Final Technical Report:

Machar Marshes Wetland Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development

Prepared for: Nile Basin Initiative (NBI)

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Acronym

BAS- Baro-Akobo-Sobat subbasin
CBA- Cost Benefit Analysis
CBD- Convention on Biological Diversity
Bcm- Billion cubic meter
CDM- Clean Development Mechanism
CCI-LC- Climate Change Initiative land cover (CCI-LC)
CPI- Consumer Price Index
DDR- Disarmament, Demobilization and Reintegration
DSSS- national development strategy of the country
EIAs-Environmental Impact Assessments
FGD- Focus Group Discussions
ENTRO- Eastern Nile Technical Regional
ESA-European Space Agency
ESV- Ecosystem Services Value
ESA- CCI LC
FAO- Food and Agriculture Organization
GHG- Greenhouse gas (GHG)
GRSS - Government of Republic of South Sudan
GIS- Geographic Information System
KII-key informant interview
LSS- Local Service Support
LULCS- Land Cover Classification System
LULC-land use land cover
PV-present value
ICSS- Interim National Constitution of Southern Sudan
IPPC- the International Plant Protection Convention
INDC -Intended Nationally Determined Contributions
MA- Millennium Ecosystem Assessment
MODIS-Moderate Resolution Imaging Spectro radio Meter
NAPAs- National Adaptation Programs of Action
NBI- Nile basin initiative
NDS-Nation Development Strategy
NGO- Non- governmental organizations
NPV- Net Present Value
RS-Remote Sensing
SDGs -Sustainable Development Goals
SEIA- Summary environmental impact assessment
SSDP- South Sudan Development Plan
SSWS- South Sudan Wildlife Service
REDD- Reduced Emission from Deforestation and Forest Degradation
RS- Remote Sensing
TCRSS- The Transitional Constitution of the Republic of South Sudan
TLU- Total livestock units
TEEB- The economics of ecosystem and biodiversity
TRMM-Tropical Rainfall Measuring Mission
TCU-true color unit
VFS-Vegetative filter strip
UNFCCC- United Nations Framework Convention on Climate change
UN- United Nations
USGS-United States Geological Survey

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EXECUTIVE SUMMARY

One of the recent developments and initiation in Nile basin is that A "TEEB-inspired study", focusing on wetland ecosystems. The Nile Basin Wetlands TEEB, coordinated by the Nile Basin Initiative (NBI), focusing on raising awareness about the importance of wetland ecosystem services to regional, national, sectoral and local-level development processes. Under this process, fairly sizable, with more than 200 published documents on ecosystem valuation were identified covering all the riparian countries. Although incorporating a wide range of wetland types, the geographical distribution of the studies is patchy and South Sudan is among the countries with limited attempt of such studies. It is based on this backdrop that this in-depth site-specific valuation study to conduct TEEB analysis on the Machar Marshes wetland is undertaken. The key objective of this assignment by Nile Basin Initiative (NBI) is to conduct economic valuation of biodiversity and ecosystem services of Machar Marshes wetland to inform green infrastructure planning and development in the face of in situ and ex-situ development interventions. To achieve the stated objective, we applied standard economic valuation analysis using the Economics of Ecosystems and Biodiversity (TEEB) as a major methodological approach.

We conducted LULC analysis and mapping for Machar Marshes wetland using satellite data of the year 1995, 2005 and 2015. The LULC result revealed that tree cover and grass land cover show a decreasing trend while crop land, grassland, herbaceous cover, shrub land, shrub land herbaceous cover flooded and tree cover flooded show an increasing trend. Machar Marshes provides key provisioning and regulating ecosystem services that directly and indirectly support the livelihood of the local community. The Machar Marshes wetland provides an estimated economic value of $622 million per year of which $351.8, $262.8, $7.3 are from provisioning (i.e. the basic economic activities that the local community relies such as crop production, timber production, papyrus harvesting, fishing and so on), regulating (carbon sequestration, sediment retention, flood attenuation) and biodiversity ecosystem services, respectively.

The major findings enhance decisions in wetland policy formulation and enhancing integrated development decision makings through evaluating alternative wetland conservation and development options. Taking in to consideration of the trend of land-use land-cover change and the forthcoming economic values of the wetland ecosystem services, we strongly recommend four potential conservation options to maintain, conserve and restore Machar Marshes wetland that

include: conserving the foothill of the wetland, floodplain of the wetland, permanent wetland restoration and intervention to maintain inflow of water to the wetland.

To ensure sustainable ecosystem service of the Machar wetland, all the key stakeholders should work together and undertake their respective responsibilities appropriately on the implementation of the aforementioned alternative wetland conservation and restoration options. For the effective implementation of fast-tracking alternative conservation option, we suggest the following instrumental approaches:

- Widely promote awareness creation programs about the sustainable management of wetlands resources and ecosystems,
- Development processes directly rely on wetland ecosystem services; thus, the wetland ecosystem services value should be considered to maintain sustainability and development,
- Collaborating key stakeholder together to support conservation and restoration alternative options,
- Introducing incentivized community-based wetland management initiative (especially; foothill and floodplain areas) conservation options would be viable to improve the wetland ecosystem services.

The rest of the draft technical report proceeds as follows: brief introduction; review of enabling policy environment, strategies, policy, and direction related to wetland, brief overview of Machar Marshes wetland, a step-wise methodological approach, results and discussions, implication of the finding and supplementary as appendix.

I. Introduction

The concept of ecosystem services has become of considerable interest to both environment and development policy communities at local, national, regional and international scales especially since 2005 following the publication of the Millennium Ecosystem Assessment (MA) (MA, 2005); 18 of the 24 ecosystem services assessed in the MA study were found to be deteriorating. Wetland is one of them. Although globally wetlands provide services estimated to be worth US$4.9 trillion annually (Ramsar 1971), the earth wetland coverage decreased by 50% since 1900. The degradation of wetland highly affects the poor people that their livelihood highly dependent on the wetland ecosystem than non-poor. Wetlands provide multiple direct ecosystem services, for example food, grazing land and fish for poor who lives in the surroundings. So as to eradicate poverty and to conserve the ecosystem many countries draw different strategies to conserve wetland and most of them sign the Ramsar agreement (Rasmar, 2012).

Wetlands have multidimensional contribution for the ecosystems. For instance it provides provisioning ecosystem services (i.e. food and fiber, fuel, medicines, and fresh water for the local community around the wetland); it gives regulating ecosystem services (i.e. sediments retention, flow regulation and water purification); it also provides supporting ecosystem services (i.e. soil formation and nutrient cycling service as example) and it gives cultural ecosystem services, notably related to tourism, recreation, and research (Smakhtin 2012a). Currently numerous studies verify the importance of wetland for the ecosystem (Dessu et al., 2014; Skourtos et al., 2003; Schuyt, 2005; Agimass and Mekonnen, 2011; Mulatu et al., 2014; Mulatu et al. 2018), but most of studies focused on valuation of developed country wetland. From this, we noted that very limited research works have been done in the developing countries, especially in African countries. African wetlands are the most degraded wetlands in the world and its' sized is shrinked by 0.927% annually (Davidson 2017). According to wetland international[1] report, currently 131 million ha of the African continent is covered by wetland areas and about 18.3 million ha of wetland area located in the Nile Basin. Therefore, conducting economic valuation of biodiversity and ecosystem services to inform green infrastructure planning and development in the face of in-situ and ex-situ development interventions is vital for better understanding of sustainable wetland management in Nile Basin (Smakhtin 2012a).

Nile is one of the longest rivers in the world; it flows through ten countries of which five of them are the poorest nation in the world. Despite the fact that Nile has productive ecosystem, the Nile's land

[1] http//www.africa.archive.wetlands.org

and water are underutilized and degraded at an alarming rate. The wetland areas in the basin are one of the most degraded parts of the Nile, which covers 5% of the basin. These wetlands' have important role on sustaining the livelihood of million households by furnishing provisioning ecosystem services (i.e. Nile Basin wetlands have vital role to cultivate small scale agriculture and grazing land for livestock by retaining moisture for long time even in time of drought). In addition, especially wetlands in Uganda, headwater wetlands around Baro Akobo, Lake Albert, Sudd, Machar Marshes and Bahr Ghaz have significant role for the hydrology of Nile River by regulating the water flow, attenuate flow and improving water-related ecosystem services of the Nile Basin. These wetlands not only contribute for the ecology of Nile riparian countries, but also benefits for the global community.

Although the Nile wetlands have the above mentioned benefits, these wetlands' are vulnerable to infrastructure development close to water resources, conversion to agricultural land, increasing populations and overexploitation of resources, expansion of invasive species, extraction of minerals and oil, and climate change(Smakhtin 2012a). To address the challenges, NBI draws wetland management strategy which gives especial focus for trans-boundary wetlands. The main objective of this strategy is to promote sustainable and cooperative wetland management, to strength national policy and institution for effective wetland management by strengthening data and knowledge repository of Nile basin riparian countries regarding wide range ecological and socioeconomic benefit of wetlands (Henry Busulwa 2012).

Recently Nile Basin Initiative (NBI) coordinates the Economics of Ecosystem and Biodiversity (TEEB) to value wetland ecosystems for biodiversity and ecosystem services in the decision making at all levels. Under these processes there are more than 200 published documents on ecosystem services valuation which cover all riparian countries. Although most of the studies cover a wide range of wetland types, species diversity, economic valuation and geographical distribution, studies are still limited in South Sudan wetlands, except (Mohamed 2019, El Tahir & Vishwanath (2015), Ibnaof et al.(2013), Nile-Eco-VWU (2015), Nile-Eco-VWU (undated)) specifically on the economic valuation wetland ecosystem services in Machar Marshes wetland.

Machar Marshes wetland is the largest wetland in the Baro-Akobo-Sobat subbasin. It is located in the eastern part of South Sudan and western part of Ethiopia, east of White Nile and north of Sobat river (Negm 2017). This wetland played crucial role related to environmental quality (e.g. ground water recharge, flow regulation); sustaining livelihoods (e.g. fisheries, fuel wood, timber, medicinal

herbs) and maintaining biodiversity (home for fish, birds, reptiles, mammals) (NBI 2012) (NBI 2012). Although Machar Marshes wetland provides multiple ecosystem services, the physical incapability, its remote nature and limited infrastructure development, limited to explore more regarding its biodiversity richness, water-related ecosystem services, provisioning services and contribution to annual flooding control (Mohamed 2019). It is the least known wetland system in South Sudan (NBI 2009). Research works are limited on the current ecological benefits of the wetland, current wetlands' degradation level and alternative way of intervention to restore the wetland (TAMS-ULG 1996, as cited by Wood 2000). Therefore, to fill the knowledge gap and to support decision making in the Nile basin, this report evaluate the current economic value of the Machar Marshes wetland ecosystem services. The study findings support decisions in wetland policy formulation and enhancing integrated development decision makings through evaluating alternative wetland conservation and development options. Specifically, the following objectives are addressed:

- To investigate beneficiaries of the Machar Marshes wetland generated economic benefits,
- To determine the current economic value of the Machar Marshes biodiversity and ecosystem services,
- To determine the economic impacts of the Machar Marshes wetland degradation and loss,
- To determine the value-added or costs avoided in investing on the Machar Marshes wetland conservation and wise-use of available resources for integrated development decisions.

2. Brief Overview of Wetland and Related Policies and strategies in South Sudan

At the country's formation in 2011, formal governing institutions were created, but given the years of conflict and the breakdown of former structures, they commenced from a generally low foundation. The new government's capacity to formulate policy and implement programs is still limited, but is developing and evolving. It should be further strengthened. South Sudan is signatory to the Montreal Protocol to the Vienna Convention on Substances that Deplete the Ozone Layer, the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol to the UNFCCC, the International Plant Protection Convention (IPPC), the Convention on Biological Diversity (CBD), and the UN Convention to Combat Desertification. The institutional frameworks to accomplish environmental and climate-change commitments, however, are still at the nascent stage due to the low priority given to them in the context of the ongoing situation of conflict, as well as the lack of technical capacity and financial resources.

Being a young Government, the Government of Republic of South Sudan (GRSS) is still in the process of enacting various legislations, and among the pieces of legislation that are yet to be developed is a comprehensive Environmental Act. For this reason, only pieces of legislation that are relevant to the environment have been enacted and reviewed in this report.

Table 2. 1: Summary of the different Environmental and Wetland Policies, Laws, Regulations and Plans

Policy, law, regulation, and plan	Relevant provision (theme)
Post 2015 SDGs	The 15th Goal states "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forest, combat desertification and halt and reserve land degradation and halt biodiversity loss. This goal is directly linked to wetland conservation and intervention related to improving land health.
Intended Nationally Determined Contributions	South Sudan prioritizes three sectors for low carbon development and puts forward several options per sector: Energy generation and use, reforestation and deforestation, and transport sectors.
The Interim National Constitution (ICSS), 2005	Part three, article 44 of the Interim Constitution of Southern Sudan (The Environment) has guaranteed every person or community the right to have a clean and healthy environment.
The Transitional Constitution (TCRSS), 2011	Under Article 14 – every person or community shall have the right to clean healthy environment, the obligation to protect the environment, the right to have the environment protected through appropriate legislative action and other measures.
The National Development Strategy (2018-2021)	conducting a baseline survey on the status and sources of environmental pollution as well as developing legislation, regulation, standards and guidelines on environmental pollution management among others.
South Sudan Development Plan (SSDP), 2011-2016	Sustainable development through enforcing environmental and social impact assessments; accede to and ratify applicable and beneficial multilateral environmental treaties, conventions and agreements; and promote inclusive participation, access to information and good governance.
NAPA to Climate Change 2016	Promotion of reforestation and agroforestry; sustainable management and conservation of wetlands; promotion of climate-smart agriculture; improved drought and flood early warning systems; and strengthening institutional capacity
The environmental Protection Bill 2013	Aims to protect the Environment and to promote ecologically sustainable development that improves the quality of life.
The Wildlife Conservation and Protected Areas Bill 2015	Covers all matters concerned with Wildlife Conservation, the establishment and management of protected areas and the sustainable management and conservation of South Sudan's natural heritage and wildlife for the benefit of its citizens.
The Draft Wildlife Bill 2013	Coordination with other relevant authorities of all issues affecting wildlife management including issues of security, infrastructure, private investment and land use planning.
The Forests Bill 2009	Is meant to operationalize the Forestry Policy covering all matters concerned with all forests and woodlands and all forest reserves in the country.
The Water Bill 2013	Aims to conserve available water resources, to manage water quality and to prevent pollution of ground and surface waters; manage floods and droughts and mitigate water-related disasters, and; establish

	appropriate management structures including mechanisms for inter-sectoral coordination and stakeholder participation.
Draft National Environment Policy 2013	Aims to maintaining the balance between the environment and development needs through sustainable use of the natural resource base; creating public awareness of the importance of protecting the environment; and providing the basis for formulation of biodiversity and ecosystem protection and management policies, laws and guidelines.
The South Sudan Wildlife Conservation and Protected Area Policy 2012	Envisions an effective and professional Wildlife Service that will guide the sustainable management and utilization of natural resources, including land, water, fauna and flora for the benefit and enjoyment of the people.
The Environmental Policy and the Environmental Protection Bill 2010	Emphasizes the importance of carrying out Environmental Impact Assessments (EIAs) in relation to any activity that may affect the environment.
The Water Policy	States that the right to water shall be given the highest priority in the development of water resources; rural communities shall participate in the development and management of water schemes; and the involvement of NGOs and the private sector in water projects shall be encouraged.
The Forestry Policy 2014	Proposes the ratification of the UNFCCC so that the country can benefit from the Clean Development Mechanism (CDM); emphasizes the need for measures "so that South Sudan can access financing under Reduced Emission from Deforestation and Forest Degradation (REDD)."
Minerals Law and Policy	The Mining Act 2012 - provides a framework for the management of the mining sector consistent with international standards; and provides for Community Development Agreements for Mining Licenses and environment and social provisions. The Petroleum Act 2012 - emphasizes maximum petroleum recovery within a framework that seeks to ensure the safety, security and protection of the environment, and requires transparency, accountability and ethical behavior on the part of both licensees and the government; requires conducting SEIA.
Fisheries Policy	Decentralization and co-management; embeds the FAO Code of Conduct for Responsible Fisheries; integration into sector wide and national planning; facilitates monitoring and progress

2.1. Post 2015 Sustainable Development Goals (SDGs)

The SDGs framework addresses key systemic barriers to sustainable development such as inequality, sustainable consumption patterns, weak institutional capacity, and environmental degradation that the MDGs neglected (ISSC, 2015). It has seventeen (17) Goals (SDGs) and one hundred sixty-nine (169) targets (UNDG 2015). The 15th Goal states "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forest, combat desertification and halt and reserve land

degradation and halt biodiversity loss" is essential for fulfilling the environmental, socio-cultural and economic needs of present and future generations and, therefore, plays a vital role in the international agenda for achieving a better life for all human societies. This goal is directly linked to wetland conservation and intervention related to improving land health. Furthermore, Goal 13 of the SDGs highlights the importance of taking urgent action to combat climate change and its impacts which could have direct implication for wetlands such as Machar Marshes.

2.2. Intended Nationally Determined Contributions (INDC)

South Sudan submitted its Intended Nationally Determined Contributions (INDC) in September 2015, but has not submitted its First NDC to the UNFCCC. Taking into consideration the 50 years of conflict that destroyed the little infrastructure and governance structure that existed prior to the conflict, in its INDC South Sudan presents itself as being highly vulnerable to the negative effects of climate change, mainly due to the dependence of its population on climate-sensitive natural resources for their livelihoods, limited institutional and technical capacity, appropriate technologies and financial resources to support the implementation of for climate adaptation interventions. The INDC notes that in South Sudan climate change is already occurring – particularly unpredictable rain patterns, recurrent droughts, flash flooding and excessive heat that result in food insecurity and famine. Implementation costs of adaptation and mitigation actions up to 2030, is estimated at over USD 50 billion and is conditional upon international support.

In its INDC the country commits to undertake a national GHG-inventory to allow assessment for mitigation potential and to quantify emission reductions. South Sudan prioritizes three sectors for low carbon development and puts forward several options per sector: Energy generation and use, reforestation and deforestation, and transport sectors. For adaptation, a sectoral approach was adopted for the INDC with priority actions based on observed adverse effects of climate change on the sectors: agriculture and livestock; health; adapting vulnerable communities to climate change; forests, biodiversity and ecosystem; infrastructure; and institutional and policy options. The country's objective in this regard includes prioritizing the enhancement of climate resilience in the agricultural sector through the promotion of climate-smart agriculture, livestock improvement, enhancement of fisheries productivity and soil erosion control. In the Capacity building and transfer of technology component of the INDC, the areas identified which would benefit mitigation and adaptation include renewable energy technologies, climate information systems, water technologies

(e.g. waters savings, recycling, harvesting and irrigation), methods and tools to assess climate impacts, vulnerability and adaptation, and transportation technologies that are climate resilient.

2.3. The Interim National Constitution of Southern Sudan, 2005 (ICSS)

The ICSS was the supreme law of Southern Sudan which stipulates the legal aspects for the protection and management of the environment and natural resources. The environmental record of South Sudan dates back to its ICSS where there were clear provisions on environmental issues of relevance for the country at large and its people in particular. Part three, article 44 of the Interim Constitution of Southern Sudan (The Environment) has guaranteed every person or community the right to have a clean and healthy environment. The Constitution further commits all levels of government in Southern Sudan to sustainable development in order to ensure that the environment is protected for the benefit of present and future generations, through reasonable legislative action and other measures that prevent pollution and ecological degradation, promote conservation and secure ecologically sustainable development and use of natural resources while promoting rational economic and social development so as to protect genetic stability and bio-diversity of Southern Sudan. And also, all levels of government in Southern Sudan shall promote energy policies that will ensure that the basic needs of the people are met while protecting and preserving the environment.

The Interim Constitution also specifies land issues that are under National powers (Federal level) and those under the control of states as well as joint powers (concurrent powers) shared by the Federal and States institutions. The states manage issues related to State lands that are not under National control. These include: management, lease and utilization of lands belonging to States, town and rural planning and agricultural lands within the state boundaries. The concurrent powers include matters related to urban development, planning and housing, electricity generation, waste management, consumer safety and protection, water resources other than inter – state waters and regulation of land tenure and the rights on land. Articles of the Constitution have also provisions on the right to expropriate land and compensation to the owners, protection of cultural heritage and religious sites, as well as issues related to the safety and protection of the inhabitants, beside penalties incurred for environmental damage and pollution as well as respect of the International Environmental Agreements, ratified by the Government of the Republic of South Sudan.

2.4. The Transitional Constitution of the Republic of South Sudan, 2011 (TCRSS)

In 2011, the Government of South Sudan adopted an amendment to the 2005 Interim Constitution renaming it the "Transitional Constitution of the Republic of South Sudan". Under Article 14 "The Environment" the Transitional Constitution states in part (1) that every person or community shall have the right to a clean and healthy environment. While in part (2), it states that every person shall have the obligation to protect the environment for the benefit of present and future generations. And, in part (3) every person shall have the right to have the environment protected for the benefit of present and future generations, through appropriate legislative action and other measures that: (a) prevent pollution and ecological degradation; (b) promote conservation; and (c) secure ecologically sustainable development and use of natural resources while promoting rational economic and social development so as to protect genetic stability and bio-diversity. Also, in Part (4) that all levels of government shall develop energy policies that will ensure that the basic needs of the people are met while protecting and preserving the environment.

2.5. The National Development Strategy of South Sudan (2018-2021)

In the Nation Development Strategy (NDS) several issues are considered to be critical to deliver the NDS objectives for the people of South Sudan. Four cross-cutting issues specifically are identified as important: environment, women and youth, capacity-building and Local Service Support (LSS). The broad nature of these issues means that they cannot be categorized into any of the other clusters. The NDS aims to mainstream these important cross-cutting issues across all clusters through integrating initiatives into sectoral action programs during implementation. Facilitating access and participation by women and youth in governance, peacebuilding and economic opportunities must be clearly reflected in implementation of cluster strategic priority actions. Environmental concerns must be seriously considered for the sustainability of potential gains in economic development and service delivery. The ultimate aim of the NDS is to improve the standard of living of the people of South Sudan.

Among the issues identified to be priority strategic actions in this regard are conducting a baseline survey on the status and sources of environmental pollution as well as developing legislation, regulation, standards and guidelines on environmental pollution management among others. Under the natural resources sector the following activities are highlighted to be performed: a) to review and update policies and strategies for development of the agricultural sector, b) to develop priority

infrastructure for wildlife conservation tourism c) to improve the productive capacity of livestock and fisheries resources, and d) to conduct baseline

2.6. The South Sudan Development Plan (SSDP) (2011 – 2013 and later extended to 2016)

The main guiding document for the development of the country was the South Sudan Development Plan (SSDP) which addresses conflict management, poverty reduction and economic development. One of the goals of the document was to strive for less dependence on oil. The Government's role was not to undertake economic activities itself, but to create an enabling environment for economic development by assuring peace, security, rule of law, macroeconomic stability, basic infrastructure and effective tax administration (GOSS, 2011).

The SSDP was structured through four 'Pillars', namely: (1) governance, (2) economic development, (3) social and human development, and (4) conflict prevention and security. Within these pillars, cross cutting issues are defined as (1) anti-corruption, (2) capacity development, (3) environment, (4) gender, (5) HIV and AIDS, (6) youth, and (7) human rights. Under the Governance Pillar, the Government's role is to:

a) ensure that development is sustainable through enforcing environmental and social impact assessments for all development programs and projects, b) accede to and ratify applicable and beneficial multilateral environmental treaties, conventions and agreements, and c) promote inclusive participation, access to information and good governance in sustainable natural resources management and environmental protection.

The Economic Development Pillar covers the following priority programme areas: (a) agriculture and forestry, (b) roads and road transport development, (c) development of energy, mineral and mining sectors (including oil), (d) animal resources and fisheries, and (e) Water resources management, development, utilization and provision of sanitation services. Environmental sustainability of economic development and related activities including oil extraction, logging and charcoal production is to be ensured. The use of environmental impact assessments (EIAs) is required for infrastructure and power supply development.

The Social and Human Development Pillar envisages environmental awareness-raising of children, and improved health and sanitation facilities focusing particularly on the youth. A national early warning system will be developed to reduce risks of disasters. The Conflict Prevention and Security

Pillar will ensure environmental awareness-raising of disarmament, demobilization and reintegration (DDR) participants as well as the requirement of EIAs for all major construction projects.

2.7. The Republic of South Sudan National Adaptation Programs of Action (NAPA) to Climate Change 2016

National Adaptation Programmes of Action (NAPAs) serve as simplified, rapid and direct channels for Least Developed Countries to identify and communicate priority activities to address their urgent and immediate adaptation needs. NAPAs emerged from the multilateral discussions on adaptation measures within the UN Framework Convention on Climate Change (UNFCCC). South Sudan's NAPA therefore specifies five priority activities (referred to as Priority Adaptation Projects) for effective climate change adaptation across the five-identified priority thematic areas, namely: i) Environment: Promotion of reforestation and agroforestry to reduce vulnerability to droughts and floods; ii) Water Resources: Sustainable management and conservation of wetlands in South Sudan; iii) Agriculture: Promotion of climate-smart agricultural techniques to improve livelihoods and food security under changing climatic patterns; iv) Disaster Risk Reduction: Establish improved drought and flood Early Warning Systems in South Sudan through an improved hydro-meteorological monitoring network; and v) Policy and Institutional Framework: Strengthening the institutional capacity of the Government of South Sudan to integrate climate change into national policies and planning processes. These five Priority Adaptation Projects therefore represent the most urgent and immediate adaptation needs in the country.

However, it is also noted that the other Adaptation Project Options identified through the NAPA process remain important and that ideas/activities/elements can be blended across projects and thematic areas when designing final project concepts for implementation in the country. The NAPA process also identified other guiding principles for adaptation projects in South Sudan, including that:

- Adaptation projects should promote conflict resolution and peace-building.
- Gender equality should be considered in the design of adaptation projects.
- Adaptation projects should target those groups most vulnerable to climate change impacts.
- Adaptation projects should contribute to the further development of legislative and regulatory frameworks in South Sudan.
- Adaptation projects should promote livelihood diversification.

- Capacity building – of human, institutional, technical and financial resources – should be included in the design of adaptation projects.
- Adaptation projects should promote long-term research on climate change adaptation, including the collection of baseline information.
- Indigenous knowledge should be included in the design of adaptation projects.
- Land tenure must be considered when deciding the location for adaptation projects.

2.8. The National Biodiversity Legislation

Many of the key national legislations for biodiversity management in South Sudan are still in the form of Bills before the National Legislative Assembly. The Bills include: The National Environmental Protection Bill 2013; The Draft Wildlife Bill 2013 and the Wildlife Conservation and Protected Areas Bill 2015; The Water Bill 2013; and the Forests Bill 2009. The Draft Policies include: The Draft National Environment Policy 2013; and the South Sudan Wildlife Conservation and Protected Area Policy (Draft of June 2012). Currently, the South Sudan government also developed a new biodiversity action plan to maintain the country's biodiversity as National Biodiversity Action Plan (NBAP). The inclusion of these draft bills is due to the fact that there is no adequate information on the current status of the drafts; i.e., whether they are still at draft stage or they have been ratified. In addition, the inclusion of such drafts shows at least the intention and desire in terms of managing the resources stipulated in each draft which mainly address the ecosystem services considered in this study.

2.8.1. The Environmental Protection Bill 2013

This bill is a key pending legislation that aims to protect the Environment in South Sudan and to promote ecologically sustainable development that improves the quality of life. It grants the right to a decent environment to every person and the concomitant right to bring an action to enforce that right if it is threatened as a result of an activity or an omission. The Bill if enacted into law will empowers the Ministry of Environment and Forestry to supervise and co-ordinate all matters relating to the environment and to be the principal instrument of government in the implementation of all policies relating to the environment including biodiversity. This will include stock taking of the natural resources in the country and their utilization and conservation; examining land use patterns to determine their impact on the quality and quantity of natural resources, and; carrying out surveys which will assist in the proper management and conservation of the environment. That means

establishing an Environmental Information Centre that will undertake an inventory of South Sudan's biological diversity and ecosystems as a priority for the Ministry.

2.8.2. The Wildlife Conservation and Protected Areas Bill 2015

The Bill covers all matters concerned with Wildlife Conservation, the establishment and management of protected areas and the sustainable management and conservation of South Sudan's natural heritage and wildlife for the benefit of its citizens.

2.8.3. The Draft Wildlife Bill 2013

The Bill establishes an autonomous South Sudan Wildlife Service (SSWS) as proposed by the Constitution with a board of trustees and headed by a Director-General both appointed by the President. One of its key functions will be coordination with other relevant authorities of all issues affecting wildlife management including issues of security, infrastructure, private investment and land use planning. This will be done by ensuring the enforcement and implementation of the law with respect to the use of wildlife, the management of protected areas and other uses of natural resources.

2.8.4. The Forests Bill 2009

The Forest Bill is meant to operationalize the Forestry Policy covering all matters concerned with all forests and woodlands and all forest reserves in the country. The Bill provides for a governance structure for all the forests in the country, national sustainable forest management standards, certification systems and schemes, and private and voluntary standards; procedures and decision-making processes, and; complaint and appeal mechanisms.

2.8.5. The Water Bill 2013

This bill provides protection of water sources from pollution, erosion or any other adverse effects by creating Protected Zones within a catchment draining to, or above any water facility forming part of a water supply or any catchment, lake, reservoir, aquifer, wetland, spring, or any other source of water (section 34). The Bill aims to develop procedures for prioritizing allocation of water resources for different social, economic and environmental uses, efficiency, system reliability and environmental sustainability principles. It also aims to conserve available water resources, to manage water quality and to prevent pollution of ground and surface waters; manage floods and

droughts and mitigate water-related disasters, and; establish appropriate management structures including mechanisms for inter-sectoral coordination and stakeholder participation.

2.8.6. Draft National Environment Policy 2013

The aim of the drafted Bill is to ensure the protection, conservation and sustainable use of the natural resources of South Sudan without compromising the tenets of inter-generational equity. This includes maintaining the balance between the environment and development needs through sustainable use of the natural resource base; creating public awareness of the importance of protecting the environment; and providing the basis for formulation of biodiversity and ecosystem protection and management policies, laws and guidelines.

2.8.7. The South Sudan Wildlife Conservation and Protected Area Policy (Draft of June 2012)

It envisions an effective and professional Wildlife Service that will guide the sustainable management and utilization of natural resources, including land, water, fauna and flora for the benefit and enjoyment of the people of South Sudan. It provides for the formulation of legal frameworks for rationalizing the protected area system and wildlife utilization and benefit sharing.

2.8.8. The Environmental Policy and the Environmental Protection Bill (Draft January 2010)

The South Sudan National Environmental Policy has been drafted to achieve sustainable development in light of the following factors (draft January 2010): 1) The upcoming huge investment and development activities following the attainment of comprehensive peace in the country; 2) Emerging environmental management challenges pertaining to diversion of land use systems, urban sprawl, oil exploration in the Sudd wetlands, loss of biodiversity, waste management and others; 3) Ineffective environmental governance due to inadequate institutional capacity and limited government budgetary allocation for environment; 4) The need to harmonize the environmental legal frameworks with sectoral legislation and guidelines; 5) The need to decentralize and devolve management of the environment to the lowest levels of government within the framework of the federal system of rule; 6) The current state of environmental degradation as manifested in widespread pollution by the oil industry, increasing loss of biodiversity due to over-exploitation of forests, inadequate environmental sanitation associated with urban sprawl, and desert

encroachment southwards; 7) Lack of reliable information and data on the environment and limited research capacity.

The policy is based on the following principles: good governance, sustainable development, prevention, subsidiarity, the precautionary principle, scientific knowledge, skills and expertise, and 'The Polluter Pays'. The policy gives guidance to all relevant sectors: agriculture, biodiversity, energy, fisheries, forestry, health, human settlements, industry, livestock, mining, oil, roads, tourism, transportation, water and sanitation. It emphasizes the importance of carrying out Environmental Impact Assessments (EIAs) in relation to any activity that may affect the environment.

2.9. Current Policies and Legislation

As stated above, no adequate information is available, at least for now, whether those bills are still at draft stage. Hence, we assume the following are the policies and legislations that are in use for the different environmental and resource issues. Like the draft bills, these also cover a range of issues that have direct implications for this study. The land policy has direct implication for the ownership and governance of land and resources while the water, forestry, and fisheries policies stipulate on the use and management of these resources and the resultant ecosystem services.

2.9.1. The Land Policy

The Transitional Constitution of 2011 states that all land in South Sudan is owned by the people of South Sudan, and charges the government with regulating land tenure, land use and exercise of rights to land. The constitution classifies land as public, community or private land, and requires the Government of Republic of South Africa (GRSS) to recognize customary land rights when exercising the government's rights to land and other natural resources. The constitution does not clarify the extent to which customary rights can limit government's rights, but does require that all levels of government incorporate customary rights and practices into their policies and strategies. As a result, the Land Act (2009), the Local Government Act (2009) and the Investment Promotion Act (2009) were developed to establish the institutions and mechanisms of governance that would address pressure points and fill vacuums created by conflict, uneven development and lack of transparency and accountability in resource governance (GRSS, 2011).

The three laws mentioned above established the fundamental framework for the fair and transparent administration of land rights in South Sudan. For example, the Land Act regulates land tenure and

equally recognizes rights to customary, public and private tenure. Only South Sudanese citizens can own land, but foreigners can lease land. The document defines rights and restrictions of land users and owners. The Land Commission supervises the application of the Land Act and its institutional set-up at the different administrative levels is elaborated in the Act. The Act prescribes EIA for investment projects, but there are no elaborate provisions for land use planning such as land use categories or planning and allocation procedures. The Local Government Act defines primary responsibilities of local government and traditional government authorities in the regulation and management of land, which includes charging customary institutions with particular responsibilities for administering community land rights.

On the other hand; the Investment Promotion Act establishes procedures for facilitating access to land for private investment, including by foreign investors, in ways that balance the interests of both current right holders and investors. Although a framework has been developed, government officials have a poor understanding of the laws and lack the capacity to interpret and carry them out. There is also a lack of awareness by the population as a whole, which further impedes progress (GRSS, 2011).

2.9.2. The Water Policy

In December 2007, the GRSS adopted the South Sudan Water Policy, which states that access to sufficient water of an acceptable quality and quantity to meet basic human needs is a human right. The policy provides that: the right to water shall be given the highest priority in the development of water resources; rural communities shall participate in the development and management of water schemes; and the involvement of NGOs and the private sector in water projects shall be encouraged. Apart from customary laws governing access to grazing and fishing grounds for communal use at a local level, currently there is no formal system for allocating water resources for different social and economic purposes in the country.

2.9.3. The Forestry policy 2014

Recognizes the critical role played by forests in providing "critical environmental services, water catchment and in mitigating climate change." The forestry policy proposes the ratification of the UNFCCC so that the country can benefit from the Clean Development Mechanism (CDM). It also proposes establishing a designated national authority "to facilitate the flow of climate change benefits to South Sudan." The policy also emphasizes the need for measures "so that South Sudan can access

financing under Reduced Emission from Deforestation and Forest Degradation (REDD)." It calls for delineation and gazettement of forests to attain a national forest cover of 20 per cent of land area.

2.9.4. Minerals law and policy

The Interim constitution of South Sudan states that all levels of government will protect and ensure the sustainable management and utilization of minerals, including oil.

The Mining Act of 2012: provides a framework for the management of the mining sector consistent with international standards, including licensing, environmental protection guidelines and the use of technology to ensure as much mineral resources as possible are recovered from the ground. It also provides for Community Development Agreements for Mining Licenses and environment and social provisions.

The Petroleum Act 2012: The Act states that ownership of petroleum is vested in the people and to be managed by the government for their benefit. The Act also emphasizes maximum petroleum recovery within a framework that seeks to ensure the safety, security and protection of the environment, and requires transparency, accountability and ethical behavior on the part of both licensees and the government (SSIS, 2012).The Petroleum Act is relevant because of the increasing adverse environmental impacts associated with petroleum development in the country on the one hand, and the potential to use funds generated from petroleum sales and taxes for biodiversity management: Oil exploration is carried out mainly in the central flood plains of Jonglei, Lakes and Upper Nile States which are also endowed with vast natural resources including forests, livestock, wildlife and aquatic resources. The Petroleum Act provides that a SEIA to be undertaken by that the oil contractor or licensee in compliance with international standards to determine any present environmental and social damage, establish the costs of repair and compensation and determine any other areas of concern. Whereas the petroleum industry in the country has express a desire for environmental compliance, the Ministry of Petroleum and Mining is still developing policies and measures to safeguards the environment and govern the oil and mining sector to include EIA, environmental sensitivity atlas, multi-institutional monitoring, hazardous waste management, conservation of drilling and campsites, and oil spill contingency plans.

2.9.5. Fisheries policy

The 2006-2011 Fisheries Policy also placed inadequate emphasis on co-management as the key to management of capture fisheries and aquaculture, and failed to place the private sector squarely as the main engine for growth in the sector. A new Fisheries Policy is required with a different emphasis. This new policy:- a) is consistent with the aims and ideals of the transitional constitution, including decentralization of powers and co-management as a guiding theme through the whole sector b) embeds the principles contained in the FAO Code of Conduct for Responsible Fisheries in all activities and sub sectors c) places the private sector as the engine for growth in the sector d) provides a coherent and participatory roadmap to the sector objectives, which can be seen and understood by all stakeholders from all sectors e) provides a sound basis for integration into sector wide and national planning f) facilitates the capture of funds to address the priority policy areas g) facilitates monitoring of progress towards achieving the stated objectives h) is realistic and implementable.

2.10. Concluding Remark on the Enabling Environment for Wetland in South Sudan

South Sudan, the newest nation among the comity of nations, getting its independence in July 2011, is endowed with vast and rich natural resources. Its natural capital includes arable land, grasslands, tropical forests, rivers, wetlands, lakes, biodiversity, minerals, oil, etc. One of the top priorities of the Government of South Sudan is to develop and implement sustainable management plans in the sub-sectors of the environment sector, so that the exploitation of natural resources does not adversely impact the environment. Hence, different attempts have been made, albeit insufficient, towards these goals in collaboration with different international organization. In the above paragraphs an attempt has been made to highlight the different formulation of environmental policies, standards and guidelines, and enforcement of these instruments with some bearing to wetlands in particular and environmental issues in general.

Though a new nation, there has been some strives to formulate different rules and regulations that have direct bearing on the environment. Starting from the ICSS, environmental issues have been clearly stated. Article 44 of the ICSS and Article 14 of the TCRSS give provisions for environmental issues. Both the national development strategy of the country (DSSS) and the South Sudan Development Strategy (SSDP) considers environmental issue in cross cutting category as it has implications on different sectors of the economy. In its INDC, South Sudan has considered reforestation and deforestation activities among the proposals for low carbon development while in

its adaptation strategies agriculture and livestock, forests, biodiversity and ecosystem were put forward as areas for priority actions. The five priorities thematic areas (environment, water resources, agriculture, disaster risk reduction, and the policy and institutional framework) identified in the NAPA of South Sudan have direct implications for wetland management. All these measures show that environmental issues have been given some consideration which can be considered as a good enabling condition for wetland management in the country.

Though the legislative initiatives towards national biodiversity are many, this is the area where most of the initiatives remained at draft level. These initiatives have direct implication for the Machar Marshes wetland and hence finalizing these draft bills into legislation could be important in partially protecting wetlands of ecosystem importance such as Sudd, Machar Marsh and other wetland. The continued conflict and war in the country has not only hampered the completion of such legislative initiatives but also the protection of natural resources of high importance and Machar Marsh wetland is one of them. This latter condition could further exacerbate the conflict in the means of forced migration and competition for resources. Sustainable and equitable management of resources, such as forests, oil, wetland, water and minerals, will contribute to peace and economic prosperity and one way to ensure this is to establish mechanisms for protecting and sustainably using natural resources. Hence such legislative initiatives should be given high priority as they set the rules of the game.

All the above discussion set the rules of the game both for the use, ownership and management of the Machar Marsh and other wetlands and the ecosystem services that are derived from it. They all are important for this study because they have direct bearings to one or more of the ecosystem services considered in this study. Namely: provisioning (crops, timber, grazing, fuel wood, fishing, etc.) cultural (transport, education, tourism), and regulating services (carbons sequestration, water purification and attenuation, and soil erosion). Also, one of the efforts of this study, for example, will be to propose conservation options for the wetland and such proposal will be incomplete without thoroughly understanding the rules of the game and the organizations involved in managing the ecosystem services and the resources that generate such services.

3. Rationale, scope and purpose of the study

The key objective of this technical report is to conduct economic valuation of biodiversity and ecosystem services, by taking Machar Marshes wetland as experiment to inform green infrastructure planning and development in the face of in situ and ex situ development interventions in South Sudan wetlands.

The specific objectives are:

- To investigate economic, social and cultural beneficiaries of the Machar Marshes wetland
- To determine the current value of the Machar Marshes wetland ecosystem services
- To determine the economic impacts of the Machar Marshes wetland degradation and loss
- To determine the value-added or costs avoided in investing on the Machar Marshes wetland conservation and wise-use of available resources for integrated development decision making

The key research questions guiding this study are:

- What are the current challenges and drivers of the challenge of the wetlands in South Sudan?
- Who are the beneficiaries and losers from the wetlands?
- What are the current investments and development interventions around the wetland areas?
- What are the other optional investments in wetland areas?
- How best can influence policy making and planning for better development decision makings?

The scope for this report is defined geographically, conceptually and methodologically. Geographically, it has been challenging to exactly delineate the boundary of Machar Marshes wetland partly due to the seasonality and trans-boundary nature of the wetland. As well, there is no an officially demarcated boundary for the Machar Marshes wetland. We developed the map of the wetland with coordinates of the boundaries using the GIS data collected from ENTRO and NBI-Sec, and by consulting other literature that could provide us useful inputs for this exercise. Accordingly, based on these inputs and the map, we developed Machar Marshes wetland map that is displayed in Figure 3.1. However, the detail presentation of Machar Marshes wetland map refined using the available better coordinates and land use land cover maps that can enable us to describe the wetland in different extent. The Machar wetland located at the north eastern parts of South Sudan, it is found

at Upper Nile South Sudan States, close to the exit of the White Nile. It is located at an altitude of with a range of 395-415 meter above mean sea level, the total areas delineated are estimated about 9000 km2, lying in between 32° 00' 00"to 34° 00' 00" E longitude and 9°00' 00" to 10°00' 00" N latitude (Figure 3.1).

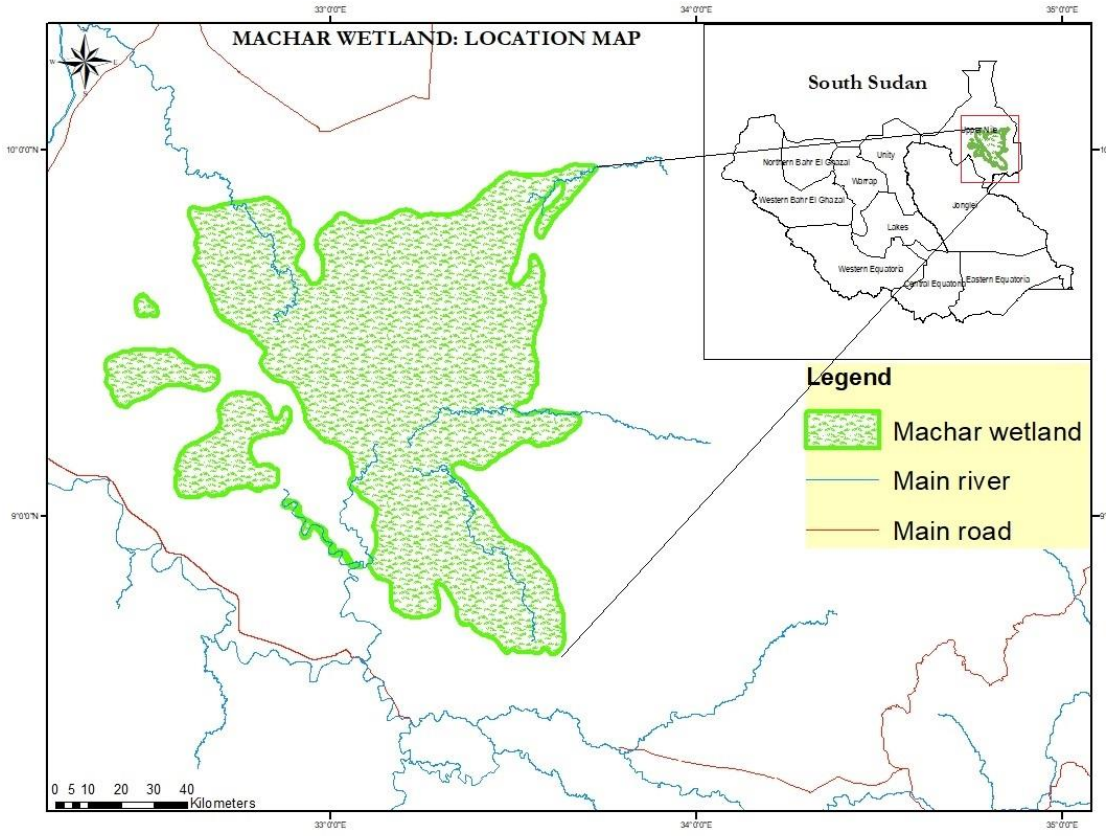


Figure 3. 1: Location of Machar wetland

Conceptually, we initially proposed to use the total economic valuation framework. But, during Kampala technical TEEB evaluation meeting, it was clearly highlighted that the framework is just a framework to guide environmental valuation studies. Indeed, it is not possible to value everything as stated in the framework and we have been advised to select the major ecosystem services provided by the Machar Marshes wetland. Accordingly, for the Machar Marshes wetland, based on the Kampala technical TEEB evaluation meeting, provisioning services, biodiversity, the green infrastructure via maintaining the regulating services (water-related ecosystem services, and local climate) have been identified. These ecosystem services are further elaborated in the methodology part of this report and the expected method and data collected to value different wetland ecosystem services.

Figure 3. 2: Nile Basin Wetlands TEEB: Valuation Studies Technical Meeting – focus on the context for the economic valuation of wetland ecosystem services of Machar Marshes wetland- Kampala, Uganda

Methodologically, initially developed inception report has been ambitious and optimistic on the availability of data and the possibility of primary data collection; being cautious though. We developed the survey and data collection instruments that could help us to conduct such exercises. However, from Kampala, TEEB technical review meeting and Juba, stakeholder consultation meeting, it was clear that the issue of primary household level data collection is challenging and available secondary sources are also very limited. Hence, we exhausted and collected the available primary and secondary sources of data; we opt to apply the benefit transfer approach for regulating and supporting ecosystem services of the wetland and market price (revealed) approach has been applied for provisioning ecosystem services of the wetland.

Figure 3. 3: Nile Basin Wetlands TEEB: Valuation Studies Technical Meeting of Nile basin Wetlands– focus on the context for the economic valuation of wetland ecosystem services-Kampala, Uganda

Figure 3. 4: South Sudan National Wetlands consultation workshop–briefing the expected TEEB exercise to the participants related to wetland ecosystem services valuation– Juba, South Sudan.

4. A Brief Overview of Machar Marsh Wetland in South Sudan

South Sudan has an area of approximately 640,000 km^2. The country is situated in the Nile catchment area, receiving water from the highlands of the Central African Republic, Democratic Republic of Congo, Ethiopia and Uganda. The lowest part of Nile basin forms wetlands', such as Sudd wetland, Machar Marshes wetland and other smaller wetlands. Altitude varies between 600 and 3000 m above sea level; the lowest point is found in the extreme north of Upper Nile State and the highest in the mountains of Eastern Equatorial State. Most of South Sudan has a semi-humid climate, with annual rainfall ranging from 200 mm in the southeast (Eastern Equatorial) to 1200-2200 mm in the forest zone in western Equatorial and the Equatorial highlands. In the northern state rainfall varies between 700 and 1300 mm and the average temperature vary between 26°C and 32°C. The rainfall pattern is seasonal: a rainy season from April to December that causes seasonal flooding of floodplains. The seasonal climate patterns cause cyclic relation with the local ecosystem and hence determine land use patterns of cultivation, livestock grazing and fisheries (MoE and UNDP, 2012). The Nile wetlands ecosystems include a wealth and variety of swamps, marshes, seasonally inundated grassland cover, swamp forests, floodplains and the wetland edges of lakes and rivers.

Biophysical Features Machar Marshes Wetland

The Machar Marshes wetland is one of the largest wetland in Baro-Akobo-Sobat (BAS) sub-basin (Mohamed 2019) that covers about 13.2% of BAS sub-basin (ENTRO 2007). Machar Marshes wetland located in the eastern part of Sudan and western part of Ethiopia, east of White Nile and north of Sobat river. It is located between $8^0 27' - 9^0 58' N \; and \; 32^0 11' - 34^0 9' E$, with an estimated wetland area around 900,000 ha (ENTRO, 2016).

The flooded area coverage (swamp and grassland) of the Machar Marshes is subject to variability. Research is limited in this wetland area due to physical inaccessibility and political instability. Various studies provide different wetland area that ranges from 3500 km^2 to 20,000 km^2. For instance, the following estimates that are cited in Amare (2007) indicated different estimates for permanent and seasonal swamp areas of Machar Marshes wetland. JIT (1954) estimated about 6000 to 20,000 km^2 for the swamp and grassland annually flooded; El-Hemry and Eagles (1980) estimated the area of permanent swamp as 8,700 km^2 (of which 60 percent was grass and forest)by using Landsat imagery; FAO Africover estimated the permanent and seasonally flooded swamp about 967 km^2 and 1,947km^2, respectively, including the grassland area about 5,392km^2, which has been partly seasonally flooded. Sutcliff and Parks, (1999) estimated the area of inundated area that ranges from

1500-6000 km^2; the area of inundated estimated to 3000 km^2 based on thermal infrared image (Amare 2007).

The topography of Machar Marshes is characterized by very flat slope of less than 1%. The marsh is dominated by seasonal flooding of the swampy plains. The wetland temperature ranges from 20 ^0C to 35^oC, with extremes of 11–43^oC. The annual rainfall over the marshes is about 800 mm/year. The evapotranspiration over the wider catchment around the Machar Marshes is about 1,300 mm/year (Mohamed, 2004) and mean annual volume of the wetland is 12,878 mm^3 (ENTRO 2016).

Water balance of the Machar Marshes Wetland

The combination of local perception, the torrents which originated in Ethiopia high lands and spill over to Baro, Akobe and the Sobat are major sources of water to Machar Marshes wetland. Spills from upper and lower Baro river occur during the flood peak when flows exceed 1.5 km^3 between July and October. JIT study's estimated inflow to the Machar swamp from the spilling of Baro for the years 1980-2000 is 2.374bm^3. The MIT Study made an estimate of 3.54 km^3 but included spill during low flows of the Baro-Sobat. If these are excluded their estimate is 2.873 km^3. Sutcliffe and Parks using the 1950-55 (years with below average rainfall) flow data estimated northward spill as 2.328 km^3.

The Machar Marshes wetland also fed by the eastern torrents (the Tombak, Ya bus, Daga and other small stream) which drain from Ethiopian Highlands, which joins the Khor Daga and the Khor Adar (Henry Busulwa 2012). Based on several estimation cited in Amare (2007) for example the JIT study, the total runoff entering to Machar Marshes from the eastern torrents estimated around 1.744bcm. Furthermore, Machar is fed by local presumptions and the mean annual rainfall of marsh estimated about 800mm, an annual supplying of 15km^3(over an area of 20,000 km^2). The MIT Study used a mean annual rainfall of 933 mm over an area of 8,700 km^2 giving an annual supply of 8.12 km^3. Sutcliffe and Parks estimated the average annual rainfall 1950-1955 to be 933 mm over a mean flooded area of 3,350 km^2 giving an annual supply of 3.125 km^3. Water watch (2001) estimated the annual rainfall for the year 2001 using the Tropical Rainfall Measuring Mission (TRMM) satellite sensor as 784 mm (Amare 2007).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Spill from Baro towards Machar (1905 - 1955)												
0	0	0	0		44	218	504	738	689	135	0	2328
Spill from Baro River (1980 - 2000)												
0.0	0.0	0.0	0.0	0.0	22.2	396.6	954.9	1096.3	551.1	11.4	0.0	3032
Inflow of Yabus at Yabus Bridge (1950 - 1955)												
9.88	4.7	3.39	3.15	8.59	17.7	30.1	88.7	118	108	42.8	19.6	455
Inflow of Daga at Daga Post (1950 - 1954)												
1.78	1.24	0.31	1.04	5.85	16.4	48.1	113	93.8	91.5	36.3	10.9	421
Total Estimated inflows from east Torrents to the Machar Swamp (1950-1955)												
23	12	7	8	29	68	156	401	423	398	158	61	1744
Average Rainfall over the Machar Watershed (1905-- 1955, mm)												
0	2	3	31	109	126	179	241	139	77	26	0	933
Average Evaporation (mm)												
217	190	202	186	183	159	140	140	150	177	189	217	2150

Table 4. 1: **Components of Machar marshes water balance (mcm, after analysis by MIT, 1980) (Amare 2007)**

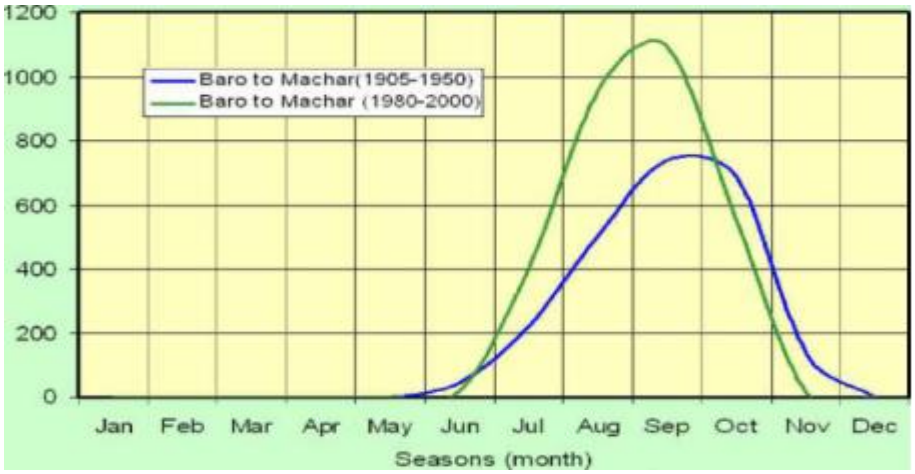


Figure 4. 1: **Comparison of mean monthly inflows from Baro to Machar Marshes Wetland inflow swam for the periods of 1980- 2000 (Amare 2007)**

Similarly, the wetland loss its water by drainage to the White Nile and evaporation and it directly drains to White Nile through Khors Adar and Wol. The estimated mean annual water loss through Ada was to be 0.150 and through the Wol to be 0.100 km3.The MI T study estimated evaporation rate of wetland to be 1,340 mm/yr (Amare 2007). On other hand Amare (2007) estimated annual evaporation rates of the wetland is between 1,666 – 1,900 mm.

The Natural Resources and Ecosystem services of the Machar Marshes wetland

Biodiversity

The Machar Marshes wetland is rich with its flora and fauna and it is an extensive wetland system (Henry Busulwa 2012). Since there is a seasonal climate variation from wet rainy season (June to October), to a long dry season (November to May), seasonal river spills into the wetland provides the marsh areas with their unique alternating wet/dry habitat characteristics (Mohamed 2019). This wetland has three distinct zones and each distinct zone content different type of flora.

i. **Permanent Swamp**: it is located on the deep of the wetland and it covers around 870,000 ha (El-Hemry and Eagleson1980, based on Landsat imagery), (Henry Busulwa 2012). These parts of the wetland are dominated by papyrus sedge, common cattail and common perennial reed (Phragmites karka), Cyperus papyrus forming tall stands along the innumerable watercourses, fringing numerous waterlogged and permanently inundated areas.

ii. **Flood plains of the wetland:** These areas of the wetland are experienced with high variability in flood timing and intensity. During the wet season, this area of wetland is swampy and covered by tall grasses. During the dry season, floodplain is an important grazing area for Nuer and Dinker communities. As well, it is habitat for migratory mammals and birds during the dry season. Oryza longistaminata and by Echinochloa pyramidalis are the dominant vegetation of seasonally flooded grassland areas.

iii. **Foothill of the wetland (Woodland)**: The fringe of the marshes is dominated by Acacia trees and scattered shrubs. These trees have higher value on timber production, firewood, building poles and wild fruits. Forests are also habitat for many floras.

The Machar Marshes wetland provide rich habitat that support for about 400 different bird species and more than 100 mammal species (Smakhtin 2012b). In the Marcher Marshes wetland especially on grassland mosaic maintains, important population of large mammal species are commonly

conducting annual migration due to the seasonality of the grass land cover including the emblematic species for this area, the White-eared Kob (Kobus kob leucotis) and the Nile Lechwe (Kobus megaceros). In addition, other big mammals which live in the swampy areas of the wetland are available like Elephant (Loxodonta Africana), Buffalo (Syncerus caffer), Tiang hartebeest, (Damaliscus Korrigum Tiang), and the Oribi Antelope (Ourebia Ourebi) extend their range up to the river's edge during the dry season. Hippopotamus (Hippopotamus amphibious) are quite frequent and the region harbors are home for large populations of the Nile crocodile, (Crocodylus Niloticus) (HCENR(The Higher Council for Environment and Natural Resources) 2009). The wetland is also habitat for migratory birds from Eurasia to Africa

The Machar Marshes wetland is habitat close to 92 different fish species (ENTRO 2007b). Some of these fish species are found in the deep parts of the wetland that include: Barbus spp., Citharinus spp., Clarias spp., Gymnarchus Niloticus, Heterotis Niloticus, Labeo spp., Oreochromis niloticus, and Polypterus bichir and Gymnarchus niloticus (Henry Busulwa 2012).

Current Land Use of Machar Marshes and the Ecosystem Services

The Machar Marshes wetland land use land cover serve significant numbers of functions and provide multiple ecosystem services, the most notable are listed as follow**:**

1. Papyrus or by Phragmity or Typha: It grows around the permanent swamp and the flooded plain parts of the wetland. It provides major provisioning ecosystem servicer such as construction of reed boats, mats, rope, and basket. The papyrus plant also served as shelter for aquatic animal.
2. Extensive Grassy Vegetation: It locates around the flooded plain areas of the wetland. It serves as habitat for numerous mammals and birds during dry seasons. It also provides fodder and used as grazing area for the local community livestock's and source of grass resources to construct house for the local community. It enhances the supporting and provisioning ecosystem services.
3. Lowland forest and savanna woodland: It locate around the foot hill areas of the wetland, these forests provide provisioning ecosystem services for the local community (i.e. by supplying timber and fuel wood), habitat for wildlife, and regulating ecosystem services (e.g. carbon sequestration/sinking).

4. Crop land: It locates close to and around the flooded plain of the wetland which is cultivated by the local community.
5. Open access grassland cover: this grassland cover located around the flooded plain of the wetland. It provides fodder for the livestock's and regulating ecosystem services (i.e. protect soil Erosion and sinks carbon).

Machar Marshes wetland played a vital role for the ecosystem and surroundings for the local communities. The wetland provides provisioning ecosystem services for Nilutic, Nuer, baggara, Ingessana, morle and Dinka communities. It provides grazing land access for livestock and wild animals on the flood plain areas of the wetland on the dry season, as a source of house building materials and fire wood, fishing and hunting for the local community. This wetland also support the regulating ecosystem services of the Nile hydrological system by regulating the water flow, maintaining water-related ecosystem services and attenuate the water flow of the white Nile (Smakhtin 2012) .

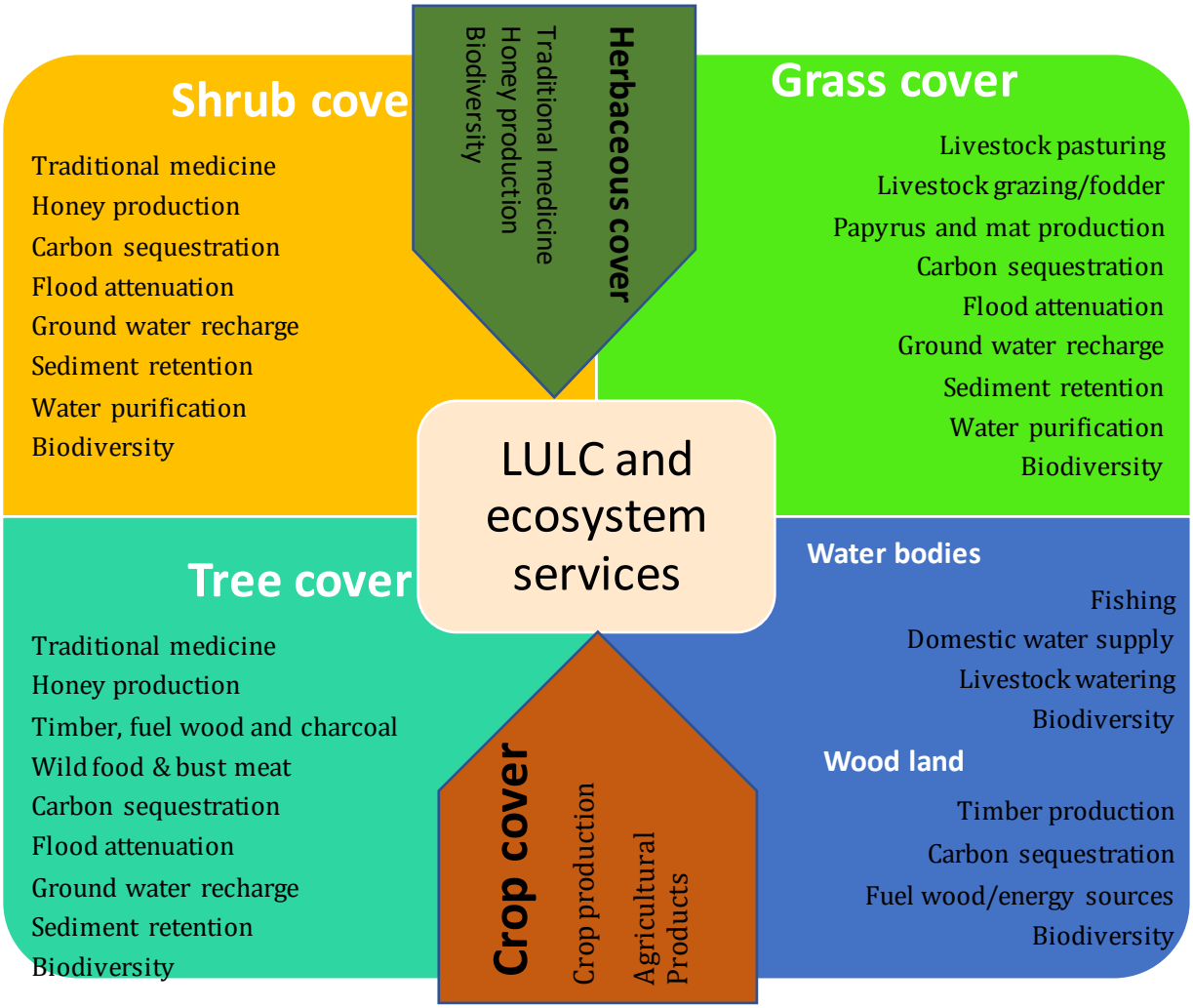


Figure 4. 2: Machar Marshes LULC classes associated wetland ecosystem services

Threats of Machar Marshes Wetland

Although Machar Marshes wetland is one of the most degraded and the list conserved wetland, still different threats contribute for further degradation of the wetland:

- Ethiopian government has studied the possibility of storage reservoirs at Gambella and other sites on the Baro river sub-basin for multipurpose regional development in the sub-basin, including irrigation and hydropower generation. Machar Marshes got 3032 mcm spill inflow from Baro river. The construction of hydrology power and dam will reduce the spill to Machar by 20%. These will affect the extent of flooding area and in particular the toish grassland will shrieked by 12% (Amare 2007).
- *"The Machar Marshes Canal Scheme, This was a proposed water diversion scheme along the Sobat River aimed to provide "new water" for downstream users, by building a canal to collect*

spill from the Sobat that partly flows to the Machar Marshes" and by transmit the spill directly to the White Nile (Amare 2007). The construction of these canal would make the marsh wetland effectively dry apart from some localized flooding from the local rain fall (Henry Busulwa 2012).

Contrary to the dam construction impact (Blackmore and Whittington 2008) argued that either the construction of the dam and hydrology power in Baro or the cannel construction on Sobate river have insignificant impact on the hydrology of Machar since the Machar Marshes only found 1 bcm Spills from the Baro and Sobat, which is low as it compared with the local rainfall about 11 bcm.

- Oil exploration and extraction is another threat for further Machar Marshes wetland degradation. The extraction of oil could affect the wetland in two ways. In one hand, oil is pumped together with water and the two have to be separated appropriately. If these couldn't happen, the wetland water will be contaminated. Thus, the livelihood of the local inhabitants and water supply would seriously affect. On other hand, so as to transport the oil from the source to the destination, all whether road have to be constructed. If the construction of these all-weather roads undertaken without effective drainage and adequate culverts to conserve the wetland areas, it may cause serious flooding on the upstream side and impacted water availability to the downstream parts of the basin. Given the very complex drainage systems within the Machar Marshes, any disruption in water flow can have serious impact on the distribution of the important "toich" grazing areas (Amare 2007).
- The livestock population around the wetland is most likely increased due to influx of population (i.e. in-migration) in areas that had been deserted due to civil wars. These large number of livestock population expose the wetland for potential challenges of land degradation, soil erosion and associated sedimentation of water bodies (Henry Busulwa 2012).

On the other hand, communities who live around Machar Marshes wetland are one of the poorest communities in Nile Basin and their life is highly depending on the wetland's ecosystems. If Machar Marshes wetland conserved, the welfare of these communities might be improved. Thus, conserving this wetland could improve the wetland's ecosystems and the livelihood of the people. Furthermore according to ENTRO (2010) report, this wetland have higher potential for developing water conservation projects so as to increase the supply of Nile water, if it conserve appropriately (Mohamed,2019).

5. Methodology

This section of the report presents the main approaches applied in to develop this technical report that include potential data sources, assessments of ecosystem conditions and trends, key informant interview and focal group discussion, document review, valuation of ecosystem services and alternative wetland conservation interventions, and risks and threats in developing this report.

5.1. Sources of Data

For the successful accomplishment of the stated objectives, both primary and secondary data have been collected and analyzed. Wetland related policies in particular and environmental related policies, strategies, and plans in general are briefly reviewed and incorporated under this report to understand the enabling policy and strategy environment to implement wetland conservation activities and to support integrated development decisions. Other relevant information from secondary sources was consulted to complement this review with relevant local and international experts. Given the benefit transfer approach is the plausible option considering the circumstances of the study site; much information will be extracted from secondary sources and literatures to conduct the valuation of regulating and biodiversity ecosystem services of the wetland. The existing global and regional TEEB reports and valuation studies have been reviewed and considered as a good asset for this purpose. Activities performed in and around the wetland, benefits obtained from the wetland area, challenges of the wetland, wetland conservation options, wetland conservation option expected costs and benefits and related information were generated both from primary and secondary sources. Population data of the wetland area, states and national level, agricultural production data, Consumer Price Index (CPI), statistical bulletins, published and unpublished materials about these issues were consulted and collected from South Sudan Statistical Office to value the marketed ecosystem services (i.e. mainly provisioning ecosystem services of the wetland). We explored and collected available data and reports from ENTRO data base and we consulted experts at ENTRO to validate the generated information from the data base and reports.

5.2. Assessing Ecosystem Conditions and Trends

In order to assess the ecosystem, we combined available remotely-sensed data (satellite imagery) in combination with Geographical Information Systems (GIS) approach and ecosystem models as analytical methods. As well, available natural resource and biodiversity inventories, indicators of ecosystem conditions, and socioeconomic data that are viable were collected and analyzed from ENTRO reports and data base. To prepare this report, we also conducted Key informant interview

(KII) and focus group discussion Discussions (FGD). A generic presentation staging of the potential required information, data sources and analytical approaches for assessing ecosystem condition and trends are presented in Table 5.1, Table 5.2 and Table 5.3 for provisioning, regulating and biodiversity ecosystem service, respectively.

The provisioning services provided by the Machar Marshes wetland includes timber, fuel wood, charcoal, crop production, domestic water consumption, grazing and water for livestock, fish, natural medicines, papyrus and mat production. Local communities settled around Machar Marshes, South Sudan, neighboring countries and the global communities are also benefited from the wetland ecosystem services. The potential provisioning ecosystem service, valuation method, model, data, and its source for respective ecosystem service are presented in Table 5.1.

Table 5. 1: **Potential Valuation Method Sources of Required Date for Estimating Values of Provisioning Ecosystem in Machar Marshes Wetland South**

Product/service	Valuation Method	Data needs	Model2	Model explanation3	Sources of data
Timber	Market prices	-Potential Production Volume (M3) - Average estimated cost of production (variable and fixed cost) - Estimated average selling price of the timber	$T_v = (Q_i * P_i) - C_i)$	Where, T_v is the economic value of the product/output, Q_i is the quantity of good/product; P_i is farm gate average price of the product, C_i is the cost of production,	Actual local Market prices and quantity supplied Central Bureau of statics in Sudan Literature and annual reports
Fuel wood	Market price	-Potential Production Volume (M3) -Average estimated cost of production (variable and fixed cost) -Estimated average selling price of the firewood	$T_v = (Q_i * P_i) - C_i)$	Where, T_v is the economic value of the product/output, Q_i is the quantity of good/product; P_i is average farm gate price of the product, C_i is estimated average cost of production,	Regional reports Central statics' biro of South Sudan
Papyrus	Market price	Area coverage by papyrus and its' productivity Average value/ price of papyrus per head load	Vp= s*j*k Adopted from (Merriman, J.C., Murata 2016)	Vp= average value of papyrus s= Total area under papyrus (ha) j= average productivity per hectare (head loads) k= average selling price per head load (US$)	Existed literature National reports
Agricultural crops	Market prices	-Production volume, local units and conversion, cost of production, and Market prices	$T_v = (Q_i * P_i) - C_i)$	Where, T_v is the economic value of the crop, Q_i is the quantity of crop; P_i is the average farm gate price of the product, C_i is the average cost of production,	Actual local Market prices and quantity supplied, Central Statistical biro of South Sudan

[2] The equation are adopted from (Langat & Cheboiwo 2010)

[3] The values, costs and benefits will be calculated per Hectare to develop the enterprise budget

				The values, costs and benefits will be calculated per Hectare to develop the enterprise budget	
Domestic water supply	Market price	Number of households whose water source is from the wetland -Average daily water use per household -Average Water use price/ price per m3	Vw=l*m*n*365 day	l= Households dependent on wetlands for water supply m=Average use of water per household per m3 n= Market price per m3 (US$) Vw= Average total annual value of water for domestic consumption (US$)	Central statics bureau of South Sudan Regional /National report
Livestock grazing	Market price	Number of cattle which graze from the wetland Average value/cost of pasture consumed per day per animal	Vg=o*p*365 days Adopted from (Kakuru, Turyahabwe, and Mugisha 2013)	Vg= Average value of grazing o= Number of cattle raised in wetland area p= Average value/price of pasture consumed per day per animal (US$)	Review of existing literature National reports South Sudan Central Statistical bureau
Livestock watering	Market price	Number of cattle which drink water from the wetland Average volume of water consumed per head per day Cost of water per 20litres or perm3 Number of days per year (365)	Vlw=p*q*r*365 days Adopted from (Kakuru, Turyahabwe, and Mugisha 2013)	Vlw= value of livestock grazing p= Number of cattle obtaining water from wetlands q= Amount of water consumed per day per head of cattle r= Cost of water per 20litres/m3(US$)	Local market price National report
Fish	Market price	Potential quantity in Kg (any other local measurement) Estimated cost of the production	Tf= (Qf *Pf) - Cf	Tf = total value of fish Qf = quantity of fish Pf = price of fish Cf = cost of fishing	Local market price National report

Hunting (bush meat)	Market value	Annual meat which obtained from the wetland wild animals	Vh=r*s-t Adopted from (Kakuru, Turyahabwe, and Mugisha 2013)	Vh= Economic value of hunting r= Annual gross hunted meat per ton (e.g. tonnes/year) s= Unit price of meat. USD/tonne t= Unit cost for hunting good (e.g. USD/tonne)	Existing literature South Sudan Central Statistical bureau
Wild fruits and vegetables	Market value	Annual gross harvested fruits from the wetland	Vf=u*v-w	Vf= Economic value of wild fruit and vegetable u= Annual gross harvested/cultivated amount (e.g. tonnes/year) v= Unit price of the good (e.g. USD/tonne) w= average unit cost for harvesting/cultivating the good (e.g. USD/tonne)	Existing literature South Sudan Central Statistical bureau
Natural medicines	Market price	Number of people treated by natural medication Average estimated cost of medication	$T_m = (Q_m * Pm))$	Tm- the economic value of medication Qm – number of people who treated by natural medication Pm- estimated value/price of medication saved	Existing literature South Sudan Central Statistical bureau
Honey	Market prices	-Quantity of honey produced (Kg), - Cost of harvesting -Average selling price of honey per Kg	$T_h = (Q_i * P_i) - C_i)$	Where, T_h is the economic value of the honey, Q_i is the quantity of honey/kg; P_i is price honey/kg, C_i is the cost of harvesting	Actual local Market prices and quantity supplied, South Sudan Central Statistical bureau Literature and annual reports

Fodder	Surrogate, Market prices	-Potential quantity in kg, sacks and/or other local measures to be converted to kg - Estimated cost of production -Average selling price of fodder	$T_f = (Q_f * P_f) - C_f)$	Where, T_f is the economic value of the fodder, Q_f is the quantity of fodder/kg; P_f is of fodder/kg, C_f is the cost of production	

The Machar Marshes wetland supports enormous regulating ecosystem services that includes carbon sequestration, groundwater recharge, and flood attenuation. The regulating ecosystem services provided by Machar wetland benefited at different spatial scales: local, regional and global scale. Table 5.2 describes the potential regulating ecosystem services, valuation methods, models, data, and its source for respective ecosystem services.

Table 5. 2: Potential Valuation Method Sources of Required Date for Estimating Values of Regulating Ecosystem in Machar Marshes Wetland, South Sudan

Product/service	Valuation Method	Data needs	Model[4]	Model explanation	Sources of data
Carbon Sequestration	Market prices	-Above ground biomass (AGB), -Below ground biomass (BGB), - Soil biomass	$V_R = (Q_r * P_c * S_r) - (Q_d * P_c * S_d)$ It is adapted from In VEST model	Where: VR=the carbon sequestration value of conservation transition; Qr=carbon sequestration (CO2) in restored area; Pc=the international carbon sequestration price; Sr = the area restored (ha); Qd is the is carbon sequestration (CO2) in degraded area; Sd is the area degraded (ha)	Existing literature that estimated CO2 sequestration level at local or regional level. IPCC reports National and/or regional and/or local level carbon sequestration levels
Water Attenuation	Market price and avoided cost	Number of Households around the wetland affected by flood Annual Estimated cost which incur for flood control	Vw= A*B Adopted from (Merriman, J.C., Murata 2016)	Vw- value of water attenuation A- Total household likely damaged by disaster without wetland ecosystem B- Annual Estimated cost per household for flood control or storm surge protection or wave attenuation	Existing literature National and regional reports
Water Purification	Market price and avoided cost	Total number of household who uses wetland as a major sources of water The economic cost/value of water purification per m3	Vp=A*B Adopted from (Verma and Negandhi 2011)	Vp is the economic value of water purification A= total purification cost per household if there were no wetland B= total number of house hold who uses the wetland as a source of water	Exciting literature National reports

[4] The equation are adopted from (Langat & Cheboiwo 2010)

Soil protection (prevented soil erosion)	Avoided cost	-cost of 1 ton of sediment removal How much ton of soil sediment retain in the wetland -ratio of sediment entering to rivers or reservoirs to total soil lost -Soil erosivity for restored and non-restored areas (tons/ha)	$V_k = K * G \sum_{n=1}^{n} S_i * (d_i - d_0)$	Where Vk is the economic value of soil-erosion regulation; -K is the cost of 1 ton of sediment removal; -Si is the area of forest-vegetation types in hectares; -G is the ratio of sediment entering rivers or reservoirs to total soil lost;-di is the erosivity of non-restored land (tons/ha); and do is the erosivity of restored area (tons/ha).	-- Literature, - water resource management bureau -Land resource management bureau - National and/or regional and/or local level soil maps

Table 5. 3: Potential Valuation Method Sources of Required Date for Estimating Values of biodiversity Service in Machar Marshes Wetland, South Sudan

Product/service	Valuation method	Data needs	Model	Sources of data
Biodiversity	Revealed price and value transfer	Expenditure (budget) or investment for biodiversity conservation by local, national and international actors.	Not applicable (Value transfer and/or actual investment on biodiversity conservation)	National budget, annual report and existing literature

5.3. Key Informant Interviews (KII)

Key Informant Interviews (KIIs) has been carried out with selected experts at different levels of the administrative and institutional hierarchy to solicit information about the wetland using a checklist that is prepared as a guide for interviewing and consultation process. We conducted KII's with selected experts in Juba, South Sudan in August 26-29, 2019. We also conducted a technical review meeting with technical experts and reviewers of the NBI to validate the approach and setting the stage in preparing this report in Kampala, Uganda in July 21-23, 2019. The technical review meeting contributes to structure the focus of the report, to identify the relevant ecosystem services of the wetland, to refine the methodology and approach of the report and to redefine the practical implication of the report for integrated wetland development and management decision. These technical and KIIs meetings note reports annexed for reference as Annex IV and Annex V. The list of consultation meeting participants is annexed in Annex I (Table 2.1). In addition, information about the existing situation of the wetland, stakeholders impacted by the wetland, wetland conservation options given the local circumstances, viability of the different wetland conservation options, socioeconomics and biophysical characteristics of the wetland, current and expected of costs and benefits of alternative wetland conservation options (if any), expert outlooks of the state of the wetland and other information are outlined and obtained from the KIIs workout. The Key informant checklists to conduct the KII exercise are presented in the appendix (See Annex II).

Figure 5. 1: **South Sudan National Wetlands consultation workshop – The participants split into different groups for discussion on South Sudan wetland ecosystem services and challenges – Juba, South Sudan**

5.4. Focus Group Discussions (FGDs)

Again, we conducted focus group discussions (FGDs)with target groups of different stakeholders that may have better information about the wetland issues in the community. We conducted focus group discussion in Juba, South Sudan in August 26-29, 2019. Members of the FGDs are selected and identified in a close consultation with local administration and experts. The lists of guiding questions and the potential stakeholders involved in the FGDs exercise are presented in the appendix (see Annex IV and Annex I (Table 2), respectively)

5.5. Document Review

The team apprehends the importance of secondary data for better understanding of enabling policy environment for wetland conservation. In view of this, desk review of various documents was conducted in context of wetland ecosystem services and conservation. We reviewed available policies, strategic documents, plans, convictions, progress reports of different stakeholder projects, both national and regional proclamations, research findings conducted on similar issue s, and review of best practices at international arena. Specifically, we collected and analyzed the following documents, but not limited to: NBI research and report data base, Rasmar convention, and South Sudan wetland and related policies and strategies

5.6. Conducting valuation of wetland ecosystem services and alternative wetland conservation interventions

We conducted a well-executed logical sequence of the following steps to value wetland ecosystem services and alternative wetland conservation interventions:

Step 1: **Specify the set of wetland conservation and integrated development decision making options**

In wetland conservation intervention, the first step is to set conservation transitions (options) for different LULC changes that impacted the wetland. The main activities to be done at this stage are:

- What are the major classes and trends of Land use land cover changes in and around the wetland area? For this study, this can be done using **avail remote sensing information on land use and land cover**.
- What are the major reasons for wetland degradation?

- What kind of wetland conservation options is appropriate (identifying conservation options to improve wetland productivity and the wetland ecosystems[5])?
- What are enabling environment and potential challenges of wetland conservation? (policy dimensions and programs for wetland conservation)
- What are the options to integrated development decision makings and who are the key actors?

Step 2: Decide whose costs and benefits count (identifying stakeholders and mapping of stakeholders)?

Wetland conservation and development interventions impacted different institutional and spatial scales. It is vital to count the costs and benefits to all people residing in the area and potential stakeholders. More importantly who will invest and participate in the proposed wetland conservation actions? Who will be affected by the proposed wetland conservation and development interventions? What are the likely impacts of wetland degradation? What are the interest and influence of different stakeholders interested in this wetland? **This step will address one of the assignment objectives' i.e. to investigate beneficiaries of the Machar Marshes wetland generated economic benefits.**

Step 3: Identify the impacts

Identifying the full impact of each wetland conservation option is important to identify the incremental costs and benefits for each wetland conservation option, relative to the base case scenario (which will normally be 'what would happen if the current arrangements were to continue?). All the effects of proposed wetland conservation interventions that are considered desirable by those affected are benefits; all undesirable effects are costs. Alternative wetland conservation options and expected costs and benefits are presented in Annex I (Table 7).

Costs

Detailed expected categories of costs to be considered as: the common expected wetland conservation cots are implementation cost, opportunity cost, and transaction cost reflected in alternative wetland conservation options.

[5] Alternative wetland conservation options and expected costs and benefits are indicated as an annex for reference.

Opportunity cost: This are the benefits foregone by investing on degraded wetland activities through transition environmental enhancing of the LULC options that was normally generated from the degraded wetland: such as crop yields, foregone income from previous (often) unsustainable activities (for example, fishing, logging, fuel-wood collection, unsustainable agricultural practices, overgrazing of animals, etc.)

Transaction costs: These are costs incurred that support the transition of conservation activities, including daily labor, experts' time, training costs and etc. In wetland conservation, the commonly transaction costs are related to search costs: identifying program participants, identifying funding sources, etc. Bargaining cost: time spent at informal and formal meetings and communications; monitoring and enforcement costs.

Implementation costs: These are the cost incurred in the transition of wetland conservation activities**,** including seedling cost, Excavation and grading cost, compensation, equipment and etc. For example: capital expenditures on equipment and infrastructure; annual operations and maintenance costs; and labor costs for administration and implementation equation

Benefits

Defining the institutional and ecological benefits of alternative wetland conservations is necessary to understand the full impact of conservation intervention. The ecosystem improvements' which comes by the conservation of wetland benefited different stakeholders at local, regional, nationaland international level. For instance, wetland conservation intervention benefits the local community directly by providing provisioning ecosystem services and indirectly by maintaining microclimate. On national level, wetland conservation helps the government to achieve the target set in National Development Strategy. Furthermore, the global community also benefited from conservation interventions that support the regulation of global climate (e.g. global warming, and carbon emissions). We identified expected costs and benefits of alternative wetland conservation.

Measuring the physical impacts

The Millennium Ecosystem Assessment (MA, 2005) categorizes ecosystem services into: regulating services, supporting services, provisioning services and cultural services. The different ecosystem services affect stakeholders at different scale. Measuring the physical impact will involve definition of the ecological scales for each impacted ecosystem services in physical units with a time dimension

to reflect the fact that ecosystem services provide benefit over time. For example, crop production (t $ha^{-1}yr^{-1}$), timber production (m^3 yr^{-1}), fuel wood production (m^3 yr^{-1}), crop yields (t $ha^{-1}yr^{-1}$), prevention of erosion (t $ha^{-1}yr^{-1}$), carbon sequestration (t $ha^{-1}yr^{-1}$), water attention, water flow regulation and water purification.

Key questions projected to be addressed:

- What are the likely impacts of the conservation interventions on individual, local (community), regional, national and global level?
- Who are the stakeholders that will be impacted most (identifying the stakeholders)?
- What are the indicators to measure the impacts?
- What costs and benefits are accrued by different stakeholders -typology of stakeholders and costs and benefits associated with wetland conservation interventions and alternative development options?

Step 4: Predict the impacts over the life of the proposed conservation opportunities

We will follow a framework of: ecosystem to services; services to value; value to institution; and institution to decision to indicate how ecosystem services are integrated with decision makings. It helps us to understand the proposed wetland conservation and integrated development decisions. To quantify the benefits (impacts) of the proposed conservation intervention, biological production function has been applied. Biological productions functions relate the structure of ecosystem to outputs of goods and services. For example, crop production is a function of or related to the quantities and quality of the various inputs (e.g. seeds, labor, chemicals, and irrigation). As well, carbon sequestration and water flow regulation are related to the area of forest and/or permanent wetland restored. However, due to rareness of data and limited research on relationship between wetland conservation and changes in ecosystem services in South Sudan, specifically to develop location specific parameters, we applied value transfer/benefit transfer approach through extensive review of peer-reviewed and grey literature. The global TEEB database and the Nile Basin TEEB data base were also reviewed that could be great help in this regard.

Valuing and mapping wetland ecosystem services

Value transfer/benefit transfer involves the adaptation of existing valuation information to new program contexts where valuation data is absent or limited. Although data limits could be a challenge

for value transfer, it has become an increasingly practical way to inform decision-makers in the presence of budget and time constraint, and when expected payoffs to original research are small (Troy & Wilson, 2006). We will follow Troy & Wilson (2006) approach, a decision framework for mapping ecosystem service values at different scales. **This will enable us to map economic value of ecosystem services at local scale. Mapping the ecosystem of the area will help us to determine the current economic value of the Machar Marshes biodiversity and ecosystem services.**

The followings are the core steps in mapping wetland ecosystem services value of a given wetland:

1. Study area delineation: spatial designation/delineation of the extent of the study area. It has been done by considering the maximum and the minimum extent of the wetland to have an optimal wetland area for the analysis. It has a significant impact on the final results when estimating the economic value of ecosystem service.

2. Typology development: establishment of a land use and land cover (LULC) typology. This step starts with a preliminary survey of available cite level data with GIS to determine the current LULC.

The ESA-CCI-LC product (version 1.4 available at http://maps.elie.ucl.ac.be/CCI/viewer/ and the data products can be downloaded from http://maps.elie.ucl.ac.be/CCI/ viewer/download.php) is derived combining remotely sensed surface reflectance and ground-truth observations at 300-m resolution (Alkama & Cescatti 2016b) the land use land cover classes are based on the United Nation Land Cover Classification System (LCCS). The annual land cover map examined in this report is the land cover map for the years 1995, 2005 and 2015.

Meanwhile, a second dataset from MODIS land cover had been used for the year 2009, 2013 and 2018. The MODIS data can be downloaded from https://earthexplorer.usgs.gov/. The available document for classification schemes is also available at https://yceo.yale.edu/modis-land-cover-product-mcd12q1. The dataset has 500m resolution. It is used to develop a recent multi-temporal land use land cover of Machar Marshes wetland for the year 2009, 2013 and 2018.

Remote Sensing (RS) data and Geographical Information System (GIS) techniques were used for extraction of the study area, preprocessing, analysis and spatiotemporal assessment of the Machar wetlands. The LULC classification of GIS methodology helped in the identifying, delineating and mapping of the land use/land cover into several classes. The Supplemented online available land use

and land cover used for validation of multi-temporal land use / land cover mapping and change detection which was performed using digital datasets of ESA-CCI LULCC of 1995, 2005 and 2015. The analysis has been done using ARCGIS software and some graphs have been done by R programming language and excel.

3. Meta-analysis of peer-reviewed valuation literature to link per unit (area) coefficients values to available LULC types. Preliminary review of economic valuation studies to determine whether the ecosystem service coefficients value have been documented for the LULC types in a relatively similar context. But this is usually very limited in developing countries, however, we use global TEEB data base, NBI-TEEB data base and related studies as well as KII information to obtain per hectare values for identified ecosystem services.

4. Total value calculation: calculation of the total Ecosystem Services Value (ESV) has been done linking with the recent LULC types of the wetland.

5. Geographic summaries: Tabulation and summary of ESVs by relevant management geographies (spatial scales).

6. Scenario development or change analysis: This analysis conducted by changing the inputs in step 4 and 5, to highlight the different changes in the wetland LULC and how it impacts on ecosystem services in the area. The different land use and land cover provides and support different wetland ecosystem services. Wetland ecosystem services change depend on the existing LULC. Thus, wetland ecosystem services change scenarios were developed by considering the temporal and spatial dimension of the LULC changes that have a direct impact on wetland ecosystem services. We developed two/three different periods (with a minimum of five years interval) of LULC change of the wetland and analyze changes in wetland ecosystem services. **At this phase we can highlight the economic impacts of the Machar Marsh wetland degradation and loss impact on wetland ecosystem services.**

Step 5: **Monetize (place monetary values on) wetland ecosystem services**

At this stage, value of wetland ecosystem services has been conducted. Monetary values for marketed goods and services estimated from observed behavior. We measure the value people place on something by observing how much they actually pay for certain goods or services (market price/revealed prices), and the quantities of those goods and services that are consumed (i.e., using

market price and information). For non-marketed good and services value transfer/benefit transfer and stated preference approach can be conducted, if necessary. A summary of methods, data and estimation techniques to estimates the value of an estimate costs and benefits streams of each wetland conservation options has been prepared and annexed as Annex I, from Table 3 to Table 6. In some cases, monetization can be difficult because impacts are sometimes uncertain, some are difficult to value in monetary terms, and some are both uncertain and difficult to value. Some environmental goods and services are typical examples of this case. To address such challenge, an attempt has been made, when necessary, to complement this effort with qualitative analysis that is most appropriate in place of monetary values.

Step 6: Reach a conclusion and provide recommendations

The output of the work is to support and identify the most appropriate wetland conservation and development options highlighting on wetland ecosystem services valuation, stakeholder mapping and identifying alternative wetland conservation options. As well, results from economic valuation analysis can used to explore potential financing options and investments for alternative wetland conservation interventions. **At the end, the above proposed approach enable us to conduct the ecosystem service status and trend, to assess the socio-economic contribution of the ecosystem services, to estimate the cost and benefits associated with wetland conservation efforts and to analyse trade-off and synergies in wetland management for alternative land and other natural resource use in the Machar Marsh wetland.**

5.7. Risk and Threats

The applicability of the primary data collection and analysis method depend on the circumstances on the ground and logistic arrangements. However, we could able to conduct KII and FGDs on the ground in Juba, South Sudan. Value transfer approach has been applied for selected ecosystem services because this valuation method applicable in data limit areas and a practical way to inform decision-makers in the presence of budget and time constraint, and when expected payoffs to original research are small(Troy & Wilson 2006). Thus, we employ the value transfer approach for selected wetland ecosystem services. Our result might be affected by the wetland delineation; however, we adopted the ENTRO's updated version of the Machar Marshes wetland delineation, Due to seasonal variability, there is no clear demarcation to identify the wetland boundary. For selected ecosystem services, for example for biodiversity ecosystem services we couldn't find reliable data, therefore we applied

benefit transfer approach using studies and interventions conducted relatively similar wetlands with Machar Marshes. As well, we applied plausible assumptions and value transfer approach considering appropriate steps to balance the local challenging situation in South Sudan to collect recent market information and to explore in depth the available data for our analysis.

Note that we use the 2015 price as a base year due to two compulsory reasons. First all our land use land cover data is based on year 2015 data and second the price/values should be computed and considered on stable period. Considering these reasons, we prefer using 2015 price as a base year price, i.e. after 2015 there is higher price shock (inflation) in South Sudan due to the political instability. Especially the high price shock in South Sudan could overestimate the wetland service if we use the 2019 price. Thus, following the economic and financial analysis recommendation to consider stable period/year, we stick to the 2015, which is relatively stable period in South Sudan.

6. Result and Discussion

This section presents the main findings and results of the technical report that includes Machar Marshes wetland stakeholder analysis and mapping, the land use land cover (LULC) analysis and assessment of the wetland, economic value of the wetland ecosystem services and potential wetland conservation options to improve the wetland ecosystem services.

6.1. Stakeholder Analysis and mapping

In this section, the following major themes are addressed: What are the likely impacts of the conservation interventions on individual, local (community), regional, national and global level?; Who are the stakeholders that will be impacted most (identifying the stakeholders)?; What are the indicators to measure the impacts?;What are the costs and benefits of undertaking the conservation intervention (opportunity costs, transaction costs, implementation costs)?;What costs and benefits are accrued by different stakeholders-typology of stakeholders and costs and benefits associated with wetland conservation interventions and alternative development options?

Table 6. 1: Key stakeholders involved in Machar Marshes wetland

Stakeholders			Proposed intervention
Local community			Take responsibilities to conserve the wetland, sources of labor and endogenous knowledge on how to preserve the wetland sustainably.
External stakeholders	Governmental organizations	Local municipality	Administrate budget and enforced laws which written by the national government. ✓ Promote Community base wetland conservation. ✓ Helps to assimilate information on how to utilize and conservation of the wetland,
		National government	✓ Draw policy and strategies for sustainable preservation of the wetland
		Ministry of Animal Resources and Fishery	✓ By collaborating with Ministry of Environment, it will conserve the wetland so as to achieve the ministries goal of creating harmony habitat for wild lives.
		Ministry of Agriculture (MoA)	✓ MOA collaborated with MOE on the conservation of foothill wetland by planting agroforestry plantations
		Ministry of finance (MoF)	✓ Allocate, execute and mange budget for the wetland conservation.
		Ministry of water resource and irrigation	✓ drafting and overseeing the implementation of policy, guidelines, master plans and regulations for water resource development; ✓ Implementing water bill to protect water sources from pollution, erosion or any other adverse effects.
		Ministry of environment and forest	✓ Developing policy and regulatory frameworks on wetland conservation. ✓ Implement environmental bill policy to prevent the wetland from overexploitation. ✓ Advocate community level forestry and agroforestry on the foothill of the wetland so as to promote forestation. ✓ find fund for the restoration programs by linkages with donors, non-governmental organizations, and community- based organizations
	Non-governmental organizations	wildlife conservation society	✓ Give training for the local communities on wetland resource management, land-use planning, on how people and wildlife live together in harmony. ✓ Work on conservation to reduce conflict and catalyze economic development
		Non- Government Organizations (NGOs)	✓ Create awareness on the advantage of wetland conservation for the local community and way of wetland restoration ✓ Source of funds
		United Nation Environment program	✓ source of finance ✓ Support technically interventions to improve wetlands
		Wetland International	✓ Support technically interventions to improve wetlands
Researchers		NBI	✓ Source of information on how to utilize wetland resource efficiently ✓ Undertake researches on the impact of upstream development on wetland wellbeing. ✓ Undertake research on which conservation option is more visible for South Sudan wetlands', specifically Machar Marsh wetland.
		Universities	✓ Source of research base information regarding causes of wetland degradation and alternative ways of intervention. ✓ Create awareness for the local community about the negative impact of wetland degradation and on alternative ways of wetland restoration.

Based on the predetermined stakeholder groups, stakeholders' consultations were carried out at different levels in the form of focus group discussion and key informant interview. The consultation workshop conducted at Juba and Kampala interact with stakeholder from South Sudan government officials including ministries, local administrative officials, experts from various fields that are closely related with wetland conservation, researchers, experts from NBI, external reviewers from NBI and consultants. Following the outcome of FGD, we categorized stakeholders in to four groups; 1) local

community (upstream and downstream village residents), 2) government institutions (national, state and local governmental organizations) and 3) researchers (NBI, research centers and university) 4) NGOs (non-governmental organizations involved in wetland conservation programs and other humanitarian activities).

Stakeholders were categorized based on their interest and influence/power on the wetland resource use and conservation efforts. The influence and relative importance/interest of stakeholders are presented in Figure 6.1. Stakeholders in box A are different NGOs with high interest on the Machar wetland conservation and restoration but have less power to influence interventions to conserve the wetland.

Table 6. 2: Identified stakeholders of Machar Marshes wetland

S.N	Stakeholders	Brief description
1	Local community[6]	Around 554,029 residents are living around Machar Marshes wetland. Mostly reside in Maban, Longocauk, Luakpiny, and Baliet villages. Their livelihood mainly depends on fishing, subsistence farming, cattle rearing, mat making, honey production and wild fruit collection.
2	Government administrative	Government administrators at national, state and local level that are directly and indirectly involved on the political administration of the wetland resource
3	Researchers	From universities and international initiatives working on wetland conservation and restoration
4	NGOs	Domestic and international non-governmental organizations that are working on welfare and humanitarian improvement

Source: Experts and local community consultation meeting in Juba, August 2019

[6] Local community also called local stakeholder which refers the local people live close to the Machar Marshes wetland.

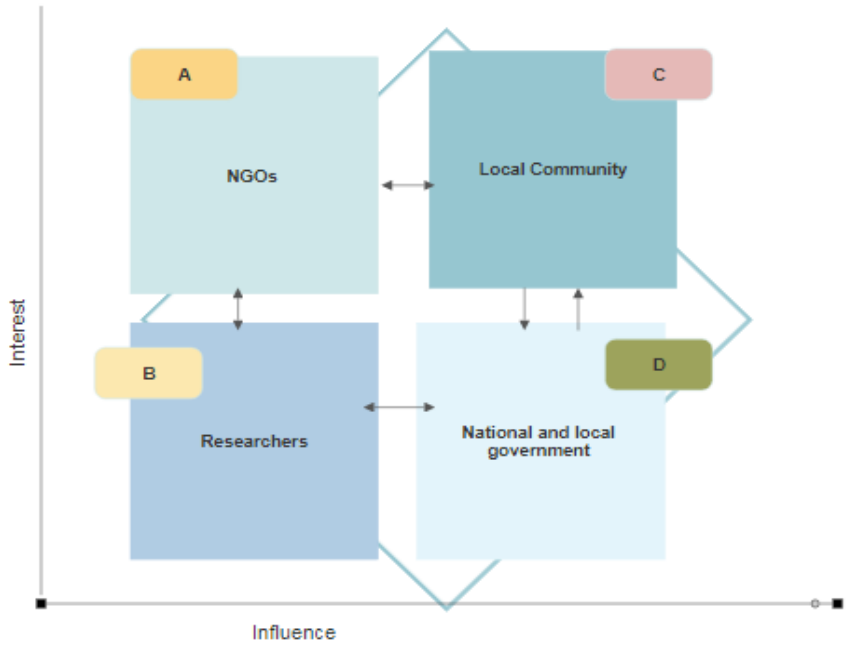


Figure 6. 1: interest-influence matrix of stakeholders in Machar Marshes wetland conservation (based on Juba consultation meeting)

While in box B, researchers are involved with minimum cost Machar Marshes wetland concerns on knowledge transfer and data repository of the wetland socioeconomic and ecological functions (like conservation, biophysical measures, and socioeconomic assessment and restoration efforts) and have little interest in the process to influence. A group of stakeholders categorized in box C are local communities which are the most important/key players of the entire process of Machar Marshes wetland resource utilization, management, conservation and restoration. National and local government presented in box D of Figure 1 has a political power to overse e and settle issues related with the wetland entire activity, particularly the states has significant influence in the process of implementation.

Table 6. 3: **Major economic activities of the local communities around Machar Marshes wetland**

ECONOMIC ACTIVITY	COMMUNITY	POPULATION
REARING LIVESTOCK	Nure ,Shai ,Bagara	Average 100,000
HONEY PRODUCTION	Nure, Shai, Anwak	70 % of Koma; 30% of Nuer and Dinka
CROP PRODUCTION	Nure, Shai, Anwak	50,000
MAT PRODUCTION	Nure, Shai, Anwak	25000
HAND CRAFT	Nure, Shai,	25000
PAPYRUS HARVESTING	Nure, Shai	475,000
BIRCK MAKING	Nure, Anwak	5000
FISHING	Nure, Anwak	40,000
OTHER ACTIVITIES	Koma, Humters	450,000

Source: Experts and local community consultation meeting in Juba, August 2019

The relationship between the stakeholders can mainly categorize in three ways; one stakeholder could influence the other decision (i.e. has power on the other); two stakeholders communicate each other but not influence each other (has balanced power) and one stakeholder could influence other's decision but the influenced stakeholder could give feedback.: In Machar Marshes wetland, the government administration at different levels can influence the decision of the local community but the local community has a power to give feedback on the government action. On the other hand, NGos' and researchers communicate with the local community and government structure but not influenced each other (Figure 6.1). Key stakeholders involved in Machar Marshes wetland in resource use, knowledge development and wetland conservation efforts are presented in Table 6.1.

6.1.1. The Benefits for Stakeholders in Machar Marshes Wetland

The Machar Marshes wetland provides multidimensional benefit for different stake holders. The local community who resides in Maiwut and Latjor state is the foremost stakeholders that significantly benefited from the Machar Marshe wetland mainly in the form of regulation and provisioning service. The main ecosystem services obtained from the Machar Marshe wetland is summarized by Figure 6.2. Especially, for the downstream community regulation service (such as flood attenuation) obtained from the wetland play very crucial role for their survival. The South Sudan government is also benefited from the wetland. For instance, the wetland's provisioning ecosystem services for the poorest surrounding community decrease the government's spending for food aid; the wetland flood attention service decreases the government's costs to support people evacuation during flood disaster and infrastructure maintenance and development costs. The wetland water purification services also contribute to avoid costs of the government which could spend to purify drinking water

for domestic consumption. The wetland's sediment retention services avoid the costs related to sediment removal. The wetland also supports the nation to preserve the environment by sinking a higher amount of carbon. Moreover, NGOs and researcher receive enormous benefits form the wetland and this stakeholder gives due emphasis for the wetland regulation and supporting service (Figure 6.2).

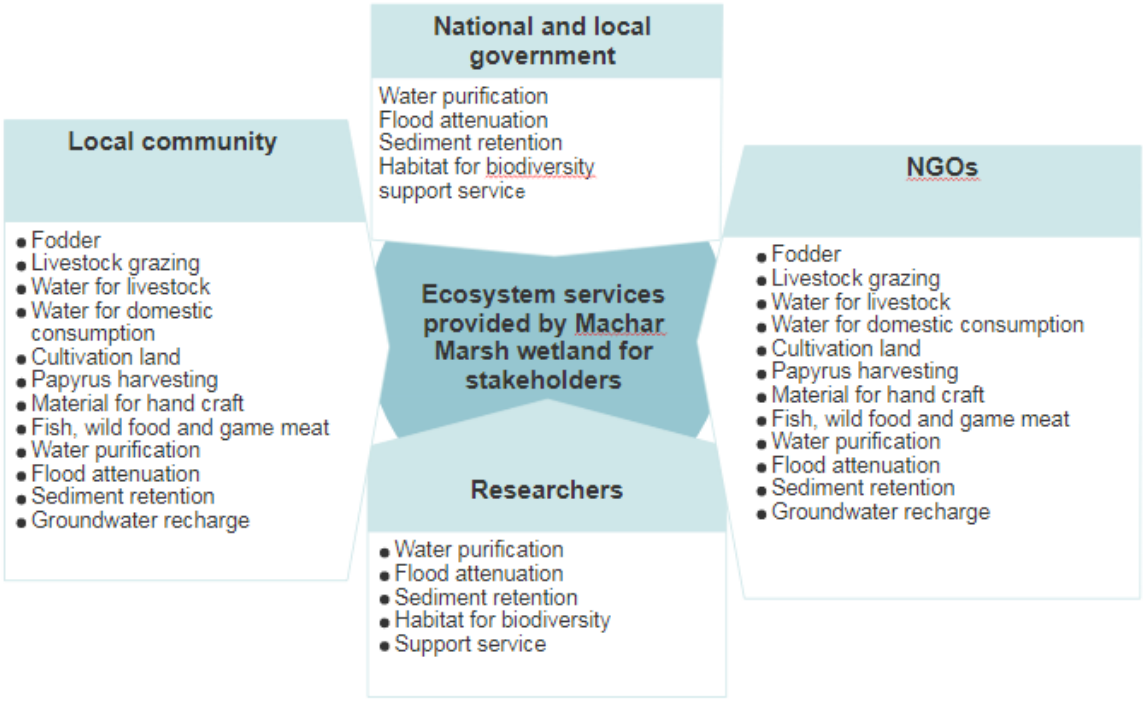


Figure 6. 2 : Mapping the Machar Marshes wetland ecosystem services and their relevance for different stakeholders

6.1.2. Machar Marshes wetland degradation causes and trends

The current and further degradation of Machar Marshes wetland could influence the local communities, the South Sudan government and non-governmental organizations and global communities. The current degradation of the wetland subjects to the action of different stakeholders. In this regard, the main responsibility remains to local community in which their day to day economic activities impacted the Machar Marshes wetland ecosystem services. As of the focus group discussion, the main causes of Machar Marshes wetland degradation are mainly related with inappropriate utilization of natural resources including deforestation, wildfire, and overharvesting.

Moreover, the wetland is under threat of degradation emanates from upstream development plan of water diversion scheme along the Sobat river for providing new water point and building canal to collect spills that flow partly from Machar Marshes. Besides, there is a plan of transmitting the spill directly to the White Nile and also Ethiopian government plan to build hydropower plant as a source of renewable energy close to Ethiopian border that may of the wetland.

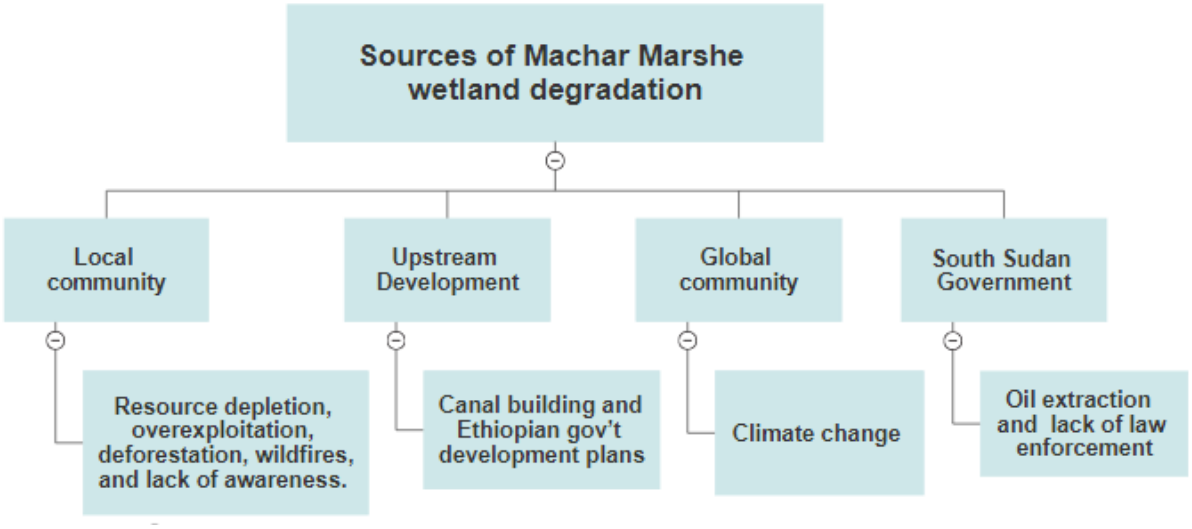


Figure 6. 3: **Main threats of the Machar Marshes wetland mentioned by the stakeholders (based on Juba consultation meeting)**

6.2. Machar Marshes Wetland Land Use Land Cover (LULC) Analysis

6.2.1. Multi-Temporal Land Use Land cover of Machar Marshes Wetland

Land use and land cover change (LULCC) is one of the critical drivers of global environmental change (Sherbinin 2002). Monitoring land use land cover change is vital for a number of environmental monitoring applications, including carbon emission estimation, biodiversity conservation and land degradation mitigation (Sherbinin 2002). LULCC is the essential human perturbation on natural ecosystems (Klein Goldewijk *et al.* 2017) and one of the main drivers of climate change (Alkama & Cescatti 2016a). This section aims to assess the LULC dynamics and its change at Machar Marshes wetland of South Sudan using the Climate Change Initiative Land Cover (CCI-LC) for the year 1995, 2005 and 2015 and Moderate Resolution Imaging Spectro radio Meter (MODIS) land cover product of year 2009, 2013 and 2018 using GIS. The LULC analysis enables us to analyze the trends of

Ecosystem services of the wetland. We also developed and analyzed scenario assessment of LULC for the year 2025, 2035 using CCI-LC and for year 2023 and 2028 using MODIS data base.

The location map and available supporting data for Machar Marshes wetland has been collected from the Nile Basin Initiative (NBI) Addis Ababa office, Eastern Nile Technical Regional Office, (ENTRO). The data was extracted from Baro-Akobo Sobot (BAS) project data base at ENTRO The Machar Marshes data shape file of the wetland was published in 2016 at NBI and post-processing of the shape file has been done for better visualization of the area. Table 6.4 indicated the revised and used shape files data source.

Table 6. 4: Data Sources Summary for LULC analysis of Machar Marshes wetland

	Items	Data Source
1	Location Shape file of Machar wetland and all administration, roads and rivers files	NBI Addis Ababa Ethiopia, Eastern Nile Technical Regional Office (ENTRO), Baro-Akobo- Sobat (BAS) document
2	Land cover 1	ESA- CCI LC
3	Land cover 2	USGS- MODIS

The LULC mapping of Machar Marshes wetland was also carried out using satellite data of the year 1995, 2005 and 2015, the identified LULC classes include cropland, herbaceous cover, tree cover areas, shrub cover areas, grassland, tree cover flooded, Shrub land herbaceous cover flooded and water bodies, Figure 6.4 indicates the spatial distribution of the 1995, 2005 and 2015 LULC of the Machar Marshes wetland. The slight precision assessment has been carried out using land cover Atlas of the republic of South Sudan from FAO and Google Earth satellite images. The FAO Atlas maps were produced by FAO in 2011 and it is available at http://www.fao.org/3/a-be895e.pdf (FAO 2011). An inspection by LULC overlay technique has been applied to compare our result with available Google Earth satellite images and the FAO Atlas products and it shows a significant agreement of the LULC classification over cropland, herbaceous cover shrub land and tree cover areas and water bodies.

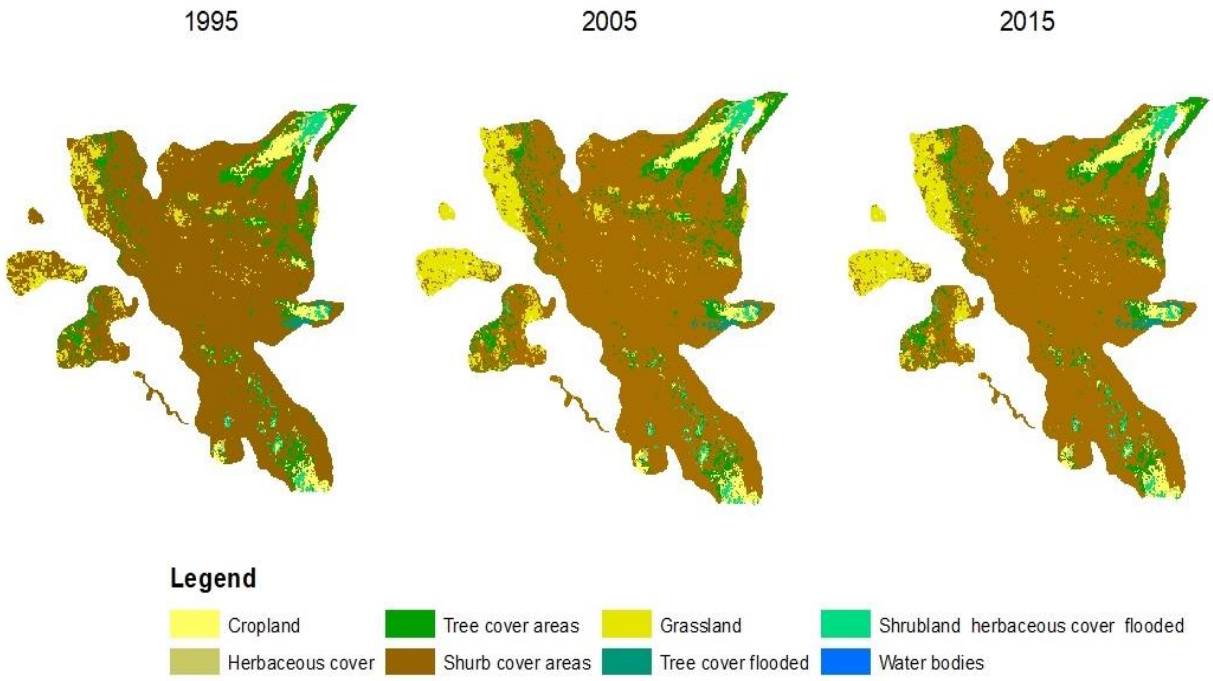


Figure 6. 4: Multi-temporal Land use and Land cover of Machar Marshes wetland

Table 6. 5: Land use and Land cover change analysis of Machar Marshes wetland, 1995-2015

LULC Classes	Area in (Km2) 1995	Area Percent (%)	Area in (Km2) 2005	Area Percent (%)	Area in (Km2) 2015	Area Percent (%)	Change Rate between (2015 -1995) in (km2)
Shrub cover areas	7531.56	79.42	7088.40	74.75	7102.35	74.89	-429.21
Tree cover areas	844.65	8.91	852.75	8.99	837.18	8.83	-7.47
Grassland	473.22	4.99	832.41	8.78	827.73	8.73	354.51
Cropland	359.55	3.79	416.16	4.39	419.67	4.43	60.12
Shrub land herbaceous cover flooded	161.10	1.70	162.72	1.72	164.25	1.73	3.15
Herbaceous cover	67.77	0.71	74.07	0.78	72.90	0.77	5.13
Tree cover flooded	43.65	0.46	54.99	0.58	57.42	0.61	13.77
Water Bodies	1.71	0.02	1.71	0.02	1.71	0.02	0.00
Total	**9483.21**	**100**	**9483.21**	**100**	**9483.21**	**100**	

Table 6. 6: **Percentage Change of Land Use Land cover, 1995 - 2015**

	Percentage of Change		
	2005 Vs. 1995	**2015 Vs. 2005**	**2015 Vs. 1995**
Shrub cover areas	-4.67	0.15	-4.53
Shrub land herbaceous cover flooded	0.09	-0.16	-0.08
Tree cover flooded	3.79	-0.05	3.74
Cropland	0.60	0.04	0.63
Herbaceous cover	0.02	0.02	0.03
Grassland	0.07	-0.01	0.05
Tree cover areas	0.12	0.03	0.15
Water Bodies	0.00	0.00	0.00

The statistical analysis of the multi-temporal land use/land cover maps of the Machar Marshes wetland revealed that few significant changes have taken place from 1995 to 2015. The Land use/land cover changes at Machar Marshes wetland during 1995, 2005 and 2015 presented in Table 6.5. Meanwhile, the LULC change in percentage of each land use and land cover classes are presented in Table 6.6. Land use/ land cover at the Machar Marshes wetland has marked mainly significant changes on Shrub cover areas. Meanwhile, there has been a reservation in shrub cover areas as about 80 % of the Machar Marshes area is covered with this LULC classes.

The changes in LULC are the result of environment and anthropogenic activities around the wetland area. Machar Marshes wetland land cover changes is summarized and indicated that the shrub cover areas has decreased (from 79.42 % to 74.89%), tree cover areas also decreased (from 8.91% to 8.83%), grassland has increased (from 4.99% to 8.73%), cropland has increased (from 3.79% to 4.43%), Shrub land herbaceous cover flooded has increased (from 1.72% to 1.73%), herbaceous cover has increased (from 0.71% to 0.77%), tree cover at flooded area has in creased (from 0.46% to 0.61%) and water bodies has resulted in no changes. The variation of LULC changes in three decades of Machar Marshes wetland presented in Figure 6.5.

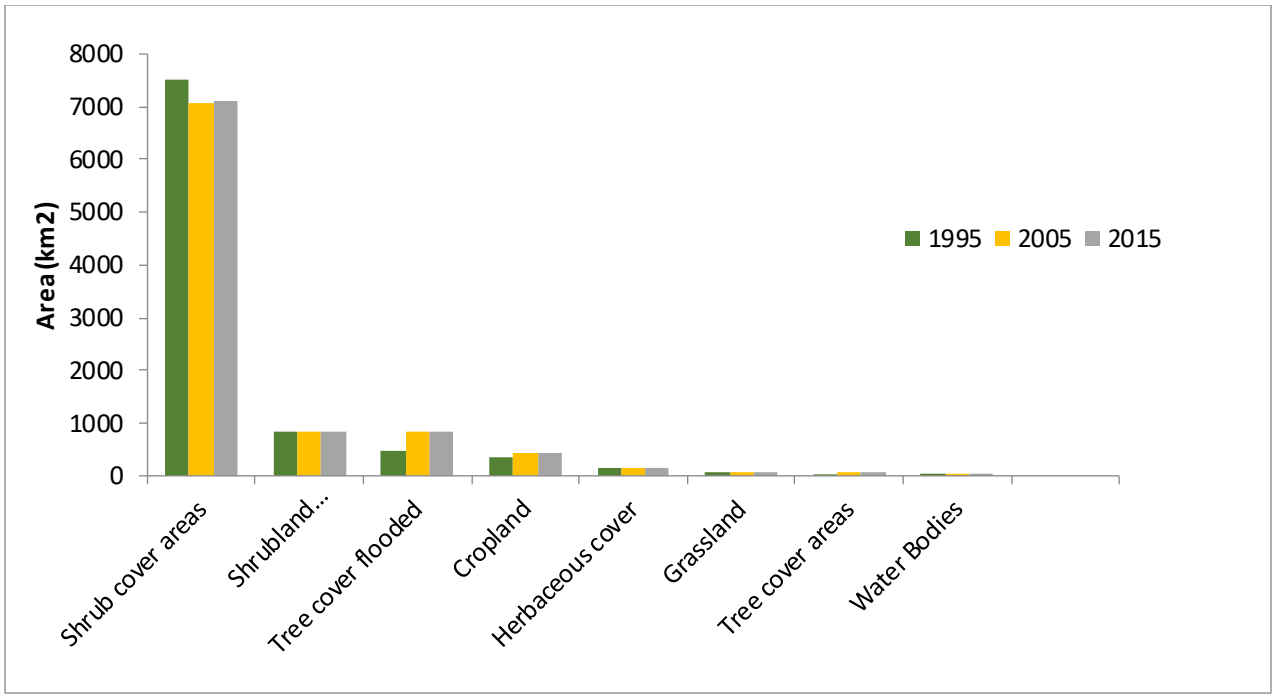


Figure 6. 5: **Variation of Land Use and Land cover in three decades of Machar wetland**

6.2.2. Spatial Distribution of Land Use Land Cover Change of Machar Wetland

A pixel-level "from-to" change analysis was run with six LULC classes of Machar Marshes. The spatial distributed LULCC of Machar Marshes result indicates that the western side of the wetlands has changed mainly from Shrub land to grassland, north eastern side changes from tree covers areas and/or shrub land to Cropland and central eastern and southern parts converted from shrub land to tree covers areas and tree cover flooded. However, the overall result indicates that about 94% of the pixels had result no change within year 1995 to 2015 (Figure 6.6). The LULC analysis indicated that significant change occurred on grassland with 3.78% and cropland account 0.76% as compared to the other land use and lance covers (Figure 6.7).

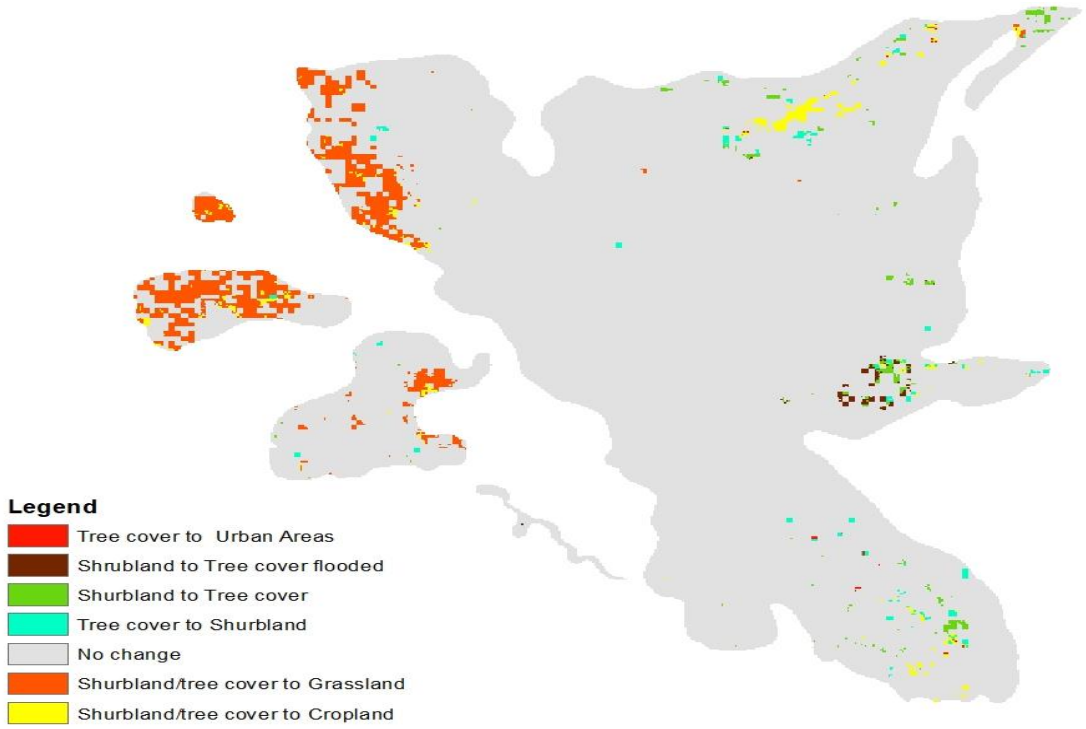


Figure 6. 6: Mapping the LULC change post-classification "change-to"

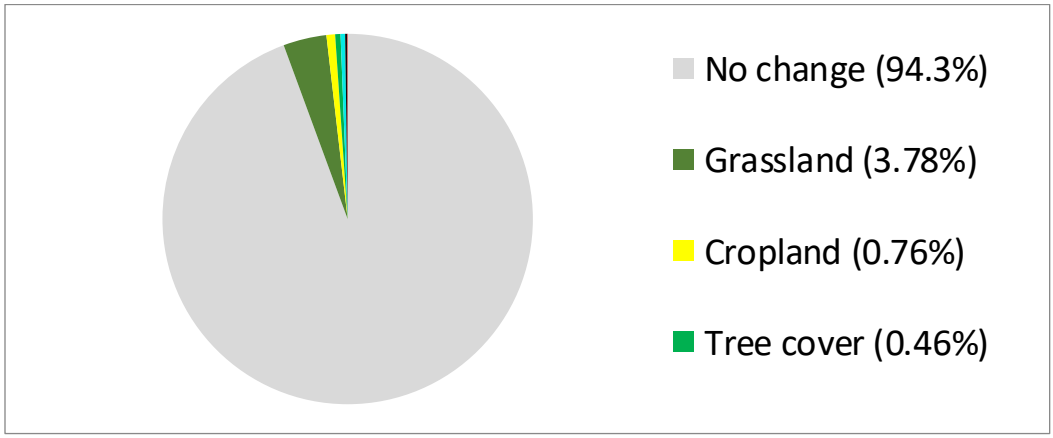


Figure 6. 7: Distribution of LULC change categories between 1995 and 2015 of Machar Marshes wetland

6.2.3. Recent Year Multi-Temporal Land Use Land cover of Machar Marshes Wetland

In order to visualize the recent year LULC dynamics of the wetland, with five years intervals over the land cover types on the Machar Marshes wetland, we used another dataset of LC from MODIS. The

MODIS LC dataset classified Machar Marshes wetland in to five major LULC classes named as mixed forest, grasslands, deciduous broad leaf forest, savannas, and cropland. Figure 6 indicates the multi-temporal land use land cover of Machar Marshes wetland for the year 2009, 2013 and 2018 (Figure 6.8). Based on this data set analysis, majority of the wetland is covered by grassland and savannas; it also indicates that cropland increased in the Machar Marshes wetland.

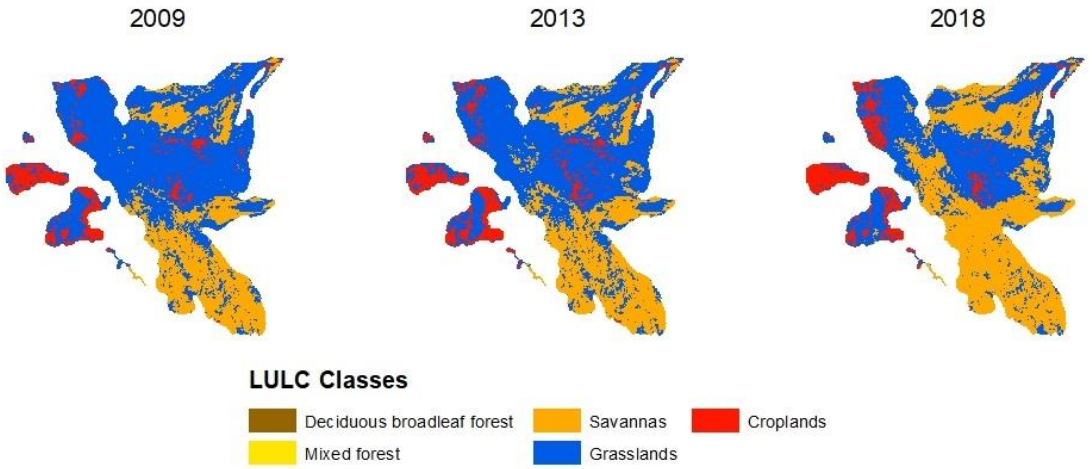


Figure 6. 8: Multi-temporal Land use and Land cover of Machar Marshes wetland using MODIS dataset

The land use land cover change in area together with the percentage change of land use land cover are presented in Table 6.7 and Table 6.8, respectively. Meanwhile, Figure 6.9 below shows that the spatial LULC distribution of Machar Marshes wetland area for the year 2009, 2013 and 2018. It indicates the comparison of three years numerical LULC of the wetland. Generally, the savanna, croplands, deciduous broadleaf forest and mixed forest has been shown an increasing pattern while grassland, results in a decrease pattern. Cropland increased with the rate of change range of 8.41% - 9.71% and the grassland cover change in to savannas within this specified period. Note that to be better understood and accounting the LULC transformation or the dynamics of the wetland area, for further study we recommend to use the Landsat image with 30 m or any other available better resolution satellite imagery resolution corresponding with ground truth and ancillary data.

Table 6. 7: **Land use / Land cover change analysis, 2009-2018**

LULC Classes	Area in (Km2) 2009	Area Percent (%)	Area in (Km2) 2013	Area Percent (%)	Area in (Km2) 2018	Area Percent (%)	Change Rate b/n (2009 -2018) in (km2)
Deciduous broadleaf forest	0.00	0.00	0.00	0.00	0.21	0.00	0.21
Mixed forest	0.00	0.00	0.00	0.00	0.82	0.01	0.82
Savannas	2744.63	28.94	3049.72	32.16	4456.73	47.00	1712.11
Grasslands	5941.76	62.66	5524.16	58.25	4104.21	43.28	-1837.55
Croplands	796.82	8.40	909.33	9.59	921.24	9.71	124.42
Total	**9483.21**	**100.00**	**9483.21**	**100.00**	**9483.21**	**100.00**	

Table 6. 8: Percentage Change of Land Use Land Cover

	Percentage of Change		
	2005 Vs. 1995	2015 Vs. 2005	2015 Vs. 1995
Deciduous broadleaf forest	0.00	0.00	0.00
Mixed forest	0.00	0.01	0.01
Savannas	3.22	14.84	18.05
Grasslands	-4.40	-14.97	-19.38
Croplands	1.19	0.13	1.31
Deciduous broadleaf forest	0.00	0.00	0.00
Mixed forest	0.00	0.01	0.01
Savannas	3.22	14.84	18.05

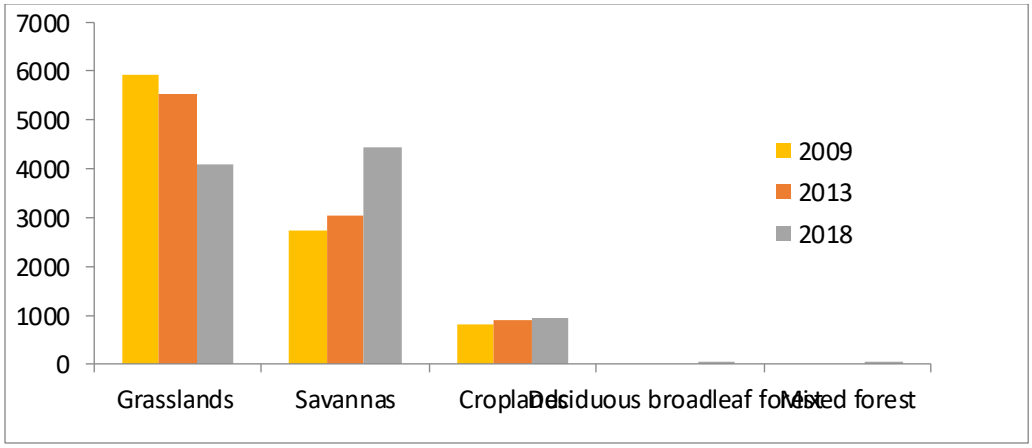


Figure 6. 9: **Variations of the LULC of Machar Marshes wetland from 2009 to 2018.**

6.2.4. Scenarios Development of Machar Marshes wetland LULC

The prediction of LULC change has been done using a trend analysis of the past LULC situation of the wetland. The ESA-CCI approach for LULC trend analysis was used to produce and develop scenarios for the year 2025 and 2035 (Figure 6.10). The MODIS LULC result and trend has been used to develop the scenario of the years 2023 and 2028 (Figure 6.11). The selection of the scenario years are based on the historical period gaps of LULC where the ESA spans ten years difference while the recent year data of MODIS LULC spans five years. Therefore, the following four scenarios were developed using these two datasets by conducting modest trend analysis. These LULC scenarios also enable to analyze the trends of ecosystem services of the wetland.

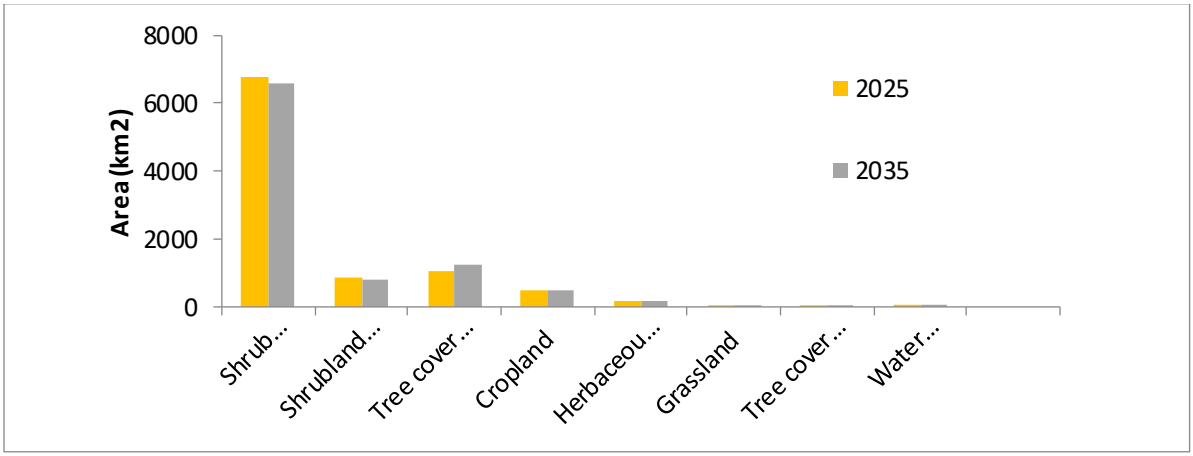


Figure 6. 10: Variations of LULC from 2025 to 2028

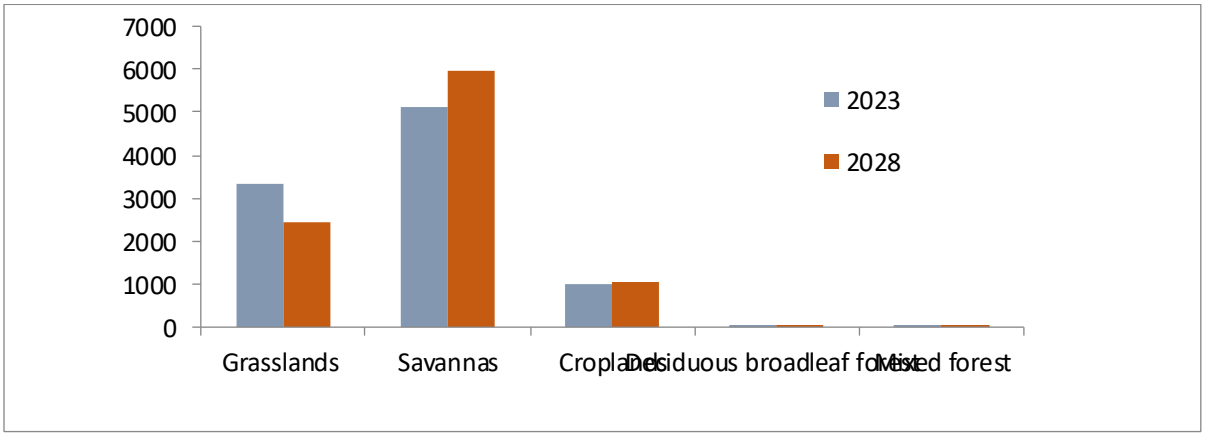


Figure 6. 11: Variations of LULC from 2023 to 2028.

6.4. Classification and Economic Valuation of Machar Marshes Wetland Ecosystem Services

6.4.1. Provisioning Ecosystem Services of the Machar Marshes Wetland

Machar Marshes wetland surrounded by Mebane, Longochuk, Balite, and Luakpiny/Nasir states. According to the South Sudan National Bureau of Statistics (SSCSA, 2015) report, the total number of populations settled around the Machar Marshes wetland estimated about 554,029 people with an average family size of 4.5 (ROSS. 2016). The population distribution of the Machar marshes wetland presented in Figure 6.12. The livelihood of the local community is highly dependent on the direct use of Machar Marshes wetland resources and ecosystems, i.e. the provisioning ecosystem services of the wetland. In this sub section, we looked to estimate the economic values of the major provisioning service of the Machar Marshes wetland in detail. The schematic presentation provisioning ecosystem services of Machar Marshes wetland highlighted in Figure 6.13. The detail estimated economic value of the provisioning services of Machar Marshes wetland are presented in Table 6.9.

Figure 6. 12: Residents in the surrounding of Machar Marshes wetland

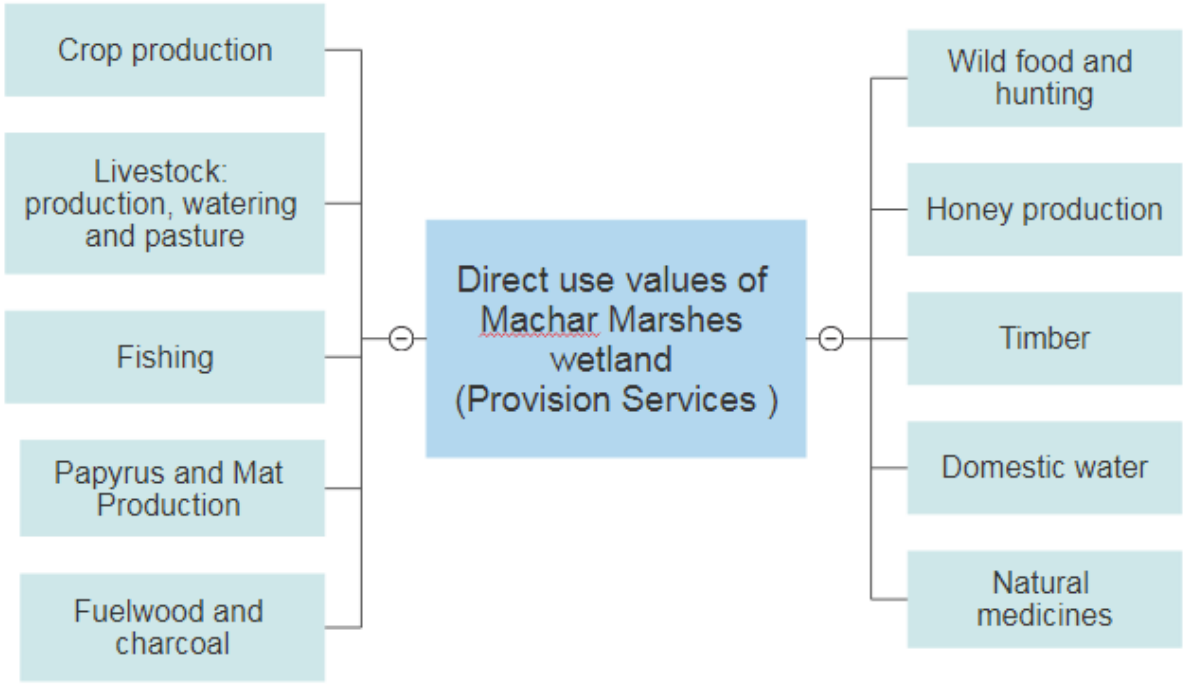
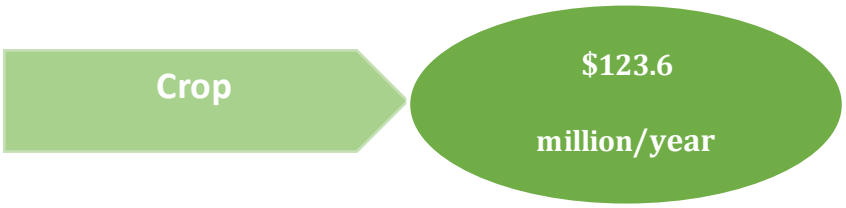


Figure 6. 13: A schematic presentation of provisioning ecosystem services of Machar Marshes wetland

I. Crop Farming

In South Sudan, crop production is cited as one of the major sources of livelihood the rural communities. Machar Marshes is one of the wetlands that directly support crop production. It supports mainly the agricultural practices of the local community by maintaining soil moisture of the crop land. Hence, flooded plain areas are enriching with nutrients attracts local farmers to engage in crop production around the wetland. Similar to other Nile basin wetlands', crop production undertaken on the flooded plain areas of Machar Marshes wetland. About 12,312 households from Nuer, Dinka, Koma and Anyuak local communities mainly produce sorghum and maize on 41,616 ha of land at the northern and northeastern parts, respectively(ENTRO 2016). As the LULC analysis shows there is an increment of crop land, imply that crop production around Machar Marshes increases and also expected expansion of cropland area by converting other LULC in the wetland. Therefore, based on the 2015 LULC area estimate, the economic value of Machar Marshes wetland for crop production is about $123.6 million/year. It is calculated using the area of land covered by

crop[7] (i.e. mainly covered by maize and sorghum), the average per hectare production (kg/ha), average price of maize and sorghum, and average per hectare production cost.



II. Livestock watering

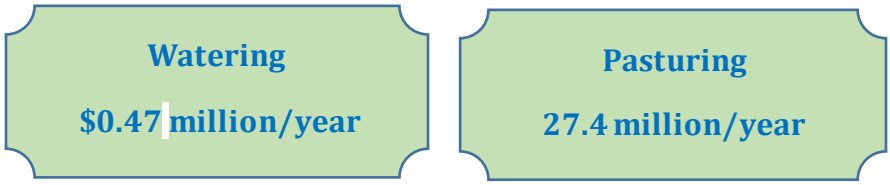
The livelihood of the local community around Machar Marshes is also predominantly dependent on livestock rearing. During our FGD exercise, it is estimated that about 61,559 pastorals from Nure, shai, Dinka, Anyuak, Murle and Baggari ethnic group are engaged in livestock production and rearing practices. The livestock sub-sector improves the local community food security through livestock products (e.g. meat, milk) and they used as an asset to measure the social status in their community (ROSS. 2016). Moreover, the Machar Marshes wetland serves as sources of pasture and watering to their livestock, particularly during the dry seasons of the wetland. About 206838.24[8] livestock population is estimated around the wetland. According to the(ENTRO 2016) about 174,406[9] of the livestock population use the wetland as watering point annually. Based on the above estimates, the annual economic value of Machar Marshes wetland for livestock watering is estimated about $0.47 million/year. We estimate this value by taking the product of annual average water consumption per TLU (mm3/year)[10], price of livestock watering ($/mm3), and number of livestock' that used wetland's water for livestock.

[7] The crop land is mainly covered by maize and sorghum during the major production season (the harvesting season for maize is from September-October, while the harvest season for sorghum is October).

[8] About 86% 0f Mawit and Longechuk households own livestock (ROSS. 2016) and on average households own 2.1 TLU (source: FAO, 2011. Land Cover ATLAS of the republic of South Sudan), thus total number livestock population around the wetland will be about = (123118*0.86) *2.1= 206838.24 TLU.

[9] As indicated on ENTRO 2016 data from 5799.06 km2 of upper Nil water, livestock demand 196249 mcm, thus how much is the livestock watering for 4689.79 km2 of Marchar marshes permanent swamp= 158709.6181mcm; as indicated on ENTRO 2016 data per livestock water demand is 0.91 mcm thus 158709.6181 mcm is 174,406 TLU.

[10] As indicated on ENTRO 2016 data, in the upper Nile there are 210300 TLU and they demand, 19621.9 mcm; thus, per livestock water demand is 10.96 mcm.



For estimating the estimated economic value of livestock pasture, we assumed the number of livestock watering and pasturing are equal, this is because in the area there is no processed livestock fodder. Therefore, all the livestock that serves water from the wetland are also used for pasture. In this case, 174,406 number of livestock used the wetland for pasturing, the imputed price of pasturing is 0.43$ per day per animal, thus annual value of wetlands for pasture is estimated at $ 27.4 million/year.

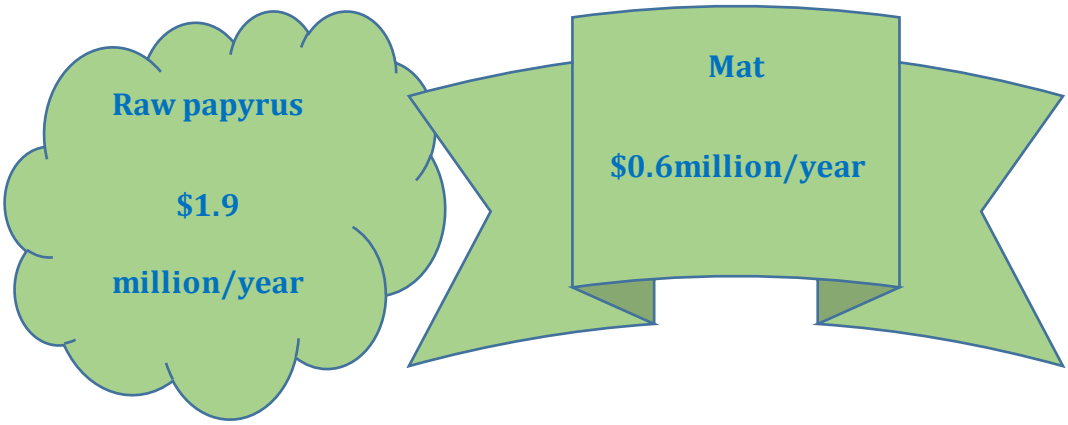
III. Fishing

The permanent marshes of Machar Marshes wetland is habitat for various fish species like Barbus spp., Citharinus spp., Clarias spp., Gymnarchus Niloticus, Heterotis Niloticus, Labeo spp., Oreochromis Niloticus, and Polypterus Bichir and Gymnarchus Niloticus (Busulwa 2012). Fishing is an important economic activity for the local community around the wetland. During the focus group discussions, it was noted that, 8% (about 9,849 households) of the local community are engaged in fishing activities, the main fishing season is from October to December (USAID 2018). In addition, the FGD participants noted that Eel, Lung and Mad are the most dominant fish species available in Machar Marshes wetland. Available fish for consumption and market from Machar Marshes wetland provides on average equivalent to $ 10.66 million/year. To calculate the wetland's average fish production, we take the average fish production of households in the main fishing season which is 110kg/ (103 kg/household during fishing season and Longechuk 117 kg/ household in dry season), number of fisher households [11](i.e. 9849), and average selling price of fish($/kg). We noted from the discussion that the local community doesn't make fishing permit payment to harvest fish during fishing season; rather they used locally available resources and household labor to harvest fish from Machar wetland.

[11]Due to the lack of data, we didn't take in to consideration individuals who harvest fish for their own consumption rather than fisher household.

IV. Papyrus Production

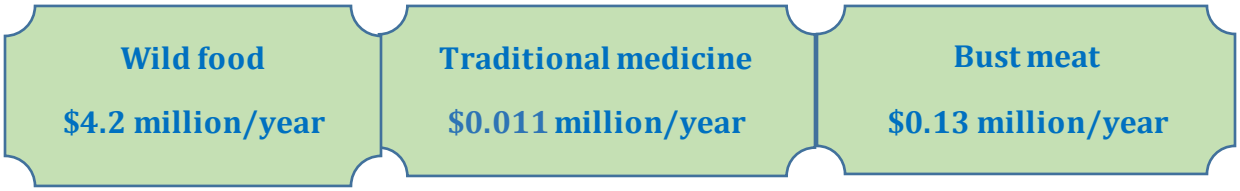
Machar Marshes is one of papyrus rich area wetland, that covers 827.73 km^2 of the wetland's permanent marshes and flooded plain area (ENTRO 2016). The wetlands' papyrus plant provides multiple benefits for the natural ecosystem and for the local people. On other hand, harvesting of papyrus is one of the sources of income for surrounding community either by selling directly or by adding values to the papyrus (for example by making mats, crafts and chairs). Participants during the FGD explained that 95% of the local community in Machar Marshes wetland engaged in papyrus harvesting. The annual estimated economic value of papyrus harvested from Machar Marshes wetland is about $1.9 million/year.



To estimate the wetland papyrus production, we consider number of households who involved on papyrus production, average household annual papyrus production, and price of papyrus per bundle. FGD participants also noted that in addition to raw papyrus harvesting, about 5% of the local community from Nure, Shai and Anwak communities earn income by making mat and craft. Based on this the estimated economic value of Machar Marshes wetland for mats production (papyrus after value addition) is about $0.6 million/year. We estimate the wetland's mat production by considering the number of households who engage on mat production, per person mat production per year and price of mat in South Sudan.

V. Wild Food and Animal

Machar Marshes wetland is source of wild food (i.e. leaves, fruits, and nubs) and provides medicinal services for the surrounding community that are collected, harvested and utilized. The wetland's wild food helps for improving food security and ensure balanced diet particularly for women, children and the local poor, who rely heavily on them. Particularly at Maiwut and Longechuk states' wild foods are collected for consumption during the periods from November to May of the year. The common wild foods that exist in the wetland include Balanities aegyptica (Lalop) fruits and nuts, Tamarindus indica fruits (Koat) and wild vegetables (Neet and Balanities aegyptica (Lalop) leaves (NPA and ROSS 2016). We estimated the economic value of wild food; it is about $4.2 million/year. It is computed by multiplying the average ton of wild food collected from the wetland with the average selling price of wild food in the local market.



In addition to wild food, the wetland's vegetation such as fruits of Tamarindusindica and Acacia nilotica, A. Complycanth, Balanitiesaegyptiaca, Nauroeasp roots, and bark of Acaciaseyal trees and other roots are used for medicine (ROSS. 2016). The FGD participants also indicated that there are about 25 traditional medicine healers and they visited by about 2000 patients per year. We computed the estimated economic value of the wetland for traditional medication by considering the number of patients who treated by the traditional healers and the average price per treatment. The estimated annual economic value of the wetland for traditional medication is $ 0.011 million /Year. Moreover, the local community realizes their food security by consuming bust meat. During our FGD, we found that annually the local communities got 75.5 ton of bust meat/year from the wetland, thus, estimated economic value of bust meat from the wetland is about $0.13 million/year. The economic value of wetland's for bust meat production is the product of the average wetland's bust meat production/ton and bust meat average selling price (i.e. $ 4/ton).

VI. Honey Production

The vast vegetation cover (i.e. forest, shrub land and grass land cover) in Machar Marshes wetland is a home for various species and hosts insects like honey bees. The local community settled around Machar Marshes engaged in bee-keeping practices and wild honey production for consumption and sold honey to diversify their income (Micheal n.d). We found during our FGD that about 400 beehives that produce about 3500kg of honey during honey harvesting seasons in Machar Marshes. Based on the total volume of honey production per year from Machar Marshes wetland, the average unit price of honey per Kg, and by considering the cost for collecting honey, thus, the estimated total economic value of honey production is about $ 0.017 million /year.

Honey production	**$0.018 million/year**

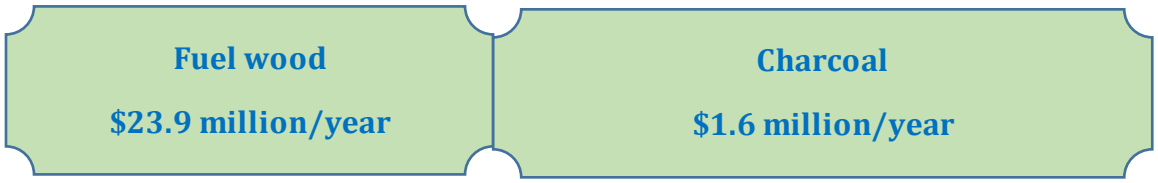
VII. Timber

The foothill part of Machar Marshes wetland is covered by 894.6 km2 of Acacia trees and scattered shrubs, which could be used for timber production (ENTRO, 2016). We estimate the wetland's timber production by taking South Sudan annual timber production (i.e. South Sudan produce 1498500 m3 of timber from 20,000,000 ha of tree, thus we expected from 83717 ha of Machar Marshes wetland area, 6272 m3 of timber can be produced by assuming liner timber production in the nation). Considering the average timber price per cubic meter and average cost of production, estimated economic value of Machar wetland for timber production is about $ 0.44 million/year.

Timber	**$0.44 million/year**

VIII. Fuel Wood and Charcoal Production

In South Sudan, the national household survey indicates that about 96% of the population depends on firewood and charcoal. Charcoal is predominantly used in urban and semi-urban areas, while 98% of rural community used firewood as primary source of energy for domestic uses(UNDP 2013). The local communities around Machar Marshes extract firewood and charcoal from the wetland for domestic use and commercial propose. There is no data that shows how much ton of charcoal and firewood extracted from the wetland for commercial and domestic purpose. In this case, we consider per person weekly firewood consumption (i.e. 0.3kg/household/week) and the weekly per person charcoal consumption (50 kg/household/week) utilization to estimate the economic benefits of the local community energy demand. Therefore, the estimated' economic value of the wetland for domestic energy consumption[12]is about $23.9 million and $1.6 million[13] for firewood and charcoal, respectively. We estimated the economic value of charcoal and fuel production by considering number of households who uses the wetland's vegetation for domestic energy consumption (98% of population uses the wetland's vegetation for firewood while only 2% of population uses charcoal for their domestic energy consumption)(UNDP 2013), weekly household consumption in cubic meter for firewood and in Kg for charcoal, number of weeks per year, price of firewood (m3) and price of charcoal per 50 kg and the cost of collection for both firewood and charcoal.

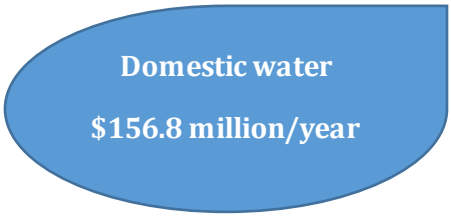


[12] 98% of rural population who use firewood for domestic consumption) *500,000(local community around the wetland) *0.81 kg/person

[13] 2% of rural household who uses charcoal *500,000(local community around the wetland) *50kg/person *15$

IX. Domestic Water

Machar Marshes wetland is the main source of drinking water as well as for domestic consumption for the surrounding community. According to the ENTRO (2016) data, there are about ten well protected hand-dug wells and three machine drilled borehole. 35% of population uses wetland's water for drinking, laundry, cooking, bathing and washing of utensils; brick making and irrigation of crops and trees. Based on these, we estimated the economic value of wetland for domestic water consumption is about $ 156.8 million/year.



It is calculated based on the number of households who use the wetland for watering, average household water consumption per day and the price of water per cubic meter.

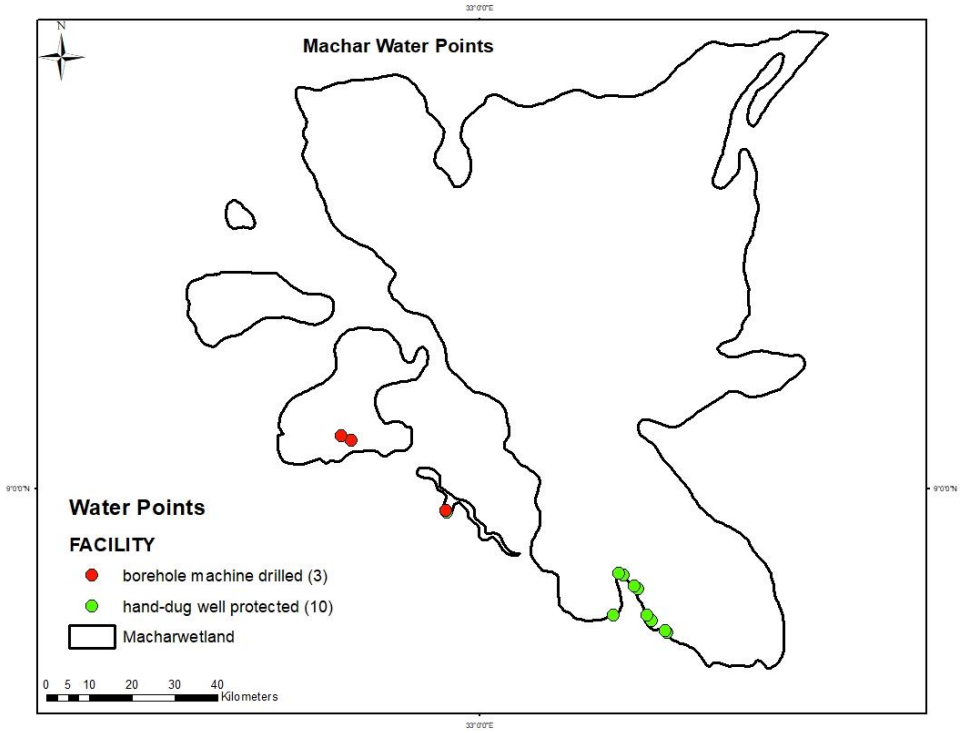


Figure 6. 14: Water points in Machar Marshes wetland

Table 6. 9: A summary of the economic values of the provisioning Ecosystem services of Machar Marshes wetland

Product/services	% of population who undertaken the economic activity	Valuation Method		Approach	Net Value ($)	Sources of data
Crop production	10% (12,312)	Area of the wetland covered by * (ha) (A)	41616	$T_v = (A_i * P_{roi} * P) - C_i)$	123,688,162.1	*ENTRO 2016 **(SSRDP n.d) **(USAID 2018) *** (SSNBS 2015)
		Average Crop (maize and sorghum) productivity (kg/ha)** (Pro)	1020			
		Average crop price ($)*** (P)	2.4			
		Number of main harvesting season	1			
		Total Cost of crop (C) ****	4793672.34			
Timber		Timber production[14] in Machar Marshes (m3) (Q_i)	3,337	$T_v = (Q_i * P_i) - C_i)$	441,208.05	*ENTRO, 2016 *** Turpie et al. 2006 **https://www.theeastafrican.co.ke/scienceandhealth/Amid-upheaval-in-South-Sudan-the-
		Price of timber ($/m3)** (P_i)	132.5			
		Cost[15] of timber production ($) (C_i)***	182843.265			

[14] South Sudan produce 1498500 m3 of timber from 20,000,000 ha of tree (Salaam, 2016), thus we expected from 83717 ha of Machar Marshes wetland (ENTRO, 2016), 6272 m3 of timber will produced by assuming liner timber production in the nation),

[15] As of Turpie et al., 2006 study in Botswana, the total cost of timber extraction is 22% of the total revenue obtained timber production.

						country-teak-forests-fall/3073694-4979690-65509uz/index.html
Fuel wood	98% (120,655)	Number of households [16]whose source of fuel is from the wetland* (Nf_i)	120,655.64	$T_v = \left(Nf_i * FP * P_i * 52\right) - C_{fi}$)	23,998,406.8	*UNDP 2013 ** Turpie et al. 2006
		Households' fuel consumption (m3 /week/hh) * (Fp)	0.45			
		Price of fuel wood (m^3/$) * (Pi)	10			
		total cost [17]**	4235012.964			
		net benefit ($)	1632544.68			
charcoal production	2% (2462)	number of households[18] who uses the wetland's vegetation for charcoal production (Nc) *	2462.36	Tv= (Nc*Hc*Pc)-Cc	1,632,544.68	*UNDP 2013 ** Turpie et al. 2006
		Household's charcoal consumption* (household/ kg/ week) (Hc)*	50			
		price of charcoal ($/ kg) (Pc) *	0.3			

[16] Hence, from the total population 98% of them use firewood for their energy demand. Therefore, to estimate the benefit we took 98% of the total population of the wetland household.

[17] The total cost of charcoal and firewood extraction is equivalent with 15% of the total revenue obtained from charcoal and firewood (Turpie et al., 2006).

[18] Hence, from the total population 2% of them use firewood for their energy demand. Therefore, to estimate the benefit we took 2% of the total population of the wetland.

		total cost (Cc)** ($)	288096.12			
Papyrus production	95% (116,962)	number of households who engage on papyrus production* (Np)	116961.15	Tv=(Np*Hp*Pp)	1,859,682.3	*FGD ** Turpie et al. 2006
		Productivity (household /bundle) ** (Hp)	6			
		Price of papyrus per head load ($) ** (Pp)	2.65[19]			
Mat Production	5% (6,156)	number of households who engage on papyrus production (a)	6,155.90	A*b*d-c	606,659.0175	*FGD ** Turpie et al. 2006 *** SSNBS, 2015
		Production (mat/household) ** (b)	3			
		Price of mat ($) *** (d)	32.85			
		Cost of mat production** (c)	18,467			
Domestic water supply	35% (43,091)	Number of Households [20]whose access water from the wetlands* (i)	43091.3*	Vw=i*m*P*y	156,842,851.91	* ENTRO 2016 **(Turyahabwe & Johnny 2013)
		Average use of water (liter /hh/day) ** (m)	60			
		Market price of water per m3 (US$) ** (P)	166.2			

[19] NB : we take Uganda's papyrus price to calculate Machar marshes papyrus economic value, but when we adopt inflation rate which is 8.61% in 2015 while it is 52.81% in South Sudan per household production and price of papyrus adopt from Nekvango delta economic valuation, when we do price difference we consider the inflation rate differential of the two nations i.e. 1.86$+44.2(1.85)= 2.63

[20] 35% of the total population get water from the wetland

		Number of days per year(y)	365			
Pasture	50% (61,559)	Number of livestock raised in wetlands(o)*[21]	174,406	Vg=o*p*365	27,373,022	*ENTRO 2016 ** (Turyahabwe & Johnny 2013)
		Average value of pasture consumed per day per animal(p) **	0.43			
		Number of days per year (365)	365			
Livestock watering	50 %(61,559)	Number of livestock which obtaining water from wetlands *(p)	174,406[22]	Vlw=p*q*r*365	476,128.8543	*ENTRO 2016 ** (Turyahabwe & Johnny 2013)
		Amount of water consumed per year per TLU (20litrejerrycans) (q) **	10.96			
		Price of water per m3 (r)	3			
Fish	8% (9,849)	Wetland's average per person fish productivity (kg/household) *(Af)	110	Tf= (Af *Fh*Pf*)– Cf	10,661,925.95	* (Ross, 2016) **FDG ***SSNBS, 2015
		Number of fisher households (fh)**	9849			
		Price of fish ($/kg) (pf) ***	10.7			

Bush meat (Hunting)	**90% (110,806)**	**Annual bush meat production in the wetland *(r)**	75,500	Vh=r*P	129,860.00	*FGD **(Olupot *et al.* 2014)
		Unit price of bust meat ($) *(P)	1.72			
Wild food		Annual gross harvested wild food (kg /year) * (U)	750,000	Vf=u*v	4,155,124.65	*FGD **Micheal, n.d.
		Unit price of the good ($/kg) **(V)	5.54			
Traditional medicines	1.62% (2000)	number of people who treated by natural medication * (Om)	2000	$T_m = (Q_m * Pm))$	11,080.33	* FGD **(Micheal, n.d)
		Price of medication ($) **(Pm)	5.54			
Honey		Number of hives in the wetland*	250	$T_h = (Q_i * P_i) - C_i)$	18,307.30	*FGD ** SSNBS, 2015 *** (Tarekegn & Bosena 2017)
		Quantity of Honey produced in the Machar marshes (Kg)* (Q_i)	3500			
		price honey/kg ($) ** (P)	5.5			
		Total cost of honey production *** (C)	1970.5			

6.4.2. Regulating ecosystem service of Machar Marshes Wetland.

The wetland covers three distinct zones of land cover that provide a range of regulating ecosystem services: permanent wetlands only in the deepest parts of the water bodies which covers about 4689.79 Km^2 of the wetland, seasonal flood plain areas inundated due to river spills which covers is about 2114.67 km^2, and the dry areas at the fringes covers is about 2678.91 km^2. The main regulating ecosystem services that the Machar Marshes wetland provides include carbon sequestration, sediment retention, water purification, ground water recharge and flood attenuation (Figure 6.15). We estimated the Machar Marshes wetland regulation service using benefit transfer/value transfer approach.

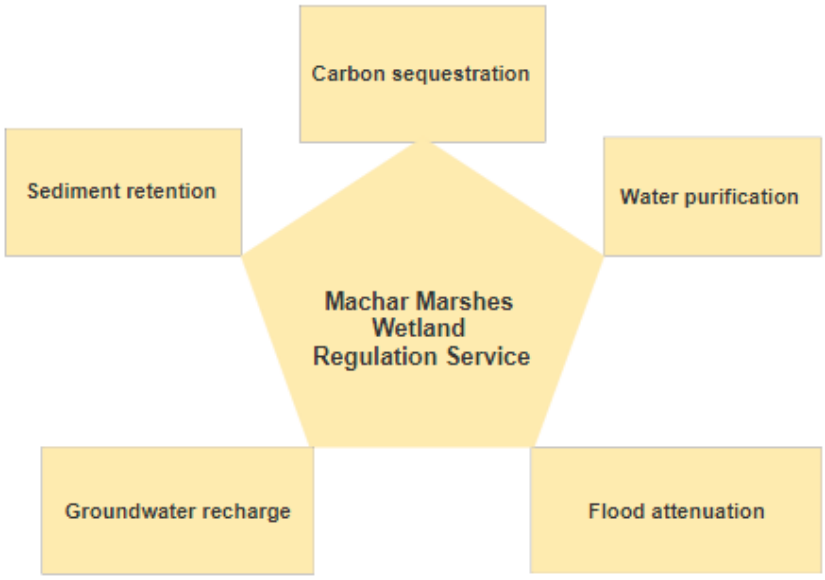


Figure 6. 15: Machar Marshes wetland major regulating ecosystem services

I. Carbon Sequestration

The concentration of greenhouse gas (GHG) has increased due to the anthropogenic (such as fossil fuel combustion, deforestation, overgrazing, inappropriate land use) and natural (such as volcanic activity and change in solar outputs) aggravating factors (Mbow *et al.* 2017). The contribution lies in two major actions: reducing the impact (i.e. mitigation) and adapting the change (i.e. adaptation). Mitigation reduces the impacts from its roots through reducing the sources of emission and increasing the sink for the greenhouse gases. Reducing the sources of GHG mainly links with energy

generation from fossil fuel, however, this significantly imposed from developed countries. Therefore, reducing the sources of emission for developing country like South Sudan doesn't make significant influence; instead investing on carbon sequestration (increasing the sink for GHGs) can have enormous positive externalities to mitigation actions. Sequestration of carbon is the most visible way for the current higher GHG emission. Basically, wetlands are globally important to sink carbon, storing vast amount of carbon and thereby helping to mitigate climate change. Wetlands soil holds 35% or more of the estimated 1,500 Giga tons (Gt, or billion metric tons) of organic carbon that is stored in soils(Mitsch & Gosselink 2015).

Wetlands' carbon sinking capacity differ among wetlands, it depends on the wetland's hydrology, vegetation cover and biomass. The carbon sinking capacity of a given wetland differs on the foothill, flooded plain and swamp of the wetland. Our study compiles different wetlands carbon sinking capacity and grouped it to world wetlands, African wetlands, Nile basin wetlands and other wetlands. On average world wetlands' carbon sinking capacity is 6.5$ Ct/ha/year, African wetlands NNP sink ranges from 2.32 -1.04 kg/m2/y , Papyrus wetlands sink on average 0.48- 2.51 kg C /m2 /year and the Nile basin wetlands sink on average 0.91, 1.212 and 1.362 tC/ha/year on the woodland, marsh and flooded plain of the wetland, respectively.

There is no standard carbon pricing mechanism. Some country, like Sweden have higher carbon price (i.e. 127$/ct) while country like Mexico have lower carbon price (i.e. <1$/ct). In case of Africa, South Africa is the only nation which give value for carbon (i.e. 8$/ct). For this particular study we consider 5$/CO2 equivalent carbon to estimate the economic value of Machar Marshes wetland for carbon sequestration. We estimated carbon sequestration value of the Machar Marshes wetland foothill, the flooded plain and permanent swamp by taking the average value of different wetlands carbon sequestration capacity. We computed the wetland's total carbon sinking capacity by transferring the average value of different fresh water wetland's carbon sinking capacity of the wetland's foothill, flooded plain and permanent swamp carbon sequestration capacity and its area coverage, which results 7,214,225 tC/year. Then after we estimate the monetary value of Machar wetland carbon sinking capacity by taking the product of the wetland's yearly carbon stock and carbon price per ton. The Machar Marshes wetland's annual carbon sequestration is estimated about $45.6 million per year (Table 6.10). It estimated by taking the products of the wetland's foothill, flooded plain and permanent swamp carbon sequestration capacity, taking the average carbon price and their area coverage.

Carbon Sequestration	**$45.6 million/year**

II. Flood Attenuation

Wetlands' have critical role on mitigating flood damage, especially for downstream community by temporarily storing floodwater on its' floodplain surface and delaying the flood peak (Zedler & Kercher 2005). The flood attenuation ability of the wetland determines by its storage capacity and storage outflow relation. These, in turn, are affected by an array of local factors such as climate, terrain, soil type, inflow source (surface water, groundwater, and precipitation), wetland vegetation, drainage pattern and frequency, land use, evaporation, and evapotranspiration management of the storage-outflow relationship within the wetland (Williams 2012). For instance, floodplains with small surface area, high gradient, high hill slope flow and high groundwater levels store water less effectively than large flat floodplains with low hill slope flow and low groundwater levels (Zedler & Kercher 2005).

The economic value of wetland's water attenuation service can be estimated either by estimating the "damage costs avoided" or avoided cost which could be damaged by downstream flooding or it could be the replacement cost. Alternatively, wetland water attenuation service can be estimated from expenditures that are allocated for taking action to develop flood control mechanisms such as barrages, dams and levees. We considered the "Damage cost avoided", to evaluate the flood attenuation service of Machar Marsh wetland. The wetlands' flooded plain cover is estimated about 2114.67 km^2. To estimate the wetland flood attenuation economic value of the wetland, we considered the total monetary value of downstream residences damaged crop production and livestock production; road maintenance cost which is damaged by flood disaster; government and non-government organizations expenses to support people evacuation during flood occurrence. Finally, the Machar Marshes wetland estimated economic value for flood attenuation is about $ 103.9 million/Year. Looking at the economic values of similar wetlands In Africa, Machar Marshes significantly contributes for flood attenuation. For instance, the South African wetlands' is estimated around $17,000 to $45,000 (Turpie 2009). Estimated value of Barotse Floodplains is about US$950 000 (r=8%; US$1 305 000-717 000, r=4-12%) (Jane *et al.* 1999). The economic value of value of Dinder wetland for flood attenuation is about 1783.82$ (NBI 2016)

Flood attenuation	**$79 million/year**

III. Sediment Retention

The Barro Akobo sub basin in which Machar Marshes located contributes about 26 billion M^3 of water for the Nile system. Barro Akobo sub basin is subject to higher sediment load due to the Barro Erosion, steep slopes, high intensity rainfall, Poor farming practices, deforestation, trampling (cattle). According to (Kiringu & Gerrit 2019) the eastern part of Bro, Alwero and Gilo rivers have a maximum of 872 ton/km^2 / annum while the south and west part have sediment load of 10 to 20 ton/km^2/year (Agwie, Akobo and Pibro river) and estimated the sediment load of the sub-basin rivers before joining Machar Marshes wetland. Since Machar Marshes wetland topography has less than 1% flat slope. The speed of the water flow declined when it entered to the wetland and part of the load settles out in the wetland. According to the ENTRO data, the wetland's received 72 to 288 ton sediment/ km2/year and the sediment load of the wetland exist to White Nile is 55 ton/km2/year, thus the wetland sinks 17 to 233 ton of sediment/km2/year.

To estimate the wetland sediment retention service, we collected the government sediment removal cost, if Machar Marshes wetland doesn't exist. Following (Adeogun *et al.* 2018) approach to estimate the cost effectiveness of sediment management strategy for mitigation of sedimentation at Jebba Hydropower reservoir, Nigeria by drawing three alternative scenarios i.e. reforestation, Vegetative filter strip (VFS) and stone bunds at the watershed upstream of Jebba reservoir in Nigeria cost N 631.20 ($3.51), N1,117.63 ($6.21) and N1,237 ($6.87) per ton of sediment abated respectively, we adopt similar estimation approach as follows.

We calculate the sediment load of the wetland; by taking the products of the wetland's per ton/km2 sediment retention capacity (i.e. 17-233 ton/km2), area of permanent swamp and foothill of the wetland and cost of sediment removal per ton (i.e. we consider three alternative sediment removal methods i.e. reforestation, VFS and an stone bunds at the water sheds up stream). As it indicated, having Machar Marshes wetland will contribute and save government expenditure that may incurred to remove sediment load is about $2.9, $5.28, and $5.84 million/year by undertaking reforestation, VFS and stone bund techniques to remove the sediment, respectively. The total average cost avoided by Machar wetland is estimated about $4.7 million/year.

Sediment retention	**$4.7 million/year**

IV. Water Purification

The Barro-Akobo sub basin water flow is exposed to industrial waste, domestic waste, agricultural runoff, erosion and mining activities pollution (Merid n.d). According to (Merid n.d) study the color of the basin water is 102 TCU (true color unit), its' PH value is 7, the TDS of water is 219 which is good. Furthermore, the water contains 17 mg/l of No3 (Nitrate) (which is higher than the standard value which is used for domestic consumption i.e. 10mg/l), 73mg/l of sodium, 28 mg/l of calcium, and 222 ALK. We estimated the economic value of Machar Marshes wetland for water purification by considering the average replacement cost and the area of Machar Marshes permanent swamp. We assumed the wetlands per hectare replacement cost by transferring the average value of different wetlands' (Sudd Wetland, Lake Nakvango, Okvango Delta Global fresh water wetlands, Gorgia, Zambize wetland, Cape Town metropolitan wetland, Dinder wetland) water purification value. Thus, on average the wetland's contributed for water purification with estimated economic value about $6.91 million/year.

Water purification	**$6.91 million/year**

V. Groundwater recharge

The wetland also contributed for water recharge during the wet season and serves as a reliable water source during dry seasons. The estimated economic value of Machar Marshes wetland for ground water recharge is about $ 126.6 million/year (Table 6.7).

Groundwater recharge

$126.6 million/year

We estimate the economic value of Machar marshes wetland for recharging water by taking the product of the wetland current ground water potential and the South Sudan water price. The spatial distribution of Machar marshes wetland groundwater recharge is presented in Figure 6.16. Note that, due to the data limitation we didn't consider in this report the value of soil for brick making and the capacity of soil to sink carbon.

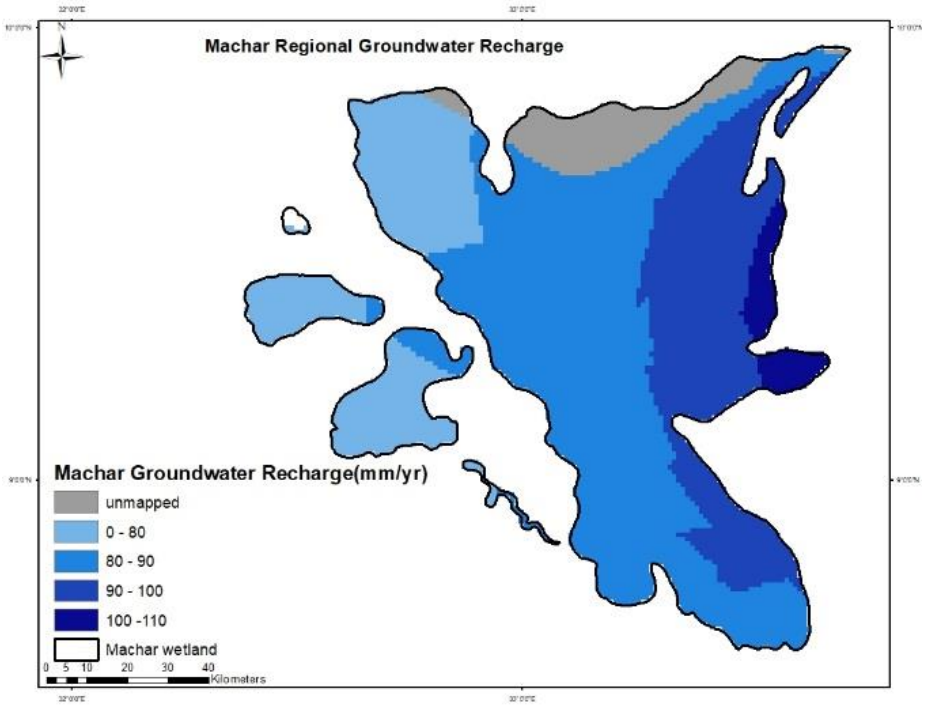


Figure 6. 16: Machar Marshes wetland ground water recharge

Table 6. 10: the economic values of Machar Marshes wetland regulation service

Product/service			Approach	Value ($)	Sources of data
Carbon sequestration	Carbon stock capacity of foothill *	8.93	$V_R = (Q_r * P_c * S_r) - (Q_d * P_c * S_d)$	45,619,145.28	* (Turpie 2000; Turpie et al 2006;Saunders *et al.* 2007; Turyahabwe & Johnny 2013; MOWE 2015 ; Gowdy and Lang n.d; Ministry of water and Environment 2014; Turyahabwe and Mugisha; 2013; Bernal 2012 ; World Bank2019) ** ENTRO 2016 *** (WB 2019)
	Area of foothill (A_f) ** (km^2)	7996.14			
	Carbon stock capacity of permanent swamp (C_{sf}) *	4.05	Vc=$V_c = (C_{sf} * P_c * A_f) + C_{sflood} * P_c * A_{flood}) + (C_{sswamp} * P_c * A_{swamp})$		
	Area of permanent swamp (A_{swamp}) **(ha)	7578			
	Carbon stock capacity of the flooded plain (C_{sswamp})*	13.79			
	Area of the flooded plain wetland (A_{flood})**	1411.29			
	Carbon price ***	5$			
Flood attenuation	estimated amount of crop which would be damages if Machar Marshes wetland doesn't exist ($) (Cd)	24,883.92	Vw= Cd+Rd+ HHe+Ld	79,052,485.73	ENTRO 2016
	- estimated spending for road maintenance which demolished by flood disaster if Machar Marshes wetland were doesn't exist (km2) (Rd)($)	15,847,669.13			
	Number of people who **evacuated by the case of flood,** if Machar Marshes wetland were doesn't exist **(HHD)**	832,9578.6			

	estimated value of livestock damage by the case of flood disaster, if Machar Marshes wetland were doesn't exist (Ld)	5,485,0415.51			
water purification	Value transfer of water purification cost	912.79 $/ha/year		6,917,133.45$	(Jane *et al.* 1999; Turpie *et al.* 2010; MOWE 2015; John & Hannes 2016; NBI 2016) (NBI 2016)
	Area of permanent swamp	7578			
Ground water recharge	Machar marshes annual ground water recharge	761,543.687		126,572,358	ENTRO 2016
	Price of water ($)	166.2			
Sediment retention	Amount of sediment load which retained in the wetland	115,675.82 ton to 1,585,439.18 ton *	$Vs = S_{lt} * (A_f + A_{ps}) * Cr$ Vs= estimated value of sediment retention, sediment load which retained by the wetland, Af- area of flooded plain, Aps- area of permanent swamp, Cr- cost of sediment removal		ENTRO 2016 ,(Adeogun *et al.* 2018)
	Cost of sediment: Reforestation	($3.51)/ton		$2,985,456.83	
	Cost of sediment: VFS	$6.21.ton		$5,281,962.075	
	Cost of sediment: stone bunds	($6.87)/ton		$5,843,330.025	
	Average wetland's sediment retention value			$4,703,582.975	

6.4.3. The Economic value of Machar Marshes Wetland for Biodiversity

Machar Marshes wetland is habitat for a diverse array of fauna and flora of the region which support biodiversity and large population of wild animals. The wetland is habitat for about 400 different bird species and more than 100 mammal species (Smakhtin 2012). In the Marcher Marshes wetland especially on grassland mosaic maintains, important population of large mammal species that are commonly conducting annual migration due to the seasonality of the grass land cover including the emblematic species for this area, the White-eared Kob (Kobus kob leucotis) and the Nile Lechwe (Kobus megaceros). In addition, other animals which live in the swamp areas of the wetland are also available like Elephant (Loxodonta Africana), Buffalo (Syncerus caffer), Tiang hartebeest, (Damaliscus Korrigum Tiang), and the Oribi Antelope (Ourebia Ourebi) extend their range up to the river's edge during the dry season. Hippopotamus (Hippopotamus amphibious) are quite frequent and the region harbours large populations of the Nile crocodile, (Crocodylus Niloticus) (The Higher Council for Environment and Natural Resources (HCENR) 2009).

The wetland is internationally recognized wild heaven for waterfowl birds. These unique habitats also support many specious not seen or in large numbers outside of Sudan, such as Nile lechwe, the shoebill stork Balaeniceps rex and white-ered kob (The Higher Council for Environment and Natural Resources (HCENR) 2009). The Machar Marshes wetland is internationally recognized habitat close to 92 different fish species (ENTRO 2007b). Some of the fish species are found in the deep of the wetland include: Barbus spp., Citharinus spp., Clarias spp., Gymnarchus Niloticus, Heterotis Niloticus, Labeo spp., Oreochromis niloticus, and Polypterus bichir and Gymnarchus niloticus (Busulwa 2012). Although the wetland is habitat for many faunas and floras, Due to the South Sudan government finance limits, sufficient budget has not yet allocated to conserve the wetland biodiversity. However, to estimate the wetland's biodiversity economic value we use value transfer approach based on the studies of (Jane *et al.* 1999; Turyahabwe & Johnny 2013; John & Hannes 2016). Hence, we noted that various wetlands host distinct biodiversity and these wetlands are also vary by size given the uncertain data, we use direct value transfer method. Thus, we handle the biodiversity difference by considering wetlands that are home for similar biodiversity with Machar Marshes wetland. Moreover, to consider the size difference, we convert different wetland's biodiversity value in km2 and multiply it by Machar marshes area and take the wetland's average biodiversity (Table 6.11). Thus, the average estimated economic value of Machar Marshes wetland for biodiversity is about $7.35 million/year (Table 6.11).

Table 6. 11: Economic value of Machar marshes wetland for biodiversity

Name of the wetland	Area	Biodiversity value of wetland's	Method	Allocated budget if it converted to Machar Marshes wetland (**9483.36 km2)**	Reference
Global wetlands		2455 $/ha/year	Benefit transfer	23,281,648.80 $/year	(Clarkson *et al.* 2013)
Zambazie wetlands		US$16.7 million/year	Contingent Valuation Method		(Jane *et al.* 1999)
Okavango delta	28,782 km^2	P77 million/year (1$=5.4P, 14,259,259$/ year) 495.43 $/ha/year	Valuation of related eco-tourism and hunting	4,698,272.76 $/year	(Jane *et al.* 2006)
Sudd wetland	640,000 km^2	65.76 million US$ per year (i.e. 102 $/ha/year)	Value transfer	974,415.24 $/year	(John & Hannes 2016)
Uganda		US$ 48.24 per hectare per year	Value transfer	457,477.29 $/year	(John & Hannes 2016)
Average estimated value of biodiversity for Machar Marshes wetland				7,352,953.52 $/year	

6.4.4. Estimated economic values of Machar Marshes wetland ecosystem services

As noted from the economic value assessment of the Machar Marshes wetland ecosystem services, it provides enormous benefit for the local, national and international communities. The trees, shrubs, grass and herbaceous land covers are home for native plants and provide significant economic and environmental benefit in different forms for about 123,117 households that reside around the wetland. The total estimated economic value of the wetland for provisioning ecosystem services estimated about $ 351.8 million/year. The major regulating ecosystem services of the wetland that include carbon sequestration, water attenuation, sediment retention have economic value that worth about $262.8 million/year and the biodiversity ecosystem service estimated about $7.35 million/year. In total Machar Marshes wetland provides more than half a billion US dollar value

annually, estimated about $622 million/year of ecosystem services value that benefits both local and international communities (Table 6.12) and summarized in Figure 6.19. Comparing the wetland ecosystem services economic value with GDP share, it is equivalent to almost 4.26% South Sudan the total GDP (Ministry of Finance and Economic Planning 2016).

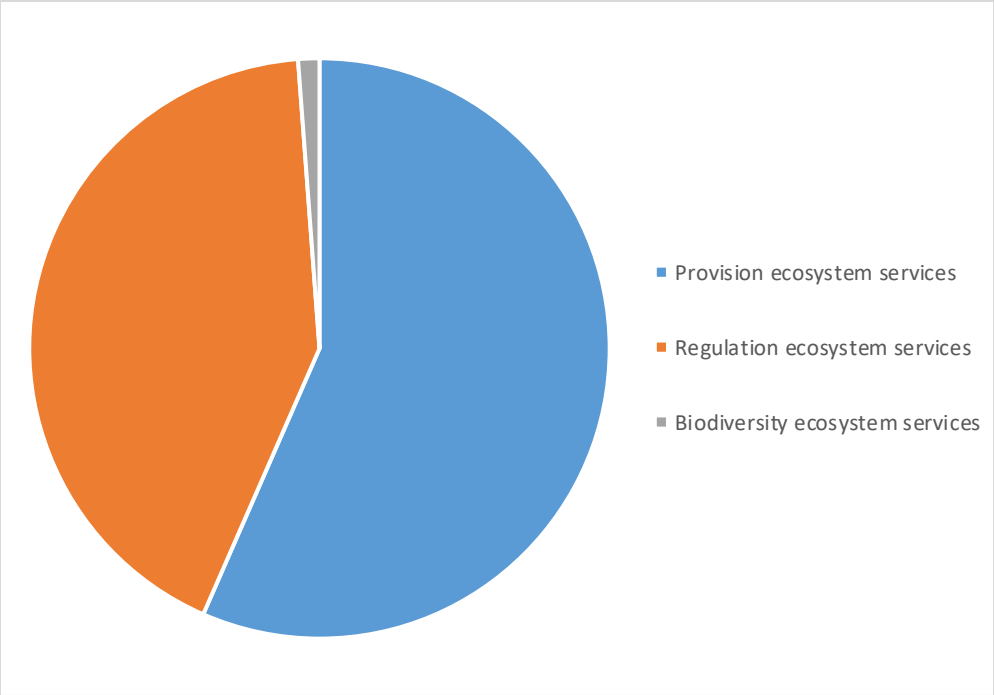


Figure 6. 17: Summary of the economic values of Machar marshes wetland ecosystem service

Note that if the current Machar Marshes wetland and resource degradation and challenges continue, the wetland's economic and environmental benefits would significantly decline. To estimate this change, we use the predicted LULC of the Machar Marshes wetland and developed three possible scenarios of Machar Marshes wetland as follows.

a) Increasing trend of crop land

From the LULC data, we observed a slight incensement of the crop land; the crop land will increase by 0.58% in 2025 and 0.84 % in 2035. This revealed that the crop land coverage will expand to 41859 and 41967 ha by 2025 and 2035 respectively. It would provide about $124.4 million and $124.7 million by 2025 and 2035 of total benefit for the local community, respectively. As the LULC data revealed the rise in cropland originates from a shift of the other land uses such as a decrease of the grass and tree covers. Parallelly, the population of Machar Marshes increase by an average rate of 3.89% which could increase the use of available limited resource. By 2025 and 2035 demand for the

wetland resources rises by at least equivalent rate with the population growth. However, if the current resource exploitation continues without any sustainable conservation action; the wetland natural ecosystem service would enormously affect. In the absence of proper conservation, expansion of economic activity such as crop farming will damage the overall ecosystem service of the wetland.

b) Decreasing trend of grass land cover

Grass land cover of Machar Marshes shows a decreasing trend that would definitely couple with ecosystem services that the grass land provides. Grass land cover in the wetland might decreased by 0.3% in 2025 and by 0.56% in 2035 which intern decreases the economic values of the related ecosystem services.

c) Decreasing trend of tree cover in Machar marshes

There is a potential shift of tree cover to other land uses (such as crop) with temporal changes. The LULC shows a decreasing trend for tree cover around Machar Marshes wetland by 1.66% in 2025 and 1.86% in 2035. Tree cover loses directly associates with many of the wetland provisioning and regulation ecosystem services. For instance, timber, fuel wood and charcoal production and benefits from these resources would be affected as tree cover declines. If current tree management practice in the wetland continues by 2025 and 2035: for instance, the economic benefit from timber would decline by $6299 and $6386 respectively. Ecosystem services of carbon sequestration, flood attenuation, sediment retention and biodiversity will be disproportionately affected by tree cover reduction.

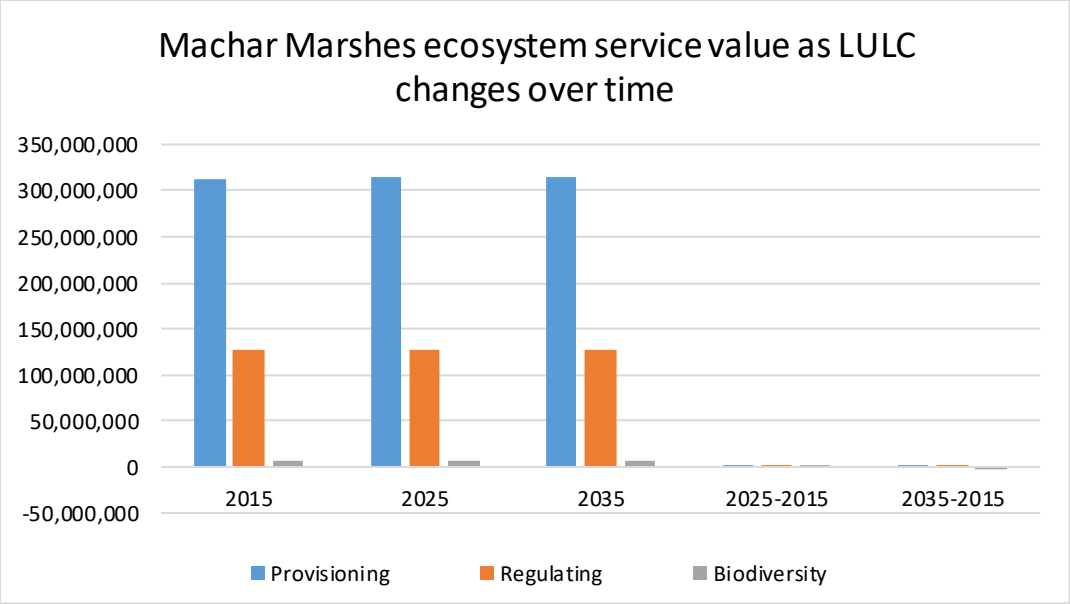


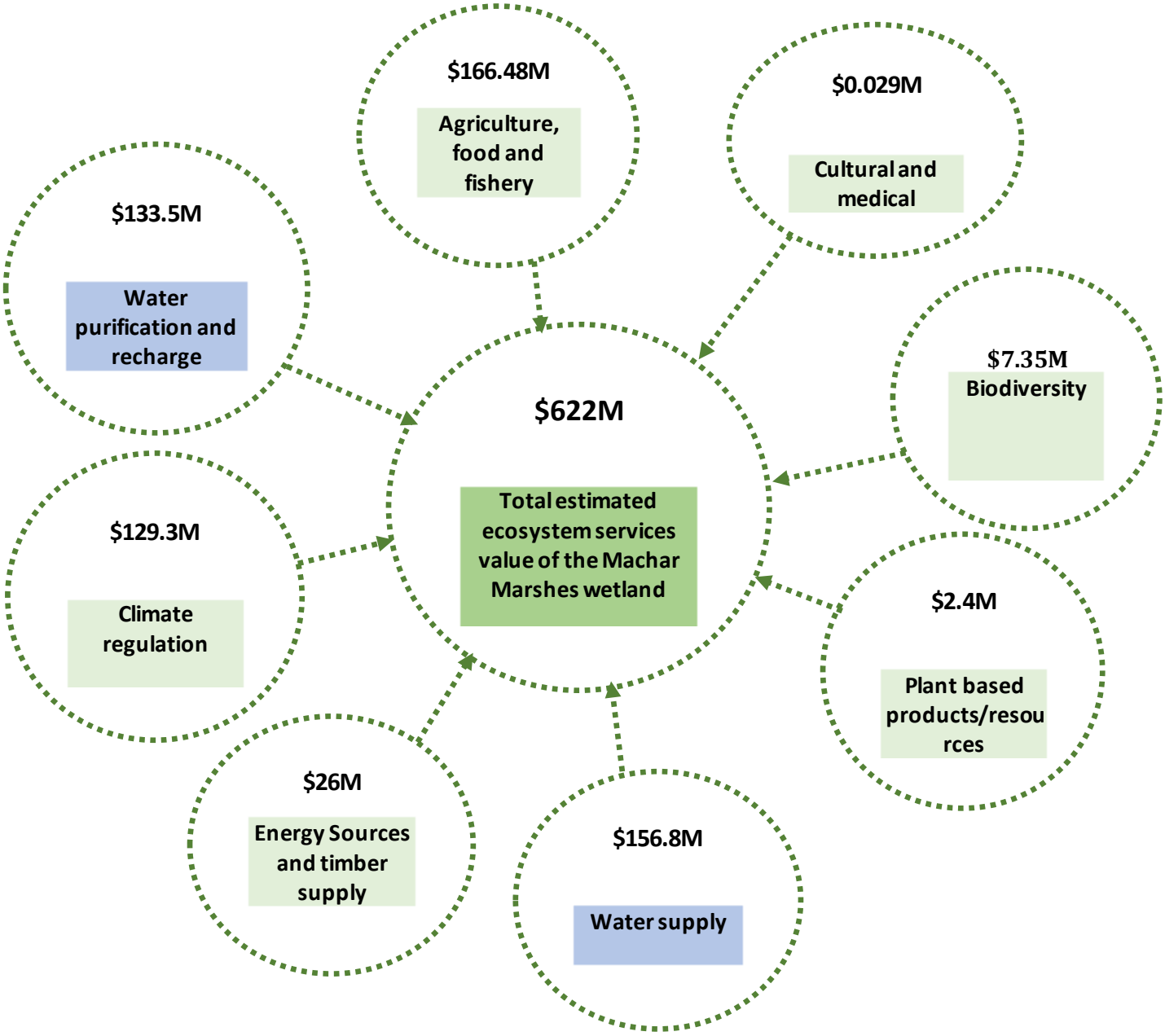
Figure 6.18: Machar Marshes ecosystem services value as LULC changes over time

Table 6. 12: Machar Marshes ecosystem service outlook as LULC changes

	Wetland Service	Estimated Net value as of 2015	Expected Net Value as of 2025	Expected Net Value as of 2035	Expected Net Value change from 2025-2015	Expected Net Value change from 2035-2015
Provision Service	Crop Production	123688162.1	124410389.7	124731379.7	722227.59	1043217.63
	Fish	10661925.95	10661925.95	10661925.95	0	0
	Timber	441208.0453	434908.8228	434821.3336	-6299.222539	-6386.711741
	Firewood	23998406.8	23086467.34	22532392.12	-911939.4582	-1466014.674
	Charcoal	1632544.68	1667896.227	1726828.902	35351.54696	94284.2223
	Papyrus	1859682.285	1926227.854	1995939.451	66545.56911	136257.1655
	Mat	606659.0175	628367.2791	651108.351	21708.26162	44449.33354
	Domestic Water	156,842,851.91	162944038.9	169282562	6101186.939	12439710.05
	Pasture	27373021.7	27290902.63	27219732.78	-82119.0651	-153288.9215
	Livestock Watering	476128.8543	476128.8543	476128.8543	0	0
	Bust Meat	129860	129860	129860	0	0
	Wild Food	4155124.654	4155124.654	4155124.654	0	0
	Traditional Medication	11080.33241	11511.35734	11959.14914	431.0249307	878.8167313

	Honey	18307.30263	17425.33333	17425.33333	-881.9692982	-881.9692982
Total Provision Service		351876656.3	357841174.8	364027188.6	5964518.52	12150532.24
Regulation Service	Carbon Sequestration	45619145.28	45625499.76	45622875	6354.48	3729.72
	Flood Attenuation	79052485.73	79212099.6	79406175.9	159613.872	353690.1704
	Water Purification	6,917,133.45	6,917,133.45	6,917,133.45	0	0
	Sediment Retention	4703582.975	4703582.975	4703582.975	0	0
	Ground Water Recharge	126,572,357.95	126,572,357.95	126,572,357.95	0	0
Total Regulation Service		262,864,705.38	263030673.7	263222125.3	165968.352	357419.8904
	Biodiversity	7,352,953.52	7352953.52	7352953.52	0	0
Total Wetland Service		622,094,315.21	628224802.1	634602267.3	6130486.872	12507952.14

Figure 6. 19: The total economic values of Machar Marshes wetland Ecosystem services[23]



[23] Agriculture, food and fishery (crop Production+ bust meat+ wild food+ livestock watering+ pasture+ fishing), Water purification& recharge (water purification+ ground water recharge), water supply (domestic water supply), plant-based products (papyrus+ mat), cultural& medical (traditional medicine + honey), energy and timber (firewood+ charcoal+ timber), climate regulation (carbon sequestration+ sediment retention+ flood attenuation), biodiversity (biodiversity).

7. Conclusion and Recommendation

7.1. Conclusion

We collected relevant information from FDG, KII, GIS data, literatures and reports to conduct economic valuation of Machar Marshes wetland biodiversity and ecosystem services. We identified key stakeholders and their roles, estimate the economic values of the Machar Marshes wetland biodiversity and ecosystem services and suggest potential alternative wetland conservation options. We conducted stakeholder analysis and mapping to assess the influence and interest of different stakeholders in Machar Marshes wetland. The key stakeholders that are influenced and impacted by Machar Marshes wetland ecosystem services include: local community from upstream and downstream areas of the wetland, government institutions from national up to local level governmental organizations, researchers (NBI, research centers, institutes and university) and non-governmental organizations involved in wetland conservation programs and other humanitarian activities.

We also carried out the LULC mapping of Machar Marshes wetland using satellite data of the year 1995, 2005 and 2015 using digital datasets of ESA-CCI LULCC, the LULC classes identified for Machar Marshes wetland include cropland, herbaceous cover, tree cover areas, shrub cover areas, grassland, tree cover flooded, shrub land herbaceous cover flooded and water bodies. To account the recent LULC trend, we conducted a LULC analysis for the year 2009, 2013 and 2018 using the LULC dataset of MODIS. The LULC revealed that grass land cover, herbaceous cover, grass land and tree cover show a decreasing trend while crop land, shrub land herbaceous cover flooded and tree cover flooded show an increasing trend.

Machar Marshes provides key provisioning and regulating ecosystem services that directly and indirectly support the livelihood of the local community. Machar Marshes wetland provides an estimated economic value of $622 million/year of which $351.8 million/year, $262.8 million/year, $7.35 million/year of provisioning ecosystem services (i.e. the basic economic activities that the local community relies such as crop production, timber production, papyrus harvesting, fishing and so on), regulating ecosystem services (carbon sequestration, sediment retention, flood attenuation) and biodiversity ecosystem services, respectively. Note that the local community incurs an estimated $11 million/year estimated cost to get an estimated $622 million/year value of ecosystem services from Machar Marshes wetland. Form this assessment we noted that the local community livelihood is highly dependent on the Machar Marshes wetland ecosystem services.

7.2. Recommendation

Even though, the Machar marshes wetland provides huge economic value for the livelihood of the local community and the natural ecosystem, the wetland doesn't get protective authority for its sustainable provision. So far, there is no institutional arrangement to manage and ensure sustainability of the wetland ecosystem service. Some ecosystem services (particularly those related with tree cover) of the Machar marshes wetland shows decreasing tendency. By considering the trend of land-use land-cover changes and the prospective economic values of the wetland ecosystem services, we strongly recommend four potential conservation options to maintain and restore Machar Marshes wetland.

Option I: Conserving the wetlands' Foothill

Conserving foothill parts of the Machar Marshes wetland would have intra-generation advantage. Conserved foothill enables to create productive farms, healthy watershed, rich biodiversity and important for wildlife habitat. The LULC trend shows a slight increment of flooded area of the tree, shrub and herbaceous cover, and crop land. On the other hand, tree and herbaceous cover declines which would have potential impact on the benefits of ecosystem services to the local community. It is also known that South Sudan energy consumption is highly dependent on charcoal and firewood which are extracted from the tree/wood land cover resources.

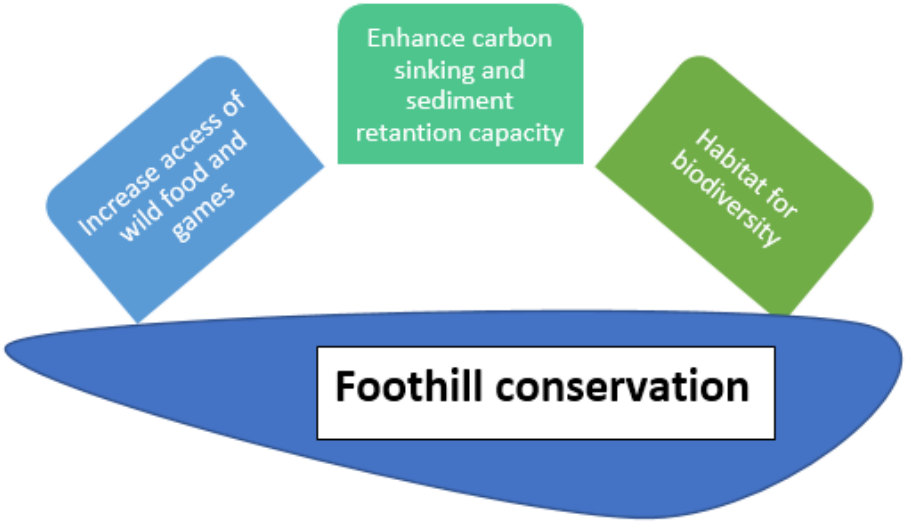


Figure 7. 1: Expected core benefits of foothill conservation for Machar Marshes wetland

Thus, restoration of the flooded and degraded area is required to ensure sustainable livelihood particularly to the local community. Note that stakeholders involved in conservation efforts should expect implementation, opportunity, and transaction costs. Realization of the wetland foothill conservation needs commitment from the state (dealing with land acquisition) and the local community/land owners (providing their land for conservation and accept compensation) in the form of long-term and short-term contract.

The foothill and integrated agroforestry conservation intervention can be undertaken on the flood suspected area as well as degraded crop lands and flooded herbaceous areas by providing compensation to the local farmers. This would in turn increase wild food, water supply and enhance the ground water recharge. Moreover, foothill conservation would increase the forest biodiversity and this in turn improve the livelihood of the local community (example: increasing of timber, fodder, firewood and quantity of honey) coupled with controlling air quality (for example. carbon stock, water regulation, soil protection).

Option II: increase energy mix and reduce fuelwood consumption

Given that 98% of the population use fuelwood as a primary residential energy source. This hugely damages the wetland forest resource. Therefore, we strongly recommend the following the use of energy mix interventions to overcome the energy challenge of the forest resource in the wetland:

- As significant number of the local community engaged in livestock raring, we recommend adoption of biogas energy as an alternative energy source for basic energy need (lighting and cooking) of the local community
- The South Sudan government and other development partners have to promote the adoption and dissemination of fuel saving improved cookstove.
- Introducing off grid (i.e. solar) electricity options for basic household energy requirements (i.e. lighting and charging)

Option III: conserving the flooded plain of the wetland

The rate of Machar Marshes wetland flooded plain degradation increases through time due to disputable use of natural resources (e.g. overgrazing) and climate change impacts (i.e. flood). Conserving floodplain areas and managing economic activities around these areas have enormous environmental value. Preserving the natural habitats on the floodplain area play an important role by controlling flood especially for the downstream parts of community during high runoff. If the floodplain conserved, it can also serve as a natural flood storage reservoir. In general, conserving flooded plain areas of the wetland could significantly increase wetland's regulating ecosystem services.

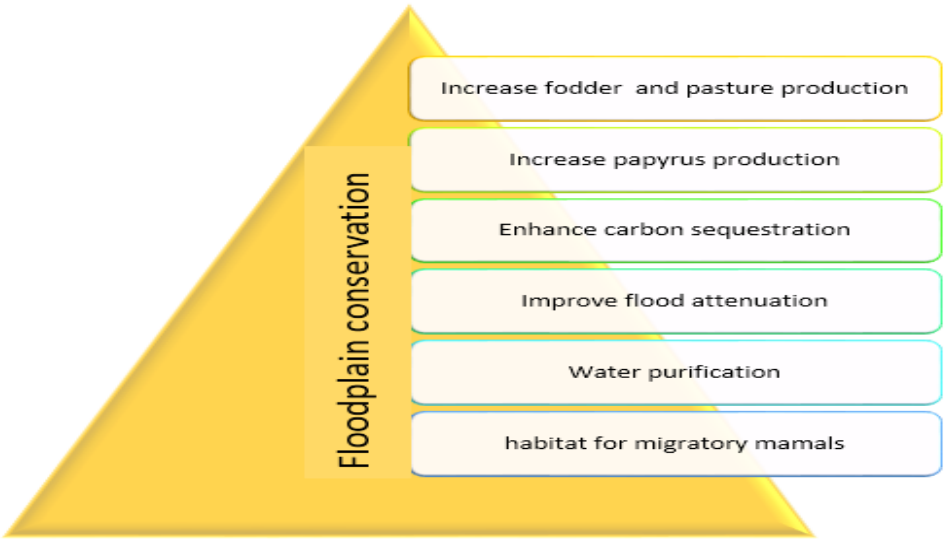


Figure 7. 2: Expected core benefits of floodplain conservation for Machar Marshes wetland

Option IV: permanent wetland restoration

Conservation of permanent wetland areas has significantly contributed for regulating ecosystem services (i.e. increase the wetland's water purification, sediment retention, and carbon sinking capacity of the wetland), provisioning service (increase the access for fish resources) and biodiversity ecosystem services of the wetland.

We noted that the wetland resource and its cultural value has a huge potential to attract tourist, however, the wetland has zero visit at the moment. Therefore, we strongly recommend to resolve the security issue and get prepared to attract tourist by promoting

investment and settle tribal disputes for good. The South Sudan government can earn revenue from tourism[24] development if the wetland manages sustainably.

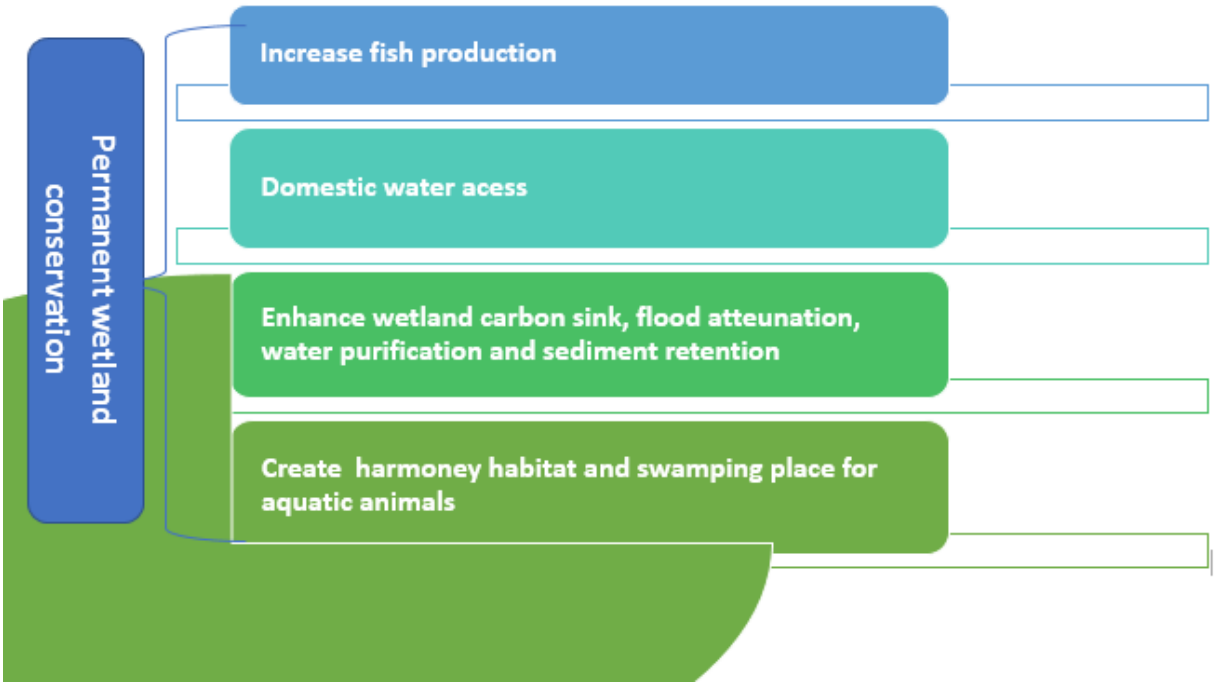


Figure 7. 3: Main prospects of permanent wetland conservation

Option V: Intervention to maintain the water inflow of the Machar Wetland

Ensuring sustainable water inflow is very essential intervention and vital to maintain the overall benefits of the Machar Marshes wetland ecosystem service. This intervention may require the collaborative initiative between countries of eastern African that shares river basin like NBI that works on river basin and wetland conservation. Maintaining water inflow to the wetland requires

[24] we couldn't capture the value of tourism due to data unavailability as currently the area has no visit at all.

trans-boundary collaboration among neighboring countries for a viable benefit of the ecosystem services of the wetland.

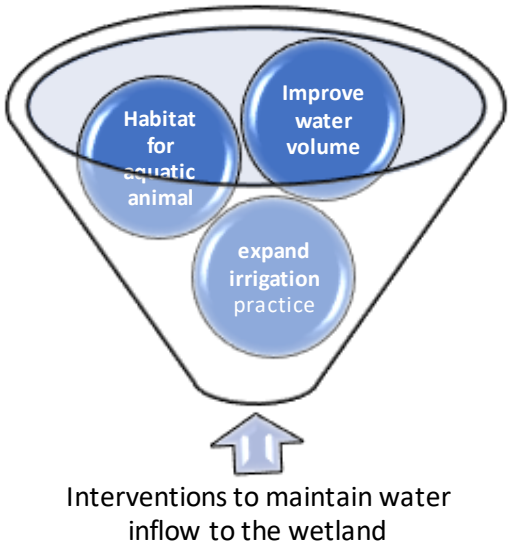


Figure 7. 4: Potential prospects of maintaining water inflow to Machar Marshes wetland

Option VI: Develop stakeholder coordination framework

Coordination of all relevant stakeholders coupled with strong institutional arrangement push forward the implementing the sustainable development agendas. Particularly, for Machar wetland resource conservation and restoration, we proposed a stakeholder coordination framework by considering the role of internal (government and local community) and external stakeholders (NGO and civil societies) (Figure 7.5). For instance, Ministry of Forest and Natural Resource design policy and strategy that controls and manages the wetland resources; Ministry of Finance allocate budget for the wetland conservation; local municipality closely control the wetland's conservation; NGO's and environment advocators involve on wetland conservation either by allocating budget or by increasing the local communities awareness on what, how and when to conserve the wetland resource. For this, we proposed the following structural framework as follows.

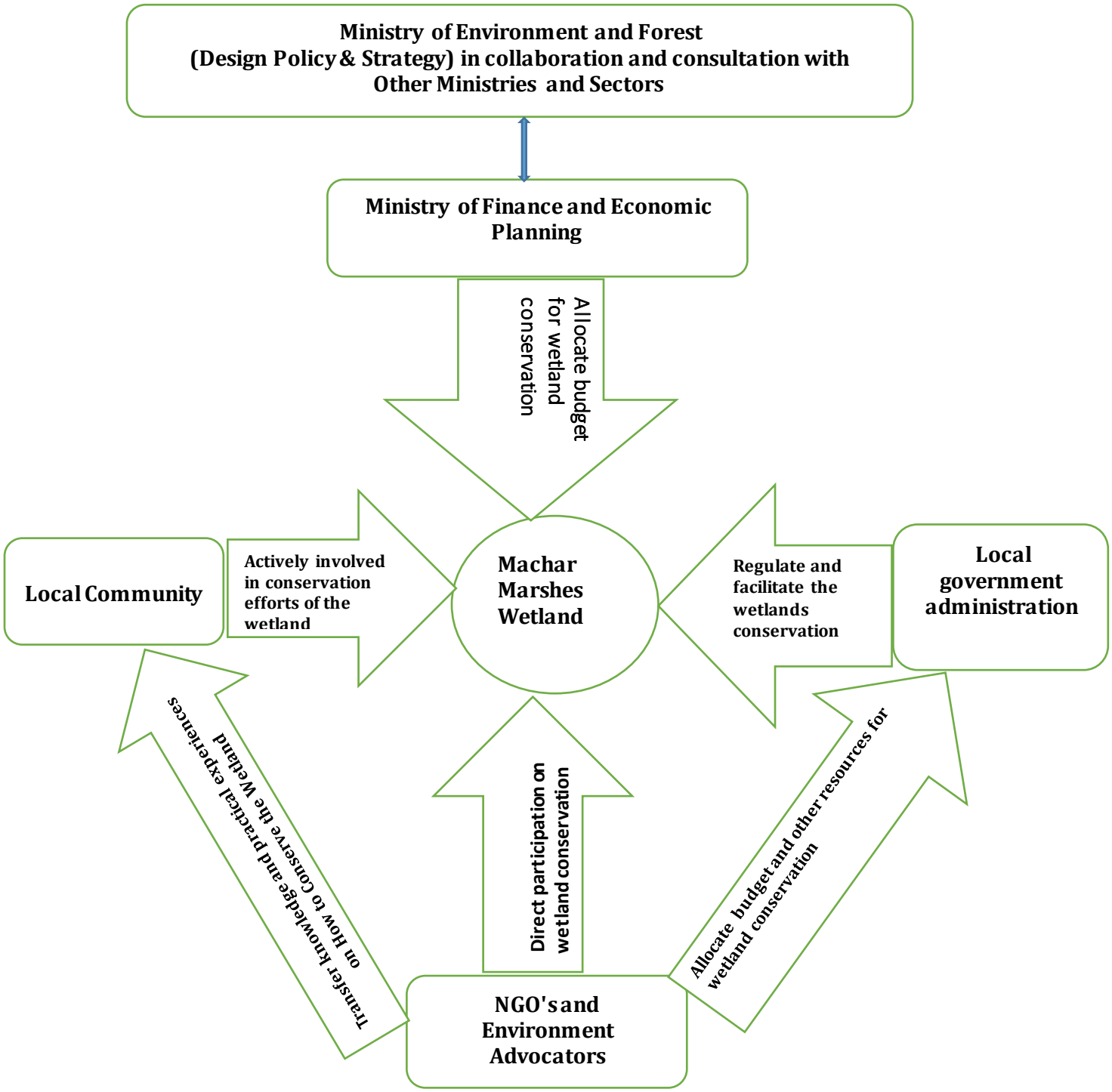


Figure 7. 5: Suggested structural framework for conservation efforts to Machar Marshes wetland

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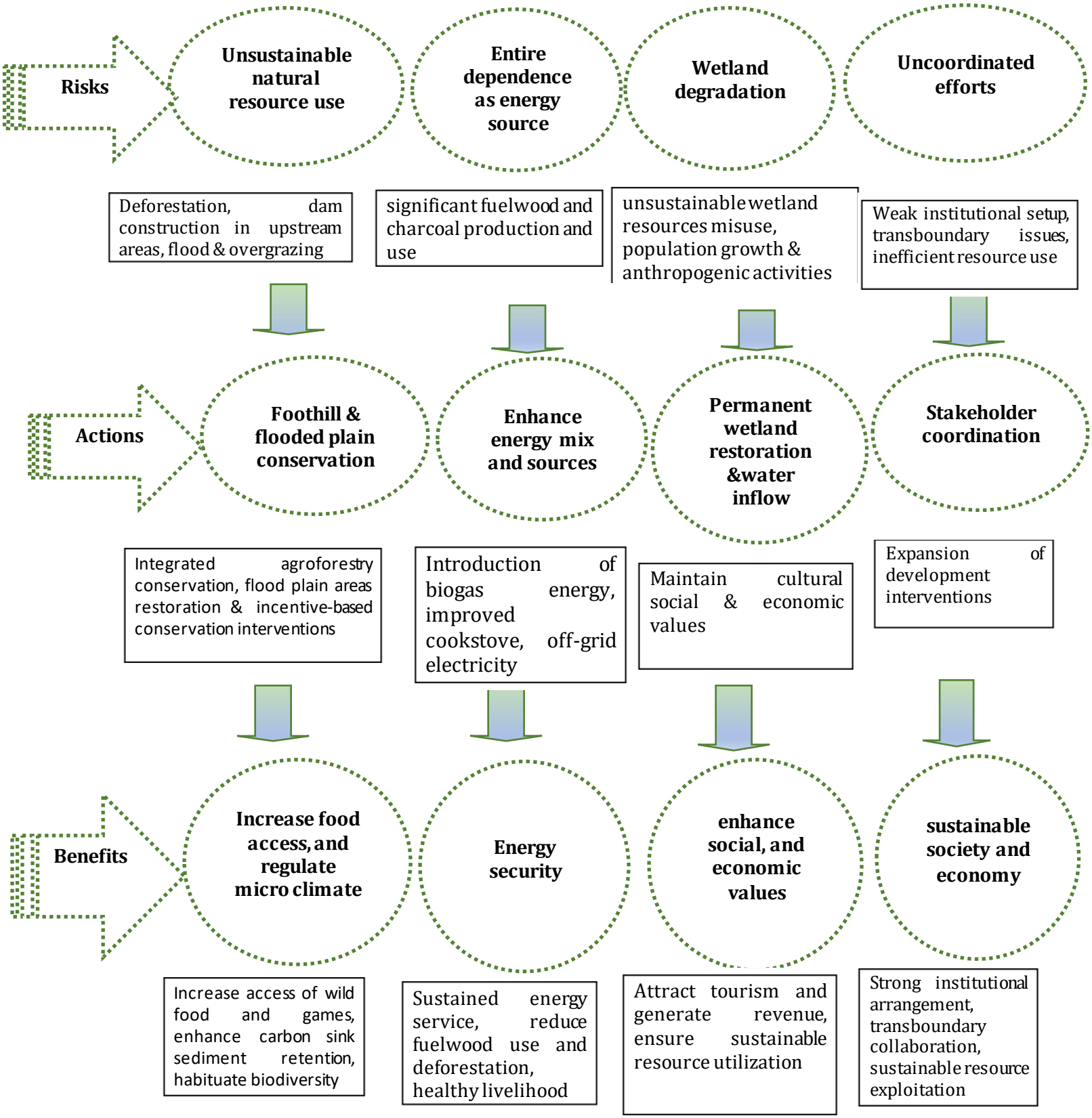
Figure 7.6: Machar Marshes wetland Risks, Actions and Benefits



As a summary the risks, actions and benefits of Machar Marshes wetland is presented in Figure 7.6. To maintain and ensure sustainable ecosystem service of the Machar wetland, all the key stakeholders should work together and undertake their respective responsibilities properly on the implementation of the above-mentioned alternative wetland conservation and restoration options. For the effective implementation of fast-tracking alternative conservation option, we suggest the following instrumental approaches:

- Widely promote awareness creation programs about the sustainable management of wetlands resources and ecosystems,
- Development processes are directly relied on wetland ecosystem services; thus, the wetland ecosystem services value should be considered to maintain sustainability and development,
- Collaborating key stakeholder together to support conservation and restoration alternative options,
- Introducing incentivized community-based wetland management initiative (especially; foothill and floodplain areas restoration) conservation option would be viable to improve the wetland ecosystem services.

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ANNEXES

Annex-I. Tables 1 – 3: Required information, data source, participants list, and potential wetland conservation options

Table A I 1: Required Information Data Source, and Analytical Method to Assess the Ecosystem Condition

Type of information required	Data sources or analytical models								
	Remote sensing and GIS	Natural resource and biodiversity	Socioeconomic data	Ecosystem models	Indicators of ecosystem condition	Indigenous and traditional knowledge	KII and focus group data	Quick house hold survey	Case studies of ecosystem response
Current spatial extent and condition of ecosystem	x	x			x			X	
Quality, quantity and spatial distributions of services provided by system		x		x					
Human populations residing in and deriving livelihoods from system			x			x	x		x
Trends in ecosystem conditions and services	x	x		x	x	x	x	x	x
Future treats for further degradation of the wetland							x	x	x
Response of ecosystem condition and services to drivers				x	x	x			x
Current conservation program which undertaken by different stakeholders							x	x	
Alternative options of conservation program							x	x	

Table A I 2: Participant List in Juba FGD and KII meeting						
No.	**Name**	**City**	**Organization**	**Position**	**Telephone**	**E-mail**
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Table A I 3: Alternative wetland conservation options and expected costs and benefits

Alternative wetland conservation options	Expected Costs	Expected benefits
Permanent wetland management	Transaction cost, opportunity cost and implementation cost	Water attenuation, ground water recharge, source of fresh water for the local community, carbon stock, source of food and habitat for aquatic animals
Flood plain conservation by vegetation cover	Transaction cost, opportunity cost and implementation cost	Carbon stock, habitat for migratory mammals and birds, supply fodder and seasonal plants for local community
Foothill land conservation	Transaction cost, opportunity cost and implementation cost	Soil erosion, carbon stock, source of wild fruits, habitat for mammals and birds
Water inflow	Transaction cost, opportunity cost and implementation cost	Increase water volume and habitat for aquatic animal

Annex-II: Key Informant Checklist for Economic Valuation and Conservation Opportunities for Machar Marshes Wetland, South Sudan

Hello. My name is _____. We are conducting a study on behalf of a team of consultants, that are hired by NBI ,that will be used to evaluate the total economic value of the Machar Marshes Wetland in South Sudan and to propose conservation options for the Wetland. You have been chosen because of the knowledge and information you have about the Machar Marshes wetland and your overall expertise on wetlands. We would like to ask you some questions about the topic of study. All of the answers you give will be confidential and will not be shared with anyone other than members of the consultancy team and the information will be used only for the purpose of this study. Hence, your sincere response and cooperation is very important towards contributing to the quality of the findings of this study. We rally thank you in advance for your willingness to participate in this survey.

1. Name of the interviewee: _____
2. Sex of the respondent (observe): _____
3. Current responsibility (position) of the respondent: _____
4. How long have you been in this position? _____
5. Education level of the respondent: _____
6. Specialization (area of expertise): _____
7. How big is the Machar Marshes wetland? (if possible, ask its size as defined by responsible office of the country).
8. How many biophysical categories are there in the wetland? What are the criteria for such classification? What is the size of each biophysical category?
9. How many people live in and around the Machar Marshes wetland? (if possible, ask the number by ethnicity and/or clan).
10. How do you describe the availability of livestock in the wetland? (If possible, could you provide us data on the different types and number (if no official data is available, your expert guess is welcome) of livestock and other animals found in the wetland.
11. What are the major benefits derived from the Machar Marshes wetland for the local community in particular and the country (South Sudan) in general? (if possible, list them by ecosystem services such as provisioning services, cultural services, regulating services and biodiversity services). (Refer table below)
12. Could you explain the trend of the wetland in terms of degradation and improvement situations? That is; whether it is improving over time or not. What are the degradation and improvement factors?
13. What are the major challenges facing the wetland? Please elaborate in detail.
14. Are there situations that could be regarded as positive potential for improving the situation of the wetland (enabling conditions for wetland conservation)?
15. There are two projects which could potentially decrease the water inflow to Machar Marshes (i.e. proposed project to construct a dam for Hydrology power and irrigation on Baro River) What is your view regarding these issue?

16. What are the most appropriate conservation options for the wetland? (if possible, propose conservation options for each biophysical category).

Table A II 1 : Appropriate conservation options as proposed by the interviewee (please probe him/her by giving him/her example wetland conservation options identified for this wetland from different sources)

No.	Conservation options	Conservation option	Benefits
1	Biophysical category one		
2	Biophysical category two		
3	Biophysical category three		
4	Biophysical category four		

17. Are there any existing conservation programs underway in or around the wetland? Who is the owner or initiator of such programs?
18. Could you please explain the process of identifying and implementing conservation programs? Include also the role of the local community in such process.
19. What is the future prospect of the wetland? Why?
20. In Table 2 below : please List of ecosystem services that could be potentially provided by Machar Marshes wetland

Table A II 2 : List of ecosystem services that could be potentially provided by Machar Marshes wetland

No.	Questions and filter	Coding categories		
20	Which of the following ecosystem services do you get from the wetland? RATE THEM IN ORDER OF IMPORTANCE			
20a	A) Provisioning	Yes	No	Order of importance
	i. Timber	1	2	
	ii. Fuelwood	1	2	
	iii. Agricultural crops	1	2	
	iv. Domestic water supply	1	2	

	v. Grazing	1	2	
	vi. Livestock watering	1	2	
	vii. Fish	1	2	
	viii. Hunting	1	2	
	ix. Wild fruits and vegetables	1	2	
	x. Natural medicine	1	2	
	xi. Honey	1	2	
	xii. Fodder	1	2	
20b	B) Cultural services	Yes	No	Order of importance
	i. Transport	1	2	
	ii. Cultural	1	2	
	iii. Educational	1	2	
	iv. Tourism	1	2	
20c	C) Regulating services	Yes	No	Order of importance
	i. Carbon sequestration	1	2	
	ii. Water attenuation	1	2	
	iii. Water purification	1	2	
	iv. Soil protection (protection from soil erosion	1	2	
20d	D) Support services	Yes	No	Order of importance
	i. Biodiversity services	1	2	
	If you believe there are other major ecosystem services that are provided by Machar Marshes wetland but not mentioned in the above list, you may mention them	1. _____ 2. _____ 3. _____		

21. We would like to estimate the enterprise budget for different wetland conservation options that you proposed in above in question No. 16. As an expert on the area, we believe you have better ideas on the following issues and we would appreciate for patiently completing the table below.

No.	Conservation options	Benefits	Costs		
			Transaction costs	Opportunity costs	Implementation costs
1	Biophysical category one				
2	Biophysical category two				
3	Biophysical category three				
4	Biophysical category four				

Thank you again!

Annex-III: Focused Group Discussion Guide for Economic Valuation and Conservation Opportunities for Machar Marshes Wetland, South Sudan

Hell. My name is _____. We are conducting a study on behalf of a team of consultants, that are hired by NBI, that will be used to evaluate the total economic value of the Machar Marshes Wetland in South Sudan and to propose conservation options for the Wetland. You have been chosen to participate in this discussion because of the knowledge and information you have about the Machar Marshes wetland. We would like to ask you some questions about the topic of study. All of the answers you give will be confidential and will not be shared with anyone other than members of the consultancy team and the information will be used only for the purpose of this study. Hence, your sincere response and cooperation is very important towards contributing to the quality of the findings of this study. We rally thank you in advance for your willingness to participate in this discussion.

1. Name and responsibility of the participants (the size of an FGD should not exceed 8 individuals)

No.	Name of the participant	Gender	Sub-location	Responsibility	Main occupation
1					
2					
3					
4					
5					
6					
7					
8					

2. How big is the Machar Marshes wetland? (If possible, ask its size as defined by responsible office of the country).
3. How many biophysical categories are there in the wetland? What are the criteria for such classification? What is the size of each biophysical category?
4. How many people live in and around the Machar Marshes wetland? (if possible, ask the number by ethnicity and/or clan).
5. How do you describe the availability of livestock in the wetland? (If possible, could you list the different types of livestock and other animals found in the wetland.
6. What are the major benefits derived from the Machar Marshes wetland for the local community in particular and the country (South Sudan) in general? (if possible, list them by ecosystem services such as provisioning services, cultural services, regulating services and biodiversity services). (Refer table 2 below)

7. Could you explain the trend of the wetland in terms of degradation and improvement situations? That is; whether it is improving over time or not. What are the factors/reasons for degradation and improvement?
8. What are the major challenges facing the wetland? Please elaborate in detail.
9. Are there situations that could be regarded as positive potential for improving the situation of the wetland (enabling conditions for wetland conservation)?
10. What are the most appropriate conservation options for the wetland? (if possible, propose conservation options for each biophysical category).

Table A III 1: Appropriate conservation options as proposed by FGD participants

No.	Conservation options	Expected Benefits	Costs		
			Transaction costs	Opportunity costs	Implementation costs
1	Biophysical category one				
2	Biophysical category two				
3	Biophysical category three				
4	Biophysical category four				

11. Are there any existing conservation programs underway in or around the wetland? Who is the owner or initiator of such programs?
12. Could you please explain the process of identifying and implementing conservation programs? Include also the role of the local community in such process.
13. What is the future prospect of the wetland? Why?

Table A III 2: List of ecosystem services that could be potentially provided by Machar Marshes wetland

No.	Questions and filter	Coding categories		
14	Which of the following ecosystem services do you get from the wetland? Rate in the order of importance			
14a	A) Provisioning	Yes	No	Order of importance
	i. Timber	1	2	
	ii. Fuel wood	1	2	
	iii. Agricultural crops	1	2	
	iv. Domestic water supply	1	2	
	v. Grazing	1	2	
	vi. Livestock watering	1	2	
	vii. Fish	1	2	
	viii. Hunting	1	2	
	ix. Wild fruits and vegetables	1	2	
	x. Natural medicine	1	2	
	xi. Honey	1	2	
	xii. Fodder	1	2	
14b	B) Cultural services	Yes	No	Order of importance
	i. Transport	1	2	
	ii. Cultural	1	2	
	iii. Educational	1	2	
	iv. Tourism	1	2	
14c	C) Regulating services	Yes	No	Order of importance
	i. Carbon sequestration	1	2	
	ii. Water attenuation	1	2	
	iii. Water purification	1	2	
	iv. Soil protection (protection from soil erosion	1	2	
14d	D) Support services	Yes	No	
	i. Biodiversity services	1	2	
	If you believe there are other major ecosystem services that are provided by Machar Marshes wetland but not mentioned in the above list, you may mention them	_____ _____		

Annex IV: Technical Note for the NBI- Writeshop Meeting on TEEB for wetlands in Nile River Basin case studies, July 22-23, 2019: Kampala, XANADU Hotel

Prepared by: Dawit W. Mulatu (TEEB Consultant)

Day-I: July 22, 2019

The meeting started by welcoming address from Nile-Sec (Leonard Akwaney) and introduction, the objective of the meeting, presentation & discussion of case study objectives and methodologies were presented by Lucy. Followed by, each wetland case studies presentations. Expected to each case studies to have a detailed methodology at the end of the Writeshop workshop:

1. Preparatory desk review- expected output will be inception report
2. Field scoping exercise- expected output will be detailed methodology
3. Data collection- expected output will be mid-term report
4. Analysis and reporting- expected output will be technical reports

- Purpose, scope , focus and methods should be cleared
- Foster peer review and exchange from within the panel
- Expected output of the assignment for Sudd and Machar wetlands is to provide Input for economic value wetland and water-related ecosystem services into integrated wetland management planning and Overall River planning and development decision making.
- The other three case studies focus is to contribute for wetland conservation plan
- The sources of finance for conservation efforts (GCF)
- Refine the focus!!!!

Reflection on Machar Marshes:

- ❖ We need to add objective on how to make it usable this document and for whom
- ❖ Knowing where are we going?
- ❖ Most suitable valuation method: consider accessibility, community, available resources (time, budget and other resources)
- ❖ Expected products (like report, paper, policy brief)
- ❖ Products for whom?
- ❖ The team is seriously ambitious is one of the comments from the technical reviewers, which is taken as positive, starting in broad will benefit to synthesise the report,
- ✓ Distribution of key features
- ✓ Per hectare value need area identification for different interventions and wetland settings
- ▪ Clearly articulate the objectives (but they were taken from the ToR)
- ▪ Agree on the wetland area/delineation due to its variability/fluctuation
- ▪ Improve the flow and consistency, this reflection is well taken.
- ➢ Consult with hydrology experts to understand the dynamic of the area that has vibrant hydrological system,

Proposed Method will be:

1. Identify and mapping of stakeholders (whose costs and benefits, interest, influence, expected role and power)
2. List potential Ecosystem Services(ES),(if possible trends and status)
3. Conduct LULC analysis (with agreed LULC classifications)
4. Identify alternative restoration options, impact and implications
5. Value transfer/benefit transfer (due to the existing challenges to conduct SP method, detail review to conduct benefit transfer)
6. Develop future scenarios of LULC change and impact on wetland ES
7. Analyse the different scenarios
8. Provide policy implications
9. Main Deliverables of this assignment (expected outputs and for whom?)

Tailoring the case studies:

- Increasing the policy impact of ES assessment and valuation (recent GIZ document)
- *To bring the economic value of wetlands and water-related ecosystem services into integrated wetland management planning and overall River planning and development decision making.*
- Policy questions Vs Research questions
- The research questions demand a rigorous/technical process/language Vs policy questions that demand quick response/simple/explanatory

Discussion points on how to influence decision makers and the line of argument for Machar Marshes Wetlands:

What decision making process does the case study seek to guide or influence?

- Policy formulation
- *Integrated development decision making.*

In which way:

- Cost benefit analysis (CBA); Demonstrate the value of these wetlands (+ve and –ve externalities of these values
- Distributional effects (e.g how many people are benefited?)

Who are the main decision makers?

Ministry of Finance
Ministry of Environment and Forest
Ministry of Water
Ministry of Petroleum
Ministry of Dams and energy
Ministry of wildlife and Tourism
State Governments (Counties)

Target Audience: local community, NGOs, research institutes

The overall policy questions:

Why investing in wetland restoration options?
What will be the likely impact of the wetland restoration option on local communities?

The story line of argument

Machar Marshes wetlands in Nile basin are highly degraded,

These wetland treats emanate from both internal and external ….identifying potential Interventions to conserve the wetland are vital….we conducted the CBA of these interventions should be valued with BAU and alternative restoration options……we highlighted the implication of these intervention and required investment….thus, it demand policy decision and finance allocation for implementation and implement additional instruments and incentive mechanisms (like PES)

Sequence of research questions:

- What are the current challenges and drivers of these challenges the wetlands?
- Who are the beneficiaries and losers?
- What are the current investments?
- What are the other optional investments?
- How best can influence policy and planning?

Comments for the line argument: Target audience (people who do you want to influence? Or users of this information), Line of reasoning…. and additional instruments and incentives, PES….leveraging private sector investment can be considered in policy implication part of the report

Day-II: July 23, 2019

The meeting started with a re-cap of the first day and presentation on what needs to be valued and the day activities continue with two round case study team with technical reviewers discussions/group meetings.

I. Determining what need to be valued?

What ES to be value for and for whom; in light of the limited time and resources.

What are the most relevant from the list of ecosystem services?

- ❖ Identify and assess ES v
- ❖ Estimate and demonstrate
- ❖ Capture the value of the ES and seek solutions

Identify and balancing

- ❖ Dependencies
- ❖ Impacts
- ❖ Risks
- ❖ Opportunities

Discussion Points Machar Marshes Wetland-I:

- ✓ Which ES are most relevant?
  - o Machar Marshes wetland: Provisioning services, Biodiversity, the green infrastructure via maintaining the regulating services (water-related ecosystem services, and local climate)
  - o Note! Be clear on either measuring the resource stock or the resource flow!
  - o TEV, the direction is to highlight the Total Economic Value of the ES (TEVES)
  - o Aim and why these ES are selected
- ✓ Which groups, sectors and sites?
  - o Local community, the delineated wetland (Identified spatial scale), local/state government counties, national, Nile-basin region countries , and global community (carbon and biodiversity),
- ✓ Which values will be considered and distributional aspect?
  - o TESV
  - o PS= Market value,
  - o RS=ESV with benefit transfer,
  - o CS=TCM or value transfer
  - o Biodiversity= Estimated and potential investment to conserve via Value transfer
- ✓ Distributional aspects: Incentive, PES, tax, and fees

II. Dealing with time and change, refining scenarios to be modelled?

- ❖ Spatial,
- ❖ Temporal
- ❖ Connectivity

- ❖ Causality and complexity
- ❖ Risk and uncertainty
- ❖ Trade-offs and synergies

Discussion Points for Machar Marshes Wetland-II:

Which trade-off or change?

- ❖ There could be a trade-off agricultural land use Vs wetland (depending on the type of crops cultivated)
- ❖ There could be a trade-off settlement Vs vegetative cover
- ❖ There could be a trade-off grazing land (livestock) Vs species diversity/richness
- ❖ There is a trade-off wetland Vs accelerated water-flow (i.e through canal development)

Which scenario?

- ❖ The status-quo
- ❖ Improved management of the wetlands
- ❖ Green development initiatives
  - o We proposed potential restoration options from our review but these will be refined through KII and FGDs that is planned next month in Juba.

Which parameter or conditions?

- ❖ More or less the parameters or conditions are linked with identified indicators
- ❖ i.e. the indicators are changing in a positive directions

Which indicators?

- ❖ Water volume and water quality
- ❖ Species richness
- ❖ Vegetation cover
- ❖ Wetland cover (size)
- ❖ Livelihood (Household income, number of household, food security, and asset building)
- ❖ Qualitative indicators: Perceptions related to the value of wetland, willingness to participate and willingness to pay)

III. Elaborating the information to be generated, methods to be applied and data needs/sources?

Matrix:

- ❖ List of ES
- ❖ Valuation method
- ❖ Key data needs,
- ❖ Info. on biophysical linkage/causality

IV. Work plan and methodology revisions and next steps!

- ❖ **Way forward:**
  - ✓ Work on the new reflections
  - ✓ Concretize the ideas,
  - ✓ The ToR and timeline still alive
  - ✓ Tap available resources and data

End of the workshop

Annex V: Notes and Reflections in Juba Meeting:

South Sudan National Wetlands Consultation Workshop: Building Knowledgebase and Capacities for Wise Use of South Sudan Wetlands for Healthy River Nile - Grand Juba Hotel, Asmara Hall, Juba, South Sudan

Prepared by: Dawit W. Mulatu and Jemal Ahmed (TEEB consultant)

Day I – 27 August 2019

The workshop is planned to be held for three days. The workshop organized with theme on "**South Sudan National Wetlands Consultation Workshop"**. The first two days organized to share the Sudd wetland base line studies and the third day organized for Sudd and Machar Marshes wetlands TEEB case studies. The workshop started at about 9:30 A.M. with a speech delivered by three officials from two ministry offices. Among the speeches that capture our attention was the one made by Peter and he iterated that "if you want to go fast, move alone; and if you want to go far, move in a group". He raised this idea to emphasize on how working in a group or in a team allows sustainable results/produces than other setups. Then, he also quotes Ms. Michelle Obama, the former first lady of U.S.A., said that 'if want to solve a problem, come as a community'. When you come as a community, you will find that the person you are looking for to solve the problem, which is the community itself. Following Peter, Joseph delivered his speech and he highlighted that conducting Environmental and Social Impact Assessment is mandatory according to the interim constitution of South Sudan. Finally, Mr. David emphasized in his speech on some of the challenges and problems the country are facing regarding its wetlands and integrated development. Particularly, he stated that Water hyacinth is becoming a major problem on the Sudd wetland and conflicts over the river Nile is becoming a challenge on South Sudan wetland areas. He also added that limited research and knowledge development related to socio-economic component of the wetlands in South Sudan, and pointed that more research should be conducted for better decision making.

Following this, Leonard, from NBI-Nile Sec, presented the NBI wetlands and workshop objectives. Leonard presentation focus on NBI-wetland program: The presentation emphases on various themes mainly include: NBI-wetland program objectives, NBI Nile basin wetland best practices, biodiversity conservation and sustainable utilization of wetland ecosystem services, Nile basin wetlands work force, regional wetlands status report, on-going wetlands portfolio work, wetlands knowledge base development, wet (peat) land, wetland management plan, networking and capacity building, and wetland engagement platforms (presented by Leonard Akwaney, NBI). Subsequently, Titus from Wetland International (WI) Kenya Office and a focal person of WI for South Sudan, presented project objectives, tasks, timelines and cooperation needs among others. Particularly his presentation focus on on wetland challenges, environmental threats, management plan, ecosystem services, and capacity building (presented by Titus Wamae, WI)

The presentation continued by Dr. Georg Petersen from HYDROC. His presentation concentrations was on project objectives, tasks, timelines, work packages and cooperation need of HYDROC for the assignment with the following major **Work Packages (WP)**: **WP1**-wetland mapping (The 2018 LULC analysis, the vegetation class considered are open water, reeds, papyrus, and wetland grass); wetland inventory: about 68 wetlands in Nile river basin, wetland atlas; **WP2**: wetland modelling; **WP3**: Ecosystem services (Regulating ES: climate regulation, bioclimatic services; Provisioning ES: food, water for direct consumption and non- consumption uses, transport; Cultural ES); **WP4:** Biodiversity assessment; **WP5:** environmental flow assessment; **WP6:** Wetland policy choices and assessment framework; **WP7:** Draft framework wetland management plan (presented by Dr. Georg Petersen).

Georg, from HYDROC, presented six of the eight work package tasks and needs during the first day. One of the points raised during his presentation was the wetland units. There are different wetland

units; namely: vegetation cover, geology, flood, water sources, landscape, and ecosystem. However, vegetation cover is the important one and it can lead to see the others. A question was asked on the Sudd's link to ecology in wetland modeling. Georg explained that the Sudd wetland soil is black soil with cracks and it's like a plastic layer. Hence, compared to evapotranspiration, in filtration is very minimal for the modeling project (it may not be the exact words and we stated this the way we understood). As well, the water in Malakal is clear due to the sedimentation and navigation is becoming difficult due to the expansion of the sedimentation.

The issues of Sudd wetland boundaries on inflow and outflow was raised, and George stated that inflow at Mangala and outflow at Malakal are the major ones and the others are smaller in volume inflow and outflow. One important point that strikes us is Georg pointed out that pollution is consumption. In his presentation of work package 4 which deals with biodiversity assessment, Georg stated that, so far, they have identified a total of 675 species in this regard of which 4 are at critical stage, 5 endangered, 17 near endangered, 15 vulnerable and 8 are conservation dependent species, there was productive discussion regarding biodiversity aspects of Sudd wetlands in the middle of the presentation. The final activity of the day was participants to break-up in to groups to discuss based on the presented work packages.

End of Day I

Day II – 28 August 2019

The day activity started with brief highlight by the moderator to re-cap of the first day meeting and setting the stage for the second day (Mr. Leonard lead this session). Particularly, what was learnt from the first day activities, expectation of the second day, what should be the major points during the first day were the main re-cap themes of the dialogue. Then, the groups continue their discussion to finalize their dialogue and prepare a report for presentation focusing of the first six work packages. The groups presented their discussion major points to participants on policy related challenges, and what should be done to address the challenges.

Presentation of the HYDROC continued by Georg and presented **WP7:** the presentation focus on draft framework wetland management plan on elements, objectives, trade-off, and synergies (presented by Dr. Georg Petersen). The participants again break out in a group to discuss in WP7. Groups presented back with different themes of discussion: definition of involved parties: listing specific stakeholders; implementation guidance for the wetland framework plan; policies and strategies; wetland resources and ecosystems; and stakeholder's role, interest, capacity and decision making power.

Presentation continues on highlights on HYDROC **WP8**: Discussion on Sudd diagnostic analysis: consultation, stakeholder identification, policy understanding, and wetland management scenarios. This theme focus on diagnosis analysis of the Sudd that has the following three pillars: :

a. Stakeholders and counterparts
b. Sustainability
c. Implementation and capacity

The remaining time of the day was used for group discussion and presentations which were an interactive and productive session. Finally, the participants raised and reflect on the work packages: the work packages are exhaustive, and required involvement of many stakeholders on the ground, field work should be conducted for biophysical measurements and socioeconomic information gathering and validation, and bear in mind that the Sudd wetland is dynamic in terms of hydrology, economy, population and biodiversity asspoects.

End of Day II

Day III: 29 August 2019

South Sudan National Wetlands consultation workshop and the Nile Basin Wetland TEEB: Case studies on Sudd and Machar Marshes Wetland Economic Valuation (29, August, 2019)

Mr. Leonard gave brief information on the day's activities. Then, Dr. Dawit (consultant for Sudd and Machar Marshes wetland TEEB study) delivered his presentation for both Sudd and Machar Marshes wetlands. The presentation focused on setting the context for the evaluation of the two wetlands, brief introduction on the wetlands, methods to be used among others. After the presentation, one participant stated that Bagara is not among the communities in the Machar wetland and they are not South Sudanese. However, the other participants explained that they used to cross from Sudan and live there. Following this, Dawit gave briefing on the activities to be performed for the day. Accordingly, the participants were divided into four groups (two on each wetland). The groups were formed as:

1. One group composed of individuals that came from the Sudd wetland area alone (Sudd states)
2. One group comprising individuals that came from Machar Marshes wetland area alone (Machar states)
3. The experts that came from the federal bureaus and other offices, they were split into Machar and Sudd groups which was done randomly.

Then each group was informed to work on the first two parts of the KII instrument that was distributed to the participants. The participants started discussing with groups and the consultants (Dawit and Jemal) were moving around to follow, guide, and observe the discussion and to elaborate some of the issues when the need arises. The group discussion continued after the health break. Then groups started presenting the results of their discussion and the first two groups presented before the lunch break.

The remaining two groups presented the discussion points after lunch. Then, the participants went to group discussion on the 3rd and 4th sessions/parts of the guide questions. The groups were informed to spend an hour to discuss the issues at stake due to shortage of time. Also, instead of making each group discuss all the parts, the task was divided in to two and each task was discussed by two groups. After discussing for an hour, we noticed that they still need additional minutes or hours to discuss the questions. Hence, instead of making them present what they have discussed so

far, it was better to give them more time to discuss and the discussion continued until 5 P.M. The power-point slides of each group were then collected for further references. The participants were given a chance to reflect on the last day's exercise. They highlighted on the importance of modifying and simplifying the language use, the allotted time was limited compared to the task, and make the questions specific. Dawit, then, gave concluding remark and in his speech, he thanked the participants for their patience, time, and active participation.

In general, day three presentation session's theme was on Nile Basin Wetland TEEB: Case studies on Sudd and Machar Marshes Wetland Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development. The presentation focused on the objective of the project, the expected deliverable from the participants, and the day activities, including the discussion guide instruments (i.e the focus group discussion (FGD) and Key informant Interview (KII) instruments).

The participants conducted two round group discussions and presented by the group major themes of discussion. The participants discussed general themes and stakeholder mapping exercise in the first round. Regarding wetland ecosystem services and wetland conservation options, they discussed in the second round. The discussion note and presentation slides are collected for input to develop the reports.

Finally, the participants made a final remark and reflection about the day: They mentioned the importance of the TEEB study in South Sudan, It is the first of its kind to explore TEEB in South Sudan wetlands, the time limit to discuss thoroughly the proposed TEEB issues, the participants propose it would much manageable if it was a two day exercise, they propose to send such TEEB instrument in advance and participants will get enough time to read, practice and understand the guiding questions, such material would also be great if it is supported by video, media and other communication schemes, the organizers should consider media people invitation to outreach and disseminate the idea to a broader community and stakeholders through news, TV broadcast. The communication and response issues have been raised up; creating smooth communication and timely response are required from all stakeholders for further meetings and consultations to advance in preparation and participation in workshops.

Notes: All group discussion points, notes and presentations are collected and compiled by Nile-Sec.

End of the workshop.

Annex V: Technical Note on the Juba Validation Workshop as workshop report for South Sudan's Wetlands Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development

On 12 March 2020, the morning session was allotted for South Sudan's wetlands Economic Valuation of biodiversity and ecosystem services for Green Infrastructure planning and development. The two wetlands are Sudd and Machar Marshes wetland. The morning session started with brief given to the participants what is expected from this validation workshop by Mr. Leonard from NBI. Followed by Dr. Dawit presentation on the major findings of both ***Machar Marshes and Sudd Wetland Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development***.

Points raised for Machar Marshes wetland ecosystem services and biodiversity valuation presentation:

- What is the implication of having 98% of the local community depend on the forest resources of the wetland as energy source, which have a direct impact on forest resources? Propose some actions/interventions to overcome the challenge in energy sources?
- Value of the tourism not yet captured, what is the reason and even if currently zero visit to the area, how we can capture the tourism potential
- No-institutional arrangement, what will be the potential enforcement mechanism to implement well-functioning institutional system,
- How about considering the UNECA-Natural capital account (NCA) to capture the value of the wetland ecosystem in the economy using SEEA,
- There is a new developed National Biodiversity action plan (NBAP), which we requested the participant to share us and will include it in the report
- The methodology should have a clarity on the assumptions and based on realistic approach to justify the findings,
- Better to add in the recommendation to consider Agroforestry and Forest and Landscape restoration approach, protected area management as potential intervention,
- Better to re-check the considered 8% of the household for fishery,
- Clarify what do we mean by SS with limited resources? (both the human capacity and other resources)
- Potentially to include the soil contribution for house construction and bricks makings, the soil capacity to sink carbon,
- When mapping the stakeholders, account the interest behand the stakeholders to engage in wetland conservation and utilization of the wetland resources,

The points are well taken and addressed in the development of the final report.

After tea break (11:30 to 1 PM), the time was allotted for the presentation and discussion of the "Total Economic Valuation of Ecosystem Services of the Sudd Wetland for Green Infrastructure Planning and Development". Dr. Jemal presented the major findings of this report. The presentation took about 45 minutes and the remaining time was used for question and answer session. Among the questions asked during the discussion session are: Why not studies in South Sudan are not

considered? Why tourism is not included in the valuation exercise? Why a study from Uganda is used as a policy site? There are stakeholders that are not mentioned in the study; If we would like know the total economic value of charcoal consumption in Juba, how do we do that? Why navigation is considered as cultural service than provisioning?

An explanation was given to the satisfaction of the participants. On the issue of why studies in South Sudan were not considered, it has been explained that there are no similar valuation studies in the country and the reason the study on Uganda was considered as policy site is that the study covers eight wetlands in different agroecological zones, there are many similarities between the two countries, an adjustment was made for infrastructural and income differences between the two countries. While we acknowledge that there are stakeholders on the Sudd wetland that were not listed in the study, we also believe that it is not possible to list all the stakeholders. But we tried our best to include the major ones. On the issue of tourism, though Sudd can be considered as huge potential for tourism activities, currently there are little or no tourism activities in and around the wetland. Since we are evaluating what is currently existing, it was not necessary to include tourism for now. If sufficient information is readily available, the best way to evaluate the value of charcoal use in Juba is to apply the market price approach. And, on the issue of navigation, its true that some authors include it under provisioning service while others in cultural services. So, the categorization is not a big deal. The above raised pointes are well taken and incorporated in the development of the final Sudd wetland report as well.

Day III, March 13,2020:
Household level questionnaire training:
Friday afternoon (15/03/2020), our team presented the household survey instrument (the household survey questionnaire) to all the participants and an explanation was provided on each part of the questionnaire. Special focus was given for the issue of contingent valuation part of the questionnaire and an elaborated explanation was provided on how to conduct the bidding process and the initial bidding. Afterward, the participants were split into four groups to discuss and fill the questionnaire and to conduct a form of pilot testing of the questionnaire. The main objective of these exercises is to understand the household level questionnaire is manageable or not, particularly to accommodate the local context of South Sudan in the questionnaire. About an hour was allotted for the exercise and each group presented its discussion and comments for the whole participants.

Some of the comments and questions raised during the group presentations and discussions include:

- ✓ For the education level of the respondent, instead of asking the years of schooling, it is better to list the education level as primary, secondary, and so on.
- ✓ Since some people could be willing to contribute not in cash but in kind (labor) it is good to include that possibility.
- ✓ Use sub-village, village, county and state instead of sub-village, village, district, and state.
- ✓ Include gum Arabic among list of the provisioning services.
- ✓ Better to state as randomly selected than you are selected by chance.
- ✓ Better to put ranges for age, income, and distance from the wetland and nearest market of the respondent.
- ✓ Better to say traditional than clan conflict mechanism.

And, finally, three groups proposed the amount of money they proposed is better for the initial bidding process.

Group I: SSP 250 per month or 3000 per year
Group II: SSP 1000 per year
Group III: SSP 3700 per year

Group IV: didn't reach to that part of the questionnaire during the group discussion session. We evaluated the minimum bid and Indeed, most of the comments are noted and incorporated in the final version of the household questionnaire. For the initial bidding amount, an average of the three groups is calculated and that is considered as the initial bidding in the final version of the questionnaire. It is estimated an average of about 200 SSP per month to be set as an initial bid for the contingent valuation exercises. After the household questionnaire training and presentation, Mr. Leonard presented the major practices undertaken in wetland peatland studies in South Sudan and participants reflected on the presentation.

Finally, the way forward on the 2nd South Sudan wetland consultation workshop is undertaken and the following major points are raised:

- Strengthen the coordination of this effort and engage other potential stakeholders, not to miss their role and contribution,
- Participatory mechanism to engage more,
- Sharing all the available information through available mechanism, and invite media people for communication outreach,
- Ensure the community leader's engagement in further consultations,
- Venue, time plan and arrangement of the facility room of the workshop,
- Consider the new institutional structure of South Sudan,
- Training and capacity building on wetland management plan and institutional arrangements, economic valuation of wetland ecosystem services, basic concept of wetland, importance of wetland, on how to collect data related to wetlands, modeling, linkage between wetland and climate change, concept of RS and GIS, on how to conduct surveys, and early warning systems,
- Align the above demand that is proposed as training and capacity building with project resources and NBI context
- Having a national level wetland related consultation committee/ working group to ease the process and facilitation of activities related to wetlands
- There was an initiative to have SS National level wetland and biodiversity working group is not progress well, due to the link with specific project and does not have a plan on how to sustain it. It is recommended to follow and apply international experiences to address these challenges (like the Ramsar convention). Better also to share regional experiences from neighboring countries on how they manage in sustaining the wetland and biodiversity working group.
- Tentative team members established to work on as SS wetland and biodiversity working group

End of the presentation and discussion session.