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Economic Assessment of Wetland Biodiversity and Ecosystem Services as an Input for Development of Wetland Investment Plans: A Case Study of the Sio-Siteko

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Document Sheet

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List of Acronyms

CH_4	Methane
N_2O	Nitrous oxide
BAU	Business as Usual
BCR	Benefit Cost Ratio
BOD	Biological Oxygen Demand
CBA	Cost Benefit Analysis
CIP	Conservation Investment Plan
CPUE	Catch Per Unit Effort
CS	Consumer Surplus
CVM	Contingent Valuation Method
FAO	Food and Agriculture Organisation
FC	Fixed Cost
FGD	Focus Group Discussion
GDP	Gross Domestic Product
HH	Household
IPCC	Intergovernmental Panel on Climate Change
KE	Kenya
KNBS	Kenya National Bureau of Statistics
Kshs.	Kenya Shillings
LPG	Liquefied Petroleum Gas
MEA	Millennium Ecosystem Assessment
NB	Net Benefit
NBI	Nile Basin Initiative
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NEMA	National Environment Management Authority
NGOs	Non-Governmental Organisations
NPV	Net Present Value
NTU	Nephelometric Turbidity Units
PS	Producer Surplus
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UBOS	Uganda Bureau of Statistics
UBS	Uganda Bureau of Standards
UG	Uganda
UGX	Uganda Shillings
UNICEF	the United Nations Children's Fund
VC	Variable Cost
WSP	Water Service Providers
WTA	Willingness to Accept
WTP	Willingness to Pay

Executive Summary

- This study seek to build the economic case for wetland conservation and wise use, with a specific focus on generating evidence on the economic value of wetland as 'green' water infrastructure. By so doing, it intends to bring wetland ecosystem values to the attention of river basin planners and managers, and to thereby promote better-informed, more effective, inclusive, equitable and sustainable conservation and development decision-making. It is also good to appreciate that instrumental economic value obtained from ecosystem services is only one constituent of the comprehensive value of a wetland environment, and that the intrinsic value of nature also provides a case for the conservation a wetland ecosystem and its biodiversity. The main objective of this study is to generate information on economic value of the Sio-siteko wetland ecosystem services to inform the development of conservation investment plans
- The Sio-Siteko wetland system spans the Kenya-Uganda border. It traverses Busia district in Uganda and Busia County in Kenya and is part of the wider Sio-Malaba-Malakisi catchment (World Bank, 2009). In this study, the wetland's size is regarded to occupy an area of 60 km^2 based on the 2019 Sio-siteko wetland monograph which shows that the wetland size is slightly under than 60 km^2. In this study, only sub locations and parishes that border the wetland in Kenya and Uganda respectively have been considered as the buffer zone with direct influence on the wetland resource use. These include thirteen parishes (South East, Central, South West, Nangwe, Buyengo, Buhehe, Bulwenge, Budimo, Lumino, Junge, Dadira, Bumunji, and Majanji) in Uganda and sixteen sub locations (Busijo, Agenga, Bujwang'a, Sigalame, Luchululo, Luanda, Buloma, Lugala, Ludacho,Mango, Sibinga, Nang'oma, Muyafwa, Mundika, Mayenje, and Mjini in Kenya (NBI, 2009). However, in the household survey, sub locations and parishes in Busia towns of Kenya and Uganda were excluded since the study mainly focused on production and urban dwellers were viewed as more likely to be consumers.
- Sio-siteko wetland faces a host of challenges such as: (1) encroachment for crop farming within the wetland and also river banks, (2) mass harvesting of papyrus for sale to UAE

traders without consideration of regeneration, (3) indiscriminate sand harvesting leading to degradation of the wetland functions such as breeding sites, (5) Overgrazing due to large herds of cattle in the area, (6) conflict between livestock keepers and crop farmers due to destruction of crops and lack of pasture for livestock keepers, (7) freshwater availability is low and decreasing, as springs, shallow wells, boreholes dry up due to falling groundwater levels and diversion of water courses, (8) poor water quality due to pollution, (9) decline in fish stocks due to predation of other fish species by Nile perch, and destructive fishing gears especially at the river mouth (10) weak policy and law enforcement (NBI, 2020). Currently, more than 80% of the wetland has been reclaimed majorly for crop farming, and according to a 2010 National Environment Management Authority in Uganda report; wetlands around the Lake Victoria region undergo degradation at a rate of 4% per year.

- The study assessed the baseline economic value (based on year 2019) for fifteen ecosystem services which included: provisioning ecosystem services namely; crop farming, livestock grazing, grass harvesting, capture fisheries, aquaculture, sand harvesting, brick making, firewood, domestic water supply, herbal medicine, mat making; regulatory ecosystem services; flood attenuation, biodiversity maintenance, water purification, and groundwater recharge.
- The valuation techniques that were used included; (1) market price method which was used to value all the provisioning ecosystem services through household surveys; (2) contingent valuation, which was used to value biodiversity maintenance, (3) damage cost avoided, which was used to value flood attenuation, and (4) replacement cost technique which was used to value water purification and groundwater recharge ecosystem services.
- Both primary and secondary data were utilized in the study and the sources included household surveys, focus group discussions, key informant interviews, and secondary sources. Household survey was used to mainly collect data for provisioning ecosystem services and biodiversity maintenance from 419 households living within the 22 sub locations (Kenya) and parishes (Uganda) combined. The household survey was preceded by both focus group discussions and key informant interviews; the finding not only informed the design of the survey tools but also provided useful information for analytical purposes of the survey data. Survey was also used to collect data from households who have consistently

observed flood damage for the last five years. Other sources for use in valuing flood attenuation were based on secondary data.

- Three potential wetland management scenarios were identified through stakeholder consultations, and they included; business as usual, wetland conservation through a management plan, and agricultural intensification mainly through aquaculture in Kenya and rice farming in Uganda. In the business as usual scenario, the current reality and practice in wetland use and management (what the policy, legal and regulatory frameworks say not withstanding) will persist into the next 25 years, that is the current drivers of land use and land use change in the wetland will persist, they for instance include; general degradation of wetlands around the Lake Victoria which is said to be at an annual rate of 4%, population growth which is assumed to be directly proportional to demand for certain wetland ecosystem services such as firewood, and domestic water supply.
- Results of baseline economic valuation showed that the total economic value of the wetland ecosystem services was worth USD 29 million. Some of the provisioning ecosystem services even though were providing positive financial benefits to the individual household members of the local community at the current state of use, were however, yielding negative economic returns, such services included; growing of maize and beans, brick making, livestock grazing, mat making, and accessing water for domestic use from wetland. The rest however, had positive net economic returns.
- Cost benefit analysis was conducted for the three potential scenarios for managing the wetland. Results showed that business as usual scenario was not economically desirable, while both wetland conservation through a management plan and agricultural intensification are both economically sensible. Based on a 10% discount rate and a management period of 25 years, the agricultural intensification option has the highest present value benefit (USD 296 million), while conservation management plan has a present value benefit of USD 166 million, and the business as usual scenario has a present value loss of USD 166 million. However, conservation management plan offers the best value for money since it has a higher benefit to cost ratio at 4.75 compared to the 3.19 of the intensification option. The business as usual option had a benefit to cost ratio of 0.54. While the conservation management plan will seek to enhance the intrinsic values of nature within the wetland and

enhancement of all other wetland values albeit through limiting household populations that would appropriate some of these benefits, agricultural intensification will wipe almost all the other ecosystem services including maintenance of biodiversity and degrade fish breeding sites just by the fourth year of such an investment. Business as usual will also wipe out majority of the ecosystem services in the next 23 years.

- Valuable knowledge gaps still exist such as on the full spectrum role the wetland plays in water purification as an ecosystem service given that only turbidity was valued in this study owing to data limitation for other important parameters such as nutrients. Similarly, it is acknowledged that as living standards improve, demand for some ecosystem services will begin to decline, such services may include: direct drawing of domestic water from the wetland, which may be replaced with piped water; firewood, maybe replaced with kerosene, charcoal, and LPG; and keeping of indigenous cattle, which may be replaced with exotic cattle. However, these potential dynamics were not included in the analysis because there were no data on potential onset and or rate of uptake or replacement of these ecosystem services.

Chapter 1: Introduction

1.1. Background

Both Uganda and Kenya formally acknowledged the value of wetland ecosystems when they signed the Ramsar Convention on Wetlands in 1988 and 1990 respectively. The two countries have since formulated policies and enacted laws and regulations governing wetland ecosystems. However, wetlands still remain under threat from a number of human induced factors such as population growth, reclamation for agriculture and industrial investments among others. Wetlands are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival.

The Nile Basin Initiative which is an inter-governmental organization initiated and led by the Nile riparian countries with a mandate of promoting joint development, protection and management of the common Nile River Basin water resources has initiated a "TEEB-inspired study" focusing on wetland ecosystems. This TEEB study is motivated by the need to address the problem of a lack of a systematically developed potential "green infrastructures" i.e. ecosystem services investment options. The Nile Basin Wetlands TEEB, coordinated by the Nile Basin Initiative (NBI), has the goal of raising awareness about the importance of wetland ecosystem services to regional, national, sectoral and local-level development processes. It seeks to build the economic case for wetland conservation and wise use, with a specific focus on generating evidence on the economic value of wetlands as 'green' water infrastructure. By so doing, it intends to bring wetland ecosystem values to the attention of river basin planners and managers, and to thereby promote better-informed, more effective, inclusive, equitable and sustainable conservation and development decision-making in the Nile River Basin. To this end, NBI initiated a TEEB study for Sio-Siteko Wetland which will help in supporting basin planning and investment agenda into the conservation and sustainable use of the wetland for sustainable provision of the ecosystem services for the local economies of Busia County in Kenya and Busia district in Uganda, and reduction in biodiversity loss.

1.2. Purpose of the study

The study aimed at generating information on economic value of the wetland ecosystem services to inform the development of conservation investment plans and hence make a case for public and private investment for improved management of the wetland and trade-offs between different development trajectories

1.3. Objectives and research questions that guided the study

The objectives of the study included;

1) Identification of Sio-siteko wetland ecosystem services and their beneficiaries
2) Estimation of the current economic value of the Sio-siteko wetland biodiversity and ecosystem services
3) Identification of and economic assessment of the costs and benefits of potential management options for the Sio-siteko wetland
4) Comparison of the costs and benefits of the potential wetland management options

While the research questions that the study was designed to answer included:

1) How and for whom does the wetland generate economic benefits?
2) What is the current value of biodiversity and ecosystem services generated by wetland?
3) What would be the costs of the wetland degradation and loss?
4) What would be the value-added from investing in enhanced wetland conservation and wise use?

1.4. The target audience of the study

The target audience in this study are the stakeholder group (s) that have the ability to influence wetland ecosystem conservation status and or funding of this environmentally significant area. The main task is to generate the evidence that is needed to convince them to support investments in conservation of the wetland and this usually should resonate with advancing their core mandates or interests, securing value for investments, and broad public support or goodwill either from immediate local community, regional and national, and intergovernmental and international community. Table 1 shows such target audience, expected roles, and their information needs.

Table 1: Target audience, expected interests, and information needs

Target Audience	Expected role /interest	Information needs
County government of Busia in Kenya and the county council of Busia in Uganda	Allocation of wetland land for conservation, agricultural intensification or persistence of status quo	Number of household or individuals that would benefit from conservation vs other land uses. Revenues generated for the county government or municipal council from conservation, agricultural intensification or status quo
Development Partners (examples include: GIZ, UNDP, among others)	Funding of conservation, or other investment options in the wetland; Promotion of conservation of biodiversity of global significance	Value of investment returns of conservation compared to other development options
Regional bodies (examples include Lake Victoria Basin Commission, the Nile Basin Initiative among others)	Funding of conservation, or other investment options in the wetland	Value of investment returns of conservation compared to other development options Options that advance regional harmony
National irrigation boards and department of agriculture	Promotion of irrigation schemes in natural water systems such as wetlands	Value of investment returns of irrigation vs conservation
Fisheries departments and department of agriculture	Promotion of aquaculture in natural water systems such as wetlands	Value of investment returns of aquaculture vs conservation
Local community	Engage in consumptive and non-consumptive use of the wetland ecosystem	Value of investment returns of conservation vs status quo and agricultural intensification
Civil society organizations (Examples include; Water Resource Users Associations, Sio-Siteko wetland users association, Wetlands International among others)	Biodiversity conservation; Poverty reduction, secure livelihoods	Value of investment returns of conservation compared to other development options

Chapter 2: Overview of Economic Valuation of Wetland Resources

2.1. Value and Value systems

Value refers to the contribution of an object or action to specific goals, objectives, or conditions (Costanza, 2004). Costanza further fronts that value of an object or action may be tightly coupled with an individual's value system because the latter determines the relative importance to the individual of an action or object relative to other actions or objects within the perceived world, where value systems refer to intrapsychic constellations of norms and precepts that guide human judgment and action (Farber et al., 2002). They refer to the normative and moral frameworks people use to assign importance and necessity to their beliefs and actions and are therefore internal to individuals but are the result of complex patterns of acculturation and may be externally manipulated through, e.g. awareness creation (Farber et al., 2002; Costanza, 2004)

People's perceptions are limited, they do not have perfect information, and they have limited capacity to process the information they do possess (Farber et al., 2002; Costanza, 2004). An object or activity may therefore contribute to meeting an individual's goals without the individual being fully (or even vaguely) aware of the connection (Farber et al., 2002; Costanza, 2004). The value of an object or action therefore needs to be assessed both from the subjective standpoint of individuals and their internal value systems and from the objective standpoint of what we may know from other sources about the connection (Farber et al., 2002; Costanza, 2004).

Reasoning on value of ecosystems runs between two approaches: (1) the anthropocentrism/utilitarian approach: Elements of Ecosystem Services are valuable insofar as they serve human beings; Valuable is what creates 'the greatest good for the greatest number'; and (2) eco- or biocentrism approach-rejects the 'dominant species' argument and replaces utility with intrinsic value: "value in and for itself, irrespective of its utility for someone else.

Some services of ecosystems, like fish or timber, are bought and sold in markets. Many ecosystem services, like wildlife viewing, are not traded in markets. Markets for most ecosystem services are missing but we still can measure their dollar values. We require a measure of how much one will give up to get the service of the ecosystem, or how much people would need to be paid in order to give it up. The value of an eco-system can be interpreted in many different ways e.g. (1) the value of the current flow of benefits provided by that ecosystem; (2) The value of future flows of benefits; (3) The value of conserving that ecosystem rather than converting it to some other use.

2.2. Valuation

This is the process of expressing a value for a particular action or object. Value is a measure of the maximum amount an individual is willing to pay (WTP) for goods and services, it entails financial value which is measured in prevailing market prices and economic value which is measured in economic or efficiency prices. The economic value prevails in a competitive market, free of any market imperfections (e.g. monopolies) or policy distortions (e.g. taxes or barriers to trade). It is a more accurate reflection of the contribution of a good or service to social welfare (Bishop, 1999).

In valuing ecosystem services we are interested in: (1) *Value of the total flow of benefits from ecosystems*: Contribution to economy by adjusting national account--We use total economic value; (2) *Net benefits of interventions that alter ecosystem conditions*: Arises in a project or policy context: We use marginal or net values; (3) *Examining distribution of costs and benefits of ecosystems:* This is to different stakeholder groups; (4) *Identifying potential financing sources for conservation (*Pagiola et al., 2004).

2.3. The concept of willingness to pay

In principle, economic valuation of ecosystem services is based on "people preference" and their choices. Therefore, it is quantified by the highest monetary value that a person is willing to pay in order to obtain the benefit of that particular service (Mehvar et al., 2018). The "willingness to pay" approach determines how much someone is willing to give up for a change in obtaining a certain ecosystem good or service (MEA, 2005). Thus, the key outcome of valuation studies is to illustrate the importance of a healthy ecosystem for socio-economic prosperity and to monetize the gains that one may achieve or lose due to a change in ecosystem services (Sukhdev et al., 2014).

2.4. Ways of measuring the value of ecosystem services

The value of ecosystem services can be measured in three different ways (Tinch and Mathieu, 2011): (1) Total economic value (TEV) that refers to the value of a particular ecosystem service over the entire area covered by an ecosystem during a defined time period; (2) average value of an ecosystem service per unit, which is often indicated for a unit of area or time; (3) marginal value which is the additional value gained or lost by an incremental change in a provision of a particular service.

Valuation starts from estimating a TEV of an ecosystem, which is in fact a sum of Consumer Surplus (CS) and Producer Surplus (PS). This is done by applying different valuation techniques. By definition, CS is the difference between the actual market price of the product and the maximum amount that people are willing to pay, while PS refers to the benefit that the producer earns when the market price is higher than the costs of production (also called net income). For example, in the case of tourism, PS is the direct or indirect benefit from the local ecosystems for the tourism sector by considering the revenue made from tourists minus the costs of providing these services to them (van Beukering et al., 2007). In addition, CS conveys the maximum amount that tourists are willing to pay for visiting the specific recreational area.

Value of nature depends on the perspective of various stakeholders such as local residents, visitors, policy makers, etc. The key factor of valuation studies is to show how a healthy ecosystem is important for socio-economic prosperity (Sukhdev et al., 2014).

2.5. Valuation techniques

Valuation methods can be separated into two broad categories: stated preference and revealed preference methods. Each of these broad categories of methods includes both indirect and direct techniques. Revealed preference methods are those that are based on actual observable choices that allow resource values to be directly inferred from those choices. Stated preference methods use survey techniques to elicit willingness to pay for a marginal improvement or for avoiding a marginal loss (Tietenberg & Lewis, 2016).

Table 2: Valuation techniques

Methods	Revealed Preference	Stated Preference
Direct	Market Price	Contingent Valuation
	Simulated Market	
Indirect	Travel Cost	Choice Modelling
	Hedonic Property Values	○ Choice experiment
	Hedonic Wage Values	○ Choice ranking
	Avoidance Expenditures	○ Choice rating

Source: Adopted and Modified from Tietenberg & Lewis (2016)

Chapter 3: Methodology

3.1. Introduction

This section covers the study location and population, data needs and sources for the study objectives and ecosystem services under consideration, the data collection strategies for each of the ecosystem services, and data analysis. In general, valuation of the wetland's ecosystem services was carried out in four phases. Phase one entailed a literature review or an appraisal of the various ecosystem services of the Sio-siteko wetland and riverine wetlands in general, this led to the establishment of over ten (10) wetland ecosystem services to be discussed in chapter four. The second phase entailed a scoping which was geared towards refocusing the ecosystem services and working with only important ecosystem services that are manageable in light of time and resource constraints. The third phase was pre-testing in which data collection tools were tested for effectiveness in collecting the intended information. While the final phase entailed actual data collection.

The first objective of this study which mainly focused on identification of Sio-siteko wetland ecosystem services and their beneficiaries was conducted during the scoping phase of the study. Its findings are briefly presented in chapter 4.

3.2. Study Location, boundaries and coverage

The Sio-Siteko wetland system spans the Kenya-Uganda border. It traverses Busia district in Uganda and Busia County in Kenya and is part of the wider Sio-Malaba-Malakisi catchment (World Bank, 2009). The wetland consists of a number of interconnected secondary and tertiary wetland subsystems that drain into Lake Victoria. According to a 2014 Situation Analysis Report for Lower Sio Sub-Catchment (NBI, 2014), the Ugandan side of lower Sio sub-catchment has wetlands of about $77km^2$. In this study, the wetland's size is regarded to occupy an area of 60 km^2 based on the 2019 Sio-siteko wetland monograph which shows that the wetland size is slightly under than 60 km^2.

The lower Sio sub catchment in which the wetland is located is comprised of six sub counties (Buhehe, Busia Municipal Council, Dabani, Lumino, Majanji, and Masinya) in Busia district of Uganda, and the three sub counties (Matayos, Nambale, and Funyula) of Busia County in Kenya (NBI, 2014.). In this study, only sub locations and parishes that border the wetland in Kenya and Uganda respectively have been considered as the buffer zone with direct influence on the wetland resource use. These include thirteen parishes (South East, Central, South West, Nangwe, Buyengo, Buhehe, Bulwenge, Budimo, Lumino, Junge, Dadira, Bumunji, and Majanji) in Uganda and sixteen sub locations (Busijo, Agenga, Bujwang'a, Sigalame, Luchululo, Luanda, Buloma, Lugala, Ludacho,Mango, Sibinga, Nang'oma, Muyafwa, Mundika, Mayenje, and Mjini in Kenya (NBI, 2009). However, in the household survey, sub locations and parishes in Busia towns of Kenya and Uganda were excluded since the study mainly focused on production and urban dwellers have been viewed as more likely to be consumers.

Sio-siteko wetland is in close proximity to both Busia towns in Kenya and Uganda. The major socio-economic activity within the twin towns is trade. While in the rural areas surrounding the wetland proper, majority of the people are dependent for their livelihoods on subsistence farming, employment, family support, and business enterprises (UBS 2014; NBI, 2020). Within the Sio Siteko wetland landscape, people's livelihoods comprise a wide spectrum of activities, including agricultural production, livestock production and fishing, as well as trade (NBI, 2020).

Sio-siteko wetland faces a host of challenges such as: (1) encroachment for crop farming within the wetland and also river banks, (2) mass harvesting of papyrus for sale to UAE traders without consideration of regeneration, (3) indiscriminate sand harvesting leading to degradation of the wetland functions such as breeding sites, (4) encroachment into the wetland compromises the ecological functions of wetland hence undermining biodiversity development, and also increasing human-wildlife conflict in the wetland, (5) Overgrazing due to large herds of cattle in the area,(6) conflict between livestock keepers and farmers due to destruction of crops and lack of pasture for livestock keepers, (7) freshwater availability is low and decreasing, as springs, shallow wells, boreholes dry up due to falling groundwater levels and diversion of water courses, (8) poor water quality due to pollution, (9) decline in fish stocks due to predation of other fish species by Nile perch, and destructive fishing gears especially at the river mouth (10) weak policy and law enforcement-Local communities and other wetland users do not always adhere to set rules and regulations in their operations in the wetland, posing a threat to the ecological functioning of the wetlands, and leading to an ever increasing number of conflicts between different users (e.g. crop farmers, herdsmen, plant harvesters, grass harvesters clay miners, sand miners) and between users and the responsible authorities (NBI, 2020).

Other challenges include inadequate political support for local institutions, limited incorporation of scientific knowledge in management policies, as well as limited application and sustainability of the interventions. Additionally, sporadic and limited funding jeopardizes the functioning of institutions and increases the dependence on NGOs (NBI, 2020).

Currently, more than 80% of the wetland has been reclaimed majorly for crop farming. According to a 2010 National Environment Management Authority in Uganda report; wetlands around the Lake Victoria region undergo degradation at a rate of 4% per year.

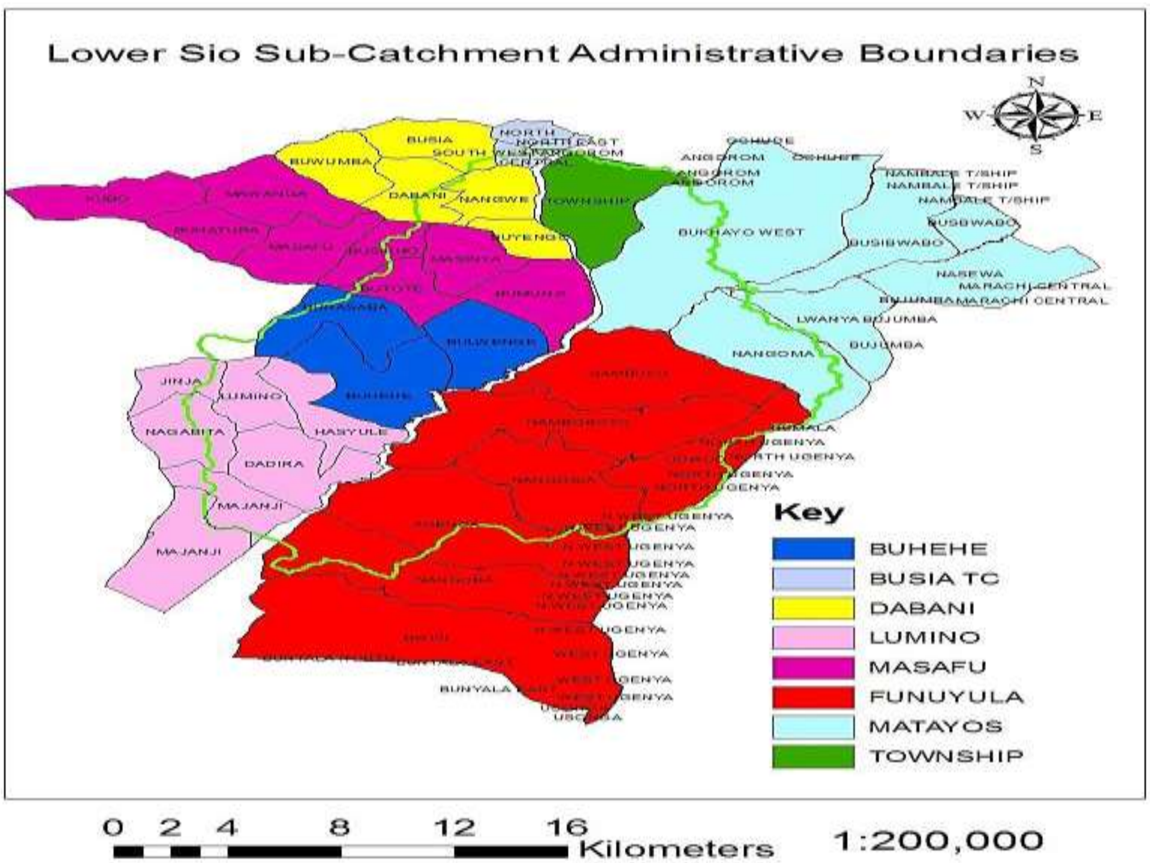

Figure 1: Map of Sio-siteko sub basin showing sub locations bordering the wetland on both Kenya and Uganda sides
Source: NBI, 2014

3.3. Data Needs and Sources

While over twenty ecosystem services were identified during situational analysis (literature review and appraisal of ecosystem services phase) only fifteen of them were prioritised for full study economic valuation. Estimation of the baseline economic value of the Sio-siteko wetland biodiversity and ecosystem services was conducted using four valuation techniques i.e. market price method for provisioning ecosystem services, contingent valuation method for biodiversity maintenance ecosystem services, damage cost avoided for flood attenuation services, replacement cost method for water purification and groundwater recharge ecosystem services. Each of these techniques has different data requirements as highlighted in the next paragraphs.

For market price technique, data collected over time is the most ideal since with it one is able to correct potential sources of biases such as effects of seasonality. For the case of the Sio-siteko wetland, discussions with governments departments revealed that there are no wetland specific regular data collections. Given the lack of wetland specific longitudinal data from government departments, only self-reported cross-sectional data was used in this study. Table 3 shows the various provisioning services that valued using Market Price Method and their data needs

Table 3: Data needs for estimating baseline economic values of provisioning ecosystem services

Ecosystem Service	Data needs under Market Price Method
Production services	
Water supply	Number of household using wetland water; Quantity of water used for domestic purpose, price per unit quantity of water supplied by WSP, cost of access to water
Capture fishery	Annual total fish catch in weight, price of fish by weight, area of wetland inhabited by fish, number of fisher folks, cost of fishing
Non timber forest products (herbal medicines, papyrus,	Quantity harvested, rate of harvesting, price per quantity, price of substitute products, area of wetland used for harnessing the

grass)	products, cost for harnessing these services
Firewood	Number of households accessing firewood from the wetland, annual extracted quantity, price per quantity, area of wetland under tree cover, cost of harvesting firewood
Carrier Services	
Crop farming (only taking place in the area demarcated as wetland)	Quantity produced, market prices, production costs, subsidies, taxes, fees, size of wetland area used for farming
Livestock grazing	Number & type of animals grazing in the wetland, duration of grazing, estimated daily forage uptake per animal, market prices of hay, size of wetland area used for grazing, cost of grazing in the wetland, number of households grazing in the wetland
Aquaculture i.e. fish farming	Annual total fish harvests (biomass), price of fish harvests, number of fish farming households, number and sizes of fish ponds, production costs
Sand harvesting	Volume of sand per track, price per track, number of tracks per year, transport costs, licenses & permits, duration in business, size of land used in sand harvesting, number of households engaging in sand harvesting
*Brick Making	Quantity of bricks made, cost of production, market price, size of land in the wetland used in brick making, permits & licenses, number of households taking part in brick making within the wetland

For the replacement cost method, useful information for water purification ecosystem services valuation included cost of replacing an ecosystem services with artificial or man-made products, infrastructure or technologies, in terms of expenditures saved (Emerton, 2009). When applying infrastructure or technologies, the method assess the cost of replacing wetlands role in water purification and waste assimilation services with artificial waste treatment plants or water supply system. Data needed include: bill of quantities for the construction, operation and maintenance, and decommissioning of a sewerage treatment facility; or bill of quantity for cost of construction, operation, maintenance, and decommissioning of a water supply system, level of pollution of water at the start of the wetland ecosystem, level of water pollution at the lower reaches of the wetland. Useful parameters include; Nutrients such as nitrates, phosphates and others, turbidity among others. Data needed for groundwater recharge valuation under the replacement cost method included: assessment of the extent of flooding, its contribution to the depth and replenishment of water tables and aquifers, as well as the impacts of changes in wetland status on these variables. It involves determination of costs providing shallow wells and boreholes, and the number of people using them in the area, and comparing with the development of alternative water sources. That is, one would look at the costs of replacing existing shallow-dug wells and boreholes, which depend on the groundwater recharge and water supply functions of the wetland, with other forms of water supply such as boreholes made elsewhere, water trucks, or water pipelines.

For the damage cost avoided, the data needed for the study included: determination of the area and population, property, production system which would be affected by floods in the event of the loss of wetland protection, determination of the boundary beyond which assessment will not take place, estimated frequency of flooding or erosion events, probability of damages given the estimated frequency of flooding or sedimentation, output value of crops per unit area and or average cost of house construction, damage factor (flood damage as a % of construction or production costs (Salcone et al, 2016).

For contingent valuation method, the data needed included; knowledge of biodiversity richness and abundance and roles in the wetland, attitudes towards biodiversity richness and abundance maintenance, biodiversity maintenance scenario description, payment vehicle, and socio-demographic characteristics.

For the third objective of identification and economic assessment of the costs and benefits of potential management options for the Sio-siteko wetland, data needed included identification of the management options, drivers of change and rate of change, determination of sustainable levels of extraction in relation to land use change, identification of depletion of the ecosystem services, discount rate, and appropriate time planning horizon. While data needed for comparison of the costs and benefits of the potential wetland management options included number of beneficiaries and losers under the management options, distributional effects, the economic, social, and environmental effects of each option, and value for money for each investment option.

3.3. Data Collection

3.3.1. Key Informant Interviews

Key informant interviews were used to obtain information from government agents from Ugandan and the Kenyan sides of the wetland, and also local community leaders. A total of 18 (9 each from both Kenya and Uganda) interviews were conducted with representatives of wetland related departments such as water resources, water supply, wildlife management, land management, agriculture, fisheries, forestry, and environment. Informants were interviewed on the basis of sectors of jurisdiction, for instances fisheries officers were majorly interviewed on matters fisheries. Key talking points included; status of the ecosystem service in the wetland, threats and challenges facing the wetland in relation to an ecosystem service of interest, future plans of the department in relation to the sector for the wetland, patterns and level of use of the wetland by the local community and other stakeholders, data availability, among other parameters.

3.3.2. Focus Group Discussions

Focus group discussions were conducted with an aim to inform and complement household survey by obtaining objective information through in-depth exploration and exposition of information, and on common data on various ecosystem services. The issues explored by the focus group discussions included; identification of the various ecosystem services in the wetland, patterns and levels of consumption, drivers of change, prioritisation based on perceived level of importance, levels and volumes of production by a typical household, periods of major activities, trips, and man hours for production, costs involved and typical unit prices for quantities of products harnessed from the wetland among others.

A total of six (three each for Kenya and Uganda respectively) focus group discussions were conducted comprising wetland resources user groups from both Kenya and Uganda. All Allfocus group was made up of 6 participants each drawn from members and leaders of various wetland resource user groups were represented, including; hunters, grazers, grass harvesters, fishermen, herbal medicine users, brick makers, sand harvesters, crop farmers, water users, salt makers, mat makers. Discussions held on the Kenyan side were conducted in Mayenje, Nangoma, and Ageng'a sub locations, while in Uganda, they were held at Junge parish, Maduwa landing site, and at the Busia district fisheries offices.

3.3.3. Household Survey

3.3.3.1. Questionnaire development and sampling strategy

Household survey was designed to collect market price data for provisioning ecosystem services, and contingent data for biodiversity maintenance ecosystem service; hence the questionnaire was divided into two parts. The questionnaire was preceded by a consent form to be read to potential respondent. Part A of the questionnaire captured market price data information for each of the ten (10) provisioning ecosystem services. Key information sought from household heads or spouses for each ecosystem service included: identification of ecosystem services that they access from the wetland, the quantity of the ecosystem they access annually, and price they sell a unit of the service if they also engage in selling the service, and the costs involved in extracting and selling the ecosystem service.

Part B of the questionnaire captured information for contingent valuation of the biodiversity maintenance ecosystem services. Biodiversity maintenance was viewed from the perspective of richness and abundance of the various plants and animal species found in the wetland. Other ways for conducting the valuation of biodiversity include valuation of biodiversity at genetic diversity level and or valuation at ecosystem level. Here, biodiversity assessment has been conducted through the perspective of richness and abundance only. Contingent Valuation Method (CVM) is a stated preference technique that relies on a direct questionnaire approach, asking a sample of individuals to state their hypothetical maximum willingness to pay (WTP) for conserving an environmental resource or their minimum willingness to accept (WTA) for suffering the loss of that resource. This contingent market defines the service itself, the institutional context in which it would be provided, and the way it would be financed. A random sample of people is then directly asked to express or reveal, in some way, their maximum WTP (or WTA) for a hypothetical change in the level of provision of the service (van Beukering et al, 2007). Contingent Valuation Method and choice modelling are the only valuation techniques that are capable of shedding light on the monetary valuation of the non-use values. While choice experiment is viewed as superior to contingent valuation, the latter has the advantage in valuing services that can be co-generated so that there is no risk of double counting, for instance a unit area of wetland will provide both habitat services for fish and also a breeding and nursery ground at the same time. In Contingent Valuation Method, the elicitation of a monetary measure for the changes in utility due to changes in an environmental good is done with the help of elicitation methods. The most common methods include: open-ended, dichotomous choice (single/ double), iterative bidding, and payment card. The information sought through the questionnaire included; knowledge about wetland biodiversity, description of the changes about biodiversity, description of the constructed market, information on management or institutional context, information on the type of payment vehicle (labour, commodity, or cash money) and frequency of payment, debriefing questions after response to willingness to pay, and socio-demographic characteristics of the respondents. An initial questionnaire was designed for pre-testing and it contained open ended bid format, with three numeraires as payment vehicles i.e. cash, commodity and labour. Respondents were required to only pick one of the three numeraires. The purpose of the pre-testing was to (1) test if data collection tool was capturing the intended information, (2) identify the most preferred numeraire for the payment vehicle, (3) identify the most appropriate anchor bid (the modal willingness to pay amount). The pre-testing questionnaire was administered to 72 people residing in the buffer zone of the wetland, and labour was the preferred numeraire for the payment vehicle while five hours (5 hrs) per month was the modal amount of cost, these were then incorporated in the final questionnaire (see attached appendix for the final questionnaire). The final questionnaire was a single bound dichotomous format followed by an open ended question asking respondents to give their maximum willingness to pay irrespective of their response to the bid question asked earlier. Further, they were asked to state the amount in cash they would give as their maximum amount were they to be asked to give monetary contribution.

Sampling strategy deployed for the study was probability sampling of the target population to facilitate generalization of the findings to the entire delineated area of study. The target populations were the local community who reside in the sub locations (in the case of Kenya) and parishes (in the case of Uganda) bordering the wetlands. These include fifteen (15) sub locations of Matayos and Funyula sub-counties in Kenya which are: Busijo, Ageng'a, Sigalame, Bujwanga, Luanda, Buloma, Lugala, Luchululo, Sibinga, Mango, Mundika, Nang'oma, Munyufwa, and Mayenje. While for Uganda, the target population were the local Parishes community of Junje, Budimo, Lumino, Nangwe, Buyengo, Buhehe, and bulwenge parishes. The total individual and household populations in the study area are has been computed as shown in table 4.

It was assumed that all the ecosystem services are at least drawn in similar proportions in the entire wetland, therefore simple random sampling was adopted for this study. The sampling unit was the household in which the household heads or their spouses were interviewed; this is based on the assumption that household heads or their spouses are in a position to make financial decisions for the entire household.

An assumption of normal distribution of the ecosystem services under consideration among the sub locations was made hence simple random sampling was proposed, and Yamane (1967) sample size calculation formula (equation 1) was used to determine the minimum sample size for socio-economic survey of the local community utilization (consumption and production) of the wetland's ecosystem services

$$n = \frac{N}{1+N(e)^2} \qquad (1)$$

Where n is the sample size, N is the population size, and e is the level of precision. Desiring a 95% confidence level and precision levels of 0.05, the minimum number of households to be surveyed will be 419 household heads.

Table 4: Target household population for survey and sample sizes

sub county/ district	sub location/ parish	Individual population at the time of census	Household population as at the time of census	Projected household population as at 2019	Sub location/ parish sample size
**Funyula sub county	Busijo	4274	814	1074	15
	Ageng'a	4383	897	1184	17
	Sigalame	3960	804	1061	15
	Bujwanga	4383	1158	1529	21
	Luanda	4221	889	1173	16
	Buloma	3457	721	952	13
	Lugala	1953	413	545	8
	Luchululo	1657	348	459	6
	Sibinga	1969	583	536	7
	Ludacho	2802	581	767	11
	Mango	1899	406	536	7
**Matayos sub county	Mundika	9966	1964	2592	36
	Nang'oma	4500	948	2592	15
	Muyafwa	3881	792	1045	15
	Mayenje	9170	1919	2533	35
	Junge	3481	682	782	11
*Lumino sub county (Uganda)	Budimo	3071	571	657	9
	Hashule	2262	455	523	7
	Majanji	3481	682	784	11
	Dadira	2132	388	446	6
Dabani Sub county (Uganda)	Nangwe	5005	861	990	14
	Buyengo	2581	434	499	7
Buhehe Sub county (Uganda)	Buhehe	6900	1354	1557	22
	bulwenge	4821	958	1102	15
Masinya Sub county (Uganda)	Bumunji	5242	987	1135	16
	Masinya	5637	1043	1199	17
Western Division	South West	7668	1719	2118	29
Eastern Division	South East	4096	1123	1318	18
Total		**107,088**	**21652**	**31688**	**419**

** Based on 2009 census report; projection into 2019 based on the average national annual household growth rate of 3.2%

*Based on 2014 census report, projection into 2019 is based on the average national annual growth rate of 3.5%

Source: KNBS, 2010; UBS, 2014

3.3.3.2. Questionnaire Administration

Both the market price questionnaire and contingent valuation questionnaires were responded to by the same respondents to optimise time and financial resource constraints. Ten experienced research assistants were hired and trained adequately to collect data. Data was randomly collected from the sub locations and parishes adjoining the wetland between 8am and 6pm daily for a period of 13 days between 6^{th} to 19^{th} of October 2019 using surveyCTO mobile data collection kit. Research assistants were required to make transect walks/rides across the villages interviewing (upon being granted consent) heads or spouses of every 74^{th} household in order to maintain fidelity to probability sampling rules.

3.3.4. Secondary data

Time and financial resource constraints did not permit access to all primary data ever needed in the study, therefore primary data was equally complimented with secondary data which were obtained from governments' records, reports, and other studies conducted within Sio-siteko or elsewhere but with application relevant for the wetland. Such data and information have been duly referenced and acknowledged whenever applied throughout this report.

3.4. Data Analysis

3.4.1. Analysis of market price data for baseline economic values of provisioning services

Economic valuation of market price methods entails assessment of both financial and economic analyses for each of the provisioning ecosystem services. Data for provisioning ecosystem services was obtained through household survey and complimented with key informant interviews, focus group discussions, and other objectively available data such as fisheries data.
The general methods/ formulas for conducting financial analysis and economic analysis are presented in table 5 below.

Table 5: Parameters for calculating financial and economic values

Economic indicator	Expression
Gross value (Financial)	Units harvested, produced, sold, or used * price per unit, based on local prices
Gross value (economic)	Units harvested, produced, sold, or used * price per unit, based on shadow prices
Net financial value	Gross financial value – input costs, based on local prices
Net economic value	Gross economic value – (economic inputs)- (labour, based on rural wage rates recommended by governments)
Costs	fixed costs (FC) + variable costs (VC)
Gross cash income	Units sold * price per unit.
Net cash income	Gross cash income – cost of inputs.
Subsistence consumption value	Gross value - gross cash income or units used at home * price per unit.
Gross /net / cash returns to land	Value ÷ acres of land from which goods are harvested/ produced / sold.
Gross /net/cash returns to labour	Value ÷ no. of days required to harvest, use, produce or sell goods.

Since the wetland is a transboundary wetland between Kenya and Uganda, most of the basic data have been expressed in dollar equivalents and also standardized for universality. The currencies for the two countries were converted to their dollar (buying) equivalents using the 2018 mean exchange rates obtained from the central banks' aggregates which translated into 1 USD being equivalent to Kshs.103 and UGX 3611 for Kenya and Uganda respectively. The recommended minimum wage rates for casual labour in both Kenya and Uganda were used as the shadow labour costs. Given the high employment rates especially in rural settings in both countries, the opportunity cost for labour has not been factored in the analysis.

Table 6: Currency conversion and basic labour rates used in economic analysis

Basic data	Kenya	Uganda
Currency	Kenya Shillings (Kshs)	Uganda Shillings (UGX)
Exchange rate (local: US$)	103	3611
Shadow daily wage rate for casual labour (Imputed for Uganda)	350	6500
Dollar values of daily wage rates	3.40	1.80
Estimated hourly wage rates in dollars	0.63	0.33

The prices and durability of capital and variable inputs were determined through household surveys, key informant interviews and focus group discussions. Annual costs of capital assets were determined either through the local market rental or lease rates, or through simply dividing the total costs of the asset by the number of estimated asset's functional life. The various indicators and measures of financial and economic values at both aggregate and marginal values, and their explanations are given in table 5

In general, financial analysis equation for analysis of financial value is given by the below expression

$$Gross\ financial\ value\ =\ Quantity\ harvested\ *\ market\ price\ (per\ quantity) \quad (2)$$

$$Net\ financial\ value\ =\ (Quantity *\ market\ price) - (Costs)\ +\ subsidies - Taxes \quad (3)$$

Whereas for the equation for economic value

$$Gross\ economic\ value =\ Quantity\ harvested\ * \\ market\ price\ or\ shadow\ price\ (per\ quantity) \quad (4)$$

$$Net\ economic\ value =\ (Quantity\ \ * Market\ price\ or\ shadow\ price) \\ -\ Costs\ (Excluding\ taxes\ and\ subsidies) \quad (5)$$

Given the peasantry nature of the wetland ecosystem, taxes were minimal and considered negligible and sometimes totally non-existent for some ecosystem services. While there was a fertilizer subsidy in Kenya, household surveys showed that rarely did farmers use fertilizers in the wetland especially on the Kenyan side; hence the economic pricing reverted to financial pricing in most of the cases. Labour was to a large degree family provided and so the minimum recommended labour for rural areas by the governments of Kenya and Uganda were applied for the net economic valuation.

For capture fisheries financial and economic analysis was calculated by subtracting the costs of fishing from the total revenue of fishermen as shown in the following equations

$$Value\ to\ fisher\ =\ Fishing\ Revenue_{\$} - Fishing\ Costs_{\$} \quad (6)$$

This could be further broken down by fishing type. Revenue is the quantity of fish harvested times the market value of those fish (P)

$$Value\ to\ fisher_{(\$)} = (\sum E_{i(hrs)} * CPUE_{i\left(\frac{kg}{hr}\right)} * P_{i\left(\frac{\$}{kg}\right)}) - \sum C_{i(\$)} \quad (7)$$

Where $E_{i(hrs)}$ refers to hours per fishing method and $CPUE_i$ is the catch per unit of effort for that method i, and $\sum C_{i(\$)}$ is the total harvest cost for the fishing method

3.4.2. Analysis of contingent data for baseline economic values of biodiversity maintenance

The first step in analysis of CVM data is the definition of the bid function to be employed, it explains the variation in WTP responses based on the change in and the characteristic of the service and socio-economic characteristics of the respondents. An indirect utility function U can be defined, that describes the maximum amount a respondent derives from his income,Y, given the prices of goods, P, and the level of provision of the service, Q. It is also assumed that the utility of the respondent will depend on other demographic and economic factors, S. Hence, the indirect utility of the respondents can be written in the general form:

$$U(Y, P, S, Q) \quad (8)$$

When answering a CVM question, respondents are assumed to be comparing their utility or well-being at the two levels of provision of the environmental service, $Q^0$and Q^1. The quantity C can be defined such as: $U(Y, P, S, Q^0) = U(Y - C, P, S, Q^1)$ where C is the household's maximum WTP to achieve the increase in biodiversity richness and abundance. From the equation, C can be defined as a function of the other parameters in the model. This function, denoted as C, is known as the bid function and can be written in a general form as:

$$C = C\ (Q^0, Q^1, Y, P, S) = WTP \quad (9)$$

According to Haneman et al. (1991), one of the main objectives of estimating WTP based on the contingent valuation survey response is to find the central value (or mean) of WTP distribution. The mean willingness to pay for the open-ended contingent valuation questions is computed by taking the average of the households' maximum willingness to pay amount.

$$Mean\ \text{WTP} = \mu = \sum \frac{Mi}{n} \quad (10)$$

Where, Mi = is the reported maximum willingness to pay amount by surveyed households and n = the sample size

The total economic value is given by multiplying the mean willingness to pay by the total number of households as shown below.

$$TEV = N * MeanWTP \quad (11)$$

Where TEV is the total economic value, N= total household population, $MeanWTP$ is the Mean willingness to per household in a years.

Responses from the follow-up question after initial single bounded dichotomous were used in the analysis to assess the willingness to pay; they were censored for zero responses and the descriptive mean value taken as the mean maximum willingness to pay in hours per month or cash per month.

To assess the effects of the socio-economic factors on the household's willingness to contribute, tobit model (censored towards zero) in stata 11 was used with the second bid (open ended maximum willingness to pay in both labour and cash forms). Several explanatory variables were tested to select the ones with better explanatory power to perform empirical analysis. As a consequence, the empirical model of the bid function is shown in the below equation.

$$MWTP = \beta 0 + \beta 1 age + \beta 2 gender + \beta 3 household + \beta 4 membership + \beta 5 sourceofincome + u_i \quad (12)$$

3.4.3. Analysis of damage cost avoided for baseline economic value for flood attenuation

Flood attenuation was assessed using damage cost avoided method and adjusted unit value transfer method based on the findings of a study conducted at the Kampala-Mukono corridor in Lwajjali, Nakiyanja and Namanve wetlands by Wasswa et al (2013). The following steps were applied in using the adjusted unit value transfer.

Step one involved converting garden flood attenuation economic value at the study site (Kampala-Mukono Corridor) into unit value i.e. obtaining the US$ per household. The second step involved adjusting the unit value of the Kampala-Mukono Corridor value to the Sio-siteko site, with the main factors considered being the year of value and difference in income. In making adjustments for the year of valuation, the values were adjusted from the year of the Kampala-Mukono Corridor study (2018) to the year 2019 of the Sio-siteko study using GDP deflators that measure the annual rate of price change in economy using equation 13

$$WTP_p = WTP_s\ (D_p\ /\ D_s) \tag{13}$$

Where:

WTP_p = willingness to pay at the Sio-siteko site

WTP_s = willingness to pay at the Kampala-Mukono Corridor

D_p = GDP deflator index for the year of the Sio-siteko assessment

D_s = GDP deflator index for the year of the Kampala Mukono-Corridor

While for making adjustment for differences in income, Brander (2013), advises the use of information on the responsiveness of willingness-to-pay (WTP) for the ecosystem service in question with respect to income. That is “income elasticity of WTP”, which is a measure of how much the WTP for an ecosystem service changes with income. Estimates of the income elasticity of WTP for different ecosystem services are available from primary valuation studies and meta-analyses that include income as an explanatory variable in estimated value functions. For example, estimates of the income elasticity of WTP for wetland ecosystem services from recent meta-analyses are in the range 0.295-1.16 (Brander, 2013). The formula for this adjustment is shown in equation 14.

$$WTP_p = WTP_s(\frac{Y_p}{Y_s})^E \tag{14}$$

Where:

$WTP_p =$ willingness to pay at the policy site (Sio-siteko)

WTP_s = willingness to pay at the study site (Kampala-Mukono Corridor)

Y_p = income per capita at the policy site (Sio-siteko)

Y_s= income per capita at the study site (Kampala-Mukono Corridor)

E = income elasticity of willingness to pay (taken as

The third step involved analysis of the annual number of households in Sio-siteko whose farms are affected by floods, and the final step involved multiplication of the unit value by the change units in Sio-siteko to estimate the aggregate change in the value of the damage cost avoided given that the areas that are receiving annual floods are bare areas not covered by wetland plants.

3.4.4. Analysis of replacement cost for baseline economic value of water purification and ground water recharge

While valuation of water purification as an ecosystem service entails assessment of a number of parameters such as nutrients, turbidity, among others, in this study, data available which was obtained from wetland monograph (see annex 11) could only permit valuation of turbidity. The results should therefore be considered to be conservative estimation of the role the wetland plays in water purification. Cost of artificial products (Aluminium Sulphate) was used as the replacement cost for the role of the wetland. The application of Aluminium Sulphate has been considered in this study at the point of use level i.e. at household level. Using Aluminium Sulphate entails constituting a solution (7 grams in 8 litres of water) which is applied at a ratio of 1 part of Aluminium Sulphate solution for every 100 parts of the water to be coagulated (Imagine Care, 2020). It follows therefore that the annual amount of Aluminium Sulphate that could be applied at the point of use (households) can be established through these equations.

$$Annual\ domestic\ water = Average\ daily\ water\ *\ Total\ population\ * 365 \quad (15)$$

The Aluminium sulphate dosage is given by Thammavongsa (2004) formula

$$Dosage\ Alum\ (mg/l)\ =\ 0.0635\ * NTU\ +\ 9.7776 \qquad (16)$$

The total dosage of Aluminium sulphate required for the population given the annual wetland surface water resource usage is given by

$$Total\ dosage\ =\ dosage\ (mg/l)\ *\ total\ volume\ of\ water\ drawn \qquad (17)$$

The average price of Aluminium sulphate was USD 17.48 for 500 grams packet (Imagine Care, 2020). Therefore the annual amount of Aluminium Sulphate was given by the formula,

$$Cost\ of\ Alum\ =\ \frac{Total\ dosage * 17.48}{500} \tag{18}$$

For the groundwater recharge, data analysis was based on replacement of cost for sinking boreholes and shallow wells in the surrounding wetland area with cost of sinking shallow wells and boreholes in areas far off from the wetland but within the aquifer belt. The economic value was therefore the difference in the aggregate total cost of all the shallows wells and boreholes in the wetland's area of influence and the corresponding number of boreholes and shallow wells in non-wetland areas. Typically, the cost of sinking a borehole is comprised of

$$Total\ cost\ =\ drilling\ cost\ +\ submersible\ pumps\ and\ electrical\ systems\ +\ professional\ fees \tag{19}$$

3.4.5. Cost benefit analysis for the wetland management options

3.4.5.1. Introduction

After obtaining the baseline values of the wetland ecosystem services, the next step is to determine what will happen to those values over time, under alternative management scenarios. It involves demonstrating the economic issues and trade-offs involved in wetland management by assessing the economic impacts of different wetland management scenarios, and attempting to find the optimal broad management scenario from an economic perspective. The underlying economic causes of the present degraded state of the wetland are explored and some conditions that would be necessary to maximize their future value are identified. Cost Benefit Analysis is the approach that has been deployed in this study to help in determining those values.

Cost Benefit Analysis is a systematic process for identifying, valuing and comparing costs and benefits of a project, plan, or policy implementation among others. The primary objective of CBA is to determine whether the benefits of a project or a management plan outweigh its costs and by how much relative to other alternatives. The purpose of this is to: (1) determine whether the proposed project is a sound decision or investment; and or (2) compare alternative project options, and make a decision on the preferred option. The key features of a CBA are: All related costs (losses) and benefits (gains) of a project are considered, including potential impacts on human lives and the environment; Costs and benefits are assessed from a whole-of-society perspective, rather than from one particular individual or interest group (that is, a public and not a private perspective is taken); Costs and benefits are expressed as far as possible in monetary terms as the basis for comparison; and Costs and benefits that are realized in different time periods in the future are aggregated to a single time dimension (discounting). The main performance indicators for the cost–benefit analysis are: the net present value, the internal rate of return, the benefit-cost ratio, and the payback period (Musaoglu et al, 2014). The net present value and benefit-cost approaches are the performance indicators of choice in this study.

The net benefits (NB) of a management action are simply the difference between management benefits and management costs (NB= benefits- costs). The difference between present value benefits and present value costs is referred to as the net present value (NPV):

$$NPV = PVB - PVC \text{, and} \quad (20)$$

$$PVB = \sum_{t=0}^{n-1} \frac{B_t}{(1+r)^t} \quad \text{While } PVC = \sum_{t=0}^{n-1} \frac{C_t}{(1+r)^t} \quad (21)$$

Hence

$$\text{NPV} = \sum_{t=0}^{n-1} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n-1} \frac{C_t}{(1+r)^t} \quad (22)$$

Net present value can be estimated in a number of ways: (1) based on a simple projection of present net benefits; (2) Based on a stream of present net benefits in which future values are altered from the current values along the lines of feasible or expected growth or declines in value; (3) Using dynamic ecological economic models to predict the change in the resource base and hence the change in the benefit streams yielded by different resources. This takes ecological linkages between different resources into account (Turpie et al., 1999).

Benefit-Cost Ratio (BCR) is the ratio of management benefits versus management costs. It is calculated as the present value of benefits of a management option divided by the present value of costs of the management option (Shively & Galopin, 2013).

$$BCR = \frac{\sum_{t=0}^{n-1} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n-1} \frac{C_t}{(1+r)^t}} \quad (23)$$

Three possible management scenarios were identified through stakeholder consultations and they included, status quo persisting as one possible management strategy, the second one is the wetland management plan strategy, which represent a concerted effort towards wetland conservation and wise use, and the third one is agricultural intensification strategy which is concerned with commercial aquaculture and rice farming on the Kenya and Ugandan side respectively.

The maintenance of status quo option involves taking no major actions either to conserve the wetland or to develop and alter its land use and hydrology significantly. It represents a situation where existing local utilisation of wetland resources continues to rise in line with population growth and demand for the various ecosystem services, and the current wetland degradation rate continues into the foreseeable future. Other factors that will affect the use of the wetland's resources include; literacy levels, rate of unemployment, poverty trends/wealth growth.

The wise use and conservation option entails implementation of the currently proposed management plan which entails conservation and wise use of the wetland resources. It entails establishing measures to conserve the Sio-Siteko wetland to utilize it sustainably. It would involve some level of restriction on wetland resource utilisation activities, in particular, those that are already unsustainable and those likely to become unsustainable. Sustainable consumptive and non-consumptive resource utilisation activities would be advanced. It would also entail efforts to engage adjacent communities much more in wetlands management, and to set in place a range of rural development activities aimed at strengthening local livelihoods and to decrease local reliance on wetlands products.

The agricultural intensification option would entail rice farming on the Ugandan side and fish farming on the Kenyan side. This is because rice farming is currently picking up on the Ugandan side of the wetland, while the fisheries department in Kenya is keen on promoting aquaculture in Busia County and there exist a pilot programme going on in Bukani area. Under this option, farmers already engaging in some form of farming will shift to fish farming in Kenya and Rice farming in Uganda.

There are various parameters that influence use and rate of use of the wetland resources, and in this study we make assumptions on the general trends on the rates of change of the parameters or future preferences of various ecosystem services and hence their future values for humanity or for the wellbeing of the ecological integrity of the wetland ecosystem. The Sio-siteko wetland is composed of a mosaic of six landscape forms which include; trees, shrubs, grassland, cropland, built up areas, and water as shown in table 7.

Table 7: Baseline land cover and size of the Sio-siteko wetland

Land Cover	Coverage	Area in acres
Trees	11.1%	1,644
Shrubs	1.1%	165
Grassland	4.2%	623
Farmland (aquaculture, bricks making space, crop farming)	80.9%	11,994
Built up	1.2%	178
Water	1.5%	222

Source: NBI (2019)

Similarly, figure 2 shows the Sio-siteko wetland land cover characteristics.

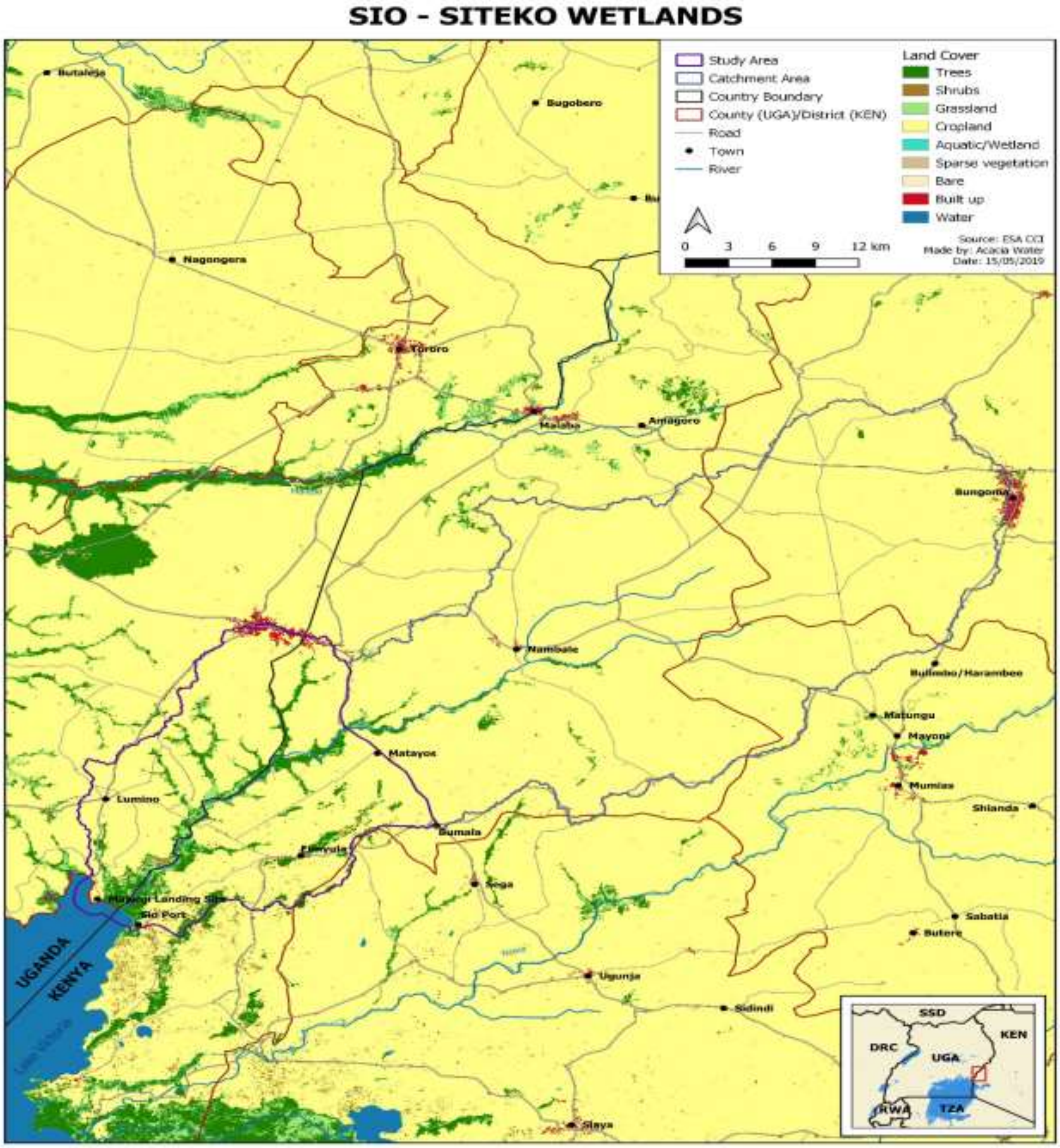

Figure 2: Land Cover Map of Sio Siteko Wetland (Source: NBI, 2020)

The analysis of Cost Benefit Analysis of the various ecosystem services under the different management options is premised on a number of parameters and assumptions. Table 8 shows the general parameters considered. However, some ecosystem services have case specific drivers, i.e. demand rates, supply rate, and regeneration potential. Overall, cost and benefit analysis is conducted under Net Present Value approach and Benefit Cost Ratio analysis approaches.

Table 8: Parameters used for projection of future economic and net present values of the ecosystem services

Parameter considered	Description and or value assumed/considered
Baseline economic value	Baseline economic value (2019 calculations) serves as the reference year upon which changes in the ecosystem services values are premised.
Flow / Demand	Flow or demand is the amount/level of ecosystem services that will be demanded or drawn annually by the local population as driven by the drivers of demand or change such as population growth among others
Carrying capacity/ regeneration potential	These are the levels or amount of ecosystem services produced that can be sustainably harvested or tapped without compromising the ability of the wetland to continue generating these ecosystem services on annual basis based on spatial areas and regeneration rate of the ecosystem service
Degradation /depletion / depreciation	These are the levels or amount of a particular ecosystem service that are extracted or demanded over and above those that can be sustainably harvested from the wetland
Discount rate	Taken as 10% being the average economic opportunity cost of capital for Kenya and Uganda
Time horizon	Period which the benefits and costs of ecosystem services are assessed. Taken as 25 years which is considered sufficient enough to visibly see the impacts of each option on the wetland ecosystem.

To estimate the future (up to 25 years' time horizon) gross values for the various ecosystem services in each of the three potential management options was used, and a number of mathematical expressions and formulae were adopted and they are described in the next subsequent paragraphs.

The general formula for determining the annual economic values of the ecosystem services is given by the diminishing balance method to predict how the future of aquaculture, brick making, and crop farming will evolve amid competing land use practices. The general equation for the diminishing balance method is,

$$R_t = Ar(1-r)^{t-1} \qquad (24)$$

Where: A= Original Area of land available, R= Reclaimable area i.e. total reclamation during the time horizon under consideration, r = Rate of reclamation in decimal term, t= period under study. It is held that both brick making and aquaculture will be expanding at a faster rate than crop farming, hence land available for crop farming will be increasing at a decreasing rate till full reclamation occurs.

In addition, for the non-carrier but extractive resources such as firewood, domestic water supply, indigenous cattle, herbal medicine, grass harvesting, and sand harvesting, the differencing equation (25) was applied given the rate of demand being postulated to be contingent to population growth and in some cases other demands, e.g. housing need. It is also important to note that firewood, domestic water supply demand, and indigenous cattle population may change overtime to declining rates given the prospects of more desirable and convenient alternatives as purchasing power may dictate. However, data on exactly how these could change in terms of onset and rates was limiting hence this curvilinear approach was not utilized, readers are therefore advised to beware that demand for firewood, direct drawing of water from the wetland, and indigenous cattle may be on the decline into the future. Equation 25 shows the general expression for this group of ecosystem services.

$$D_t = P_o * e^{rt} \qquad (25)$$

Where, D_t = Demand for firewood/water/herbal medicine etc in *t* years,

$P_o = Household\ population\ at\ the\ base\ year,$ *e = is the Euler number (2.71828), r= % domestic water (for example) demand growth rate, t = is period in years they in question.*

While all these services were estimated at both demand level, their sustainable levels of provision were also estimated. For instances, estimation of livestock grazing needed the following further expressions to ensure that only grazing within the carrying capacity of the wetland was considered benefit, and grazing over and above this was considered as degradation/ depletion and in deed cost.

$$Carrying\ capacity = \frac{Forage\ supply}{Forage\ demand} \geq 1 \tag{26}$$

Forage in the wetland for a year is given by the following equation

$$Forage\ supply\ =\ forage\ production\ x\ area \tag{27}$$

Forage demanded for the baseline is given by the following equation

$$Forage\ demanded\ =\ 2\%\ x\ bodyweight\ x\ grazing\ days \tag{28}$$

Therefore total forage demanded (used) given by,

$$Total\ forage\ demanded\ =\ annual\ forage\ used/cow\ *\ cattle\ population \tag{29}$$

For the capture fisheries, given that the data collected in this survey was cross sectional, it was difficult to predict how the future use of the wetland's fisheries will behave in the next 25 years. To go about this, a surplus production model in which time series or reasonable panel data on useful parameters from the Lake Victoria fisheries was an option to be used as value transfer and the requisite data for such an analysis included; projected annual number of fishers, projected annual sustainable harvests, projected dollar values of fish per ton, projected effort, projected annual actual harvest, and projected annual value of fish per unit ton of fish. Alternatively, the Crul (1992) equation for fisheries productivity in the tropical areas floodplains and swamps was also an option, and in deed it was the one applied in the analysis. The equation is given as;

$$catch\ (t\ yr^{-1}) = 8.78\ flood\ area^{0.90}\ \ (r = 0.93) \tag{30}$$

Under the agricultural intensification scenario, aquaculture and rice farming in Kenya and Uganda respectively will be main programmes. It is hypothesized that intensification will take a five year programme for the full conversion of the wetland into aquaculture and rice fields in which the current farmers in the wetland will be enrolled into the programme in year one of the project and the remaining parcel of the wetland will be fully reclaimed proportionately for the next five years. The mathematical expressions applied to aquaculture and farming will still apply for this programme. Perhaps a new mathematical expression to be introduced should relate to the expected generation of greenhouse gas associated with flooding agriculture, and this will be an externality of rice intensification in the wetland. If we assume that under this Sio-siteko agricultural intensification management programme, there will be continuously flooded paddy rice farming, then equation 1 (one) under the revised Intergovernmental Panel on Climate Change (IPCC) guidelines of 1997, would apply as shown in equation 31 below

$$F_c = EF * A * 10^{-12} \qquad (31)$$

Where: F_c= estimated annual emission of methane from a particular rice water regime and for a given organic amendment, in Tg per year; EF = methane emission factor integrated over integrated cropping season, in g/m^2; A = annual harvested area cultivated under conditions defined above. It is given by the cultivated area times the number of cropping seasons per year, i.e., in m^2/yr.

The IPCC guidelines recommended arithmetic mean of methane emission factor of $20g/m^2$ for continuously flooded paddy rice has been used in this study to estimate the amount of methane gas that would be emitted under the agricultural intensification programme.

Chapter 4. The Ecosystem Services-Economic Linkages and the Beneficiaries

Ecosystem services are defined as ‘‘the benefits human populations derive, directly or indirectly, from ecosystem functions’’ (Costanza et al., 1997), and according to the Millennium Ecosystem Assessment (2005) study report, wetland ecosystem services can be classified into four major categories namely provisioning services, regulating services, cultural services, and supporting services.

4.1. Provisioning services

Provisioning services are products obtained from ecosystems such as fresh water, food, natural medicines and pharmaceuticals (Russi et al, 2013). A number of provisioning ecosystem services provided by the Sio-siteko wetland were appraised through literature review and stakeholder consultations during scoping exercise. They included; water supply, herbal medicine, traditional salt making, game meat, crop farming, capture fisheries and aquaculture, mat making using papyrus, pasture for livestock, grass harvesting among others. In addition, there are a number of abiotic provisioning services whose utilization remains contentious; they include brick making, sand harvesting, and pottery.

Water Supply

As a provisioning ecosystem services, the aspects of water that meets this criterion include the utilization of water for domestic use such as drinking, cooking and washing; irrigation; livestock; and industrial use. People are able to access clean water for drinking for both themselves and their animals in addition to other household uses. The principal supply of renewable fresh water for human consumption primarily comes from inland wetlands like swamps. Sio-Siteko wetland stores and purifies the water which flows into Lake Victoria. It plays a major role in detoxifying and treating a wide range of waste products including nutrients.

Figure 3: Community members accessing water from the wetland

Water from the wetland is used for drinking by both the people and animals. This water is also used by members of the community to irrigate their crops, a factor that has enabled crops like sugarcane, arrowroots and maize to thrive well in the area.

Water from the wetland support human and animal life system and its sustainability is threatened mostly by pollution from both industrial and domestic factors. Water has been used to dilute and wash away pollutants throughout human history. The degradation of this vital resource can be measured as the loss of natural systems, their component species and the amenities which they provide (Mitsch et al, 2015). These pollutants come as a result of the agricultural activities taking place around the wetland, which emanate from the fertilizers used during these activities.

Livestock fodder

One of the major ecosystem services that were identified by the local community is fodder. Wetlands are sources of fodder for livestock; they present valuable areas for the production of fodder. The grasses and supply of running water are very beneficial to livestock farming. This has enabled people to feed their livestock thus saving them from hunger.

Figure 4: Livestock grazing in Sio-Siteko wetland

Over exploitation of wetland vegetation is a threat to the sustainability of this resource as it will render the vegetation depleted with time. Poverty and lack of alternative livelihoods also contribute to the over reliance of this resource in feeding livestock which can also lead to it's over exploitation. Climate change especially adverse conditions like drought and floods also threaten the availability and access to wetland vegetation (Mitsch et al, 2015). Dry seasons mean heavy reliance on wetland vegetation for fodder for livestock and floods mean poor accessibility of livestock to the wetland areas especially in flood prone communities.

Crop farming

The use of wetlands for agricultural purposes has been known for decades. This is because of their fertile soil which comes as a result of the regular sediment deposition when flood events take place. They support plants which are adapted to the wet conditions. The Sio-Siteko wetland community identified the resource as a key area that contributes to crop farming. The key crops grown include arrow roots, rice, chewing cane, potatoes, maize, cabbages, tomatoes, kales, millet among others. Much of the wetland has already been reclaimed (over 80%) for purposes of crop farming.

Figure 5: Rice farm in Madira A in Ugandan side of the wetland

Increased rural income from agricultural activities has enabled these people to improve their diets. Crop farming has also enabled households to have the opportunity of producing, purchasing and consuming better and even affordable food (Houdet et al., 2015). A lot of people now have access to food; this has greatly brought about poverty alleviations. The water from the wetlands is also important in irrigation of farms and this helps in improving farm yield for farmers.

The wetland is particularly farmers' favourite during dry season because of the near constant water supply for irrigated farming which normally boost their household earnings. There are increased incidences of encroachment into the wetlands during dry season because it is believed that the wetlands are more productive than the terrestrial land and so all farmers scramble for the most productive options. This leads to the destruction of the wetlands and impairs its integrity so much so that it reduces its capacity to function well in provision of these services.

It is however, not a bed of roses for the farmers though; in most of the cases there occur conflicts with livestock grazers since cattle destroy crops. Wildlife conflict is also experienced especially during dry periods from major crops destroying animals such as monkeys and baboons, Hippos, and bovidaes. Extreme weather events like floods and climate change also greatly impact the exploitation of this service to the communities which live in proximity to the wetland ecosystem. Over the years, wetlands continue to be drained and destroyed for purposes of agriculture without putting into considering the consequences of this act. People are not aware that this greatly reduces the services that are provided by these wetlands. Land use changes continue to be a serious driver to changes in the provision of ecosystem services like crop farming. Crops and grazing areas have widely been affected by this throughout history. They face increased risk due to intensified land use. Population increase is also a major threat to this, considering the fact that the more population increases the greater the pressure of reclaiming the remaining natural areas of agricultural activities.

Capture fisheries & Aquaculture

Wetlands harbour a wide diversity of fish communities. The survival of these species in wetlands depends on the changing biotic factors, especially the level and temperature of water as well as biotic factors like food availability which are available in the wetlands. Fluctuations of water level have a number of significant functions which results to nutrient input and the abundance of fish. The stocks of wetland fish can well be sustained as long as the flood regime pristine if retained as the disturbance of this flooding pattern greatly interferes with the nutrient flow and fish breeding.

Fisheries and aquaculture have improved the health and nutrition of the rural communities. They have greatly reduced the levels of hunger and poverty in these communities by increasing incomes and in turn improving their livelihoods.

During scoping, the local community reported reliance on the wetland for fish supply, both for domestic nutrition and for sale. They pointed out that fishing is mostly carried out during the rainy season between the months of April and July, and between the months of October to December.

Figure 6: Artisanal fisherman in Sio-Siteko making fish traps for harvesting of fish

Capture fisheries in wetland areas typically face a number of threats such as overfishing. This is an act that adversely affects the benefits which accrue from most wetlands. Pollution has also been a main threat facing fisheries and aquaculture considering it affects the lives of fish. This is brought about by processes like eutrophication that leads to the overgrowth of plants and algae which reduces the concentration of dissolved oxygen in water that as a result kills fish and brings about loss of biodiversity.

Figure 7: Aquaculture farm at Nangwe-Uganda in the wetland

Necessary measures which can be taken to promote sustainability include reduction in the fishing capacity of every individual; establishment of appropriate regulatory systems that reduces detrimental effects of aquaculture in a wetland. Strict regulations on the fisheries paying keen attention on fishing quotas; education and capacity building on alternative livelihoods innovation can also greatly reduce the pressure accorded to the fishery resources of wetlands.

Brick making

Brick making is one of the activities taking place in Sio-Siteko wetland and the surrounding farm lands. Households that make bricks are in some cases organised to associations or just working individually. The soil in the wetland provides good composition for good bricks. The making of lucrative bricks requires the clearing of vegetation and digging up soil and this distorts the ecosystem.

Figure 8: Brick making in Marachi D in Sio-Siteko wetland

Brick making destroys the ecosystem through soil extraction which affects nutrient composition and vegetation in the wetlands. The resource however helps in building and construction industry and it employs a good number of people such as brick masons. In the event of a rise in construction activities, the intensity of brick molding increases and this further impacts the ecosystem. Population pressure and poverty have also led people to engage in this activity within wetland ecosystems. The constant clearing and digging up of wetlands also destroy animals' habitats and tampers with the integrity of the wetland ecosystem. Waterborne diseases are also a threat as the resulting open peats from the brick making process provide suitable breeding grounds for insects like mosquitoes.

To promote sustainability, there should be measures put in place to promote the development of green brick making. A process and product that does not require destroying the wetlands to acquire the needed construction resource should be adopted in the building and construction industry. There should also be provisions against the harvesting of brick from wetland ecosystems as this is a highly destructive activity to the wetland. In addition to these, there needs to be the facilitation of alternative livelihoods which will diffuse the brick making market by ensuring that less people are pushed towards engaging in the practice.

Sand harvesting

Sand harvesting is one of the economic activities that some of the households living around the wetland of Sio-Siteko engage in. Sand harvesting is the extraction of sand from the ecosystem. There are different ways in which sand harvesting is done; in-stream harvesting involves the extraction of coarse sand suitable for concrete slabs whilst flood plain harvesting involves the extraction of fine sand suitable for brick laying and plastering. Sand mining employs people in the building and construction industry, making it an important source of livelihood. Sand is important in building purposes; it is therefore a construction material to the local people. They also earn income through selling of the sand, enabling them to secure livelihoods. In addition, sand can also be used to purify the water for domestic and industrial uses.

Figure 9: Sand harvesting in Sio-Siteko wetland

However, excessive sand harvesting can alter the river bed, force the river to change course, erode banks and lead to flooding. It also destroys the habitat of aquatic animals and micro-organisms besides affecting groundwater recharge (Pitchaiah, 2017). So, even though sand harvesting is one of the major economic benefits that the local population derives from the wetland, it is also one of the wetland utilization strategies that are hardly sustainable since the rate of harvesting rarely corresponds to the rate of sand deposition. In deed in some parts of Kenya, the practice has been banned; an example is the Saiwa swamp because of the massive destruction to the habitat of the Sitatunga Antelope (Houdet et al., 2015).

Wood-based energy & timber (Firewood & Charcoal; Timber & Pole Wood)

Sio-Siteko transboundary wetland occurs in the rural areas of both Kenya and Uganda. In these parts of the country, the main source of energy is biomass which can be extracted from the wetland vegetation (Houdet et al., 2015). Wetlands plants like papyrus reeds and Ambatch trees are usually harvested for the production of wood fuel for cooking and lighting. Trees cut down from the wetlands are also used for making timber and poles for building and construction.

People need energy for their survival; they use it for food preparation and preservation, for lighting, purification of water through boiling and a myriad of other domestic and commercial services. These products also have an economic value as there are people who extract and sell the products for profit which they use to support their livelihoods.

Figure 10: Fuelwood harvested from the wetland

The sustainability of these wetlands goods and services is however threatened by the over reliance of people on biomass for energy production and the inadequate access of the alternative options, which consequently results into the over dependence on the wetland vegetation leading to over exploitation of the resource.

Non timber wetland products

There are also a number of non-timber products in Sio-Siteko wetland. These include wild fruits which are used as food for nourishment; and herbal medicine from different plant materials which are used traditionally in the treatment of diseases or boosting the immune system and other nutritional health benefits. Grass is also used as fodder, thatching, and making of brooms.

Figure 11: Grass for thatching

There are also papyrus plants which are used for making crafts, furniture and energy production;

Figure 12: Papyrus for making mats

4.3. Regulating Services

Regulating services are those functions that relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through biogeochemical cycles and other biosphere processes (Vo et al., 2012), examples include water regulation, erosion regulation, water purification, waste regulation, climate regulation and natural hazard regulation (e.g. droughts, floods, storms) among others.

Water Regulation

Water regulation services in Sio-siteko wetland include*;* water storage and recharge, flood attenuation, water purification. Wetlands store large amounts of water during floods. This is because they modify stream flows by decreasing the peak discharge which is the volume of water within a given time and increasing the concentration time (time between flood event and the release of water into streams). The wetland recharges ground water by allowing it to soak into the ground; this plays a significant role in water supply to thousand or millions of people who are dependent on it. Another natural function of wetlands particularly wetland vegetation is the uptake and storage of nutrients which are found in water and the surrounding soil. Examples of these plants in Sio- Siteko wetland include; Typha, papyrus and phragmites (reeds) (Houdet et al., 2015). The uptake of these nutrients takes place in the stems, leaves and roots of the plants. This ability of wetlands to cycle both nutrients and sediments balances aquatic ecosystems. There is access to clean water for drinking for both human beings and their animals in addition to irrigation. This water is also used for brick making, fishing activities and also transportation, all which enable the local community to earn a living. People are also protected from the adverse impacts of floods.

Breeding, Nursery, Spawning grounds & refugia for wetland animals and plants

Nearly all water birds of the world utilize wetlands for breeding and feeding grounds. The migratory water birds usually use these wetlands in their range which many at times is literally from pole to pole. The Sio-Siteko wetland is a very important habitat for both fauna and flora having 29 fish, 8 reptiles, several invertebrates and 206 plants. In addition to this, the wetland also has more than 300 bird species including the blue swallow which usually migrates all the way from South Africa every year for breeding purposes due to the conducive environment of the Sio-Siteko wetland. The present bird species also include the near threatened papyrus Gonolek and the Pallid Harrier. The mammals found in the wetland include the Otter, water mongoose, Hippopotamus, Vervet monkey, Waterbuck, and Sitatunga. In deed the wetland is one of the four most important fish breeding sites in Uganda, and especially for the Nile Tilapia. An ecosystem that supports biodiversity is very important to humanity. The provision of breeding places and habitats ensures the safety of plants and animals as it increases their numbers. This in the long run positively contributes to the economic, social and even cultural aspects of people.

4.4. Cultural Services

Cultural services are defined as those non-material benefits that people gain from ecosystems, through spiritual enrichment, cognitive development, recreation or aesthetic experiences (MEA, 2005). Wetlands are associated with long term cultural practices taking place around them. Human beings have been able to preserve their cultures through these services. In Sio-Siteko wetland, the main cultural services include; recreation and experiential services, research and education, and shrines for worshipping and cleansing (NBI, 2020).

Sio-siteko wetland has over time been used for recreational purposes. It has sites that have been visited by tourists from all over the world to view the rich flora and fauna species found in the wetland as well as other activities which take place within the wetland (Businge, 2012). The activities include; bird watching, photography, hiking and fishing. The Sangalo beach is one good example of a recreational area at Sio-Siteko.

Researchers have also been able to acquire a lot of information from this wetland. Students have been able to acquire both formal and informal education and training from the same place.

Chapter 5: Results and Discussion

5.1. Baseline Economic Values of the Ecosystem Services

5.1.1. Capture Fisheries

The riverine fish species commonly fished at the wetland include; Mud fish, *Eningu, Esire, Obuyako, Duri, Obudokori, Efulu, Obuduba, Vidonge*, others fish species caught included *Imonye, Ekhanga, and Masurubana*as as they are commonly referred to in the local dialect.

During the survey, 27% of the households reported to harvest fish from the wetland. The most harvested fish is the Synodontis (locally known as Vidonge) with 28% of the fishermen reported to be actively involved in harvesting it. According to the Ugandan fisheries officials, the Synodontis is on high demand by Nile perch fishermen as baits and over 60,000 synodontis fish are caught per week for this goal. A mature synodontis species weighs between 300-400grams. If we assume that these weekly harvest are achieved throughout the year, then the potential mature fish harvests for the year is 1248 tonnes of mature synodontis annually (Key Informant).

Fish catches from the wetland are never handled by the beach management units; hence the measurements of weights are judgements by the fishermen and remain rough estimates. There were significant variations between reported weights during the cross-sectional survey of households and the estimates given by the fisheries officials on the biomass (weight) of harvested synodontis fish species. The estimates by the fisheries officials were deemed to be more realistic hence were used to correct the total harvest for the other fish species reported during the household survey. Annual harvests for all the combined fish species harvested was estimated to be around 3600 tonnes, and from the focus group discussions, the average landing price of fish was USD 1.94 per kilogramme (FGD, 2019), the total gross value of capture fisheries in the wetland is USD 6,984,000. Table 9 shows the kinds of commonly harvested fish species.

Table 9: Major fish species harvested from the Sio-siteko wetland

Fish type	Percent of fishers	Total fishermen	Total fish harvests (tons)	Gross value (USD)
Synodontis *(Vidonge,Okoko)*	28%	2413	1248.0	2421120
Obuyoko	19%	1619	639.1	1239854
Smooth head Catfish *(Eduri)*	12%	1009	398.3	772702
Obuduba	8%	672	265.3	514682
Catfish *(Esire)*	8%	672	265.3	514682
Lung fish *(Imonye)*	8%	672	265.3	514682
Tilapia *(Ingeke)*	7%	581	229.4	445036
Haplochromines (Efulu)	5%	428	169.0	327860
Labeo victorianus (Eningu)	4%	305	120.4	233576
Total	**100**	**8554**	**3600**	**6,984,000**

Source: Household survey, 2019

The harvest costs related to fishing included lines, hooks, nets, baskets, and boats (though negligible), and man hours spent on fishing. It costs a household an average of 31.29 dollars per year for the fishing gears hence the total costs of fishing in terms of gears in the wetland was USD 267,654.66, while the average annual man hours spent on fishing by a household was 500hours. If we monetise fishing effort using the mean recommended hourly (USD 0.48) wage rates for casual work, then the total value of fishing effort in the wetland is USD 2,052,960. Table 10 shows the computed financial and economic values of fisheries resources.

Table 10: Financial and economic value of fish harvested from Sio-Siteko wetland

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	6,984,000	6,984,000
Net value	6,716,345	4,663,385
Marginal values		
Gross values/ household/ year	816	
Gross values/ *acre/year	31,404	

- This is taken from the size of area occupied by water channels in the wetland as shown in the Sio siteko wetland monograph ,which was 1.5% of the wetland area (14,826 acres)

Fishing within the wetland is largely artisanal, however, at the delta there are commercial harvesting of small fish species largely as baits for Nile perch fishermen. The wetland is dominated by riverine fish species and those that typically breed at the wetlands such as Tilapia..

There are discussions on declaring the flood plain of the wetland to be a protected area for fisheries breeding, this is because the Sio-siteko wetland is considered as one of the four most important fish breeding grounds (in Uganda) especially for the Tilapia fish species which is the second most important income earner for the fisheries species in the Lake Victoria region. The main activities that are likely to interfere with breeding and breeding sites for fish include: fishing, sand harvesting, reclamation of the wetland, and pollution of the wetland. This therefore means that fish harvesting in the sub locations of Busijo, Bujwanga, Sigalame, Agenga, Majanji and Dadira parishes respectively can be regarded as harvesting of fingerlings and breeding fishes and hence not a sustainable fishing, 8.4 percent of the local community who reported to engage in fishing are residents of these areas. It is highly unlikely that these fishermen would leave these areas and fish elsewhere in the wetland; however it is possible that fishermen who are not residents of these areas can go and fish there.

5.1.2. Crop Farming

A number of households living around the wetland practice farming in the wetland. During the survey, around 47% of the respondents reported to be conducting crop farming in the wetland. Among the crops grown include; maize, arrow roots, chewing canes, vegetables, rice, and beans.

The mean size of a wetland farm was 0.8 acres. The value of the crop farming was arrived through assessing average annual harvests per crop, farm gate prices of the crops per unit weight, input costs, capital costs (mainly rates of lease on land) and labour in the form of man hour requirements for every crop, as shown in tables 8 and 9

Households undertaking arrow root farming comprises 6.7% of the population, and an average arrow root farm is 0.5 acres which produces average of 3 bags of arrow roots in a year and 1 bag of arrow roots is sold at a mean price of USD 53.47.

Table 11: Financial Value of Individual Crops

Crop	Arrow roots	Maize	Beans	Chewing cane	Rice	Vegetables	Total
Number of Farmers	2137	4914	1400	1031	221	5157	14860
Average farm size in acres	0.5	1.2	0.8	0.8	0.8	0.5	-
Total Farm size	1068.5	6119.4	1120	824.8	176.8	2578.5	11888
Average quantity per farm	3	5.4	1	69	10	21	-
Farm gate Price (USD) per bag	53.47	17.5	97	4.26	38.8	8.3	-
Gross Value	**342,796.2**	**557,247.6**	**135,800**	**303,052.1**	**85,748**	**89,8865.1**	**2,323,509**
Total Input Costs	497	83296	6188	2450	6214.5	36,099	113225
Net Financial Value	**342,299.2**	**473,951.6**	**129,612**	**300,602.1**	**79,533.5**	**862,766.1**	**2,188,765**
Average Man days needed	33	78	52	52	52	33	-
Daily labour rate	2.6	2.6.	2.6	2.6	2.6	2.6	
Economic value of labour	183,354.6	996,559.2	189,280	139,391.2	29,879.2	442,470.6	1,980,935
Net economic value	**158,944.60**	**-522,607**	**-59,668**	**161,210.90**	**49,654.30**	**420,295.50**	**207,830**

5.1.3. Aquaculture

Aquaculture is practiced in both Uganda and Kenya though in small scale. There were records of aquaculture obtained from the fisheries department in Busia Uganda for the year 2018. There are approximately 186 fish farmers on the Ugandan side of the wetland who mainly kept Tilapia and Catfish with each having an average of 2 fish ponds per farmer, and each pond yields an average of 229 kg of fish. The total area under fish farming was approximately 49 acres. In Kenya, there were plans to put up an approximately 100 fish ponds of 300 m^2 each in Bukani area with future plans for expansion into all other areas. However, during the household survey, some fish farmers were encountered especially in the sub locations of Bujwanga, Buloma, sibinga, Muyafwa, and Nangoma in which main fish kept included Tilapia, and Catfish (*both Eduri* and *Esire)*. There are approximately 246 fish farmers on the Kenyan side, with an average of 2 two ponds per farmer. The average yield per pond was reported to be around 236 kg, while the cumulative pond size was estimated at 221, 400 m^2 (55 acres).

Costs included fixed and variable costs. Fixed costs were mainly the costs of fish pond construction, pond maintenance, and equipment (mainly machete, hoe, and baskets/buckets). Variable costs included; feeds, fingerlings, and labour-typically family supplied. The average cost of construction of a standard fish pond was USD 97 and its average use before abandonment was 6 years, therefore the annual cost of fishpond (capital cost) is USD 16.18, average annual maintenance of a fishpond is USD 48.54. Variable costs i.e. fingerlings at USD 97, feedstock at USD 244.66. Labour was mainly family supplied however it needed 420 man hours.

The table in annex 7 shows the parameters for computing aquaculture economic values as presented in table 12 showing the computed financial and economic values of fisheries resources

Table 12: Economic value of Aquaculture in Sio-siteko wetlands

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	402,624.00	402,624.00
Net value	351,112.32	176,929.92
Marginal values		
Gross values/ household/ year	932	
Gross values/ acre/ year	3834.5	

5.1.4. Livestock Grazing

The local community in both Ugandan and Kenyan side of the wetland practice livestock grazing in the wetland. In this study, the assessment of livestock grazing in the wetland mainly focused on cattle grazing and specifically assumed that it is the indigenous breeds (Zebu) that are grazing there, so the valuation has been premised on fodder consumption requirements for local cattle breeds. The proportion of the sampled population who reported to graze their cattle in the wetland was 57%. The average number of cattle grazed by a household was seven (7) and the reported frequency of grazing during the dry months (December to March) was six times in a week and twice a week during wet months, a period in which over forty percent (47%) of the households who typically graze in the wetland never take their cattle for grazing in the wetland. The major costs incurred by cattle keepers who graze in the wetland is veterinary medical supplies for their cattle and the average costs is USD13 per household in a year. The value of grazing was taken as the amount of grass eaten by the total cattle population that graze in the wetland and the price of hay taken as proxy indicator of price value. Generally, a zebu cow weighs between 250- 300kg (Kamuanga et al., 2001; Milogo, 2010) and such a weight would need between 5.4 – 6 kg of dry matter intake per day which is equivalent to 21 – 30 kg of fresh grass per head per day (Setianto, 2015). It is therefore assumed in this study that an average cow would consume 21 kilogrammes of fresh grass (or 5.4 kg dry matter) daily for the period they feed in the wetland, the average price of a bale of hay (15 kg and dry matter) was taken as USD 1.9, therefore using the price of hay as price of forage, an average cow would consume grass of value USD 0.35 daily. For labour we assumed that each household assigns one adult person to take care of the animals daily. Table 13 therefore presents the output of the computation of both financial and economic values of grazing in the wetland, while annex 8 shows a table of parameters used for estimating the financial and economic value of livestock grazing.

Table 13: Economic value of livestock grazing in the wetland

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	6,531,580	6,531,580
Net value	6,296,774	-399,893
Marginal values		
Gross value / household / year	361.6	361.6
Net value / household / year	348.8	-22

The figures used in the estimation of the economic values of livestock grazing as an ecosystem service is based on the household survey conducted in the month of October 2019 which showed that the total cattle population in the wetland's area of influence was 127,428. Even though a synthesis by the wetland monograph for the area showed that Busia County in Kenya has a cattle population of 71,000 while Busia district of Uganda also had a cattle population of 3800, and the project area has a population of 19,100 cattle. Other latest studies that have compiled local cattle population in both Busia district and county respectively include: Uganda Bureau of Statistics (2008) which showed that Busia district in Uganda had 26,790 cattle in 2008; Egis International (2014) which indicated that livestock population in Busia county was 171,775 in 2014; Ogutu et al, (2019) which indicated that Busia town in Kenya had a cattle population of 132,804.

5.1.5. Mat making

Mat making by the local community mainly rely on the use of papyrus and reeds obtained from the wetland. About 16 % of the households reported to use papyrus and reeds in making mats. Only 2% of the households make mats purely for domestic use, while the other 14% engage in mat making for selling. Majority of the mat makers never engage in making mats throughout the year but skip some of the months for reasons such as flooding of the wetland during rainy season, other commitments, dwindling markets, while some only make mats on order only.

The average mat an individual makes in a year is around 115 and the average price per mat is USD 0.75. Common costs incurred in mat making include strings (costs around USD 0.19 per mat) for joining the papyrus, man hours for harvesting and making a mat (average of 12 hrs inclusive of travel time, cutting time, and making time) and in some cases hired labour though this was very rare. The price of selling mats were taken as farm gates hence transport and market charges by municipal or county governments have not been included. Table 14 shows the results of analysis and synthesis of information collected using mixed approaches of household survey, focus group discussions, and key informant interviews. From the basic information obtained from the population engaging in mat making (see annex 9), the gross value (financial and economic- given that there was no compelling evidence for correction of market prices) of mat making was USD 437,288 while the net financial value was 326,508 and net economic value was in the negative of -1,078,642 after monetisation of the self-supplied labour by the mat makers, as shown in table 14

Table 14: Financial and Economic Value of Mat Making in Sio-Siteko Wetland

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	437,288	437,288
Net value	326,508	-1,078,642
Marginal values		
Net value per household per year	64.4	-212.75

5.1.6. Grass Harvesting

Around 24.6% of the households in the buffer zone reported to be grass harvesters. There are multiple uses of grass such as direct sales, thatching, broom making, and animal feeding (zero grazing).

Regarding harvesting of grass for thatching, 21.5% of the households reported that they engage in grass harvesting for thatching. The average amount of bundles used in roofing from the household survey was 118 bundles while the average duration a thatched roof lasts before renovation is 3 years. While households generally access the grass for free, the average price of a bundle of grass for sale was USD 0.93 per bundle and the average labour cost paid for thatching was USD 6.44.

Broom makers comprise 1.38% of the local community, a bundle of grass was reported to yield a total of 30 brooms, and the average annual brooms made in a year by a household was 360 brooms. The average price of a broom was USD 0.29 based on focus group discussions. A broom lasts for about six months.

Some 3.2% of the households in the local community harvest grass from the wetland for sale, a bundle of grass sell at USD 0.93 per bundle, and the average bundles sold by a household in a year were 118.

Similarly, 1.67 % of the households access grass from the wetland to feed their livestock at home (zero grazing), the average number of cattle fed by such grass was five (5) cows, with a monthly harvest of 13 bundles per cow.

The gross value of grass harvesting was also computed to obtain marginal gross values for households annually, and also the marginal values per unit measure of land, where it was assumed that only 0.25 of an acre of the grassland (155 acres) was being harnessed for grass harvesting while the rest were available for grazing.

The major costs associated with grass harvesting is mainly the self-supplied labour, and sickle or machete (average price of a machete is USD 5.8 and average lifespan was 6 years) for livestock, broom, and harvesting for sale. Another additional cost was payment for thatcher in case of thatching.

Table 15 below, shows the computed (see annex 10 for the parameters used in computation) gross financial and economic, net financial and economic, and also the marginal values of grass harvesting.

Table 15: Financial and economic value of grass harvesting in Sio-Siteko wetland

Type of Value	**Zero grazing**	**Sale**	**Broom Making**	**Thatching**	**Total**
Aggregate values for the whole wetland					
Gross value (Financial)	383,011	111,276.36	45,831.60	747,658.62	1,287,778
Gross value (economic)	383,011	111,276.36	45,831.60	747,658.62	1,287,778
Net value (Financial)	382,499	110,293	45,406	726,402	1,264,599
Net value (Economic)	337,883	97,282	38,557	639,127	1,112,849
Marginal values					
Gross value/ household/ year	725.40	109.74	104.40	109.74	146.44
Gross value/*acre/year					8308.24

5.1.7. Water Supply

Residents of the wetland area use water obtained from the wetland for either domestic use or for selling purposes. During the household survey, 83% of the households reported that they draw water from the wetland. Majority (83%) of the water users draw water for domestic use, among them, only 3% engage in selling water. The mean daily trips a household makes in drawing water from wetland is 5 trips with the average container used being 20 litre jerican. This means that the average daily household water supply from the wetland for domestic or selling is 100 litres. Around 12% of the households hire people to deliver for them water and they pay around USD 0.1 per trip for a 20 litre jerican of container. Some of the costs incurred in access to water include; assets such as carts, bicycle, and containers. The annual value of a 20 litre jerican estimated at USD 0.97 given an assumption that such a container last for 1 year and costs an average of USD 0.97, hiring transporters (some 12% of the population at an average of USD 0.1 per container) is another cost. The average man hours for a single trip of drawing water from the wetland is 0.5 hrs. Therefore the computed financial and economic values of water supply for both domestic and selling is shown in table 16

Table 16: Financial and Economic Value of Water Supply for Domestic and Selling in Sio-Siteko

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	3,374,640	3,374,640
Net value	3,333,939	-7652088
Gross subsistence value	2,349,000	2,349,000
Net subsistence consumption value	2,323,683	-7,177,464
Gross cash income	1,025,640	1,025,640
Net cash income	1,010,256	551,016
Marginal values		
Net subsistence value /household/year	89	-276
Net cash income /household/year	1241	677

5.1.8. Firewood

Various plants are used to supply timber, charcoal and firewood for both rural and even urban households. From the survey, there are no households' actively harvesting timbers or burning charcoal using plants or plant materials from the wetland. However, 20% of them reported to be accessing the wetland to obtain plant materials to use as firewood. The average annual household bundles of firewood is 35 bundles, out of this some 14 bundles are sold per household by 17% of the households who access the wetland for firewood or 4.2% of the total household population in the area. A bundle of firewood is sold at an average price of USD 1.46 for the two countries (focus group discussion, 2019). Self-supplied labour is the main cost incurred in firewood harvesting and an average of 1.5 hrs is spent by a household in gathering firewood. Other Costs related to firewood access include transport and municipal or county costs however, these have not been factored since the focus is on the farm gate prices. Table 17 shows the computed financial and economic values of water supply.

Firewood	Average annual harvest per HH	Average price / bundle	%t users	Average man hours cost per bundle (KE)	Average man hours cost per bundle (UG)	Total HH (UG)	Total HH (KE)
Subsistence	21	1.46	20	0.95	0.5	13110	18578
Selling	14	1.46	4.2	0.95	0.5		

Table 17: Financial and economic value of firewood from Sio-siteko wetland

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	221,426	221,426
Net value	221,426	43,913
Gross cash income	27,103	-
Net cash income	27,103	-
Subsistence consumption value	194,323	-
Marginal values		
Net returns to land	-	-
Net returns per household ($/Yr/HH)	34.94	6.93

5.1.9. Herbal Medicine

A total of 16% of households reported to use herbal medicine obtained from the wetland. From the sampled households, some of the ailments mentioned by respondents included; stomach aches, malaria, skin infections, teeth infections, diabetes, high blood pressure, ulcers, respiratory infections, loss of appetite, libido boosting among others. Slightly more than half (54%) of herbal medicine users are just for subsistence use, while 46% of them use herbal medicine for commercial gain. Commercial herbalists represent 7% of the population and the average number of patients treated in a year is 6 people by an herbalist. The average price charged per patient is USD 9 in Kenya and USD 5 in Uganda, therefore he average benefit accruing from herbal medicine use is USD 7. The main costs incurred mainly include travel time to see patients though in most cases it is the patients who go to the medicine men and firewood for those herbal medicines that need boiling which in most cases consume firewood valued at 0.97. Therefore the average costs in handling one patient take a mean value of USD 0.97. In terms of man hours, the average duration it takes to access and prepare an herbal remedy for sickness was eight (8) hours. The computed financial and economic value of herbal medicine in Sio-siteko is as shown in table 18

Table 18: Financial and Economic Value of Herbal Medicine in Sio-Siteko

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	326,340	326,340
Net value	281,119	205,128
Gross subsistence value	177156	152607
Net subsistence value	152607	111355
Gross cash income	149184	128511
Net cash income	128511	93773
Marginal values		
Net value per household	54	40

Herbal medicine users were asked how they perceive the level of abundance of the plant species they use and over 70% of them reported that the plants are declining in population as shown in table 19.

Table 19: Perception of herbal medicine users on herbal plants levels of abundance

Status of plants	Frequency	Percentage (%)
Abundant	11	16%
Stable	7	10%
Declining	49	70 %
Increasing	3	4 %
Total	70	**100 %**

5.1.10. Sand Harvesting

About 12.5% of the local community residing in the wetland's buffer zone engage in sand harvesting activities. Sand harvesting within the wetland typically take place on the river beds (3.7%), river banks (2.3%), and within the farms in the wetland area (6.5%). Harvesting of sand on the river banks is considered an unhealthy practice since among its consequences include: destabilizing the river bank. It also affects fish breeding sites. Overall, sand harvesting is a necessary evil since while sand is a key component of building industry and indeed one of the measures of descent living is one where people live in concrete houses of which sand is a key resource. It is therefore recommended that where possible sand harvesting should be done in some sustainable way such as at the river bed and not at the river banks.

Sand mining as an economic activity is conducted by individuals who sometimes also belong to self-help groups or associations. Sand harvesting takes place throughout the wetland area but it is more common in Funyula Sub County in the sub locations of Busijo, Bujwanga, Ageng'a and Sigalame in Kenya and in the Parishes of Majanji in Uganda. In the extraction of sand, harvests are organized into "trips" in which a "trip" is typically a 5 tonnes heap of sand normally extracted by an individual. The average "trips" by an individual in a month is usually 4. A trip of sand or 5 tonnes of sand is sold at an average price of USD 19.42. Extraction costs usually involve payment for loaders per trip (an average of USD 1.45 per loader). In some cases farm owners (within the wetland) also lease farms to sand miners at an average rate of USD 2.91 per "trip" i.e. a 5 tonne mound of sand. Sand harvesting is commonly done during dry season (December, January, February, March, August, and September) and majorly takes place in the farms if extraction is carried during rainy season (April, May, June, July, October, November). However, sand harvesting takes place throughout the year in five sub locations of Nangoma, Mundika, Mayenje in Kenya, and also Nangwe and Masinya in Uganda. Labour for extraction is typically self-supplied, and if we monetise it using the recommended daily wages by the government, then a trip of sand or 5 tonnes of sand takes 5 days to harvest which is about 87.5% of the gross revenue. The computed value of sand harvesting for the entire wetland is as shown in table 20

Table 20: Financial and economic value of sand harvesting in Sio-siteko wetland

Type of Value	**Financial Value (in $)**	**Economic Value (in $)**
Aggregate values for the whole wetland		
Gross value	3,765,178	3,765,178.00
Net value	3,663,792	369,261.25
Marginal values		
Net value / household/ year	925	93

The Sio-siteko wetland is an important fish breeding ground and sand harvesting on fish breeding areas definitely destroys such sites. Both the governments of Uganda and Kenya have recommended strict protection of the river delta as an important fish breeding area. If we assume that such a protected area would cover up to two kilometres moving inland from the river mouth, then sand harvesting activities in the sub location locations of Busijo, Bujwanga, and sigalame in Kenya, and Majanji parish in Uganda would become an unsustainable use of the wetland. Therefore economic values from sand harvesting that accrue from mining in such areas should be excluded from sustainable economic valuation of the wetland, other unsustainable sand harvesting include those mined from river banks.

Place/Type of sand harvesting	Baseline Number of harvesters	Gross value of quantity harvested for the baseline
Sand harvested on wetland farms and outside fish breeding areas	692	664443
Sand harvested on River beds outside fish breeding areas	1232	1181232
*sand harvested on River banks outside fish breeding areas	462	442962
*Sand harvested in fish breeding areas	1540	1476541
Total	**3926**	**3,765,178**

*unsustainable (wetland degrading) sand harvesting

5.1.11. Brick Making

Brick making is one of the activities that take place in the wetland. Making of bricks from the wetland is a carrier function that leads to competition for space in the wetland with other potential uses and it also represents mining activity that is likely to be unsustainable given the longer period of time it takes for even a one centimetre of soil to be formed. This service has been reluctantly considered for valuation in this study, and the interest was mainly to assess the population that partakes of it rather than to actively consider it as an important benefit worth promoting. In total, about 8% of the households in the local community engage in brick making where they earn a total of gross financial value of USD 1, 254, 485 a year, production costs represents up to 69% of the gross values (water, grass, timber, and brokers). Labour is typically self-supplied, however, if they are monetised at casual work rate, then labour alone constitutes 52.5% of the gross revenues. Table 21 shows the computed gross and net financial and economic values and the net marginal values too.

Table 21: Financial and Economic value of brick making in Sio-Siteko wetland

Type of Value	Financial Value (in $)	Economic Value (in $)
Aggregate values for the whole wetland		
Gross value	1,254,485	1,254,485
Net value	388,890.35	-269714
Marginal values		
Net value / household/ year	153	-106

5.1.12. Biodiversity Maintenance Economic value

Households were asked to give their opinions about the status of the wetland in terms of degradation and 39% of them were of the view that the wetland is heavily degraded, and 42% of them thought that the wetland is somewhat degraded. While 16.5% of them were of the view that wetland was in good state and a further 2.5% were of the view that the wetland was in excellent state.

The knowledge of the respondents about some of the ecological and hydrological functions of the biological diversity found in the wetland was tested though a six point Likert scale (which was later merged into four) for the various such theoretically known functions. The wetland's role in flood control is least famous among the functions with 27% of the households disagreeing with role, also around 20% of the households disagree that wetland offer water purification services and further 12% have no idea whether it does purify water, other results are also presented (see annex 12)

Asked whether they thought that conservation of the wetland was important, there was near universal approval (98%). However, 10% of them were opposed to some various plants and animal diversity being left in their natural state. They were then asked how then they would prefer the plant and animal biodiversity (in general without breaking or singling out some of the plant and animal communities) to be conserved, and 68% approved conservation of all of the biodiversity, 22% approved conservation of most of them, 7% approved conservation of half of the biodiversity, while only 2% and 1% approved conservation of little and none of them respectively.

As articulated in the data analysis section, biodiversity valuation was conducted contingent valuation, and the elicitation format was a singled bound dichotomous method followed by (second elicitation process) open bid format. The results of the second elicitation process was used to establish the average willingness to pay using descriptive statics i.e. an anchor bid of five (hrs) per month was initially presented to respondents, followed by an open ended question on the maximum amount they would be willing to pay even if they said yes to the initial bid. The results showed that the average amount of time in hours that a household was willing to contribute was nine (9) hrs per month and using the recommended daily wages, these hours translated into mean value of USD 2.98 per month. After respondents answered the open ended questions in hours, they were equally asked to state what they would be willing to contribute in cash and the average amount in dollars was USD 2.89 per household per month .Computed aggregate willingness to pay for biodiversity maintenance is shown in table 22

Table 22: Aggregate WTP for Biodiversity Conservation

Parameters	% willing	Total Population	Average/ month	Value in monetary terms ($)	Aggregate values in $	Mean Marginal values in $
Labour contribution	80%	27010	9 hrs	2.98	965,877.6	35.76 hh/yr
Monetary Contribution	67%	18204	2.89 $	2.89	631,314.2	34.67 /hh/yr
N/B: These are mean values for the two countries combined						

Annex 6 shows the results of a Tobit regression model used to assess the determinants of willingness to pay. While the final questionnaire was purposely designed to ask for labour contribution, monetary contribution was equally asked as an alternative to labour as a cure for the much claimed high level of uncertainty over payment vehicles other than money. The results of the Tobit regression showed that older heads of households were less willing to contribute towards biodiversity maintenance. Ironically households who reported to be organized into some form of fisher or environmental groups were less willing to pay towards biodiversity maintenance. However, respondents whose main source of livelihoods was fishing were more willing to contribute towards biodiversity maintenance compared to others such as crop farmers, livestock keepers, business people, and those in formal employment.

5.1.13. Flood Attenuation Services

Key informants and focus group discussants revealed that flooding in River sio is not quite a menace like it is in other major rivers within the Lake Victoria Basin such as Nzoia and Yala on the Kenyan side. Flooding of the river and its tributaries mainly affects farms, and not houses and other major infrastructures in the area, and so during the survey, households were asked if they have ever experienced flooding from the River Sio and its tributaries and 34% of them affirmed that in deed they have ever experienced flooding, and the average size of a farm destroyed was 0.8 acres. Asked about when they last experienced flooding, 25% of them said 2019, 26% of them said 2018, 11% said 2017, while 17% of them said 2016, and 8% of them said 2015. Using benefit transfer as articulated in the data analysis section, the study conducted by Wasswa et al (2013) at the Kampala-Mukono Corridor in Lwajjali, Nakiyanja and Namanve wetlands was used as a study site whose values were deemed transferable to the Sio-Siteko situation. According to the Wasswa et al (2013) study, wetlands' role in protecting farms for 52 households was valued at USD 805. The unit value was therefore USD 15.48. The second step involved adjusting the unit value of the study to comparable levels with Sio-siteko wetland, and even though two parameters were identified for this, i.e. difference in year of value and income disparities, there were no site specific general income levels from study site to facilitate this. Therefore the only adjustment done was to correct for the effect of inflation based on equation 13 above, and the adjusted unit value was USD 19.668. From the households survey conducted in this study (the policy site), the mean proportion of households who reported destruction of crops by flooding over the past five years was 6% of the population representing 1902 households with a total of 1522 acres. We assume that these farmers are exposed to annual flooding, and that this is due to exposure of their farm due to destruction of the vegetative plant community of the wetland and hence damage cost avoided by reestablishment of wetlands plant community in these areas would be valued at USD 37,812 as shown table 23.

Table 23: Parameters and economic value of flood attenuation

Parameter	Value
Unit value for study site (Kampala-Mukono Corridor) (805/52)	15.481
GDP deflator index for the year of the Sio-siteko assessment (2019)	104.730
GDP deflator index for the year of the Kampala Mukono-Corridor (2013)	82.430
Mean income per capita at the policy site (Sio-siteko) (USD)	619.310
income per capita at the study site (Kampala-Mukono Corridor)	missing
income elasticity of willingness to pay (taken as average of the common elasticities)	0.7275
Unit value for policy site (Sio-siteko wetland)	19.880
Annual number of households in Sio-siteko whose farms are affected by floods.	1902
Economic value (Unit value*annual number of households)	**37,812**

5.1.14. Water Purification Services

Wetlands have the potential to filter nutrients and sediments thereby improving the quality of water downstream, leading to increased water clarity and improved water conditions for domestic supply, fishing, recreation and other ecological needs of water by both flora and fauna of the natural environment (Miranda, 2017). Water quality parameters typically considered for surface water include; pH, temperature, BOD, dissolved oxygen, conductivity, nitrates, phosphates, turbidity, E. coli, total coliforms and various heavy metals (Fleet, 2002; Dunca, 2018; Khatri & Tyagi, 2015).

In this study, parameters selected included nitrates, phosphates, and turbidity. From the available data (by Acacia water Ltd, a NELSAP study, and Water Resources Authority in Kenya) showed that the level of nitrates across the entire wetland was less than 5 mg/litre, which was below the maximum recommended levels (50mg/Litre) by the World Health Organisation (1998) for human drinking. Similarly, the nitrates data did not show variation in concentrations across the gradient. Data on phosphates was however only available for the water intake point just before the area demarcated as the Sio-siteko wetland hence did not have a comparable concentration levels with the lower reaches of the wetland. The third category of pollutants under this ecosystem service was turbidity levels, a measure of the degree to which the water loses its transparency due to the presence of suspended particulates, also referred to as level of cloudiness

(Myre & Shaw, 2006; Altaher, 2012). High turbidity levels would suggest that there were considerable amounts of suspended solids (Miranda, 2017). Turbidity is measured in NTU (Nephelometric Turbidity Units) and the World Health Organization (2017) recommends a maximum of less 4 NTU for household and drinking water. Data collected by Acacia Ltd (2019) showed an average of 75 NTU at the upper reaches (Sio Bridge) and less than 5 NTU at the lower reaches near the lake. In general, surface water will need pre-treatment to reduce turbidity before it is disinfected (Wisner, 2002). Treatment methods which reduce turbidity include sedimentation, roughing filters, rapid and slow sand filters, chemical coagulation and flocculation, and ceramic filters. Chemical coagulation and flocculation has been used for households and water supply by companies including in the surrounding areas to the project area and it is viewed in this study as a more efficient way of removing turbidity. It is there adopted as a proxy measure of the economic value of the role that the wetland plays in water purification with a particular focus on turbidity removal. The common coagulants used include the inorganic compounds of Aluminium Sulphate and Ferric Sulphate or Chlorides though there are cost and potential health concerns (World Health Organization, 2003; UNICEF, 2008). Use of nature based coagulants have also been advanced especially *Moringa oleifera*, though its downside in comparison to the two inorganic compounds is that the former also acts as disinfectants capable of destroying bacteria, fungi, spores and also killing molluscs while it does not (Pandit & Kumar, 2015). The application of Aluminium Sulphate has been considered in this study at the point of use level i.e. at household level, even though there was no evidence of its use by the local community. However, there has been its use in both Kenya and Uganda at household levels (Smet & van Wijk, 2002.). From the household survey, the average household daily use of water was 100 litres from the wetland, and the number of households who reported to use water from wetland for domestic was 26,301 households. From equation 15, the annual domestic water use was $959{,}986{,}500\ Litres$. Similarly, from equation 16, the Alum dosage for that volume of water was 14.22 mg/litre, and the total dosage of Aluminium sulphate required for the population given the annual wetland surface water resource usage based on equation 17 was $13,651{,}008\ grams$. The cost of Alum which is the replacement of the wetland for turbidity removal was then estimated based on equation 19 which was $\boldsymbol{US\$\ 477,326}$.

If we take it that the vegetated areas of the wetland plus the water channels and excluding other crop farming, other bare areas such as brick making areas are the ones responsible for water purification services, and also assuming the effects of gradient, then we attribute an area of 2654 acres to be responsible for the purification and likewise the monetary value is as shown in table 24

Table 24: Value of benefits of Turbidity removal role of the wetland (water purification services)

Type of Value	Value (in $)
Aggregate values for the whole wetland	
Cost removing turbidity/ benefit of wetland removing turbidity	477,326
Marginal values	
Value / household/ year	18.15
Value / per area/ year	179.82

5.1.15. Groundwater Recharge

Groundwater recharge occurs when wetlands serve to intercept precipitation during the wet season, so that it infiltrates into the ground rather than flowing downstream. This water may be utilised elsewhere via boreholes or wells (Thompson and Goes, 1997, in Acharya, 2000; Turpie et al., 2006b) or may be released lower down in the catchment over a delayed period, thereby helping to augment base flows (the portion of river flow that comes from subsurface sources) during the dry months (Turpie and van Zyl, 2002). The Groundwater Recharge ecosystem service helps maintain natural rates of groundwater recharge and aquifer replenishment. The recharged groundwater is tapped by households and even investors to abstract both shallow wells and boreholes to avail water for varied purposes such as domestic use, farming, and commercial supplies.

The economic value of groundwater recharge is attributable to the benefits the society derives now or the future option of deriving some benefits (Georgiou & Turner, 2012); such benefits may be direct, such as abstraction of water for irrigation or domestic use, or indirect, such as the maintenance of water table levels. In addition to these use values, there may be non-use values of maintaining groundwater supplies. Non-use values can be attributed to the maintenance of groundwater supplies for subsequent generations, but only if use of the reserves is anticipated (Turner et al., 2004).

Various economic valuation techniques exist for the valuation of groundwater recharge ecosystem service value of wetland ecosystems, such methods include: replacement costs for domestic and or commercial supply of water. ; Production costs especially where groundwater is abstracted to be used as a factor input for marketed goods e.g.in industrial production, irrigated agriculture among others.

The replacement cost approach for example involves: assessing the extent of flooding, its contribution to the depth and replenishment of water tables and aquifers, as well as the impacts of changes in wetland status on these variables − the importance of wetlands in local water balance; the number of people using shallow wells and boreholes in the area and the costs of providing these water infrastructures; the development of alternative water sources, that is, one would look at the costs of replacing existing shallow-dug wells, which depend on the groundwater recharge and water supply functions of wetlands, with other forms of water supply such as boreholes, water trucks or water pipelines.

Productivity method would entail assessing the losses in productivity arising from falling water table and depleted aquifer. However, estimation of water dependent functions is always data intensive and in this case such data were equality unavailable, hence replacement cost method was adopted.

Sio-siteko wetland provides a platform for the groundwater recharge and discharge that are used by the surrounding local community to dig-up shallow wells and sink boreholes. The wetland, which has a total area of about 14,826 acres (Nile Basin Wetland Monograph, 2019), is situated within the lower Sio sub catchment which also begins from the area demarcated as the upper reach of the wetland and then expands to an area of 405.7 km^2 beyond the wetland extent (NBI, 2014). While one may be tempted to take it that the wetland serves the entire sub-catchment in terms of furnishing it with groundwater recharge that may not necessarily be case since the structures and layout of the underground aquifers do not necessarily conform to the surface water drainage pattern. The current available information about the below aquifer is not sufficient to provide data useful to the valuation exercise, this study has therefore only valued groundwater recharge services for the local community found in the area delineated as directly affecting the wetland from the surface water system perspective and distance. The results should therefore be taken to represent lower bound estimates as the wetland is probably more likely to serve a larger area of the below aquifer.

The Water Resources Authority of Kenya records show that there are 20 functional boreholes on the Kenyan side of the wetland, and if we assume a similar number on the Ugandan side of the wetland, then we have around 40 boreholes altogether. The average depth of a borehole around the wetland is 53.65 feet (or 16.35 metres) deep; similarly, the average yield of the boreholes was 2.66m^3/hour, while the average sustainable yield was 1.60 m^3/hour. Though there were no documented records of shallow wells for the area, information on total number of shallow wells and boreholes for Busia county (458 and 154 respectively) was available (Busia County, 2013); a ratio of three to one for shallow wells to boreholes respectively was assumed, i.e. 120 shallow wells for the wetland's immediate area of influence.

The average cost of sinking a shallow well in the area is around USD 582; and the cost of sinking a borehole is typically USD 73 per drilled metre, there also exist hydrological survey cost typically USD 485, other costs might include environmental impact assessment (costs usually varied) whose lower bound costs could be around USD 437, submersible pump and related system could cost around USD 2900. It follows therefore that the average cost of a borehole is around USD 5015.55. Total infrastructural costs is shown in table 25

Table 25: Total cost of groundwater infrastructures in the Wetland

Value Parameter	**Value**
Number of boreholes in the area	40
Cost per borehole (US $)	5015.55
Total cost for boreholes	*200,622*
Number of shallow- wells in the area	120
Cost per shallow well (US $)	582
Total cost of shallow wells	*69840*
Total cost of groundwater infrastructures	**270,462**

The costs of replacing existing shallow-dug wells and boreholes around the wetland was assessed against shallow wells and boreholes sunk in areas considered far off (Vihiga, Siaya) from influence of wetland but within the same aquifer, that is, the Archaean (Nyanzian) volcanic (basalts, rhyolites, andesite, and rhyolitic tuffs over basement), poor intergranular and fracture – flow aquifer where reviewed boreholes were drilled at 130 and 82 metres respectively (Namwamba, 2012; Ngirigacha, 2017). We therefore considered that depths of boreholes within the aquifer but several kilometres away from the wetland could be drilled in such range, and here we used 100 metres as our standard alternative depth in the absence of groundwater recharge from the wetland, such a borehole cost around US $ 14,052, in which the cost of submersible pump and electrical system cost at around US $ 5830, drilling costs (US $ 7300), professional assessments (US $ 922), while the cost of a shallow well in these areas was taken as US $ 680. From cost of boreholes and shallow wells in areas far off from the wetland areas, it follows that the cost of sinking a shallow-well without the wetland is US$ 98 and that of a borehole is US $ 9036.45. Therefore the replacement cost of the groundwater recharge of the wetland is as shown in table 26

Table 26: Replacement cost of wetland groundwater recharge

Value Parameter	**Value**
Number of boreholes in the area	40
Replacement cost per borehole (US $)	9036.45
Total replacement costs for boreholes	*361,458*
Number of shallow- wells in the area	120
Replacement cost per shallow well (US $)	98
Total replacement cost of shallow wells	*11,760*
Total replacement cost of groundwater infrastructures	**373, 218**

From the household survey, 17% of the households use underground water either from the boreholes or shallow dug wells translating into 4436 households. It also assumed that the vegetative plant community (2654 acres) in the wetland plays the greatest role in holding precipitation and flooding to facilitate underground seepage hence the groundwater recharge

5.1.16. Summary of the baseline ecosystem services

The valued ecosystem services in this study, with a focus on both financial and economic values are summarized in table 27 shown below.

Table 27: Summary of the baseline economic values of Sio-siteko wetland ecosystem services

Ecosystem service	Aggregate Gross Value (US$)	Community Households beneficiaries	Acreage in use	Gross value per household	Net economic value /hh
Capture Fisheries	6,984,000	8554	2654	816	545
Livestock grazing	6,530,093	18062	467	362	-22
Sand harvesting	3,765,178	3961	-	951	951
Water supply	3,374,640	26301	2654	128	-291
Crop Farming	2,323,509	14860	11888	156	14
Bricks making	1,254,485	2535	2.3	495	-106
Grass harvesting	1,249,118	7795	156	160	143
Biodiversity	965,878	27010	2432	36	36
Water purification	477,326	26301	2432	18	18
Mat making	459,103	5070	165	91	-213
Groundwater recharge	373,218	4436	2654	84	84
Aquaculture	370,576	432	104	858	410
Herbal medicine	326,340	5070	2432	64	40
Firewood	221,426	6338	1644	35	7
Flood Attenuation	37,812	1902	2432	20	20
Total	**28,763,082**				

5.2. Cost Benefit Analysis

5.2.1. Cost Benefit Analysis of the Business as Usual Option

5.2.1. 1. Aquaculture

Aquaculture currently occupies approximately 104 acres of the wetland land. This land is part of the reclaimed area of the wetland considered to be crop land. Aquaculture is the fastest growing food production sector in the world (FAO 2013). Its uptake rate in Kenya is at 20% per annum as records show for the period between 2000 and 2018 (Obiero et al., 2019). The baseline gross value of fish farming is USD 370,576 per year. Given the capital requirements for setting up aquaculture and the presumed high poverty levels in the wetland area, we assume a modest annual compound growth rate of 10%. We also assume that the average fish pond size and number per farmer will remain constant. In the next 25 years, a total of 1267 acres shall have been reclaimed for fish farming and the total Present Values of the benefits is **USD 9,928,793**

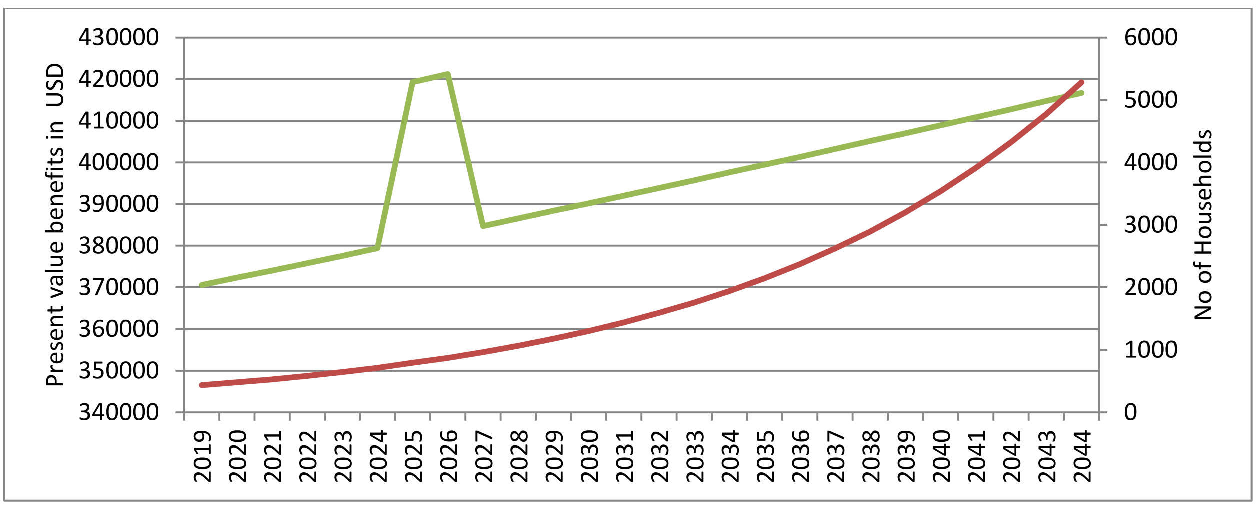

Figure 13: Present values of aquaculture under the BAU scenario

Source: Author's computation

5.2.1.2. Brick making

Demand for bricks will be on the rise given the continued need for modern housing and growth of urbanisation. Majority of brick makers prefer wetland areas because of the quality of soils found in wetlands and water availability. We therefore argue that the production of bricks will continue in a similar proportion to demand for housing (*see sand harvesting sub section)* but split between bricks and curved stones and concrete in a 50% to 50% ratio. Hence unlike in the case of sand, bricks growth will be at 2.4% (Kay & Nagesha, 2016; UN HABITAT & Ministry of Lands Housing and Urban Development, 2016). Brick making is an extractive use of land and hence lead to land degradation unless there is careful rehabilitation programme. In the business as usual option there is no rehabilitation programme instead brick makers will be abandoning sites that they have used and moving to the next. Based on key informant's interview with key brick makers, production of a standard kiln of 14000 bricks which takes about six (6) weeks to make requires soil that can be extracted from a space of 5 square metres. It follows therefore that the total space of wetland area that was used for bricks making in the baseline year was 9230 square metres or 2.3 acres of land. With an assumption of annual growth of 2.4% for bricks demand, the total land that shall have been reclaimed for bricks making in the next 25 years is 4.19 acres, and the gross present value of bricks making benefits over the next 25 years is USD **14,275,761.**

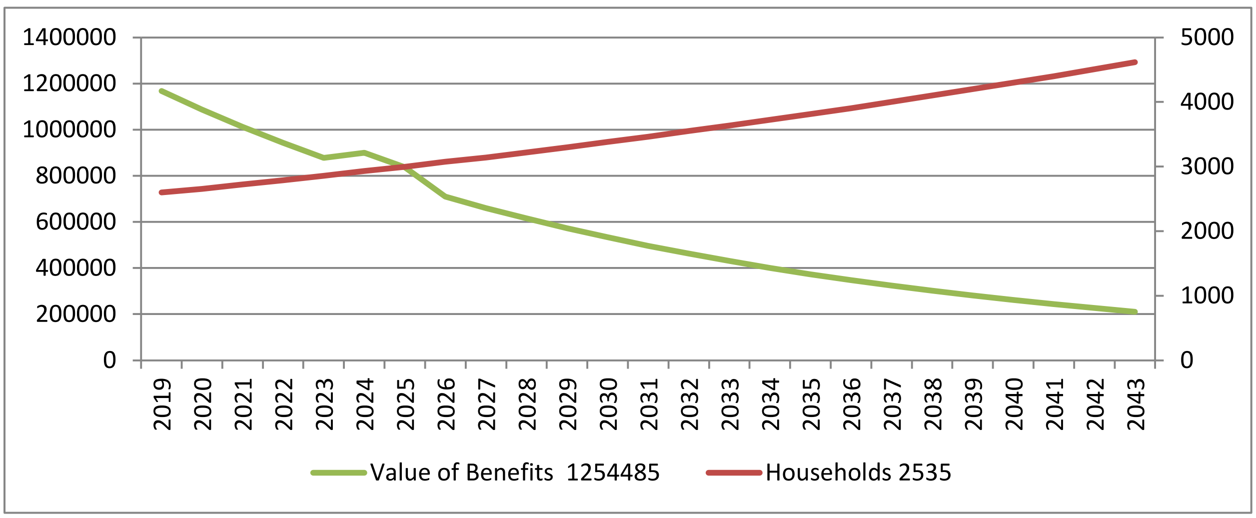

Figure 14: Present values of bricks benefits and households population

5.2.1.3. Crop farming

There is competition for space in the reclamation of the wetland for carrier services such as fish farming, bricks making, and crop farming. While crop farming is the main stay of the local community, here we argue that it gives up space for aquaculture and bricks making expansion.

From the land use change taking place as a result of reclamation activities, we assume that water mass and built-up areas are not currently being reclaimed for agricultural expansion.

As a result of this reclamation for agriculture, other ecosystem services will decline in value as agricultural expansion takes up wetland landscape. Land available for reclamation after conversion into brick making and aquaculture will be taken up for crop farming at the estimated rate of land degradation of 4% per annum (NEMA, 2009) .The baseline proportion of the wetland occupied by farmland landscape is 80.9%. The amount of land used for crop farming projected to the next 25 years is based on equation 24 and if we take it that crop yields will remain constant and that prices will also not change, then the total present value of crop farming **benefit**s over the next 25 years is USD **25,776,438** based on equation 21

5.2.1.4. Sand harvesting

Sand harvesting is currently taking place in the river banks, river beds, and farms within the wetland. We anticipate that the demand for sand will increase at least at the rate of the growth of urban areas which require construction of concrete housing. The average urban growth rate in Kenya it is at 4.34% and for Uganda it is at 5.2 % per annum (Kay & Nagesha, 2016; UN HABITAT & Ministry of Lands Housing and Urban Development, 2016). In this study we take the average between the two countries which is 4.78%.

However, some of these benefits cross the line of sustainable sand harvesting. It is therefore important that the benefits that accrue beyond sustainable levels be captured as degradation of the wetland hence is considered as costs. Such benefits include sand harvesting on the river banks, and harvesting in fish breeding areas. In the next 25 years, the gross present value of **benefit**s obtained from sand harvesting from the wetland is **USD 26,637,687**, while the gross present value of the **cost** of degradation of the wetland due to sand harvesting over the same period is **27,703,212.**

Table 28: Patterns and the present values of gross benefits and costs of sand harvesting is in Sio-siteko

Place/Type of sand harvesting	Baseline number of sand harvesters	The baseline gross value of sand harvested	Present value of sand harvesting over the next 25 years
Sand harvesters on wetland farms and outside fish breeding areas	692	664443	
Sand harvesters on River beds outside fish breeding areas	1232	1181232	**26,637,687**
*Sand harvesters on River banks	462	442962	
*Sand harvesters in fish breeding areas	1540	1476541	**27,703,212**

*unsustainable (wetland degrading) sand harvesting

5.2.1.5. Livestock grazing

About 4.2% (623 acres) of the wetland landscape is grassland which the local community use to graze their livestock. From the baseline valuation, 57% of the households take their cattle to graze in the wetland. The baseline economic value of grazing was $ 6,530,093.

The parameters needed to estimate the benefits and costs of livestock grazing over the next 25 years using the gross values of livestock grazing as an ecosystem service included; the baseline biomass removal quantity and value, expected trends in livestock population over the next 25 years, livestock grazing patterns in the wetland, wetland grassland area over the next 25 years, the intrinsic growth of grass, and the carrying capacity of the wetland's grassland. Computation of these variables shows that intrinsic growth rate was taken as 4511 kg/acre per year of dry matter (Downing, 2018). One kilogramme of dry matter can be computed to be equivalent to 4 kilogrammes of fresh grass hence the rate of growth of grass is also 18044 kg/acre per year of fresh grass. The growth of livestock population in both Kenya and Uganda has been on ascendancy, with a mean growth rate of 2.5% for local indigenous cattle between 2008 and 2017 in Uganda (UBOS, 2014; UBS, 2012). Equation 25 was used to estimate the annual indigenous cattle population. The baseline population of cattle was 127,428 animals.

The amount of livestock that can graze in the wetland's grassland area for a year without degrading the wetland area is considered to be the carrying capacity of the wetland grassland area for providing livestock grazing ecosystem service and this was obtained using equations 26-29. Where forage production is taken as 18,044 kg/acre/year, and area is 623 acres for the baseline year which is affected as year's progress by the rate of reclamation of the wetland for crop farming and aqua culture. For the baseline year, the forage demanded is 2% x 250kg x 120 days = 600kg/year/ cow. Therefore total forage demanded (used) is 76,456,800kg/year, and the carrying capacity is 0.1, it follows that the current use of the wetland for livestock grazing is 10 times degrading the wetland grassland landscape. The baseline carrying capacity for grazing animals is 14,044 cows.

Given the reclamation of the wetland largely for crop farming under the business as usual, the amount of land available for other landscape and land uses (livestock grazing) will be on the decline as year's progress; hence the carrying capacity for livestock grazing will not remain constant but rather decline. The true benefits of livestock grazing without compromising the carrying capacity of the grassland given the gravy train situation of reclamation of the wetland for crop farming under business as usual is the economic value obtained from the number of cattle in excess of the carrying capacity grazing is considered as an economic cost of livestock as shown in the table 32 The gross present value of livestock grazing benefit in the wetland is **USD 17,107,538.** While the present value of **cost** of degradation of the wetland grassland due to livestock grazing is **USD 290,493,473**

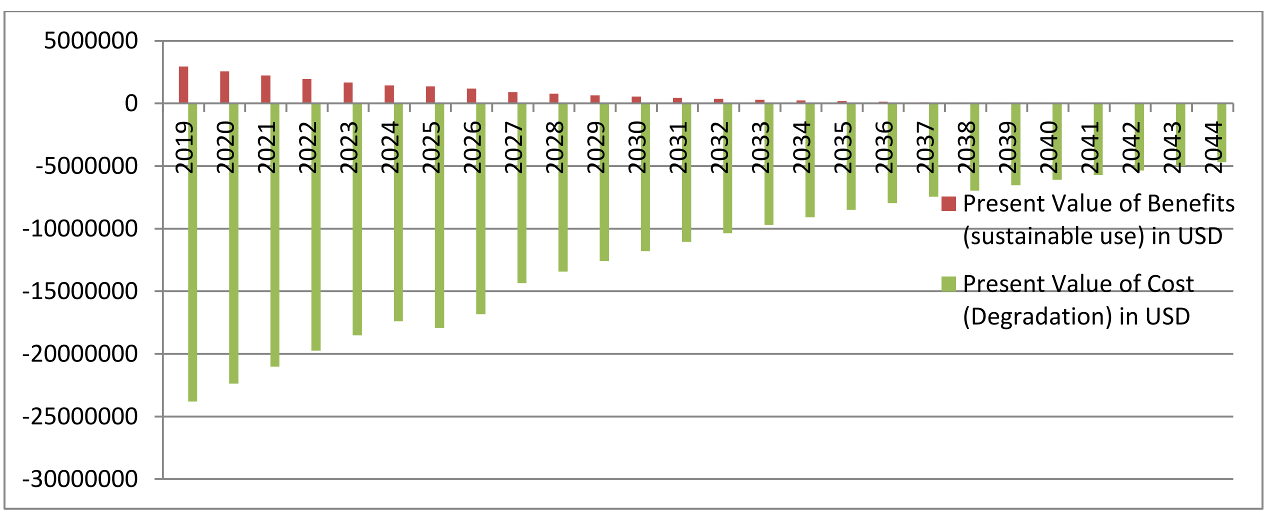

Figure 15: Present Values of Sustainable grazing and values of degradation in BAU

5.2.1.6. Grass harvesting

Grass is mainly harvested for four purposes; (1) to feed livestock under zero grazing system (we assume these are majorly dairy animals), (2) selling (we assume this is majorly for hay preparation), (3) broom making, (4) thatching. We argue that grass harvesting for livestock feeding and selling will increase at the rate of dairy cattle growth considered to be 4.1% per annum (Odero-Waitituh, 2017). We also assume that broom making will also continue and in this case at the rate of population growth rate (3.02%). Grass harvesting for thatching will was thought of to change at the rate of population growth less the rate of uptake of iron sheet roofing. However, data on the rate of change to iron sheet in rural areas for both Kenya and Uganda was not available, it was therefore assumed that roof thatching using grass will stagnate hence it was left at the baseline value. From key informant interviews, what is called a bundle of grass is not a standard mass of grass and vary from use to another, We assume that a bundle of grass harvested by the local community for thatching is 15 kg just like a bale of hay (Auma et al, 2015), and grass harvested for animals is assumed to be around 2 kg per cow per trip. It was assumed that a quarter portion (156 acres) of the wetland grassland area is mainly used for grass harvesting. Using the concept of carrying capacity, then the annual available supply of grass for harvesting was obtained through multiplying grass production by the area under grass, in which grass production is taken as 18,044 kg/acre/year, and area is 156, therefore total available grass for harvesting is 2, 814,864 kg/year for the baseline year. The carrying capacity for the subsequent years is shown in table 34. The projected harvest rates is given by equation 27

The baseline population of cattle was 7578 animals; the rate of growth of zero grazed (assumed to be largely dairy cattle) is 4.1 % per year, t is the number of years from 2020 to 2044 i.e. 25 years. The cattle population across the years is shown in Table 34. Similarly it is assumed that grass harvesting for selling is for hay for livestock feeding, hence the rate of growth is also taken as the rate of growth of 4.1% for dairy cattle. We assume that a bundle of grass harvested in the context of the local community for animal feeding is in the range of 2 kilogrammes perc. For broom making, it was assumed that there will be annual increment in broom makers at the rate of population growth of 3.02% per annum. The landscape for grass harvesting will, however, be declining at the rate of reclamation of the wetland for crop farming, aquaculture and bricks making. This will therefore affect the carrying capacity given the annual rate of harvest. The gross present value of the benefits of grass harvesting over the next 25 years at annual discount rate of 10% is **USD 2,639,449.** Similarly the gross present value of costs of grass harvesting in terms of depletion and degradation of the wetlands grassland is USD **10,957,877.**

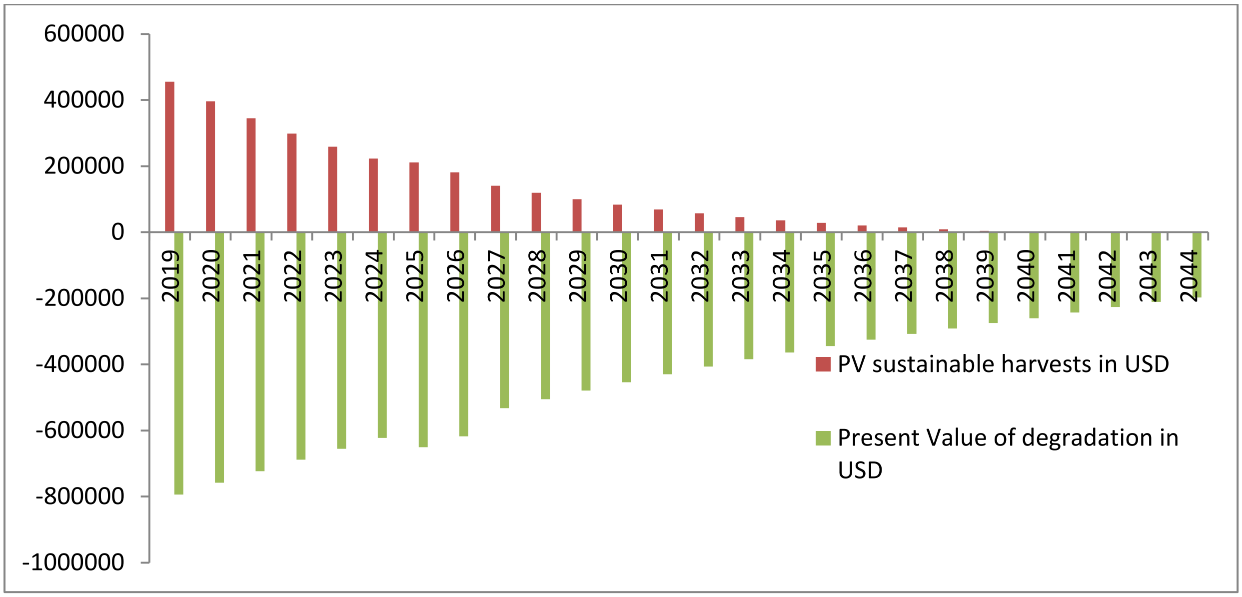

Figure 16: Present value of sustainable grass harvests and degradation

5.2.1.7. Herbal medicine

Most (70%) of the local community are in general agreement that the plants used for herbal medication are on the decline. Such a decline could be attributable to land degradation such as reclamation or over extraction due to high demand. Given that it is the leaves that are mostly extracted for the commonly used plants for herbal medication such as *Embiririsi*, and *Omusengese*, we argue that the decline in the plants abundance is due to land reclamation rather than use. Herbal medicine use is generally on the rise, World Health Organisation places growth in herbal medicine at 15% (Booker et al, 2012; Tilburt & Kaptchuk, 2008). The gross present value of the **benefit**s of herbal medicine over the next years at 10% discount rate under the business as usual scenario is therefore USD **5,559,136.** Similarly, the gross present value of herbal medicine **losses** due to degradation of wetland over the 25 years at 10% discount rate is USD **12,466,428**

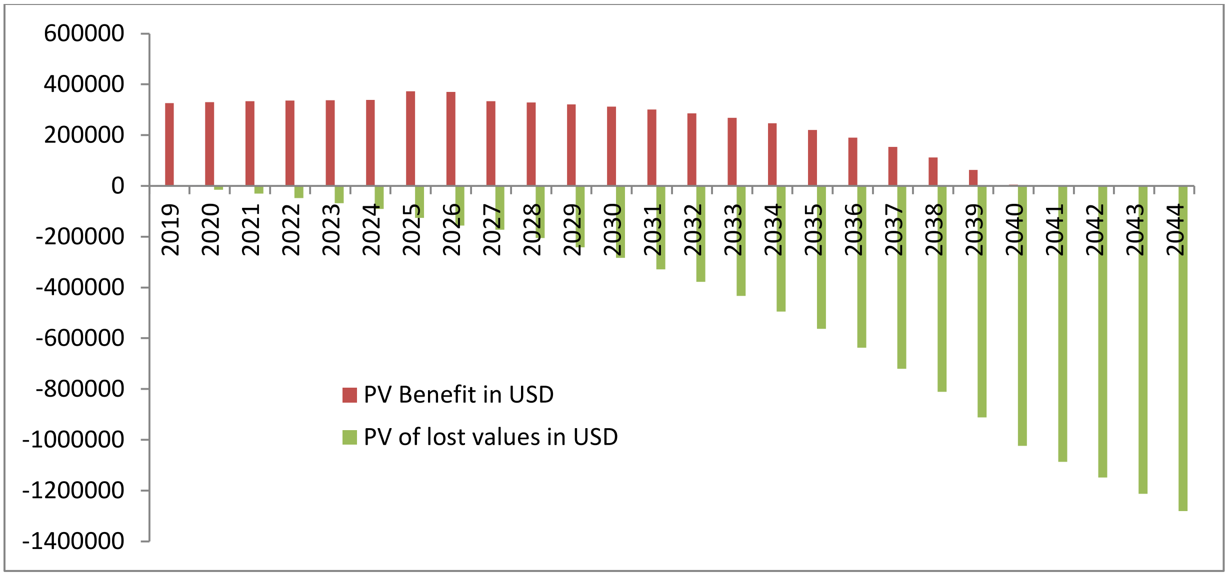

Figure 17: Present values of benefits and lost values of herbal medicine under BAU

5.2.1.8. Firewood

Between 1999 and 2019, the proportion of households using the three stones open fire dropped from 76% of the population to 58% in Kenya. This represents an average decline of 1.07% per year. However, the overall aggregate numbers was still higher over the same period given population growth. We assume here that overall, the demand for firewood will be on the decline (1.07%), but aggregate figures will remain high because of the annual population growth rate of 3.02% per annum. A critical question is whether the amount of biomass available will be able to supply the demanded firewood. To answer this question we need to know the carrying capacity of the 'forested' area and the annual regeneration rate. The baseline area of trees landscape wetland is 1644 acres. However, it is on the decline given the overall wetland degradation rate.

Firewood access from the wetland is generally modest and involves traditional harvesting through collection of dried pieces rather than clear cutting of standing trees. We argue therefore that firewood collection from the wetland is sustainable if held at the current harvest levels. The total benefit of firewood over the next 25 years is USD 2,367,228, while total cost of wetland reclamation in relation to firewood is USD 3,168,422. The present value of **benefits is USD 1,284,707** while the present value of **cost is 749,042**

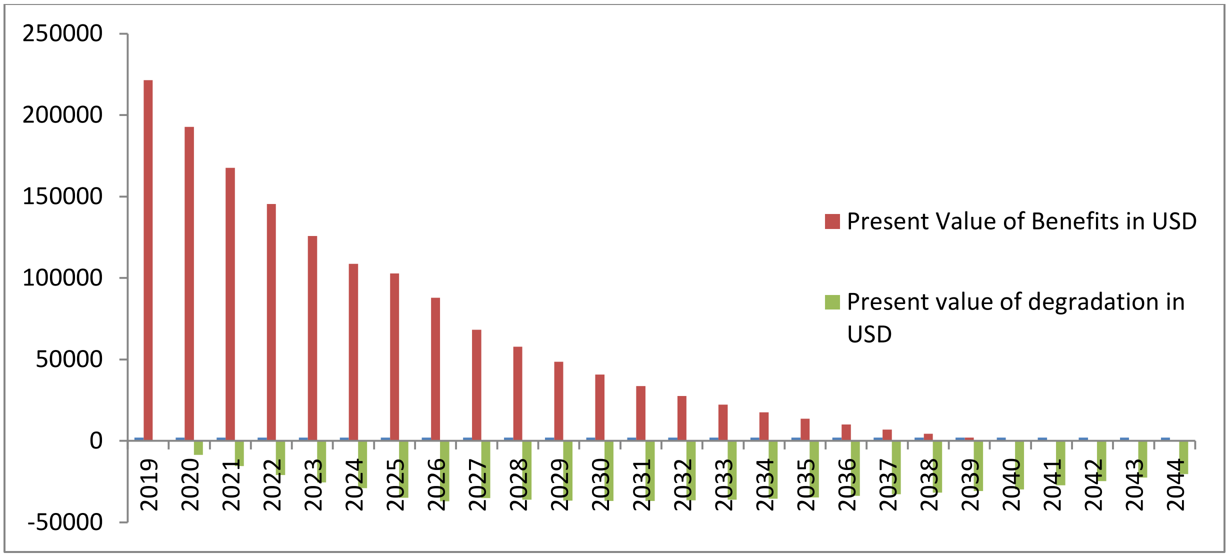

Figure 18: Present value of benefits and degradation of firewood in the BAU scenario

5.2.1.9. Mat Making

The baseline value of mat making from papyrus (assumed to be accessed in the shrubs landscape) is USD. 459,103. We assume that the demand for mats made from papyrus will remain constant hence will only rise at the rate of population growth (3.02%). During the data collection process, key informants observed that papyrus generally regenerates after short period of time (6 months). We therefore assume that current papyrus harvests rates are sustainable as long as shrubs (papyrus) landscape is not degraded. The current population engaging in mat making is 5070, and the current landscape area providing papyrus is 165 acres. This area will however, experience degradation under business as usual scenario given general decline in wetland landscapes occasioned by reclamation for farming. Therefore, the gross benefit of mat making over the next 25 years is USD 6,259,645 and gross revenues lost (cost) is 11,142,546. Similarly, the present value of the **benefits** at10% discount rate is **3,189,608** and that for losses **(cost) is 2,354,599**

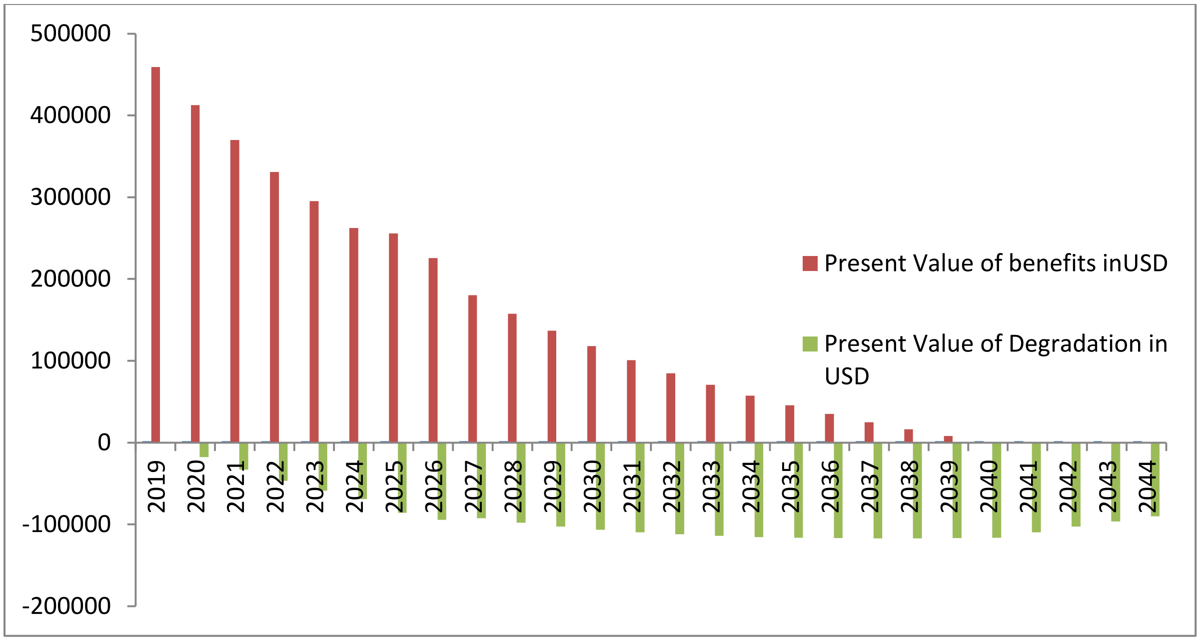

Figure 19: Present value of benefits and degradation of papyrus for mat making under BAU scenario

5.2.1.10. Water supply

Baseline value of domestic households water supply from the wetland is USD 3,374,640. It is assumed that under business as usual scenario, there will be an annual increase in access to water at the rate of population growth (3.02%). The gross present value of water supply benefits from wetland for the next 25 years using a 10% annual discount rate is **USD 61,904,963**

5.2.1.11. Capture fisheries

The baseline benefit of fisheries is USD 6,984,000 per year for a total of 8554 households, and if the built up areas, farm lands, and bricks making areas are excluded while the remaining land use types are considered to be capture fisheries productive areas, then the baseline area for capture fisheries is 2654 acres or 10.74 km^2. For the business as usual option, we assume the main factors affecting capture fisheries resources include; (1) population growth which affect demand and it is assumed that fisheries value will increase proportionately to the population growth rate (3.02 %), (2) destruction of fisheries breeding sites through activities such as fishing in the breeding areas, use of destructive gears, and sand harvesting on the river banks; (3) pollution of the wetland's water though chemicals such pesticides among others. The last two factors lead to degradation of fisheries resources. While the first one is about the benefits accruing from fisheries resources up to where sustainable harvesting is not possible owing to overfishing and other factors. Using equation 30 for fisheries productivity in the tropical areas floodplains and swamps, the area of the wetland available for fisheries is 2654 acres or 10.74 km^2 for the baseline value, but is bound to change given the annual encroachment and reclamation of the wetland leading to degradation. The true benefits of fishing without compromising the carrying capacity of the fisheries resources of the wetland is the economic value obtained under the productivity equation above and its gross present value of US$ **1,051,469** obtained using a discount rate of 10% at annual demand of 3.02% (based on projected population growth rate), and over a 25 year period. The current excess harvested fish and the projected demand for fish based on population growth rate, and loss of fisheries ground due to reclamation, are estimated as cost, i.e. depletion (depreciation) of fisheries resources and are valued at a gross present value of US $ **83,428,880**

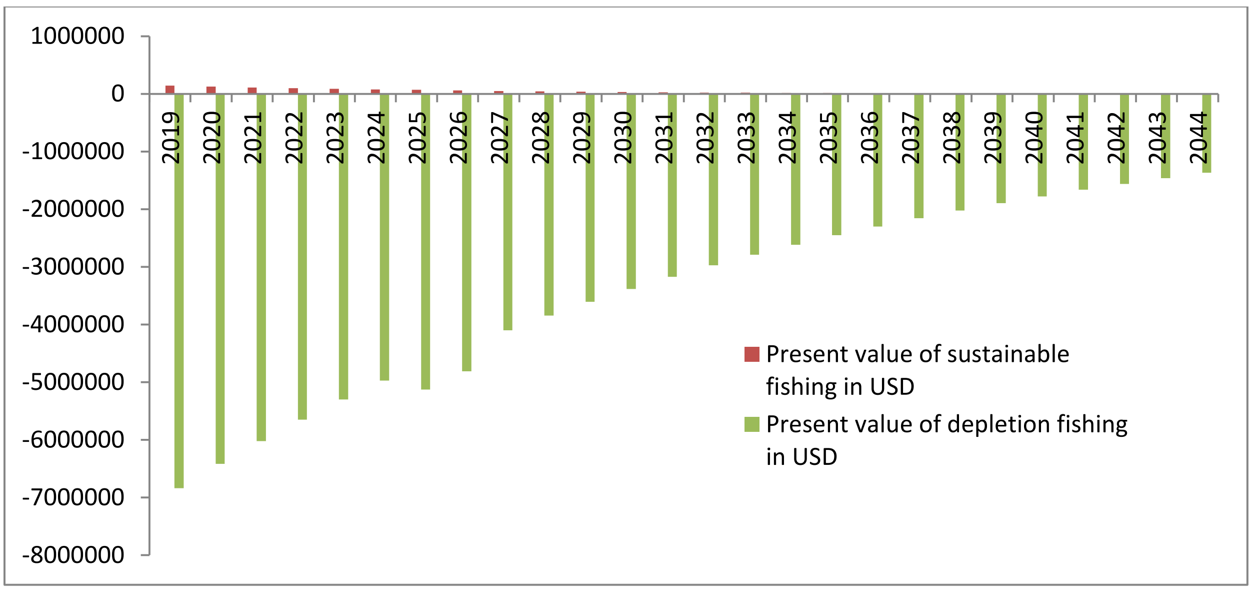

Figure 20: Present value of benefits and depletion of capture fisheries under BAU

5.2.1.12. Biodiversity maintenance

The landscape of Sio-siteko comprises water channels, grassland, built environment, cropland, shrubs, and trees. The biodiversity of the wetland comprises both flora and fauna. We argue that enhancement of shrubs, grasslands, and trees will increase the ability of the wetland to help in biodiversity maintenance. Given that the current trend in the wetland management entails reclamation of the wetland into majorly cropland, aquaculture, sand harvesting, and bricks making, we will see decline in space and quality of the biodiversity habitats at the rate of wetland degradation and reclamation. Table 32 shows the combined loss of shrubs, trees, and grassland which we assume to be directly proportional to the current economic value of the biodiversity. The baseline value of biodiversity maintenance is USD 965,878. The total gross value of biodiversity maintenance benefit over the next 25 years is USD 10,345,452 while the present value of the **benefits** is USD **5,605,753.**

Similarly, the total cost of biodiversity maintenance degradation over the next 25 years is USD 13,801,498 while the present value of **costs** of degradation for the biodiversity value is **USD 3,265,621**

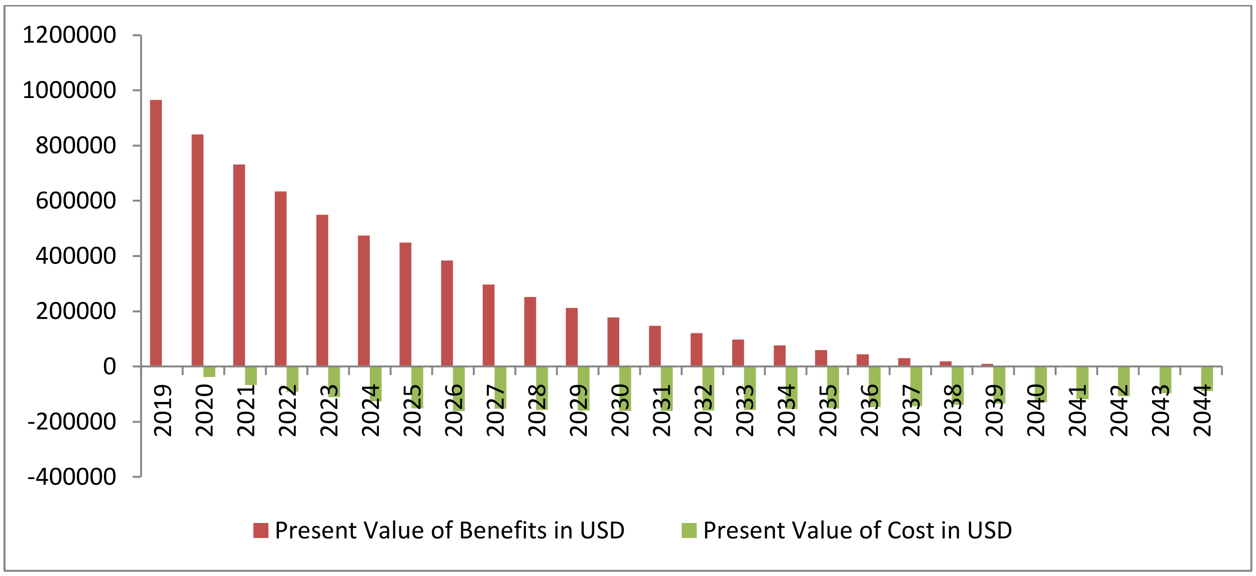

Figure 21: Present value of benefits and costs of biodiversity maintenance under BAU

5.2.1.13. Flood Attenuation

Flood attenuation role of the wetland is largely offered through the shrubs, trees, and grasslands that break the speed and spread of the river waters when it (the river) breaks its banks due to heavy rainfall. Conversion of wetland into cropland, and aquaculture exposes the wetland to flooding, we therefore argue that economic value of the wetland will be declining overtime given the degradation of the wetland at the rate of reclamation of the shrubs, trees, and grasslands, therefore the economic benefit of flood attenuation role of the wetland over the next 25 years will be **USD 404,192** and the present value of the benefits is **USD 219,357**. Similarly, the gross value of cost of loss of flood attenuation services due to reclamation is USD **541,108** and the present value of the costs over the next 25 years at 10% annual discount is USD **127,938**

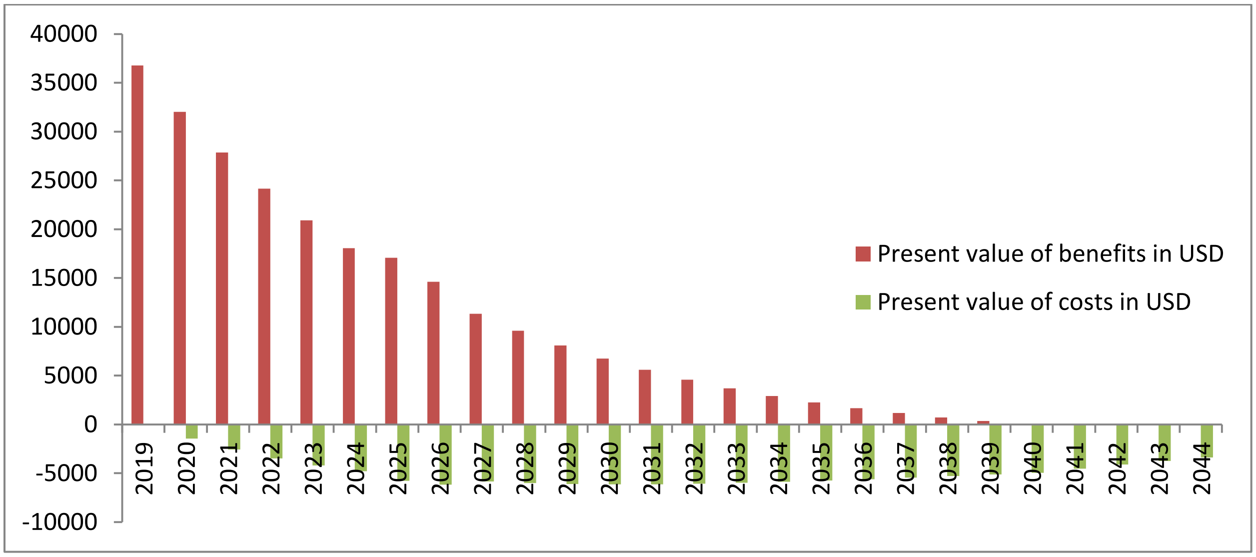

Figure 22: Present values of benefits and costs of flood attenuation under BAU

5.2.1.14. Water Purification

The baseline value (benefit) of water purification (turbidity removal) was US$ 477,326 and the removal took place over a landscape covering a total area of 2654 acres and served 26301 households. Under the business as usual scenario, land use change will affect the spatial extent of area currently helping removal of over 70 NTU of turbidity. We make a simple assumption that there is removal of 0.0264 NTU of the wetland surface water by every one unit (acre) value of the currently conserved area of the wetland. It is important to bear in mind that this is a simple assumption and it also does not consider other factors that potentially affect the wetland ability to filter water. Given the annual degradation which reduces the wetland's conserved area attributed to crop farming, and other land use change practices, population growth which increases the number of households that access water by 3.02% per annum, a present value benefit under the business as usual scenario of US$ **14,771,698** was obtained based on a discount rate of 10%, and a 25 year time horizon. Given the anticipated decline in wetlands conservation area, it is expected that effectiveness in the ability of the wetland to remove turbidity will decline, such decline has been considered in this study as cost of the degradation in relation to water purification ecosystem services, and it is valued at a present value of US$ **3, 652,592** based on 10% discount and 25 year planning period.

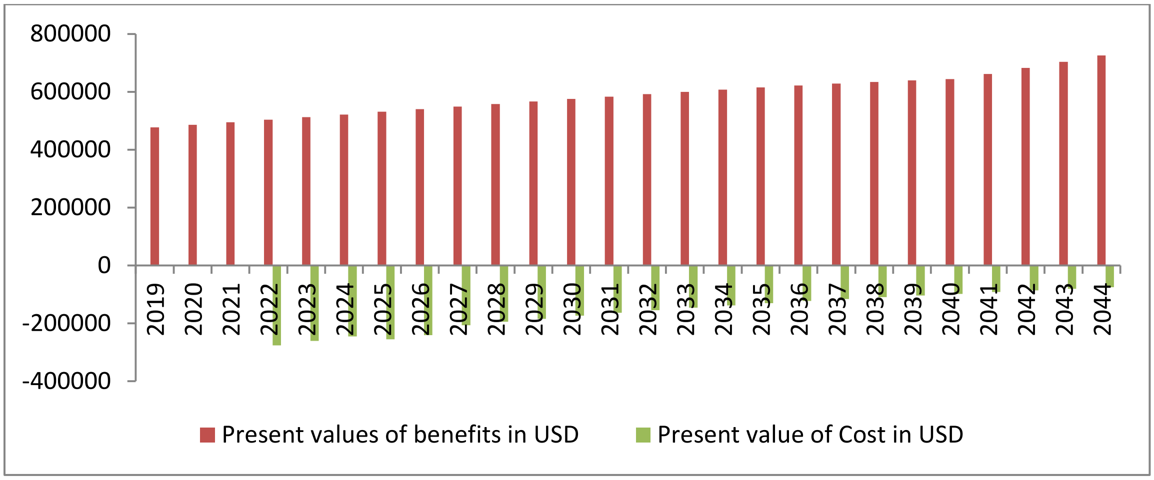

Figure 23: Present value of water purification benefits and of costs under BAU

5.2.1.15. Groundwater recharge

Here we consider future trend/availability of groundwater in relation to household's domestic demand, and availability of groundwater given the land use patterns that affects the conserved wetland associated with ground water recharge. We also assume that there will be growth in the number of boreholes and shallow-wells commensurate with the household's population growth. A direct assessment is the consideration of a relationship between reduction in the wetland conserved area and a drop in the groundwater tables. However, such kind of information was not available in Sio-siteko wetland. We therefore used value transfer from a study conducted by Thompson and Goes (1997) in Hadejia-Nguru wetlands in Nigeria, which showed that there was a drop of 1 to 4 metres in the water table with a 25% reduction of the flood plain area of the wetland. Taking a value transfer of this wetland to Sio-siteko, and assuming that a reduction of 25% of the wetland conserved area will lead to a drop in the water table by a mean depth of 2.5 metres, and that this change is gradual in which a change in the annual degradation rate of the wetland table, then the Sio-siteko wetland water table would decline by 0.4 metres annually given the current degradation rates of 4% per annum.. Similarly, we assume that the growth of boreholes and shallow-wells in the area will be at the rate of population growth i.e. 3.02% per annum. The present value of groundwater recharge benefits based on infrastructure replacement cost for the next 25 years and at a discount rate of 10% is **US $ 4,507,792** in a 25 year period and under 10% discount rate. On the other hand, the extra cost of sinking boreholes and shallow wells at extra depths annually will comprise the cost that degradation of the wetland will place on the local community for accessing groundwater services, and this has a present value of US $ **147,367** over the next 25 years at a discount rate of 10%.

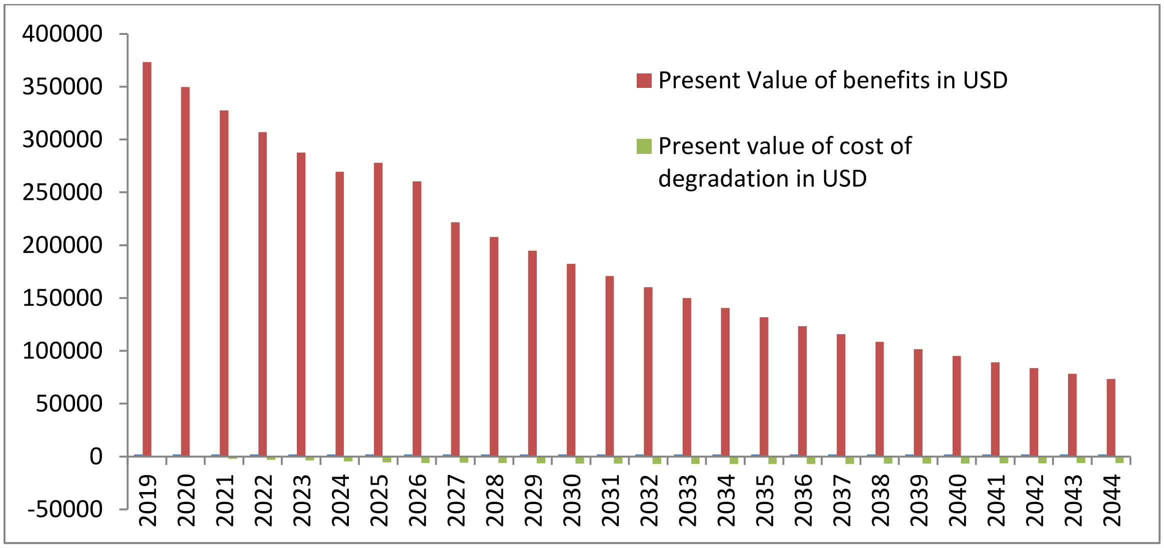

Figure 24: Present value of benefit and of cost under BAU

5.2.1.16. Opportunity Cost

Opportunity cost is the cost of a benefit that could have been received but which has been given up to pursue a certain course of action. The opportunity cost considered under the business as usual scenario is the value of leasing land and this is typically US$ 29 per season for an acre or US$ 58 per year per acre. The present value of the opportunity cost of business as usual scenario for the wetland (14826 acres less built up areas and water channels) is US$ **7,684,661.**

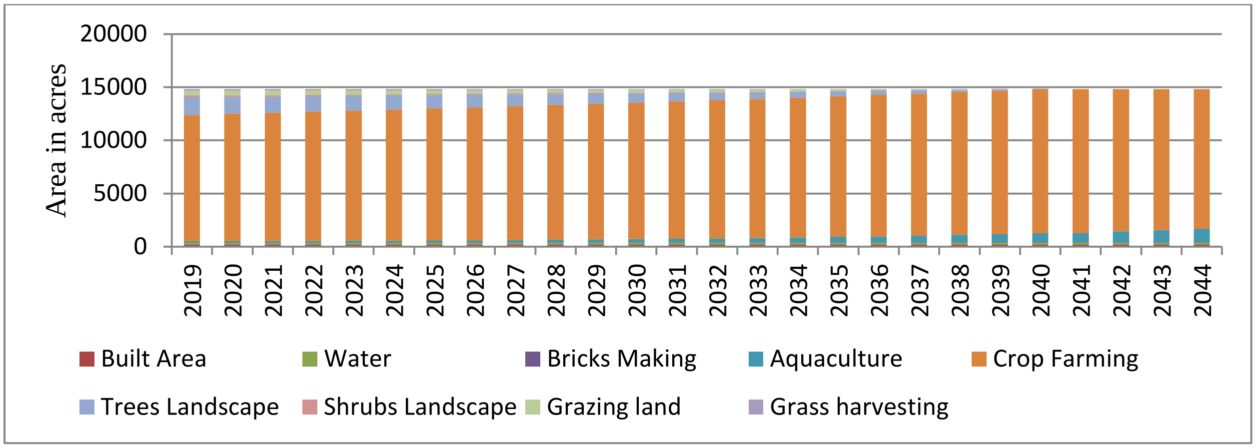

Figure 25: Land use change under BAU

5.2.3. Summary of the Benefit and Costs for Business as Usual Option

Table 29: Net Present Value of Business as Usual Scenario

ITEM	VALUE (USD)
A. Benefits	
Aquaculture	9,928,793
Bricks making	14,275,761
Crops farming	25,776,638
Sand harvesting	26,637,687
Livestock grazing	17,107,538
Grass harvesting	2,639,449
Herbal medicine	5,559,136
Firewood	1,284,707
Mat making	3,189,608
Water supply	61,904,963
Capture fisheries	1,051,469
Biodiversity	5,605,753
Flood attenuation	219,357
Water purification	14,771,698
Groundwater recharge	4,507,792
Total Benefits	**193,408,880**
B. Costs (Degradation costs)	
Sand harvesting	27,703,212
Livestock grazing	290,493,473
Grass harvesting	10,957,877
Herbal medicine	12,466,428
Firewood	749,042
Mat making	2,354,599
Capture fisheries	83,428,880
Biodiversity	3,265,621
Flood attenuation	127,938
Water purification	3,652,592
Groundwater recharge	147,367
Total Costs	351,918,149
C. Opportunity Cost	
Revenues from leasing land for farming	7,684,661
Total Cost	**359,602,810**
Net Benefits (Net Present Value) ***(Present Value Benefits- Present Value Costs)***	**-166,193,930**
Benefit –cost ratio ***(Present Value Benefits/ Present Value Costs)***	**0.54**

5. 2. 2. The Wise use and Conservation Option Approach

The wise use and conservation management strategy is based on the proposed management plan. The management plan option has the overall objective of seeking to restore the wetland and ensure retention of ecosystem services for the benefit of people.' It has three strategic objectives which include; (1) promoting conservation of the wetland ecosystem and its catchment, (2) promoting and supporting adoption of sustainable sources of livelihoods for the local (3) Supporting the establishment and strengthening of governance structures for the management of the transboundary wetland.

In promoting conservation of the Sio-siteko wetland ecosystem and its catchment, the plan proposes five targets namely: to Enhance the protection of wetland water resources for improved water quality and quantity; to Integrate wetland wise-use into river basin development planning; to promote conservation of woody and non-woody vegetation in the wetlands for enhanced socio-economic and ecological benefits; to promote adoption of sustainable fishing practices and responsible aquaculture for improved fish diversity and abundance; to rehabilitate and restore 5% of degraded wetland biodiversity annually. The cost of implementing these targets over a ten year period is **USD 9,297,543** and with a present value of **USD 7,753,779**

For the promotion and support of adoption of sustainable sources of livelihoods for the communities' dependent on the Sio-Siteko transboundary wetland strategic objective, four targets have been proposed in the plan: to promote paludiculture pilots in 60 acres of land for improved ecological integrity and socio-economic benefits; to promote conservation of wetland resources with natural beauty and cultural heritage within the wetland landscape for ecotourism development; to promote adoption of sustainable agricultural practices for improved livelihoods and food security; to promote value-addition of capture fisheries and aquaculture to improve the value chain. The cost of implementing these targets over a ten year period **USD 29,939,199** and with a present value of **USD 24,968,094**

The third strategic objective of the plan is geared towards supporting the establishment and strengthening of governance structures for the management of the Sio-Siteko transboundary wetland, and it has two targets; one is to enhance transboundary coordination and cooperation of transboundary wetland institutions and two is to enhance communication, education and public participation and awareness. The cost of implementing these targets over a ten a year period will be **USD 12,811,375** and with a present value of **USD 10,684,174**

5.2.2.1. Water Resource Management

The major action points under water resource management include; springs protection, rehabilitation/construction of sewer facilities, reforestation of degraded wetland sites and its catchment among others. These activities will be implemented in a span of 5 years and will cost USD 1,212,052. The key highlight of the documented benefit as per the management plan is that 50% of the households will have access to clean water. From the baseline study, 83% of the local community obtain water for domestic use from the wetland, leaving out only 17%. This intervention will therefore increase domestic use of the wetland's water to 92% in five years. It is expected that the intervention will also retain current 83%. In reality however, should more potable water be made available through piping or water kiosks, then the direct drawing of the wetland water may reduce, nevertheless, available piped water is being abstracted from the wetland still.

According to the Sio-siteko monograph, the ground water (mostly boreholes) had higher levels of nitrates and faecal matter compared to the surface waters; they also had higher levels of electrical conductivity, an indication that they are more saline. This essentially mean that surface water, (though more vulnerable to pollution than groundwater in general) may be cheaper to purify and slightly safer compared to the ground water.

Under the water resource management theme, the plan also proposes rehabilitation of degraded areas of wetland (presumed here to be the areas reclaimed for farming) with a total of up to 500,000 wetland friendly trees. Such kind of plant community will have two clear implications, one is that it will take away land being used for agriculture, two, is that it will have an additional benefit of carbon sequestration. If we assume that the proposed wetland friendly trees is bamboo plants, and using the recommended spacing of 5 feet between plantlets, then a total of 73 acres of land will be needed, and in this case crop farming will give way.

Assuming that there will be an even investment in water resource management in the next five years, we can argue that there will be an annual growth rate of domestic water supply from the wetland by 1.8% per annum for the next 5 years. Also, given the annual population growth rate of 3.02% in the project area, the water demand will similarly increase by the same magnitude. In reality though, the demand for the direct access of wetland water might decline into the future given the potential for rural supply of tap water, as to when this will take place and rate of uptake is not yet known since there was no evidence of such plans or documented existing trends in the uptake of rural tap water, hence the reason for not incorporating such as curvilinear approach for this ecosystem service. The total cumulative value of water supply for domestic use over the next 25 years under the management plan is USD **133,667,176** while the gross present value of the benefits of water supply for the next 25 years is **USD 41,789,427**

Planting bamboo for example, has potential benefits such as carpentry enterprises, and or carbon sequestration among others. Bamboo plants generally reach maturity after five (5) years (Arori et al., 2013), and one hectare of bamboo can potentially sequester between 100 and 400 tonnes of carbon (Van der Lugt et al., 2018). The proposed rehabilitation of the wetland with "bamboo" will cover a total of 73 acres (29.2 ha), assuming a carbon price of USD 40 per ton, then the cumulative value of carbon over the next 25 years is USD 4,672,000 and the present value of gross benefits (over 25 year period at 10% discount rate) of bamboo forest establishment project for the rehabilitation of the wetland is **USD, 1,260,035.**

5.2.2.2. Wetland plants conservation

The proposed wetland management plan aim at promoting wise use of the wetland's plants on some sixty (60) acres of land for improved ecological integrity and socio-economic benefits of the local community. This will be attained through planting of trees on the degraded sites, mapping papyrus thriving areas in the wetland, conducting training on rotational harvesting of papyrus and making quality papyrus products, establishing cottage industries for papyrus products. The ecosystem services of interest here is papyrus utilization for mat making.

Away from the papyrus, the plan will promote bamboo establishment for the buffer zones, and related wise use and value addition of bamboo.

Under the management plan, grass thriving areas will be mapped, and also wetland friendly grass such as Napier grass for fodder. A total of 60 acres of land will be established for fodder grass value chain addition as an income generation activity.

From the baseline study, papyrus (represented by shrubs in the landscape mapping) occupies a total of 156 acres. With an active value addition programme under the management plan, it is reasonable to take it that mat making and other related products will not stagnate but instead will grow, and we assume that the growth rate will be at the rate of population growth (i.e. 3.02%). Napier grass has an average yield of dry matter of 10,000 kg/acre/year. Sixty (60) acres will therefore produce 600,000 kg/year of dry matter yield of Napier grass. Using the average price of a bale of hay (15kg) of USD 2.42, the average value of an acre will be USD 1613 per annum. Therefore the total value of benefits of wetland plants conservation initiative under the management plan (papyrus and papyrus products enterprises and fodder grass promotion) will be USD 19,684,585 over the next 25 years and the present value of the **benefits** is USD **6,776,546**.

5.2.2.3. Land Us and Associated Resources Management

According to the management plan, soils, sand, and clay resources will be utilized sustainably to improve the livelihood of resource users by 10% annually. Through the plan; groups will be formed and trained on sustainable sand harvesting techniques, enforcement of regulatory authority's guidelines on sand harvesting, there will be rotational harvesting programme and rehabilitation of degraded sites due to sand harvesting activities, and establishment of trees nurseries for rehabilitation purposes and income generation. The ecosystem services of interest under this strategic thematic category include sand harvesting and bricks making.

From the baseline TEEB study, sand harvesting and brick making are the main soil extraction activities in the wetland area. The management plan has not specified specific action points on brick making through. It is therefore assumed that brick making from the wetland will be eliminated in this management strategy. It can therefore be assumed that brick makers and sand harvesters in areas considered as not meeting sustainability criteria such as river banks and fish breeding areas will be incorporated either into sand harvesting on farms and in river beds outside protected areas, and also enrolled for alternative income generating activities.

So here we take it that the starting baseline will be current sand harvesting values for the farm and river beds outside the area earmarked for protection as fish breeding ground, but for the entire sand harvesting and brick making population and the interventions under the land management will grow annually at 10%. The present value of gross **benefit** of land resource management (sustainable sand harvesting and reallocation of sand and brick makers) over the next 25 years is USD**, 49,450,924.**

5.2.2.4. Forest Conservation

The management plan proposes that 50% of woody and non-woody vegetation in the wetland be conserved for socio-economic and ecological benefits. The action points include; establishment of nurseries to raise fast-growing fruit trees suitable for wetland conservation and planting (mangoes, citrus, pineapple, bananas) 100,000 plants. If mango trees are considered for instance, and given the recommended spacing of 8m by 4m, then a total of 198 acres will be established from fruit trees. Similarly, wetland friendly trees will be planted on 5 hectares (12 acres) of degraded sites. The plan will also establish herbaria in the wetland for the supply of herbs and shrubs for planting in the wetland. From the wetland monograph, trees (presumed to be woody and non-woody plants) constitute 11.1% of the wetland area i.e. they occupy an area of 1644 acres.

The ecosystem services of interest under this thematic category include firewood, fruit trees, carbon sequestration & herbal medicine. From the baseline findings of the TEEB study, the local community mainly draws fuelwood from the wetland alongside herbal medicine. During the household survey, herbal plants were reported to be on the decline by majority of the households. With the planned efforts towards enhancing regeneration of plants including establishing herbaria, and ensuring as standing biomass of 50%, it is safe to conclude that continued use of firewood and herbal medicine from the wetland will not lead to degradation of these resources, we assume the trees landscape will not under further reclamation and that it provided medicinal plants value proportional to its size. Similarly, we take it that an acre of land of bamboo will produce 200 metric tons of carbon per year after 5 years, and that 1 ton of carbon is valued at USD 40. So the carbon value of the bamboo after the fifth year will USD 96000 (200*40*12) per year and USD 1,920,000 for the next 25 years, and present value is USD **517,823.**

Under this strategic objective, 100,000 mango fruit trees will be grown, if it is taken that a fully grown (6 years after planting) mango tree yields an average of 300 mango fruits annually and assuming a farm gate price of USD 0.05 per fruit, then, the annual value of mango fruit trees will be USD 1,500,000 after the sixth year (Jurgen, 2009), and the total value over the next 25 year is USD 28,500,000 in which the present value at 10% discount per year is USD **7,159,592.**

Tree landscape (1644 acres) is also taken to produce 66.6% of total value of herbal medicine under sustainable wetland management, and this will lead to generation of a total of 65,758,226 over the next 25 years USD **12,185,044** per annum.

Firewood production will generate benefit of USD 5,535,650 over the next 25 years and present value of USD **2,033,748** over the same period under 10% annual discount rate.

5.2.2.5. Biodiversity conservation

The proposed wetland management plan, aim at promoting sustainable utilization of wetland biodiversity by 5% annually. Key action areas include planting 5000 fodder trees along buffer zones, clear demarcation of wetland boundaries, protection of breeding sites for animals, birds, worms, ants, termites and bees by use of hedge rows, formulation of laws on hunting and burning in wetland areas, sensitization and capacity building on sustainable management of wetland biodiversity through community meetings, radio talk shows; enforcement of laws protecting wildlife, promotion of anti-poaching through alternative income generating activities like bee keeping, craft making.

The baseline value of biodiversity is USD 965,878. Given the scale of the proposed interventions, it is reasonable to expect that the level of appreciation of biodiversity and subsequent willingness to contribute towards conservation will increase; it is therefore taken that the annual willingness to contribute towards biodiversity conservation will grow by 5%. The present value of gross **benefit** of biodiversity conservation over the next 25 years is USD **14,268,838.**

5.2.2.6. Sustainable Management of Fisheries Resources

The management plan proposes to sustainably manage the fisheries resources in order to increase food security, nutritional security and livelihood improvement by 5% annually. The main action points here include; protection of fish breeding sites, establishment of two hatcheries in the catchment area, construction of 200 fish ponds, and stocking and provision of fish farm inputs i.e. 200, 000 fingerlings. Protection of fisheries breeding site will cost $ 98,392, while promotion of aquaculture will cost $ 413,243. Here we assume that the 200 fish ponds will be constructed within the wetland. The most sustainable size of a fish pond is $500m^2$, it follows that the management plan will add an additional 25 acres of the wetland land for aquaculture. From the baseline assessment, the average number of fish ponds owned by an individual was two; it can be assumed that 100 farmers will be beneficiaries of the new fish ponds, and total number of farmers will therefore be 532 (baseline farmers was 432), and total area under aquaculture will be 128 acres (baseline area was 103 acres). We assume that the 200 fish ponds will established on the first year of implementation of the conservation management plan and so benefits will accrue from the second year, and the number will remain so for the next 25 years. The gross present value of the benefits from aquaculture of the next 25 years at 10% discount rate is **US$ 4, 140, 091.**

From the baseline land use, naturally vegetated areas and water channels occupied 2654 acres, and proposed activities of restoration in the management will add further 464 acres from degraded areas and we assume these are will be taken from cropland areas, making areas available for capture fisheries productivity 3118 acres (12.62km^2) by the fifth year of the conservation management plan implementation. Using equation (19), the total sustainable value of fish over the next 25 years is **US $ 4,125,777** and the gross present value based on 10% discount is **US $ 1,494,998.**

5.2.2.7. Agriculture and livestock production

The proposed wetland management plan aim at sustainable food production by 50%, though it does not emphasize promotion of active crop farming or grazing in the wetland. It mainly promotes growing of 100,000 seedlings of indigenous vegetables around wetland areas, and value addition of tubers and roots (presumed to be arrow roots) of up to 5000 products. The ecosystem services of interest under this strategic objective include; crop farming, livestock grazing, grass harvesting, and grassland landscape herbal medicine. Taken that both indigenous, tubers and roots production will take place around the wetland and not inside the wetland, and if we presuppose that with the management plan there will be no reclamation of the wetland for crop farming expansion. Suppose that each seedling and tubers and roots products yields USD 1, then over the next 5 years indigenous vegetables will USD 100,000, while the roots and tubers will yield USD 5000 hence the total benefits will be USD 105,000. The cost of carrying out these activities will be around USD 76,775 over a five year period. It can also be presupposed that the initiative will be sustainable so that a steady stream of income will flow after full investment by the end of the fifth year. One way of advancing sustainability is through investing the final cost of implementing the intervention each year through the community established structures and this could be apportioned from the benefits that the community derives from the two initiatives. Therefore the gross benefits over the next 25 years, assuming constant returns, will be USD 2,323,772 and costs over the same period will be USD 238,003. Similarly present value of the **benefits** over the next 25 years at 10% annual discount rate is **USD 803,157**.

It is also assumed that restoration activities on degraded areas will take up space from crop farming land in the wetland, and that there will be no more reclamation of the wetland, hence land available for crop farming from the baseline will be 11426 acres. We use the figure of the land available for crop farming which is above the mean total crop land (10307 acres) reported by households during the survey. The total value of crop farming within the wetland over the next 25 years will be USD 64,017,469 and present value at 10% annual discount rate is **USD 23,614,407.**

Similarly, it is also assumed that only sustainable grazing and grass harvesting will be allowed under the wetland plan management. The value of sustainable grazing for the next 25 years is USD 73,731,000 and the present value at 10% annual discount rate is **27,088,112**; while the value for grass harvesting is USD 11,827,998 and the present value is **4,178,366.** Curtailment of further degradation of the grassland will also benefit herbal medicine ecosystem services**,** and it is expected that the value of herbal medicine over the next 25 years will be USD 2089450 and the present value of herbal medicine at 10% discount rate is USD **767,829.**

5.2.2.8. Ecosystem services not directly aligned to the direct targets of the strategic objectives

Flood attenuation ecosystem service

Flood attenuation role of the wetland is assumed to be directly linked with the spatial extent of shrubs, trees, and grasslands that break the speed and spread of the river waters when it (the river) breaks its banks due to heavy rainfall. Conversion of wetland into cropland and aquaculture exposes the wetland to flooding, while restoration of the wetland, like it is proposed in the wetland conservation management plan reduces the vagaries of wetland flooding. A total of 464 acres of degraded land will be restored based on the proposed wetland management after five years. Here again we make a simple assumption (even though it is also commonly know that some other factors like soil characteristics, topography, soil moisture status also contributes to wetlands ability to help in flood attenuation) that an acre of conserved wetland would help save upto 24.84 dollars in maize in 0.8 acres of land (Acreman & Holden, 2013). Therefore, the total economic contribution of flood attenuation will be **USD 1,111,225**, with a present value of **USD 401,578** over the next 25 years and at10% discount.

Water purification ecosystem service

Establishing the economic value of water purification services for conservation scenario is based on the same principles used in the business as usual case, except that while the land use change attributable to water purification is declining in the business as usual scenario, here restoration efforts over the next five years will increase surface area purifying turbid water. We also assume the efforts will be self-sustaining beyond the five years of conservation management implementation, i.e. degradation will not resume, though we take it that there will be no further restoration of reclaimed wetland areas. Again we assume that mean NTU (75) will remain constant over the next 25 years. Therefore, the cumulative economic value of water purification services under conservation management plan in the next 25 years is **USD 18,412,786** and present value based on a 10% discount rate over the same period is **USD 5,864,251.**

Groundwater recharge ecosystem services

Based on the observation that a reduction in the flood plain area of the wetland leads to lowering of water table (van der Kamp & Hayashi, 2009), we also assume that an increase in the surface area of the flood plain of the wetland would lead to an increase in the water table. Using value transfer from Thompson and Goes (1997) study of the Hadejia-Nguru wetlands in Nigeria, we presume that an increase in the flood plain by 25% or more would lead to an average increase in the water table of 2.5 metres of the water table. The conservation management plan would restore a total of 464 acres in five years, equivalent to 3.5% annually for five years. Assuming that the benefits starts accruing from the second year, and that 3.5% would then increase the water table by 0.35 metres, that the growth of the boreholes and shallow-wells will increase annually at population growth rate of 3.02%, and using the concept applied in section 5.3.5 and 6.2.16 then the replacement cost of the benefits under conservation will be **USD 14,328,490** over the next 25 years and at a discount rate of 10% per year, the present value of the replacement cost will be **USD 4,556,287.**

Opportunity cost of Conservation

The opportunity cost of wetland conservation, considered in this study is value of foregone agricultural expansion under the business as usual scenario. The conservation management plan proposes to restore 464 acres of degraded wetland areas. The baseline valuation the gross value of benefits from crop farming is **USD 223.38** per acre. Assuming that there will be an even restoration of the wetland i.e. 92.8 acres annually for the next five years, then the total opportunity cost over the next 25 years will be **USD 2,383,911** and its present value at 10% discount rate over the same period is **USD 779,867**.

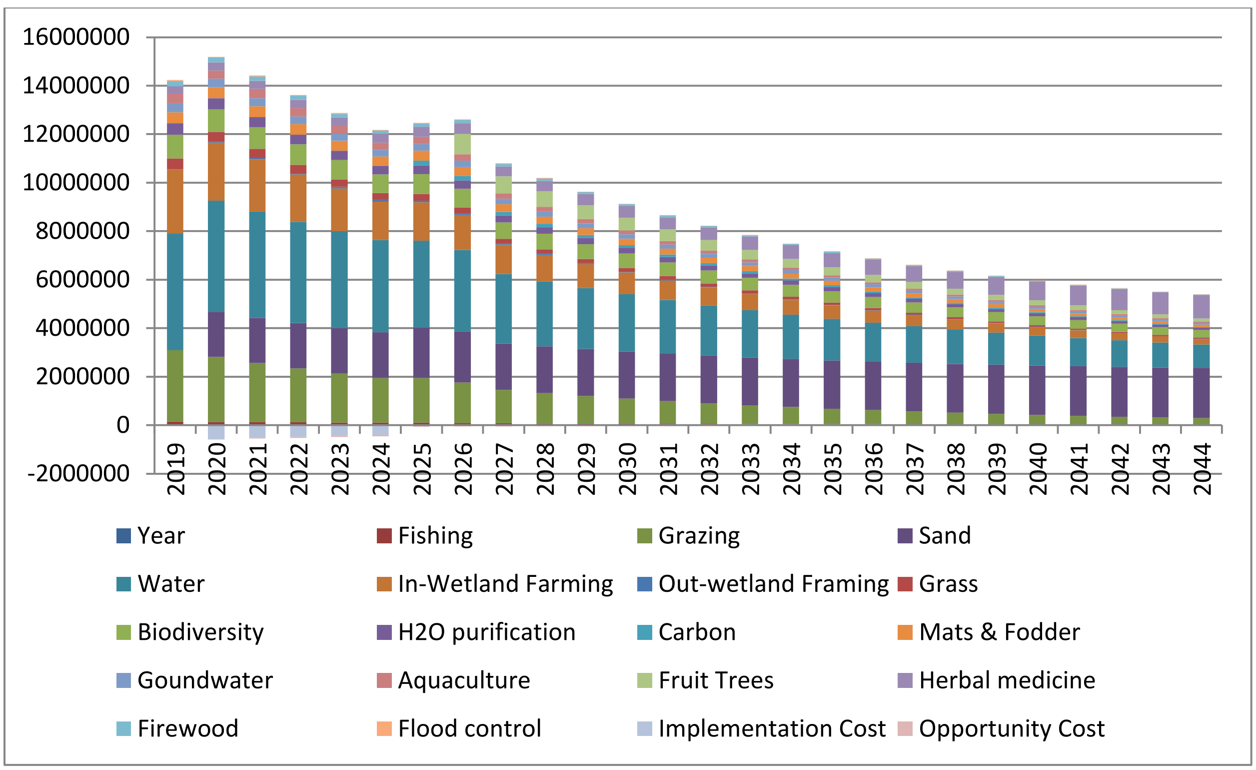

Figure 26: Present Values of benefits and costs under the conservation management scenario

5.2.3. Summary of benefit and costs for wetland management plan option

Table 30: Present value of benefits and costs of wetland management plan

Item	Value (USD)
A. Benefits	
1. Domestic water supply	42,145,677
2. Carbon sequestration	1,777,858
3.Capture fisheries	1,494,998
4.Aquaculture	4,140,091
5. Sand harvesting	49,450,924
6.Mat making & fodder grass	6,776,546
7. Herbal medicine	14,175,825
8.Firewood	2,033,748
9. Fruit trees	7,159,592
10.Crop farming within the wetland	23,614,407
11.Crop farming around the wetland	803,157
12.Grazing	27,088,112
13. Grass harvesting	4,178,366
14. Biodiversity maintenance	14,268,838
15.Flood attenuation	401,578
16. Water purification	5,864,251
17.Groundwater recharge	4,556,287
Total value	***209,930,255***
B. Costs	
1. Implementation costs	43,406,048
2. Opportunity cost (Crop farming)	779,867
Total value	***44,185,915***
Net Present Value (Benefits-Costs)	***165,744,340***
Benefit-Cost Ratio	**4.75**

5. 2. 4. The Agricultural Intensification Option Approach

5.2.4.1. Introduction

This management option entails introduction of intensive fish and rice farming on the Kenyan and Ugandan sides of the wetland respectively. We assume that only farming activities currently taking place in the wetland are the ones to persist, in which crop farmers on the Kenya side will switch to intensive fish farming and their counterparts in Uganda will also switch to rice farming.

Economic analyses of both rice and fish farming have been considered, covering both revenues and production costs. In addition, environmental benefits and costs if any on the environmental dimension have also assessed. However, the estimation of the economic values for baseline values, and the subsequent use in business as usual and conservation scenarios have used gross values, it is only the gross values of the intensification scenario has been presented in this report for consistency in the application of the values. The intensification scenario is a hypothetical scenario since there are no working documents for such programmes, the figures used are therefore based on value transfer from intensification programmes.

It is documented that wetlands in the Lake Victoria basin typically undergo an annual degradation at a rate of 4%, we assume that this is in relation to reclamation of wetland (which is majorly for agricultural production). Therefore like in the case for business as usual, there will be a 4% (equivalent to 594 acres) annual expansion of land for both rice and aquaculture.

The casualties of this expansion will be shrubs (papyrus), trees landscape, and grasslands, water quality will also deteriorate given active use of fertilizers associated with this option. Assuming that there is a 50-50 share of the Sio-Siteko wetland on both sides of Kenya and Uganda respectively, the proportion of the crop land that will be available for the initial intensive rice farming and aquaculture will be 5997 acres for each, and the entire available wetland landscape on each side is 7213 acres.

5.2.4.2. The Benefits under Agricultural Intensification option

Gross value of baseline Rice Intensification = $ 9,824,541 for an area of 5553 acres or $1769 per acre. Given the annual degradation of the wetland through reclamation at a rate of 4% per annum, we argue that each year, 4% equivalent of the current size of the wetland on the Ugandan side will be converted to rice farming. This is equivalent to an addition of 297 acres annually for rice farming which will translate into an annual increment of gross value of $ 525,393. However, since the total wetland land on the Ugandan (taken to be 50%) of the total wetland size) is 7213 acres. It follows that under agricultural intensification which is also assumed to expand at the current rate of land degradation, expansion will peak in the next six (6) years upon which the whole of the wetland shall have been reclaimed for rice farming.

Generally, it is always expected that productivity will decline due a number of factors such as overuse of soil nutrients; however, it is argued here that production will not see a decline due to scientific research which will enable for more innovative ways of enhancing productivity. Rice production under this management will rise to USD 12,761,081 by 2025 and thereafter levels off because of lack of any more wetland space for cultivation. The total present value of rice farming b**enefit**s under agricultural intensification over the next 25 years is USD **111,672,681.**

Similarly, the most likely intensification agricultural scenario in Kenya is aquaculture given the discussions with government officials. We take it that it is the current fish farming or crop growing households that are likely to be the initial lot of fish farming households under this intensification programme. It is also argued that there will be new fish farming households entrants annually whose cumulative entry into fish farming will reclaim 297 acres of land annually consistent with the documented annual degradation rate of the Lake Victoria basin wetlands of 4% per annum. Based on the size of the wetland, it will take only six (6) years under this programme for the available wetland land that can be reclaimed on the Kenyan side to be fully harnessed for fish farming. The average fish pond size in Kenya measure $300m^2$ and the most preferred fish for aquaculture in Kenya is the Tilapia. Under an intensive programme, in a year, such a pond yields a total of around 200 kilogrammes of fish and at an improved farm gate price of $ 2.9 per kilogramme, and assuming each pond has perimeter area of 2 metres wide, then a total of 50,985 ponds can be established from the current wetland area under reclamation. This can lead to a total gross value of fish equivalent to $ 29,571,300 per year. With an annual reclamation of 297 acres per year in the next six (6) years, the total gross present value of aquaculture **benefit**s is $ **318,725,856**. The total gross present value of agricultural intensification **benefits** for Sio-siteko wetland **$ 430,398,537**

Table 31 : Present values of benefits for the agricultural intensification scenario

Agricultural intensification programmes	PV in 5 yrs	PV after 10yrs	PV after 15 yrs	PV after 20 yrs	PV after 25 yrs
Rice farming in Uganda	42,839,583	74,251,640	92,901,619	104,482,109	111,672,681
Aquaculture in Kenya	126,875,806	214,426,779	266,407,578	298,684,459	318,725,856
Total	169,715,389	288,678,419	359,309,197	403,166,568	430,398,537

5.2.4.3. The cost of wetland degradation and loss under agricultural intensification option

Costs related to agricultural intensification in a wetland typically include: (1) production costs such as labour, fertilizer, pesticides, feed, fingerlings, water, seeds among others; (2) environmental impacts; and (3) loss of land for ecological and other socio-economic benefits. In this study, we have used gross values for the benefit section; hence it is not necessary to assess production costs.

The environmental impacts associated with intensive paddy rice farming in a wetland like Sio-siteko typically entails climate change (caused by fertilizers and anaerobic processes emitting methane gas), ozone depletion (caused by pesticides and allied chemicals), human toxicity (majorly caused by pesticides and other allied chemicals), acidification of the terrestrial environment (majorly caused by fertilizers), and eutrophication of the water systems (also caused by fertilizers) (Fusi et al., 2014).

Similarly, the environmental impacts associated with aquaculture in a riverine wetland ecosystem entails; changes on landscape and hydrological patterns, salinization/acidification of soils, pollution of water for human consumption, eutrophication and nitrification of effluent receiving ecosystems among others (Martinez-Porchas & Martinez-Cordova, 2012). While there are a number of environmental impacts as highlighted in this subsection, it is only an ex ante evaluation of greenhouse gas emission potential that has been assessed.

Emissions of greenhouse gas (fertilizers and methane)

Application of conventional fertilizers is associated with greenhouse gas emissions which contribute to climate change. The effect of such fertilizer application is greater in intermittently flooded rice farming compared to continuous flooded rice farming which is majorly associated with emission of methane gas (de Miranda et al., 2015). Both Methane (CH_4) and Nitrous oxide (N_2O) are greenhouse gases with global warming potential of 25 and 258 in comparison to carbon dioxide gas (Brander & Davis, 2012). The baseline area for rice growing under this management option is 5553 acres in which rice can be grown twice a year therefore the baseline methane gas emissions for the baseline year would be T_c= 8.9892 X 10^{-4}million tons. If we assume a price of USD 40 per ton of carbon (Adkin, 2017), then the present value of methane gas (converted into carbon dioxide equivalent) over the next 25 years is USD **10,324,540**

Water supply losses

Since water from the wetland will be used for irrigating rice fields and fish ponds within the wetland without transferring it to distant locations, there will be no net loss of water supply outside the wetland as a result of agricultural intensification, except of some enhanced evapo-transpiration due to loss of sufficient vegetation cover. However, like identified elsewhere, this water may not be fit for domestic home use, given the levels of fertilizers, pesticides and other products dumped into the water resource. Intensive paddy rice farming may include application of herbicide, insecticide; mollussicide and fungicide. Each of this type of pesticide has different toxicity level (lethal dose 50). Owing to the limitation of data, the environmental costs of fertilizer and pesticide has not been monetized, rather we assume that water will not be fit for domestic use, hence the projected water supply identified in the business as usual is taken as the an externality of both aquaculture and intensive rice farming hence a cost. This will result into a present value loss of water worth USD 61,904,963 over the next 25 years.

Loss of land for ecological, hydrological, and other socio-economic functions

Biodiversity loss

Around 17.9% of the wetland's landmass hosts various plants and animals hence the annual loss of 4% of the wetland to agricultural intensification directly impacts the biodiversity maintenance value, most of the plants will be lost, majority of mammals will also be lost, and there will be massive decline of aquatic animals. Wetland area currently available for biodiversity maintenance is 2654 acres and the baseline value of biodiversity if USD 965,877 per year. The annual loss of 4% translates into 593 acres of land; it follows that land available for biodiversity maintenance will be lost in four (4) years under this management. We assume that this will lead to 60% loss in biodiversity value; we also assume that the first 4 years of annual loss of 4% of land will lead to a 15% annual decline in the value of the biodiversity. The total present value of biodiversity loss under this management option for the next 25 years is **USD 4,579,362.**

Flood attenuation loss

Flood attenuation role of the wetland is largely offered through the shrubs, trees, and grasslands that break the speed and spread of the river waters when it (the river) breaks its banks due to heavy rainfall. Conversion of wetland into cropland, and aquaculture exposes the wetland to flooding, we therefore argue that economic value of the wetland will be declining overtime given the degradation of the wetland at the rate of reclamation of the shrubs, trees, and grasslands, therefore the present value of flood attenuation role of the wetland that will be lost over the next 25 years will be **USD 213,411**

Fisheries habitat, breeding ground loss

The productivity of capture fisheries will decline given the fact that water will be diverted into rice farms and fish ponds. We therefore assume that only the current water channels will be available for fish habitation. Therefore the economic value of fisheries resources based on the decline of the fish refugia at the rate of adoption of intensification programme and the anticipated persistence of the water channels is USD 927,975.for the next 25 years and has a present value of **USD 467,234** at 10% discount rate. Lost productivity due to reclamation constitute the cost of capture fisheries and this has total economic value of USD 3,752,780 over the next 25 years, and a present value of **USD 1,470,047** over the

Livestock grazing losses

About 4.2% (623 acres) of the wetland landscape is grassland which the local community use to graze their livestock. From the baseline valuation, 57% of the households take their cattle to graze in the wetland. The baseline economic value of grazing was $ 6,530,093. Even though the growth of local breeds of cattle is likely to decline going forward given their low productivity, the increase in human population growth will put pressure on private land owners and the wetland grassland is likely to experience greater usage as a grazing ground, it is therefore argued here that the value of the wetland as a grazing ground will increase at the rate of population growth till the carrying capacity is reached. However, this value will be wiped out by intensive farming which will reclaim the entire wetland in its fourth year of adoption. Hence the value and potential growth in value of livestock grazing role of the wetland will be a lost value to the local community members owning livestock. The present value of the loss sustainable livestock grazing is USD 17,116,058.

Grass harvesting losses

It was assumed that grass was being harvested from an area not exceeding156 acres (one quarter) of the grassland area. Four major uses of harvested grass included; livestock feeding at home, thatching, broom making, and sale. It is thought that all these uses of grass will increase as population increases except thatching which will experience a decline as people favour iron sheets for roofing given decline in poverty levels. Past trends in poverty decline has never been predictable, hence difficult to establish an annual projected rate of decline of poverty levels for the next 25 years. The value of thatching has therefore been left at a constant rate, while the demand for other services is projected to increase at the rate of population growth rate which is 3.02 % per annum. Given the quick regeneration rate of grass, it is assumed the annual demand of 3.02% will be sustainable for the next 25 years. The reclamation of the wetland (at an annual rate of 4%) land will however lead to total loss of this service by the fourth year despite the demand. We therefore present this as a projected value lost in the next 25 years due wetland landscape reclamation for intensive agricultural investment. The present value of grass that will be lost in the next 25 years is USD 2,639,449.

Firewood services loss

Here we consider the economic value of sustainable firewood harvests that will be lost due agricultural intensification over the next 25 years, and also short intervals of 5 years each. Firewood losses/costs are mainly due to reclamation of the trees landscape for fish and rice farming in a more intensified agricultural management of the wetland. This will result into present value loss of firewood ecosystem services worth US 1,284,707.

5.2.5. Assessment of benefit cost ratio for agricultural intensification option

Table 32: Present value of benefits and costs of agricultural intensification scenario

ITEM	COST (USD)
A. Benefits	
1. Rice Farming	111,672,681
2. Aquaculture	318,725,856
3. Capture fisheries	467,234
Total Benefits	***430,865,771***
B. Costs (externalities)	
1. Greenhouse gas emissions	10,324,540
2. Water supply	61,904,963
C. Costs (opportunity costs)	
3. Sand harvesting	26,637,687
4. Livestock grazing	17,116,058
5. Grass harvesting	2,639,449
6. Herbal medicine	5,559,136
7. Firewood	1,284,707
8. Mat making	3,189,608
9. Capture fisheries	1,470,047
10. Biodiversity	4,579,362
11. Flood attenuation	213,411
Total Costs	***134,918,968***
Net Benefits (Net Present Value)	**295,946,803**
Benefit –cost ratio	**3.19**

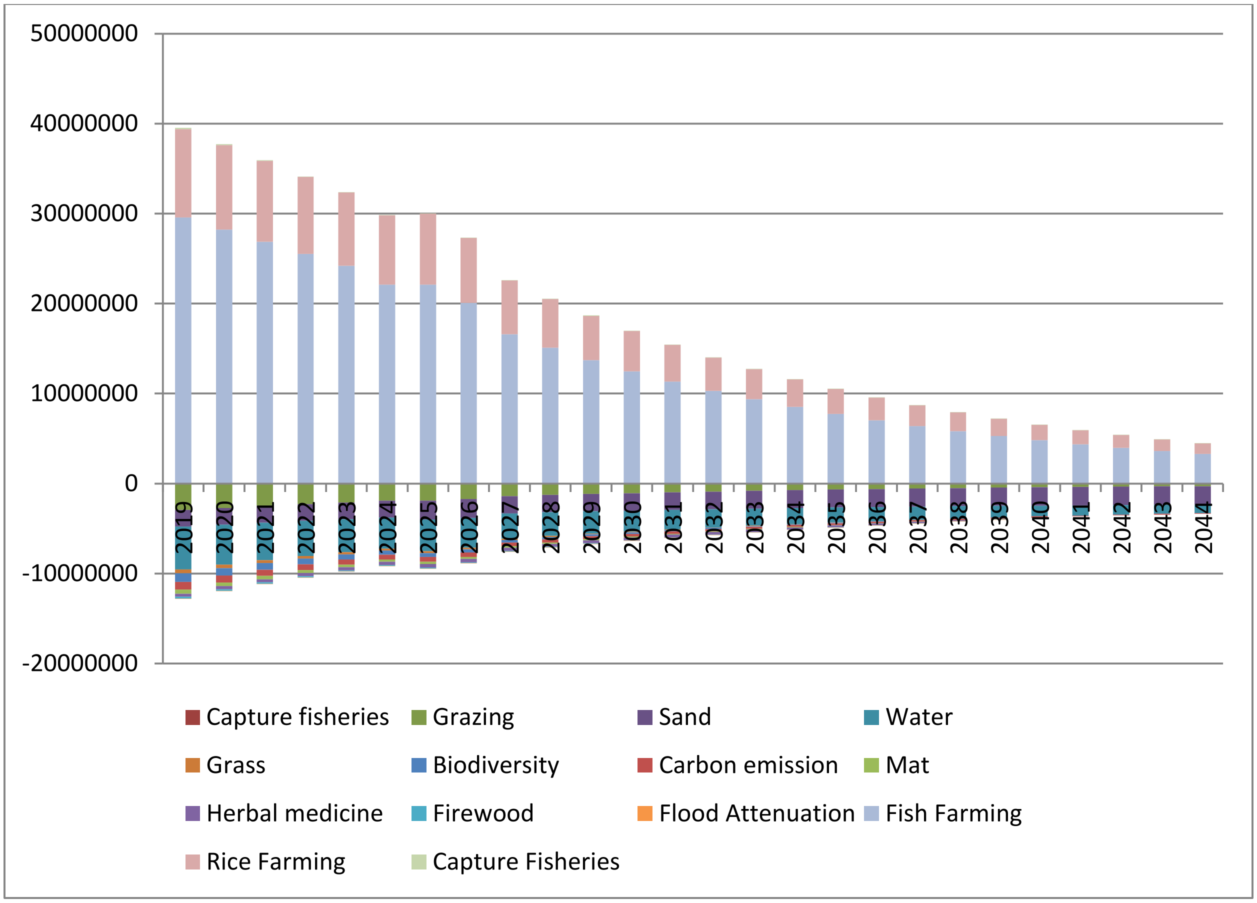

Figure 27: Present values of costs and benefits of agricultural intensification scenario

5.3 Summary of benefits and costs of the management options

Table 33: Comparison of benefits and costs of the different management options

CBA Indicator	Business as usual	Conservation	Agricultural Intensification
Present value of Benefits	193,408,880	209,930,255	430,865,771
Present value of Costs	359,602,810	44,185,915	134,918,968
Net Present Values	-166,193,930	165,744,340	295,946,803
Benefit-Cost Ratio	0.54	4.75	3.19

Chapter 6: Analysis of the Distributional Effects of the Management Options

6.1. Overview

By their very nature, the different management options considered in this study have distributional impacts since each would change the consumption and production patterns of the wetland's ecosystem services by households. This chapter therefore seeks to highlight the distribution of impacts among stakeholders from changes in ecosystem services. The distributional effects have been assessed in terms of spatial distribution (where the impacts will occur), temporal distribution (when the impacts will occur), and distribution among the wetland ecosystem services beneficiaries (identification of who will and how they will be affected).

6.2 Spatial distributional effects

In spatial distributional effects, the concern is to assess how a management option affects the distribution and availability of the ecosystem services at local, regional and global scales. The ecosystem services that have global effects are mainly carbon sequestration and emissions, biodiversity maintenance, water purification, and capture fisheries (fish breeding site). This is because carbon sequestration and emissions are related to climate change which is a global phenomenon whose effects or emissions transcends beyond national borders irrespective of the point of origin. The conservation management option will contribute to climate change mitigation due to planting of trees and enhancement of wetland carbon sequestration capacity, while the agricultural intensification will lead to increase in release of greenhouse gases thereby contributing to climate change. Wetlands are known to be home to globally endanger animal species such as the water-bucks and *Sitatunga* group of antelopes, this make biodiversity maintenance a global service. Water quality and capture fisheries breeding sites would affect the quality and quantity of fish in the Lake Victoria which are also traded in export market hence global in nature. The management option which provides a better quality of these services is the wetland conservation management plan; there is a gradual and consistent deterioration in quality and quantity of these ecosystem services under the business as usual scenario, while the agricultural intensification will almost decimate the availability of these services by the fourth year given the assumptions considered.

Ecosystem services with regional impacts include aquaculture, rice farming, and groundwater recharge. Agricultural intensification presents the best option for providing the region with increased rice supply and farmed fish. While the conservation scenario presents the best option for groundwater recharge across the aquifer.

The ecosystem services with local impacts include; capture fisheries (fishing), livestock grazing, firewood, domestic water supply, sand harvesting, herbal medicine, grass harvesting, among others. These services are best offered under conservation management option and business as usual scenario.

6.3. Temporal distributional effects

Temporal distributional effects concerns assessment whether the effects will be short, medium or long term. Generally, changes in ecosystem services are considered to take quite some time in order for change to manifest. Within the realms of government's planning, 25 years is typically considered the minimum duration for a long term planning, while five years and ten years are considered short and medium terms respectively. The business as usual scenario will lead to complete reclamation of the wetland by 2041 and most ecosystem services such livestock grazing, mat making, flood attenuation among others will be wiped out. It is only under the conservation management scenario where the current ecosystem services will persist past 25 years from the baseline year of 2019.

6.4. Beneficiaries distributional effects

Assessment of beneficiary distributional effects is based on economic values gained or lost (collectively) by the different wetland resource user groups under each potential wetland management option. Based on focus group discussions, key informant interviews, household surveys, and review of the draft wetland management plan, the beneficiaries of the Sio-siteko wetland ecosystem services can be divided into over ten user and interest groups, and each group will be impacted disproportionately by each of the management options.

6.4.1. Sand harvesters

Sand harvesters will receive unhindered benefits under the business as usual scenario. Entry and exit of the business will free probably till 2041 when the entire wetland shall have been reclaimed under this scenario. Though sand deposition will still be taking place, those who shall have reclaimed the wetland for crop farming will most likely make attempts to block sand harvesters from accessing to wetland. The battle for accessing the wetland for extraction sand will probably begin early under the agricultural intension (as early as the fifth year after the roll the roll of such a programme). Under the conservation scenario, access to the wetland will be restricted to some areas only. However, access to the unrestricted areas will not be hindered as is the case with the other two scenarios

6.4.2. Brick makers

Bricks making is a regulated venture in the wetland and easily be classified as an illegal activity, though it is thriving at the moment and, they will remain beneficiaries under the business as usual option. The user groups have not been taken care of under conservation scenario, and will also run into conflict with the agricultural intensification management option.

6.4.3. Domestic water users

Users of surface water will enjoy access of the resource from the wetland in both business as usual scenario and conservation scenario though the latter will see more friendly use and enhanced usage. The need to purify the resource will be less costly under the conservation management option while it will be costly under the business as usual scenario. The resource will appear unfit for home use under the agricultural intension since there will be a lot of abstraction into both rice and fish farms coupled with pesticides and chemical fertilizers, and increased turbidity. Access of groundwater under conservation scenario will be cheaper compared to the other two scenarios under the former the water table will be higher.

6.4.4. Fish farmers

Fish farmers will be beneficiaries in both business as usual and conservation scenario since both options promote fish farming. However, conservation scenario will provide the incentives and infrastructural needs for successful fish farming hence it offers better option for fish farmers than the business as usual scenario. The agricultural intensification will also provide incentives for fish farmers, but this will be limited to the Kenyan side hence those fish farmers in Ugandan side of the wetland will miss out.

6.4.5. Capture fisheries Fisher folks

Capture fisheries in wetland is currently overfished, therefore the conservation scenario might seek to limit number of people engaging in fishing. Agricultural intensification will also degrade the fishing breeding and spawning areas including habitat hence there will be very fewer people engaging in fishing under this scenario within the fourth year operation.

6.4.6. Crop farmers

Crop farmers will be beneficiaries in both business as usual and conservation scenario since both options promote Crop farming. However, conservation scenario will provide the incentives and infrastructural needs for successful crop farming around the wetland instead of further reclamation of the wetland. As such under conservation there will be no further growth of farming families within the wetland as opposed to the business as usual scenario. The agricultural intensification will also provide incentives for crop farmers, but this will be limited to the Ugandan side hence those current fish farmers on the Kenyan side of the wetland will miss out.

6.4.7. Firewood harvesters

Access to firewood in the wetland is less common, nevertheless it will diminish under the business as usual scenario towards 2041 and agricultural intensification within the first five years. It will however be enhanced under conservation scenario since it is assumed that there will be no further reclamation of the wetland.

6.4.8. Livestock grazers and grass harvesters

The conservation scenario should limit the number of cattle grazing in the wetland to permit sustainable use of the wetland for pasture access. It follows therefore that livestock grazers might be called upon to look elsewhere for grazing part of their stock. In agricultural intensification scenario, livestock grazers will lose pasture land in its entirety. Under the business as usual scenario there will be no any form of restriction on access, however, because of reclamation and overgrazing, pasture and pasture land will be lost with time be lost eventually.

6.4.9. Herbal medicine users

There will be some value addition incentives for herbal medicine users and enhancement of access to this ecosystem service under the conservation scenario. However due to wetland reclamation under both business as usual and agricultural intensification, access to herbal medicine rom the wetland will be degraded and lost these two latter management options.

6.4.10. Mat makers

Mat makers will have a sustainable supply of papyrus and enhanced value of papyrus products such as mats under the conservation scenario. However, this service will be lost quickly under the agricultural intensification scenario and will also be diminished and eventually be lost under the business as usual scenario.

Chapter 7: Sensitivity Analysis

To assess the robustness of the results, sensitivity analysis is used to determine the effect changes in key assumptions and parameters have on the estimated values (Olsen & Shannon, 2010). The main objective in this chapter was to establish if changing the values of parameters used in the study affect the economic benefits or costs, and sufficiently to make the present values negative or positive. This was explored through the following key parameters: (1) discount rate; (2) time horizon; (3) application of 30% of conservation implementation cost as an annual management cost throughout the next 25 years under the conservation option without further expanding conservation investments. The results of sensitivity analysis are presented in table 34

Table 34: Results of sensitivity analysis

Original assumption	Revised assumption	Revised NPV BAU	Cons.	Agri.	Effects on NPV BAU	Cons.	Agri.
The underlying assumptions							
Original discount rate (10%)	5%	-446,059,863	386,074,132	463,003,396	No effect	No effect	No effect
	15%	-168,531,025	125,789,412	211,018,796	No effect	No effect	No effect
Time horizon (25 years	5 yrs	-76,132,139	65644116	120,149,151	No effect	No effect	No effect
	10 yrs	-139,287,270	121,079,034	205,287,603	No effect	No effect	No effect
Cost based parameters on conservation management plan							
Conservation investment cost (One off for the first 5 years)	30% of the mean annual investment after the initial 5 yrs	-164,484,740	205,716,101	295,946,803	No effect	No effect	No effect

The three assumptions tested have impacts on the economic values but not to the extent of yielding making the present values negative outcome. In particular, using a lower discount rate increase the present values of all the management options, the converse is true for higher discount rate. Applying 30% mean annual implementation cost of the management plan (assumed to be recurrent expenditure for facilitating enforcement and compliance with trade-offs accepted), lowers the present value of its benefits but not negatively and it still remains more competitive compared to business as usual.

Chapter 8: Conclusion and Implication for Conservation Investment Planning

8.1. Conclusion

The study aimed at generating information on economic value of the Sio-siteko wetland ecosystem services to inform the development of conservation investment plans and hence make a case for public and private investment for improved management of the wetland and trade-offs between different development trajectories. To this end, the study identified three potential wetland development trajectories, these included; a business as usual scenario, a conservation management scenario, and an agricultural intensification scenario. The study therefore provides an estimate of the value of the current flow of Sio-siteko wetland ecosystem services, the benefits, and the losses and damages to be incurred under the baseline scenario, conservation scenario, and under agricultural intensification scenario for the period 2020 to 2044.

The total estimated economic value of the ecosystem services based on 2019 as the baseline year was around USD 29 million. The wetland is also undergoing a degradation which will result into an economic loss equivalent to a present value of over USD 166 million in the next 25 years under the business as usual scenario. Investing in wetland wise use and conservation will lead to an economic gain equivalent to a present value of over USD 165 million over the next 25 years, and reclamation of the wetland for a more intensive agricultural activities involving intensive rice farming in Uganda and aquaculture in Kenya will lead to positive net present value of USD 296 million over the next 25 years, based on 10% discount rate. Agricultural intensification has the largest net present value implying that it has the greatest economic benefit. Conservation management plan on the other hand has the highest benefit to cost ratio, which implies it offers the best value for money. Business as usual scenario has negative net present value which implies that it is an option which is not economically advisable.

The agricultural intensification scenario will improve the economic well-being of the farmers taking part in farming, but it will lock out large number of the community members who benefit from other ecosystem services that will be lost due to conversion of the wetland. Its implementation will need serious stakeholder engagement on tenure system for the farmers and how to deal with the rest of the community who will lose out first of all on the other numerous ecosystem services and the intensified agricultural investments as well. Aside from benefiting the least number of households in the community, it is also the least environmentally friendly since it will hugely degrade and even erase vital ecosystem services (in less than five years of its implementation) that are probably not replaceable such as the vital use of the wetland by a number of fish species (such as Nile Tilapia among others) as breeding and spawning site. There are a number of externalities and opportunity costs associated the agricultural intensification that have not been considered for monetary valuation because of lack of data which also implies that its net present value is an overestimation, users are therefore advised to be cognizant of this fact.

The conservation management plan option will promote enhancement of wetland ecosystem services (regulatory, provisioning, and cultural and supporting services). However, to successfully do this, there will be need to make adjustments on the number of households who have access to the benefit from the wetland ecosystem at any one given period to ensure that the carrying capacity for the various ecosystem services are not overstretched by high numbers of the expected users. It will require serious stakeholder engagement and awareness raising since it will require limiting the scale of some activities such as: restriction of further reclamation of the wetland for crop farming; limiting the number of cattle grazing in the wetland since the current practice is unsustainable, restricting fishing to areas that do not serve as main fish breeding areas, relocation and resettlement of brick makers and some sand harvesters (those who harvest sand in fish breeding areas and those who harvest at the river banks).

8.2. Implications for Conservation Investment Planning (CIP)

Economic valuation of ecosystem services provides useful information in articulating the economic returns and value-added from investing in enhanced conservation of a wetland. The findings of the study can provide justification of an economic case for investments in the CIP and a justification based on sustaining economic benefits derived from different ecosystem services and mitigating losses that can be incurred from loss or degradation of the conservation area (Lake Victoria Basin Commission, 2018). Table 35 shows typical economic returns questions that investing in conservation investment plan would achieve based on the findings of this valuation study.

Table 35: Economic return questions of conservation investment planning that this economic valuation study can clarify

Conservation investment plan Question	Sio-Siteko wetland economic valuation
What is the current value of the ecosystem services considered in the study for the Sio-siteko wetland ecosystem as a whole?	The current value of the Sio-siteko wetland as a whole is estimated at USD 29 million
What is the relative economic importance and value of different ecosystem services or habitat types?	See table 27 for the net economic values per household for the various ecosystem services
What is the economic importance of ecosystem services for different groups, sectors or levels of scale?	Sio-siteko wetland ecosystem has over fifteen (15) wetland ecosystem user groups, out of which economic worth to eleven (11) of the user groups were assessed and aggregated including the population appropriating the services. These can also be seen in table 27.
What do ecosystem values contribute to key economic indicators such as sectoral output, GDP, foreign exchange, public revenues, employment, household cash income and livelihoods?	Sio-siteko wetlands directly support livelihoods of more than 26,301 households who live in the sub locations and parishes that adjoin the wetland.
How much are the gains, value-added and costs avoided from biodiversity being conserved (and/or the costs, losses and damages incurred from biodiversity continuing to be degraded)?	Investing in the sustainable management of the Sio-siteko wetland would save losses and damages to wetland biodiversity and ecosystem services equivalent to a net present value of USD 165 million over the next 25 years, and USD
How will implementing the CIP benefit key groups, sectors, levels of scale or indicators (and/or how will failing to implement the CIP incur costs to them)?	Without implementation of the CIP, Sio-siteko wetland will be fully reclaimed in the next 23 years and the following wetland user groups are gradually losing out as the wetland land use changes towards crop and aquaculture farming only; Livestock grazers, mat makers, grass harvesters, herbal medicine users, domestic water users, firewood collectors, among others. In addition to the wetland user groups, the following

	sectors will also be losing out without conservation investment; flood attenuation, water purification ecosystem services, groundwater recharge, biodiversity maintenance, particularly fish breeding and spawning ground since the wetland is one of the four most important fish breeding sites in Uganda.

Source: Questions adopted from (Lake Victoria Basin Commission; 2014)

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ANNEXURES

Annex 1: Household survey consent form

HOUSEHOLD SURVEY INSTRUMENT

CONSENT FORM

INTRODUCION

Read this to the Respondent

Hello, my name is _________ and are from ………………………
We are in this area doing a survey for the Nile Basin Initiative about how people use the wetland for their livelihood. I would like to talk to the head of your household, if possible.

(*If the head is not present, ask to talk to next most senior person, e.g. wife or son. Aim to have adult members of both sex present). (Make sure everyone is settled and comfortable.)*

The purpose of this discussion is to find out more about how your household uses wetland resources. Your input, along with other households, will help us better understand how important wetland resources are to the people of this area. In the end we hope that our findings will help the communities and their leaders make the best decisions about how to manage these resources in the future.
When we ask a question about things you do, we are really interested in you as well as all the other members of your household. For example, if we ask "do you fish", we mean you or your spouse or any other person in this household.

The information you give will be treated with confidentiality and will not be shared to third parties. The interview takes approximately one hour. You may terminate the interview at any point if you do not wish to proceed. If you would like to know more about this study, please contact Mr Philip Otieno at +254 (0) 724 857 647

Consent Granted: *YES: Proceed with interview*
NO: Thank the person and look for next respondent. You are required to keep this questionnaire whether the respondent agreed to participate or not.

Annex 2: Household survey questionnaire for Market Price Data on provisioning ESs

SIO SITEKO HOUSEHOLD SURVEY FORM

Name of Enumerator

What is your name?

Interviewee

□ Location

What is your Sub Location?

□ Busijo □ Bujwanga □ Sigalame □ Agenga □ Luchululo □ Mulwanda □ Buloma □ Lugala □ Mango □ Ludacho □ Sibinga □ Muyafwa □ Nangoma □ Mundika □ Mayenje□ Nangwe □ Marachi □ Madibira □ Buyengo □ Masinya □ Madibira □ Buyengo □ Masinya □ Bumunji

What is your Village ……………………………………………

Distance from the Wetland

How far do you live from the wetland in kilometers?.................................

Benefits Obtained from the Wetland

Do you obtain the following benefits from the wetland?

Benefit	Yes	No
Water Supply		
Capture Fisheries		
Herbal Medicine		
Papyrus Harvesting		
Grass Cutting		
Wood Based Energy (Firewood, Charcoal, Timber)		
Crop Farming		
Livestock Grazing		
Aqua Culture		
Sand Harvesting		
Brick Making		

WATER SUPPLY

Do you obtain any water from the wetland?

□ Yes □ No

If Yes, What is the purpose of the water?

□ Domestic □ Selling

If Domestic, Ho many times do you fetch the water in a day? ……………………

What is the size of the container you use to fetch the water in Litres ……………………

Do you hire people to fetch for you this water for domestic use?

□ Yes □ No

If Yes, How much do you pay them ………………………………..

If Selling, how many 20L containers do you sell in a day ……………………….

How much do you pay people who help you in selling the water per month ………………………..

How much do you pay Busia County / Busia Municipal per month for permits for selling water ………………

How much do you pay Busia County / Busia Municipal per month as tax for doing water ………………………..

What do you use to transport the water you sell?

□ Donkey □ Bicycle □ Motorbike □ Kart □ Wheelbarrow

If Donkey, How much did you buy it ………………..

When did you buy it ……………………………

If Bicycle, How much did you buy it ……………………….

When did you buy it ………………………….

If Motorbike, How much did you buy it ………………………..

When did you buy it …………………………………

If Kart, how much did you buy it ……………………………

When did you buy it …………………………….

If wheelbarrow, how much did you buy it ………………………..

When did you buy it …………………………..

If No water is obtained from the wetland, Is there an alternative source of water apart from the wetland that you use?

□ Yes □ No

If Yes, which is the alternative source that you use ……………………………….

Do you spend any money getting water from the wetland

□ Yes □ No

If Yes, How much ………………………………..

What is the maximum amount of money you would pay to obtain water from the wetland …………………….

Why ………………………………………………………………………………………………

MAT MAKING

Do you use any papyrus reeds from the wetland for Mat making

If Yes, which months do you make the mats?

□ January □ February □ March □ April □ May □ June □ July □ August □ September □ October □ November □ December

If January, How many mats did you make ……………

If February, How many mats did you make ……………..

If March, How many mats did you make ……………..

If April, How many mats did you make ……………..

If May, How many mats did you make ……………..

If June, How many mats did you make ……………..

If July, How many mats did you make ……………..

If August, How many mats did you make ……………..

If September, How many mats did you make ……………..

If October, How many mats did you make ……………..

If November, How many mats did you make ……………..

If December, How many mats did you make ……………..

How much do you sell one mat for………………..

Do you hire people to help you in mat making

Yes No

If Yes, How much per mat ………………..

What is the cost for transporting the mats to the market …………..

How much do you pay the county government / municipal council as tax in the market per month…………

Why don't you make mats in some months …………………………………………………

HERBAL MEDICINE

Do you use any plants from the wetlands to make herbal medicine?

Yes No

If Yes, what are the plants that you use …………………………………………

What are they types of diseases that you treat people for …………………………..

How much do you charge per patient ……………………………………………….

How many patients did you treat last year ……………………………………..

Do you spend any money when treating a patient

Yes No

If yes, which costs do you incur when treating a patient ……………………….

How much ……………………………………………

In your opinion, what is the trend of availability of the plants you use from the wetlands to treat patients

Abundant Increasing in Population Stable Population Decline in Population

CAPTURE FISHERIES

Do you conduct any fishing activities in the wetlands?

Yes No

If Yes, Which type of fish do you catch?

Vidonge Esiree Obuyoko Eningu Edurii obuduba (Omena) Efulu Tilapia Nile Perch Imonye Ekhanga Masurubuna

If Vidonge, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ……… July ………. August ……….. September …………. October …………… November ………. December ………..

If Esiree, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ……… July ………. August ……….. September …………. October …………… November ………. December ………..

If Obuyoko, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ……… July ………. August ……….. September …………. October …………… November ………. December ………..

If Eningu, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ……… July ………. August ……….. September …………. October …………… November ………. December ………..

If Edurii, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

If Obuduba, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

If Efulu, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

If Tilapia, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

If Nile Perch, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

If Imonye, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

If Ekhanga, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

If Masurubuna, How much money did you earn from selling them in January?

February ……………….. March ……………….. April …………… May………… June ………
July ………. August ……….. September ………… October …………… November ……….
December ………..

How many hours do you take for one fishing trip ………………

How many KGs of fish do you catch in one trip ………..

How many trips do you make in a peak month ………..

How many KGs do you make in an off peak month ……….

Do you incur any costs when fishing?

Yes No

Input costs

How much did you spend on bait last year ……………

How much did you spend on hook and line last year …………..

How much did you spend on baskets last year ……………….

Capital Costs

What is the cost for renting a boat for one month……………

Labor costs

Do you hire people to fish for you?

Yes No

If yes, How many people do you hire in 1 trip …………………….

How much do you pay for permits in one year ……………….

How much tax do you pay in a month …………………….

<u>AQUACULTURE</u>

Do you have any fish ponds within the wetlands?

Yes No

If Yes, which fish species do you farm

Tilapia Catfish others

If Others, Please Specify ………………………………………

How many Kgs of fish do you harvest in 1 year ………………………

What is the price of 1kg of fish ………………………..

What is the size of 1 pond in square metres ……………………………

How much did it cost you to construct the pond……………………………………..

How much do you pay people who work for you in the fish ponds per month …………………..

How much do you spend on feeds per month ……………………………..

How much do you spend on stocking fingerlings per year ………………………….

How many years does a fish pond last before it is abandoned ……………………………

How much do you spend in a year to maintain the fish ponds ……………………………..

How much do you spend on permits per year ………………………..

How much do you spend on tax per month ………………………………

How much do you spend on transporting the fish to the market ……………………

How many people did you employ for your fish farming business last year ………………….

What kinds of equipment do you use for the fish farming

GRASS HARVESTING

Do you harvest any grass from the wetland?

Yes No

If yes,

What do you use the grass for?

Domestic Selling

If Domestic,

What do you use the grass domestically for?

Thatching houses   Livestock feeding   Direct Selling

If Thatching,

How many bundles do you use ………..

How long does the roof last ………………………..

When was the roof last done ………………

How much did you spend on labor ………………………

If livestock feeding

How many cows do you feed from the homestead …………….

How many bundles of grass do you feed them in a week ………………

If selling, what do you use the grass for?

Broom making   Basket weaving

If Broom making,

How many brooms do you make in one month ………………..

How much do you sell one broom for ………………………….

How much do you pay the people who help you in making the brooms per month …………

How much do you spend on tax per month …………………..

If basket Weaving,

How many baskets do you make in one month ………………

How much do you sell one basket for …………………….

How much do you spend on labor per month………………………

How much do you spend on transport to the market per month …………………

How much do you spend on tax per month …………………..

If Direct Selling the Grass,

How many bundles do you sell in one month …………………

How much do you sell one bundle for …………………………..

How much do you spend on labor per month ………………

How much do you spend on transport to the market per month …………………..

How much do you spend on tax per month …………………..

LIVESTOCK GRAZING

Do you take your livestock to graze in the wetland?

Yes No

If Yes,

How many cows do you graze in the wetland ……………………………

How many times do you take your cows to graze in a week during the dry season ……………….

How many times do you take your cows to graze in a week during the wet season ……………….

How much do you pay a herds boy per month …………………………..

How much do you spend on treatment of cows for grazing in the wetland in one month ………..

TRADITIONAL SALT MAKING

Do you use any resources from the wetland to make traditional salt?

Which plants do you use to make the salt …………………………………………

How many sachets do you make in one month ……………………………………

How much do you sell one sachet for …………………………………………

How many bundles of firewood do you use in one month to process the salt …………………

How much is one bundle of firewood

How many people do you employ to help you in making salt per month …………..

How much do you pay one person per month …………………..

How much do you spend on packaging the salt per month …………………..

How much do you pay the county / municipal per month ………………………….

HUNTING

Do you conduct any hunting activities in the wetland?

Yes No

If Yes,

Which animal do you hunt …………………

How many times do you hunt in a month during the dry season …………………

How many times do you hunt in a month during the wet season …………………..

Why do you hunt?

For food For Fun Controlling wildlife

SAND HARVESTING

Do you harvest any sand from Sio-Siteko Wetland?

Yes No

If Yes,

How many trips of sand do you produce in one month during the dry season ………………

How many trips of sand do you produce in one month during the wet season ………………..

How much do you sell one trip of sand for ………….

How much do you pay people who help you in harvesting the sand per trip …………………..

How much do you pay for loaders per trip ……………………

Where do you harvest the sand?

Riverbed River Bank Farms within the swamp

In which village do you harvest the sand …………………………………………….

Which equipment do you use to harvest sand...

How many days does it take to harvest a trip of sand……………………………

BRICK MAKING

Do you conduct any brick making activities in the wetland?

Yes No

If Yes,

How much do you earn from brick making in one year ……………

Which village do you carry your brick making business in ……………….

How many times in a year do you make the bricks ……………………………

CROP FARMING

Do you conduct any farming activities in the wetland?

Yes No

Which Types of crops do you farm?

Vegetables Maize Yams Rice Sugarcane Beans

If Vegetables,

How many sacks did you harvest last year ……………

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year …………….

How much did you spend on tax at the market last year …………….

If Maize

How many sacs did you harvest last year ……………

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year …………….

How much did you spend on tax at the market last year …………….

If Yams

How many sacs did you harvest last year ……………

What was the maximum price of one sack …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year …………….

How much did you spend on tax at the market last year …………….

If Rice,

How many sacs did you harvest last year ……………

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year …………….

How much did you spend on tax at the market last year …………….

If Sugarcane,

How many sacs did you harvest last year ……………

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year …………….

How much did you spend on tax at the market last year …………….

If Beans,

How many sacs did you harvest last year ……………

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year …………….

How much did you spend on tax at the market last year …………….

Which equipment do you use for farming?

Sprayers Jembe Tractor Ox plough Bull Irrigation kits Panga Wheelbarrow

If Sprayers,

How much did you buy it for …….

When did you buy it ……………..

If Jembe,

How much did you buy it for …….

When did you buy it ……………..

If Tractor,

How much did you buy it for …….

When did you buy it ……………..

If Ox plough,

How much did you buy it for …….

When did you buy it ……………..

If Bull,

How much did you buy it for …….

When did you buy it ……………..

If Irrigation kits,

How much did you buy it for …….

When did you buy it ……………..

If Panga,

How much did you buy it for …….

When did you buy it ……………..

If Wheelbarrow,

How much did you buy it for …….

When did you buy it ……………..

How many people did you employ for your farming activities last year ………

Do you grow crops directly in the wetland?

Yes No

IRRIGATION

Do you use any water from the wetland to irrigate crops grown outside the wetland?

Yes No

If Yes, which crops ………………………….

What is the size of the farm that you irrigate (In acres) …………………..

Which equipment do you use for irrigation ……………………….

How much do you buy the equipment for ………………………….

When did you buy them ………………………….

FIREWOOD

How many bundles of firewood do you get from the wetland per month during dry season (January, February, March, August, September, and December?) ……………

How many bundles of firewood do you get from the wetland per month during wet season (April, May, June, July, October, and November?) ……………

How many bundles do you sell per month during season? ……………

How many bundles do you sell during wet season? ……………

How much do you sell a bundle of firewood per month during dry season? ……………

How much do you sell a bundle of firewood per month during wet season? ……………

How much do you pay (per bundle) people who collect for you firewood during dry season ……………

How much do you pay (per bundle) people who collect for you firewood during wet season ……………

How long does it take you or a member of your family to collect a bundle of firewood during dry season? ……………

How long does it take you or a member of your family to collect a bundle of firewood during wet season? ……………

How much does it cost you to transport a bundle of firewood to the market during the dry season? ……………

How much does it cost you to transport a bundle of firewood to the market during the wet season? ……………

How much do you pay as permit to Busia county government or Busia municipal council per month or per year firewood selling business? ……………

How much do you pay as tax (ushuru) to Busia county government or Busia municipal council bundle of firewood ……………

CHARCOAL PRODUCTION

Do you make charcoal using poles and timber obtained from the wetland?

Yes No

If Yes

How many sacks of charcoal do you get from the wetland per month during dry season (January, February, March, August, September, and December?) ……………

How many sacks of charcoal do you get from the wetland per month during wet season (April, May, June, July, October, and November?) ……………

How many sacks of charcoal do you sell per month during dry season? ……………

How many sacks of charcoal do you sell per month during wet season? ……………

How much do you sell a sack of charcoal per month during dry season? ……………

How much do you sell a sack of charcoal per month during wet season? ……………

How many people do you employ to help you in charcoal making per month dry season? ……………

How many people do you employ to help you in charcoal making per month wetland season? ……………

How much do you pay people who help you in charcoal making per person per month during dry season? ……………

How much do you pay people who help you in charcoal making per person per month during wetland season? ……………

How much does it cost you to transport a sack of charcoal to the market during the dry season? ……………

How much does it cost you to transport a sack of charcoal to the market during the wet season? ……………

How much do you pay as permit to Busia county government or Busia municipal council per month or per year charcoal selling business? ……………

How much do you pay as tax (ushuru) to Busia county government or Busia municipal council per sack of firewood? ……………

TIMBER PRODUCTION

Do you obtain timber from the wetland?

Yes No

If Yes

How many scores (20 poles) of timber do you get from the wetland per month during dry season (January, February, March, August, September, and December?) ……………

How many scores (20 poles) of timber do you get from the wetland per month during wet season (April, May, June, July, October, and November?) ……………

How many scores (20 poles) do you sell per month during season? ……………

How many scores (20 poles) do you sell during wet season? ……………

How much do you sell a score (20 poles) of timber per month during dry season? ……………

How much do you sell a score (20 poles) of timber per month during wet season? ……………

How much do you pay (per score) people who harvest for you during dry season? ……………

How much do you pay (per score) people who harvest for you timber during wet season ……………

How long does it take you or a member of your family to harvest a score of timber during dry season? ……………

How long does it take you or a member of your family to harvest a score of timber during wet season? ……………

How much does it cost you to transport a score (20 poles) to the market during the dry season? ……………

How much does it cost you to transport a score of timber to the market during the wet season? ……………

How much do you pay as permit to Busia county government or Busia municipal council per ……………

How much do you pay as tax (ushuru) to Busia county government or Busia municipal council per score of timber? month or per year for timber selling business? ……………

FLOODS

Have you ever experienced flood destructions in your home or farm?

Yes No

If Yes, what size of your farm was destroyed (In acres) ……………….

Which is the latest year that you experienced the floods …………………….

Annex 3: Household survey questionnaire for contingent valuation of biodiversity maintenance

CONTINGENT VALUATION DATA COLLECTION FOR BIODIVERSITY MAINTANANCE

a. Preliminary question pretested to know the right numeraire and anchor price

CONTINGENT VALUATION OF BIODIVERSITY MAINTENANCE

Sio-siteko wetland is one of the places in Kenya and Uganda which is considered to be an environmentally significant place since they host a rich diversity of plants and animals; in particular it does the following; it is one of the three most important fish breeding grounds in Uganda and also an important one for Kenya, it is also a habitat for rare and threatened birds and animals like Sitatunga, it has rich diversity of wetland plants among others.

If some of the plants and animal community in the wetland were threatened by degradation of the wetland, would you be willing to make some contribution to help to ensure that the amount of the wetland still conserved would remain un-reclaimed to help conserve the threatened plants and animals?

Yes No

If yes, which type of contribution would you be willing to make? (Tick one only)

- ❖ Volunteer time for conservation of the wetland…………………………
- ❖ Contribution of commodities as such maize………………………………
- ❖ Cash contribution…………………………………………..

How much of your contribution would you be will to make? (Use only one method of contribution)

Contribution	Monthly	Twice a year	Once a year
Volunteer labour in hours			
Maize in tins or sacks			
Amount of Cash			

b. Actual survey Questionnaire

General Questions

Sub-location……………………… Village………………………………………………………..…

Date……………………………………

How far do you live from the wetland in kilometres? ……………………………….

Knowledge about Wetland Ecosystem Services

Think about the status of sio-siteko wetland. Which box do you think best describes the condition of the wetland in terms of degradation? (Please tick one box)

01. Heavily degraded
02. Somewhat degraded
03. Good State
04. Excellent state

In a scale of 1 to 5, do you agree that diversity of plants and animals in sio-siteko provide the following services to the people?

The wetland acts a nursery and breeding ground for fish

- ❖ Fully disagree
- ❖ Disagree
- ❖ Somewhat agree
- ❖ Agree
- ❖ Fully agree
- ❖ No idea

The wetland acts a nursery and breeding ground for fish

- ❖ Fully disagree
- ❖ Disagree
- ❖ Somewhat agree
- ❖ Agree
- ❖ Fully agree

- No idea

The wetlands plants abundance helps control flooding

- Fully disagree
- Disagree
- Somewhat agree
- Agree
- Fully agree
- No idea

The wetlands plants abundance helps in purification of the river

- Fully disagree
- Disagree
- Somewhat agree
- Agree
- Fully agree
- No idea

The wetland is home to some of the globally threatened plants and animals

- Fully disagree
- Disagree
- Somewhat agree
- Agree
- Fully agree
- No idea

Each member of the plants and or animal species plays an important in that ecosystem

- Fully disagree
- Disagree
- Somewhat agree
- Agree
- Fully agree
- No idea

Contingent Valuation Exercise

Do you think conservation of the sio-siteko wetland is important?

Yes No

The Sio-siteko wetland consist of papyrus, reeds, open water channels, grasslands and trees, and wild animals, does it matter to you whether these plants and wild animal communities in the wetland exist in their natural state.

Yes No

How much of these plant and animal communities should be conserved in a natural state

- All of them
- Most of them
- Half of them
- Little of them
- None of them

Sio-siteko wetland is one of the places in Kenya and Uganda which is considered to be an environmentally significant place since they host a rich diversity of plants and animals; in particular it does the following; it is one of the three most important fish breeding grounds in Uganda and also an important one for Kenya, it is also a habitat for rare and threatened birds and animals like Sitatunga, it has rich diversity of wetland plants among others.

If some of the plants and animal community in the wetland were threatened by degradation of the wetland, would you be willing to volunteer your time i.e. provide unpaid labour to help to ensure that the amount of the wetland still conserved would remain un-reclaimed to help conserve the threatened plants and animals?

Yes No

Would you be willing to contribute 5 hours of your useful time on a monthly basis towards conservation of the wetlands biodiversity without being paid?

Yes No

If yes, what is the maximum amount of hours you would be willing to contribute per month?

………………………………………………………………………………………………..

If no, what amount of hours you would be willing to contribute per month?

………………………………………………………………………………………..

Suppose you are asked to make cash contribution instead of volunteer time what is the minimum amount of money you would be willing to contribute monthly?

…………………………………………………………………………………………………….

Suppose you are asked to make cash contribution instead of volunteer time what is the maximum amount of money you would be willing to contribute monthly?

………………………………………………………………………………………………………

[Hint: please consider your household financial needs and your monthly earnings and only propose that amount which you are willing to contribute out of this your monthly earnings]

What institutional framework would you like to coordinate the volunteer programme for conservation of the wetland?

- ❖ By Both Busia County Govt and Busia Municipal Council of Kenya and Uganda Respectively
- ❖ By Non-Governmental Organizations
- ❖ By Local Community Members Organized in Groups
- ❖ By Joint Committee of all the Above Groups

On a scale of 1 to 5, how certain were you about your response to the contribution you offered?

1=very certain
2=Certain
3= fairly certain
4= uncertain
5= very uncertain

If you are not willing to contribute towards the conservation of the biodiversity of the wetland, please share with us the reason as to why you are not willing to do so?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………

………………………………………………………………………………………………………
………………………………………………………………………………………………………

In your opinion, which management strategy for the Sio-Siteko wetland do you prefer?

1) Full conservation of the entire wetland
2) Conservation of a considerable section of the wetland
3) Conservation of only a small section of the wetland
4) Full reclamation of the wetland for agriculture
5) Full reclamation of the wetland for fish farming

Household Characteristics

What is your age in years?

……………………………………….

What is your gender?

01. Male
02. Female

How many people live in your household, including yourself? (Please count separately the number of adults and children)

01. Adults
02. Children (below 18 years)

What is the highest level of education you have obtained (until now)?

01. Never went to school , Years….0
02. Primary, Years…….
03. Secondary, Years…….
04. Diploma, Years ………
05. Certificate, Years……….
06. University degree, Years…………
07. Post-graduate degree, Years …………

Do you belong to any environmental or social group?

01. Environmental organisation
02. Fishing Industry
03. Agricultural industry
04. Other (specify)…….

What is your main source of income? (Tick one only)

01. Fishing
02. Crop farming
03. Animal keeping
04. Business
05. Salary
06. Wages
07. Remittance
08. Other (specify) ………………..

What is the distance in km from your place of residence to the nearest market?
……………………………………………………………………………………….
Do you have access to loan?

01. Yes
02. No

Annual household income – Please indicate the approximate total **annual income** (before taxes) by all members of your household. The ranges between brackets are annual income

*[Extract for Kenya side only***]**

01. Under Ksh. 28,800
02. Ksh. 28,801- 60,000
03. Ksh.60,001-120,000
04. Kshs. 120,001- 180,000
05. Kshs. 180,001-240,000
06. Ksh.240,001-300,000
07. Kshs.300,001-360,000
08. Ksh.360,001-480,000
09. Ksh.480,001-600,000
10. Ksh.600,001-1,200,000
11. Above Kshs. 1,200,001

Annex 4: Key Informant guiding questions

General inquiry

- ❖ Identification of the various ecosystem services in the wetland
- ❖ Patterns and levels of extraction/production and consumption or sale
- ❖ Factors driving change (causes of encroachment into the wetland and extraction of other ecosystems services from the wetland)
- ❖ Prioritisation/ ranking of ecosystem services based on perceived level of importance

Aquaculture information

- ❖ Kinds of fish kept for fish farming
- ❖ Standard size of fish ponds……………….
- ❖ Construction costs of fish ponds
- ❖ Equipment used in fish farming, their prices, and longevity……………….
- ❖ Number/weight of fish per fish pond…………………………
- ❖ Price of 1kg of fish ………………………..
- ❖ Common number of fish ponds in the community per household ……………
- ❖ Man hours required to operate two ponds in a year…………………………..
- ❖ Cost of feeds annually for a standard fish pond ……………………………..
- ❖ Cost of fingerlings for a standard fish pond ………………………….

Mat Making

- ❖ Whether mat making is for sale or home use only………………
- ❖ The sizes of mats made and prize size…………………………………
- ❖ Number of mats a household may produce in a month……………………………
- ❖ If there are periods (months) when mat making is not taking place or very low…………
- ❖ Costs involved in mat making…………………………………………..
- ❖ Average number of hours it takes to produce a mat………………………….
- ❖ Taxes and fees levied on mat making………………………………

Herbal Medicine

- Kinds of plants used as herbal medicine………………
- Kinds of ailments treated by the herbal medicine……………….
- Average number of patients treated in a month and the charges …………….
- Costs incurred for offering herbal medicine to patients……………….
- Duration it takes to harvest and prepare single lot of herbal medicine, and the number of patients served…………………………
- General prevalence in use of herbal medicine…………….
- Trends in the availability of the plants used for herbal medicine……………….

Capture fisheries

- The species of fish caught from the wetland ………………………………………..
- How often fishing is conducted (including months of active and inactive fishing..
- Number of trips conducted in a month
- The average biomass of fish harvested per trip………………………..
- If fishing is primarily for sale, home use or a combination of both…………………
- Price of selling fish for those who sell………………………
- Fishing methods/gears mostly used ………………………………
- Costs incurred in harvesting fish………………….

Livestock Grazing

- Peak and off peak months of grazing in the wetland
- Average number of animals per household are taken in the wetland
- Kinds of animals grazed in the wetland
- Daily duration of grazing animals in the wetland
- Number of people who graze animals in the wetland per household
- Alternative sources of pasture for the animals other than the wetland
- Costs incurred for grazing animals in the wetland
- Presence of conflict between livestock and other wetland resource users

Sand harvesting

- ❖ Areas of sand harvesting within the wetland
- ❖ Periods/months of sand harvesting
- ❖ Amount of sand (tonnes) an individual can harvest in a month
- ❖ Price per ton of sand
- ❖ Duration in days it takes harvest the tonnes in a month
- ❖ Costs an individual would incurred in harvesting and selling of sand
- ❖ Challenges sand harvesters face
- ❖ Challenges that sand harvesting pose to the wetland

Brick making

- ❖ Wetland resources used for making bricks
- ❖ Number of bricks in a kiln
- ❖ Price of a brick
- ❖ Costs incurred in making a kiln of brick

Crop farming

- ❖ Kinds of crops grown in the wetland
- ❖ Average size of a farm in the wetland
- ❖ Amount of harvests in a typical average farm
- ❖ Whether produce are for sale or home use
- ❖ Price per unit of measurement for sale of produce in case they are sold
- ❖ Frequency of farming in the wetland in a year per crop
- ❖ Inputs used in farming in the wetland
- ❖ Prices of the various inputs used in farming
- ❖ Kinds of tools used in crop farming in the wetland
- ❖ Duration typical equipment lasts
- ❖ Price of each tool and equipment
- ❖ Labour requirements for each of the crops grown, and costs of labour
- ❖ Average price for leasing land in the area

Firewood collection

- Kinds of plants used as herbal medicine………………
- Kinds of ailments treated by the herbal medicine……………….
- Average number of patients treated in a month and the charges …………….
- Costs incurred for offering herbal medicine to patients……………….
- Duration it takes to harvest and prepare single lot of herbal medicine, and the number of patients served…………………………
- General prevalence in use of herbal medicine…………….
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Grass harvesting

- Types and use of grass harvested from the wetland……………………
- Prevalence of grass harvesting and usage in the wetland
- Average typical harvest in a trip for grass harvesting depending on purpose of harvest
- Duration it takes to harvest a bundle of grass from the wetland
- Frequency and places of harvest of grass in a month by a typical household………….
- Tools and equipment used for grass harvesting
- Costs incurred in carrying out grass harvesting
- Price of a bundle of grass harvested from wetland in case it is for sale

Water supply for domestic use

- Types of domestic use water drawn from the wetland
- Average number of trips made in a day by a typical household in access for water
- Duration it takes to bring water home from the wetland per trip
- Typical containers used to obtain water and their capacity, their prices and duration they last
- Whether the water is treated and by what means………………………..
- Whether there are alternative sources of water to the wetland resource, and there names
- Whether money is spent in accessing water from these alternative sources and the amount they spend per 20 litre jerican

Annex 5: Focus Group Discussions Checklist

General inquiry

- Identification of the various ecosystem services in the wetland
- Patterns and levels of extraction/production and consumption or sale
- Factors driving change (causes of encroachment into the wetland and extraction of other ecosystems services from the wetland)
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- ❖ Duration typical equipment lasts
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- ❖ Average price for leasing land in the area

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- Costs incurred for offering herbal medicine to patients……………….
- Duration it takes to harvest and prepare single lot of herbal medicine, and the number of patients served…………………………
- General prevalence in use of herbal medicine…………….
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- Typical containers used to obtain water and their capacity, their prices and duration they last
- Whether the water is treated and by what means………………………..
- Whether there are alternative sources of water to the wetland resource, and there names
- Whether money is spent in accessing water from these alternative sources and the amount they spend per 20 litre jerican

Annex 6: Tobit Results on the influence of socio-economic WTP

Variable	Labour		Monetary	
	Coe	Sig.	Coe.	Sign.
Age	-0.035	0.107***	-0.001	0.938
Gender (Male)	-0.510	0.364	-0.968	0.081***
Household (Adults)	0.260	0.080***	0.16	0.286
Household (Children)	0.174	0.048**	0.229	0.009*
Group membership				
❖ Environmental	-.800	0.459	-2.386	0.025
❖ Fishing	-2.538	0.033**	-2.788	0.028
Source of income (Fishing as base)				
❖ Crop farming	-1.497	0.145***	-2.123	0.049**
❖ Animal keeping	0 .120	0.946	-1.276	0.478
❖ Business	-2.159	0.055***	-2.761	0.018*
❖ Salary	-0.131	0.934	-1.537	0.323
❖ Wages	-1.813	0.260	-2.181	0.185
❖ Remittance	-1.33	0.455	-3.077	0.077**
Distance from wetland	-0.251	0.634	1.349	0.374
Education	0 .0707	0.262	-0.413	0.428
Earning	0 .0005	0.212	0.118	0.057**
Constant	3.135	0.038	0.002	0.000
Log likelihood	-1250		-779.6261	
Observations	363		363	
R^2	0.043		0.030	

Annex 7: Parameters for the computation of aquaculture economic values

Parameters for computing Aquaculture economic values

Parameter	**Value**
Number of aquaculture fishers	432
Average number of fish ponds per farmer	2
Number of standard fish ponds	864
Mean annual quantity of fish harvest per pond (kg)	233
Total quantity of fish harvested annually (kg)	201,312
Average price of fish per kg (USD)	2.22
Gross value of fish	402,624
Annual value of capital cost (average usage + maintenance)	64.72
Total value of capital cost (annual value of a pond)	55918.08
Average annual input cost per pond (fingerlings, feedstock)	341.66
Total annual input cost per pond (fingerlings, feedstock)	295194.24
Total man hours in a year per pond	420
Total man hours for aquaculture for fish farmers	362,880
Mean annual value of labour per hour	0.48
Total value of labour for aquaculture in wetland (USD)	174,182.4

Annex 8: Parameters for the computation of livestock grazing economic values

Parameters for estimating the economic value of livestock grazing

Parameter	**Value/amount**
Households grazing in the wetlands	18,062
Average no. of livestock per household	7
Total cattle	126, 434
Average grazing days in a year	147.6
Average value of daily fodder per cow (USD)	0.35
Total value of grazing in a year	6,531,580
Number of grazers	18,062
Number of grazing days per grazer per year	147.6
Average daily rural wage rate (USD)	2.6
Total labour value (USD)	6,931,473
Input cost (medical supplies) per household year (USD)	13
Total input cost (USD)	234,806

Annex 9: Parameters for the computation of the economic value of mat making in Sio-siteko wetland

Parameters for estimating the economic value of mat making in Sio-siteko wetland

Parameter	Value/amount
Households making mats	5070
Average annual no of mats made per household	115
Total amount of mats made in a year	583,050
Average price per mat (USD)	0.75
Gross value	437,288
Average input cost per mat (USD)	0.19
Total annual input cost (USD)	110,780
Average number of mats made in a day, including average time for collection of papyrus	1
Total annual days for mat making	583,050
Average daily wage rate (USD)	2.6
Total labour value (USD)	1,515,930

Annex 10: Parameters for the computation of economic value of grass harvesting

Parameter	Value/amount			
	Zero grazing	Sale	Broom Making	Thatching
Number of households engaged	528	1014	439	6813
Annual bundles harvested/ brooms made per household	780	118	360	118
Total bundles harvested/ brooms made in a year	411,840	120,101	158,040	805,615
Average price per bundle/ brooms (USD)	0.93	0.93	0.29	0.93
Gross value	383,011	111,276.36	45,831.6	747,658.6
Average value of a machete (price/lifespan) in USD	0.97	0.97	0.97	0.97
Total annual cost of Machetes (USD)	512.16	983.58	425.83	6608.61
Average number of man days in a year for grass harvesting /broom making	88	5	6	5
Total annual days for mat making	17160	5004	2634	33,567.29
Average daily wage rate (USD)	2.6	2.6	2.6	2.6
Total labour value (USD)	44,616	13011	6848.4	87,274.95
Thatcher cost value in a years (one off payment/ duration of the roof)	-	-	-	2.15
Total value of thatching costs	-	-	-	14,647.95

Annex 11: Example aquaculture data production in Sio-siteko wetlands in Uganda

Sub county /Division	Total Number of farmers	Number of ponds	pond sizes in M^2	Production – Tilapia(Kg)	Production – catfish (Kg)	Total Production	Estimated Value (UGX)	Estimated value ($)
Eastern Division	**2**	**5**	**1400**	**0**	**0**	**0**	**0**	**0**
Western Division	5	15	8,200	2,500	700	3,200	25,600,000	7089.449
Masinya	10	26	13,500	1,600	800	2,400	19,200,000	5317.087
Dabani	25	45	19,000	1,700	300	2,000	16,000,000	4430.906
Buhehe	24	43	38,000	950	400	1,350	10,800,000	2990.861
Majanji	6	8	6,000	24,000	260	24,260	194,080,000	53746.88
Lumino	8	13	9,300	1800	500	2,300	18,400,000	5095.541
Totals	**186**	**155**	**196,900**	**45,441**	**7,660**	**35,510**	**424,808,000**	**117,642.8**

Source: Fisheries department of Uganda, 2019

Annex 12: Knowledge and Attitude towards Biodiversity

Knowledge Question	Disagree	Somewhat Agree	Agree	No Idea
The wetland acts a nursery and breeding ground for fish	12%	10%	70%	8%
The wetlands plants abundance helps control flooding	27%	18%	48%	7%
The wetlands plants abundance helps in purification of the river	20%	18%	50%	12%
The wetland is home to some of the globally threatened plants and animals	9%	6%	78%	7%
Each member of the plants and or animal species plays an important in the wetland ecosystem	5%	17%	63%	15%

Annex 13: Field measurements of water quality measured at various types of surface water and groundwater in Sio-Siteko

Type	Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Date	EC (µS/cm)	T (°C)	NO3 (mg/l)	Turbidity (NTU)
Lake	Lake Victoria, Majarija Landing Site	0,24132	33,99199	11/04/2019	108	28,0	<5	60
Lake	Lake Victoria	0,23909	33,99734	11/04/2019	107	27,9	<5	36
River (perennial)	River Sio outlet	0,23419	34,00766	11/04/2019	133	27,3	<5	50
River (perennial)	River Zoa (Sio)	0,24255	33,99857	11/04/2019	150	27,6	<5	95
Borehole (handpump)	Maduwa village	0,24876	33,99117	11/04/2019	893	27,0	30	<5
Borehole (not in use)	Maduwa village	0,24694	33,99164	11/04/2019	6700	30,9	45	<5
River (perennial)	River Sio	0,30505	34,05103	11/04/2019	169	30,0	5	60
Stagnant water		0,33646	34,01648	11/04/2019	886		<5	<5
Borehole (handpump)	Kateruhana West	0,33946	34,03178	11/04/2019	726	27,3	25	<5
Borehole (not used)	Kateruhana East	0,33470	34,03306	11/04/2019	1986	26,3	15	<5
Stagnant water in valley	Lugudu wetland	0,35982	34,09190	11/04/2019	578		<5	<5
River (perennial)	River Sio	0,35161	34,09813	11/04/2019	154	27,8	<5	225
Lake	Lake Victoria, Sio Port beach	0,22366	34,01570	12/04/2019	145		<5	<5
Stream (perennial)	Wahunga Stream	0,28489	34,06409	12/04/2019	567	25,7	<5	48
Borehole (electric pump)	Nyakwaka girls' secondary	0,29733	34,06622	12/04/2019	1416	26,8	40	<5
River (perennial)	River Sio	0,30418	34,05232	12/04/2019	148	27,8	<5	85
Open well in wide valley	Sugarcane plantation	0,31800	34,06142	12/04/2019	353	24,6	<5	<5
Borehole (handpump)		0,31365	34,06418	12/04/2019	407	26,2	30	<5
River (perennial)	River Sio	0,36036	34,13184	12/04/2019	139	28,0	<5	85
River (perennial)	River Sio bridge	0,38339	34,14599	12/04/2019	138	27,4	<5	75
River (seasonal)	River Buyosi	0,40099	34,10249	12/04/2019	358	27,9	<5	190
Stream (perennial)	Mabale Stream	0,42538	34,12023	12/04/2019	342	28,8	5-10	140

Source: Acacia Ltd, Sio-siteko wetland monograph study for the Nile Basin Initiative in 2019

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ONE RIVER
ONE PEOPLE
ONE VISION

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