FEASIBILITY STUDY FOR THE POTENTIAL TO HARVEST WATER-HYACINTHS IN ETHIOPIA'S LAKE TANA BIOSPHERE RESERVE WITH A VIEW TO PRODUCE BIO-FUEL AND ORGANIC AGRO-FERTILIZER

UNESCO

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INSTITUTE OF SUSTAINABLE HALOPHYTE UTILIZATION
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Centre and Network

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List of acronyms

AAAA- Addis Ababa Action Agenda

ADLI- Agriculture Development-Led Industrialization

AFAP- Amhara Forestry Action Program

AfDB- African Development Bank

APV- Africa Power Vision

AU-African Union

AUC- African Union Commission

BF- Bio-Fuel

BoEPLAU- Bureau of Environmental Protection, Land Administration and Use

CAADP- Comprehensive Africa Agricultural Development Programme

CBD- Convention on Biological Diversity

CDM- Clean Development Mechanism

COP- Community of Practice

CRGE- Climate-Resilient Green Economy

CSP- Climate Smart Agriculture

EARO- Ethiopian Agricultural Research Organization

EEA- The Ethiopian Energy Authority

EEPCo- The Ethiopian Electric Power Corporation

EFAP- Ethiopian Forestry Action Program

EPLAUA- Environmental Protection Land Administration and Use Authority

EPSE- Ethiopian Petroleum Supply Enterprise

ESIA- Environmental and Social Impact Assessment

ESEMF- Environmental and Socio-Economic Management Framework

EWCA- Ethiopian Wildlife Conservation Authority

FRC- Forestry Research Center

GDP- Gross Domestic Product

GPP- Gross Primary Production

GTP- Growth and Transformation Plan

IBC- Institute of Biodiversity Conservation

IPCC- The Intergovernmental Panel on Climate Change

IPRF- Institutional Policies and Regulations Framework

IRENA- International Renewable Energy Agency

ISHU – Institute for Sustainable Halophyte Development of the University of Karachi

IUCN- International Union for the Conservation of Nature

FAO- Food and Agriculture Organization of the United Nations

GHG- Green House Gas

HOAREC&N-Horn of Africa Regional Environment Center and Network

MAB- Man and Biosphere

MoWIE- Ministry of Water, Irrigation and Energy

NBI-Nile Basin Initiative

NBSAP- National Biodiversity Strategy and Action Plan

NCS- National Conservation Strategy

NEPAD- New Partnership for Africa's Development

NRODA- The National Reserve Oil Deposits Administration

OAF- Organic Agro-Fertilizer

PASDEP- Plan for Accelerated and Sustained Development to End Poverty

SDGs- Sustainable Development Goals

SDPRP- Sustainable Development and Poverty Reduction Programs

UNCCD- UN Convention to Combat Desertification

UNECA- United Nations Economic Commission for Africa

UNFCCC- UN Framework Convention on Climate Change

UNEP- United Nations Environmental Programme

UNESCO- United Nations Educational, Scientific and Cultural Organization

UNFCCC- United Nations Framework Convention on Climate Change

WB- World Bank

WNBR- World Network of Biosphere Reserve

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EXECUTIVE SUMMUARY

Recently added to the list of UNESCO Biosphere Reserves (2015), Ethiopia's Lake Tana is a multi-purpose lake facing multi-dimensional challenges, among them water-hyacinth invasion. According to the Water Hyacinth Coverage Survey Report, produced by scholars from Bahir Dar University in May 2015: "*in September 2011, it was officially recognized that one of the top ten ecologically dangerous and worst invasive weeds, water hyacinth (Eichhornia crassipes), infested Lake Tana. According to the 2012 survey, about 20 ha of the shore on the north-eastern part of Lake Tana was infested. Following this infestation, Bureau of Environmental Protection, Land Administration and Use (BoEPLAU) made a physical removal campaign. It is estimated that between 90 – 95 % of the water hyacinth was basically removed from the lake through this manual removal approach in 2013. In August 2014, the survey report by experts revealed water hyacinth re-outbreak in the lake. More than 50 000 ha of the shore area and about 128 km shore length was infested by this deadly weed.*"[1] As suggested by Ogutu-Ohwayo [2], the plant might have been introduced "unintentionally" by botanists in the 1980's. The plant is causing a great threat to the general ecosystem of the lake and human activities as well, mainly by reducing water quality. The "invasion" phenomenon is even more exacerbated by massive eutrophication resulting from nutrients (P and N) emanating from intensive agriculture surrounding the lake. The negative impacts of water-hyacinth have pushed the scientific community to call for an urgent mobilization of expertise. Facing the limits of biological, mechanic and chemical control, a critical need for paradigmatic change is required, in order to minimize the spread of the species.

The purpose of this feasibility-study is to provide a comprehensive picture of the water-hyacinth's biology and associated challenges on Lake Tana while contributing to the paradigmatic shift of considering the plant as an opportunity rather than a threat. This feasibility study will test the potential harvest of water hyacinth towards the production of bio-fuel and organic agro-fertilizer, which will be highly valuable for biodiversity conservation

[1] Wassie Anteneh, Dereje Tewabe, Addisalem Assefa, Abebaw Zeleke, Befta Tenaw and Yitayew Wassie (2015). Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.

[2] Ogutu-Ohwayo R, Hecky RE, Cohen AS, Kaufman L (1997) Human impacts on the African Great Lakes. Env Biol Fishs 50: 117-131.

and ecosystem management purposes in similar tropical Biosphere Reserves and other wetlands.

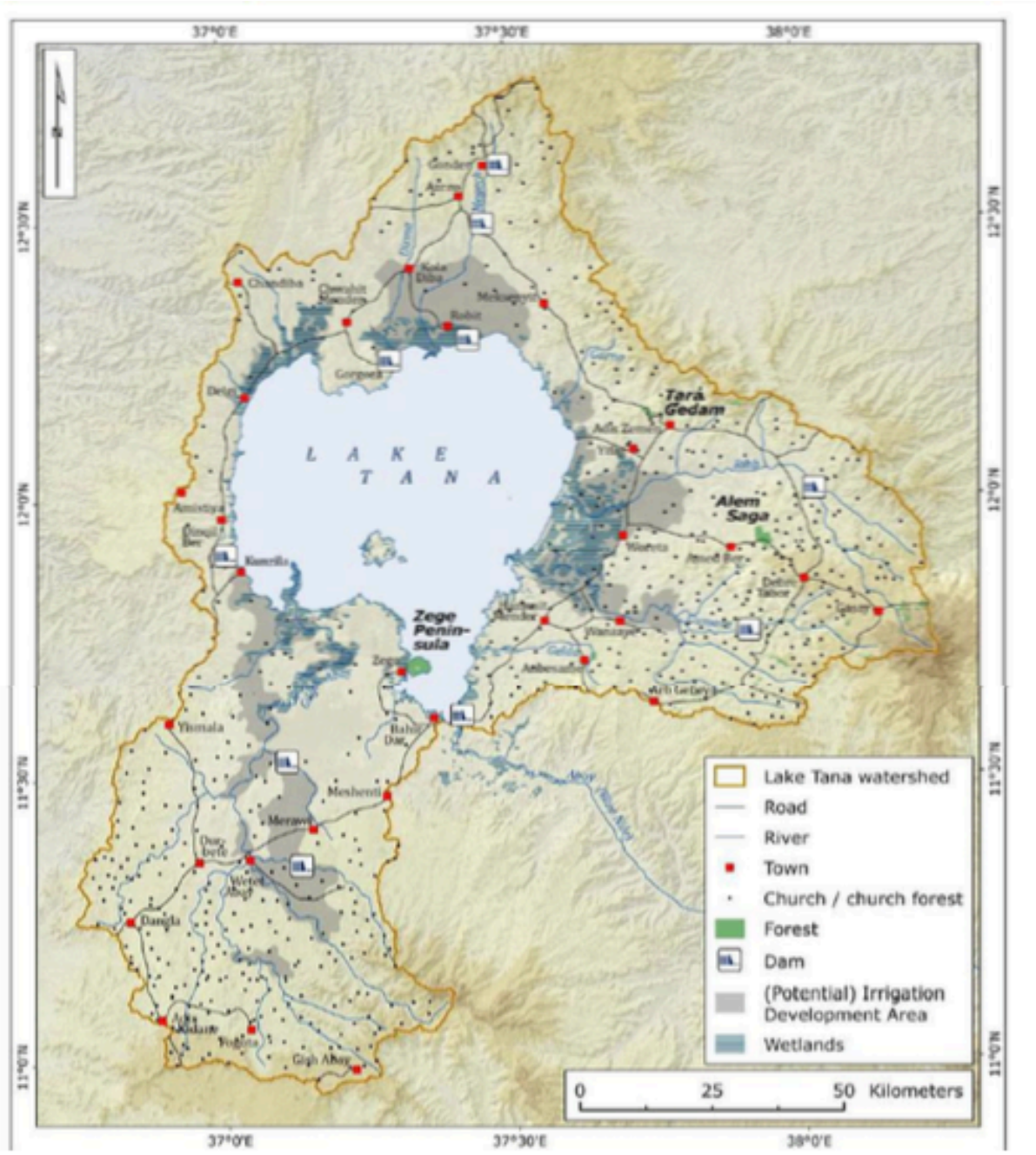

Figure.1 Map of Lake Tana Showing Dam Construction Sites, Water Pump Sites and The Extents of Proposed Irrigation Areas (Source: Zur Heide, 2012).

I-INTRODUCTION

Conservation of biodiversity and the use of science and innovation for sustainable human development and nature conservation are among the core elements of UNESCO's biosphere reserves. Acting as a contribution to the recommendations and pledges from UNESCO's Conference Series *Quest 4 Africa*, this feasibility study intends to analyze the potential to harvest water-hyacinth in Ethiopia's Lake Tana biosphere reserve with a view to produce bio-fuel and organic agro-fertilizer.

The main objectives of this feasibility study will be to: 1) identify the environmental incidence of water-hyacinth on Lake Tana and its impact on the Biosphere Reserve at large (water-quality, altering of ecosystem services and processes, reducing native species abundance and richness, decreasing genetic diversity of ecosystems, socio-economic loss, impacts on livelihoods and culture…). 2) provide a clear Institutional Policies and Regulations Framework (IPRF) in order to maximize the validation and integration of the program at the international and national levels and eventually identify gaps or contradictions; 3) complete the Environmental and Social Impact Assessment (ESIA), including environmental, physio-hydro-chemicals, socio-economic and zoning settings suitable for the harvest of water-hyacinths in Ethiopia's Lake Tana biosphere reserve with a view to produce bio-fuel and organic agro-fertilizer ; 4) develop the premises of an Environmental and Socio-Economic Management Framework (ESEMF) that establishes clear procedures and methods for the environmental and social impact assessment in relation to sustainability, determine the training and capacity building needs of the implementing institutions, and specify the roles and responsibilities (Government, civil society, local populations and Academia); 5) outline the necessary management procedures towards monitoring technical, environmental and social indicators related to the program, design active research protocols and issue projections towards enhancing long-term economic sustainability, innovation and performance.

The environmental parameters will include the analysis and mapping of functions, positive and negative impacts of water-hyacinth, and general incidence on UNESCO's Lake Tana Biosphere Reserve.

The Institutional Policies and Regulations Framework (IPRF) outlines the larger UN and international institutional frameworks, from the Kyoto Agreement to the Addis Ababa Action Agenda of the third international conference on financing for development (AAAA), UN framework on sustainable development goals in transforming our world: the 2030 agenda for sustainable development (including the 17 Sustainable Development Goals - SDGs), and the latest COP 21 Paris agreement. I also intend to focus on the only convention that regulates invasive species at the International level – The Convention on Biological Diversity. The IPRF also encompasses the Ethiopian National policies and regulations framework related to land, water, energy, agriculture, economy and environment. The aspects related to fertilizer are regulated by the Abuja Declaration on Fertilizers for an African Green Revolution.

The Environmental and Social Impact Assessment (ESIA) include assessing environmental and socio-economic factors that require due consideration, identifying gaps and environmental parameters within UNESCO and governmental policies and regulations that might restrict or exclude such endeavor, assessing the engineering and up-scaling of harvesting and transforming technologies and potential socio-economic impacts of harvesting water-hyacinth, biomass utilization and production of bio-fuel and organic agro-fertilizer, risks and mitigation measures. Complementary parameters will be assessed such as carbon sequestration resulting from use of both bio-fuel and organic agro-fertilizer, eco-systemic benefits, agriculture practices related to climate change, as well as additional recommendations towards the potential negative impacts of water-hyacinth on The Ethiopian Renaissance Dam.

1.1-Methods

The ESIA is prepared by collecting primary and secondary data as well as compiling information through extensive review of project documents, environmental policies, laws, regulations, proclamations and guidelines at the local, national and international levels, consultative discussions with project team members under the auspices of UNESCO, consultations with legal experts, monitoring and evaluation experts at the international level and environmental regulatory experts.

1.2-Review of the Relevant Institutional Policies and Regulations Framework (IPRF), Environmental and Social Impact Assessment (ESIA), and Environmental and Socio-Economic Management Framework (ESEMF) Guidelines.

A thorough review of the relevant Institutional Policies and Regulations Frameworks (IPRF), socio-economic and socio-environmental elements relevant to policies, management and plans are integrated with the guidelines emanating from the Environmental and Socio-Economic Management Framework (ESEMF) in order to produce a global understanding of principles and mechanisms for harvesting and transforming water-hyacinth. The socio-economic and socio-environmental elements will serve as references for the preparation and assessment of impacts (ESIA). The results of the ESIA will serve as references for the preparation and implementation of the Environmental and Socio-Economic Management Framework (ESEMF) and plan.

1.3-Purpose and objectives of Environmental and Social Impact Assessment (ESIA) of harvesting and transforming water-hyacinth

The Environmental and Social Impact Assessment (ESIA) is prepared to serve as collateral framework to examine the environmental and social impacts of harvesting and transforming

water-hyacinth to be financed and implemented within UNESCO's Lake Tana biosphere reserve. The ESIA intends to create guidelines while exploring a range of parameters such as land mapping, potential implementation areas and registration, production of bio-fuel and organic agro-fertilizer. The ESIA outlines the principles, rules, and procedures to be followed during the screening of potential recipient against any potential environmental and social impacts at the national and local levels. The document guides in designing appropriate measures and plans to reduce, mitigate and or offset adverse impacts and enhance positive outcomes.

The objectives of the ESIA are:

- To establish clear procedures and methods for the environmental and social impact assessment, review, and approval.

- To assess and document key socio-economic and socio-environmental factors that require consideration; to identify socio and environmental vulnerabilities as well as the necessary impact mitigating measures.

- To specify appropriate roles and responsibilities, and outline the necessary reporting procedures, for managing and monitoring environmental and social concerns related to project investment (Recommendation).

- To determine the training and capacity building needed;

- To establish the budget required to implement the ESIA requirements.

In addition, the ESIA is prepared to address in a non-limitative way key social and environmental issues such as land acquisition and valuation, off-shore activities' rules and regulations, water and land legislations.

1.4-Purpose and objectives of the Environmental and Socio-Economic Management Framework (ESEMF)

The Environmental and Socio-Economic Management Framework (ESEMF) focuses on estimating the general cost of the program including means of production of bio-fuel and organic agro-fertilizer, cost of implementation, capacity building, technical and environmental management. ESEMF will also issue the recommendations to enhance long-term economic sustainability, innovation and performance. The ESEMF outlines the scientific, engineering and capacity of the water-hyacinth harvesting program as a system inclusive of ESIA concerns and applications.

The objectives of the ESEMF are:

- To identify and assess items and costs considered as appointed by the programs (material and non-material) from both accounting and conceptual standpoint.

- To identify and assess productive items (income), in our case the use of related

products, by-products and services from water-hyacinths as well as the costs of operations;

- To determine and assess the cost for impact mitigating measures;

- To determine and assess the cost of training and capacity building;

In addition to meeting the above objectives, the ESEMF is intended to facilitate the implementation of the project based on the following principles:

- Provide support to national authorities and local communities to develop their sub-project application to avoid or minimize environmental and social safeguards concerns;

- Provide support to local authorities to review applications and determine if additional, more detailed environmental and social planning is required before applications can be approved;

- Provide fund for extension teams (inclusive to Academia) to assist communities in preparing their sub-project applications;

- Provide support to communities, local authorities and extension teams in carrying out their respective roles by funding substantial training, information resources and technical assistance.

- Provide funds for annual review for assessing compliance, learning lessons, and providing future performance, as well as assessing the occurrence, and potential for cumulative impacts due to funded project and other development activities.

1.5-Feasibility components

The feasibility study will approach ten components: 1) Environmental incidence of water-hyacinth on Lake Tana and its impact on the Biosphere Reserve at large. 2) Ethiopia's development equation: demography, water management, agriculture and energy nexus. 3) Institutional framework. 4) The structuration of paradigmatic change. 5) Organic agro-fertilizer and the challenges of climate change and agricultural development in Ethiopia. 6) environmental impacts, eco-system benefits and valuation. 7) Bio-fuel's potential for Ethiopia. 8) environmental impacts, eco-system benefits and valuation. 9) production of other economic products and integrated systems. 10) execution, formal active research, monitoring and evaluations principles.

1) Environmental incidence of water-hyacinth on Lake Tana and its impact on the Biosphere Reserve at large: this section will analyze the biological and environmental incidence of water hyacinth on Lake Tana and projections.

2) Ethiopia's development equation: demography, water management, agriculture and energy nexus: this component intends to explain the relationship between the four topics as well as their incidence if their equilibrium is disrupted. I will use the results of this assessment in order to legitimate the proposal of harvesting water-hyacinth with a view to produce bio-fuel and organic agro-fertilizer.
3) The Institutional framework: beyond the latest conferences and agreements that have a favorable inclination towards sustainable development driven projects, I would like to dedicate this component while focusing on three major texts, first at the international level "The Decision Adopted By The Conference Of The Parties To The Convention On Biological Diversity At Its Tenth Meeting" and at the Ethiopian National level the "Second Growth and Transformation Plan (GTP II)" and Ethiopia's "Climate-Resilient Green Economy- Green Economy Strategy (CRGE)".
4) The structuration of paradigmatic change: Based on the recommendations from component 3, this component intends to demonstrate the process and implications of a paradigmatic change.
5) Organic agro-fertilizer and the challenges of climate change and agricultural development in Ethiopia: In the context of the critical role of agriculture in Ethiopian society, this component will analyze the implications of shifting agricultural practices especially towards the use of organic agro-fertilizer, not only as a general assessment but in relation to Lake Tana.
6) Environmental impacts, eco-system benefits and valuation: the section focuses on potential environmental impacts, including eco-systemic benefits related to the production of organic agro-fertilizer.
7) Bio-fuel's potential for Ethiopia: I endeavor to demonstrate how Ethiopia will benefit from investing in the production of bio-fuel made from water-hyacinth rather than sourcing agricultural crops such as sugar cane.
8) Environmental impacts, eco-system benefits and valuation: focuses on potential environmental impacts, eco-systemic benefits related to the production of bio-fuel and bio-fertilizer.

9) **Production of other economic products and integrated systems:** extrapolates on the complementary use of biomass from water-hyacinth towards the production of valuable products.

10) **Execution, formal active research, monitoring and evaluations principles:** structures the implementation (preparation for dissemination and involvement through a pilot memorandum for actors at the local level- local partnerships) as well as the research (M.Sc. and Ph.D. level studies into water management, agriculture, design and engineering, cash crop development, renewable energies and large-scale economics) and evaluation.

1.6-Questions

Questions to be studied:

Component	Questions
Component 1: Environmental incidence of water-hyacinth on Lake Tana and its impact on the Biosphere Reserve at large	• What are the identified dynamics of water-hyacinth on Lake Tana and their impact? • What are the possible remediation?
Component 2: Ethiopia's development equation: demography, water management, agriculture and energy nexus	• What is at stake for Ethiopia in terms of development and economic growth? • Do Agriculture and Energy have conflicting goals? • What could be water-hyacinth's contribution?
Component 3: The Institutional framework	• Does the Institutional Policies and Regulations Framework (IPRF) is fully adapted to the harvest and transformation of water hyacinth into bio-fuel and organic agro-fertilizer?
Component 4: The structuration of paradigmatic change	• What are the implications of paradigmatic change for the Lake Tana Biosphere Reserve and Ethiopia?
Component 5: Organic agro-fertilizer and the challenges of climate change and agricultural	• What are the principles of utilization and transformation of water-hyacinth into

development in Ethiopia	organic agro-fertilizer? • How much organic agro-fertilizer can be produced with Lake Tana's water-hyacinth?
Component 6: Environmental impacts, eco-system benefits and valuation.	• What are the environmental and socio-economic impacts of harvesting water hyacinth towards organic agro-fertilizer within UNESCO's Lake Tana biosphere reserve? • What are the identified eco-systemic benefits? • What is the economic valuation and potential impact?
Component 7: Bio-fuel's potential for Ethiopia	• What are the principles of utilization and transformation of water-hyacinth into bio-fuel? • How much bio-fuel can be produced with Lake Tana's water-hyacinth?
Component 8: Environmental impacts, eco-system benefits and valuation.	• What are the environmental and socio-economic impacts of harvesting water hyacinth towards bio-fuel within UNESCO's Lake Tana biosphere reserve? • What are the identified eco-systemic benefits? • What is the economic valuation and potential impact?
Component 9: Production of other economic products and integrated systems	• What are the principles of project management, ownership and partnership?
Component 10: Execution, formal active research, monitoring and evaluations principles:	• What are the principles of project management, ownership and partnership?

II-Project Description

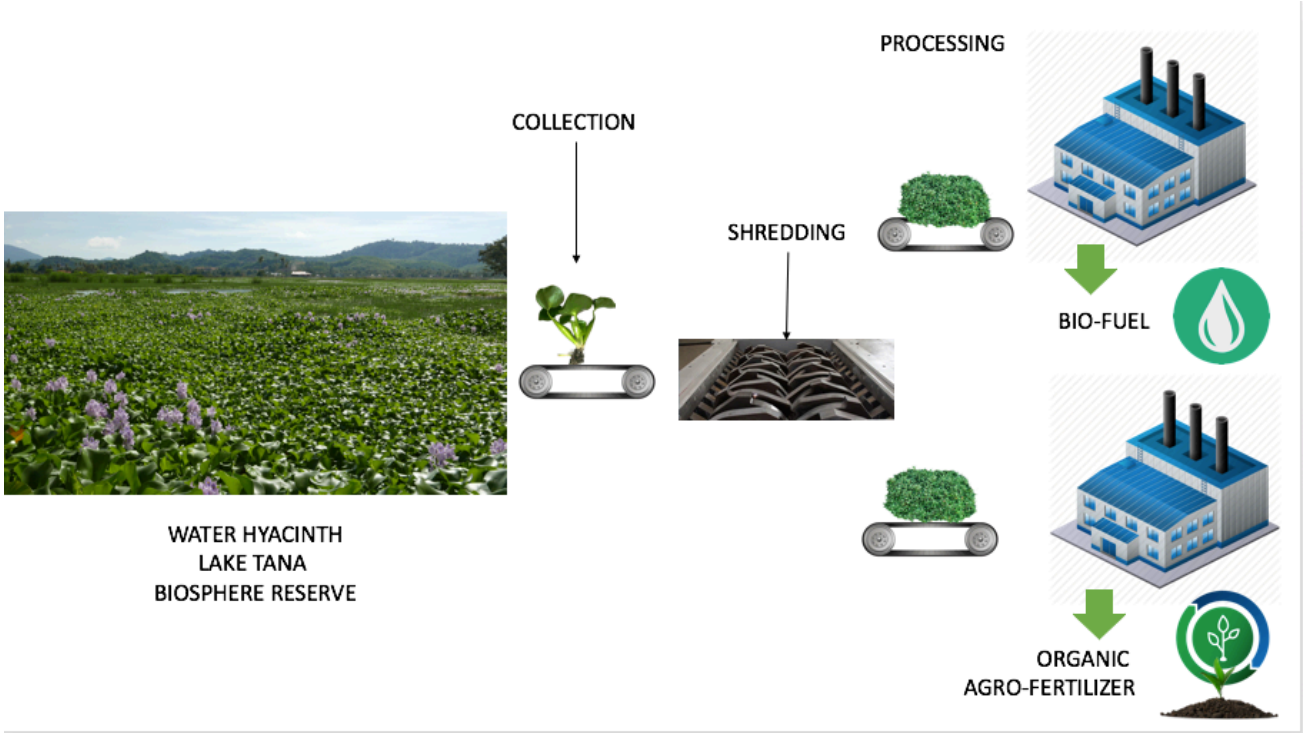

Figure 2. Project Description

The project consists in sustainably collecting a substantial amount of water-hyacinth every day to diminish its negative impacts and process it into two major products, bio fuel and organic agro-fertilizer. The production of bio-fuel implies a drying process as powdered hyacinth is used to produce bio-fuel with a standard ratio of 1 ton of dry product to 500 liters of finished product (synthetic diesel, bio-kerosene…). Concerning organic agro-fertilizer, several protocols can be deployed and result in liquid fertilizer, enriched compost, pellets among others.

No timeline can be associated with the project as projection over water-hyacinth stock cannot yet be determined and engineering requirements remain to be met.

III-Environmental Incidence of Water-Hyacinth on Lake Tana and Its Impact on The Biosphere Reserve At Large.

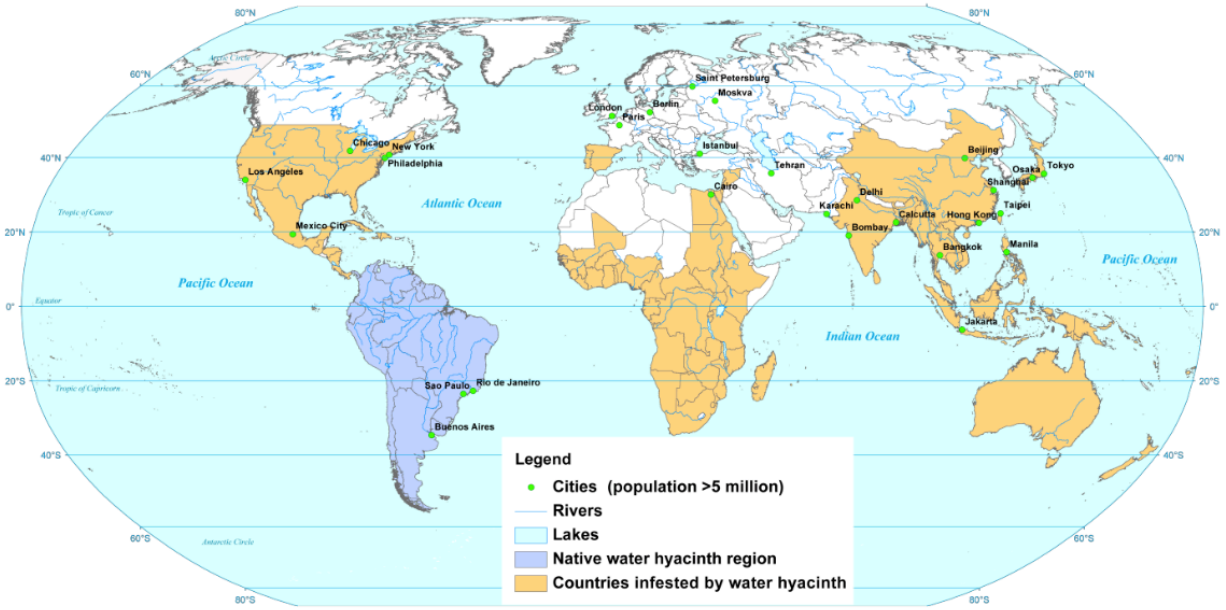

Figure 3. Global Distribution of Water Hyacinth (Map Redrawn By UNEP/DEWA from Téllez Et Al. 2008).

Water hyacinth also known as *Eichhornia crassipes* is a perennial aquatic plant (hydrophyte) native to the Amazon basin that has spread across the world as shown on the map above. The plant is also known as one of the fastest growing, doubling its population every two-weeks depending on the nutrient contents of its environment. Adding to this, each plant produces around 3000 seeds, and seeds are known to remain viable up to 28 years.[3]

When not controlled and under favorable conditions, water hyacinth can cover entire water bodies. Its main identified negative impacts are the diminution of water flow, obscuration of water surfaces decreasing photosynthesis activity, increase evapotranspiration, oxygen depletion and reduced water quality (hypoxia), blockage of waterways hampering agriculture, fisheries, recreation and hydropower. Water-hyacinth also plays a critical role in the dispersion of infectious diseases acting as a breeding ground for pests and vectors such as mosquitoes causing malaria as well as species of snail responsible for schistosomiasis (bilharzia or snail fever).[4]

Water hyacinth also has an economic impact, as mentioned in a UNEP Report: **"***They cause substantial economic losses estimated by one study to total US$120 billion annually in the*

[3] Sullivan, Paul R. and Wood, Rod. 2012. Water hyacinth, Eichhornia crassipes (Mart.) Solms, seed longevity and the implications for management. 18th Australasian Weeds Conference. Melbourne: Conference Proceedings CD

[4] Water Hyacinth and the transmission of schistosomiasis, Trans R Soc Trop Med Hyg (2008) 102 (6): 619-620 doi :10.1016/j.trstmh.2008.0

USA (Pimentel et al. 2005, Kettunen et al. 2009.) In South Africa, estimated economic costs due to invasive alien species are currently above US$ 700 million (R6.5 billion) per annum or 0.3% of South Africa's GDP, and could rise to over 5% of GDP if invasive plants are allowed to reach their full potential (Wilgen and Lange 2011)" and "In Africa, for example, where water hyacinth is listed by law as a noxious weed in several countries, it is the most widespread and damaging aquatic plant species. The economic impacts of the weed in seven African countries have been estimated at between US$20-50 million every year. Across Africa costs may be as much as US$100 million annually (UNEP 2006). "[5]

There are several control mechanisms for preventing the spread of, or eradication of, water hyacinth. The three main mechanisms used are biological, chemical and physical control. Chemical control is the least favored due the unknown long-term effects on the environment and the communities with which it comes into contact:

"Biological control: Biological control is the use of host specific natural enemies to reduce the population density of a pest. Several insects and fungi have been identified as control agents for water hyacinth. These include a variety of weevils, moth and fungi. Biological control of water hyacinth is said to be environmentally benign as the control agents tend to be self-regulating. One major drawback is that it can take a long time to initiate such projects because it can take several years for the insect population to reach a population density sufficient to tackle the pest problem.

Chemical control: The application of herbicides for controlling water hyacinth has been carried out for many years. The common herbicides are 2, 4-D, Diquat and Glysophate. It has been found that there is a good success rate when dealing with small infestations but less success with larger areas. Application can be from the ground or from the air and requires skilled operators.

Physical control: Mechanical removal of water hyacinth is seen as the best short-term solution to the proliferation of the plant. Mats of water hyacinth can be enormous and can have a density of up to 200 tons per acre. Manual removal of water hyacinth is suitable only for extremely small areas. It is difficult, labor intensive work and in some areas, there is serious health risks associated with the work (crocodiles, hippopotamus and bilharzia in Lake Victoria for example). Transportation of the harvested weed is also costly, because it has such high-water content. Chopping can reduce the volume and the water content."[6]

Lake Tana is symptomatic of other issues such as eutrophication caused by extensive agriculture in the surrounding areas of catchment which feeds the lake with nutrients (N and P). This data will be critical later on in the study in order to understand the challenges of water management, agriculture and alleviation of water-hyacinth on Lake Tana.

[5] UNEP Thematic focus: Ecosystem Management, Water hyacinth – Can its aggressive invasion be controlled? April 2013

[6] Technical Brief, Water Hyacinth Control and Possible Uses, http://library.uniteddiversity.coop/Water_and_Sanitation/water_hyacinth_control.pdf

The limits of current physical/mechanic removal devices in the face of volumes present on Lake Tana and other water bodies demonstrates the need for alternative methods: *"Available water hyacinth chopper cum crusher was found superior as highest volume (66%) and weight (32%) reduction was achieved at maximum capacity (1.35 t/h) in comparison to other forage choppers but it has the problem of frequent chocking and unbalancing. The developed machine can reduce the specific volume up to 73 per cent and weight up to 45 per cent from its initial level at 2 t/h feed rate (capacity) with 36 blades mounted on cutting cylinder and operating the system at cutting cylinder speed of 13.33 m/s and crushing roller speed of 6.66 m/s. The capacity of the developed system was found to be 2t/h and 65.7 per cent reduction in cost of transportation can be achieved with the introduction of mechanical system*." [7]

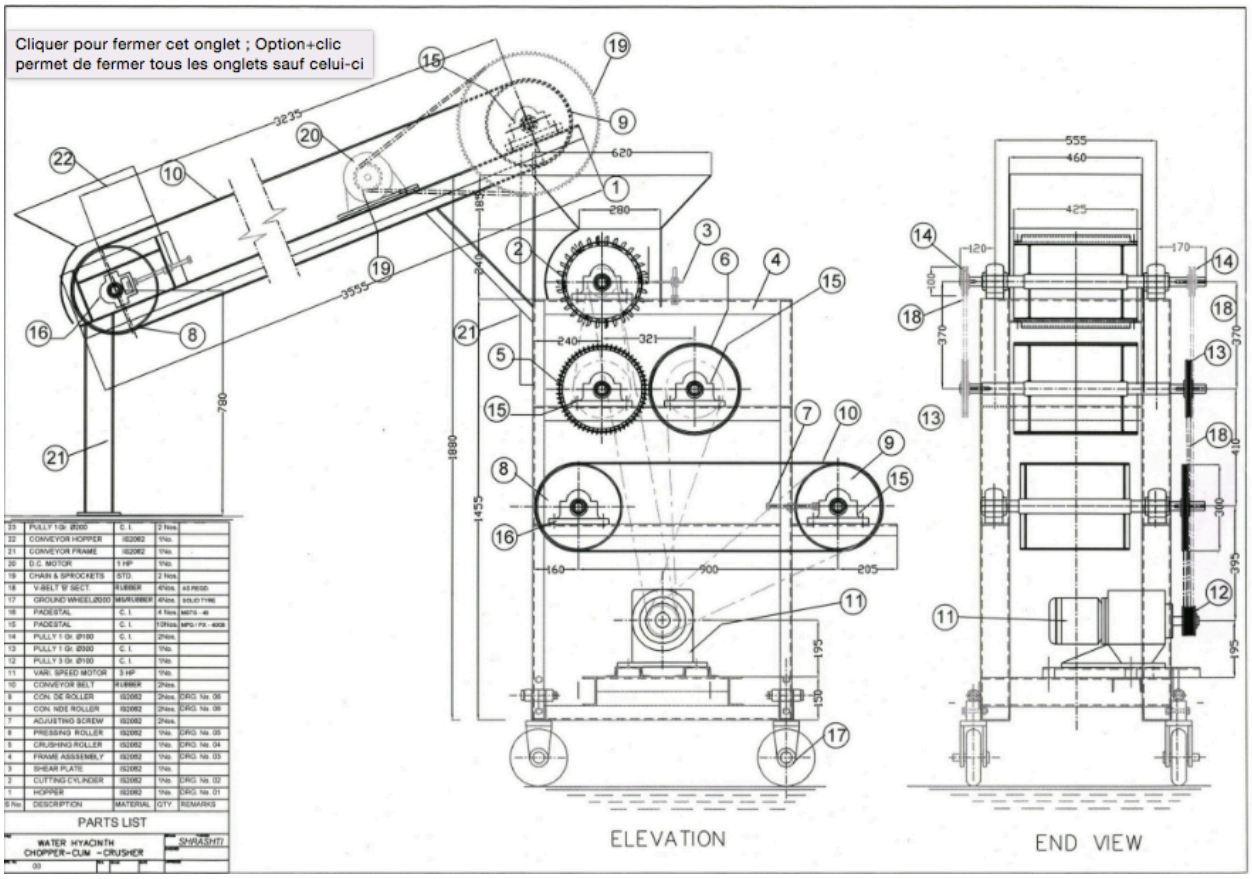

Figure 4. Constructional Details of Water Hyacinth Chopper Cum Crusher [8]

As indicated in the figure below, summarizing the evolution of the infestation on the lake, the current quantities are too massive to be handled under the three conventional mechanisms

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[7] *Water hyacinth ((Eichhornia crassipes [Mart.]solms) Chopper cum Crusher : A Solution for Lake Water Environment*, Shailendra Mohan Mathur, Journal of Energy Technologies and Policy, ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online), Vol.3, No.11, 2013 – Special Issue for International Conference on Energy, Environment and Sustainable Economy (EESE 2013)

[8] Ibid.

evoked earlier. The need for an adjusted and advanced technology and method of control and potential transformation is required.

Timeline	Zonation	Extent
September 2011	Megech River on the northern shores of the lake	-
June 2012	Lemba Arbaytu, Tana Woyna, Jarjar Abanor and Adisgie Dingie Kebeles bordering Lake Tana shore areas. The three Kebeles (Teza Amba, Kab Abo and Agid Kirehna) in Libo Kemkem Woreda were very sparsely infested.	20 000 ha
October 2012	Local communities in the bordering kebeles of Lake Tana were mobilized without any payment…t is estimated that between 90 – 95 % of the water hyacinth was basically removed from the lake through this manual removal approach (Edwards, 2013).	<2000ha
August 2014	Re-outbreak of water hyacinth in Lake Tana…	50 000 ha
May 2015	All the 18 Kebeles in the five Woredas bordering Lake Tana which were infested during the 2014 survey are also infested in the present assessment.	34 500 ha

Figure 5. Summary of Water-Hyacinth Infestation on Lake Tana[9]

There is no identified or factual explanation in the decrease noticed between August 2014 and May 2015.

[9] Wassie Anteneh, Dereje Tewabe, Addisalem Assefa, Abebaw Zeleke, Befta Tenaw and Yitayew Wassie (2015). Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.

No.	Degree of Infestation	Coverage (ha)	*Kebele*	*Woreda*
1	Thick	3162	Fikra Dangurie, Lemba, Mitsiriha Abawarka, Sheagomengie	Gondar Zuria
			Jarjar Abanor, Aberjah, Tana Woyna, Adisgie Dingie, Seraba Dablo	Dembya
2	Intermediate	2591	Adisgie Dingie, Achera, Seraba Dablo Jarjar Abanor, Aberjah, Tana Woyna	Dembyiaa
			Fikra Dangurie, Lemba, Mitsiriha Abawarka, Sheagomengie	Gondar Zuria
			Agid Kiregna, Kab Abo	Libo Kemkem
3	Scatter	28687	Fikra Dangurie, Lemba, Mitsiriha Abawarka, Sheagomengie	Gondar Zuria
			Adisgie Dingie, Achera, Seraba Dablo Jarjar Abanor, Aberjah, Tana Woyna, Mangie	Dembiaya
			Teza Amba Kab Abo Agid Kiregna	Libo Kemkem
			Nabega, Wagetera	Fogera
			Tana Mitile	Dera

Figure 6. Water Hyacinth Degree of Infestation and Associated Kebeles as Well as Woredas 2015[10]

[10] Wassie Anteneh, Dereje Tewabe, Addisalem Assefa, Abebaw Zeleke, Befta Tenaw and Yitayew Wassie (2015). Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.

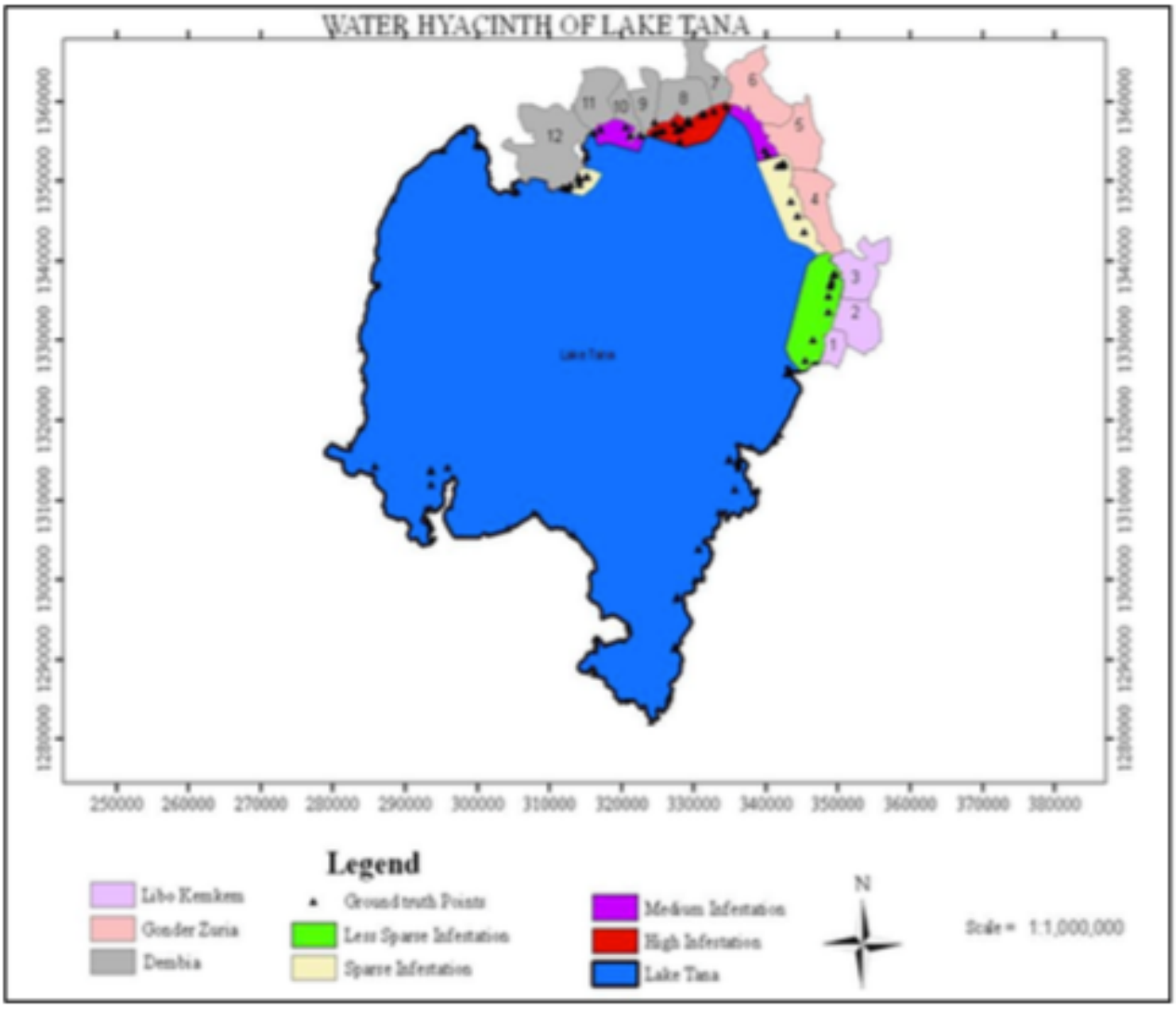
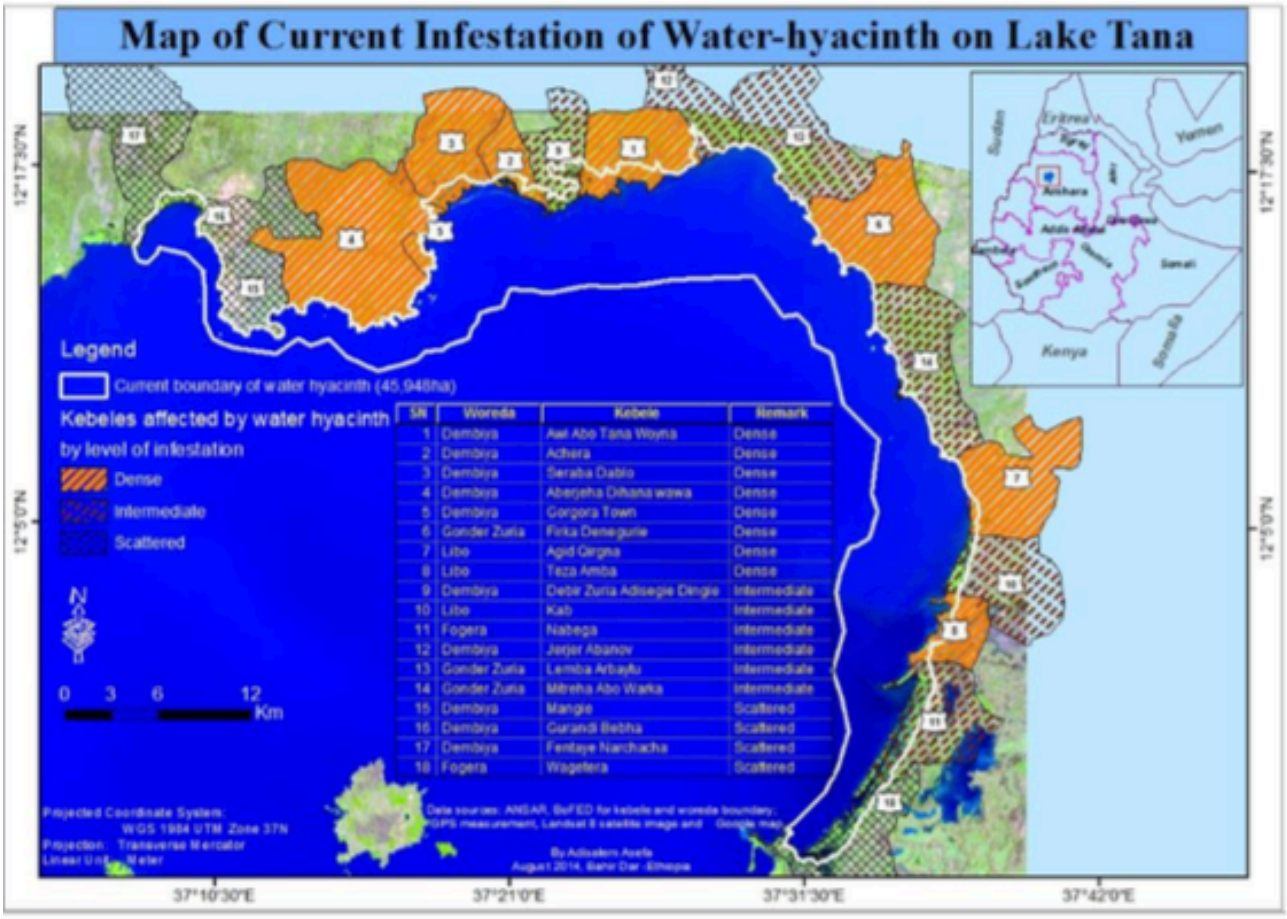


Figure 7. Map Showing Water Hyacinth Infestation During July 2012 (Source: Boeplau, 2012).[11]

[11] Wassie Anteneh, Dereje Tewabe, Addisalem Assefa, Abebaw Zeleke, Befta Tenaw and Yitayew Wassie (2015). Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.



SN	Woreda	Kebele	Remark
1	Dembiya	Awi Abo Tana Woyna	Dense
2	Dembiya	Adhera	Dense
3	Dembiya	Seraba Dablo	Dense
4	Dembiya	Aberjeha Dihsha wowa	Dense
5	Dembiya	Gorgora Town	Dense
6	Gonder Zuria	Firka Denegurie	Dense
7	Libo	Agid Gergna	Dense
8	Libo	Teza Amba	Dense
9	Dembiya	Debir Zuria Adisegie Dingie	Intermediate
10	Libo	Kab	Intermediate
11	Fogera	Nabega	Intermediate
12	Dembiya	Jerjer Abanov	Intermediate
13	Gonder Zuria	Lemba Arbaylu	Intermediate
14	Gonder Zuria	Mbreha Abo Warka	Intermediate
15	Dembiya	Mange	Scattered
16	Dembiya	Gurandi Bebha	Scattered
17	Dembiya	Fentaye Narchacha	Scattered
18	Fogera	Wogetera	Scattered

Figure 8. A Map Showing The 50 000 Ha Water Hyacinth Infestation Kebeles and Woredas During August 2014 Survey (Wassie Anteneh Et Al., 2014). [12]

[12] Wassie Anteneh, Dereje Tewabe, Addisalem Assefa, Abebaw Zeleke, Befta Tenaw and Yitayew Wassie (2015). Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.

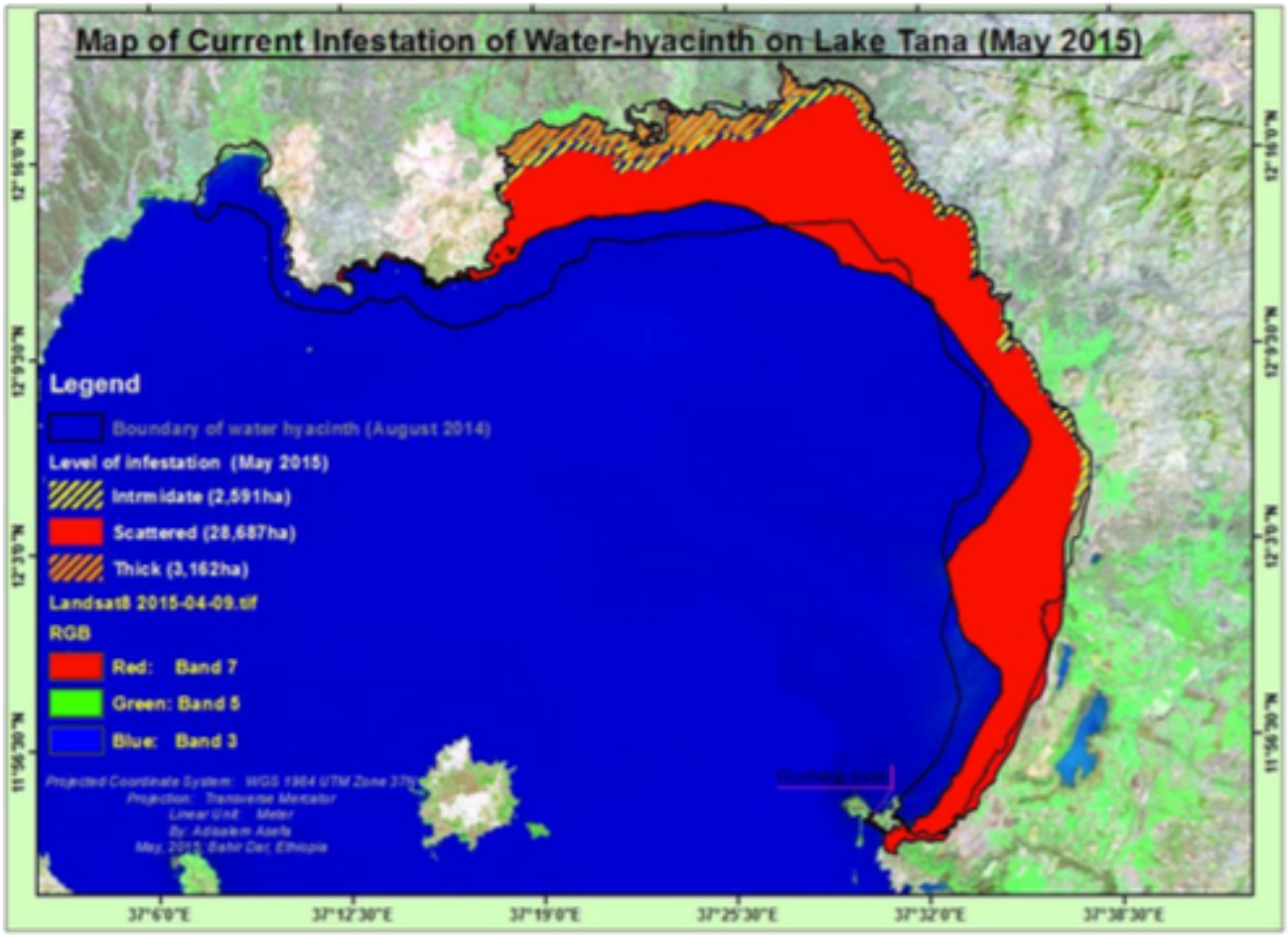


Figure 9. Water Hyacinth Infestation Current Status on the Shore of Lake Tana (May, 2015).[13]

[13] Wassie Anteneh, Dereje Tewabe, Addisalem Assefa, Abebaw Zeleke, Befta Tenaw and Yitayew Wassie (2015). Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.

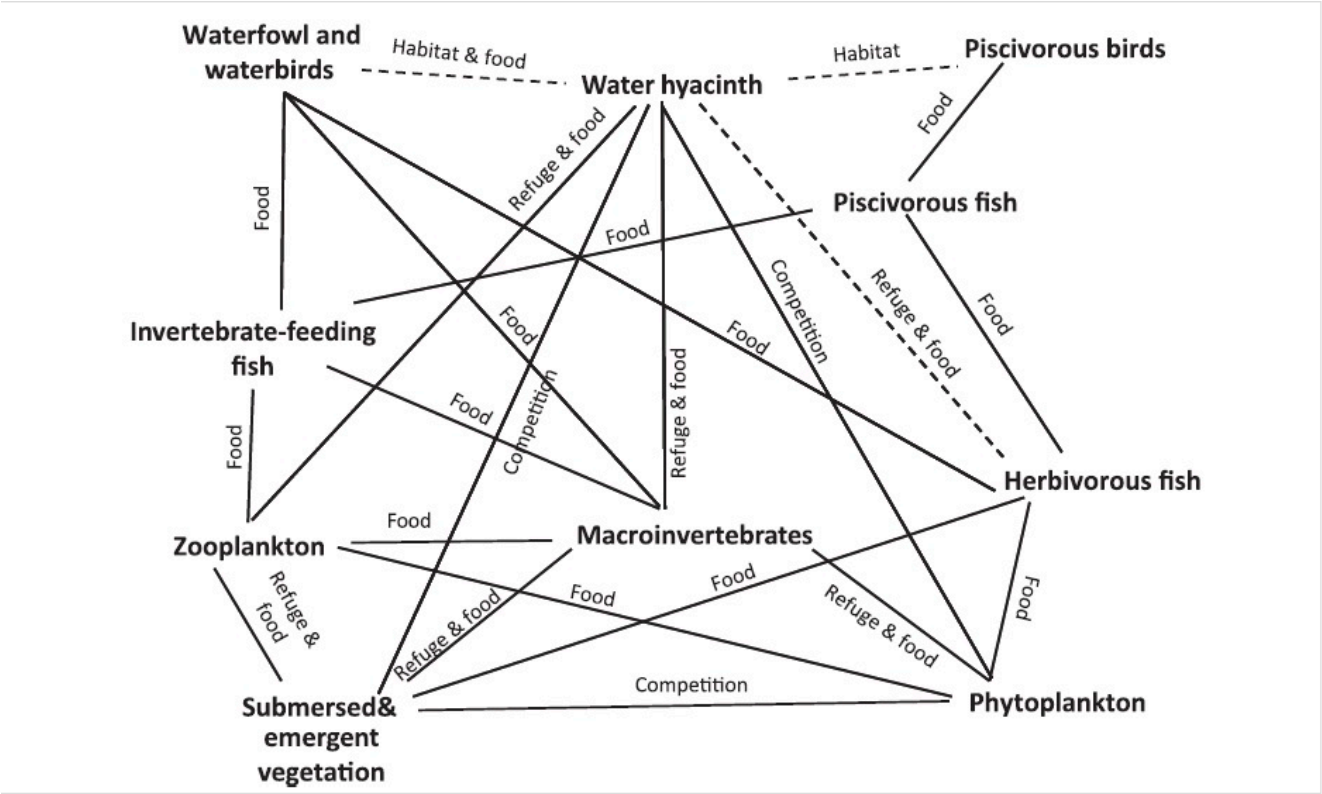


Figure 10. Interactions Between Non-Native Water Hyacinth and Ecosystem.[14]

The contamination over Lake Tana is quite recent and well documented in the "Water Hyacinth Coverage Survey Report[15]", produced by scholars from Bahir Dar University in May 2015. While being mainly portrayed as a threat and problem, water-hyacinth does contribute positively to some functions such as food and refuge for some species as mentioned in the figure above.

3.1-Water-Hyacinth at The Center of Complex Societal Systems

The Ethiopian societal analysis reveals a complex nexus between demography, water management, agriculture and energy which equilibrium is the essence of positive development, however if this relationship is disrupted or becomes conflictual then phenomena such as the recent famine will put tens of millions at risk "*According to a statement issued by the World Food Programme (WFP) on 6th February, over 10 million of the most vulnerable require urgent humanitarian assistance. This figure was published in the Joint Government and Humanitarian Partners' Document (HRD) in December last year, and does not take into account the seven and a half million people who annually receive support from Ethiopia's Productive Safety Net Programme – PSNP, (established in 2005 to enable,*

[14] Villamagna, A. M. & Murphy, B. R., 2010. Ecological and socio-economic impacts of invasive water hyacinth (Eichhornia crassipes): A review. Freshwater Biology, 55(2): 282–298.

[15] Wassie Anteneh, Dereje Tewabe, Addisalem Assefa, Abebaw Zeleke, Befta Tenaw and Yitayew Wassie (2015). Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.

"*the rural poor facing chronic food insecurity to resist shocks, create assets and become food self- sufficient), taking the total in need to almost 18 million. The worst affected areas, according to USAID, are the pastoral areas of Afar and Ogaden Region – where people rely totally on their livestock – and the agricultural lowlands of East and West Haraghe – close to the capital Addis Ababa.*[16]

The objective is to determine now how trans-sector development can be functioning while avoiding conflicts on similar environment resources.

3.2-Ethiopia's Development Equation: Demography, Water Management, Agriculture and Energy Nexus

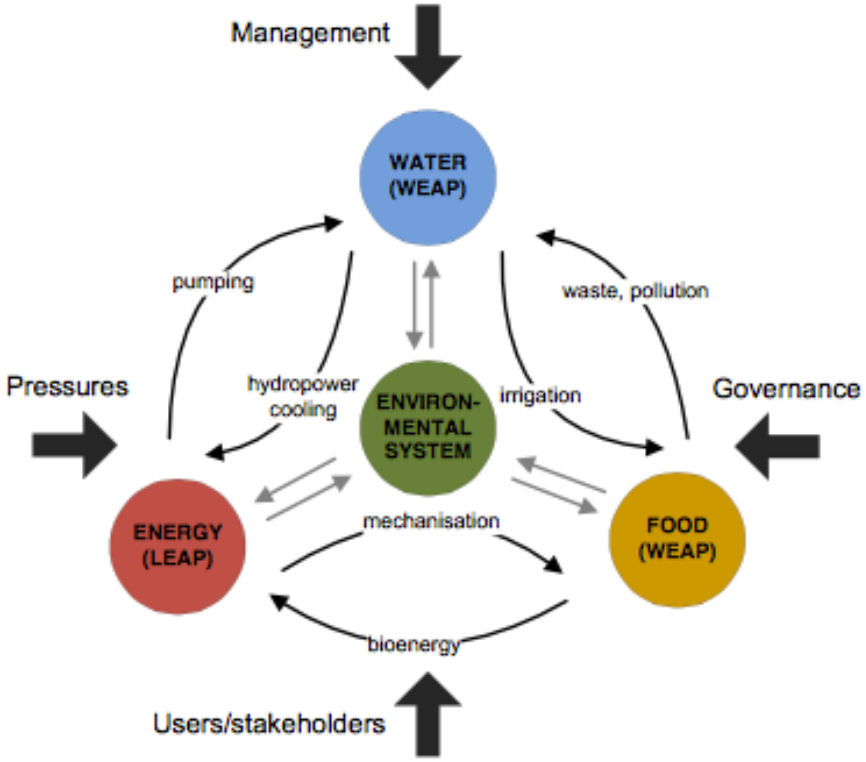


Figure 11. Illustration of Interlinkages Within and Between Sectors and The Environmental System[17]

[16] Hungry and Frightened: Famine in Ethiopia 2016- Article by Graham Peebles APRIL 29, 2016: http://www.counterpunch.org/2016/04/29/hungry-and-frightened-famine-in-ethiopia-2016/

[17] Karlberg, L; Hoff, H.; Amsalu, T.; Andersson, K.; Binnington, T.; Flores-López, F.; de Bruin, A.; Gebrehiwot, S.G.; Gedif, B.; zur Heide, F.;Johnson, O.; Osbeck, M. and Young, C. 2015. Tackling complexity: Understanding the food-energy-environment nexus in Ethiopia's Lake Tana Sub-Basin Water Alternatives 8(1): 710-734

Ethiopia's development has been articulated with the ultimate goal to become a middle-income country by 2025. In order to achieve this goal, strategic sectors such as agriculture and energy will require transformation, as both sectors will have to accommodate a great demographic intensification (Figure. 10). In a publication titled "*Tackling complexity: Understanding the food-energy-environment nexus in Ethiopia's Lake Tana Sub-Basin Water Alternatives*", Karlberg approaches the concept of inter-dependence and inter-competitiveness between water-energy and food in Lake Tana's sub-basin. As agriculture is leaning towards intensification it becomes more dependent on energy and while the energy needs are increasing, with 90% of its resources originating from biomass, the essential choice resides now on how water should be managed. A great dilemma appears between water's availability and demand, as well as between food production and crop for fuel in the face of a great environmental stress and resource shortages.

Demographic Indicators	Year		
	2012	2032	2050
Population (millions)	83.7	133.5	171.8
Working-age population (millions; % of total population)	48.3 (56%)	81.7 (61%)	117 (68%)
Dependent population (millions; % of total population)	37.4 (44%)	51.8 (39%)	54.8 (32%)

Figure 12. Projecting Ethiopian Demographics from 2012–2050[18]

Karlberg raises that *"In line with the GTP and CRGE national plans, there have been a number of recent developments in the Lake Tana Region related to intensifying and transforming agriculture and energy transitions. This includes, for example, the construction of a number of irrigation dams, which allow some farmers to plant a second and, sometimes, a third yearly crop, which allows them to increase their share of cash- crops. Following the national plans, significant growth in the use of tractors and fertilisers is expected, as agriculture is intensified (Federal Democratic Republic of Ethiopia, 2012). These trends cause additional energy demand for pumping of water, production of fertiliser, machinery use, etc. Meanwhile, the completion of the Tana Beles transfer and hydropower plant in 2010 offers some hope of an energy transition in the region, together with national plans, which predict 100% grid coverage as early as 2020. Nonetheless, grid coverage may be substantially different from grid access, and historical trends will need to change substantially in the coming years if this target is to be achieved. On the issue of energy demands for cooking, it is assumed that efficient stoves, or those which use alternative fuels, will replace conventional wood stoves in greater numbers and that animal dung which may otherwise be consumed directly for cooking, is instead redirected into digesters for the production of biogas. Bioethanol*

[18] Projecting Ethiopian Demographics from 2012–2050 Using the Spectrum Suite of Models *Brief*, Alemayhu Bekele and Yihunie Lakew Ethiopian Public Health Association, July 2014.

(primarily for export) may also be produced in the region from sugarcane, adding to competition for agricultural land and water.[19]*"*

The issue, in our case, is that agricultural development (intensification) is a reinforcing indicator, in direct relation, with the extent of water-hyacinth problematics on Lake Tana (cause of eutrophication). The list of negative impacts of such practices as well as an outstanding number of dilemmas inherent to the current policy framework (GTP and CRGE national plans), can potentially jeopardize Lake Tana's integrity as water becomes over-demanded for human consumption, irrigation and hydropower. There is also a correlation between the search of high productivity and land degradation that usually results in loss of productivity and organic matter and nutrients from the soil, and socio-economic aftermath. Figure.11 represented below, illustrates how land-use informs environmental problematics on Lake Tana.

[19]Karlberg, L; Hoff, H.; Amsalu, T.; Andersson, K.; Binnington, T.; Flores-López, F.; de Bruin, A.; Gebrehiwot, S.G.; Gedif, B.; zur Heide, F.;Johnson, O.; Osbeck, M. and Young, C. 2015. Tackling complexity:Understanding the food-energy-environment nexus in Ethiopia's Lake Tana Sub-basin Water Alternatives 8(1): 710-734

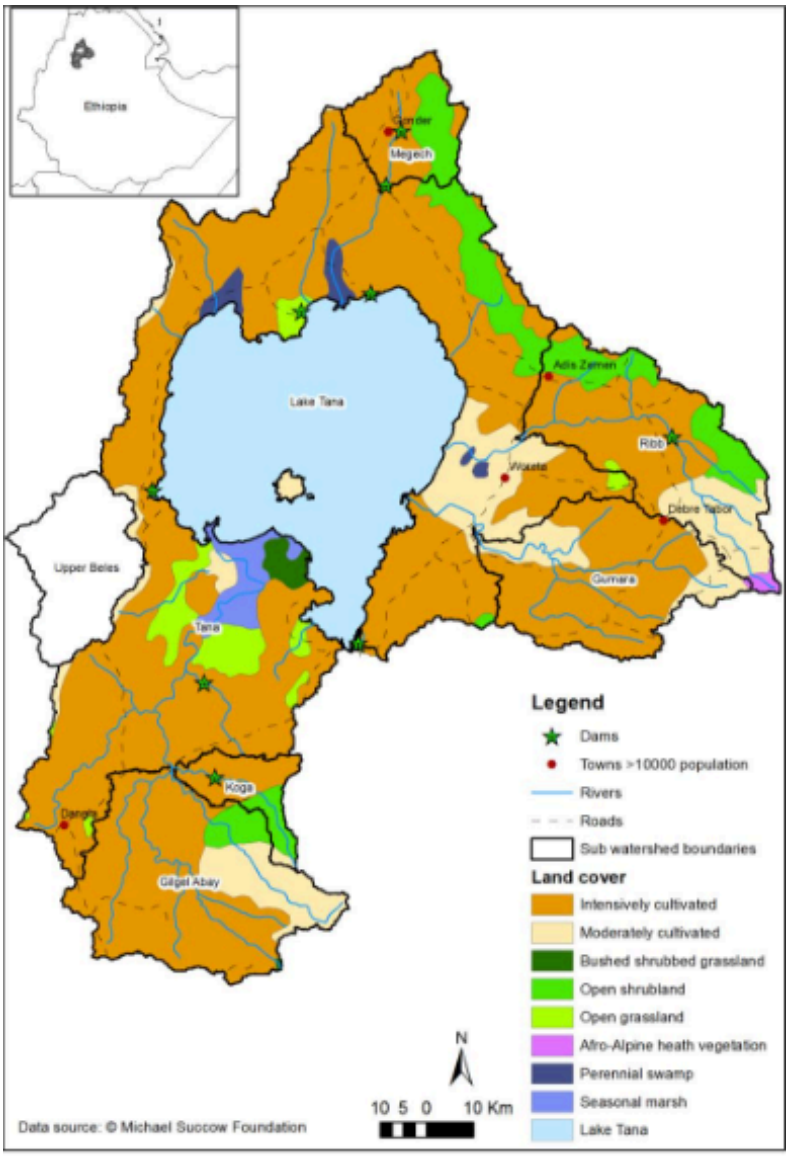


Figure 13. Land-Use Map of Lake Tana (Upper Beles) Sub-Basin[20]

It becomes then critical to estimate the contribution of water-hyacinth through its transformative products as an alternative for chemical fertilizer and dependency on biomass for energy. The production of organic agro-fertilizer will support a more sustainable agriculture in the face of climate change and need for productivity, it will also progressively diminish the introduction of land-based pollutants and nutrients to the lake and will reduce progressively (estimate of 30 to 50 years) the levels of eutrophication. On the other hand, the industrial production of bio-fuel or by-products arising from water-hyacinth could diminish the pressure on traditional biomass sources.

[20] Karlberg, L; Hoff, H.; Amsalu, T.; Andersson, K.; Binnington, T.; Flores-López, F.; de Bruin, A.; Gebrehiwot, S.G.; Gedif, B.; zur Heide, F.;Johnson, O.; Osbeck, M. and Young, C. 2015. Tackling complexity: Understanding the food-energy-environment nexus in Ethiopia's Lake Tana Sub-Basin Water Alternatives 8(1): 710-734

IV-Institutional Policies and Regulations Framework

4.1-Purpose and Objectives of the Institutional Policies and Regulations Framework

In the recent year, institutional policies and regulations have evolved in the face of the ever-growing stress on human societies, ecosystems and resources caused by non-sustainable behaviors. The Institutional Policies and Regulations Framework (IPRF) is an exhaustive collection of agendas, declarations, conventions, agreements, plans of actions, visions, principles and commitments that will ground the activity of harvesting water-hyacinth in view of producing bio-fuel and organic agro-fertilizer. As a sum of clear benchmarks, the most recent endeavors such as the Kyoto Agreement, the Addis Ababa Action Agenda (AAAA) of the third international conference on financing for development, the UN framework on sustainable development goals in transforming our world: the 2030 agenda for sustainable development (including the Sustainable Development Goals Agenda-SDGs), and the latest COP 21 Paris Agreement have proven to be sufficient to deploy a fair analysis. At the national level a qualitative analysis of land, water, energy, agriculture, economy and environment policies and regulations will be performed.

4.2-International Policies and Regulations Framework's Relevance

- The reference to the Kyoto agreement is relevant if we quantify the methane resulting from the natural degradation of water hyacinth under-water or the one resulting from removal and disposal on shore. The harvesting of water-hyacinth and its transformation into organic agro-fertilizer and bio-fuel could create a series of added products qualifying for GHG reduction.

- The reference to the UN framework on sustainable development goals in transforming our world: the 2030 agenda for sustainable development (including the Sustainable Development Goals Agenda SDGs) echoes the activities related to the potential positive impacts on the water body as well as the transformative activities at large. I will extrapolate on the activities, their quantification and potential monetarization in the Environmental and Social Impact Assessment (ESIA), as well as in the Environmental and Socio-Economic Management Framework (ESEMF).

- The contribution to the COP 21 Paris agreement concerns the agricultural and energy impact as an indirect contribution through bio-fuel, methane emission reduction and potential carbon sequestration (organic agro-fertilizer).

While the institutional framework mentioned above would be favorable in principles, without mentioning directly the use of invasive species, for which the Convention on Biological

Diversity through its *The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets* in particular are standing up to inform a rather limited approach.

DECISION ADOPTED BY THE CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY AT ITS TENTH MEETING

X/2. The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets [21]

Annex

STRATEGIC PLAN FOR BIODIVERSITY 2011-2020 AND THE AICHI BIODIVERSITY TARGETS

"Living in harmony with nature"

The purpose of the Strategic Plan for Biodiversity 2011-2020 is to promote effective implementation of the Convention through a strategic approach, comprising a shared vision, a mission, and strategic goals and targets ("the Aichi Biodiversity Targets"), that will inspire broad-based action by all Parties and stakeholders. The Strategic Plan will also provide a flexible framework for the establishment of national and regional targets and for enhancing coherence in the implementation of the provisions of the Convention and the decisions of the Conference of the Parties, including the programmes of work and the Global Strategy for Plant Conservation as well as the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of the Benefits Arising from their Utilization. It will also serve as the basis for the development of communication tools capable of attracting the attention of and engaging stakeholders, thereby facilitating the mainstreaming of biodiversity into broader national and global agendas. A separate Strategic Plan has been adopted for the Biosafety Protocol that will complement the present one for the Convention…

I. THE RATIONALE FOR THE PLAN

1.Biological diversity underpins ecosystem functioning and the provision of ecosystem services essential for human well-being. It provides for food security, human health, the provision of clean air and water; it contributes to local livelihoods, and economic development, and is essential for the achievement of the Sustainable Development Goals, including 1, 2, 3, 6, 7, 8, 11, 13, 14, and 15.

1. The Convention on Biological Diversity has three objectives: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of benefits arising out of the utilization of genetic resources. In the Convention's first Strategic Plan, adopted in 2002, the Parties committed themselves "to a more effective and coherent implementation of the three objectives of the Convention, to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all

[21] CONVENTION ON BIOLOGICAL DIVERSITY COP10: https://www.cbd.int/decision/cop/?id=12268

life on Earth." The third edition of the Global Biodiversity Outlook (GBO-3), drawing upon national reports, indicators and research studies, assesses progress towards the 2010 target, and provides scenarios for the future of biodiversity.

The 2010 biodiversity target has inspired action at many levels. However, such actions have not been on a scale sufficient to address the pressures on biodiversity. Moreover, there has been insufficient integration of biodiversity issues into broader policies, strategies, programmes and actions, and therefore the underlying drivers of biodiversity loss have not been significantly reduced. While there is now some understanding of the linkages between biodiversity, ecosystem services and human well-being, the value of biodiversity is still not reflected in broader policies and incentive structures…

2. Achieving this positive outcome requires actions at multiple entry points, which are reflected in the goals of this Strategic Plan. These include:

(a) *Initiating action to address the underlying causes of biodiversity loss*, including production and consumption patterns, by ensuring that biodiversity concerns are mainstreamed throughout government and society, through communication, education and awareness, appropriate incentive measures, and institutional change;

(b) *Taking action now to decrease the direct pressures on biodiversity*. Engagement of the agricultural, forest, fisheries, tourism, energy and other sectors will be essential to success. Where trade-offs between biodiversity protection and other social objectives exist, they can often be minimized by using approaches such as spatial planning and efficiency measures. Where multiple pressures are threatening vital ecosystems and their services, urgent action is needed to decrease those pressures most amenable to short-term relief, such as over-exploitation or pollution, so as to prevent more intractable pressures, in particular climate change, from pushing the system "over the edge" to a degraded state;

(c) *Continuing direct action to safeguard and, where necessary, restore biodiversity and ecosystem services*. While longer-term actions to reduce the underlying causes of biodiversity are taking effect, immediate action can help conserve biodiversity, including in critical ecosystems, by means of protected areas, habitat restoration, species-recovery programmes and other targeted conservation interventions;

(d) *Efforts to ensure the continued provision of ecosystem services and to ensure access to these services, especially for the poor who most directly depend on them*. Maintenance and restoration of ecosystems generally provide cost-effective ways to address climate change. Therefore, although climate change is an additional major threat to biodiversity, addressing this threat opens up a number of opportunities for biodiversity conservation and sustainable use;

(e) *Enhanced support mechanisms for: capacity-building; the generation, use and sharing of knowledge; and access to the necessary financial and other resources*. National planning processes need to become more effective in mainstreaming biodiversity and in highlighting its relevance for social and economic agendas. Convention bodies need to become more effective in reviewing implementation and providing support and guidance to Parties…

IV. STRATEGIC GOALS AND THE AICHI BIODIVERSITY TARGETS

3. The Strategic Plan includes 20 headline targets for 2015 or 2020 (the "Aichi Biodiversity Targets"), organized under five strategic goals. The goals and targets comprise both: (i) aspirations for achievement at the global level; and (ii) a flexible framework for the establishment of national or regional targets. Parties are invited to set their own targets within this flexible framework, taking into account national needs and priorities, while also bearing in mind national contributions to the achievement of the global targets. Not all countries necessarily need to develop a national target for each and every global target. For some countries, the global threshold set through certain targets may already have been achieved. Others targets may not be relevant in the country context.

Strategic goal A. Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

Target 1: By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.

Target 2: By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.

Target 3: By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio-economic conditions.

Target 4: By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

Strategic goal B. Reduce the direct pressures on biodiversity and promote sustainable use

Target 5: By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

Target 6: By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

Target 7: By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.

Target 8: By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.

Target 9: By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage

pathways to prevent their introduction and establishment.

Target 10: By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

Strategic goal C: Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

Target 11: By 2020, at least 17 per cent of terrestrial and inland water areas, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Target 12: By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

Target 13: By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.

Strategic goal D: Enhance the benefits to all from biodiversity and ecosystem services

Target 14: By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

Target 15: By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

Target 16: By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.

Strategic goal E. Enhance implementation through participatory planning, knowledge management and capacity building

Target 17: By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.

Target 18: By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous

and local communities, at all relevant levels.

Target 19: By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.

Target 20: By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

While the Convention on Biological Diversity through *The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets* evokes invasive species in its Target 9 "**Target 9: By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.**[22]" This statement implies two main challenges for Lake Tana, first, by 2020 we might reach a point of non-return concerning the management of the plant and second, the option of transforming the plant does not appear. It becomes then necessary to look at the Ethiopian National Policies and Regulations Framework to determine if it could be favorable to consider such endeavor.

4.4-Ethiopian National Policies and Regulations Framework

Concerning the study of the Ethiopian National Policies and Regulations Framework I intend to focus my analysis on two major text, the Second Growth and Transformation Plan (GTP II) (2015/16-2019/20) also known as GTP as well as the Ethiopia's Climate-Resilient Green Economy Strategy also known as CRGE.

4.5-The Second Growth and Transformation Plan (GTP II.) (2015/16-2019/20)

The GTP is a policy document compiled in September 2015 by the National Planning Commission and aims at establishing the strategies for growth and transformation of the Ethiopian economy. I intend to screen parts related to land, water, energy, agriculture, economy and environment.

The Second Growth and Transformation Plan (GTP II) (2015/16-2019/20)[23]

[22] CONVENTION ON BIOLOGICAL DIVERSITY COP10: https://www.cbd.int/decision/cop/?id=12268

[23] The Second Growth and Transformation Plan (GTP II) (2015/16-2019/20: https://www.africaintelligence.com/c/dc/LOI/1415/GTP-II.pdf

1.1 Objectives and basic strategies of GTP II

1.1.1 The main basis for the Growth and Transformation Plan (GTP II)

*The country's vision, the achievements of PASDEP (*Plan for Accelerated and Sustained Development to End Poverty*), and the lessons drawn from its implementation, were the basis for formulation of the next five-year (2010/11 – 2014/15) Growth and Transformation Plan (GTP). Factors which constrained growth and external shocks were taken into account in the formulation of the GTP.*

1.1.2 The main objectives of the first Growth and Transformation Plan (GTP I)

1) Maintain at least an average real GDP growth rate of 11.2 % and attain MDGs.

2) Expand and ensure the qualities of education and health services and achieve MDGs in the social sector.

3) Establish suitable conditions for sustainable nation building through the creation of a stable democratic and developmental state; and

4) Ensure the sustainability of growth by realizing all the above objectives within a stable macroeconomic framework.

1.1.3 Strategic Pillars of the first Growth and Transformation Plan (GTP I)

1. *Sustaining rapid and equitable economic growth,*
2. *Maintaining agriculture as major source of economic growth,*
3. *Creating conditions for the industry to play key role in the economy,*
4. *Enhancing expansion and quality of infrastructure development.*
5. *Enhancing expansion and quality of social development.*
6. *Building capacity and deepen good governance, and*
7. *Promote gender and youth empowerment and equity…*

1.3 Performances of Major Sectors

1.3.1 Agriculture and Rural Development

Major efforts were made to ensure adequate agricultural input supply and strengthen agricultural extension services, to increase agricultural productivity and commercialization. As a result, agriculture continued to be source of growth and poverty reduction. Agricultural value added registered an annual average growth rate of 6.6% during the first four years of GTP period. This is lower than the average growth target for the GTP period. This growth performance would not be far from the target pending the estimate forthcoming for the final year of the GTP (2014/15) …

Natural Resources Management: *significant achievements have been registered through natural resource conservation and management activities undertaken throughout*

the country. During the GTP period major activities have been carried out in water-shed management, soil and water. Conservation works through productive and organized social mobilization. Forestry development, protection and utilization was also implemented with increased effectiveness by active engagement of communities across the county. Ethiopia's Green Economy Strategy has inspired and mobilized the nation….

Food security, Disaster Prevention and Preparedness:- Ensuring food security was one of the preventing element during the first GTP especially through implementation of productive safety net program. It was planned to prepare risk assessment profiles for 697 Woredas. Risk assessment profiles were prepared for 351 Woredas to reduce the incidences of natural and man-made disasters. With regard to food security, 7.7 million chronically food insecure citizens benefited from the Productive Safety Net Program (PSNP). Furthermore, it was planned to benefit food insecure households through the provision of family level credit package, which enabled them create assets. Graduation from the program has been short of expectation. (p.8)

1.4 Performances of Economic Infrastructure 1.4.1 Energy

Ethiopia's investment in infrastructure is quite significant. This is clearly seen in the energy sector. Big investment projects have been initiated to meet the growing demand and support the on-going efforts to build rapid and sustainable development in Ethiopia. The Great Renaissance Hydro Electric Power Project (with 6,000 MW), Gilgel-gibe III (1,870 MW) and Genale-Dawa III (254 MW) and other Wind Power Projects (Adama and Ashegoda), were the distinctive features of the first Growth and Transformation Plan. They are all well in progress and the wind power projects such as Ashegoda, Adama No. I and II have already started generating electricity. Generally, the initiated projects, when completed, are expected to transform the energy sector of Ethiopia.

It is not enough to increase generation capacity. Complementary investment in sub-stations, power transmission and distribution is also required to carry power to users. Accordingly, many projects have been initiated and are under construction including 400 and 500 KV lines. Overall, electricity service coverage at national level has increased from 41% in 2009/10 to 54% in 2013/14, during the first four years of GTP implementation period.

1.5 Strategic Pillars of GTP II

In order to achieve the objectives of GTP II set out above the following pillar strategies will be pursued:

a) Sustaining the rapid, broad based and equitable economic growth and development witnessed during the last decade including GTP I;

b) Increase productive capacity and efficiency to reach the economy's productive possibility frontier through rapidly improving quality, productivity and competitiveness of productive sectors (agriculture and manufacturing industries);

c) Enhance the transformation of the domestic private sector to enable them become

capable development force;

d) Build the capacity of the domestic construction industry, bridge critical infrastructure gaps with particular focus on ensuring quality provision of infrastructure services;

e) Proactively manage the on-going rapid urbanization to unlock its potential for sustained rapid growth and structural transformation of the economy;

f) Accelerate human development and technological capacity building and ensure its sustainability;

g) Continue to build democratic and developmental good governance through enhancing implementation capacity of public institution and actively engaging the citizens;

h) Promote women and youth empowerment, ensure their effective participation in the development and democratization process and enable them equitably benefit from the outcomes of development;

1. *Building climate resilient green economy;*

1.3.1 Maintaining rapid, sustainable and equitable economic growth and development

During the Second Growth and Transformation Plan, concerted and coordinated effort will be made to ensure the rapid, sustainable and equitable economic growth that translates into creating decent job opportunities accompanied by significant poverty reduction; and structural transformation. Sustaining the broad based economic growth, maintaining agriculture as a major source of growth, accelerating industrial development, and promoting the service sector to play its role to enhance growth will also be pursued by creating decent jobs, enhancing productivity, quality, and competitiveness to realize the bases of structural economic transformation. To this effect, coordinated and strong forward and backward production linkages will be strengthened to ensure rapid, inclusive, resilient and sustainable economic growth during GTP II.

1.3.4 Expand the accessibility and ensure the quality of infrastructure development through strengthening the implementation capacity of the construction sector.

In the Second Growth and Transformation Plan period, lessons learned, and experience gained during the first Growth and Transformation Plan implementation periods will be carried forward to develop and sustain reliable and affordable infrastructure development. Enhancing investment in the sector and pursuing import substitution strategy that reduce the pressure on foreign exchange demand as well as offer opportunity for technology learning and job creation. Private sectors investment in infrastructure development will be promoted through providing the necessary incentives and support to enhance the private sector participation in allowed investment areas. The Post-2015 global and regional development goals related to infrastructure development will be mainstreamed and

implemented aligned with prioritized national development agenda.

In general, expansion of infrastructure development such as road, railway, dry port, air transport, energy, telecommunication, water and irrigation schemes which resulted in attracting investment, creating market opportunities, enhance competitiveness and boost regional economic integration will have a special consideration in in GTP II.

1.3.9 Building climate resilient green economy

During the Second Growth and Transformation Plan, the Government is committed to building climate resilient Green Economy. Thus, Ethiopia will focus on adaptation to climate change and mitigation of greenhouse gases emissions, reducing greenhouse gas emission through enhancing productivity of the crop and livestock sub-sectors that improve food security and income of farmers and pastoralists, protecting and rehabilitation of forests for their economic and ecosystem services. Expanding electricity power generation from renewable sources of energy for domestic & regional markets, leap frogging to modern and energy efficient technologies in transport, industry and buildings strategies will be a major agenda to build climate resilient green economy. The post -2015 sustainable development goals related to green economy will be integrated and implemented aligned with the sectors' climate resilient green economy development strategy.

Major Objectives : The major objectives of the sectors are to expand sustainable potable water supply and improved sewerage systems; to improve potable water supply services and expand accessibility; to establish and improve urban sewerage systems; to assess the quantity and quality of the country's water resources and their contribution to the development of the economy; to mitigate flood and runoff impacts; to develop and expand medium & large scale irrigation; to develop and expand efficient, sustainable irrigation farming; to conduct medium and large scale irrigation study and design activities and make them ready for relevant stakeholders and to supply reliable and sustainable meteorological data to the general public and national preparedness.

Comments: The Second Growth and Transformation Plan (GTP II) (2015/16-2019/20) is a well- informed document that does not necessarily touch Lake Tana's environmental problematics directly, however, it approaches the strategic importance of water management. The document shows a great sense of planning. Nevertheless, it does let the door open for the analysis of sustainable development through "The Climate Resilient Green Economy Development Strategy."

4.6-Ethiopia's Climate-Resilient Green Economy Green Economy Strategy (CRGE)

Ethiopia's Climate-Resilient Green Economy Strategy is a document that articulates the need to protect the country from the adverse effects of climate change and to build a green economy that will help realize its ambition of reaching middle- income status before 2025. Active since 2011, the production of a strategy document has been steered under the leadership of the Prime Minister's Office, the Environmental Protection Authority, and the Ethiopian Development Research Institute.

Ethiopia's Climate-Resilient Green Economy Strategy[24]
The CRGE effort has estimated that its selected initiatives would reach up to two- thirds of the whole economy (by 2030) and move them onto a more sustainable pathway (Figure 11 – Illustration of Interlinkages Within and Between Sectors and The Environmental System.) Some of the initiatives also support the creation and growth of new business opportunities, e.g., the local production of efficient stoves. The initiatives have the highest reach within agriculture by creating a green agricultural sector that generates increased output originating from higher yields rather than from an expansion of agricultural land or the cattle population. As initiatives have been identified for most of the industrial sub-sectors, a high share of these sub- sectors is also likely to be positively affected by the green economy. In addition, a smaller part of the service sector will also be reached by the green economy through initiatives identified in transportation and buildings. *Adopting a green economy development path would have benefits for the population, the environment, and the economy: it would improve public health through better air and water quality and accelerate rural development by increasing soil fertility, food security, and rural employment. Households would benefit from higher energy efficiency – especially from more efficient cooking/baking and transport – with savings worth up to 10% of household income (particularly in rural areas). This would lead to an increase in domestic savings and hence result in an enhanced investment capacity.* *From a macroeconomic perspective, green economy initiatives would also improve the balance of payments by reducing dependency on imports of goods, e.g., fossil fuels, and create a more secure power supply, an essential prerequisite for sustainable economic development. This effect alone could improve the balance of payments by several billion USD (in 2030). The low-carbon supply of goods and services (e.g., manufactured goods, power) can easily be marketed as a major competitive advantage for Ethiopia's exports. Moreover, the decision to commit to sustainable economic development opens the door to different sources of international environmental funding, such as "Fast Start" funding, CDMs, and voluntary markets, that could complement the funds earmarked for development.* *The agriculture sector has a total abatement potential for soil- and livestock- related emissions of 90 Mt CO_2e, representing around 35% of the total domestic abatement*

[24] Ethiopia's Climate-Resilient Green Economy / Green Economy Strategy (CRGE)

potential.

Soil. Considering soil amelioration techniques, the introduction of lower-emitting techniques, such as conservation agriculture (including applying zero or minimum tillage), watershed management, and nutrient and crop management, could reduce emissions by 40 Mt CO_2e in 2030. The introduction and enhancement of these lower- emitting techniques will form a priority for the soil sector in the coming years and the initiative will target 75% of rural households by 2030. Moreover, through agricultural intensification and capture of new agricultural land in arid areas through irrigation, techniques from crop production help to increase the abatement potential from saved forests. In fact, these initiatives increase the sequestration from forests by 38 MT CO_2e in 2030.

ABATEMENT LEVERS – POTENTIAL AND COST CURVE

In total, the Soil STC (did we explain STC?) identified an abatement potential in 2030 of 40 Mt CO_2e of soil-based emissions and 38 Mt CO_2e through agriculture abatement levers that reduce deforestation, thereby achieving a combined abatement potential of 78 Mt CO_2e). The abatement potential of the crops-related initiatives that reduce emissions through deforestation is accounted for in the Forestry STC. The four soil sector initiatives can be grouped into three categories:

Enhancing of lower-emitting techniques for agriculture: By speeding up the introduction of low-emission techniques and sustainable land management practices, emissions would be reduced while maintaining production levels. These techniques include agronomic best soil practices to increase carbon storage, optimal nutrient management to improve nitrogen use efficiency, effective tillage and residue management practices, terracing and other water- harvesting techniques, and agro-forestry practices to prevent soil erosion and degradation. Within this lever, massive community-based soil conservation activities on watershed development and natural resources management through different interventions are highly important. The adoption of lower- emitting techniques has an abatement potential of 40 Mt CO_2e.

Enhancing of yield-increasing techniques for agriculture: This initiative would promote and introduce best practices aimed at increasing agricultural yield and value per ton, thereby reducing the need for new agricultural land created from forest areas. Ethiopia's farmers could dramatically increase crop yields by using improved seeds (new varieties and higher quality) and basic, low-cost irrigation systems, increasing the use of fertiliser and manure, and adopting agronomic best practices (e.g., harvest and post-harvest management). The adoption of yield improving techniques has an abatement potential of 27.2 Mt CO_2e in 2030 through reduced deforestation, which has been accounted for by the Forestry STC.

Creation of new agricultural land in arid areas through irrigation: Through the use of small, medium, and large-scale irrigation schemes, new agricultural land could be generated from un-cultivated non-forest areas, thereby reducing emissions from the expansion of total cropland. The creation of new agricultural land in arid areas through irrigation has an abatement potential of 10.6 Mt CO_2e in 2030, which is also accounted for by the Forestry

STC.

Soil lever 1– Enhance lower-emitting techniques for agriculture *Emissions from crops are set to grow rapidly over the next 20 years due to carbon- intensive crop residue and tillage management practices, and the increasing usage of manure and synthetic fertiliser. The introduction of lower-emitting techniques for agriculture offers an opportunity to check this increase while maintaining production levels. This initiative includes improved agronomic practices that increase soil carbon storage, nutrient management to more efficiently use carbon/nitrogen, improved tillage and soil management, integrated systems (mixed crop-livestock- agriforest), and water management (irrigation, terracing, and other water-harvesting techniques). This programme would build on the existing government plans to strengthen the agriculture extension system.*

Soil nutrient and crop management. Improved agronomic practices can lead to increased soil carbon storage. Examples of such practices include: using improved crop varieties responsive to optimum external inputs (fertilizers and pesticides); sowing forage legumes in growing cereal crops; adopting cropping systems with reduced reliance on external inputs such as green manuring of legume crops, double cropping of cereals, and use of beneficial microorganisms and earthworms in compost making. Nitrogen management should also be considered. Nitrogen causes significant leaching and emissions. Employing techniques that could maximize the efficient use of nitrogen on crops reduces N_2O emissions. Examples of such practices include adjusting application rates to crop needs and soil test-based nitrogen application; applying nitrogen at times when loss is minimal; splitting application rates between crop establishment and critical vegetative growth periods and manipulating soil chemical properties (such as liming) to release immobilised nutrients by raising soil pH to a neutral range.

Tillage/residue management. Soil disturbance tends to hasten decomposition and erosion whereas reduced tillage results in soil carbon gain and reduction of CO_2 emissions. To achieve the latter effect, conservation agriculture will be promoted, including the use of zero and minimum tillage through the application of non-selective herbicides. The level of organic matter in the soil depends on the inputs from plant growth by reducing the losses due to erosion, harvesting, and microbial respiration. Even though returning crop residues into the soil is one of the main emissions drivers, reintroduction of an increased amount can maintain or enhance soil quality and productivity through favourable effects on soil properties and life- supporting processes. While emissions result from the practice, reintroduction of crop residues increases the carbon stock of soil and, on balance, causes a reduction of greenhouse gases into the atmosphere as compared with other uses of crop residues. For example, avoiding burning and over-exploitation as animal feed may help reduce organic matter loss in soils under cultivation.

Watershed-based integrated farming systems. Combining the production of livestock and food crops on land that also grows trees for timber, firewood, or other tree products would increase the standing stock of carbon above ground relative to equivalent land use without

trees. Examples of practices of this type include shelterbelts, introduction of high-value tree crops such as fruit trees, agrisilvo pasture practices like growing fodder trees within crop fields as source of livestock feeds, live fences, and multi-story crop production.

Water management: This category includes the promotion of terracing, particularly in hilly regions with high soil erosion hazards, and the improvement of water harvesting and irrigation structures, such as providing supplementary irrigation by focusing on increased water use efficiency, which can enhance carbon storage in soils through enhanced yields and residue returns. The lower-emitting techniques programme proposed by the STC would target 75% of farmers, reaching over 13 million households by 2030 through the government extension system. Through a combination of lower-emitting techniques tailored to local soil conditions, weather, and crop-livestock mixes (i.e., different practices in the highlands than in the lowlands), this initiative would lower emissions per hectare by an average of 3 tons of CO_2e per year and have an abatement potential of 40 Mt CO_2e in 2030. The estimate of the abatement potential of this initiative is based on the UNIQUE 2010 study 'Carbon Finance Opportunities in Ethiopia's Agricultural Sector'...

Soil lever 2 – Enhance yield-increasing techniques for agriculture There is significant potential to increase agricultural productivity. By boosting yield per hectare and value per ton of crops, it is possible to achieve the crop GDP target of 9.5% per year without rapid expansion of the total land under cultivation. Through this initiative, it would be possible to achieve an annual yield growth rate of 3.5% (as opposed to 2% in the BAU) and a value growth rate of 4% (as opposed to 3.3% with BAU), thereby reducing the need for expansion of crop- land to 1.7% per year (compared to 3.9% under BAU). These numbers are based on averages for lowland and highland areas. The Soil STC estimated yield and value growth rates under a yield-increasing programme using historical trends for yield (CSA data) and value (Dorosh and Ahmed cereal price index). This initiative would reduce the need for new cropland from 14.3 million additional hectares under the BAU scenario to only 5.1 million additional hectares by 2030. The proposed yield-increasing techniques include:

Improved seeds. Introduction of tissue culture, new varieties and high- quality seeds to lower the incidence of pests and diseases and increase yield

Irrigation. Introduction of basic/low-cost irrigation systems to allow continuity of production, especially in the dry season, reduce variability of output, and enable a shift to higher-value crops

Organic and inorganic fertiliser. Increase usage of slow-release fertilisers and manure, thereby replenishing soil nutrients to ensure sustainable soil fertility

Best agronomic practices. Introduction of planting, harvest, and post-harvest management best practices to lower the incidence of pests and disease, improve quality, and decrease spoilage. The yield-increasing techniques programme proposed by the STC would target 75% of farmers, reaching over 13 million households by 2030. The programme would build on the existing government plans to strengthen the agriculture extension system. This initiative would lower emissions by reducing the need for new agricultural land by 9.1

million hectares. Given an average carbon sequestration rate per hectare preserved of 53.5 tons of CO_2e, this initiative has an abatement potential of 27.2 Mt CO_2e in 2030. This calculation is a conservative estimate of the abatement potential as it does not count the reduction in soil-based emissions from crop growing that would have occurred on land cultivated in the BAU scenario but not in the scenario where this lever is implemented.

The abatement cost calculations for a programme introducing yield-increasing techniques are based on the following assumptions:

Programme implementation in combination with a programme promoting lower-emitting techniques (see Soil Lever 1) through the Ministry of Agriculture extension service

Household expenses totalling USD 233 per hectare to bring land into the programme, followed by USD 90 per hectare annually for running costs.

Supporting investments including:

Seed production: six facilities costing USD 2,200,000 each to set up

Fertiliser manufacturing plants: two facilities costing USD 100 million each to set up

Irrigation equipment production plants (pumps, agriculture equipment, etc.): seven facilities costing USD 44.7 million each to set up

Herbicide/pesticide/fungicide formulation plants: two plants costing USD 5 million each to set up

Tissue culture labs: 42 labs costing USD 3 million each to set up.

Soil lever 3-4 – Creation of new agricultural land in arid areas through irrigation (small scale and large scale) *These two initiatives reduce emissions by creating new agricultural land out of uncultivated non-forest arid areas, thereby reducing the need for deforestation and avoiding the associated emissions. The STC estimates that a total area of 1.7 million hectares of new agricultural land could be created through small- and large-scale irrigation projects in arid areas based on estimates of total irrigable land from the Bekele 2009 Irrigation Report and a feasibly factor for irrigation projects of 64% based on the historic performance of irrigation projects. Irrigation increases output from the land and avoids deforestation, both of which constitute economic benefits. The main sources used by the STC include surface irrigation potential estimates from Bekele 2009 Irrigation Report, expert interviews, and statistics from MoWE, MoARD, and IWMI.*

Given an average carbon sequestration rate per hectare preserved of 53.5 tons of CO_2e, the abatement potential in 2030 is 2 Mt CO_2e for small-scale irrigation and 9 Mt CO_2e for large-scale irrigation.

Transport levers 4-5 – Biodiesel and ethanol in fuel mixtures *Incorporating 5% biodiesel into the national diesel fuel mixture has an abatement potential of 0.7 Mt*

CO_2e in 2030. Increasing the ethanol content of the gasoline from 10% in the Addis Ababa fuel mix to 15% nationally – the maximum feasible ethanol mix that does not require mechanical alteration to vehicles – has an abatement potential of 0.2 Mt CO_2e in 2030. These initiatives would require about 486,000 hectares of arable land to support bio-diesel and 25,000 hectares of arable land for ethanol. However, the government plan is to produce biofuels entirely from crops on marginal land and by-products/residue of crop processing. Increasing the ethanol mix to 85% is technically feasible but was rejected in this case due to the high level of infrastructure investments needed in the fleet, storage, and pumping facilities. The abatement potential of these levers was estimated using the following calculations:

Fuel consumption projections. The amount of fossil fuel that would be substituted by biodiesel and ethanol was based on the STC's demand forecast for passenger-km and freight-km, and on the Ministry of Water and Energy's bio- fuel production forecasts. Imports of diesel are expected to increase from 1.1 billion litres in 2010 to 11.1 billion litres in 2030, while gasoline imports are expected to increase from 0.3 billion litres in 2010 to 1.2 in 2030. Due to the lower caloric value of ethanol, increasing the ethanol content of the fuel blend to 15% was assumed to lower vehicle fuel efficiency by 10%.

Biofuel production. In accordance with the Ethiopian Biofuel Development and Utilisation Strategy, ethanol would be produced from sugarcane, and bio- diesel primarily from jatropha as well as from castor oil and palm oil. Implementing 5% biodiesel and 15% ethanol blends would substitute for 0.28 billion litres of diesel and 0.09 billion litres of gasoline in 2030.

Emissions from fuel. The following fuel emissions factors were used:

– Diesel: 2.67 kg CO_2e/litre.

– Gasoline: 2.42 kg CO_2e/litre.

Fleet modification. The STC assumed that all vehicles in the existing stock could be used with the new fuel mixtures (5% biodiesel and 15% ethanol) without a need for user-initiated vehicle modification. The abatement cost of biodiesel and ethanol blends is calculated to be around USD 0 per USD/t CO_2e and –USD 0 per USD/t CO_2e respectively. These abatement costs incorporate the following elements:

Fuel cost savings. Fuel prices for biodiesel and ethanol were assumed to be at price parity with diesel and gasoline (adjusted for caloric content). This assumption was based on the equivalence of prices for diesel and gasoline imports. Part of the production of ethanol and biodiesel may take place inside the country, in which case the fuel price may slightly differ.

Programme cost and additional operating expenditure. Implementing changes to the fuel blend would entail a programme setup cost of USD 5 million. Operating costs, including

programme management and monitoring, were estimated at USD 500,000/year. Because the costs are so low relative to the abatement potential, they appear as zero in the cost curve.

Comments: The CRGE is a high-level strategy document, as attested by the number and quality of experts committed to its production. The CRGE does provide a comprehensive analysis of needs and solution towards water management, energy and bio-fuel, agricultural practices. However, these topics are never put in context, at least in the context of the water-hyacinth on Lake Tana. It would be critical to test the hypothesis of harvesting water-hyacinth for bio-fuel and organic agro-fertilizer as it might move the lines and comprehension and if their productivity is attested it might solve the conflict on resources (water use for crops for fuel production) and the stress on the development equation evoked earlier in the study.

4.7-Other Relevant Key Policies, Conventions and Institutions

The collection of relevant key policies, conventions and institution is sourced out of the work done by Friedrich zur Heide for the Michael Succow Foundation, who produced a very valuable publication that served as a feasibility study on Lake Tana towards its application to the Unesco Biosphere Reserve list: [25]

-Ethiopia´s Poverty Reduction Strategy Paper called Sustainable Development and Poverty Reduction Programs (SDPRP) was prepared in 2002, prioritizing the following areas for action: land degradation, the strengthening of regulatory and institutional capacity, and the enhancement and protection of biodiversity. Build on this, Ethiopia prepared a ***Plan for Accelerated and Sustained Development to End Poverty (PASDEP)*** *in 2005 which "aims to mainstream environment into development, to strengthen city and regional governments for environmental protection and to develop regulatory frameworks and systems for alleviating deforestation and soil degradation, which are major causes of food insecurity and poverty in Ethiopia. "[26]*

-Ethiopia´s role in the New Partnership for Africa's Development (NEPAD), including the ***Comprehensive Africa Agricultural Development Programme*** *(CAADP)* as *"It aims at fostering a broad-based agricultural-led economic growth in African countries by focusing on enhancing agricultural productivity and competitiveness. In this context, Ethiopia has*

[25] Feasibility Study for a Lake Tana Biosphere Reserve, Ethiopia, Friedrich zur Heide; Michel Soccow Foundation 2012.

[26] Plan for Accelerated and Sustained Development to End Poverty (PASDEP): http://www.ethioembassy.org.uk/Facts%20About%20Ethiopia/Ethiopia's%20Sustainable%20Development%20and%20Poverty%20Reduction%20Strategy.htm

issued the Agriculture Development-Led Industrialization (ADLI) strategy as being the country core economic development strategy[27].

-With respect to water policies, Ethiopia is a member of the ***Nile Basin Initiative*** *(NBI) of the Nile riparian countries as equal members in a regional partnership to promote economic development and fight poverty throughout the basin. It is guided by the vision "to achieve socio-economic development through the equitable utilization and benefit from the common Nile Basin water resources"*[28]*. As the source of the Blue Nile, the Lake Tana Basin plays a crucial geopolitical role in utilization and conservation of the Nile water resources.*

Ethiopia has a wide range of national policies that commit the country to a comprehensive and integrated management system for the protected areas and institutions mandated for promoting sustainable development and biodiversity conservation.

Conventions:

• Convention on Biological Diversity (CBD); • Convention on Migratory Species; • Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); • UN Convention to Combat Desertification (UNCCD); • UN Framework Convention on Climate Change (UNFCCC); • Kyoto Protocol to the UNFCCC; • World Heritage Convention (heritage sites as core areas); • Ramsar Wetland Convention.

Policies:

-Environmental policy: issued in 1997 for a sound management and use of natural resources;

-National Policy on Biodiversity Conservation and Research Policy (1998);

-National Conservation Strategy (NCS) of Ethiopia 1997: umbrella strategy that; comprises all relevant sectors (agriculture, forestry, wildlife, fisheries, soil, water and minerals); sets main objective for biodiversity conservation;

-Biodiversity Conservation and Development: Strategy and Action Plan for Ethiopia, December 2005, by the IBC;

-National Livestock Development Programme (1997);

-Rural Development Strategy (2002);

-National Food Security Strategy (2003) and Programme.

[27] The Agriculture Development-Led Industrialization (ADLI) strategy: https://webapps01.un.org/nvp/indpolicy.action?id=124

[28] Nile Basin Initiative: http://www.nilebasin.org/index.php/media-center/press-releases/32-nile-basin-water-ministers-address-strategic-issues-to-advance-the-nile-cooperation/file

Institutions:

-Institute of Biodiversity Conservation (IBC): established by proclamation; objectives: ensure appropriate conservation, research, development and sustainable utilization of biodiversity in Ethiopia; as part of the Ministry of Environment & Forests.

-Ethiopian Wildlife Conservation Authority (EWCA): Protected Area System focus on management and conservation of large fauna; under the umbrella of the Ministry of Culture & Tourism, which is also charged with the development of UNESCO World Heritage Sites.

-Forestry Research Center (FRC): research on species establishment, nursery techniques, etc.; as part of the Ministry of Environment & Forests.

-National Herbarium: established in 1959, managed by Addis Ababa University Biology Department, depository of collected flora, it is a centre for scientific information undertaking studies on plant species;

-Ethiopian Agricultural Research Organization (EARO): legally mandated to conduct agricultural research, coordinate other research of universities; is this part of the Ministry of Agriculture.

-Ministry of Science & Technology is the federal authority dealing with UNESCO Biosphere reserve issues, and hosting the Men & the Biosphere National Committee.

-Ministry of Environment & Forests.

-Ethiopian Forestry Action Program (EFAP): issued in 1994.

-The country has committed itself to issues pertaining to sustainable development and biodiversity conservation in a number of international conventions, which are synergetic with the objectives of the MAB programme, namely the Convention on Biological Diversity (CBD), the UN Convention to Combat Desertification (UNCCD), the UN Framework Convention on Climate Change (UNFCCC), the World Heritage Convention (heritage sites as core areas) and the Ramsar Wetland Convention (currently under preparation). These conventions could in parts be fulfilled by the tool of biosphere reserves by developing showcase projects under the BR umbrella. Protocols between the MAB programme and the respective conventions have already been established (UNESCO 2011: 15-18).

-Ethiopia ratified the UN Convention to Combat Desertification (UNCCD) in 1997 and developed a National Action Program (NAP) in 1998 focusing on the management of natural resources, the intensification and diversification of agriculture, the promotion of alternative livelihoods and rural credit to improve institutional capacity, particularly at the community level. Accordingly, in 2002 the Amhara National Regional State government through the Environmental Protection Land Administration and Use Authority (EPLAUA) prepared a Regional Action Program (RAP) to Combat Desertification, within the framework of the NAP. The federal and regional governments enacted a wide range of policies, strategies, action

plans and programs against land degradation (IFAD 2007: 9)[29].

-The country ratified the ***Convention on Biological Diversity*** *(CBD) in 1994 and developed its National Biodiversity Strategy and Action Plan (NBSAP) in 2005 to meet the planning requirement of Article 6 of the convention. In addition, the Cartagena Protocol on Bio-safety was ratified in 2003. A "Conservation Strategy of Ethiopia" (CSE) was developed in 1997 with the help of World Conservation Union (IUCN) and accordingly, the ANRS formulated and developed a Regional Conservation Strategy (RCS) in 1999 with the overall objective of conserving and protecting the natural resources and environment of the region. As a party to the CBD and in fulfillment of its obligation, Ethiopia prepared the final draft of its biosafety law in 2007. "The NBSAP document defines the current status of, pressure on, options for, and priority action to ensure the conservation, sustainable use, and equitable share of benefits accrued from the use of biological diversity of the country" (IFAD 2007: 9).*[30]

-In the face of the still ongoing serious deforestation and overall environmental degradation, Ethiopia issued a 20-year Ethiopian Forestry Action Program (EFAP) in 1994. ANRS developed the ***Amhara Forestry Action Program (AFAP)*** *in 1999 with following main objectives: (a) increasing output of forest products on a sustainable basis; (b) increasing agricultural production through reduced land degradation; (c) increasing soil fertility; (d) conserving forest ecosystems as well as genetic resources; (e) and improving the welfare of rural communities (IFAD 2007: 9)*[31]*. So far there is no institutional set-up for the conservation of forest genetic resources.*

Structures

Ministry of Water, Irrigation and Energy (MoWIE): *MoWIE which replaced the former Ministry of Water and Energy (MWE) is the leading government institution in the energy sector whose primary role is developing, planning and management of energy resources as well as creation of strategies, policies and regulation of different institutions of energy sectors. After 2010 national election, the ministry renamed as Ministry of Water, Irrigation and Energy (MoWIE). The mandates and responsibilities include development, planning and management of energy resources, policies development, strategies and programs, development and implementation of laws and regulations, managing petroleum operations and oversee rural electrification, promote development of alternative energy, set standards for petroleum storage and distribution, determine volume of petroleum reserves and provide technical support to regional energy bureaus and offices. MoWIE is the energy policy making organ of the government. Based on studies and recommendations of one of its departments, energy policy implementation follow-up and supervision, the MoWIE formulates various energy sector policies and supervises their implementation when approved (Ministry of Water and Energy, 2011).*

The Ministry is currently trying to establish a Regional Eco-Hydrology Center under the auspices of UNESCO.

[29] IFAD report 2007: https://www.ifad.org/documents/10180/1fa4ece8-5865-4fbf-98b8-a97dbf9d3dab

[30] Ibid.

[31] Ibid.

The Ethiopian Energy Authority (EEA): EEA which replaced the former Ethiopian Electric Agency will regulate all energy activities in Ethiopia, including energy sector investment in the country (licensing, safety and quality standard) and also set the prices for the private sector and sate owned power distributors (FfE, 2010, p. 89)

The Ethiopian Electric Power Corporation (EEPCo.): The Ethiopian Electric Power Corporation was one of state owned giant public utilities, until recently, engaged on energy generation, transmission, distribution and sale (FfE, 2010, p. 88). Late 2013, the corporation split and renamed in to two corporate entities, the Ethiopian Electric Power (EEP) and Ethiopian Electric Utility (EEU). EEP is responsible for the power supply and tasked to undertake and oversee the country's power project including the mega hydro dams and the transmission lines, while EEU is responsible for delivering electricity services, operations distribution and sales. The split came due to the vast expansion of the power sector and the need for modernizing the service delivery of the company which EEPCo could not carry. The more detailed engagement of the corporation is outlined at the end of this chapter (FfE, 2010, p. 93).

The National Reserve Oil Deposits Administration (NRODA): NRODA was established in 1997 to operate and maintain the national petroleum reserve of the country and to ensure security of supply (Ibid, p. 89). The administration merged with Ethiopian Petroleum Enterprise (EPE) and formed Ethiopian Petroleum Supply Enterprise (EPSE).

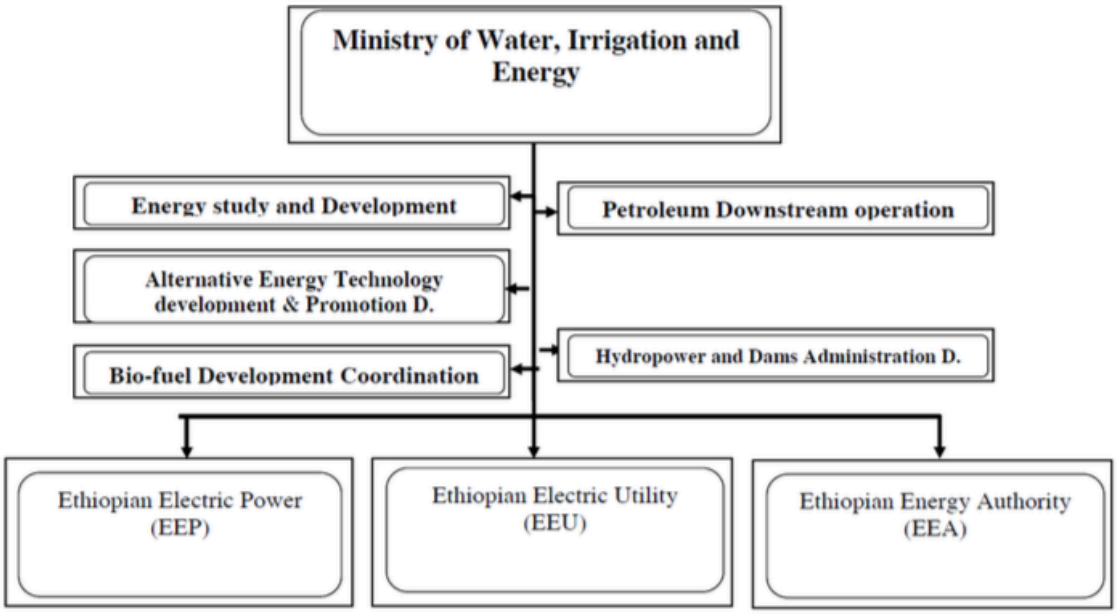


Figure 14. Institutional Framework of The Energy Sector in Ethiopia Source: Mowie, 2013[32]

[32] Feasibility Study for a Lake Tana Biosphere Reserve, Ethiopia, Friedrich zur Heide; Michael Soccow Foundation 2012

The energy sector also has a key institution with the Ministry of Water, Irrigation and Energy vital for the promotion of energy access and security. Beyond these institutions there are further programs and organizations with relevance of the energy sector. These include:

Regional Energy Agencies are government bureaus responsible for promoting and facilitating modern energy technology programs.

Alternative Energy Technologies Program conducts research in technology development and promotion of rural energy technologies such as improved stoves, PV solar, and biogas.

Ethiopian Petroleum Enterprise (EPE): EPE is an operational wing of government entrusted with the responsibility of implementing fuel procurement and storage.

Universal Electricity Access Program oversees universal electricity access activities, with responsibility of supporting and promoting off-grid rural electrification projects by cooperatives and private sector operators operating outside the national grid.

Ministry of Trade plays the role for setting retail prices and regulates the distribution of petroleum products by oil distribution companies.

Ministry of Finance and Economic Development oversees public finance for projects

Ministry of Mines takes the responsibility of Geothermal and hydrocarbon resources exploration.

Environmental Protection Agency regulates environmental aspects of energy development. Source: Girma, 2000, p. 21-32 & USAID 2013, p. 15-17

4.8-The Abuja Declaration on Fertilizers for an African Green Revolution

Background:

In June 2006, the African Union (AU) and the New Partnership for Africa's Development (NEPAD) convened the Africa Fertilizer Summit to address the fertilizer crisis facing Africa. Thirty countries and four Regional Economic Communities (REC) developed country and regional fertilizer strategies that resulted in the publication of the Abuja Declaration on Fertilizers for an African Green Revolution. Resolution 12 requested the African Union and NEPAD to monitor and evaluate progress in implementation and report to the African Union Summit every six months. Since 2006, four biannual progress report have been prepared by NEPAD and submitted to the African Union based on data and information received from the countries and Regional Economic Communities.

Countries involved: (January-June 2008)

Respondents	Countries by Region (18)	
RECC (6)	Region	Countries
EAC, ECCAS, ECOWAS, SADC, COMESA, IGAD	Southern Africa (7)	Namibia, Swaziland, Angola, Mozambique, Madagascar, Seychelles, Lesotho
	East Africa (5)	Burundi, Uganda, Djibouti, Tanzania, Kenya
	Central Africa (1)	Cameroon
	West Africa (3)	Nigeria, Togo, Mali
	North Africa (2)	Egypt, Algeria

NEPAD's Contribution

The New Partnership for Africa's Development has declared that the vision of economic development in Africa must be based on raising and sustaining higher rates of economic growth (7 percent per year). To realize this vision, the African Heads of State and Government adopted the Comprehensive Africa Agricultural Development Programme, which calls for a 6 percent annual growth in agricultural production, as a framework for the restoration of agricultural growth, food security and rural development in Africa.

A move toward reducing hunger on the continent must begin by addressing its severely depleted soils. Due to decades of soil nutrient mining, Africa's soils have become the poorest in the world. It is estimated that the continent loses the equivalent of over $4 billion worth of soil nutrients per year, severely eroding its ability to feed itself. Yet farmers have neither access to nor can they afford the fertilizers needed to add life to their soils. And no region of the world has been able to expand agricultural growth rates, and thus tackle hunger, without increasing fertilizer use.[33]

[33] NEPAD: http://www.nepad.org/resource/abuja-declaration-fertilizer-african-green-revolution

African Fertilizer Development Financing Fund[34]:

The Fertilizer Fund hosted by and supported by the African Development Bank is designed to mobilize and pool resources to finance, in particular, fertilizer production, distribution, procurement and use in Africa. The Fertilizer Fund's resources shall be devoted primarily to:

- facilitation activities including policy formulation, technical assistance, information dissemination, law reform, and project preparation;
- the development of Africa's fertilizer manufacturing capacity;
- providing credit guarantees for fertilizer importers and distributors;
- support establishment of regional fertilizer procurement and distribution facilities; and
- developing financing mechanisms in support of fertilizer production, distribution, and agriculture generally.

Comments:

The Abuja Declaration sets up an interesting platform to support the transformation of water-hyacinth into organic agro-fertilizer. However, Ethiopia is not yet part of the involved countries.

V-Lake Tana Biosphere Reserve

5.1-Background

The Lake Tana Biosphere is located in the Amhara National Regional State. As informed by UNESCO: "*The biosphere reserve comprises Lake Tana, the largest lake in Ethiopia, the main source of the Blue Nile, which provides important ecosystem services. The area is a hotspot of biodiversity, internationally known as an Important Bird Area and is of global importance for agricultural genetic diversity. The area is characterized by an enormous heterogeneity of land uses and natural ecosystems.*[35]" With a surface of 3156 km^2 stretching approximately 84 km north-south and 66 km east-west, Lake Tana is the largest lake of Ethiopia and one of the largest in Africa. Its maximum depth is 14 m with a decreasing trend due to erosion-based siltation and lowering water level. As the main source of the Blue Nile at its upper course, the Lake Tana Basin accounts for 50 % of the inland water amount, draining a long way through Khartoum in Sudan to the Mediterranean Sea.

Lake Tana's water plays a crucial role in the making of ecological processes within the Lake. The water resource is central as it accounts for 50% of total inland water, used for human consumption, irrigation, hydropower among others.

Lake Tana's fish resource, as informed by Dereje Tewabe: "*Twenty of the twenty-seven fish*

[34] Abuja Declaration: http://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/african-fertilizer-financing-mechanism/abuja-declaration/

[35] UNESCO Lake Tana Biosphere Reserve: http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/africa/ethiopia/lake-tana/

species of Lake Tana are endemics to the Lake Tana catchment. Despite the unique fish biodiversity and its high economic value for Lake Tana, fish resources are under pressure from several threats. The major threats are illegal fishing and habitat destruction (wetlands, rivers and the lake itself) due to human intervention. The observed decline in densities of those economically important fish spp. stresses the need for the urgent development of a management plan focusing on ensuring wetlands and rivers connectivity, fishing effort, respecting closing seasons, gear type and mesh size restrictions and control in the river mouths and major tributaries during the breeding seasons of a year.[36]"

Lake Tana's Wetland ecosystems have a high local and global significance as natural and economic resource. They provide a wide set of environmental services, such as flood control and biodiversity maintenance, and socioeconomic services for production and use, such as plants, crops, fish and grazing and thus are important for human use as well as for plants and animals. Wetlands also play a critical role as a regulating instruments of carbon cycle.

The regional socio-economic context is highly dependent on Lake Tana's ecosystem benefits as subsistence based agriculture and livestock are the two main sources of income. Livelihoods systems remained quite traditional in Ahmara. There is a significant socio-economic vulnerability with a significant part of the population living in extreme poverty.

Lake Tana's Biosphere Reserve is exposed to a set of inter-related environmental problems, by land and water use, notably deforestation, erosion, sedimentation, water level reduction, erratic rainfall, excessive flooding of the wetlands, competition for water resources, pollution, introduction of alien species affecting local species' gene pools, including alien invasive water-hyacinths. One of the major underlying forces that endanger the ecosystems and biodiversity around Lake Tana is population growth exerting further resource-use pressure. This goes along with, for example, overgrazing and horizontal farmland expansion (formal and informal), cultivation of marginal lands like wetlands, encroachment of communal land and massive vegetation removal to meet demand for food, feed and fuel wood. Other underlying causes that threaten biodiversity and forests in particular are: limited governmental, institutional, and legal capacity; land degradation; weak management of protected areas; and deforestation.

These threats have been well identified in the "*Feasibility Study for a Lake Tana Biosphere Reserve, Ethiopia*":

"*Land degradation caused by deforestation, overgrazing, unsustainable agricultural practices and wetland degradation. The lakes buffering capacity to deal with stress is reduced from sediment loads and conversion, destruction and encroachment of important natural buffers like wetlands. Despite this high diversity of fauna and flora, several of the existing species are endangered due to loss and fragmentation of habitat. In particular, the degradation of forests and wetlands has caused severe habitat destruction for both flora and fauna. As a result, various species are very few in numbers and are at the risk of, at least, local extinction;*

[36] Feasibility Study for a Lake Tana Biosphere Reserve, Ethiopia, Friedrich zur Heide; Michael Soccow Foundation 2012.

Risk of eutrophication: from an increasing use of fertilizers and pesticides in agriculture, from construction material from Bahir Dar triggering macrophyte growth and phosphorus level rise. Rooted macrophytes and alien species, such as water hyacinths, are favored by the muddy sediments and an alkalinity of 50 mg/l $CaCO_3$ arising from construction activities in Bahir Dar (Teshale et al. 2001: 40);

Environmental pollution: the lake is a sink for dumping municipal, industrial and domestic wastes of a growing urban population (Bahir Dar). Solid wastes and effluents from homes, factories and hotels reach the lake untreated, enhanced by an urban run-off from paved surface. This increases the risk of toxification;

As a consequence of reduced water quality, irrigation with freshwater from the lake during the dry season would not be possible in the future (Teshale et al. 2001). There are also increasing signs of stress from local algal blooms and pollution-induced fish decline. Fishermen become increasingly marginalized by the ongoing environmental changes;

The decline rain fall amount for the Kiremt season (June-September) is estimated to be 14 % (Marye 2010: 3). Besides global climate stressors, the main driving forces in decline of precipitation pattern are mainly the changes in land vegetation cover. The regional climate seems to show an increasing trend in rainfall variability that causes droughts and floods around Lake Tana. During the 2003 drought, the lake surface level dropped by two meters reducing the surface area by 35 km2. During the 2006 flood, 15,000 ha were inundated, 10,000 people displaced, 2,500 domestic animals killed and many houses demolished (World Bank 2008: 3). The World Bank (2008) states that there is an urgent need to protect the wetlands and reduce the vulnerability to devastating floods;

Resulting from the massive alteration of the hydrological regime from water development activities, the lake water level is lowering considerably, while its total water depth is continuing to shrink due to massive input of sediments from the watershed;

Climate Change: Some species are particularly at risk by climatic stress, like Cordia africana, Olea europea (olive), Juniperus procera (East African juniper) and Hagenia abyssinica (African redwood), due to patchy habitats, low population numbers, limited climatic ranges and restricted habitat requirements like Labeobarbus in Lake Tana (IFAD 2007). Montane centres are the ecosystems most vulnerable to temperature increase due to their isolation, which leaves no option for horizontal or vertical migration (forests). The recorded temperature increase also has an effect on the length of the growing period and a shift in agro-ecological zones. It thereby reduces agro- biodiversity of barley, pea and fava bean varieties having declined in the cooler parts of the watershed, while in the medium and lower elevations traditionally grown tef, sorghum and noug varieties have already disappeared (IFAD 2007: 18). It is also likely that livestock productivity will be further undermined by climate impacts on the quantity and quality of forage as well as by the spread in internal and

external parasites.[37]"

5.2-Zoning

The zoning of Lake Tana's Biosphere Reserve has been subjected to discussions as inclusive and exclusive criteria are interdependent. A great challenge between conservation and sustainable development was at the center of the initial propositions (Figure.15) Finally, the proposed zoning available on Lake Tana's Biosphere Reserve's website proposes a very composite zoning, that remains favorable for the harvesting of water-hyacinth as the main bodies are located within the buffer and transition zone.

[37] Feasibility Study for a Lake Tana Biosphere Reserve, Ethiopia, Friedrich zur Heide; Michel Soccow foundation 2012.

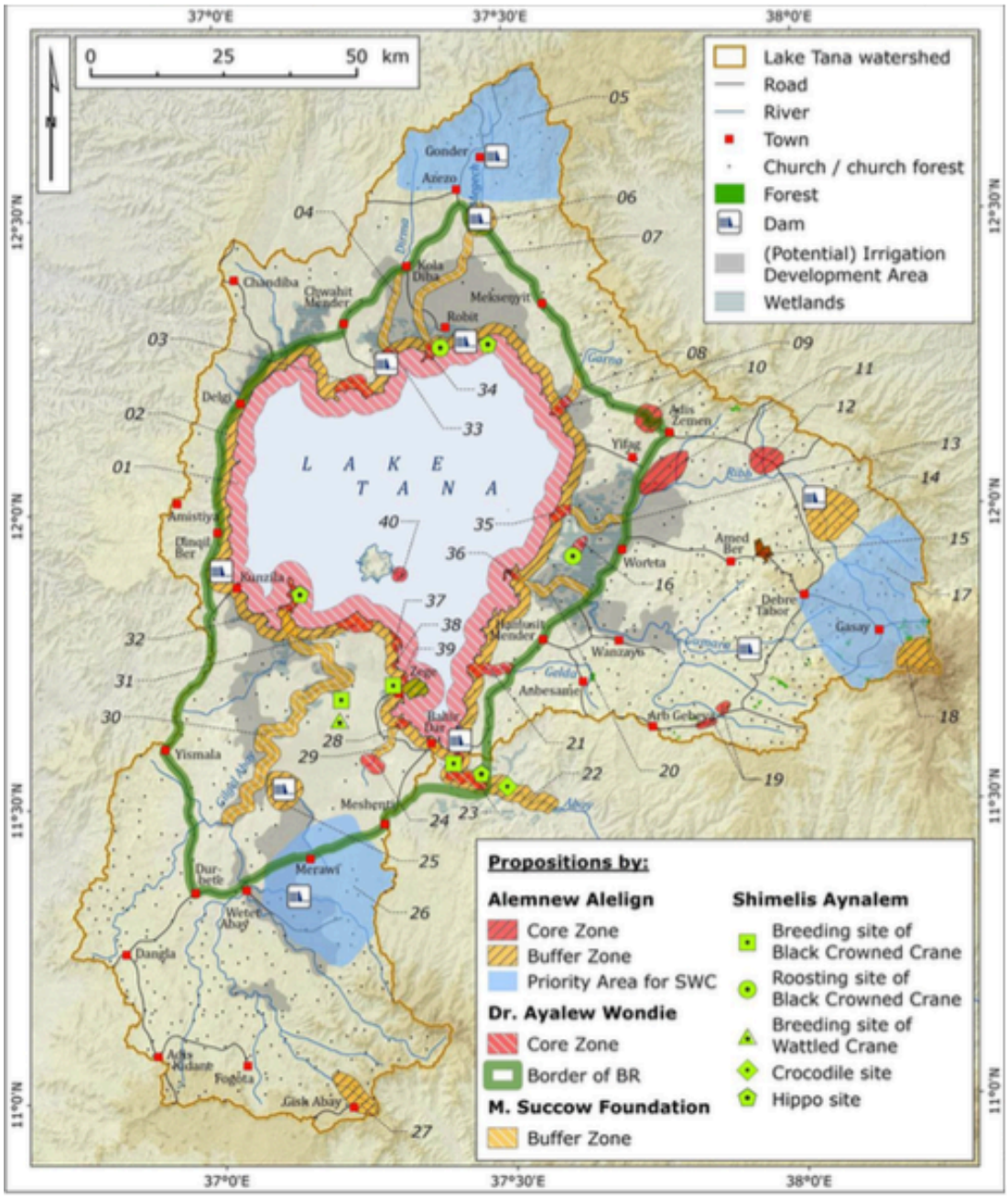


Figure 15. Consolidated Zonation Map with Proposed Core Zones, Buffer Zone Development Based on Various Experts' Opinions[38]

[38] Ibid.

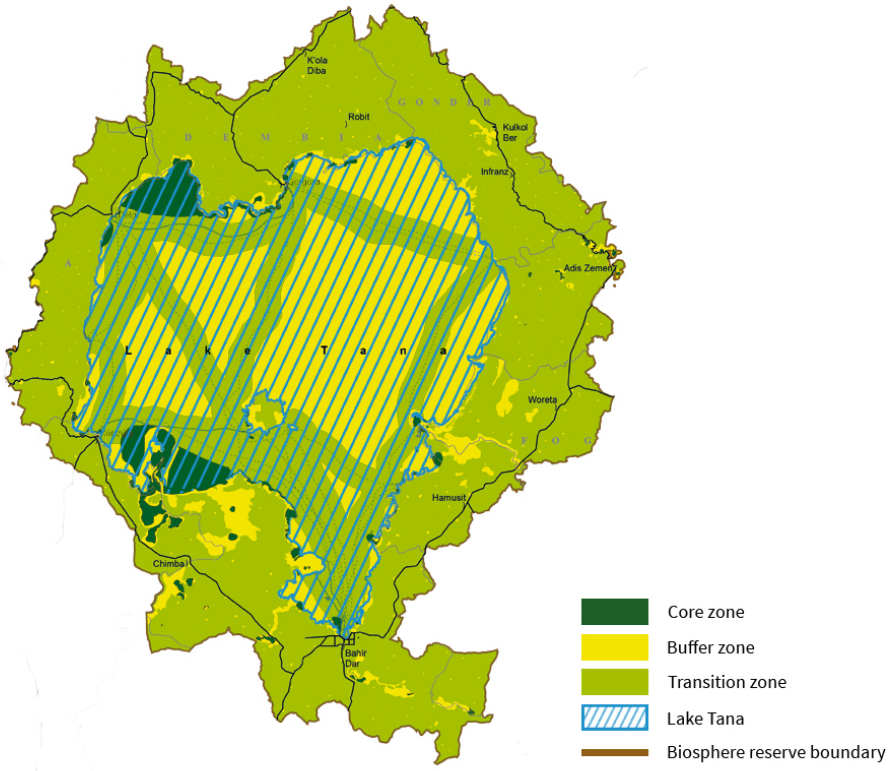


Figure 16. Lake Tana Official Zoning[39]

VI-The Structuration of Paradigmatic Change:

The question of paradigmatic change could seem purely rhetorical however it is deeply rooted in economic and sustainable principals. This change, if the engineering requirements are met, could hypothetically provide a significant enhancement for Ethiopia. Considering the amount of biomass and its potential to reproduce, once the intellectual commitment to transformation rather than control and eradication is achieved, then it opens up a world of applications. While the literature remains pretty scattered between scientific and technical publications; a deep-stigmata of "cursed" plant remains associated with water-hyacinth. It is certain that, like any other groundbreaking discovery, the transformation of water-hyacinth into organic agro-fertilizer and bio-fuel might disrupt the status quo.

[39] Lake Tana UNESCO Biosphere Reserve Zoning: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/images/Zonierung_Tanasee_web-eng.jpg

If we estimate the capacity of production of both items:

6.1-Bio-Fuel

The postulate will be to transform 1 ton of dry water-hyacinth to make 500 liters of bio-fuel

- Standard density for 1 hectare of water hyacinth: between 300 and 442 tons/hectare
- Annual productivity of between 930 and 2,900 tons per hectare
- The number of water hyacinth plants doubled every 11.2 to 15 days (makes 26 cycles per year)[40]

- The potential of Lake Tana is 50 000 hectares with a renewal capacity of approximately 26 cycles per year

50 000 ha x 3000 T/ha (low value per year) x 26 number of reproducing cycles/year =
150 000 000 x 26 = 3 900 000 000

If we have 3 900 000 000 tons of wet mass available

96% of the plant is constituted of water

The dry mass available is 156 000 000 tons

Transformation of dry mass into bio-fuel: 156 000 000 / 2 = 78 000 000 liters of bio fuel

Scenario 1: 1 liter of bio fuel (ethanol E85) costs 0,85€/liter[41]

The potential value of transforming water-hyacinth into bio-fuel is estimated at 66 300 000 euros (without cost of transformation)

Scenario 2: 1 liter of bio-kerosene (Bio Jet fuel) costs on Monday August 22nd 2016: US$1.20[42]

The potential value of transforming water-hyacinth into bio-kerosene (Bio Jet fuel) is estimated at 93 600 000US$ (without cost of transformation)

The informed quantity of fuel imports for Ethiopia is estimated at 1,093, 073 metric tons.[43]

6.2-Organic Agro-Fertilizer

[40] L. Lareo, "Crecimiento de Jacinto de Agua (Eichhornia crassipes (Mart) Solms Laubach), en el Tropico," Arch. Latinoamer. Nutr., 31: 758 (1981).
[41] Price of Ethanol E85: https://ethanol-e85.fr/prix_ethanol_E85.html
[42] Price of Bio Jet Fuel: http://www.kic-innoenergy.com/wp-content/uploads/2016/03/RREB_Biofuels_in_Aviation_Draft_Final.pdf
[43] http://www.sudantribune.com/spip.php?article46020

- Standard density for 1 hectare of water hyacinth: between 300 and 442 tons/hectare
- Annual productivity of between 930 and 2,900 tons per hectare
- The number of water hyacinth plants doubled every 11.2 to 15 days (makes 26 cycles per year)[44]

- The potential of lake Tana is 50 000 hectares with a renewal capacity of approximately 26 cycles per year

Let's estimate that for the organic agro-fertilizer we keep 6% water in the plant (4% of dry mass); and while we will never be able to harvest 50 000 hectares we can potentially produce:

50 000 ha x 3000 T/ha (low value per year) x 26 number of reproducing cycles/year =
150 000 000 x 26 = 3 900 000 000

10% (4% dry mass + 6% wet mass): 390 000 000 tons

What is the global need for Nitrogen fertilizer?

According to FAO "*In 2018, Africa will demand 4.1 million tons, Europe 15.7 million tons, the Americas 23.5 million tons and Asia 74.2 million tons. Even though overall fertilizer use in sub-Sahara Africa is projected to grow at a 4.7 percent annual pace, the fastest in the world, Africa will remain a major exporter of nitrogen, providing an additional 3.4 million tons to the global balance.*"[45]

Global need in millions of tons: 4.1+15.7+23.5+74.2=117,5 millions of tons

Lake Tana produces then: 95 times the need of the African Continent.
: 3.3 times the global need.

[44] L. Lareo, "Crecimiento de Jacinto de Agua (Eichhornia crassipes (Mart) Solms Laubach), en el Tropico," Arch. Latinoamer. Nutr., 31: 758 (1981).
[45] FAO, Fertilizer Use to Surpass 200 Million Tonnes in 2018:
http://www.fao.org/news/story/en/item/277488/icode/

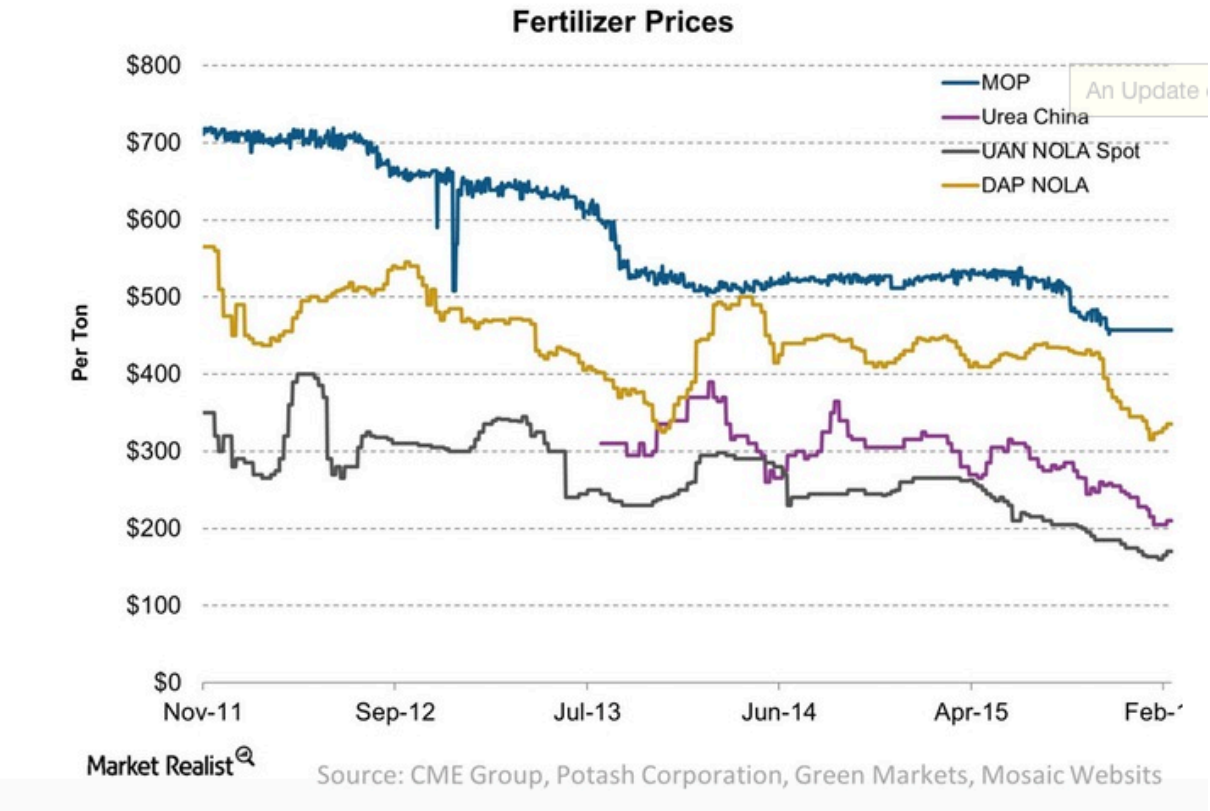


Figure 17. Prices of Fertilizer[46]

Scenario 1: If the average price per ton for Anhydrous Ammonia is US$720[47]

The potential value of transforming water hyacinth into organic bio-fertilizer on Lake Tana as a substitute for Anhydrous Ammonia is estimated at US$280 800 000 000 (without cost of transformation).

Scenario 2: if the average price per ton for MOP is US$456[48]

The potential value of transforming water hyacinth into organic bio-fertilizer on Lake Tana as a substitute for MOP is estimated at US$177 840 000 000 (without cost of transformation).

[46] Prices of fertilizer: http://marketrealist.com/2016/02/update-npk-fertilizer-price-trends/

[47] Averages and Seasonality of Prices for Nitrogen Fertilizers, Gary Schnitkey, Department of Agricultural and Consumer Economics, University of Illinois *farmdoc daily* (6):65 : http://farmdocdaily.illinois.edu/2016/04/averages-and-seasonality-of-prices-nitrogen.html

[48] http://marketrealist.com/2016/02/update-npk-fertilizer-price-trends/

6.3-Synthesis

-Scenario 1: The potential value of transforming water-hyacinth into bio-fuel is estimated at 66 300 000 euros (without cost of transformation).

-Scenario 2: The potential value of transforming water-hyacinth into bio-kerosene (Bio Jet fuel) is estimated at US$ 93 600 000 (without cost of transformation).

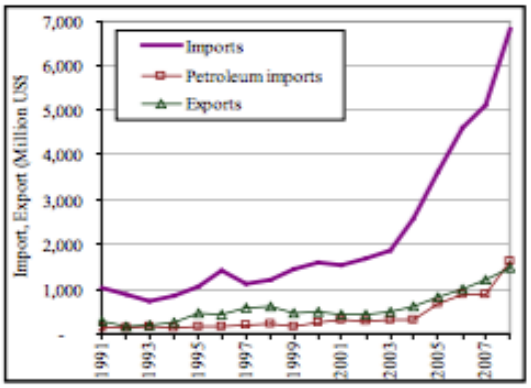
-Scenario 1: the potential value of transforming water hyacinth into organic bio-fertilizer as a substitute for anhydrous ammonia on Lake Tana is estimated at US$280 800 000 000 (without cost of transformation).

-Scenario 2: The potential value of transforming water hyacinth into organic bio-fertilizer on Lake Tana as a substitute for MOP is estimated at US$177 840 000 000 (without cost of transformation).

The transformation into organic bio-fertilizer seems more profitable than the other two products. While economy is not the only medium to induce the paradigmatic change, it contributes greatly. When placed at the center of the Ethiopian context it could significantly contribute to the realization of political vision and economy.

6.4-Economic Impact for Ethiopia

In this section, I intend to focus primarily on the projection of economic impact of bio-fuel and organic agro-fertilizer.



Item	2004	2005	2006	2007	2008
All imports	2,587	3,633	4,593	5,126	6,811
Petroleum imports	310	667	860	875	1,621
All exports	600	818	1,000	1,185	1,466

Figure 18. Petroleum Imports of Ethiopia Source: National Bank of Ethiopia, Annual Statistics 2009, P. 23

As informed by the Sudan Tribune, Ethiopia, as a non-producing country, has a high dependency on fuel products: "*Saturday that the nation has imported over 1 million metric tonnes of petroleum from neighbouring Sudan via the port of Djibouti. Officials said the stated fuel amount was imported at a cost $1.12 billion over the past six months. A similar amount of petroleum is expected to be imported over the next six months to meet the growing demand for energy in one of Africa's emerging and fastest growing economies. The fuel imported during first half of the Ethiopian fiscal year was a rise of 21% in comparison to the same period last year. According to EPSE's spokesperson, Alemayehu Tsegaye, the imported 1,091,823 metric tonnes of fuel surpasses the initial planned target of 1,093, 073 metric tonnes. Ethiopia imports up to 85% of its annual oil consumption from neighbouring Sudan, largely due to its geographic proximity. The Horn of Africa nation saves at least $10 million in transit related costs per year by using Sudanese oil sources rather than importing from markets further afield, such as the Middle East. During the stated period of the budget year, Ethiopia has also imported over 125,000 metric tonnes of coal and spent over $20 million on maintaining sustainable energy supplies for manufacturing and industry. Over 50% of Ethiopia's imports are to meet the nation's fuel demand…. Under Ethiopia's five-year Growth and Transformation Plan (GTP) launched two-and-a-half years ago, the government is spending billions of US dollars on the construction of several power plants, including the Ethiopian Great Renaissance Dam on the Blue Nile River, which will be Africa's largest once complete. Ethiopia's electricity generation capacity is set to increase to 10,000 MW by 2015 up from the current level of about 3,000 MW once the power projects are complete, making the country a regional power hub. Ethiopia hopes that power exports can provide a crucial bridge to its plans to develop the country's economy*." [49]

While the conversion of impact of fuel vs bio-fuel is a rather complex and tenuous question, The Ethiopian News Agency informs us that "*Ministry of Mines and Energy said over 59.6 million liters of ethanol has been blended with benzene in the last five years. Alemayehu Tegenu, Minister of Water, Irrigation and Energy said the intervention saved Ethiopia 46.9 million USD from oil purchase. Starting from 2009, Ethiopia has been blending ethanol with benzene with five percent ethanol content and later with 10 percent. Nile, Oil Libya and National Oil Company (NOC) are blending benzene with ethanol provided by Metehara and Fincha sugar factories.*"[50]

The potential of 78 000 000 liters produced from Lake Tana's water-hyacinth could help the Ethiopian government to save US$ 61,4 million. Again, the quantification has been simplified, but one can imagine that the impact would be greater over time as the resource would be managed in a sustainable way.

[49] Fuel import dependency: http://www.sudantribune.com/spip.php?article46020

[50] Ethiopian News Agency: http://www.2merkato.com/news/alerts/4041-ethiopia-blends-596-million-liters-ethanol-with-benzene-in-5-years

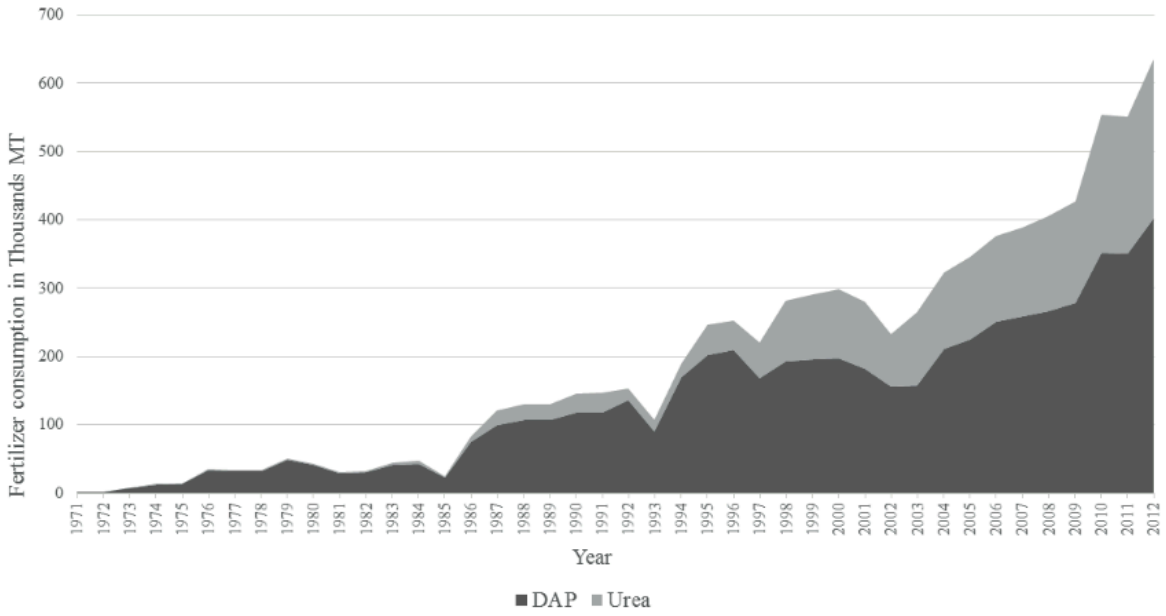


Figure 19. Fertilizer Consumption in Ethiopia, 1971-2012 (Source: Moa, 2013).

As informed by an article published in the Addis Fortune in January 2015, Ethiopia is also highly dependent on fertilizer import despite having taken the initiative to invest in local production plants: "*The government is expecting to receive three consignments of fertilizers, each carrying 50,000ql this January, which is part of the 900,000ql the government purchased with 431.9 million dollars from five companies. The five supplier companies are Yara Switzerland Ltd, Agri Commodities Group, Witraco, Helm AG and India Agro. The fertilizer started entering the country by the beginning of November 2014 and seven consignments close to 350,000ql have reached the port of Djibouti and have started entering the country, according to Shiberu Demisse, director of agricultural input marketing at the Agricultural Input Supply Enterprise (AISE). […] This is the second year in a row that the Enterprise has bought NPS, a replacement for DAP, which it dropped two years ago. NPS has become favored over DAP because it has everything DAP has and Sulfur, according to Amarech Bekele, director of communication at the Enterprise. Yara will supply 571,000ql of fertilizers, of which 371,500ql is NPS with a total cost of 286.4 million dollars, Agri Commodities won for the supply of 100,000ql of Urea with 30 million dollars, Witraco will supply 150,000ql of NPS with 78.5 million dollars, Helm Ag is to supply 50,000ql Urea with 19.1 million dollars and India Agro will deliver 22,539ql of Urea with 9.8 million dollars.[…] The Enterprise imported 552,000tns of fertilizer in 2010/11 and 560,000tn the following year. Its imports in 2012/13 were down to 477,000tns. The government is constructing four fertilizer factories in the Tigray, Amhara, Oromia and Southern regional states, with annual capacities of 25,000tns of fertilizer. Currently, the Country cultivated 14.1 million hectares of land with cereal and pulses and the use of fertilizer per hectare reached 63Kg, according to a data from the MoA. The government is constructing four fertilizer factories with annual capacities of 25,000tns*"[51]

[51] Addis Fortune: http://addisfortune.net/articles/ethiopias-fertilizer-to-arrive-in-batches-every-month/

Ethiopia's Gross Domestic Products (GDP) was estimated in 2015 at 61,54 Billion US Dollars, depending on the production and sale of water-hyacinth based organic agro-fertilizer, the country could potentially triple (2.9 for the minimal value) its GDP. This projection results from a simplification over the potential quantification of water-hyacinth based organic agro-fertilizer, one can envision that the pattern would be different in time due to production capacity but still remain significant for the Ethiopian Economy.

6.5-Organic Agro-Fertilizer and The Challenges of Climate Change and Agricultural Development in Ethiopia:

Ethiopia presents a rather complex agriculture profile. Being the backbone of Ethiopia's economy it accounts for 46.3 percent of the nation's Gross Domestic Product (GDP), 83.9 percent of exports, and 80% of the labor force.[52] The objectives set up through the Growth and Transformation Plan (GTP) have been achieved despite structural and climate-related challenges: "*The value added of the crop subsector increased by 7.5 percent during the first four years of the GTP period. Within the crop subsector, major food crops have been the major drivers of growth in the agriculture sector. During the first four years of GTP, the productivity of major food crops (Cereals, Pulses, and Oil seeds) reached an annual average level of 17.6 quintal per hectare. This is a positive performance and would not be far from the target pending the estimate for the final year of GTP (2014/15). As a result, the production of these crops increased from 180 million quintals in 2009/10 to 274 million quintals in 2013/14. When this performance is compared with the target set for 2014/15, which was set at 267.74 million quintals, it shows that the target has been achieved one year ahead of the time line*."[53]

Beyond the achievement of productivity goals, the question a land and water quality remains highly critical. The incidence of chemical fertilizer on land and water quality, well described in a 2011 FAO report titled "*State of The World's Land and Water Resources for Food and Agriculture-Managing Systems at Risk"*, shows the paradox of willing to achieve high productivity and food security to the detriment of land and water quality. The high-solubility of chemical fertilizers results in polluting ground water as well as by extension, surface water causing eutrophication supporting the expansion of water-hyacinth. Cognizant of the ecosystem function of water-hyacinth in absorbing Nitrate, Ammonium and Phosphate, the need for change resides at the level of fertilizing practices surrounding the Lake as well as within its catchment area. The use of organic agro-fertilizer would ultimately contribute to the general decrease in nutrient content of the lake (over an undermined period) and by ricochet, help in decrease the environment stress of water-hyacinth over the general ecosystem of the lake.

The relevance of using organic agro-fertilizer is also motivated by climate induced phenomena such as drought. By regenerating soils using organic agro-fertilizer, agriculture will require less water and will be more productive as organic agro-fertilizer helps to maintain

[52] US Department of State report http://www.state.gov/p/af/ci/et/

[53] The Second Growth and Transformation Plan (GTP II) (2015/16-2019/20: https://www.africaintelligence.com/c/dc/LOI/1415/GTP-II.pdf

nutrient available for the plant rather than passing through and impacting ground water.

The case of Lake Tana has been approach through the modeling of Phosphorous data.

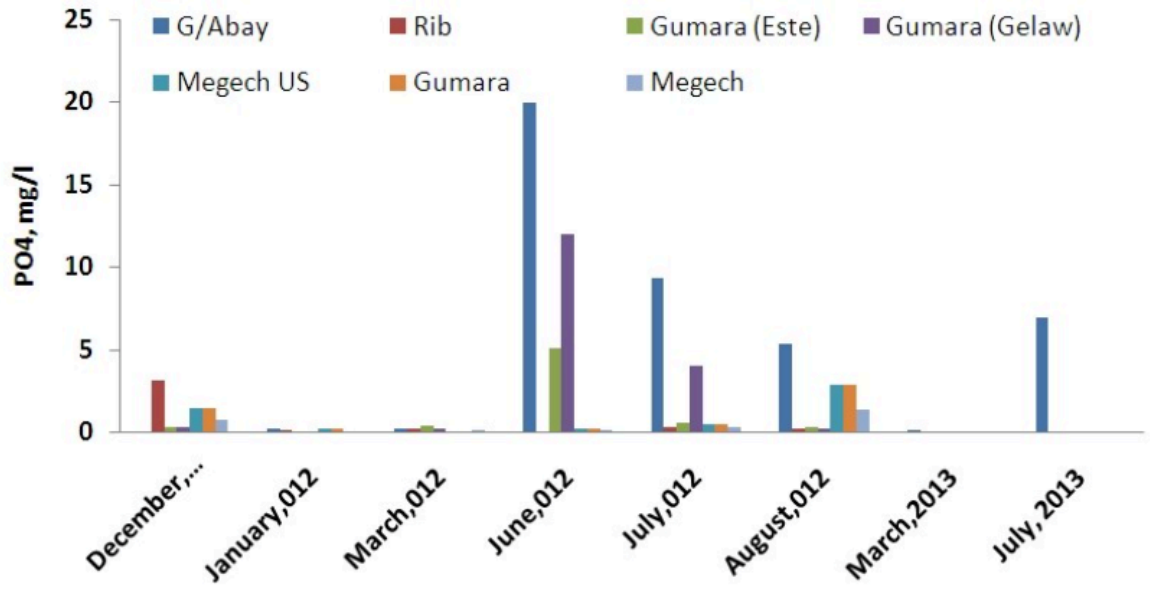


Figure 20. Measured PO_4 Data for The Indicated Water Quality Stations[54]

The study reveals that beyond practices, level of nutrient in ground is in itself a more complex system: "*solving agricultural NPS P pollution is difficult because of measurement and regulation of NPS P and this may take long time. Many soils have soil P levels that are so high that even when P fertilizer or manure is not applied, P losses still remain high."*[55] *In surface water, even after terrestrial P loads have been reduced eutrophication levels may not decrease substantially because of the steady source of P in the sediments in the bed of the stream or lake that have accumulated P and continue to release it.*[56]"

Finally, it is important to underline the fact that soil erosion and sediment also contribute negatively to nutrient transport.

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[54] Ph*osphorus Modeling, in Lake Tana Basin, Ethiopia*, Tewodros Taffese, Seifu A Tilahun, Tammo S Steenhuis, Journal of Environment and Human

[55] T. Addiscott, D. Brockie, J. Catt, D. Christian, G. Harris, K. Howse, N. Mirza, and T. Pepper, "Phosphate losses through field drains in a heavy cultivated soil," *Journal of environmental quality*, vol. 29, no. 2, pp. 522–532, 2000.

[56] A. N. Sharpley, S. Chapra, R. Wedepohl, J. Sims, T. C. Daniel, and K. Reddy, "Managing agricultural phosphorus for protection of surface waters: Issues and options," *Journal of Environmental Quality*, vol. 23, no. 3, pp. 437–451, 1994.

VII-Environmental and Social Impact Assessment (ESIA) For Organic Agro-Fertilizer and Bio-Fuel

7.1-Method

The Environmental and Social Impact Assessment (ESIA) is a procedure that insures that the environmental and social implications of decisions are taken into account before the transformation of water hyacinth into organic agro-fertilizer and bio-fuel. The ESIA is constituted of both theoretical and practical elements of consultations and is prepared by collecting primary and secondary data as well as compiling information through extensive review of project documents, environmental policies, laws, regulations, proclamations and guidelines at the local, national and international levels, consultative discussions with project team members under the auspices of UNESCO, consultations with legal experts, monitoring and evaluation experts at the international level and environmental regulatory experts.

The ESIA also includes the identification, prediction, evaluation and mitigation of the relevant environmental and social impacts. Information related to the ESIA are screened and organized accordingly. The wider social and environmental benefits will be detailed in the Environmental and Socio-Economic Management Framework (ESEMF). Key elements of socio-economic and environmental benefits will be subjected in the ESEMF to quantification and monetization according to the scale and context in which they are situated. Some elements of consideration such as the ecosystem benefits and other, as complex elements to quantify or where the data is not available will be taken into consideration. The principles of the ESIA are harmonized under positive assumptions, as the purpose of this feasibility study is to validate the development of harvesting water-hyacinth in view to produce organic agro-fertilizer and bio-fuel within UNESCO Biosphere Reserves.

7.2-Organic Agro-Fertilizer and Bio-Fuel Assessment

- Background:

In our case, there is no existing equivalent of such initiative. (Organic Agro-Fertilizer-OAF and Bio-Fuel-BF)

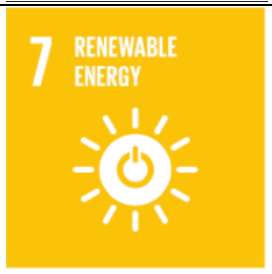
- Introduction:

Water-hyacinth based organic agro-fertilizer and bio-fuel could be defined as an innovative socio-economic and environmental mechanism that could enable productive activities for local populations within UNESCO Biosphere Reserves' buffer and transition zones, with great potential of expansion at the national, regional and international level. The assessment addresses the Environmental and Social Impact of both transformative practices, use and

activities outcomes.

- Purpose and Need for Action:

The program echoes the triptych of global decrease of ecosystem crisis, agriculture, energy as well as the means of sustainable development. It also answers directly to 11 of the 17 Sustainable Development Goals (SDGs) as established by the UN framework on sustainable development goals in transforming our world: The 2030 agenda for sustainable development.

SDG	Justification
	Acting as a platform for socio-economic and environmental development within UNESCO's Biosphere Reserves, the water-hyacinth program aims at alleviating poverty through ecosystem benefits and improving the livelihoods of concerned populations.
	The Program proposes direct and indirect means to fight against hunger. A global approach is taken in terms of identification of significant productive activities within the perimeters allocated for the program. These productive activities include in a non-limitative manner: aquaculture, farming, cattle farming…also indirectly by providing fertilizer to agricultural soils and jobs for income.
	The program addresses water management and Clean Water with a multi-dimensional system from catchment to soil and groundwater exchanges, as well as evapotranspiration and hydro-chemical elements inherent to Lake Tana. It also assists reducing eutrophication of the water-body by removing nutrients via removing plants.
	The program features a strong renewable energy component as the outcome of water-hyacinth is intended for the production of bio-fuel.
	The integration of potential economic high-value activities within the frame of the water-hyacinth program presents a significant platform for the socio-economic development of local populations and economies.

	By definition, the concept of industrially transform water-hyacinth is highly innovative and could serve infrastructural purposes. (OAF and BF)
	By creating the conditions for populations at large to be involve and participate in the socio-economic and environmental development, the program naturally contributes to reducing inequalities. Organic agro-fertilizer if made available to the poorest farmers could contribute to significant enhancement of production and means of production (water-use).
	By reducing the stress over Lake Tana's ecosystem at large and its human related activities, the program aims at creating the necessary conditions for sustainable practices in relation to harvest water-hyacinth. The program also benefits from a significant community-based component through which the principles of sustainability intend to be shared and practiced.
	The responsible consumption component is intrinsic to the functioning mechanism of harvesting and is elevated as a core value of the program.
	The water-hyacinth program features a strong climate action component as the platform deploys a set of significant ecosystem benefits that have a direct influence on improving environmental conditions. It qualifies at two different level for carbon credit and GHG emissions reduction (methane).
	By improving water conditions and biodiversity, the program contributes to the improvement of Lake Tana's general ecosystem.

- Proposed Action:

The program needs to fill the gaps in scientific and engineering knowledge in order to validate the sustainability of harvesting water-hyacinth towards the production of organic agro-fertilizer and bio-fuel as well as its up-scaling.

- Decision Framework:

Situated under the auspices of UNESCO's Biosphere Reserves, the program however remains subjugated to national policies and legislations. The analysis of the International as well as the Ethiopian Institutional Policies and Regulations Framework (IPRF) as demonstrated that all the conditions are required for the proper development of such activities.

- Public Involvement:

The harvesting of water-hyacinth program implies a structured approach towards public involvement. This involvement translates into the participation of local communities, as well as governmental and non-governmental organizations (NGO) and the Academia at large.

- Issues:

The main issue regarding the proper development of the program could be located within the capacity building gaps and engineering requirements. However, such gap should be filled by the structures committed through public involvement.

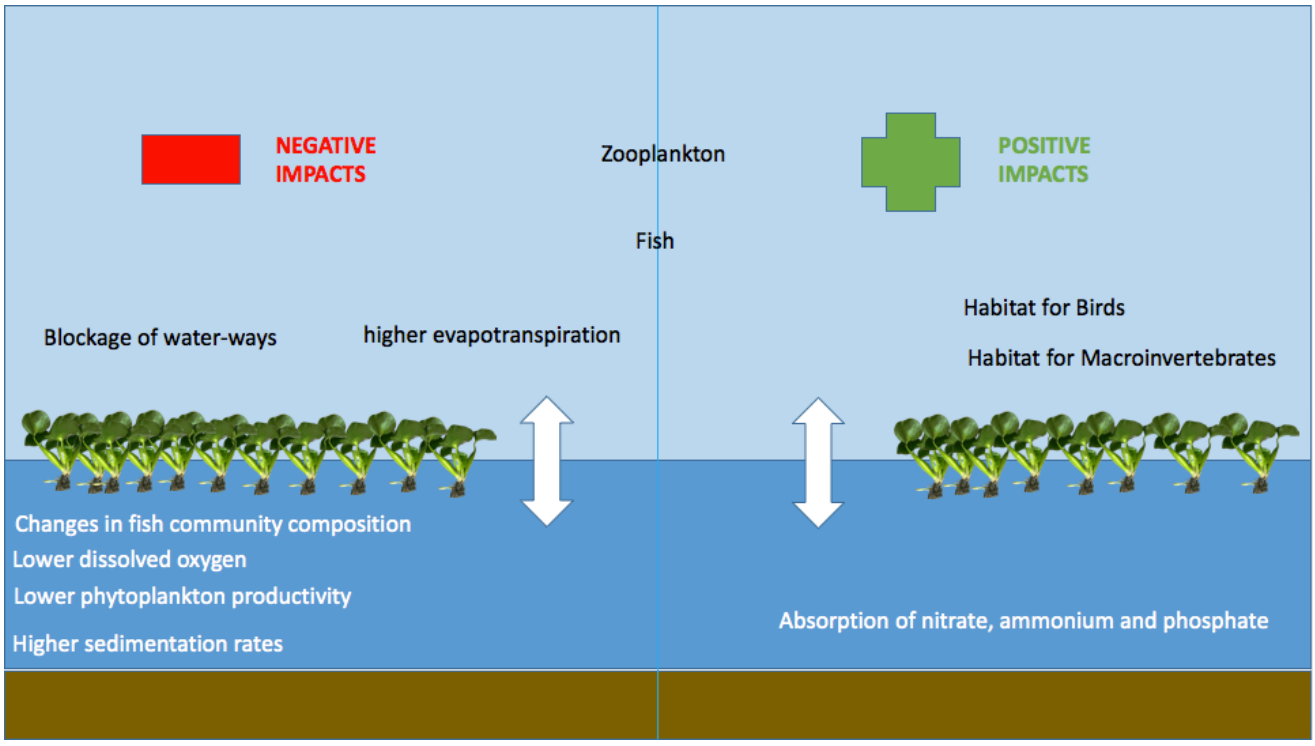


Figure.21-Negative and Positive Impacts of Water Hyacinth

List of identified Negative and Positive Environmental and Socio-Economic impacts of Water-Hyacinth on Lake Tana's Biosphere Reserve:

Environmental impacts of Water-Hyacinth	
Positive	Negative
Habitat for birds.	Diminution of water flow.
Habitat for macroinvertebrates.	Obscuration of water surfaces decreasing photosynthesis activity.
Absorption of Nitrate, Ammonium and phosphate and heavy metals.	Increase evapotranspiration.
/	Oxygen depletion and reduced water quality (hypoxia).
Zooplankton, fish	
Socio-Economic impacts of Water-Hyacinth	
/	Economic impact.
/	Blockage of waterways hampering agriculture, fisheries, recreation and hydropower.
/	Dispersion of infectious diseases acting as a breeding ground for pests and vectors such as mosquitoes causing malaria as well as species of snail responsible for schistosomiasis (bilharzia or snail fever)

7.3-Potential Environmental Impacts and Mitigation Measures

Harvesting

At the harvesting level, there is an interaction between water-hyacinth and certain (habitat) functions allocated to water hyacinth that can be disrupted especially for birds and macro-invertebrates. However, the general consensus on the mitigation of negative impacts and potential threats to the global ecosystem of Lake Tana remain a priority.

Transforming

- Organic Agro-Fertilizer: No specific impact is yet identified. It will remain important to advocate for clean mechanisms of production.

- Bio-Fuel: No specific impact is yet identified. It will remain important to advocate for clean mechanisms of production.

Use

- Organic Agro-Fertilizer: No negative impact is yet identified. The major positive impact resides in the mechanism of reduction of "excess" nutrients from chemical fertilizers that are causing hyper-eutrophication on the lake. This effect will materialize id the use of organic agro-fertilizer is widely spread. Reduce the amount of water required for production.

- Bio-Fuel: No negative impact is yet identified. Environmentally, bio-fuel will mainly help reduce GHG emissions. It will also reduce the stress on agricultural crops for bio-fuel.

7.4- Potential Socio-Economic Impacts

Harvesting

The harvesting activity is a source of income for local populations. Reduce the conflict with land use and agriculture crops for bio-fuel

Transforming

- Organic Agro-Fertilizer: If the projections are accurate it will significantly contribute to Ethiopia's GDP. Reduce dependency on imports.

- Bio-Fuel: If the projections are accurate it will significantly contribute to Ethiopia's GDP. Reduce dependency on imports.

- Other: Other applications: Pigment, crude protein, animal feed, craft, bio-gas, distilled water…

Use

- Organic Agro-Fertilizer: Contribute to an increase in productivity. (To be determined). Carbon credits.

- Bio-Fuel: Reduce the dependency on fuel imports. Carbon credits.

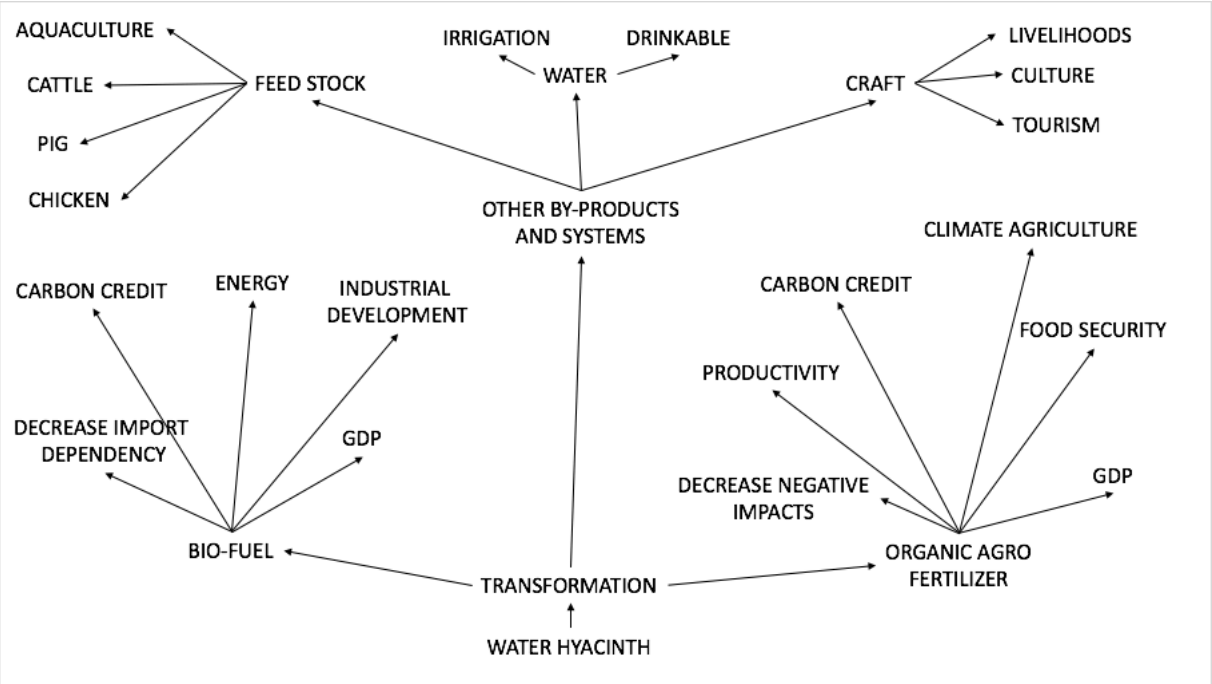


Figure 22. Vision Report.

VIII-Environmental and Socio-Economic Management Framework (ESEMF)

8.1-Introduction

Acting as a complementary instrument to Environmental and Social Impact Assessment (ESIA), the Environmental and Socio-Economic Management Framework (ESEMF) aims at constructing the factual elements supporting the financial relevance of water hyacinth for organic agro-fertilizer and bio-fuel program. The Environmental and Socio-Economic Management Framework (ESEMF) focuses on estimating the implementation principles, capacity building, technical and environmental management. ESEMF will also issue the recommendations to enhance long-term economic sustainability, innovation and performance. The ESEMF outlines the principles of implementation as a system inclusive of ESIA concerns and applications. The assessment will use the framework given by the ten (10) components identified to provide the data.

8.2 Component 1

Component 1: What are the identified dynamics of water-hyacinth on Lake Tana and their impact?
The identified dynamics and induced impact are rather preoccupying for Lake Tana's integrity. Water hyacinth impacts the Lake's ecosystem and near communities through: - An increase in evapotranspiration (reduction of water potential) - Blocks water-ways - The depletion of oxygen in water impacts negatively biodiversity at large - Reduce fish stock and diversity - Vector for infectious diseases - Significant negative impact on agriculture, fisheries, recreation and hydropower. By extension, it is important that this study serves as a warning to Ethiopian authorities, in the sense that the presence of water hyacinth could already be dormant in the area of the Ethiopian Renaissance Dam, causing harm to Ethiopia's project and electricity production capacity. Water-hyacinth's development and growth is intertwined with external dynamics such as erosion, extensive agriculture, water-body fluctuations, transport of nutrient through ground water…

Component 1: What are the possible remediation?
The possible remediation resides in the capacity to provide industrial means of collection and transformation of water-hyacinth. A system needs also to be implemented in the different catchment areas where intensive agriculture is performed. Acting as a mitigation instrument, organic agro-fertilizer will progressively contribute to the reduction of nutrient exchanges between these catchment areas and the Lake.

8.3- Component 2

Component 2: What is at stake for Ethiopia in terms of development and economic growth?
Water-hyacinth represent a significant value for investment in many capacities. The most productive value identified would be organic agro-fertilizer. Bio-fuel could also significantly contribute to Ethiopia's GDP. A complementary element resides in the alternative given to some decisions that might be limited by climatic change as well as financial requirements. The use of water-hyacinth as a substitute to sugar-cane and other agricultural crops for bio-fuel would create less conflicts of interest and potential negative impacts on land and water quality.

Component 2: Do agriculture and energy have conflicting goals?
Water and its accurate management being at the center of the system regulating agriculture and energy production naturally will generate conflicts between the two sectors. The stress applied on Lake Tana representing 50% of Ethiopia's fresh water capital, independently from Water-hyacinth presence, remain highly problematic as other relevant phenomena are also deeply impacting the lake such as water clarity, over sedimentation, eutrophication …. A great alternative for Agriculture would be to use the pure water extracted from water hyacinth during transformation. This water would not be claimed from the Lake but rather from the plant.

Component 2: What could be water-hyacinth's contribution?
Several products have been identified in the study, it is true that organic agro-fertilizer and bio-fuel are the top two values, but other products related to animal stock, drinking water and craft should be introduced in the program as sustainable socio-economic mechanisms targeting the populations surrounding Lake Tana. These products could represent a popular commodity for the tourism industry.

8.4- Component 3

Component 3: Does the Institutional Policies and Regulations Framework (IPRF) is fully adapted to the harvest and transformation of water hyacinth into bio-fuel and organic agro-fertilizer?
A major gap has been identified in the Biological Diversity Convention as invasive species are only considered through control and eradication. Water hyacinth is not identified or part of inclusion processes at the Ethiopian national level, however the framework given by the CRGE is favorable to such developments. At the continental level, the Abuja Declaration could also serve as a productive platform but Ethiopia needs to be part of it.

8.5-Component 4

Component 4: What are the implications of paradigmatic change for the Lake Tana Biosphere Reserve and Ethiopia?
The implications of paradigmatic change are mainly economic while remaining highly related to environmental concerns. The contribution to Ethiopia's GDP would be tremendous if the projections are accurate. If Ethiopia is capable of developing its own technology it could move to support other neighboring countries such as Kenya and Tanzania as well as other southern African countries (South Africa, Malawi…) that are negatively impacted with water-hyacinth.

8.6- Component 5

Component 5: What are the principles of utilization and transformation of water-hyacinth into organic agro-fertilizer?
The production of organic agro-fertilizer is regulated by chemical factors. The amount of water(moisture) in the plant needs to be extracted accordingly to the processing mechanism that would be chosen to produce the fertilizer. The chemical composition of water-hyacinth makes it favorable. The process can be accelerated by micro-organisms and technology. The best practice would be to avoid open air fermentation and control it in tanks. The use of organic agro-fertilizer is determined by the final product. The fertilizer can be produce in different format: liquid, compost, pelletized. Each method has inherent spreading principles and proportioning. Scientific data will have to be produce to validate the impact of organic agro-fertilizer on crops and land quality.

Component 5: How much organic agro-fertilizer can be produced with Lake Tana's water-hyacinth?
According to the projection: • Standard density for 1 hectare of water hyacinth: between 300 and 442 tons/hectare.

- Annual productivity of between 930 and 2,900 tons per hectare.
- The number of water hyacinth plants doubled every 11.2 to 15 days (makes 26 cycles per year)[57]

- The potential of lake Tana is 50 000 hectares with a renewal capacity of approximately 26 cycles per year

Let's estimate that for the organic agro-fertilizer we keep 6% water in the plant (4% of dry mass); and while we will never be able to harvest 50 000 hectares we can potentially produce:

50 000 ha x 3000 T/ha (low value per year) x 26 number of reproducing cycles/year =
150 000 000 x 26 = 3 900 000 000

10% (4% dry mass + 6% wet mass): 390 000 000 tons

What is the global need for Nitrogen fertilizer?

According to FAO "*In 2018, Africa will demand 4.1 million tons, Europe 15.7 million tons, the Americas 23.5 million tons and Asia 74.2 million tons. Even though overall fertilizer use in sub-Sahara Africa is projected to grow at a 4.7 percent annual pace, the fastest in the world, Africa will remain a major exporter of nitrogen, providing an additional 3.4 million tons to the global balance.*"[58]

Global need in millions of tons: 4.1+15.7+23.5+74.2=117,5 millions of tons

Lake Tana produces then: 95 times the need of the African Continent.
: 3.3 times the global need.

The issue with the projection is that it is understood a one static entity rather than an evolving one. It simplifies the understanding but would not be accurate in real life. However, to the defense of this default option it is based on factual information.

[57] L. Lareo, "Crecimiento de Jacinto de Agua (Eichhornia crassipes (Mart) Solms Laubach), en el Tropico," Arch. Latinoamer. Nutr., 31: 758 (1981).
[58] FAO, Fertilizer Use to Surpass 200 Million Tonnes in 2018:
http://www.fao.org/news/story/en/item/277488/icode/

8.7- Component 6

Component 6: What are the environmental and socio-economic impacts of harvesting water hyacinth towards organic agro-fertilizer within UNESCO's Lake Tana biosphere reserve?		
Potential Environmental Impacts	Harvesting	At the harvesting level, there is an interaction between water-hyacinth and certain (habitat) functions allocated to water hyacinth that can be disrupted especially for birds and macro-invertebrates. However, the general consensus on the mitigation of negative impacts and potential threats to the global ecosystem of Lake Tana remain a priority.
	Transforming	No specific impact is yet identified. It will remain important to advocate for clean mechanisms of production.
	Use	No negative impact is yet identified. The major positive impact resides in the mechanism of reduction of "excess" nutrients from chemical fertilizers that are causing hyper-eutrophication on the lake. This effect will materialize id the use of organic agro-fertilizer is widely spread. Reduce the amount of water required for production.
Potential Socio-Economic Impacts	Harvesting	The harvesting activity is a source of income for local populations.
	Transforming	If the projections are accurate it will significantly contribute to Ethiopia's GDP.

		Reduce dependency on imports.
	Use	Contribute to an increase in productivity. (To be determined). Carbon credits.

Component 6: What are the identified eco-systemic benefits?
The eco-system benefits are obtained by progressively diminishing the amount of water-hyacinth on the Lake. This objective can be enhanced if preliminary resolutions are taken to act on the use of chemical fertilizer within catchment area and agricultural land in general. Other phenomena such as sedimentation and water clarity require to be studied as they contribute to the degradation of the Lake's ecosystem.

Component 6: What is the economic valuation and potential impact?
Scenario 1 If the average price per ton for Anhydrous Ammonia is US$720[59] The potential value of transforming water hyacinth into organic bio-fertilizer on Lake Tana as a substitute for Anhydrous Ammonia is estimated at US$280 800 000 000 (without cost of transformation). Scenario 2 f the average price per ton for MOP is US$456[60] The potential value of transforming water hyacinth into organic bio-fertilizer on Lake Tana as a substitute for MOP is estimated at US$177 840 000 000 (without cost of transformation).

8.8- Component 7

Component 7: What are the principles of utilization and transformation of water-hyacinth into bio-fuel?
Bio-fuel is obtained from ligno-cellulosic biomass by the extraction of lignin (cell wall

[59] Averages and Seasonality of Prices for Nitrogen Fertilizers, Gary Schnitkey, Department of Agricultural and Consumer Economics, University of Illinois *farmdoc daily* (6):65 : http://farmdocdaily.illinois.edu/2016/04/averages-and-seasonality-of-prices-nitrogen.html

[60] http://marketrealist.com/2016/02/update-npk-fertilizer-price-trends/

polymer) from water-hyacinth under mild conditions and with minimal loss of polysaccharides[6162].The success of lignocellulosic bioethanol will depend on the development of simple pretreatment technologies that effectively delignifies a diverse portfolio of lignocellulosic biomass feedstocks. Reducing the enzyme cost while enhancing cellulose hydrolysis efficiency is another important consideration when developing suitable pre-treatment technologies[63] [64]. The last step of the process is a simultaneous saccharification and fermentation resulting in the final product: bio-ethanol.

Component 7: How much bio-fuel can be produced with Lake Tana's water-hyacinth?

According to the projection:

The postulate will be to transform or convert 1 ton of dry water-hyacinth (ligno-cellulosic biomass) into make 500 liters of bio-fuel

- Standard density for 1 hectare of water hyacinth: between 300 and 442 tons/hectare
- Annual productivity of between 930 and 2,900 tons per hectare
- The number of water hyacinth plants doubled every 11.2 to 15 days (makes 26 cycles per year)[65]

- The potential of lake Tana is 50 000 hectares with a renewal capacity of approximately 26 cycles per year

50 000 ha x 3000 T/ha (low value per year) x 26 number of reproducing cycles/year =
150 000 000 x 26 = 3 900 000 000

If we have 3 900 000 000 tons of wet mass available; 96% of the plant is constituted of water

[61] Limayem A, Ricke SC. Lignocellulosic biomass for bioethanol production: current perspectives, potential issues and future prospects. Prog Energ Combust Sci. 2012;38: 449–67.

[62]Brijwani K, Oberoi HS, Vadlani PV. Production of a cellulolytic enzyme system in mixed-culture solid-state fermentation of soybean hulls supplemented with wheat bran. Process Biochem. 2010; 45:120–8.

[63] Verardi A, De Bari I, Ricca E, Calabrò V. Hydrolysis of lignocellulosic biomass: current status of process and technologies and future perspectives. Intechopen; 2011.

[64] EI-Naggar NEA, Deraz S, Khalil A. Bioethanol production from lignocellulosic feedstocks based on enzymatic hydrolysis: current status and recent developments. Biotechnology. 2014;13:1 –21.

[65] L. Lareo, "Crecimiento de Jacinto de Agua (Eichhornia crassipes (Mart) Solms Laubach), en el Tropico," Arch. Latinoamer. Nutr., 31: 758 (1981).

The dry mass available is 156 000 000 tons

Transformation of dry mass into bio-fuel: 156 000 000 / 2 = 78 000 000 litters of bio fuel.

Two options are given depending on the type of bio-fuel produced it could either be used directly by cars (bio-diesel) or planes (bio-kerosene), or be blended with conventional fuel

The issue with the projection is that it is understood a one static entity rather than an evolving one. It simplifies the understanding but would not be accurate in real life. However, to the defense of this default option it is based on factual information.

8.9- Component 8

Component 8: What are the environmental and socio-economic impacts of harvesting water hyacinth towards bio-fuel within UNESCO's Lake Tana biosphere reserve?

Potential Environmental Impacts	Harvesting	At the harvesting level, there is an interaction between water-hyacinth and certain (habitat) functions allocated to water hyacinth that can be disrupted especially for birds and macro-invertebrates. However, the general consensus on the mitigation of negative impacts and potential threats to the global ecosystem of Lake Tana remain a priority.
	Transforming	No specific impact is yet identified. It will remain important to advocate for clean mechanisms of production.
	Use	No negative impact is yet identified. Environmentally, bio-fuel will mainly help reduce GHG emissions. It will also reduce the stress on agricultural crops for bio-fuel.
Potential Socio-Economic Impacts	Harvesting	The harvesting activity is a source of income for local populations.
	Transforming	If the projections are accurate it will significantly contribute to Ethiopia's GDP.

		Reduce dependency on imports.
	Use	Reduce the dependency on fuel imports. Carbon credits.

Component 8: What are the identified eco-systemic benefits?
The eco-system benefits are obtained by progressively diminishing the amount of water-hyacinth on the Lake. Other ecosystem benefits can be obtained by extension by avoiding the use of agricultural crops for bio-fuel.

Component 8: What is the economic valuation and potential impact?
Scenario 1: 1 liter of bio fuel (ethanol E85) costs 0,85€/liter[66] The potential value of transforming water-hyacinth into bio-fuel is estimated at 66 300 000 euros (without cost of transformation) Scenario 2: 1 liter of bio-kerosene (Bio Jet fuel) costs on Monday August 22nd 2016: US$1.20[67] The potential value of transforming water-hyacinth into bio-kerosene (Bio Jet fuel) is estimated at 93 600 000US$ (without cost of transformation) The informed quantity of fuel imports for Ethiopia is estimated at 1,093, 073 metric tons.[68]

8.10- Component 9

Component 9: What are the principles of project management, ownership and partnership?
Lake Tana's Biosphere Reserve implies the conversation of government and non-government organization (NABU) in the constitution of sustainable development program. The interest would be to provide the accurate capacity building content to NGO and

[66] Price of Ethanol E85: https://ethanol-e85.fr/prix_ethanol_E85.html
[67] Price of Bio Jet Fuel: http://www.kic-innoenergy.com/wp-content/uploads/2016/03/RREB_Biofuels_in_Aviation_Draft_Final.pdf
[68] http://www.sudantribune.com/spip.php?article46020

communities involve in the UNESCO Biosphere frame. These activities could be planned accordingly to zonation, policies and regulations; and be at the cross roads between mechanisms of conservation and sustainable development. By providing products such as animal feed a new set of activities could also be launched in the periphery of Lake Tana and supply other locations nationwide as well. Water for irrigation and drinkable water are also significant contribution to the enhancement of socio-economic conditions. The transformation of water-hyacinth by products in craft is also an added value to the touristic appeal of Lake Tana.

Here is an extensive list of potential activities: paper, fiber board, yarn and rope, basket work, charcoal briquetting, biogas, water purification, animal fodder, fish feed, pig feed…

8.11- Component 10

Component 10: What are the principles of project management, ownership and partnership?
Under the auspices of the Ministry of Water, Irrigation and Energy, the larger Ethiopian scientific community could benefit from researching and monitoring the harvesting of water hyacinth and assess its impacts on the lake ecosystem and communities. I would recommend to invite regional scholars in order to tackle other zone such as Lake Victoria and the Zambezi river.

IX-Report

Components	Questions	Status
Component 1	• What are the identified dynamics of water-hyacinth on Lake Tana and their impact?	
	• What are the possible remediation?	
Component 2	• What is at stake for Ethiopia in terms of development and economic growth?	
	• Do Agriculture and Energy have conflicting goals?	
	• What could be water-hyacinth's contribution?	
Component 3	• Does the Institutional Policies and Regulations Framework	

	(IPRF) is fully adapted to the harvest and transformation of water hyacinth into bio-fuel and organic agro-fertilizer?	
Component 4	• What are the implications of paradigmatic change for the Lake Tana Biosphere Reserve and Ethiopia?	
Component 5	• What are the principles of utilization and transformation of water-hyacinth into organic agro-fertilizer?	
	• How much organic agro-fertilizer can be produced with Lake Tana's water-hyacinth?	
Component 6	• What are the environmental and socio-economic impacts of harvesting water hyacinth towards organic agro-fertilizer within UNESCO's Lake Tana biosphere reserve?	
	• What are the identified eco-systemic benefits?	
	• What is the economic valuation and potential impact?	
Component 7	• What are the principles of utilization and transformation of water-hyacinth into bio-fuel?	
	• How much bio-fuel can be produced with Lake Tana's water-hyacinth?	
Component 8	• What are the environmental and socio-economic impacts of harvesting water hyacinth towards bio-fuel within UNESCO's Lake Tana biosphere reserve?	
	• What are the identified eco-systemic benefits?	
	• What is the economic valuation and potential impact?	
Component 9	• What are the principles of project management, ownership and partnership?	
Component 10	• What are the principles of project management, ownership and partnership?	

Codes		Component fully validated		Component partially validated

X-Conclusion

This feasibility study intended to provide a comprehensive portray of water-hyacinth's biology and challenges on Lake Tana while contributing to the paradigmatic shift of considering the plant as an opportunity rather than a threat. The impact assessment revealed the complexity of managing water-hyacinth on Lake Tana. The causality of water-hyacinth development is also complex as external factors come to play, among them, sedimentation and nutrient transfer through ground-water. These factors increase the quantity of nutrients in the lake and produce eutrophication and stimulate the growth of water-hyacinth.

The critical role of the Lake with regards to Ethiopia's economy needs to be approach with care as the lake also plays a critical role with regards to agriculture (irrigation) and energy (hydropower). The analysis revealed that conflicting interest might appear as the demand increase.

The economic projections have identified the potential economic valuation related to the production of bio-fuel as well as organic agro-fertilizer:

-Scenario 1: The potential value of transforming water-hyacinth into bio-fuel is estimated at 66 300 000 euros (without cost of transformation).

-Scenario 2: The potential value of transforming water-hyacinth into bio-kerosene (Bio-jet fuel) is estimated at US$ 93 600 000 (without cost of transformation).

-Scenario 1: the potential value of transforming water hyacinth into organic bio-fertilizer as a substitute for anhydrous ammonia on Lake Tana is estimated at US$280 800 000 000 (without cost of transformation).

-Scenario 2: The potential value of transforming water hyacinth into organic bio-fertilizer on Lake Tana as a substitute for MOP is estimated at US$177 840 000 000 (without cost of transformation).

The paradigmatic change induced by the study, approached the environmental and economic potential of transforming water-hyacinth into bio-fuel and organic agro-fertilizer. The projections revealed a high economic potential as bio-fuel might help Ethiopia to save on fuel imports and so reduce its fuel vulnerability; on the other hand, the case of organic agro-fertilizer becomes critical to analyze as it might modify agricultural behaviors worldwide and by extension contribute to Ethiopia's economic development.

Ethiopia's Gross Domestic Products (GDP) was estimated in 2015 at 61,54 Billion US Dollars, depending on the production and sale of water-hyacinth based organic agro-fertilizer, the country could potentially triple (2.9 for the minimal value) its GDP. This projection results from a simplification over the potential quantification of water-hyacinth based organic agro-fertilizer, one can envision that the pattern would be different in time due to production capacity but still remain significant for the Ethiopian Economy.

It is also important to note that the harvest and transformation of water-hyacinth might also mitigate the stress over conventional crops for bio-fuel, as planned by the Ethiopian Government. Nevertheless, the Institutional Policies and Regulations Framework (IPRF) highlighted the favorable frame considering the harvesting and transformation of water hyacinth as qualifying within the SDGs framework. The analysis of the 2010 Convention on Biological Diversity revealed that a necessary re-orientation towards transformation needed to introduced. The adhesion to the Abuja Declaration might contribute to support Ethiopia's endeavor towards organic agro-fertilizer.

It is critical to use this study also as warning towards the potential dispersion of water-hyacinth on the Blue-Nile and the catastrophic incidence it might have on the Ethiopian Renaissance Dam.

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