honey-gatherers usually cause many uncontrolled fires, because they are using fire to burn these trees to fly out the bees from the natural bee hives. Musk, knife and buckets are used for the production process. They usually spent 6 hours for harvesting and 2 hours for processing. The honey bee of Dinder wetland is very famous for its high quality. The price for the product in Um Alkeir village is 50 SDG in average. The honey production by one producer has a Net cost of 13,35 SDG, the Net income is 42,000 SDG and the Net Value is 40,665 SDG.

Wild animals (antelopes, birds). Local communities may hunt wild animals and birds for food. The hunters sold the game meat to workers at Agriculture farms. The Game meat cost 100 SDG/Kg (For antelope)

Water: No price for transport and consumption purpose. The villagers use the water of pools for free and transported by donkeys to their homes. But for irrigation in agriculture farms , there is cost of engine (pump) and fuel.

Clay and Bricks production

The clay at the banks of Dinder and Rahad rivers are used for producing Bricks. The amount of clay collected is about 1-6 m3 per 15 days. Four (4) men work for 13-15 days for the whole process; for producing 350 brick of large size and 1000 of small size. They use certain tools (locally known as Koreak and Tourea) for collecting the clay, wood boxes with fixed sizes and fire wood for manufacturing the bricks.

Photo 10: Bricks

The price of the brick depend on the size of the brick. It was found that the Net cost is 6485 SDG, the Net income is 8400 SDG and the Net Value 1915 SDG if they produce Small Bricks: While if they produce BigBricks,the Net cost is 29045 SDG, Net income is 48000 SDG and the Net Value 18955 SDG.

Sum up the estimated value obtained for each principle wetland benefit/function/service to obtain a Total Economic Value for the Wetland *(Is the sum up of the estimated values obtained for each wetland product, service and function)*

The following presents the estimated Net value of wetland resources (1 USD = 6.8 SDG):

Table 20: The Estimated Net Value of Wetland Resources

Resource	Net cost SDG	Net income SDG	Net Value SDG
Bricks (Clay)	29045 SDG	48000 SDG	18955
Medicine	10-30 SDG /Bundle	100-300	
Wild fruits- Okra	20 SDG/Ib).	2000 for 100 lb	2000
Game meat (For antelope)	cost 100 SDG/kg	2 x10 kg x100	2000
Honey	13,35 SDG	is 42,000 SDG	40,665 SDG.
Fish	10-20 SDG/kg	45375	22475
Dried fish	20-40 SDG/kg (Average 30x20 kg x6 months)	3600	3000

Resource	Net cost SDG	Net income SDG	Net Value SDG
Charcoal	3560 SDG	288000 SDG	
wood- blender "Mfareek	*10 Mfareek.* X 4SDG x20 x6 month	4800	4000
Saaf	3 *bundle x300 days x 4 SDG*	3600	3000
Total			**73720 SDG**

Agriculture:

Communities grow sorghum and millet in small plots by traditional rainfed cultivation, within five kilometres of their villages. The cultivation in these plots mainly by women. Most of the households have small house-garden near their homes (called locally Jobraka) where they planted vegetables for their family food, and not for sale.

The communities practice cultivation along the Gerif land where they grow fruits, vegetables and grains. Crops produced here are mostly high-value vegetables and fruits (Mango, Guava and Papaya) and beans

The following Table 21 explain the net income (in Sudanese pounds) produced for different main crops planted in the agricultural lands within Dinder wetland.

Table 21: the net income (in Sudanese pounds) produced for different main crops planted in the agricultural lands within Dinder wetland

Crop	Planting time	Agriculture Costs(pounds/ feddan)	Income (pounds	Net income (SDG pounds)
Maize	4 months	1690	5000	3310
Sesame	3 months	1920	11000	9080
Millet	3 months	1690	6000	4310
Cowpea	40 days	80	4480	4400
Total				**21100 SDG**

The following Table 22 present the estimated Net Value of some products taken into account the market price for each ton assuming it is produced per season.

The value for above crops is 21100 SDG+ 77500 =98600 SDG which is estimated from agriculture land use + livestock using pastures (159000 SDG). The total is equivalent to 114500 USD+ Wildlife use (50000 USD)= 164500 USD

Table 22: the estimated Net Value of some products taken into account the market price

Product	Market cost/ maloa (2.5 lb) by SDG	Value SDG /ton/Season
Okra	20	20000
Ground nut	10	10000
Ziziphus fruits (Lalob)	10	10000
Cowpea	10	10000
Sun flower	05	05000
Millet	12.5	12500
Balanities fruits	10	10000
Total		**77500 SDG**

Summing up of the values will give us the TEV of the wetland in the following Table 23

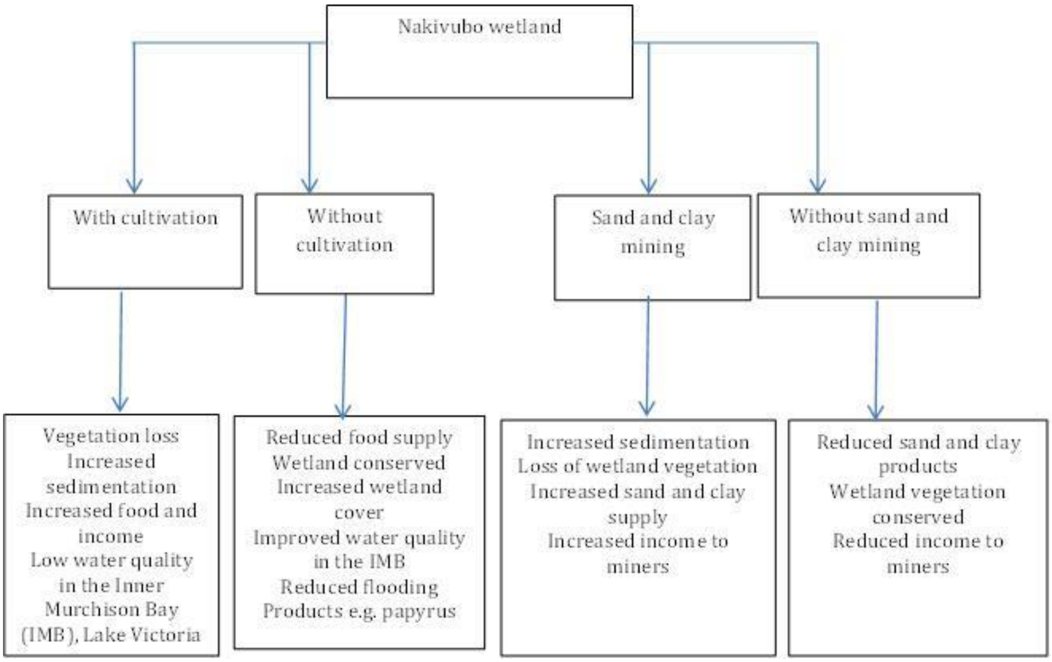
Table 23: TEV of the wetland

Total Net Value	SDG
Total Net Value of products (Table 6+8)	151220
Total Net Value of Land uses (Table (Table 8)	164500
Total Net Value of functions (Table 5)	4959798.52
Total Net Value of Wetland	5475518.52
TOTAL in USD	**805223.312**

6.3. Uganda, Nakivubo Wetlands

Principal Wetland Benefits, Functions and Services (Ecosystem Services)

Among the ecosystem services that Nakivubo wetland provides that we documented through a field survey is agriculture (crop growing). Agriculture is the main activity in the wetland and the crops grown include sugar canes, coco yams, vegetables, maize, bananas and cassava. Products that are harvested from the wetland include, sand, clay, papyrus, fish and water, in addition to the aforementioned crops.



6.3.1. Wetland beneficiaries and stakeholders for identified benefits

The beneficiaries and stakeholders for each of the wetland benefits identified are presented in Table 24.

Table 24 Beneficiaries and stakeholders for the identified wetland benefits

Benefit/service/function	Beneficiaries	Stakeholders
Crop cultivation Sugarcane Yams Vegetables Maize	Farmers Traders Consumers Land owners/land lords/ land claimers	Ministry of Water and Environment (MWE) National Environment Management Authority (NEMA) National Water and Sewerage Corporation

Benefit/service/function	Beneficiaries	Stakeholders
Cassava Banana	Tax collectors	(NWSC) Ministry of Local Government (MOLG) Local Councils (LCS)
Fishing	Fisherfolks Fish mongers Consumers Fish processing factories and industries Tax collectors	Ministry of Agriculture, Animal industry and Fisheries (MAAIF) Ministry of Trade and Industry (MTI) Kampala Capital City Authority (KCCA) LCS
Brick making	Brick makers Land owners Brick traders and buyers Construction companies Tax collectors	MWE NEMA NWSC LCS
Sand mining	Sand Miners “Land Lords”	MWE NEMA NWSC MOLG KCCA LCS
Water	Water extractors Owners of washing bays Car owners Agriculturalists	MWE NEMA MOLG

6.3.2. Method Applied to Value Ecosystem Services

Market price valuation method was used to value the benefits from Nakivubo wetland. The benefits assessed included coco yams, vegetables and sugarcane growing, sand mining, water collection for domestic purposes and fodder harvesting for feeding livestock. Market price valuation method was used because all these benefits assessed were traded in the market and therefore had an established market price.

6.3.2.1. Application of Market Price Method

Research Assistants traversed the different zones making up Nakivubo wetland interviewing people on prices, quantities and the frequency of sales of goods (benefits) that were being obtained from the wetland. To obtain the net value of the good/benefit, people were asked to provide information on the input (s) needed to produce such a good. Computation of the returns made from each good was done. To obtain the net returns per year per household obtained from each good, the total inputs in the processing of the good were subtracted from the total revenue per year per household obtained from selling the resource.

6.3.3. Value of the wetland goods/benefits

6.3.3.1. Coco Yams Growing

A total of eight (8) respondents were interviewed and each had an average of one hectare of land with coco yam grown on it. The average results for each respondent are presented in Table 25. Calculations were made on the assumption that each farmer grows and harvest yams once a year as their season averaged to seven (7) months (six months for growing the yams and one month for harvesting). The data presented therefore, is per harvest period.

Table 25 Total revenue obtained from the sale of yams per harvest and the total costs incurred

Item (Unit)	No. of units	Cost/unit (Ushs)	Total (UShs)
Average number of growers (number)	**67**		
Land (ha)	1		
Quantity Harvested (Kg/ha)	3963.5	885.42	3,509,362.17
Quantity consumed (Kg/ha)	70	885.42	61,979.4
Quantity sold (Kg/ha)	3893.5	885.42	3,447,382.77
Total inputs			1,671,261.16
Net income			**1,776,121.61**

On average 4000 kgs are harvested per hectare in a single harvest, 70 kgs are consumed by the farmer and his or her household. A farmer gets Ushs 1, 776,121.61 per year from the growth of yams per hectare. On average there are 67 yam growers around Nakivubo wetland. These account for 67 ha of land under coco yam growing in the wetland. This area has increased at the individual level since 1999 when the last study was done. Emerton*et al.* (1999) found out that each individual used 0.14 ha for growing coco yam but the figure has increased to 1 ha in 2015.

6.3.3.2. Sand Mining

A total of five (5) respondents were interviewed, all these actively participated in mining and selling of sand. The calculations were made on the assumption that each respondent gets two days to sale sand in a week. The net returns per year per person from selling sand are presented in Table 26 Net returns from the sale of sand.

Table 26 Net returns from the sale of sand

Item	No. of units	Cost/unit (UShs)	Total (UShs)
Size of pit (ha)	2		
Quantity sold (tons/year)	229.2	59,080.5	13,541,250.6
Number of sand miners	23		
Total Input(Days)	96	114,152	10,958,592
Net returns per year per ha per person			**2,582,658.6**

On average 2 ha of the wetland are used for sand mining. About 230 tonnes of sand are excavated by 3 people per year. This commands net revenue of Ushs 2.58 million per year to the person who employs the other two people on the team. On average there are 23 sand miners around Nakivubo wetland.

6.3.3.3. Water Collection for Domestic Use

Most people in the areas of Kanyogogga, Namuwongo and Luzira draw water from springs which are presumably recharged by Nakivubo wetland. During field survey, a total of 9 springs both protected and non-protected were documented. On average 0.009 hectares of land was found to be used for spring water development and there is little fluctuation in water volumes due to seasonal variation. Spring water is considered cleaner compared to other water sources for domestic purposes. The money saved per year per person from collecting and using spring water is depicted in Table 27 Net income accruing from Using Spring Water.

Table 27 Net income accruing from Using Spring Water

Item	**No. units**	**Cost/ unit UG Shs)**	**Total(UG Shs)**
Quantity harvested(litres/year)	33600	250	8,400,000
Quantity consumed(litres/year)	33600	250	8,400,000
Total inputs(Ugshs/year)	-	-	294,393.4
Net Income (HH/year)	**-**	**-**	**8,105,606.6**

Each house hold saves 8.1 million Uganda shillings (UG Shs) each year from the use of spring water around Nakivubo wetland. They draw 33,600 litres of water on average each year incurring a total cost of 294,393.4 UG Shs.

6.3.3.4. Vegetable Growing

At least 14 people participate in vegetable growing in Nakivubo wetland. The identified vegetable species were dominated by *Amaranthus*spp*, Vignaunguiculata* and *Gynandropsisgynandra*. These are grown in the southern parts of the wetland in areas of Kanyogoga, Luzira and Kijwa zones. The vegetable farmers live close to the wetland at approximately less than 2.5 km from the wetland. On average each farmer has 0.96 hectares of land under vegetable farming in Nakivubo wetland. Only single farmers with scattered and small plots were identified and interviewed by the study team. The net returns per year per person from selling vegetables are given in Table 28.

Table 28 Net returns from growing vegetables per house hold per year

Item	No. units	Cost/unit(Ugshs)	Total(Ugshs)
Quantity harvested(kg/ha/year)	2,046	633.3	1,295,731.8
Quantity consumed(kg /ha/year)	56	633.3	35,464.8
Quantity sold(kg/ha/year)	1,990	633.3	1,260,267
Total inputs(Ugshs/ha/year)			752,278.2
Net Income(/HH/year)			**507,988.8**

With an average total input of 752,278.2 UgShs, an average return of 507,988.8 UG Shs is realised by a household per year from a total sales.

6.3.3.5. Sugar Cane Growing

Nakivubo wetland supports sugarcane farming and on average, 206 farmers engage in the activity from the three parishes around Nakivubo wetland. On average each farmer has 0.356 hectares of which the area is seasonally flooded. Table 29 shows the amount of sugar canes a farmer harvests each year and the net returns he/ she gets from the sale of the sugarcanes.

Table 29 Net returns per household per year from sugar cane growing

Item	**No. units**	**Cost/ unit(UShs)**	**Total (UShs)**
Quantity harvested(kg/ha/year	104,080.3	342.8	35,684,667.8
Quantity consumed/eaten(kg/ha/year)	2,279.2	342.8	781,424.5
Quantity sold(kg/ha/year)	101,801.1	342.8	34,903,246.3
Total inputs(UShs/ha/year)			7,821,979.2
Net Income (UShs/ha/HH/year)			**27,081,264.2**

On average a farmer inputs about 7.8 million UG Shs to produce a harvest worth about 35.7 million UG Sh. Hence the net income of a farmer is about 27.1 million UG Shs per year after excluding the amount of sugarcanes that a farmer consumes along with people in his/ her household. On average the amount consumed (eaten) is 2,279.2 Kg/ha/year which is worth 781,424.5 UG Shs with the average cost of each Kg being 342.8 UG Shs.

6.3.3.6. Fodder

At least 9 people are reported to be involved in cutting grass in Nakivubo wetland for feeding cattle. The net returns per year per person from selling fodder harvested from Nakivubo wetland are presented in Table 30.

Table 30 Net returns per person from selling fodder from the wetland

Item	No. Of Units	Cost/Unit(UG Shs)	Total (UG Shs)
Quantity harvested(kg/ha/year	146,337.5	108.3	15,848,351.3
Quantity consumed	-	-	-
Quantity sold	146,337.5	108.3	15,848,351.3
Total inputs			6,950,182
Net Income(UShs/ha/HH/year)			**8,898,169.3**

On average, 11.5 bundles are cut each day and each bundle weighs 15 kilograms when wet and in total, 43901.25 kilograms are harvested a year. If each kilogram is sold at 108.3 UG Shs, it yields about 15.9 million UG Shs. With an input of about 7 million UG Shs, a household grazing its cattle or collecting fodder from Nakivubo wetland saves close to 9 million UG Shs per year.

6.4. Kenya, Mara Wetland Case Study

Mara wetland provides ES which are valued using different methods as shown in Figure 14 below. Figure 15 shows the interactions between the ES and stakeholders in the wetland.

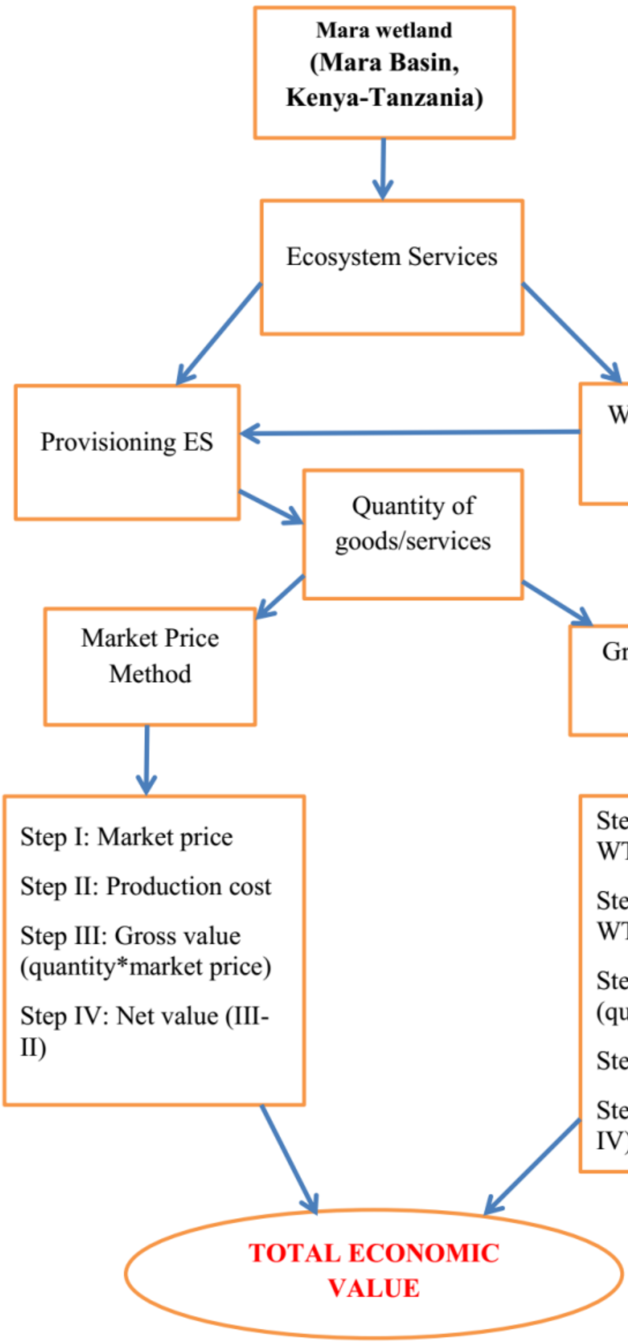


Figure 14: Conceptual framework for valuation of Mara wetland

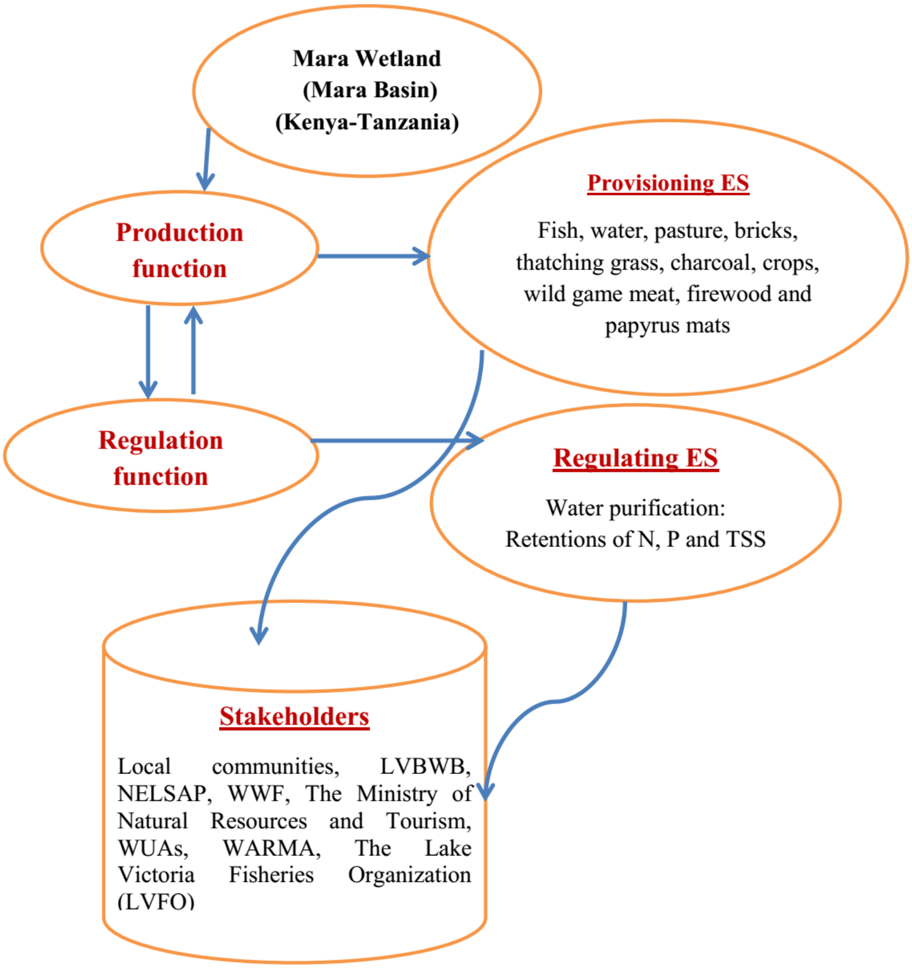


Figure 15: Interactions of Ecosystem Service and stakeholders within the Mara Wetland

6.4.1. Step 1: Define the scope of the wetland to be valued

Mara wetland is surrounded by 17 villages in three districts: Butiama, Rorya and Tarime. The villages in Butiama (Musoma) district include: Kirumi, Ryamisanga, Kitasakwa, Kwisaro, Buswahili, Wegero, Kongoto and Bukabwa. Those from Roryadistrict are Kwibuse, Marasibora, Nyamirambara and Nyanchabakenye while Tarime is composed of 4 villages: Surubu, Bisarwi, Kembwi, Kerege and Weigita. Among the 17 villages, 6 villages: Kwibuse (1.49º S, 34.1ºE) in Rorya district, Bisarwi (1.43ºS, 34.29ºE) and Kembwi (1.44ºS, 34.29ºE) located in Tarime district with the rest, Ryamisanga (1.58ºS, 34º.06ºE), Kongoto (1.61ºS, 34.19ºE) and Kirumi (1.55ºS, 33.97ºE) in Butiama district Figure 16 Map showing location of the villages in relation to the Mara wetland. were selected for economic valuation of ES in this study. The ES valued included those derived directly from the wetland such as bricks, thatching grass (*Typhadomingensis*), water, and pasture for livestock, papyrus mats, fish and water purification. In addition other ES e.g. charcoal and firewood, harvested from the catchment were also valued.

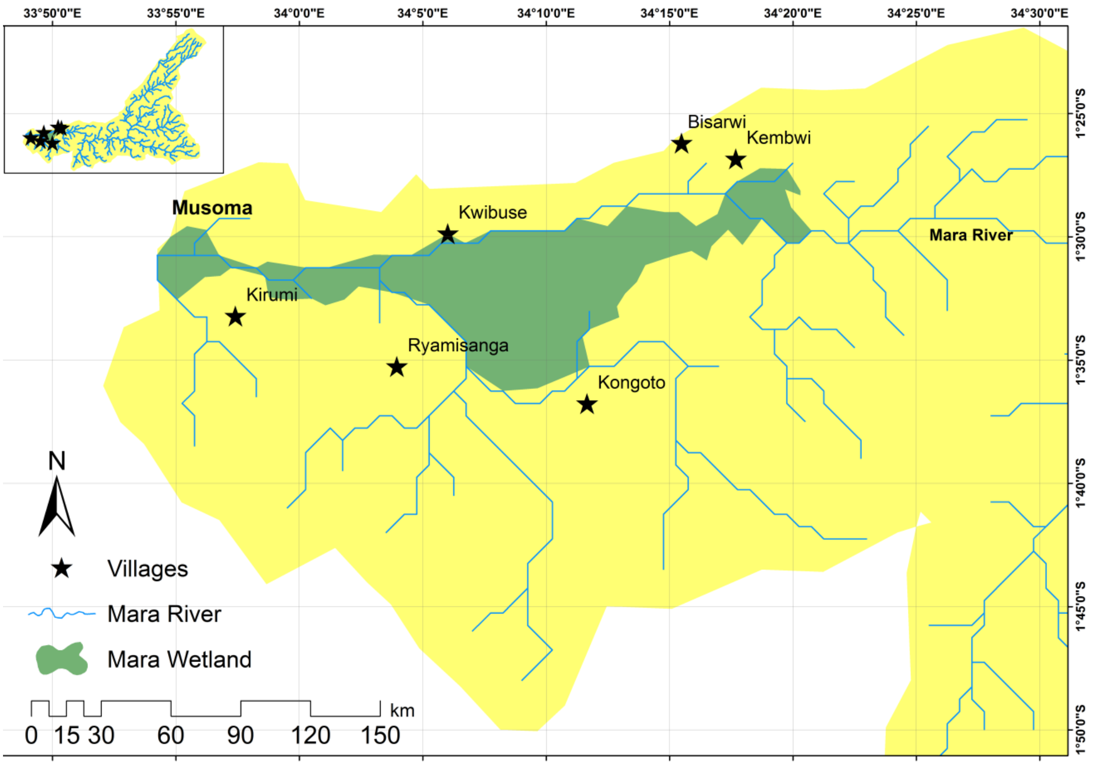


Figure 16 Map showing location of the villages in relation to the Mara wetland.

6.4.2. Step 2 Identify the principle wetland benefits/functions and services

Ecosystem functions as defined by De Groot (1992) is the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly. Since matter and energy driven processes brings about interactions among biotic and abiotic components of ecosystem resulting into ecosystem functions like production, habitat, regulation and information (De Groot, Wilson, & Boumans, 2002) form the back bone of Ecosystem Services. These are classified into provisioning, cultural, regulating and supporting services (MEA, 2005, Russi*et al*., 2013). In Mara wetland, the key wetland functions which have been assessed and documented include regulation functions such as nutrient regulation, habitat and production functions. Details of the variable are discussed below.

6.4.2.1. Habitat functions and their associated ES

Mara wetland provides a habitat for different flora and fauna. The rich biodiversity puts the wetland to be of high national, regional, and global significance for biodiversity conservation. According to Munishi (2007) approximately 14 different species of fish though at varying abundances inhabit the wetland. The common fish species in the wetland are the endangered ones in Lake Victoria Chande (2008).

For instance, the anadromous species, *Synodontisafrofischeri* and *Schilbeintermedius*dominates the Mara River. Three fish species that are of great economic significance to the local communities include Catfish (*Clariassp*), African lung fish (*Protopterusaethiopicus*) and Nile Tilapia (*Oreochromisniloticus*) (Munishi, 2007). Other fish species found in the wetland include Butter fish (*Schilbemystus*), Ningu, Nile perch (*Latesniloticus*), *Haplochromis spp.*, Domodomo, *Clariusaluwardi* (Vigugu), Kuyu and *Momirdskanume*.

Approximately 32 species of wild animals including hippos and crocodiles are also reported to inhabit the wetland over different seasons (Munishi, 2007). The wetland is a sanctuary of ornithology with 81 terrestrial bird species belonging to 28 families and 33 species of water fowls belonging to 13 families (Munishi, 2007).

In addition, Mara wetland is composed of different plant species of which the most dominant ones include: *Cyperus papyrus*, *Typhadomingensis* and *Phragmitesaustralis*(Munishi, 2007; Muraza*et al.*, 2013). Other dominant plant species accounting for more than 50% of all the plants within the wetland include *Thelpterisinterrupta*, *Echnocloapyramidalis*, *Cyperusarticulatus*, *Chara spp.*, *Eichhorniacrassipes* and *Azola spp*. Other plants present within the microhabitats of the wetland include *Pycreuselegantus*, *Scirpusconfusers*and *Ludwigiaabyssinica.* The wetland terrestrial interface is inhabited by grasses e.g. *Themedatriandra*, trees and shrub species such as *Acacia xanthophloea, Acacia brevispica, A. drepanolobium, A. tortilis, A. albida, and A. xanthoploea.*

6.4.2.2. Regulation functions and their associated ES

Mara wetland plays an important role by retaining nutrient before water is discharged into Lake Victoria and hence enhancing the lake water quality. According to Mayo *et al.*, 2013 the wetland retains 75 tonnes of N annually, which is equivalent to 3.67 kg/ha/year of nitrogen. The wetland receives approximately 0.70-1.56mg/l of N largely in the form of organic nitrogen (63.6%) and nitrates (29.1%). Nitrogen removed by plant uptake is approximately 67.9 gN/m^2 of which among all the main macrophytes in the wetland, papyrus stores more N, 77.98gm^{-2}, compared to *Typha*(49.99 gm^{-2}) and *Phragmites*(75.66gm^{-2}) (Muraza *et al.*, 2013). Ng'umbi (2009) reports N and P content in the papyrus plants ranging from 37.6-45.1mgg^{-1} and 5.2-8.6 mgg^{-1} respectively, with umbel and roots being the major storage organs. Nitrogen content of 0.38±0.06gN/kg, which translates to 201.26 ± 30.78 g/m^2 is reported by Mayo *et al.* (2013) in the wetland's sediments. The sediments' N storage however increases from the inlet to the outlet of wetland. This is attributed to the increase of plant density whose roots facilitates trapping of sediments and hence nutrients retention in the sediments. At the inlet of the wetland, sediments store approximately 0.22 ± 0.045 gN/kg while the middle and the outlet has 0.577 ± 0.2 gN/kg and 0.362 ± 0.063 gN/kg of dry sediments. In relation to denitrification process, the wetland has a potential denitrification rate of 1.99 μg N_2O/g DW/hour, with the highest of 3.08 μg N_2O/g DW/hour being recorded in permanently flooded zone of the wetland and lowest of 0.03 μg N_2O/g DW/hour in agriculture/grazing zone (Tshering, 2011). Global Water for Sustainability (GLOWS) Program (2007) reported total phosphorus concentration of approximately 0.04mg/l and Soluble Reactive Phosphorus concentration of 0.025mg/l in the wetland.

6.4.2.3. Production functions and their associated ES/benefits

Mara wetland provides a variety of provisioning ES that supports the livelihoods of the local communities. The ES include food (fish, wild game meat and crops), water, pasture for livestock, clay soil for brick making, papyrus mats, firewood, charcoal, medicinal resources and thatching/roofing grass (*Typhadomingensis*) (Bogers, 2007; Munishi, 2007; Kema 2010). According to Munishi (2007) the most important socio-economic activity to the communities living near the wetland is grazing followed by farming, fishing and harvesting of other wetland products such as papyrus.

6.4.3. Step 3: Identify wetland beneficiaries and stakeholders

The principle production functions and their associated services valued in Mara wetland in this study includes fish, water, crops pasture for livestock, clay soil for brick making, papyrus mats, firewood, charcoal and thatching/roofing grass (*Typhadomingensis*). In relation to regulation functions, water purification ES of the Mara wetland was also valued. The stakeholders associated with each service are shown in Table 31 below.

Table 31 Principle wetland functions and benefits/services valued in Mara wetland

Function	Service
Production	Provisioning ES • Fish • Papyrus mats • Bricks • Pasture for livestock • Water • Thatching/roofing grass • Charcoal • Firewood
Regulation function	Regulating ES (water purification)

6.4.4. Step 4: Identify the Constraints under Which the Valuation Will Be Carried Out

This study intends to assess water purification ES of the Mara wetland. Nutrient and Total Suspended Solids (TSS) retentions are generally used as indicators of the service in the wetland. In Mara wetland, water samples will be collected at various sites and analysed for nutrient and TSS. However, due to lack of laboratories in Musoma, Tanzania, all the water samples will be analysed at Egerton University laboratories, Nakuru, Kenya which is 460 km away from Musoma. In addition, the wetland is quite expansive (164 km2) and surrounded by 17 villages with sparse homesteads and therefore a lot of time will be used to move from one home to another during the valuation of the ES. Apart from ES valuation, assessment on gender analysis on ES utilization and wetland management will also be carried out.

Other studies are also currently being conducted in the wetland by various organizations. These imply that the respondents may experience survey fatigue and may require us to shorten the questionnaires and limit open ended questions.

6.4.5. Step 5: Choosing a Valuation Method for (LBW)

In Mara wetland, Tanzania, the ES assessed included: provisioning and regulating (water purification) services. The provisioning ES assessed through household questionnaire survey and focus group discussions included: bricks, thatching grass, water, crops pasture for livestock, papyrus mats, fish, charcoal and firewood, crops. Charcoal and firewood were not harvested directly from the wetland but within its wetland terrestrial transitional zone and the catchment. Considering that there is increasing sedimentation downstream the Mara River, mainly attributed to loss of forest cover as reported by Mutie*et al.*, 2006 and Mati*et al.*, 2008. Thus attaching monetary value to these services may explain the benefits the local communities derive from the resources. In addition, the information on firewood and charcoal production is important on determining appropriate catchment management strategies without limiting people's livelihoods.

The provisioning ES derived from Mara wetland and its catchment for instance, charcoal, bricks, thatching grass, firewood, fish and papyrus mats are traded in the local markets and therefore the market prices were used to estimate their economic values. In this case, **market price-based methods** were used to estimate their monetary values. Other provisioning ES such as water and pasture for livestock however, were not for sale. The monetary values of water and livestock's pasture were estimated by **group valuation method** through FGD consisting of 26 people utilizing the services. Water and pasture provision by the wetland in rural areas is probably better reflected through WTP rather than using replacement cost which may over-estimate the values of the ES. As noted by Anderson and Rockel (1991) replacement cost method is an upper bound on the true value since the stakeholders may not choose to actually use that alternative considered. Since water purification ES of the Mara wetland is reflected on the water provision, the water purification ES was not valued to avoid double counting. The WTP pay for the water provision captures both water quality and quantity.

Application of the selected method(s) in the Mara wetland

Questionnaire survey targeting 180 households from the six villages; Kwibuse, Kembwi, Bisarwi, Ryamisanga, Kirumi and Kongoto, neighbouring the wetland was undertaken in July 2015 to gather data on the provisioning ES derived by the local communities from the wetland and their economic values. From each village 30 households were randomly selected to ensure impartial representation of the services. Sample size was determined according to Israel (1992) formula with a precision level of ±10% and confidence interval of 95%. From the targeted samples of 180, four (4) samples were not included in the report due to unanswered questionnaires and hence only 176 samples were used for final analysis.

The questionnaires were administered to the household respondents face to face after pre-testing (photo 11). The data collected for provisioning services (papyrus mats, bricks, charcoal, firewood, water, fish, grass (*Typhadomingensis*) for house roof thatching and grass/fodder for livestock); costs incurred (labour, personal time, equipment, taxes, license, transport and storage); amount of resources harvested per day, seasonal variation on resources availability and resource price (see appendix 1).

Photo 11: Training of data collection assistants and household questionnaire survey

The quantitative indicators used to measure the annual supply of the services included amount of resources harvested, used for both commercial and subsistence purposes and market price of the products among others as shown in table 2. From the indicators of measurements used, average amount and market price of harvested products were calculated per household. The monetary indicators such as gross income, subsistence value of the services and costs incurred/expenditure were also used to estimate the average net value of the services derived from the wetland per household Table 32. The annual monetary value of the ES (subsistence and commercial purposes) and gross income were calculated as follows:

$$\text{Annual Gross Income} = \text{Amount of products} * \text{ price} * \text{no. of months} \ldots\ldots\ldots \text{(i)}$$

$$\text{Annual net income} = \text{annual gross incomes} * \text{ price} * \text{no. of monthsrcial p}$$

$$\text{Subsistence monetary value} = \text{Amount of products } * \text{price} * \text{no. of months}\ldots \text{(iii)}$$

$$\text{Annual net value} = \text{annual subsistence monetary value} + \text{annual net income}\ldots\ldots\ldots\ldots\text{(iv)}$$

Table 32 Quantitative indicators of measurement of provisioning ES

Provisioning ES	Indicator of measurement	Unit of measurement
Charcoal production	Number of bags	No. per year
	Market price per bag	TZS
	Gross income	TZS per year
	Subsistence monetary value	TZS per year
	Expenditure	TZS per year
	Net value	TZS per year
Fish production (Nile tilapia (*Oreochromisniloticus*), cat fish (*Clarias sp.*), Lung fish (*Protopterusaethiopicus*)	Number of fish	No. per year
	Market price of fish	TZS
	Gross income	TZS per year
	Subsistence monetary value	TZS per year
	Expenditure	TZS per year
	Net value	TZS per year
Papyrus mats	Number of papyrus bundles	No. per year
	Number of mats	No. per year
	Market price per mat	TZS
	Gross income	TZS per year
	Subsistence monetary value	TZS per year
	Expenditure	TZS per year
	Net value	TZS per year
Fresh water	Volume used: domestic, livestock watering and brick making	Litres per year
	WTP for water	TZS per 20 litres
Bricks	Number of bricks	No. per year
	Market price per brick	TZS
	Gross income	TZS per year
	Subsistence monetary value	TZS per year
	Expenditure	TZS per year
	Net value	TZS per year
Firewood	Number of bundles	No. per year
	Market price per bundle	TZS
Grass (Typha domingensis and other wetland grasses) for house roof thatching	Number of bundles	No. per year
	WTP	TZS
Pasture for livestock	Number of livestock	No. per household

The household questionnaire survey was followed by one FGD in January 2016. The FGD consisted of 23 people utilizing various provisioning ES from six villages: Kongoto, Kirumi, Bisarwi, Ryamisanga, Kwibuse and Buswahili surroundingthe Mara wetland. The main purpose of the FDG was to assist in authenticating the information provided by respondents in the questionnaires and also provide more information that might not have been captured or not clear from the questionnaires. In addition, through the group deliberation and consensus monetary value of water per 20 litres and livestock's pasture were derived through WTP for the services.

- **Market Price Approach (MPA):**

1. Papyrus mats production

Papyrus mats production is conducted by 29.5% (52) of the households surrounding the Mara wetland. On average, 168 bundles of dry papyrus are harvested annually which generates approximately 432 mats per household (photo 12). However, the harvesting of papyrus is either low or not taking place at all during the rainy season. The duration for drying the harvested bundles of papyrus during rainy and dry seasons is 7 and 3 days respectively. The regeneration period for harvested papyrus is about 6 months translating into 6 months of mat making per year. The market price for each mat is roughly TZS 1,600 (USD 0.74[1]).From an annual production of 432 mats per household, 97.5 % (421 mats) are sold in local markets bringing a gross income of TZS 709,160.30 (USD 328), while 2.5% (11mats) are used at the household with a subsistence monetary value of TZS 17,011 (USD 7.87). The annual costs incurred from labour, taxes, equipment, storage and transport on the other hand is approximately TZS 366,711.15 (USD 169.60) per household. Thus, a yearly net income (profit) of TZS 343,249.18 (USD 158.75) is generated from the sale of mats giving a net value (subsistence plus commercial) of TZS 360,260.10 (USD 166.62) per household.


Photo 12: Papyrus harvesting in Mara wetland and mat making from dry papyrus

2. Mara wetland fishery

[1]1 USD= TZS 2161

Fish is harvested from the Mara wetland by 73% of the households both for domestic consumption and commercial purposes. Thefish species harvested from the wetland include: lungfish (*Protopterusaethiopicus*), catfish (*Clarias sp.*), Nile tilapia (*Oreochromisniloticus*), haplochromines (*Haplochromisspp*), butter catfish (*Schlbemystus),Synodontisafrofischeri, Momirdskanume (*Domodomo or Elephant fish) and Nile Perch (*Latesniloticus*) among others. The commonly harvested fish include: lungfish (*Protopterusaethiopicus*), catfish (*Clarias sp.*) and Nile tilapia (*Oreochromisniloticus*) (photo 13). Fish abundance is reported to be high during rainy season (March-May) and low during dry season (June-February). The duration of fishing varies with season with an average of 3 and 7 days during dry and rainy season respectively. However, from the FGD the fishermen noted a decline in fish population/abundance currently (2015/2016).

It is important to note that only commonly harvested fish were valued in this study. Annually Mara wetland fisheries generate a gross income of TZS 13,108,375.62 (USD 6,065.88) of which lungfish contributes the highest monetary value of TZS 9,046,128 (USD 4,186) while Nile tilapia the lowest (TZS 1,384,533.33 (USD 640.69)) per household. Cat fish generates an annual gross income of TZS 2,677,714 (USD 1239.11). The annual monetary value of fish consumed per household is approximately TZS 2,653,467.43 (USD1, 227.89)while the expenditure cost (transport, taxes, labour and equipment) incurred is TZS 936,060.60 (USD 433.16). This translates into an annual net value of TZS 14,825,782 (USD 6,860.61) per household for fish harvested from the wetland.

Lung fish (*Protopterus aethiopicus*)

Nile Tilapia (*Oreochromis niloticus*) Catfish (*Clarias sp.*)

Photo 13: Fish species commonly harvested from the Mara wetland

3. Bricks production

Brick making from wetland soil is conducted for a period of approximately 4 months in a year (May-August) (photo 14). The people involved in brick making either work individuallyor are organized in groups. On average, annually, 12,000 and 48,000 bricks are produced by individuals and groups respectively. The price of processed bricks is TZS 200 (USD 0.09). The yearly average revenue generated from the sale of bricks is approximately TZS 2,400,000 (USD 1,110.60) with TZS 1,280,670 (USD 592.62) as incurred costs. Hence, the annual net value of brick making per household is TZS 1,119,330 (USD517.97).

Photo 14*: Brick making near Mara wetland*

4. Charcoal production

Charcoal production from trees such as Acacia polyacantha, Acacia seyal and Balanites aegyptiaca within the Mara wetland floodplains is not widely practiced by the local community. Only 17.6% (31) of the households are involved in charcoal production (photo 15). The activity is high during the dry season and low during rainy season. On average, annually, 91 bags of charcoal are produced per household from which 7 and 84 bags are used for home consumption and sales respectively. Charcoal generates a yearly gross income of TZS 1,300,026.94 (USD 601.58) and an expenditure (labour, equipment, taxes and transport) of TZS 267229.75 (USD 123.66), giving a net income (profit) of TZS 1,032,797.19 (USD 477.93) from charcoal sale. The monetary value of charcoal for home consumption is TZS 146,877.20 (USD 67.97). Therefore, the net value of charcoal production within the wetland's floodplain is TZS 1,179,674.454 (USD 545.89) per household.

Photo 15: Transportation of charcoal from the wetland floodplains to the local markets

5. Firewood collection

Firewood collection from trees such as Acacia xanthophloea, Acacia polyacantha, Acacia seyal and Balanites aegyptiaca within the Mara wetland floodplains is practiced by 28.4% of the local community. The collected firewood is used for both subsistence and commercial purposes. For commercial purposes only, 50% of the households are engaged on the activity. Each household uses approximately 4 bundles on home consumption while 10 bundles are sold per week at an average price of TZS 1,192 (USD 0.55) each. A gross income of approximately TZS 459,780.10 (USD 212.76) is generated annually per household from the sales of firewood. An expenditure on transport, storage, taxes and labour worth TZS 407,780 (USD 188.70) per year is incurred while the net income is approximately TZS 51,524.60 (USD 23.84) per household. The annual monetary value of the firewood used at home is about TZS 200,483.70 (USD 92.77), giving a net value of the firewood per year as TZS 252,008.30 (USD 116.62) per household.

6. House roof thatching from wetland grass (Typhadomingensis)

Majority of the houses owned by community members living near Mara wetland were thatched by *Typhadomingensis*(personal observation as shown in photo 16). Thatching of the houses is however an occasional activity and only takes place when the need arises for instance; when building a new house or re-thatching. As a result, only a few households (15.9%) reported this activity. Approximately 6 bundles of *Typhadomingensis*are harvested on a weekly basis. The price of each bundle is TZS 10,009 (USD 4.63) which is computed to a monetary value of TZS 60,054 (USD 27.79). The labour cost incurred for transportation of the harvested bundles of grass is TZS 10,000 (USD 4.63). This implies that the net value of wetland grass is TZS 50,054 (USD 23.15) per use by each household.

Photo 16: Houses thatched using *Typhadomingensis* in the villages

7. Crop production

Mara wetland supports crop farming particularly in Kirumi village during dry season (photo 17). The commonly grown crops include tomatoes, water melon and maize. On average each farmer owns 1 ha of land in the temporary/seasonal zones of the Mara wetland for crop production. From the FGD conducted in Kirumi village on farmers, maize, water melon and tomatoes have a net income of TZS 18,758,000 (USD 8,680.24) per annum per household (Table 33).

Table 33: Annual net income from crops production per household

Crops	Quantity harvested	Market price/unit (TZS)	Cost of production (TZS)	Gross income (TZS)	Net income (TZS)	Net income (USD)
Tomatoes	240 buckets	60,000	14,400,000	338,000	14,062,000	6,507.17
Water melon	3000 (each 2kg)	1,500	4,500,000	424,000	4,076,000	1,886.16
Maize	19 bags (each 100kg)	50,000	950,000	330,000	620,000	286.90
Total net income					**18,758,000**	**8,680.24**

Photo 17: Crop production in Mara wetland

Group valuation method:

1. Water abstraction from the wetland

Water from the Mara wetland is abstracted by 41.5% of the households (Plate 8) while the rest uses other sources of water for instance boreholes and rain water. The wetland's water is used for domestic purposes: drinking, laundry, cooking, bathing and washing of utensils; brick making, livestock watering and irrigation of crops and trees. This study attaches monetary value only to water used for domestic, brick making and livestock watering and not irrigation due to higher chance of over/underestimation of the amount of water used in a year. The volume of water utilized for irrigation is dependent on the type of crop and tree grown which was not captured in this study.

Water is abstracted from the wetland for domestic purposes for approximately 10 months annually (photo 18). The dependence on the water from the wetland for domestic use varies with season; low during rainy season and high during dry season. On average, the daily amount of water used by each household for domestic purposes is 100 litres (28,000 litres annually). Willingness To Pay for the water per 20 litres through household questionnaire survey varied among the respondents and ranged from TZS 100-1000 with an average price of TZS 186 (USD 0.09). However, from discussion in FGD, the consensus WTP for 20 litres of water was TZS 200 (USD 0.09). Therefore, through FGD and household survey water provision generates a yearly monetary value of TZS 280,000 (USD 129.57) per household. The average annual costs incurred per household from equipment (plastic pales and jericans) and water treatment through domestic chlorination (water guard) is TZS 12,104.16 (USD 5.60). This translates to anaverageannual net value of TZS 267,895.84 (USD 123.97) per household.

Livestock watering in the wetland takes place throughout the year. Based on the information gathered from the FGD, an average of 20 and 5 litres of water per day are consumed by 1 cow and 1 sheep/goat respectively. The water consumption rates by livestock indicated in this study are within the ranges reported by Chapagain and Hoekstra (2003) as 5-22 litres of water for cattle, 0.3-6 litres and 0.3-4 litres for sheep and goats per day respectively. Markwick (2002) reported water consumption rate per day per head of 40-100 litres for cattle and 2-12 litres for sheep. Water consumption rate of livestock is however dependent on breed, animal size, growth stage, water quality and environmental factors such as air temperature and humidity(Markwick, 2002;Chapagain and Hoekstra, 2003; Ward and McKague, 2007). The average number of cattle, sheep and goats owned per household is 25±21, 13±8 and 13±10 respectively. Therefore, on average 211,680 litres of water is used for livestock watering annually per household. Willingness To Pay for the wetland water per 20 litres of water was TZS 200 (USD 0.09) and hence the annual economic value of livestock watering from Mara wetland is TZS 2,116,800 (USD 979.55) per household.

During the approximately 4 months of brick making about 4,800 litres of water is used (photo 18). There was Willingness To Pay for the wetland water atTZS 200 (USD 0.09) per 20 litresjerican. This translates to an annual economic value of TZS 48,000 (USD 22.21) from water abstraction for brick making in the Mara wetland per household. Therefore, the annual Total Economic Value of water from Mara wetland is TZS 2,432,695.84 (USD 1125.73) per household.

Photo 18: Water abstraction from Mara wetland for domestic and brick making

2. Pasture for livestock

Livestock owned by 31.3% of the local community graze along the wetland's margins (photo 19) for approximately 6 months in a year. The livestock include: cattle, sheep and goats. The average number of cattle, sheep and goats owned per household is 25±21, 13±8 and 13±10 respectively. Wetland grazing is most common during dry seasons due to pasture scarcity uplands. Willingness to pay for livestock grazing in the wetland was derived/equal from farming labour cost per day which is TZS 5,000 (USD 2.31).The annual monetary value of wetland for grazing per household was estimated at TZS 900,000 (USD 416.47) per average livestock herd

Photo 19: Livestock grazing and watering in Mara wetland

The Total Economic Value of Mara wetland

The Total Economic Value (TEV) of Mara wetland in relation to provisioning and water purification ES per household is TZS 39,877,804.22 (USD18, 453.40) per annum (Table 4). Approximately, 47% of the TEV is contributed by crops followed by fish (37%) and water (6.1%) (Figure 9). Wetland fisheries being one of the highest contributors to economic value may be attributed to the assumptions that common fish species are harvested on a weekly basis. It is important to note that crop production in the temporary/seasonal zones of the wetland mainly takes place in Kirumi Village and therefore doesn't reflect wetland utilization in other villages. Thatching grass on the other hand contributes the lowest economic value (0.1%) probably due to its occasional use and changes in community lifestyle whereby roofing using wetland grasses is being replaced by iron sheets. The same scenario was noted by Ondiek, Kitaka and Oduor, 2016 in Ombeyi wetland, Kenya. Among the ES generating income, charcoal is one of the most lucrative services (Figure 17). Charcoal burning as reported by Kema (2010) in the Mara wetland is illegal even though is still being practised by the local communities. The prohibition of charcoal burning is not only exclusive to the Mara wetland but also to other wetlands in Tanzania. According to studies done by Mombo et al. (2014) in Kilombero valley wetlands in Tanzania, charcoal burning was illegal in both reserve and public forests and for one to carry out the activity especially from public forests requires an authorization permit. Deforestation for charcoal production and other activities if not done sustainably is known to cause reduction of flow of rivers, soil erosion and thus causing drying out rivers and swamps (Mombo et al., 2011). However, the local communities are dependent on the ES as their source of energy and income.

Table 34 Total Economic Value of provisioning ES in Mara wetland per household

ES	Average Net Value (TZS)	Average Net Value (USD)
Papyrus mats	360,260.10	166.62
Fish	20,305,249	6,860.61
Charcoal	1,179,674.45	545.89
Firewood	252,008.30	116.62
Bricks	1,119,330	517.97
Thatching grass	50,054	23.15
Pasture	900,000	416.47
Water	2,432,695.84	1,125.73
Crops	18,758,000	8,680.24
Annual TEV	39,877,804.22	18,453.40

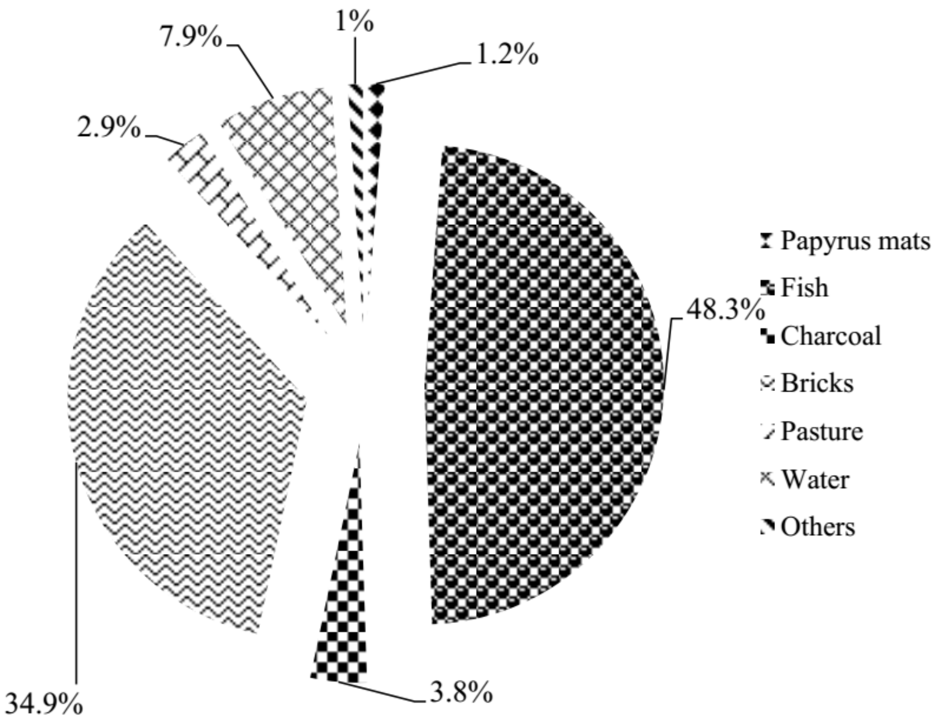


Figure 17 ***Proportion (%) of different provisioning ES to TEV***

Water quality characteristics in the Mara wetland
Field measurements and water samples collection

In order to assess water quality characteristics of the Mara wetland, physico-chemical parameters; dissolved oxygen (DO), pH, water temperature, turbidity and electrical conductivity (EC) were measured *in-situ* once a month for a period of 3 months representing different seasons (January, March and November 2016) at various sampling points in the wetland, upstream Mara River and the tributary River Tigite as shown in figure 5 below. The parameters were measured using a calibrated HQ 40d (HACH) multi-meter and turbidity meter.

During each sampling, water samples for nutrient (SRP, TP, NO_3-N, NO_2-N and NH_4-N) and TSS analysis werecollectedin duplicates using 500 ml acid-washed plastic bottles.In River Tigite, water samples were collected at two sampling points i.e. upstream and midstream. The purpose for this was get an indication of the amount of nutrients and TSS input from the surrounding activities and eventually that which is transported into Mara River (Figure 19). However, water samples were not collected downstream before River Tigite discharges into Mara River because of inaccessibility of the site. Two sampling points (Mara mines (Mrito) and Nyansurura Village) in Mara River were selected to determine the concentration of nutrient and TSS upstream of the wetland. It was not possible to get to the Mara River wetland inlet due to inaccessibility. However, the upstream Mara mines were selected as an ideal station before the wetland. To assess the nutrient and TSS flux within the wetland, three sampling points were selected; Bisarwi (upstream), Kongoto (midstream) and Kirumi bridge as the outlet of the wetland Figure 18 *Map showing various water sampling points in Mara wetland, Mara River and River Tigite* For quality control, the water samples collected from various sites in the wetland, River Tigite and Mara River were filtered in the field and transported in a cool box to Egerton University water quality laboratory for analysis immediately on arrival.

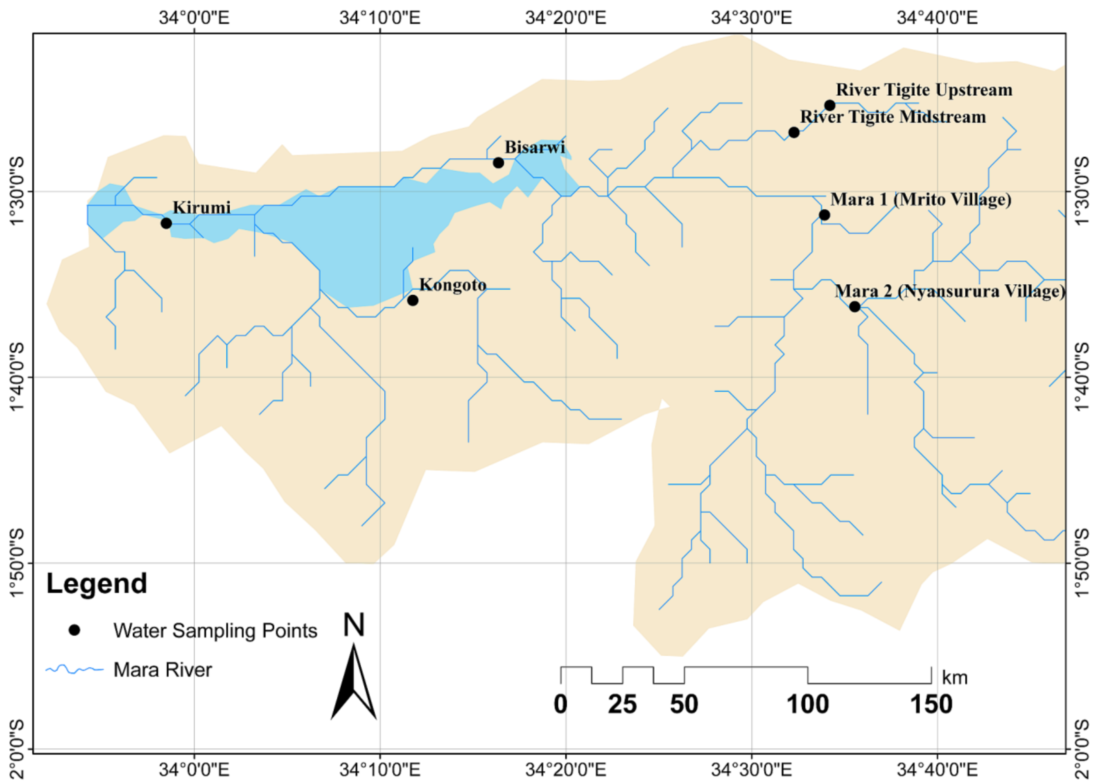


Figure 18 Map showing various water sampling points in Mara wetland, Mara River and River Tigite

Determination of nitrogen, phosphorus and TSS in the water samples

Different forms of nitrogen: Ammonium-Nitrogen (NH_4-N), Nitrate-Nitrogen (NO_3-N) and Nitrite-Nitrogen (NO_2-N) and phosphorus: Soluble Reactive Phosphorus (SRP) and Total Phosphorus (TP) were determined using standard methods according to APHA (2004). Water samples were filtered using Whatman GF/C glass micro-fibre filters (0.45µm)for determination of inorganic nutrient: NH_4-N, NO_2-N, NO_3-N, SRP and Total Suspended Solids (TSS). The NH_4-Nand NO_3-N were determined by phenol-hypochlorite and sodium-salicylate method respectively while NO_2-N was analyzed using the reaction between sulfanilamid and N-Naphthyl-(1) ethylendiamin-dihydrochloridand SRP using ascorbic acid method. Total phosphorus was analysed using persulphate digestion of the unfiltered water samples, followed by ascorbic acid method. Absorbances for different analyses were read at their respective wavelengths indicated in APHA, 2004 using a GENESYS 10uv scanning spectrophotometer. The final concentrations of NH_4-N, NO_3-N, NO_2-N, TP and SRP were calculated from their respective equations generated from standard calibration curves (APHA, 2004). Total Suspended Solids was determined using gravimetric method.

Estimation of nutrient and TSS retention in Mara wetland

Since the water level data had not been validated for the calculation of discharge and thereafter loadings, the efficiency of the wetland in retaining nutrient and TSS were calculated based on comparison of mean concentrations at the inlet to concentrations at the outlet of the system. Therefore, nutrient and TSS retention in Mara wetland was calculated according to Kanyiginya et al., (2010). The electrical conductivity at the inlet to the outlet was also used to assess the efficiency of the wetland in retaining ions.

1. Nutrient retention was calculated as:

$$\text{Nutrient retention (\%)} = \frac{\text{Inlet concentration} - \text{Outlet concentration}}{\text{Inlet concentration}} * 100 \ldots\ldots\ldots (\text{iv})$$

2. TSS retention was calculated as:

$$\text{TSS(\%)} = \frac{\text{Inlet concentration} - \text{Outlet concentration}}{\text{Inlet concentration}} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\text{v})$$

Results

(a) Variation of physico-chemical parameters: in the Mara wetland, Rivers Mara and Tigite

Dissolved oxygen concentration and temperature declined from the inlet i.e. at Mara mines to the outlet (Kirumi Bridge) of the wetland as shown in **Table 35** below. The pH was alkaline along the sampling sites while electrical conductivity (EC) decreased from the inlet to the outlet of the wetland. The lowest turbidity of 8.59±0.27 NTU was observed at the outlet of the wetland. However it's important to note that the highest EC of 460.25±68.29µS/cm was observed at the middle reaches of River Tigite.

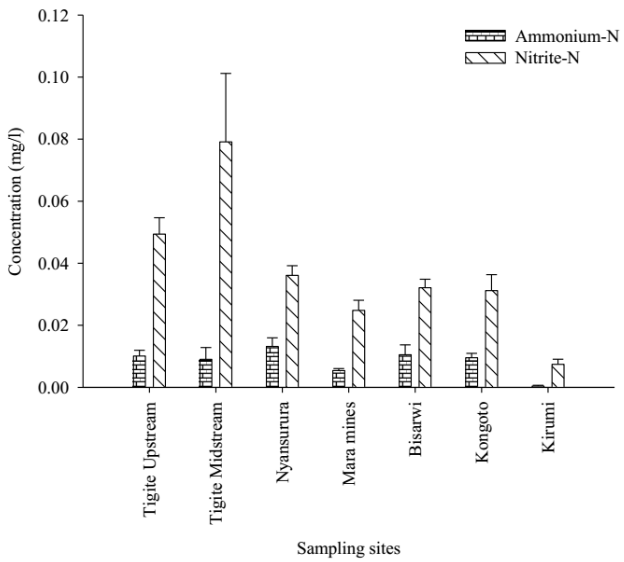
Table 35 Mean values of physico-chemical variables in Rivers Tigite, Mara and the wetland (Bisarwi, Kongoto and Kirumi). ± represents standard error of the mean (n=3).

Physico-chemical variables	River Tigite Upstream	River Tigite Midstream	Nyansurura	Mara mines	Bisarwi	Kongoto	Kirumi Bridge
DO (mg/l)	6.44±0.14	6.52±0.20	6.70±0.24	6.41±0.20	2.95±0.51	2.75±0.61	0.37±0.07
Temp °C	25.35±0.95	25.64±0.88	25.88±0.73	27.61±1.02	26.88±0.75	25.74±1.01	25.36±0.34
pH	8.3-9.43	7-10.23	7.87-11.42	7.41-8.42	6.8-9.25	6.29-8.49	6.55-7.38
EC (µS/cm)	221.99±9.54	460.25±68.29	276.09±44.71	296.8±56.39	246.84±28.96	233.38±13.08	218.95±7.03
Turbidity (NTU)	172.60±4.45	142±16.39	251.94±101.81	208.56±90.05	225±65.94	133.1±50.20	8.59±0.27

(b) Spatial variation in ammonium-nitrogen, nitrate-nitrogen and nitrite-nitrogen concentrations in River Tigite, Mara and in the wetland (inlet, within and outlet).

The NH_4-N and NO_2-N concentrations declined from the inlet to the outlet of the wetland as shown in Figure 19 below. However, within the wetland (Kongoto and Bisarwi) a slight increase in NO_2-N concentration was observed. The highest NO_2-N concentration of 0.07±0.02 mg/l was observed at the middle reach of River Tigite. Nitrate concentrations were lowest within the wetland at Kongoto and at the outlet of the wetland. The highest concentration was observed at the middle reach of River Tigite.

a



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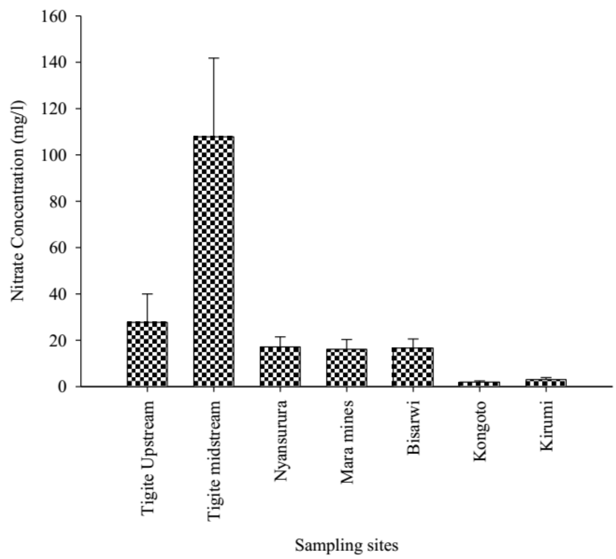

Figure 19 Variation in ammonium, nitrate and nitrite concentration in River Tigite, inlet (Mara mines) within the wetland (Bisarwi and Kongoto) and outlet of the wetland at Kirumi Bridge. Bars indicate standard error of the mean (n=3).

(c) Spatial variation in SRP, TP and TSS concentration in River Tigite, Mara and in the wetland (inlet, within and outlet)

Figure **20** shows the concentration of phosphorus and Total Suspended Solids at various sampling sites. The lowest SRP concentration of 0.02±0.001 mg/l was observed at the outlet of the wetland. Total phosphorus and TSS concentrations followed similar trend as SRP with the lowest concentrations being observed at the outlet and highest at the inlet of the wetland. Within the wetland increase in TSS concentration was observed in Bisarwi. In River Tigite, TSS at the middle reach was higher than upper reach.

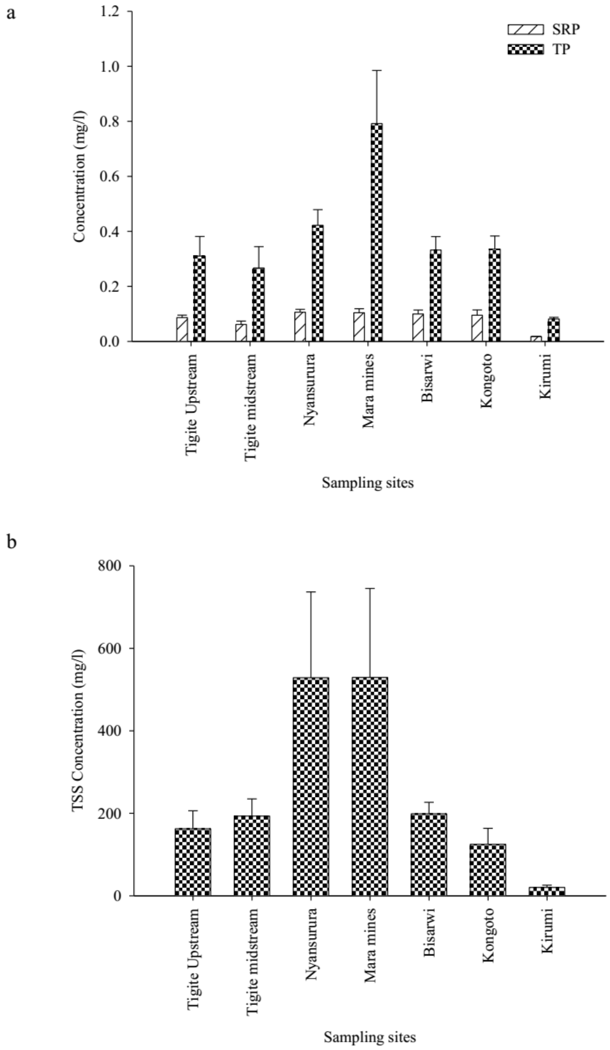

Figure 20 Variation in SRP, TP and TSS concentration in River Tigite, inlet (Mrito) within the wetland (Bisarwi and Kongoto) and outlet of the wetland at Kirumi Bridge. Bars indicate standard error of the mean (n=3).

Efficiency of Mara wetland in retaining nutrient and TSS

Nutrient and TSS retentions in Mara wetland is shown in Table 36 below. Nutrient and TSS concentrations at the inlet were higher than the outlet concentrations indicating retention. The EC at the inlet was also higher than at the outlet indicating retention of ions in the wetland.

Table 36: Nutrient and TSS retentions in Mara wetland

Variable	Concentration (mg/l)		Nutrient retention (%)
	Inlet	Outlet	
NH_4-N	0.0054	0.0004	93
NO_2-N	0.0248	0.0074	70
NO_3-N	16.13	3.02	81
SRP	0.10	0.018	83
TP	0.79	0.08	90
TSS	529.17	20.13	96
EC (μS/cm)	296.8	219.0	26.2

Trade-off scenarios for ES in Mara wetland

Figure 12 shows trade-off scenarios between provisioning and water purification ES in Mara wetland.

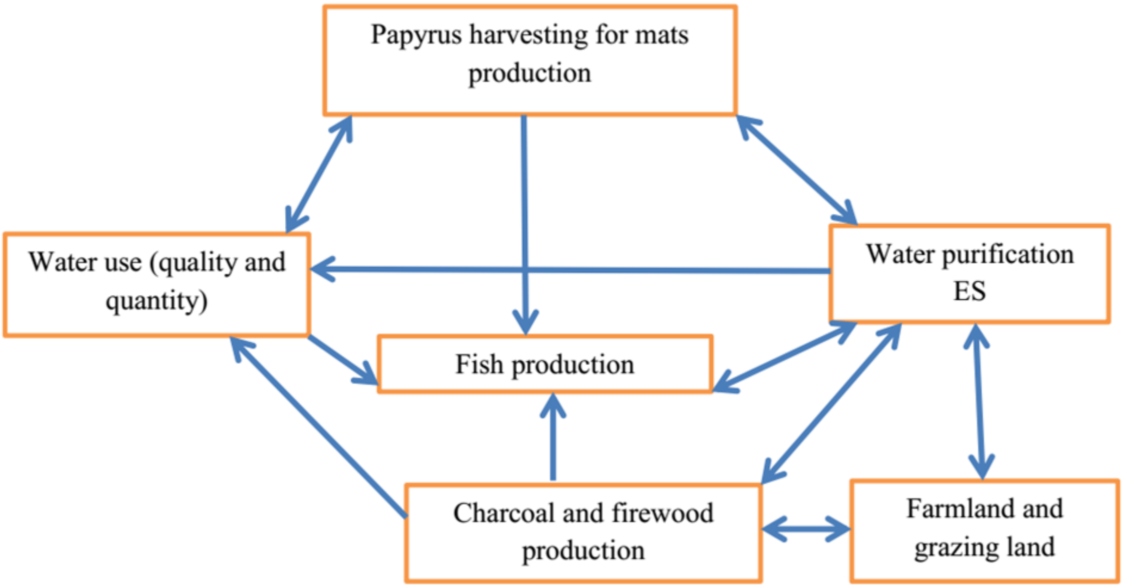

Figure 21: Trade-off scenarios of different services in Mara wetland

8. Conclusion and Recommendation

7.1. Conclusions

The wetlands ecosystems and their adjacent riparian habitats perform important ecological functions as source for water resources, flood storage, erosion control and sediment trapping. Wetlands ecosystems are amongst the richest life-support systems on Earth. It provides a variety of benefits to humans, either in the form of products, or in the form of services. Valuation is an important tool for stakeholders and decision makers to support the sustainable development of wetlands.

Economic valuation of wetlands entails non-market and market valuation techniques. In cases where the ES in question lack explicit markets where they can be traded, non-market valuation techniques may be used to establish the Willingness To Pay (WTP) or Willingness To Accept (WTA) for these dis/services. Benefit transfer may be applicable if a study already exists that valued an ES similar to the one in question.

The main conclusions for **Burullus Lake, Egypt** are:

- For Fishing activity needed more attention for marketing regulation especially for free fishing to encourage the fishermen.
- Enforce fishing laws implementation to eliminate illegal practices that led to decreasing fish quality and quantity.
- Some BLW eco-services, such as salt extraction and economic plants needed to maximize its benefits in context of environmental aspects to increase living standards of local community.
- Wetlands ecosystems are amongst the richest life-support systems on Earth. It provides a variety of benefits to humans, either in the form of products, or in the form of services.
- Valuation is an important tool for stakeholders and decision makers to support the sustainable development of wetlands.
- There are only a few studies applying the costs of supporting ecosystem services as carbon sequestration.
- Lake Burullus was declared as international important site for migratory bird (IPA) and Ramsar site in 1998.
- Burullus Lake provides important ecosystem services (provisional, supporting, recreational, regulating).
- Fishing is the main economic activity of the local communities in the districts of Burullus Lake that considered as the main source of income which can be directly evaluated using market price method.
- The limited numbers of markets and facilities around the lake affected the price of fishery income.
- The losses of the lake area and pollution affected negatively the quality and the quantity of biodiversity in the lake.
- The touristic potential around the lake are still weak and need serious support form stakeholder.
- The visits to the protectorate are locally activity mainly for school trips or visitors from other governorates.
- Dead rhizomes of P.australisare of main importance in the C sequestration process in Lake Burullus (Eid et al., 2010).

The main conclusions for **Dinder Park, Sudan** are:

- Dinder wetland provides tremendous values and products to villagers and local communities and Villagers depend on various resources for their livelihood.

- There are certain factors that affect the productivity of the wetland such as the natural hazards, disasters and limited time for collecting the wetland resources.
- The economic evaluation methods are mainly by direct use and market prices.
- The economic importance of the wetlands is definite and this TEV is still limited if compared to the real benefits from the different Dinder wetland' ecosystems.
- Wetlands conservation is considered as the most important issue in the sustainable management of biodiversity in the Dinder wetland. The wild animals have positive biological, scientific, economic, recreational, cultural, aesthetic and heritage values and even negative impacts. One of the gap in the field data is the monetary values of the wild animals.
- The nature of Dinder wetlands' habitat is the source of lives and wellbeing of humans and wildlife. It is clear that the ecosystems provide food, fruits, fuel, fibber, timber, fuel wood and medicinal plants to the local communities in and around Dinder. They depend on the wetland in their income specifically from agriculture, fishing, honey collection and sell of wood and non-wood forest products.
- The data collected during the field work by different tools, methods and the assessment valuation methods is still limited if compared to the real benefits from the different wetland' ecosystems. The interviewed targets are hesitant to answer many questions, knowing that Dinder is a National Park and by law they are prohibited to collect the resources unless having permission. Much of the information is gathered by informal discussions with some community members and from the available data.
- It is clear that Dinder Wetland has direct impact on the production and consumption of goods and services (water, food, medicinal, raw materials), and indirect values such as ecosystems functions and services: water quality, flood control, and nutrient retention, etc.
- The wetlands ecosystems and their adjacent riparian habitats perform important ecological functions as source for water resources, flood storage, erosion control and sediment trapping. They provide tremendous economic benefit e.g. water supply, fisheries, agriculture, maintenance of water and nutrient retention in flood plains, timber production, energy sources, wildlife and biodiversity conservation. They provide a wealth for non-consumptive values e.g. cultural, aesthetic and heritage values, recreation and tourism opportunities. They have special attributions in supporting cultural diversity. All these are difficult to be valuated in monetary terms.
-
- The field work results present the different needs, priorities and interests of the local communities, for the products and the services. The result reflect the challenges they face, in relation to water, land and ecosystems. The human activities are highly related to ecosystem services and interact with wetland seasonal situation.

- The data collected has highlighted the main drivers of change, such as seasonal fluctuation in wetland functions, stakeholder priorities and suggested plans as related to these changes.

The main conclusions for **Nakivubo wetland, Uganda** are:

- The direct use value of the main provisioning services of the Nakivubo wetland Local Communities (one household per hectare per year) is worth about 8,951,809.11Uganda Shillings ($14,833.88).
- This implies that a wetland is improving people's livelihoods. However, this is occurring at the expense of the main ecosystem service that this wetland used to provide, which is wastewater treatment.

The main conclusions for **Mara wetland, Kenya** are:

- The Mara wetland is an efficient bio-filter for sediments (settling) and nutrients (uptake)
- Majority of households (73%) are dependent on Mara wetland fisheries for their livelihoods while only 15% utilizes thatching grass.
- The current (2015/2016) annual total economic value of Mara wetland is TZS 39,877,804.22 (USD18, 453.40) of which crop production contributes the highest (47%) value of the TEV while thatching grass contributes the lowest (0.1%).
- Economic valuation of wetlands entails non-market and market valuation techniques. In cases where the ES in question lack explicit markets where they can be traded, non-market valuation techniques may be used to establish the Willingness To Pay (WTP) or Willingness To Accept (WTA) for these dis/services. Benefit transfer may be applicable if a study already exists that valued an ES similar to the one in question.
- In Mara wetland, the economic values of provisioning ES traded mainly in the local markets such as charcoal, crops, bricks, thatching grass, firewood, fish and papyrus mats were assessed using market price-based methods. The monetary values of water and livestock's pasture were estimated by group valuation method through an FGD consisting of 23 people utilizing the services.

7.2. Recommendations

The suggested recommendations may assist in the development of the necessary actions, including the effective management and wise use of the wetland available resources for the benefits of the local communities, the ecosystem and the region in general. Certain plans are proposed as follows:

The main Recommendations for **Burullus Lake, Egypt** are:

- Increase Awareness of local community (Beneficiaries) of Wetland Eco-Services value and the importance of their role in lake services sustainability. That could be achieved by applying a participatory (bottom –up) approach.

- More attention to monitor the environmental changes in Lake and governmental support to the bird watching service one of lake eco-services where the total income recorded that () L.E/year.

- A proposed questionnaires was implemented by the project team to be fullfilled in a new field trip for further calculation of fish catch using market price method and bird watching using travel cost method.
- An updated data is needed for calculating the operating cost of fishing gears in Burullus Lake as the available data was taken in 2005.
- More research is needed for the better understanding of the impact of environmental factors such as water pollution water level fluctuations, pH, temperature and precipitation on CSR (Ebrahim M. Eid).
- More measurement are needed for valuating of supporting ecosystem services in Burullus lake as a non-use value.
- It is necessary to protect and restore these wetland ecosystems for carbon sequestration potential, as well as other ecosystem services.
- Capacity building is needed to stakeholders in the field of ecosystem services and their valuation methods to be easly handled.
- Further supported is needed form stakeholders to improve the recreational potential around the lake.
- The consumer welling to pay is important to be taken into consideration for valuating the market status in districts around the lake

The main Recommendations for **Dinder Park, Sudan** are:

- Awareness raising, guidance programs and capacity building is best supported through a variety of traditional based approaches.
- Ecosystem services, values and the extent of benefits provided by the Dinder wetland to the beneficiaries would be sustainable through the wise use of wetland resources.
-
- More research and monitoring activities on wetland services and functions.
- Construction of paved roads and bridges (to ease their movement during the rainy season)
- The development of tourism services (Restaurants, Pensions aid Medical services ,exhibition of products and transportation and communication services) to assist the local communities to find other sources of income and jobs.
- Close collaboration with relevant partners and stakeholders, effective advocacy at the appropriate time and place are essential.

- Training program for communities in the field of handicrafts and local industries (Establishment of a home-stay tourist hostel in some villages, and tourist exhibitions for local handicraft products)
- Regulations and permits that limit the number of fishermen, tools and machinery used and the quantities and the type of fish caught and identify mayas to be used in every season
- Training of reserve personnel, and communities about the means of production, collection methods, marketing and management.
- The balance between the conservation of Dinder as protected area and the sustainable utilization of the resources by the local communities is very essential towards sustainable development. This could only being reached through proper implementation of Biosphere Reserve Concept and integration of the local communities in wise management of the wetland ecosystems.
- Development plans are needed for the effective management and wise use of the wetland available resources for the benefits of the communities, the ecosystem and the region in general.
- Further research and studies, and more efforts are needed for valuating the costs associated with ecosystem functions and the substantial economic benefits from better management and conservation of Dinder Wetland.

The main Recommendations for **Nakivubo Wetland, Uganda** are:

- The study used a market price method, which does not value all ecosystem services. In the subsequent valuations, other methods should be used so as to obtain the total economic value of Nakivubo wetland.
- Despite the fact that this wetland is providing livelihoods to the surrounding communities, this will in the long run compromise water quality in the Murchison Bay (where the water supply for Kampala is abstracted).
- In order to protect the lake from further pollution, it’s recommended that the wetland be restored with natural vegetation and agricultural activities be limited to the wetland edge, after carrying out a consultative wetland management planning.
-

The main Recommendations for **Mara wetland, Kenya** are:

- Other methods of valuing ES should be applied in Mara wetland to obtain its TEV since this study used market price and group valuation methods which do not value all the services.
- Crop production was valued from an FGD only and therefore subsequent valuations should be done at household level.
- To avoid the likelihood of over-estimation of fish production, gross income per day should be included in the valuation to countercheck calculations based on the amount/number and price of fish if the information is available.
- In the light of increasing sedimentation downstream of Mara basin, this study recommends sustainable cutting of trees used for charcoal production. In addition, the local communities should take an initiative of afforestation in the basin through Water Users Associations (WUA) and other organization so as

to ensure reduction of sediment transport downstream. For instance, in Kongoto Village, WUA and the local communities have taken the initiative of planting trees particularly in the buffer zones. The results from this site show lower (133 NTU) turbidity compared to other sites due to sedimentation as well as reduction in sediment input from the catchment.

Further research should be conducted on other ES which were not valued in this study.

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Annexes

Egypt

Annex (1)

Table (A-1) Fish capture in burullus lake (Source:study for valuation of fish production in Egypt - Source: Capmas 2013)

Years	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
No. of boats	8770	8770	6988	5619	8770	6674	2509	2600	2370	2370
No. of fishermen	2653	1742	1382	1803	3870	3870	472	880	250	2600
Production (Q) (tons)	59785	55500	55000	53909	52956	58291	52260	53401	59517	45544
Mean price (EGP/kilo)	7.7	7.5	8.4	8.8	12.3	12.3	11.4	10.6	10.3	11
Price value (P) (EGP)	459791	417280	460573	475742	649539	717430	596424	563893	612825	502552
Rate of annual change of mean price %	-	1.3	11.7	2.3	9.1	11.5	3.7	3.9	3.7	10.8

Table (A-2) the capital and operating cost – 2005

Item (size)	Samboak (smallest)	Falouka (medium)	Sailboat (largest)
Capital cost (LE)			
Fishing boat	350	1200	16000
Fishing net	325	900	2100
Total capita cost	625	2100	18100
Fishing period (day)	150	150	300
Operating cost (LE)			
Fishing boat	100	300	3000
Fishing net	150	350	1500
Wages	1500	4000	36750
Miscellaneous	100	250	1000
Total operating cost	1850	4900	42250
Return (LE)			
Total return	4247	7700	50000
Net return for owner	2397	2800	7750
Cost for owner and manager	2250	2250	2250

Net return on capital	147	550	5500
Rate return on capital (%)	22	26	30
Monthly income for owner	342	400	1107

Table (A-3) The Variation in Fish Production and Prices in Burullus Lake From 2006 To 2010

Year	2006		2007		2008		2009		2010	
Types	Production	Price	Production	Price	Production	Price	Production	Price	Production	Pric
Pelagic bissaria	1008	3.3	1006	2.52	901	1.75	977	2.5	99	2.52
Blue Tilapia	1692	8.1	21350	7.65	19124	7.2	20727	8.17	37542	8.2
Nile Perch	306	5.84	-	7.69	-	9.55	294	6.7	875	8.13
Shrimp	1260	67.2	1019	55.08	912	42.92	988	41.17	269	42.0
Common eel	1602	36.5	784	36.4	509	36.31	765	39	180	37.6
Dalophis imberbis	-	-	1478	14	1526	16	1440	2	298	7.23
Seabream	582	28.7	835	32.36	749	36.05	813	34.84	41	33.5
Mullet	26100	11.5	16250	13.51	11602	15.52	7713	16.37	12210	20.5
Bass	1152	25.3	1190	21.84	1067	18.41	1158	19	127	23.5
Catfish	9336	5.49	8395	5.94	10019	6.38	11611	6.72	2314	6.55
Nile Perch	936	14.85	306	14.04	270	13.22	-	14.23	-	13.7
Common carp	2147	5	1748	7	1892	9	2919	6.5	2500	7.8
Sole Fish	786	13.82	695	14.91	676	15.99	744	14.42	704	14.7
Spotted bass	2904	10	2490	13.75	2230	17.5	2417	11	1360	14
Other	3145	7.5	745	8.55	773	6.9	835	7	994	7.33
Total	52956		58291		52260		53401		59517	

Annex (2)

Fish questionnaire

The objective is to measure total economic surplus for the increased fish harvest that would occur if the pollution is cleaned up.

Producer

Capital cost

- What is the cost of fishing boats?
- What is the cost of fishing nets? How often do you change the nets?

Operating cost

- If you are not the owner of the ship, how much do you pay and the duration
- Is there any changes in the quantity of fish from the lake in the last ten years
- Is there any changes in the quality of fish from the lake in the last ten years
- How many kilos due you fish per month? Is there any seasonal varieties in fish production?
- What are the main profitable kinds of fish? How much you can sell per kilo?
- How often do you have maintenance to your boat? How much it cost?

Market cost

- Do you have fish market in your district? How far from your village?
  - Yes,
  - No, how much you pay to reach the market?
- Do sell you production by yourself?
  - Yes, do you pay for renting place in the market?
  - No, how much the seller earn from your production?
- How much do you earn for selling fish per month?
- Do you pay taxes for selling fish?
- What is the maximum amount that you are willing to earn form fish
- Is there any seasonal variation in fish production?
- What are the main defects that prevent you from obtaining the perfect price?
- Is there any policies that prevent you from gaining the perfect price?
- Can you consumer convince you to lower the price? How much?
- Do you export fish outside Egypt?
  - Yes: , how much per kilo? What are the main kinds?
  - No: , what prevent you?

Consumer

- Is there any changes in the quality of fish from the lake in the last ten years
- What are the main fish types do you buy? Why? How much per kilo?
- What is the perfect price you are willing to buy for fish?

- How often do you go to the market to buy fish?
- How many kilos do you buy each time?
- Do you have fish market in your district?
  - Yes, how far from your village?
  - No, how much you pay to reach the market?
- Is fish price constant or vary according to the seller welling?
- What prevent you from paying the perfect price for fish?
- Is there any alternative cheaper product that you can buy instead of fish?
- Do fish price varied by season? Which season?

Bird watching questionnaire

The survey might ask for the following information:

- Location of the visitor's home – how far they travelled to the site

١. ماهى وسيلة السفر الى المحمية
- لا
- نعم، اذكر المسافة

٢. ماهى تكاليف الاقامة اليومية

- How many times they visited the site in the past year or season

٣. ما هى عدد المرات التى قمت بها بزيارة المحمية خلال السنة الماضية او الموسم
- ١-٣ مرات   ٣- ٥ مرات   اكثر من ٥ مرات   اخرى

- The length of the trip

٤. ما هى المدة الزمنية التى يمكن ان تقضيها فى كل رحلة
- يوم   اسبوع   شهر   اخرى

- The amount of time spent

٥. ما هى الفترة الزمنية التى يمكن ان تقضيها داخل المحمية
- ١-٣ ساعة   ٣-٥ ساعة   اخرى

- Travel expenses

٦. ما هى تكاليف الانتقال

- The person's income or other information on the value of their time

٧. ما هو دخلك الشهرى
- ٣٠٠-٥٠٠ جنية   ٥٠٠-١٠٠٠ جنية   اكثر من ١٠٠٠ جنية
  اخرى

- Other socioeconomic characteristics of the visitor

٨. السن - الحالة الاجتماعية - عدد افراض الاسرة - طبيعة العمل - هل عملك له يرتبط بزيارة المحمية؟

- Other locations visited during the same trip, and amount of time spent at each

٩. ما هي الأماكن الأخرى التي قمت بزيارتها خلال الرحلة وزمن الزيارة
- قمت بزيارة المحمية فقط
- مدة زيارة الاماكن الاخرى

- Other reasons for the trip (is the trip only to visit the site, or for several purposes)

١٠. ما هى الاسباب الاخرى لزيارة المنطقة (هل زيارة المحمية فقط ام هناك اغراض اخرى)
- الترفية
- عمل
- تعليمية
- اخرى

- Bird watching success at the site (how many water birds recorded on each trip)

١١. هل نجحت فى مشاهدة الطيور المهاجرة بالمحمية
- نعم: اذكر اعداد الطيور التى سجلتها
- لا

- Perceptions of environmental quality or quality of water bird at the site

١٢. ما هو رأيك فى الوضع البيئى او نوعية الطيور المائية بالمحمية
- مقبول جيد جيد جدا ممتاز

- Substitute sites that the person might visit instead of this site

١٣. هل هناك مناطق اخرى بديلة للمحمية يمكن زيارتها لمشاهدة الطيور المهاجرة
- نعم
- لا: ما هى هذه المناطق

Annex 3: Data collection sheet for provisioning ES

DATA COLLECTION SHEET		
KEY ASPECTS AND PARAMETERS TO CONSIDER WHILE VALUING DIFFERENT WETLAND RESOURCES		
1. RESOURCE CHACTERISTICS		
	RESOURCE NAME	
	SITE/ LOCATION	
	RESOURCE PRODUCTS	
	VOLUME HARVESTED (*Per person per day*)	
	NO. PRODUCTS FROM RAW MATERIALS	
	VOLUME CONSUMED (%)	
	VOLUME SOLD (%)	
	QUANTITIES HARVESTED PER UNIT AREA	
	SEASONAL VARIATION – HIGH	
	- LOW	
	REGENERATION	
	TRENDS/CHANGES OVER YEARS	
2. RESOURCE USERS		
	NUMBER (S)	
	GENDER, SEX, AGE	
	INCOME LEVELS	
3. RESOURCE PRICES		
	PRICE OF RAW MATERIALS	

	PRICE OF PRODUCTS	
	PRICE VARIATION - HIGH	
	- LOW	
	- AVERAGE	
4. LABOUR COSTS		
	DURATION SPENT HARVESTING	
	DURATION SPENT PROCESSING	
	HIRED LABOUR	
	PERSONAL TIME	
5. OTHER COSTS		
	EQUIPMENT	
	ADDITIVES	
	STORAGE	
	TAXES & LICENCES	
	TRANSPORT	