THE REPUBLIC OF UGANDA
Ministry of Water and Environment.

Forestry and Macroeconomic Accounts of Uganda:

The Importance of Linking Ecosystem Services to Macroeconomics

May 2018

UN-REDD PROGRAMME
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Authors:
Dr. Thierry De Oliveira
UN Environment
thierry.oliveira@un.org

Dr Jackie Crafford, Mr Nuveshen Naidoo, Mr Valmak Mathebula, Mr Joseph Mulders,
Ms. Dineo Maila and Mr Kyle Harris

Prime Africa, South Africa
j.crafford@primeafrica.net

Preamble and Acknowledgements

This report summarises work conducted by the Uganda UN-REDD+ National programme during 2017 to guide the development of policy instruments for the Government of Uganda in order to evaluate the contribution of forests to the economy. The work conducted comprised economic modelling and analysis with the purpose of valuing the benefits of forest ecosystem services. The preliminary results presented here have not been verified by the Uganda Bureau of Statistics (UBOS) and the National Forestry Authority (NFA), hence the ecosystem service valuations and policy recommendations are subject to change.

The work was highly reliant on data collection within Uganda. The UN-REDD+ National Programme, United Nations Development Programme, UN Environment, the Uganda REDD+ secretariat and the authors wish to sincerely thank the Government departments and agencies as well as the Civil Society organizations which contributed to and supported this study. Special recognition goes to the team from the Uganda Bureau of Statistics, who provided valuable guidance and inputs during the study.

This study would not have been possible without the support of the staff from the IUCN Uganda country office, who coordinated and steered this study on behalf of UN Environment.

This document is accompanied by a set of integrated environmental economic accounts, both in the form of a transparent set of Excel spreadsheet tables and a policy modelling tool.

Contents

Acronyms And Abbreviations

a	Annum
AfDB	African Development Bank
CRS	Cross River State
ES	Ecosystem Service(s)
ESV	Ecosystem Service Valuation
FAO	Food and Agriculture Organisation of the United Nations
FEGS-CS	Final Ecosystem Goods and Services Classification System
FRA	Forestry Resource Account
GDP	Gross Domestic Product
GEF	Global Environmental Facility
ha	Hectares
ha/a	Hectares per Annum
M	Million
m	meters
MAI	Mean Annual Increment
MEA	Millennium Ecosystem Assessment
NTFP	Non-Timber Forest Products
SCBD	Secretariat of the Convention on Biological Diversity
TEEB	The Economics of Ecosystems and Biodiversity
UNEA	United Nations Environment Assembly
UN-REDD+	United Nations Program on Reducing Emissions from Deforestation and Forest Degradation

Glossary / Definitions

Forest[1]	Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO 2015).
Other Regenerated Forest[1]	Naturally regenerated forest where there are clearly visible indications of human activities (FAO 2015).
Plantations[1]	Forest predominantly composed of trees established through planting and/or deliberate seeding (made up of forest plantation and Teak/Gmelina plantations) (FAO 2015).
Primary Forest[1]	Naturally regenerated forest of native species where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed (FAO 2015).
Forest Ecosystem Services	The set of benefits that forests of different types produces and that provides benefits to the economy of a country, in this case Uganda (MEA 2005, TEEB 2013).
Provisioning Services	Products obtained from ecosystems, e.g. fresh water, food, fibre, fuel, genetic resources, biochemical, natural medicines and pharmaceuticals (MEA 2005).
Regulating Services	Benefits obtained from the regulation of ecosystem processes, e.g. water regulation, erosion regulation, water purification, waste regulation, climate regulation and natural hazard regulation (e.g. droughts, floods, storms) (MEA 2005).
Cultural Services	Non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, e.g. cultural diversity, knowledge systems, educational values, social relations, sense of place, cultural heritage and ecotourism (MEA 2005).
Supporting Services	Services necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. Some services, like erosion regulation, can be categorised as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people. Supporting services include primary production, nutrient cycling and water cycling (MEA 2005).

[1]Definition as per classification used for spatial analysis.

Executive Summary

A key resolution adopted at UNEA-2 in Nairobi in May 2016 is entitled 'Sustainable management of natural capital for sustainable development and poverty eradication.' Under this resolution it is specifically noted that natural capital and natural resource valuation and accounting mechanisms can help countries to assess and appreciate the worth and full value of their natural capital and to monitor environmental degradation. UN Environment has conducted a number of natural capital and natural resource valuation and accounting studies in various African countries since 2011, including Kenya, Gabon, Morocco, Cote d'Ivoire, Nigeria, and in this study, Uganda.

The purpose of this study is to analyse the economic value of Uganda's forest resources, where possible, and demonstrate some policy instruments that would alleviate pressure on these natural forest systems. The methodology followed to conduct this analysis includes:

1. Development of a Forestry Resource Account (FRA) for Uganda's forest ecological infrastructure;
2. Ecosystem Service Assessment (ESA) mapping of socio-economic benefits provided by forest resources;
3. Valuation of ecosystem services and linking these to the macro-economic situation in Uganda; and
4. Testing of some policy instruments aimed at combating deforestation.

By understanding the relationship between the socio-economic climate and the contribution by ecosystem services by using market value linkages as a valuation approach, the study allows for better informed decision making that would both protect and stimulate the benefits received by forests rather than limit them.
The features of these studies have much commonality in the sense that they all deal with problems of deforestation and forest degradation, and they all include forest resource accounting, forest ecosystem services valuation and a contextualisation of forest values within the respective national economies of the respective countries.

However, the results of the different studies vary starkly, with the resultant policy response requirements equally so. The case of Uganda is highly unique because of the scale of deforestation. From 1990 to 2015, the NFA estimates that forest area in Uganda has decreased from 4.9 million ha to less than 2.0 million ha. This is a rapid and severe rate of deforestation, equivalent to an annual average forest cover loss of 120,000 ha/a. Deforestation results from a range of cumulative effects fundamentally driven by the immediate availability of woody biomass in the form of timber, fuelwood and construction timber; and the opportunity to acquire land for significantly higher agricultural returns. Together, these drivers comprise a considerable economic incentive for deforestation.

The costs of deforestation are however borne by sectors elsewhere in the economy. The forest ecosystem services of Uganda's natural ecosystems are important production factors to various economic sectors. Thus,

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Glossary / Definitions

deforestation reduces the productive capability of the economy in the immediate term. In the long term, larger risks, associated with reduction in system resilience, is possible. And ultimately natural capital wealth is lost to future generations.

The timber provisioning service is, as expected, the single largest ecosystem service at a value at 1,315,892 UGS/ha (in 2015). The NFA data and the rate of deforestation shows however that this harvest is unstainable. Thus, as deforestation proceeds, losses of other forest ecosystem services occur. The value of these ecosystem services lost includes gathering of non-timber forest products (NTFP), carbon losses and habitat provision at 149,000, 513,000 and 710,000 UGS/ha respectively. The health service, resulting from regulating malaria incidence is as large as the timber provisioning service at 1,131,000 UGS/ha while the other (still highly significant) services display values below 13,000 UGS/ha (these include water provisioning, water yield available for hydro-power generation,

effects on aquaculture and inland fishing and natural disaster mitigation by tropical forests. Although these values are derived through forest use, the unsustainable exploitation thereof and subsequent deforestation results in a net loss to the economy of Uganda.

These losses will continue for as long as there is a disconnect between the cost-benefit decisions made by land holders, users and other indirect role players, where the net benefit of deforestation is highly positive; and the cost-benefit ratio at a national scale, which, as demonstrated above, is highly negative.
Combating deforestation is a priority for the Government of Uganda. Thus, in order to address the unique deforestation challenges faced by Uganda, this study not only uses accounting and valuation of natural capital, but also makes significant progress towards designing and testing policy instruments that go to the heart of the country's deforestation problem (Valuation and environmental accounting are methods that allow for linkages with economic use of the environment). It is these policy instruments that seek to create the connections between landholder decision-making and the national economic impact by creating incentives for sustainable forest management.

UN-REDD+ has developed a carbon-storage based mechanism to serve as an incentive to internalise such damage into the economic system of decision-making. However, the benefits of deforestation mostly still far outweigh the benefits of carbon capture, and therefore carbon mechanism on its own is most often not sufficient to change behaviour. The value of the other forest ecosystem services adds another, and highly significant, 800% to carbon value.

When all of these values are considered, and assuming that suitable payments for ecosystem services measures could be found, these values would provide suitable incentives to change deforestation behaviour. However, payments for ecosystem services projects are complex mechanisms and thus the Government of Uganda needs to develop and adopt a range of policy instruments that focus primarily on economic policy instruments, but that also combines with appropriate elements of regulatory and suasion instruments.

This study proposes a combination of carbon transactions, certified plantation forestry, and woodlot cultivation through value adding initiatives as a set of policy instruments to combat deforestation. These instruments need to be designed in order to also coordinate with conservation efforts of unique forest habitats. It is important to note that carbon sequestration is likely to be a positive spin-off of all these policy instruments and therefore carbon benefits may accrue in addition to other benefits.

In this investigation, an integrated forest account, forest ecosystem services valuation and macro-economic model was developed for the Government of Uganda to test the above policy instruments. The forest account was set up using best available data, sourced through extensive data collection efforts. The methodology used was based on the UN STATS division's SEEA, and the EU's methodology for economy-wide modelling (refer to the methodology appendixes at the end of this report). The base year selected was 1990, and forest accounting methodology and ecosystem services valuation methodologies were applied to estimate the cumulative effects of deforestation on the economy. The most recent years of analysis used was 2010 and 2015 respectively. The latest years for which a macro-economic model was available was 2010, while comprehensive forestry statistics was available to 2015. The analysis shows that the contribution of forests to the economy of Uganda is underestimated in the national accounts.

Furthermore, the model was set up in a transparent and user-friendly Excel format, and converted to a user-friendly policy option analysis tool.

This study demonstrates three economic policy instruments that seek to incentivise landholders to pursue sustainable forest management. These proposed policy options are not intended to be a comprehensive final set of options for Uganda, but are rather used to demonstrate how these options could work, what they would cost, to what extent they would curb deforestation and what the relative costs and benefits to the economy of Uganda would be.

The three preliminary policy options tested are:
1. Carbon trade
2. Certified plantation forestry
3. Woodlot Cultivation (Agroforestry).

Other policy options, such as eco-tourism and conservation, as well as value-adding in secondary sectors, may be formulated and tested using the accompanying spreadsheet models.

Afforestation and Carbon trade: The United Nations' REDD+ programme (reducing emissions from deforestation and degradation) intends to provide incentives for combating deforestation. It does this through paying for carbon stock protection through paying land users for actions that prevent forest loss or degradation. These transfer mechanisms include carbon trading, or paying for forest management. The source of funds can be from carbon trading, or other voluntary funds not dependent on offsets.

An offset in this case would constitute the like for like reduction of carbon emissions based on an impact resulting in increased carbon emissions. Many scenarios may be tested, but in this case we demonstrate a scenario where a pure carbon mechanism is applied to tropical forests and returns 10% of the area deforested since 1990 (i.e. 293,000 ha) to forest area through a long term forest rehabilitation programme. This scenario makes a number of critical assumptions. The results of the analysis shows that although the annual rate of deforestation would be curbed by 100% and a net positive ecosystem services value of 88,720 million UGS/annum would be returned to the economy, the net direct economic effects are positive.

Certified plantation forestry: One of the key challenges central to a successful deforestation policy instrument for Uganda relates to the productivity of land. The usable roundwood (or weighted average mean annual increment (MAI)) of the total forest estate of Uganda is estimated at 2 m3/ha/a. Planted forests in Uganda however can achieve MAIs of up to 24 m3/ha/a. Thus, a planted forest can yield up to 12 times larger yield of merchantable and usable roundwood. Although plantation forests do not produce the same forest ecosystem services as natural forests, they do enable more effective land use and thus could "free up" additional land for natural forest regeneration, while increasing timber production per hectare. Plantation forestry certification also exist which promotes sustainably and ethically produced timber products that provide assurance to markets that principles of sustainable production has been applied. Certified plantation forestry therefore provides a potential economic policy instrument as it is fundamentally driven by a higher price incentive.

Certified plantation forestry is also expected to increase timber yield, training and generally improved land management practices. In addition, price premiums may also be available for certified products. Many potential scenarios may be tested, but in this case we demonstrate a scenario which may be akin to a single large project. In this scenario a private investor establishes (by way of illustration) a plantation forest estate of 20,000 ha, comprising a fast growing species of at least 24 m3/ha/a. We further assume that the relevant authority establishes a project implementation office at a cost of 2,000 million UGS per year.

The analysis also assumes a steady state situation (sustainable use) where the economy does not exceed ecological limits (it is to be noted that plantation forestry investment is a long term investment that may take many years to mature). The output of the analysis shows that the deforestation would be reversed. The

net direct economic effects are all positive, except for fiscal effects due to the short term government spending requirement, and balance of payments.

Woodlot Cultivation: Round wood production data for Uganda shows a large reliance on fuelwood collection. Thus, in order to relieve fuelwood harvesting pressure on the natural forest estate, agroforestry focusses on fuelwood production may be an important policy instrument. Woodlot Cultivation is a well-established farming practice incorporating trees in fields, and there is scope to improve this practice to improve productivity and diversify livelihoods, especially in the production of timber for fuel use and construction. A policy instrument could be developed that promotes planting of fast-growing tree species for timber production in conjunction with other crops.

It is important to note that carbon sequestration is likely to be a positive spin-off of this policy instrument and therefore carbon benefits may accrue in addition to the agroforestry benefits. Many potential scenarios may be tested, and in this case we demonstrate a scenario which is akin to a single large project, to be implemented anywhere in Uganda. In this scenario, the relevant authority implements a large scale Agroforestry initiative comprising distribution of fast-growing, wood producing tree species accompanied by the range of additional extension services (Additional services associated with forests). It is assumed that the initiative is suitably certified as a sustainable forest management activity. The relevant authority establishes a timber-producing agroforestry estate of 50,000 ha, comprising a fast growing species of at least 18 m3/ha/a. This scenario assumes an average crop rotation of 10 years and an average timber value of 95,000 UGS/m3. We further assume that the relevant authority establishes a project implementation office at a cost of 10,000 million UGS per year. The output of the analysis shows that the deforestation would be reversed. The net direct economic effects are all positive, except for fiscal effects due to the short term government spending requirement, and balance of payments.

Other policy instruments or permutations of the above scenarios may also be developed.

The challenge for the Government of Uganda is now to ensure:

- Development of suitable policy instruments such as those demonstrated here; and
- Institutionalisation of the policy instruments; and
- Continuing a working relationship with UN-REDD+ to develop and implement suitable policy instruments as may be developed by the relevant authorities in Uganda.

Key Messages

1.	Deforestation in Uganda is continuing at a rapid rate. The most recent estimates by the FAO indicates a rate that exceeds 120,000 ha/a in forest losses, since 1990. This results in severe losses of ecosystem services. These losses are ultimately to the detriment of the economy.
2.	The key forest ecosystem services at risk, as defined by the Millennium Ecosystem Assessment, include sustainable harvests of timber and non-timber forest products, genetic resources, eco-tourism, water regulation, water purification and waste assimilation, sediment regulation and climate regulation. Changes in these ecosystem services affect the economic production in the following economic sectors: agriculture, fishing, hydropower generation, the water sector, public administration, the health sector and various sectors comprising the tourism economy. Therefore ecosystems services losses indirectly results in losses in GDP.
3.	The total losses in forest ecosystems services for the whole country was estimated at 812,755 million UGS in 2015. The total marginal value of these ecosystems services plus the sustainable timber harvest and non-timber forest products collections, was equivalent to 491,000 UGS/ha.
4.	The incentives for deforestation clearly far outweigh the value of losses in ecosystem services. Moreover, the ecosystem services losses are borne elsewhere in the economy. Uganda therefore need to develop policy instruments that appropriately internalises ecosystems services values into the economy.
5.	This study demonstrates how such policy instruments may be tested and their effects simulated. Examples included in this report include: carbon trade, certified plantation forestry and woodlot cultivation. Additional policy options, such as eco-tourism, industrialization or other options, may be designed and tested by Uganda.
6.	It is recommended that further work be conducted by the relevant authorities in Uganda to improve forest cover data and to conduct the detailed design of appropriate policy instruments. Such design should include institutional design as well as decisions on where to invest the resource rents. The reinvestment of resource rents has a large impact on the policy effectiveness.
7.	The UN REDD+ programme has a key role to play in facilitating these processes. This includes applying the carbon income to the bouquet of policy instruments.

01. Introduction

As natural features in the landscape, ecosystems provide environmental, social and economic benefits to communities. The value of ecosystems in providing these services is becoming increasingly evident and there is a growing recognition of their importance to human well-being.

Forests are ecosystems that represent almost 30% of terrestrial land cover worldwide (3 999 million ha), (Keenan et al. 2015, FAO 2015) containing 80% of all terrestrial biomass (Shvidenko et al. 2005) providing extensive benefits from a variety of ecosystem services. Primary (undisturbed natural) forests represent a third of total forests making them especially significant contributions of ecosystem services (Foley et al. 2007, Gibson et al. 2011).

Forests function as major stores of atmospheric carbon contributing to the regulation of climate change. Global forest resources with an average storage capacity of 73 tonnes per ha store approximately 292 billion tonnes of carbon (FAO 2015). The storage capacity of primary forests (24% of total) is in the order of 250 tonnes/ha, which is 82% of forest carbon worldwide.

Forests also sequestrate atmospheric carbon and given the current extent of forests, the global sequestration rate is estimated at 2.4 billion tonnes of carbon per year (Pan et al. 2011). This makes them extremely important natural ecosystems in terms of climate regulation. The impacts of accelerated atmospheric carbon on global climate patterns, has amplified the importance of the carbon sequestration and storage benefits provided by forests.

Forests further play a key role in regulating water quantity, mitigating the effects of high flows in wet periods and low flows in the dry periods (Hodgson and Dixon 1988, Wiersum 1984). Increased infiltration regenerates local aquifers and surface streams are maintained providing water resources in drier periods. Through these processes water quality is increased as it moves through these systems (GEF 2002). Additional services include the provisioning of various goods and raw materials including timber, fuelwood and other forest products (Sousson et al. 1995), biodiversity support (Aerts and Honnay 2011, Braatz 1992) and spiritual and recreational services (Barnhill 1999, Krieger 2001, Knudston and Suzuki 1992).

These highly valuable systems are however under threat globally with a loss of 3% of global forests in the last 25 years (FAO 2015). This equates to a loss of 11 billion tonnes of stored carbon. These losses are a result of deforestation and forest degradation arising from activities such as land transformation, agricultural expansion, overgrazing, over exploitation and urbanisation (SCBD 2001).

Although attributed to an increase in reporting, a silver lining is that primary forests have been seen to increase slightly (7%) over the same period (Keenan et al. 2015). It was also seen that the annual rate of net forest loss has halved since the 1990's meaning that global deforestation and forest degradation is slowing down

(Keenan et al. 2015). The net loss of forests to date however has resulted in a loss of valuable ecosystem services at a global scale.

A global program, Reducing Emissions from Deforestation and Degradation (REDD) is starting in Uganda. Derived from the 2007 United Nations Framework Convention on Climate Change, REDD seeks to address climate change through reversing rapid depletion of the world's forest resources.

REDD is crafted on the backdrop of scientific proof that deforestation releases 20% of atmospheric Green House Gases (GHGs). A swelling canopy of GHGs (with 80% from industrial emissions) holds heat which is now linked with global warming.

Reversing deforestation controls emissions but more importantly, forests are carbon sinks that clean the atmosphere by absorbing GHGs. Under REDD, resources are mobilized through multi-lateral and bi-lateral arrangements for interventions that address 'drivers' of deforestation. Uganda's REDD program is starting with funds channeled through the World Bank. With an aggregate forest cover of 120,000 ha lost annually, REDD is timely in Uganda. Some experts have been warning that at the current rate of deforestation, Uganda's forests face total annihilation by 2050! REDD's emphasis on the underlying socio-economic drivers of deforestation will complement the legal regime and enforcement mechanisms to improve our forestry sector.

The losses in forest resources have no doubt resulted in a large-scale loss of natural ecological benefits to the socio-economic wellbeing of the country. The distribution, value and extent of ecosystem services provided by Uganda forest resources have never been determined. As a rapidly growing and developing country in Africa, it is important to understand the value of the ecosystem services provided by forests at a nation scale to better optimise decision making, effective management and sustainable utilisation of these resources.

The purpose of this study is to analyse the economic value of Uganda's forest resources and demonstrate policy instruments that would alleviate pressure on these natural systems. The methodology followed to conduct this analysis includes:

1. Development of a Forestry Resource Account (FRA) for Uganda's forest ecological infrastructure;
2. Ecosystem Service Assessment (ESA) mapping of socio-economic benefits provided by forest resources;
3. Valuation of ecosystem services and linking these to the macro-economic situation in Uganda; and
4. Testing of effective policy instruments aimed at combating deforestation.

By understanding the relationship between the socio-economic climate and the contribution by forest ecosystem services by using market value linkages as a valuation approach, the study allows for better informed decision making that would both protect and stimulate the benefits received by forests rather than limit them.

Ecosystem service valuation is a process that attempts to quantify the benefits that are provided by natural ecological infrastructure. It has been illustrated above that ecosystems provide communities with a range of benefits and services of which play a large role in influencing their socio-economic wellbeing.

The valuation of ecosystems is thus performed at this socio-economic scale, demonstrating the magnitude of benefits using a common financial currency. This common currency allows for the identification and quantification of relationships between impacts on ecological infrastructure and the resulting impacts on the ability to provide natural socio-economic benefits. This financial platform provides a valuable tool for valuing ecosystem services in Uganda, allowing these relationships to better be understood, thus informing sustainable ecologically, economically and socially inclusive decision making.

It is important to note however that the results of this study, which are presented financially, are only done so to provide insights into the relationships between natural systems and the wellbeing of beneficiaries. Caution must be taken when likening the results as financial values on these systems in terms of pricing of the ecological infrastructure.

The first step in the process is to conduct a Forestry Resource Account (FRA) for Uganda. The FRA is a national and regional account of the spatial and temporal characteristics and context of the country's forest reserves. FRA development is data intensive and data is largely sourced from the National Forestry Authority (NFA) and Food and Agricultural Organisation of the United Nations (FAO), focussing on the period of 1990 to 2015 (See Annex 4).

The next step is to conduct an Ecosystem Services Valuation (ESV) (See Annex 4). This process identifies services provided by the country's forest ecological infrastructure and measures their socio-economic value to the country. Due to the close relationship between forest resources and hydrological systems, this ESV is done per water management area (See Annex 1).

A series of production functions are used to evaluate relationships between the extent of ecological infrastructure, the ecosystem services they provide and finally the benefits provided to socio-economic wellbeing of Uganda (See Annex 5). This essentially identifies the trade-offs between land uses and forestry. The forest sector and other sector production changes are captured (internalised) into an appropriate macro-economic planning model.

The resultant integrated environmental-economic model is transparent and user-friendly, and enables easy policy analysis simulations. This allows for an understanding towards informing the resource allocation and decision-making processes. Furthermore, the model is used to run a series of scenarios informing the design of policy

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instruments aimed at mitigating against deforestation and forest degradation in Uganda.

For a detailed methodological description refer to Annexes 1, 2, 3, 4 and 5.
Please note: All values in parenthesis indicates losses.

A recommendation for streamlining the analysis undertaken would be to conduct a sensitivity analysis of the full range of MAI characteristic of the most commonly grown indigenous and exotic tree species in Ugandan plantations.

02. Introduction

2.1 Overview of the Economy

Although growth has slowed, Uganda has showed remarkable resilience in achieving modest gross domestic product (GDP) growth of 4.8% in 2016. The slowdown was mainly driven by adverse weather, unrest in South Sudan, private sector credit constraints, and the poor execution of public projects. Amidst these external shocks, and as a reflection of an unrealized fiscal stimulus.

In support of macroeconomic management, the government has continued to implement large infrastructure programmes in 2016 balanced with a cautious but expansionary fiscal policy and a prudent monetary policy aimed at maintaining price, debt sustainability and exchange rate stability. The main focus has been to grow tax-to-GDP by 0.5% per annum to propel growth. However, continued institutional capacity constraints in implementing public investment projects have constrained GDP growth below the 7% full GDP potential.

In a bid to accelerate growth and make it more inclusive, Uganda has made industrial development an integral part of the government's overall development strategy in the NDP II period. Industrial sector development is at a nascent stage in Uganda. During FY 2015/16, the sector accounted for around 18% of GDP. The industrial sector remains largely dominated by manufacturing accounting for an average of 47% of GDP of sector, followed by construction (37%), electricity (6%), water (2%) and mining and quarrying (8%) during the period 2011-15. The relative share of industry and manufacturing has not changed over the last ten years. A large share of the active labour force is engaged in entrepreneurship mainly in the service sector.

Development Challenges

Uganda surpassed the Millennium Development Goals (MDGs) target 1a of halving poverty by 2015, and made significant progress in reducing the proportion of the population that suffers from hunger, as well as in promoting gender equality and empowering women. According to the Uganda Poverty Assessment, the proportion of the population living in extreme poverty (on less than $1.90 a day) fell from 62.2% in 2002/03 to 34.6% in 2012/13, representing one of the fastest reductions in poverty in Sub-Saharan Africa.

Good weather and favourable prices in international and regional markets increased real income from crops, allowing agricultural households to account for up to 79% of the poverty reduction during this period. Other key contributing factors included urbanization and education.

Notwithstanding this progress, the vulnerability to falling back into poverty is very high—for every three Ugandans who get out of poverty, two fall back in, demonstrating the fragile gains. Extreme poverty is concentrated in the north and east of the country, accounting for 84% of those living beneath the national poverty line.

Crop decreases, droughts, and price fluctuations present risks to food security. In 2016, the country experienced an acute food shortage, with up to 1.6 million people food insecure and a further 9.3 million reported to be food stressed.

Uganda is currently experiencing the fastest growing refugee crisis in the world. The country has received an average of 1,800 South Sudanese refugees daily since July 2016, and with a total refugee population of more than 1.34 million, Uganda is currently the largest host of refugees in Africa and the third-largest in the world. A UN-backed Solidarity Summit held in June 2017 has raised about $350 million, but much more is needed to effectively support the refugees and the communities hosting them.

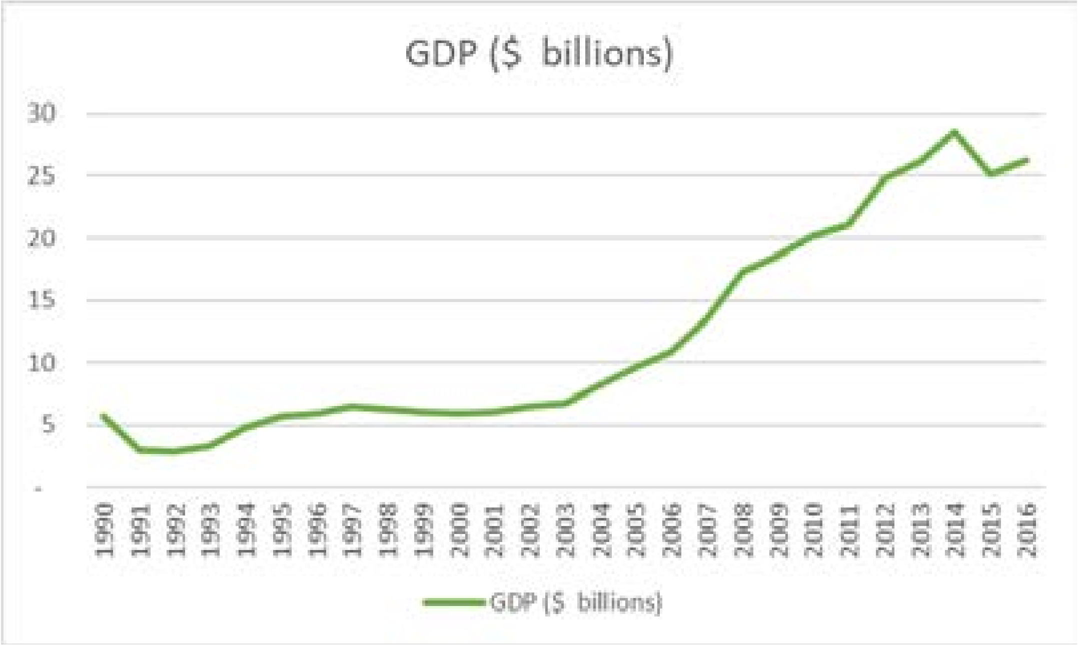

Figure 1: Growth of Uganda's Gross Domestic Product (GDP) between 1990 and 2016 (Source: World Bank)

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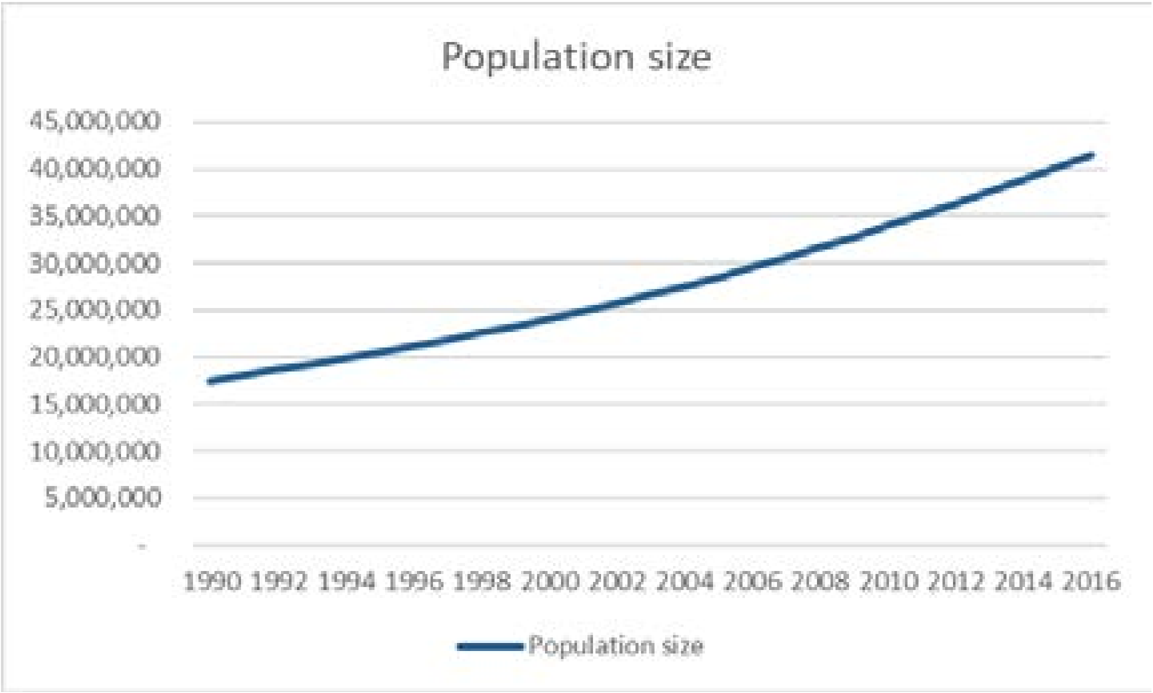

Figure 2: Growth of Uganda's population between 1990 and 2016 (Source: World Bank)

2.2 Role of Forests on the Ugandan Economy

The macro-economic and demographic trends have several impacts on the forest sector.
The commercial forest sector is small (2% of GDP (Based on value added by industries on products - 2010), about 13 times smaller than the agricultural sector. However, it must be noted that forests supply more than 1 million tons of wood charcoal per year (1.1 mil tons in 2016).

Table 2 1 Forest Sector contribution to GDP

Industry	Value (UGS Millions)	% of GDP (2010)
Logging for Timber & Poles	600205	1.58%
Logging for Firewood	845123	2.22%
Logging for Charcoal	249533	0.66%
Other Forestery Activities	8474	0.02%
Manufacture of Paper & Paper Products	93612	0.25%
Manufacture of Wood and Product of Wood, articles of straw and Cork	66071	0.17%
Construction of Buildings	88	0.0002%

Pressure on forest resources results in a reduction in forest cover, i.e. destruction of forest habitat, which in turn leads to losses of forest ecosystem services. These services include providing timber and fuelwood, medicinal plants, agricultural land, food provisioning and ecotourism. The continuous nature of these forests also support to a larger degree a range of regulating services including biological disease control, carbon sequestration, natural disaster mitigation, waste assimilation and erosion regulation. The loss of forest infrastructure directly impacts the ability of the forests to provide these natural benefits. Nevertheless, well-planned development helps to reverse forest ecosystem service losses.

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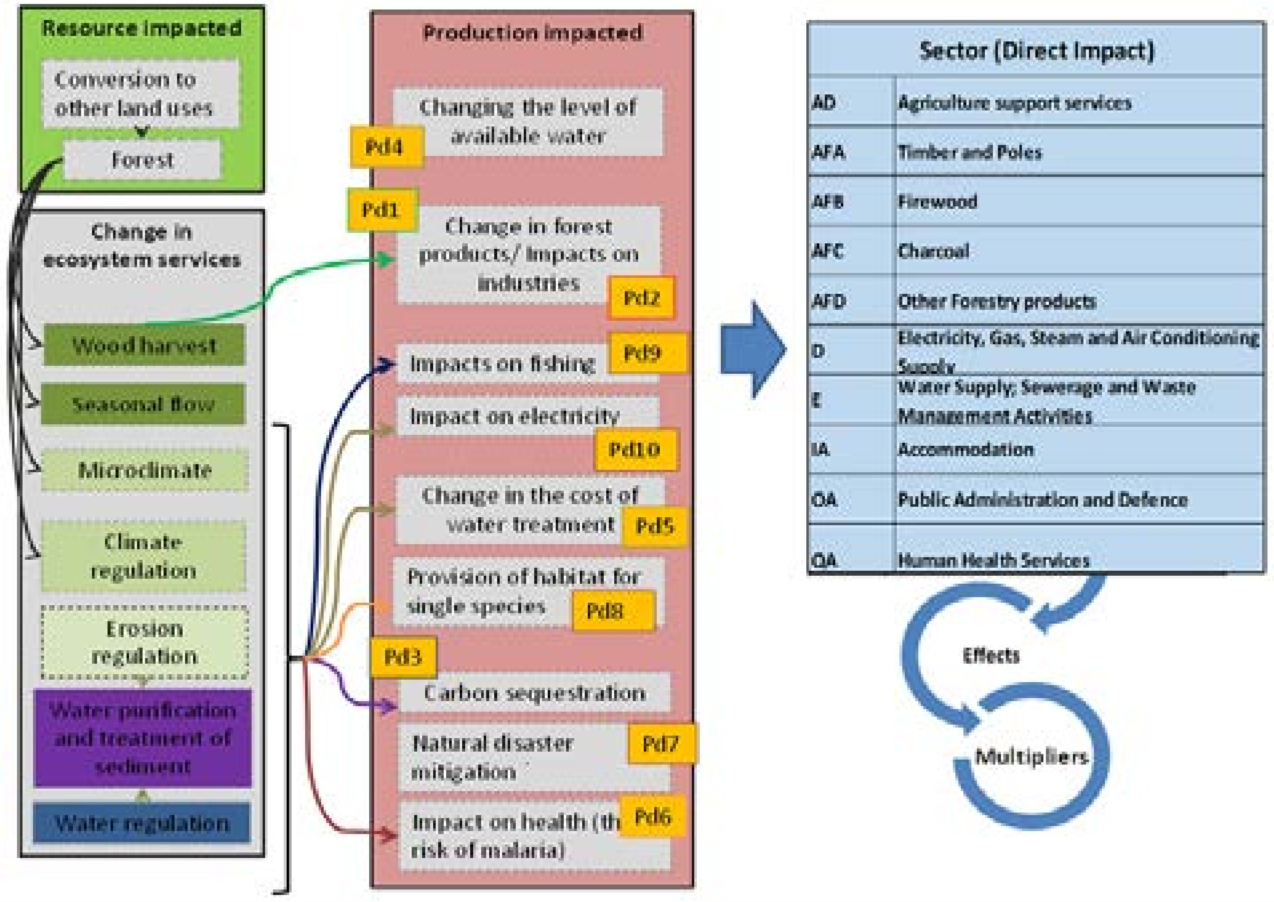

Figure 2: Growth of Uganda's population between 1990 and 2016 (Source: World Bank)

2.3 Policy Guiding Forestry in Uganda

The Uganda Forestry Policy 2001 sets out the guiding principles for forestry sector development which are reflected in the National Forest Plan core themes are conservation and sustainable development, livelihood enhancement, and institutional reform with new roles for central and local government, the private sector, local communities and NGOs .

[2] Ministry of Water and Environment. 2016. State of Uganda's Forestry 2016.

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1. Forestry on government land	The Permanent Forest Estate (PFE) under government trusteeship will be protected and managed sustainably. The main functions of the PFE include conservation of biodiversity, protection of environmental services, and sustainable production of domestic and commercial forest produce.
2. Forestry on private land	The development and sustainable management of natural forests on private land will be promoted. The main purpose is sustainable production of forest resources within the context of the wider integrated land use, and expanding agricultural needs.
3. Commercial forest plantations	Profitable and productive forestry plantation businesses will be promoted. Forest plantations may be established on private or institutional lands, either by the land owners themselves or under contract arrangements with other parties.
4. Forest products processing industries	A modern, competitive, efficient and well-regulated forest products processing industry will be promoted in the private sector.
5. Collaborative forest management	Collaborative partnerships with rural communities will be developed for the sustainable management of forests of both government and private forest lands. The purpose of this policy statement is to *"...address the disincentives associated with a protectionist approach to forest management, and the destructive practices associated with open access to forest resources"*.
6. Farm forestry	Tree-growing on farms will be promoted in all farming systems, and innovative mechanisms for the delivery of forestry advisory services will be developed.
7. Conservation of forest biodiversity	Uganda's forest biodiversity will be conserved and managed in support of local and national socio-economic development and international obligations.
8. Watershed Management	Watershed protection forests will be established, rehabilitated and conserved.
9. Urban forestry	Urban forestry will be promoted.
10. Education, training and Research	Government will support sustainable forestry sector development through appropriate education, training, and research.
11. Supply of tree seed and planting stock	Innovative mechanisms for the supply of high quality tree seed and improved planting stock will be developed.

National Forestry and Tree Planting Act (NFTPA, 2003), consolidated and operationalized the Uganda Forestry Policy (2001), the National Forest Plan (2002) and also established the National Forestry Authority (NFA) as a legal entity to manage central forest reserves (CFRs), with a goal of creating an integrated forestry sector that will facilitate the achievement of sustainable increases in economic, social and environmental benefits from forests and trees by all the people of Uganda

National Forest Plan (2002) revised in 2012. The objectives of the NFP conform to national planning framework, the Poverty Eradication Action Plan (PEAP), later replaced by the National Development Plan 1 (NDP1) and the NDP 2. The main focus of the first NFP (2002) was on the management of tree and forest resources for the economic, social and environmental benefits for all the people of Uganda, in line with the pillars of PEAP.

To this end, the NFP was designed to improve the livelihoods of Ugandans, especially those living in rural areas through raising the incomes of the poor, increasing the number of jobs and enhancing the contribution of forests to Uganda's economic development, while ensuring that the future of the country was not jeopardized in the process.

2.4 Deforestation in Uganda and its drivers

Recent years have shown a significant decrease in the Uganda's forest resources.

A key driver of deforestation and forest degradation in most African countries is agriculture. It is important to note that agriculture is an important economic sector and is crucial for ensuring food security, and it is expected that reasonable forest land areas will be converted to agriculture. Nevertheless, some optimal level of remaining forest cover would still be required to ensure sustainable forest management.

Private forests are some of the most affected areas, as owners have gained more benefits from converting these areas to farmlands than retaining them as forests. Many forests in the central region and Masindi and Hoima districts have been turned to farmlands due to their perceived fertile soils and the lure of high returns from investments in agriculture.

While in CFRs the drivers are mainly illegal charcoal burning and firewood cutting, drivers outside of CFRs include opening up land for agriculture, ranching, and settlements. The cattle corridor and the savannah woodlands of the northern region have been most affected. These are the major areas of charcoal production, supplying all urban centres as well as the neighbouring countries of Kenya, Rwanda, and South Sudan.

Increasing population has contributed to mushrooming of urban centres, and rural-urban migration. The increasing population requires more food to be produced which in turn requires opening up more land for agriculture. In many cases the search for extra land for farming results in clearing of forests or woodlands. The high population growth is also putting a lot of pressure on trees and forests for the supply of firewood and charcoal which are the main sources of energy for cooking for the majority of Ugandans. The over reliance of much of the population (approximately 96%) on biomass and the reluctance of many households to adapt energy saving technologies has raised the demand for fuelwood and the resultant destruction of forests.

The booming construction industry is one of the agents fueling illegal pitsawing that has more or less wiped out private natural forests and trees on farms. Due to the scarcity of trees for conversion into timber, pitsawyers have gone as far as cutting trees such as mangoes, jackfruit that they claim have good timber. The remaining trees in PAs are therefore under constant threat from the illegal timber dealers, who access CFRs during the night, fell trees, cut them into short billets of about seven feet and ferry them to trading centres for conversion into timber. Notorious places are Bwaise and Ndeeba in the outskirts of Kampala.

Fires are posing a very big threat to forest plantations, with tree planters incurring heavy losses every year. Even NFA's plantings in North Rwenzori and Katugo have not been spared. The effects of climate change that are being manifested in uncommonly long dry seasons lead to accumulation of dry matter in and outside plantations, conditions that cause rapid spread of fires. The absence of firefighting trucks and skilled personnel, save for the big tree planters,

compound the situation of firefighting. Many of the fires are intentionally set by herders at the onset of the dry season in order to encourage re-growth of new grass for their animals during the rainy season. Some of the fires are set by hostile communities neighbouring forest plantations in retaliation to the planters' refusal to allow them to use parts of the licensed areas to grow food crops

Habitual dry season grazing of large herds of livestock in CFRs located in the cattle corridors (Kapimpini, Kamusense, Kabwika-Mujwalanganda, Nsowe, Kalombi, Wamale, Kasagala, and Kikonda among others) and as far as South Busoga which are some of the priority forests for commercial forest plantation development, causes damage to young trees through compaction of soils, rendering them prone to erosion and nutrient loss (Kagolo, 2010). Some of the effects of this practice are manifested in crooked stems as the crop matures.

This is clearly visible in some of the plantings for Busoga Forest Company in South Busoga, and Global Wood at Kikonda which were visited by the Board of Directors of NFA in mid-2015. In order to reduce dry matter in the plantations, some licensees have requested NFA to permit them to use animals such as sheep as a form of weed control. However, in the absence of documented evidence of the practicability of such a method of weed control in Uganda, NFA has as of now declined to approve this request.

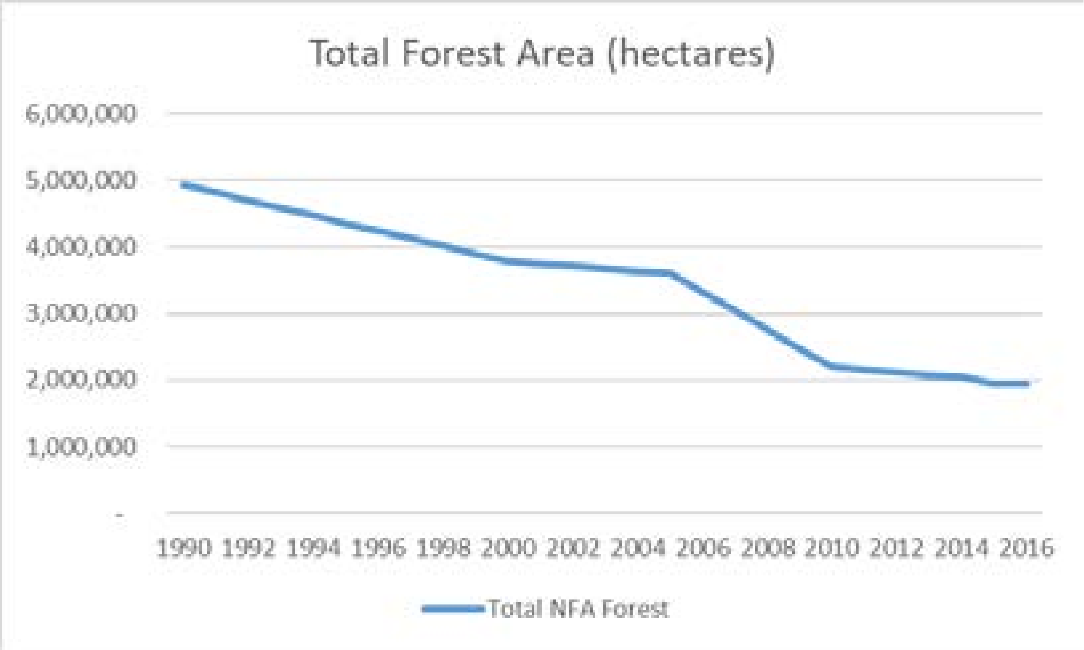

Figure 4: Ugandan forest cover and type by year (NFA 2016)

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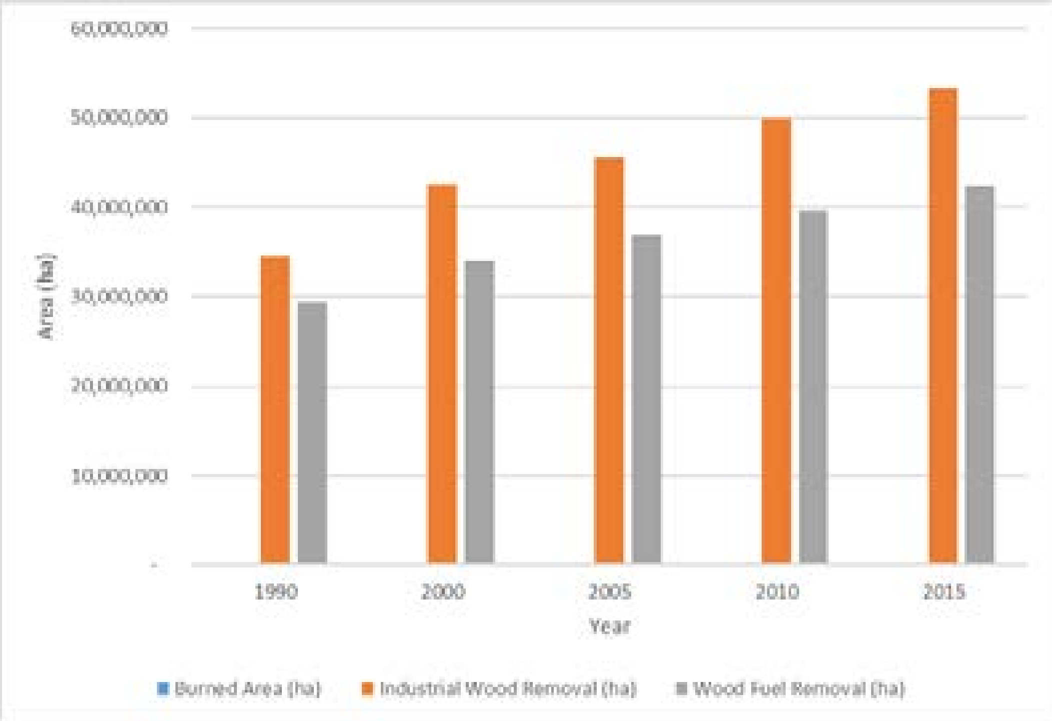

Figure 5: Direct losses to forest resources for the periods of 2000, 2005, 2010 and 2015 (FAO 2015)

2.4 Deforestation in Uganda and its drivers

Unique combination of geomorphologic, hydrologic and vegetative characteristics provide for the ecological infrastructure present in forests, allowing them to provide a range of ecosystem services. These ecosystem services are real benefits provided to people and the economy.

The Millennium Ecosystem Assessment (2005) Framework and the TEEB Assessment classify ecosystem services into four general categories: supporting (denoted by the support service provided by habitats in TEEB 2013), regulating, provisioning and cultural services.

The growth in the Ugandan economy has coincided with a loss in forest resources. The negative influence means that as land use expands (such as agriculture) and extractive activities intensify, the loss in forest extent and condition result in an indirect loss of ecosystem services and the value they provide. To ensure sustainability and understand the true cost of development, the impacts on forest systems (and their value) must be internalised into the benefits provided by developments. This will inform trade-offs between socio-economic development goals and forest loss and degradation.

The extraction of timber is by no means the primary

2.5 The impact of Deforestation on the Economy

cause of deforestation seen but can be used to illustrate where these trade-offs must be considered between direct value received (through extractive activities) and consequences on indirect value (due to loss or impacts on forests). If extraction of timber exceeds the yearly sustainable limit, then this will directly reduce the extent of forest resources in the country and there will be a loss in natural benefits provided.

Results of the study show that the value of forest ecosystem services (excluding timber extraction) to be approximately 491,000 UGS/ha. The sustainable harvesting of timber is valued at 1,200 UGS/ha meaning the cumulative benefits of other services outweigh the value received by sustainable timber extraction.

Currently, however timber harvest is unsustainable with a current value of 13,200 UGS/ha (1000% over harvested) still indicating that the value gained through over-exploitation is still below the value of other services. The problem here is through this unsustainable use there is a decrease in total forest stock and subsequent loss of value received by other services.

Very often it is the provisioning services that are over-exploited as they have a relatively obvious direct value. These findings indicate however that it is far

more beneficial to manage and utilise forest resources sustainably rather than over-exploit them, towards maintaining the other provisioning, regulating and cultural ecosystem services that provide the bulk of natural benefits to the socio-economic wellbeing of the country.

Furthermore, timber extraction is an extractive activity meaning that if done unsustainably, there will be a loss in total forest stock and thus the quantity (and value) that can be sustainably harvested. For example, as the total existing stock decreases through over extraction, there is a decrease in the amount of timber and fuelwood that can be harvested sustainably (among other services).

The total stock of Uganda's existing forests has decreased by 60% since 1990 (through a variety of impacts). This means that the total available yearly sustainable harvest has decreased from approximately 9.8 mil m3/a (in 1990) to approximately 4 mil m3/a (in 2015). This is a 47% decrease in the yearly timber available to be sustainably harvested in the last 25 years.

It is vital that relationships between development and forest resources are understood to move towards increasing the sustainability of both their utilisation and benefits received. The next section proposes policy instruments that will aim to improve the sustainable utilisation and management of forest resources warranting the preservation and conservation of natural benefits received by them.

2.6 The value of Uganda's Forest Ecosystem Services

The ecosystem services provided by forest resources including a range of provisioning, regulating and cultural services were described and valued (See Annex 3).

Ecosystems are highly complex systems of which Uganda's forest systems are no exception. The quantification of these interconnected and interlinked systems is not always as straight forward as quantifying the service provided (ecological infrastructure) and identifying beneficiaries of services for a given period of time. There are various paradigms which are characteristic of natural ecological systems, as a whole, which must be considered. One such paradigm is that of relative value due to changing extent.

This can best be described in terms of impact accumulation whereby impacts on ecological infrastructure over a given period result in cumulative losses or gains of benefits resulting in a change in the relative value of benefits provided.

For example, a loss of forest area in year one would result in a loss in soil stability and sedimentation downstream. These sediments will negatively influence the ecological infrastructure (and benefits they provide) downstream. A further loss of forest area in year two would result in additional sedimentation further impacting on ecological infrastructure downstream. By year three the value of the soil stability service of remaining forests would have increased because of the cumulative damage that would potentially be caused by its loss. This cumulative effect means that the relationship between, in the case of Ugandan forests, forest area and benefits they provide is not positive but negative as the relative value of forests increases as forests become increasingly rare (Figure 6).

As the forest resources decrease there is a marginal increase in the value provided by these systems due to cumulative impacts due to their loss (Figure 7).
Note in Figure 7 the marginal value of ecosystem services provided by forests gradually decreases between 1990 and 2015.

The increasing marginal value is both a reflection of increasing scarcity of forest resources as well as the cumulative effect of regulating ecosystem services. This is an important consideration when making decisions in terms of the costs already incurred to date through loss of ecological infrastructure and the subsequent loss in value of natural benefits.

The timber provisioning service is, as expected, the single largest ecosystem service at a value at 1,315,892 UGS/ha (in 2015). The NFA data and the rate of deforestation shows however that this harvest is unstainable. Thus, as deforestation proceeds, losses of other forest ecosystem services occur. The value of these ecosystem services lost includes gathering of non-timber forest products (NTFP), carbon losses and habitat provision at 149,000, 513,000 and 710,000 UGS/ha respectively. The health service, resulting from regulating malaria incidence is as large as the timber provisioning service at 1,131,000 UGS/ha (will be verified with UBOS), while the other (still highly significant) services display values below 13,000 UGS/ha (these include water provisioning, water yield available for hydro-power generation, effects on aquaculture and inland fishing and natural disaster mitigation by tropical forests. Although these values are derived through forest use, the unsustainable exploitation thereof and subsequent deforestation results in a net loss to the economy of Uganda.

Looking across the basins it can be seen that this value varies with the extent of forests present within the basin with, as expected, the southern basins displaying higher values. This shows that these basins which contain the greater extent of forest resources receive increased benefits from them.

Carbon sequestration is an extremely valuable service provided by forests with benefits being provided at a global scale.

Of particular interest is the ecosystem service multiplier effect of carbon. The analysis show that for every 1 UGS of carbon sequestration value, there is a multiplier of 8.0 UGS (1+7) for the accompanying value of the other ecosystem services.

Although the marginal values of forest ecosystem services (measured per hectare) has been increasing for

the reasons discussed above, the total value of forest ecosystem services has been decreasing at a rapid rate. This is because deforestation in Uganda has accelerated at a rapid rate.

The analysis shows that over the 2000-2015 year period, there was an increase in the value of harvested timber, which is categorized as a provisioning service, a decrease in forest cover and a decline in the total value of forest ecosystem services. This means that even though there was a rise in value gained from harvesting timber there was a greater corresponding loss in other ecosystem services.

The value of other provisioning services i.e. collection of NTFP (such as building materials, medicinal products, and foodstuffs), the productive use of water and fishing has decreased significantly over the 1990 to 2015 period and can be likely attributed to the loss of forest cover. The loss of the fishing provisioning service could be attributed to the loss of terrestrial forest cover as well and the resultant increased sedimentation into downstream waterways and aquatic systems.

The impact on the regulating services is also clear, with a decline in the value of the carbon sequestration service. The value of the biochemical control service, in this case expressed as a health cost, has also decreased over the 1990-2015 period. The value of the other regulating services such as natural disaster management and inputs into the hydropower sector also show a decrease. The value of the habitat services has also showed a marked decrease.

It is clear that deforestation and the subsequent loss of forest cover across all forest types have significant impacts on the delivery of ecosystem services. This has considerable impacts on the economy of Uganda as well as the communities who depend on the forest ecosystem.

The analysis shows that the contribution of forests to the economy of Uganda is underestimated in the national accounts.

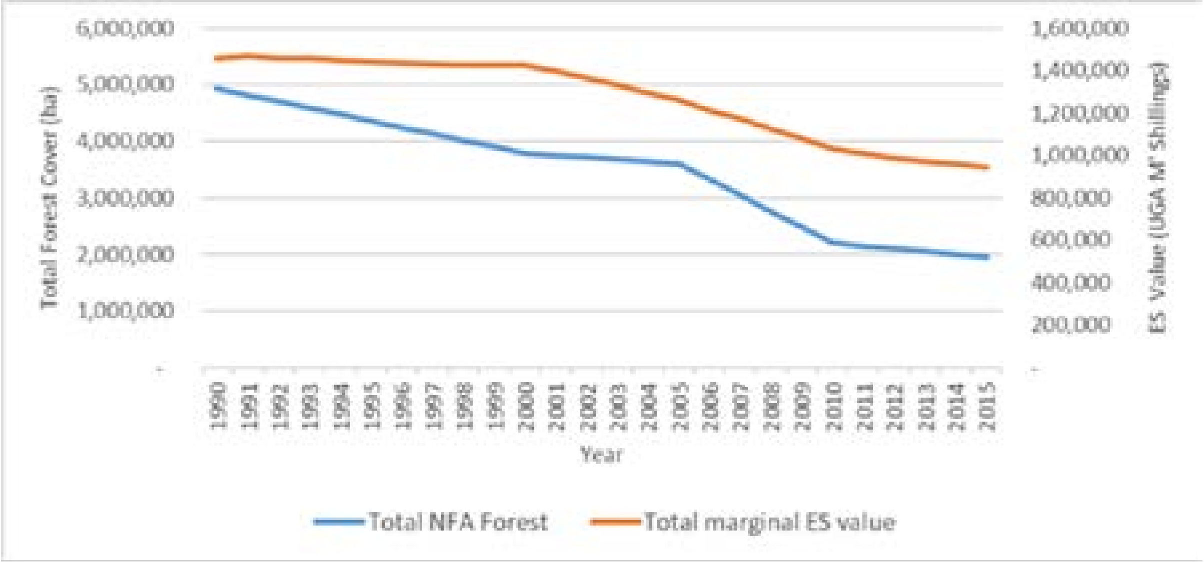

Figure 6: Forest area and corresponding ecosystem service value in Uganda between 1990 and 2015

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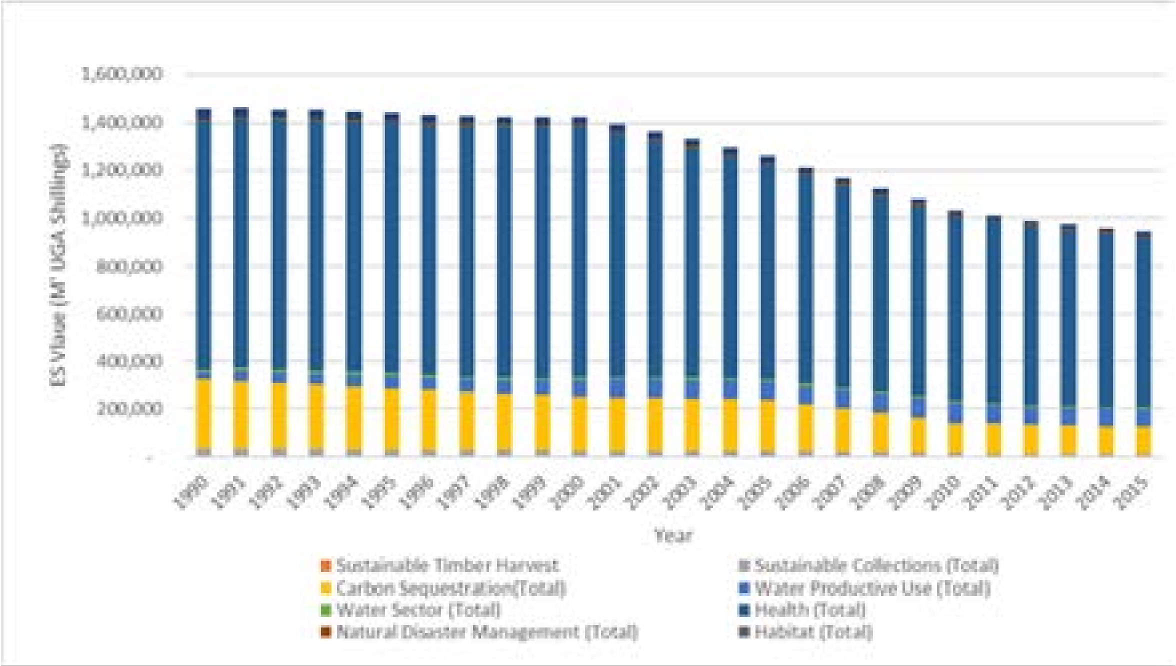

Figure 7: Marginal forest ecosystem service value per Ha between 1990 and 2015

Table 2 2: Preliminary ecosystem service mapping of the forest resources in the Albert-Nile Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
Albert-Nile (3,005,462)	Forest	2,803,372	Timber and Fuelwood	Agricultural expansion	-Ajai Wildlife Reserve			UBOS
			Other Products (T)	-Over exploitation	-Otze Forest Wildlife Sanctuary			
			Carbon Sequestration	-Over grazing				
			Water regulation (hydrological flows) (F)	-Drought				
			Water purification and waste assimilation (F)					
			Biological Control (Malaria/Water borne disease) (F)					
			Erosion regulation					
			Habitat (Biodiversity Support)					

Table 2 3: Preliminary ecosystem service mapping of the forest resources in the Aswa Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
Aswa (1,397,199)	Tropical forest	3,087,941	Timber and Fuelwood	Agricultural expansion	-Karenga Community Wildlife Management Area			
			Other Products (T)	-Over exploitation				
			Carbon Sequestration	-Over grazing				
			Water regulation (hydrological flows) (F)	-Drought and desertification				
			Water purification and waste assimilation (F)					
			Biological Control (Malaria/Water borne disease) (F)					
			Erosion regulation					
			Habitat (Biodiversity Support)					

Table 2 4: Preliminary ecosystem service mapping of the forest resources in the Kidepo Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
Kidepo (111, 635)	Tropical forest	465,649	Timber and Fuelwood	Drought and desertification	Kidepo Valley National Park			
			Other Products (T)					
			Carbon Sequestration					
			Water regulation (hydrological flows) (F)					
			Water purification and waste assimilation (F)					
			Biological Control (Malaria/Water borne disease) (F)					
			Erosion regulation					
			Recreational and tourism					
			Habitat (Biodiversity Support)					

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Table 2 5:Preliminary ecosystem service mapping of the forest resources in the Lake-Albert Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
			Timber and Fuelwood					
Lake-Albert (2,586, 999)	Tropical forest	2,052,527	Other Products (T)	-Drought and desertification	-Rwenzori Mountains National Park			
			Carbon Sequestration		-Semuliki National Park			
			Water regulation (hydrological flows) (F)		-Kabwoya Wildlife Reserve			
			Water purification and waste assimilation (F)		-Semliki Wildlife Reserve			
			Biological Control (Malaria/Water borne disease) (F)		-Kabwoya Wildlife Reserve			
			Erosion regulation		-Semliki Wildlife Reserve			
			Recreational and tourism					
			Habitat (Biodiversity Support)					

Table 2 6: Preliminary ecosystem service mapping of the forest resources in Lake-Edward Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
Lake-Edward (3, 852, 146)	Tropical forest	2,164,358	Timber and Fuelwood		-Bwindi Impenetrable National Park			
			Other Products (T)		-Kibale National Park			
			Carbon Sequestration		Mgahinga Gorilla National Park			
			Water regulation (hydrological flows) (F)		-Queen Elizabeth National Park			
			Water purification and waste assimilation (F)		-Katonga Wildlife Reserve			
			Biological Control (Malaria/Water borne disease) (F)		-Kigezi Wildlife Reserve			
			Erosion regulation					
			Recreational and tourism					
			Habitat (Biodiversity Support)					

Table 2 7: Preliminary ecosystem service mapping of the forest resources in Lake-Kyoga Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
Lake-Kyoga (10,994, 413)	Tropical forest	6,437,455	Timber and Fuelwood	-Agricultural expansion	-Mount Elgon National Park			
			Other Products (T)	-Over exploitation	-Bokora Corridor Wildlife Reserve			
			Carbon Sequestration	-Over grazing	-Matheniko Wildlife Reserve			
			Water regulation (hydrological flows) (F)	-Drought and desertification	-Pian Upe Wildlife Reserve			
			Other Products (T)		-Lake Opeta			
			Carbon Sequestration		-Lake Bisina			
			Water regulation (hydrological flows) (F)					
			Water purification and waste assimilation (F)					
			Biological Control (Malaria/Water borne disease) (F)					
			Erosion regulation					
			Recreational and tourism					
			Habitat (Biodiversity Support)					

Table 2 8: Preliminary ecosystem service mapping of the forest resources in the Eastern Littoral basin in Lake-Victoria Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
Lake Victoria (8,599, 367)	Tropical forest	3,680,612	Timber and Fuelwood		-Lake Mburo National Park			
			Other Products (T)		-Entebbe Wildlife Sanctuary			
			Carbon Sequestration		-Ngamba Island Chimpanzee Sanctuary			
			Water regulation (hydrological flows) (F)		-Lutembe Bay			
			Water purification and waste assimilation (F)		-Mabamba Bay			
			Biological Control (Malaria/Water borne disease) (F)					
			Erosion regulation					
			Recreational and tourism					
			Habitat (Biodiversity Support)					

Table 2 9: Preliminary ecosystem service mapping of the forest resources in the Victoria-Nile Basin

Basin	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (UGA Shilling/ha) and beneficiaries affected	Reference
Victoria-Nile (5,066, 606)	Tropical forest	3,680,612	Timber and Fuelwood		-Murchison Falls National Park			
			Other Products (T)	-Over exploitation	-Ziwa Rhino Sanctuary			
			Carbon Sequestration	-Over grazing	-Murchison Falls			
			Water regulation (hydrological flows) (F)	-Drought and desertification				
			Water purification and waste assimilation (F)					
			Biological Control (Malaria/Water borne disease) (F)					
			Erosion regulation					
			Recreational and tourism					
			Habitat (Biodiversity Support)					

03. Policy Response to Deforestation

3.1 Overview: Policy instruments in context

This study moves beyond the mere accounting and valuation of natural capital, but makes significant progress towards designing and testing policy instruments that tackle the heart of the deforestation problem. This section therefore provides important background on policy instruments in general and the scope for policy instrument development to combat deforestation in Uganda.

Policy is described by UN Environment as any course of action deliberately taken / or not taken to manage human activities with the view to prevent, reduce or mitigate harmful effects on nature and natural resources and ensuring that the anthropogenic changes to the water resources and surrounding environment do not have harmful effects on humans.
"Policy instruments" is the term used to describe some methods used by governments to achieve a desired effect.

Regulatory instruments are by far the most commonly used policy instruments internationally. Examples of these instruments include laws of a rationing or prescriptive nature; and regulations that permits or licenses resource use, planning controls or performance standards. A 'Command and control' approach is mostly exercised in conjunction with laws and regulations. 'Command' refers to standards or targets set and that is to be complied with; and 'Control' refers to the enforcement of compliance. Regulations and standards generally desire to achieve a uniform level of control but they can be an inflexible.

Economic instruments attempt to influence behaviour and decision-making through introducing economic incentives or disincentives into economic decision-making processes. Typically, these instruments use values and prices to achieve policy objectives. These are used as a way of influencing the actions of individuals and corporations through monetary and fiscal instruments. These may include subsidies, taxes and fees, tradable permits, administered tariffs, or production incentives. In the case of natural resource management, these economic instruments attempt to either increase or reduce demand for specific water benefits, with the purpose of incentivising certain desired micro-economic behaviour.

Suasion instruments are ethical or discretionary instruments that use moral and direct persuasion to promote appropriate behaviour. Moral suasion is defined in the economic sphere as "the attempt to coerce private economic activity via governmental exhortation in directions not already defined or dictated by existing statute law. The 'moral' aspect comes from the pressure for 'moral/social responsibility' to operate in a way that is consistent with furthering the good of the economy. Voluntarism and corporate social responsibility are additional key suasion instruments. Education and information instruments are also very important key

suasion instruments. When economic actors lack the necessary information about the environmental consequences of their actions, they may act inefficiently. The range of educational and information-based instruments is broad and can involve varying degrees of compulsion by government.

In developing appropriate policy instruments to combat deforestation, it is useful to consider policy instruments that focus primarily on economic behaviour, but that also combines with appropriate elements of regulatory and suasion instruments.

3.2. Proposed preliminary policy instruments for combating deforestation in Uganda, policy impact analysis and interpretation of results

This study proposes three economic policy instruments that seek to incentivise landholders to pursue sustainable forest management. These proposed policy options are not intended to be a comprehensive of final set of options for Uganda, but are rather used to demonstrate how these options could work, what they would cost, to what extent they would curb deforestation and what the relative costs and benefits to the economy of Uganda would be.

The three policy options tested are:
1. Carbon trade
2. Certified plantation forestry
3. Woodlots cultivation (Agroforestry)

In addition, the importance of value addition through industrialization and conservation of biodiversity is also briefly discussed.
It is to be noted that these policy options are not mutually exclusive, but may be applied in an integrated manner.

In the proceeding sections, each of these policy options are discussed in more detail and their cost-benefit relationships are discussed.

In evaluating the effectiveness of policy instruments below, two biophysical indicators and five several macro-economic indicators are of interest.
1. The net value of ecosystem services preserved measures the monetary value of forest ecosystem services gained or (lost),
2. The sustainability contribution indicator measures the extent to which the deforestation trend is reversed. If this is a 100% it means the deforestation trend (which has an average annual value of 120,000 ha/a) is exactly mitigated, if it is >100% it means forest cover is increasing.
3. GDP (Gross Domestic Product) measures the change in conventional growth of the economy including the indirect effects of forest

ecosystem services. This figure is dependent on the duration it takes for projects to mature.

4. Compensation of employees is a component of GDP and measures change in total salaries paid.
5. Balance of Payment measures the net change in international trade (exports and imports). If this value is positive it means exports increases relative to imports and Uganda's national balance sheet increases.
6. The fiscal effect measures the effect on the income of the Government of Uganda. If this value is positive Government revenues increase.

Finally, several of the macro-economic indicators have both direct and total effects. Direct effects are the direct impacts taking place in the economy, whereas the Total effect is the combination of the direct effects and the multiplier effects that follow.

All analysis was done for 2010, as this was the year for which formal supply and use tables was available.

3.3. Afforestation and Carbon Trade as a policy instrument

The United Nations' REDD+ programme (reducing emissions from deforestation and degradation) intends to provide incentives for combating deforestation. It does this through paying for carbon stock protection through paying land users for actions that prevent forest loss or degradation. These transfer mechanisms include carbon trading, or paying for forest management. The source of funds can be from carbon trading, or other voluntary funds not dependent on offsets.

Accordingly, this study tested a carbon trade policy instrument.

Many scenarios may be tested, but in this case we demonstrate a scenario where a pure carbon mechanism is applied to tropical forest area, returning 4% of the area deforested since 1990 (i.e. approximately 100,000 ha) to forest area through a long term forest rehabilitation programme. This scenario makes a number of critical assumptions.

Firstly, it assumes a voluntary carbon trade takes place at a value of 6 US$/ton carbon, and this revenue is invested into the programme. Secondly, it assumes it can be rehabilitated at a cost of 100,000 UGS/ha. Thirdly, it assumes that the required funding is raised through a corporate income tax.

The output of the analysis (Table 3 1) shows that although the annual rate of deforestation would be curbed by 101% and a net positive ecosystem services value of 88,720 Million UGS would be returned to the economy and the net direct economic effects.

Of interest in this analysis is the Total GDP effect, which is positive. This indicator is positive because of the indirect effects of ecosystem services in the economy, however these gains will only be realized when projects are mature.

Table 3 1: This scenario demonstrates a pure carbon mechanism applied to return 10% of the tropical forest area deforested since 1990 (i.e. 293,000 ha) to forest area through a long term rehabilitation programme.

Macro biophysical indicators		
Total ecosystem service value preserved	Million UGA Shilling/a	88,720
Sustainability frontier	%	101%

Macro-economic impacts		Direct Effect		Total Effect	
Indicator	Unit	Change		Change	
GDP	Million UGA Shilling/a	39,714	0.10%	56,852	0.15%
Compensation of employees	Million UGA Shilling/a	10,167	0.13%	14,302	0.18%
Balance of payments	Million UGA Shilling/a	1,890	0.03%	-14,870	-0.25%
Fiscal effect	Million UGA Shilling/a	2,307	0.08%	9,013	-0.39%

3.4. Certified plantation forestry as a policy instrument

One of the key challenges central to a successful deforestation policy instrument for Uganda relates to the productivity of land. The weighted average mean annual increment (MAI) of the total forest estate of Uganda is estimated at 2 m3/ha/a (Alderman and Abayomi, 1994). Planted forests in Uganda however can achieve MAIs of up to 24 m3/ha/a (MWE 2016). Thus, a planted forest can yield up to 12 times larger yield of merchantable and usable roundwood.

Although plantation forests do not produce the same forest ecosystem services as natural forests, they do enable more effective land use and thus could "free up" additional land for natural forest regeneration, while increasing timber production per hectare. Plantation forestry certification also exist which promotes sustainably and ethically produced timber products that provide assurance to markets that principles of sustainable production has been applied. Certified plantation forestry therefore provides a potential economic policy instrument as it is fundamentally driven by a higher price incentive. Certified plantation forestry is also expected to increase timber yield, training and generally improved land management practices.

The implementation of crop certification is not without its challenges, however, it presents an excellent precedent for a policy instrument to combat deforestation.

Once again, many potential scenarios may be tested, but in this case we demonstrate a scenario which may be akin to a single large project, to be implemented anywhere in Uganda where annual rainfall exceeds 800mm/a. In this scenario a private investor establishes a plantation forest estate of 20,000 ha, comprising a fast growing species of at least 24 m3/ha/a.

This scenario assumes an average crop rotation of 15 years and an average timber value of 194,000 UGS/m3. We further assume that the relevant authority establishes a project implementation office at a cost of 2,000 million UGS per year. The analysis also assumes a steady state situation (it is to be noted that plantation forestry investment is a long term investment that may take many years to mature).

The output of the analysis (Table 3 2) shows that the deforestation would be reversed. The sustainability contribution indicator is 192% indicating that the natural forest estate increases in size and a net positive ecosystem services value of 195,000 Million UGS would be returned to the economy which would serve to further strengthen GDP growth, when the project matures.

Table 3 2: This scenario demonstrates a certified plantation forestry project implemented anywhere in Uganda where rainfall exceeds 800mm/a.

Macro biophysical indicators		
Total ecosystem service value preserved	*Million UGA Shilling/a*	195,185
Sustainability frontier	%	192%

Macro-economic impacts		Direct Effect		Total Effect	
Indicator	Unit	Change		Change	
GDP	*Million UGA Shilling/a*	163,567	0.43%	203,680	0.54%
Compensation of employees	*Million UGA Shilling/a*	48,866	0.62%	36,077	0.46%
Balance of payments	*Million UGA Shilling/a*	4,204	0.07%	-37,893	-0.64%
Fiscal effect	*Million UGA Shilling/a*	28,084	0.96%	44,989	-1.93%

3.5. Woodlot cultivation as a policy instrument

FAO round wood production data for Uganda shows a large reliance on fuelwood collection. Thus, in order to relieve fuelwood harvesting pressure on the natural forest estate, agroforestry focusses on fuelwood production may be an important policy instrument.

Agroforestry is a well-established farming practice incorporating trees in fields, and there is scope to improve this practice to improve productivity and diversify livelihoods, especially in the production of timber for fuel use and construction. A policy instrument could be developed that promotes planting of fast-growing tree species for timber production in conjunction with other crops. It is important to note that carbon sequestration is likely to be a positive spin-off of this policy instrument and therefore carbon benefits may accrue in addition to the agroforestry benefits.

As before, many potential scenarios may be tested, and in this case we demonstrate a scenario which is akin to a single large project, to be implemented anywhere in Uganda. In this scenario the relevant authority implements a large scale woodlot cultivation initiative comprising distribution of fast-growing, wood producing tree species accompanies by extension services. It assumes that the initiative is suitable certified as a sustainable forest management activity. The relevant authority establishes a timber-producing agroforestry estate of 50,000 ha, comprising a fast growing species of at least 18 m3/ha/a. This scenario assumes an average crop rotation of 10 years and an average timber value of 95,000 UGS/m3. We further assume that the relevant authority establishes a project implementation office at a cost of 10,000 million UGS per year. The analysis also assumes a steady state situation (as in the case of plantation forestry it is to be noted that woodlot cultivation investment is a long term investment that may take many years to mature).

The output of the analysis (Table 3 3) shows that the deforestation would be reversed. The sustainability contribution indicator is 349% indicating that the natural forest estate increases in size and a net positive ecosystem services value of 355,000 Million UGS would be returned to the economy which would serve to further strengthen GDP growth, when the project matures.

The net direct economic effects are all positive, except for the fiscal effect due to the cost of the project.

Table 3 3: This scenario demonstrates a certified woodlot cultivation project implemented anywhere in Uganda.

Macro biophysical indicators		
Total ecosystem service value preserved	Million UGA Shilling/a	354,882
Sustainability frontier	%	349%

Macro-economic impacts		Direct Effect		Total Effect	
Indicator	Unit	Change		Change	
GDP	Million UGA Shilling/a	234,899	0.62%	306,972	0.81%
Compensation of employees	Million UGA Shilling/a	67,783	0.86%	64,791	0.82%
Balance of payments	Million UGA Shilling/a	7,565	0.13%	-65,218	-1.11%
Fiscal effect	Million UGA Shilling/a	30,393	1.04%	59,552	-2.55%

3.6. Other policy instruments

The outputs of this work enables practitioners to simulate additional policy options and instruments.
It is to be noted however that economic policy instruments are not suitable to all policy imperatives. This is especially so in the case of conservation of scarce habitat. In such cases, a combination of regulations and command-and-control would be required. Conservation through sustainable forest management of protected areas, may for instance be combined with an eco-tourism enabling policy instrument. Eco-tourism, a cultural ecosystem service, would make use of the benefits of habitat protection, and creates additional income for a host of economic sectors, such as transport, accommodation, restaurants, retail and a host of associated sectors.
In addition, value addition to forest products may offer interesting policy options. In the scenarios tested above, it is notable that the Balance of Payment indicators under the Total effect column are often negative. This indicates a large reliance on imported products and services associated with each scenario and this is less than desirable. The economy of Uganda would therefore benefit from a focused value addition strategy downstream in the value chain. In this case, as the forest sector grows and sustainable time production increases it would be desirable to also increase value addition in the rest of the forest value chain.

04. Preliminary Recommendations

Many challenges exist in developing and implementing successful policy instruments, and these need to be considered.

In the first instance, the most appropriate policy instruments need to be designed at a strategic level, to ensure that the benefits of deforestation is of significant magnitude. The tools developed by the UN-REDD+ and UN Environment in this study plays an important role in this policy instrument design.

In addition to the strategic design of the policy instruments, there also exists an important design requirement at a tactical level, most likely to be dealt with within a framework such as the UN-REDD+'s Biotrade approach.

These tactical considerations involves institutional and operational arrangements and logistics required to address the barriers to combating deforestation. The main barriers are effective networking, finding sufficient cash for initial investment requirements (whether private sector, donor or domestic sources), and difficulties to set up and maintain the required internal control systems.

Much work is therefore still required to ensure that the policy instruments can be effectively implemented.
The challenge for the Government of Uganda is now to ensure:

- Development of suitable policy instruments such as those demonstrated here; and
- Institutionalisation of the policy instruments; and

Continuing a working relationship with UN-REDD+ to develop and implement suitable policy instruments.

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06. ANNEX

6.1. Annex 1: System of Environmental-Economic Accounting

A proper system of economic accounts for forestry should provide policy-makers with information that gives a more complete picture of the net benefits derived from forests than is the case at present. Such information should include wood as well as non-wood products; goods as well as services or functions; and benefits from marketed as well as non-marketed goods and services.

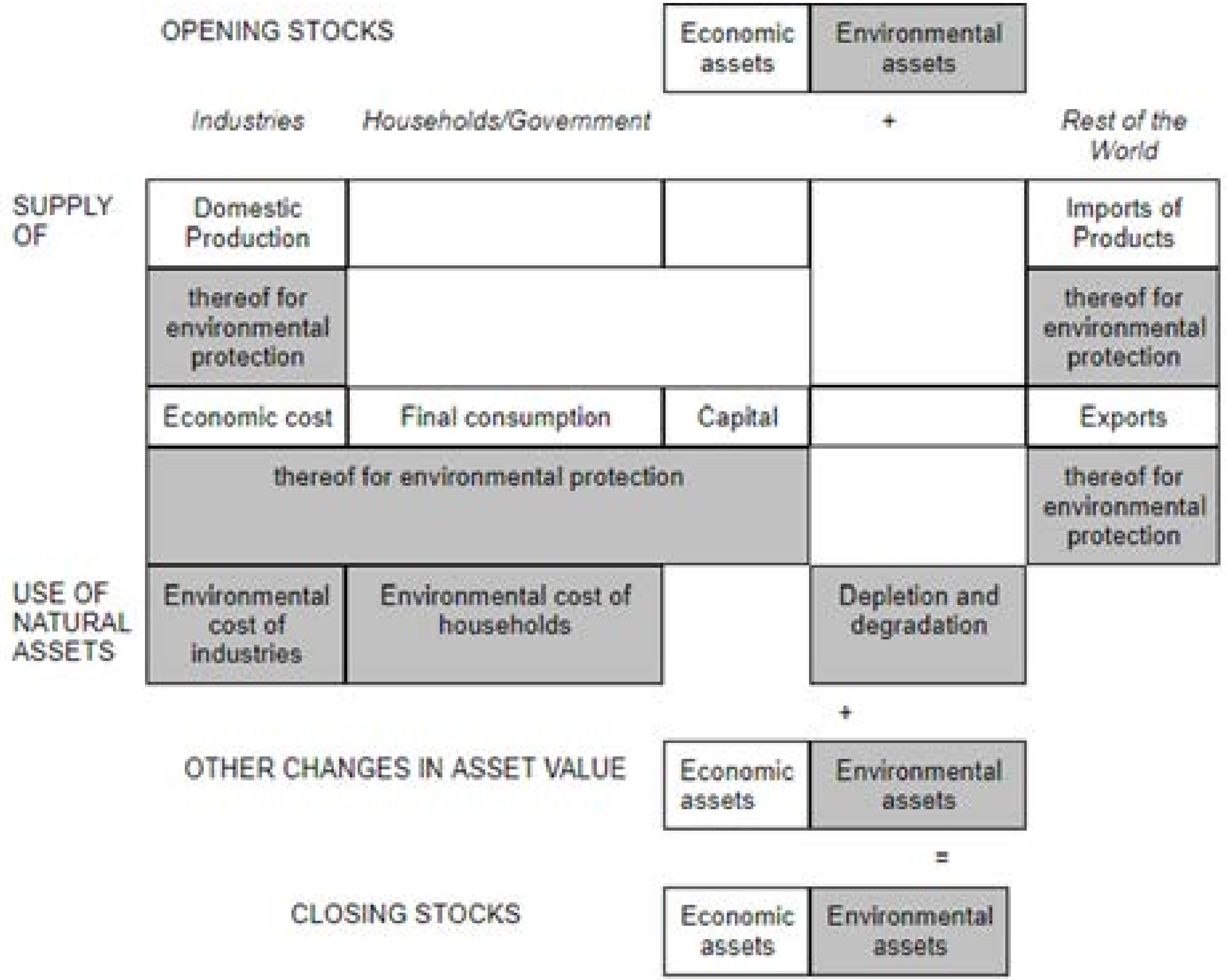
While developing the system it may be kept in mind that a clear boundary line between forestry practices and agricultural or horticultural practices, although essential for developing an accounting framework, remains very difficult in actual practice.

A lot more depends on data collection systems in specific countries. However, while developing the system, a clear mission should be that the total value of forests includes agro and social forestry values, which should be adequately credited to the forest sector. This will produce a far more comprehensive perspective for taking account of varying practices followed in different countries.

The starting point for a forest sector SEEA is the treatment of forest activities in SNA. Without a firm understanding of how forests are treated in the broader accounting aggregates of SNA, it is truly impossible to develop a reliable forest sector SEEA. This understanding is founded in the physical and monetized stocks and flows for forest activities in SNA.

SNA and forestry sector accounts
The SNA includes both flows of goods and services and stocks of assets used in the production of goods and services. The objective of the national accounts is not only to measure the flows of goods and goods and services resulting from capital investment and consumption (GDP and NDP) but also the accumulation/depletion of capital stock including natural capital. By utilizing ISIC (industry codes) and CPC (product codes) the rows and columns of table 3 can be used to identify the different products produced by various industries and the uses of these products in final consumption.

The asset accounts for economic produced and non-produced assets (see box 1 for SNA classifications of assets) are also compiled by industry (ISIC) and describe the stocks at the beginning and end of the accounting period and all changes therein.



SNA/SEEA: Flow and Stock Accounts with Environmental Assets (Source: Draft Integrated Environmental and Economic Accounting - An Operational Manual. UNSD. Feb. 1998)

6.2. Annex 2: Methodological Approach

6.2.1. Forestry Resource Account (FRA)

Requirements for conducting the FRA for Uganda was highly data intensive requiring specific forestry resource data (including forest type) at both a temporal and spatial scale. An intensive data acquisition process was undertaken to best identify and source suitable and reliable data to effectively conduct the FRA. The bulk of the data was made available by the National Forest Authority (NFA) and the Food and Agricultural Organisation of the United Nations (FAO).

6.2.1.1. Temporal Scale

Data at a temporal scale was sourced from numerous reports published by the NFA and FAO representing FRA's for the years of 1990, 2000, 2005, 2010 and 2015. The accounts included the total extent of areas, volumes (under bark) and biomass of forest ecological infrastructure at a national level.

The total extent of forest resources at various periods provided insight into their change over time (either a gain or loss of total resources), allowing the identification of trends and impacts on forest cover over time.
The FAO presented this data in terms of primary forest, naturally regenerated forest, and planted forests of which definitions are provided in Table 6 1.

Forest Type	Description
Primary forest	Naturally regenerated forest of native species where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed.
Other naturally regenerated forest	Naturally regenerated forest where there are clearly visible indications of human activities.
Planted forest	Forest predominantly composed of trees established through planting and/or deliberate seeding (made up of forest plantation and Teak/Gmelia plantations).

For the purposes of describing forest resources within each basin, a spatial component of forest distribution was further required.

6.2.1.2. Spatial data

Spatial data was sourced from the FAO in the form of land cover data at a national scale. This data was derived from the raster based Globcover regional (Africa) archive and represented 2009 land cover in the form of LCCS regional legend (46 classes). The classes identified for forest cover did not directly correspond to the data provided by the FAO and was therefore disaggregated by allocating a percentage forest for each class into total forest cover.

This data was collated into total forest cover (at a national scale) and was used to identify total forest cover within each basin. The proportion of forest cover within each basin was then used to disaggregate the temporal data (provided by NFA and FAO) across basins. This provided an overview of where the forest resources were located throughout the country and how the extent varied across time (1990-2015).

For this technique to provide an accurate representation of forest cover between basins, the assumption was made that forest loss or gain occurred at the same extent across all basins between the period of 2000 and 2015.

Volume and biomass by basin was calculated based on FAO provided volume per ha and sourced tonnes per ha respectively together with the total forest area within each. The annual rate of change in area, volume and biomass were then calculated based on the mean yearly difference between the year 1990, 2000, 2005, 2010 and 2015.

6.2.1.3. Inferences

The nature and extent of ecosystem services vary with changing ecosystem type. Thus, to effectively quantify ecosystem services provided, the extent and distributions of forest type within the greater forest resources were determined.

6.2.1.4. Forestry Losses

Forest losses were accounted for by identifying wood production statistics and losses through forest burning. Wood production statistics for Uganda were sourced from FAOStat for the period of 1990 to 2015. Extractions included roundwood and fuelwood and were similarly disaggregated into basins. Forest cover loss through annual burning was sourced from the FAO (FAO 2015).

6.2.2. Ecosystem Service Account (ESA)

The first step in the ESA required an understanding of the distribution and extent of the service provider (as described above). The next step was to understand services provided by forest resources.

Existing valuation frameworks including the Millennium Ecosystem Assessment (MEA 2015), The Economics of Ecosystems and Biodiversity (TEEB 2013) and Final Ecosystem Goods and Services Classification System (FEGS-CS 2013) were explored to comprehensively identify all ecosystem services provided by forest systems.

This process was followed by a desktop level investigation into actual services provided at a basin level. Together with literature reviews, expert consultations and satellite imagery, the investigation identified spatial features and characteristics across the Ugandan landscape. Investigations into parameters such as demographics, land use intensity, economic drivers, environmental impacts, cities, towns and communities, protected areas, environmental degradation and significant ecological features was conducted for each basin.

In this way basins were described in terms of their general social, economic and environmental characteristics allowing an understanding of the extent and nature of forest related ecosystem services and their beneficiaries.

6.2.3. Ecosystem Service Frameworks

The valuation of ecosystem services has rapidly gained traction in the development and natural resources fields and is increasingly utilized by decision makers when assessing the impacts of development on ecological systems (MA 2005; TEEB 2010). This is due primarily to the realization that biodiversity and its associated ecosystem services can no longer be treated as inexhaustible and free 'goods' and their true value to society as well as the costs of their loss and degradation, need to be properly accounted for (TEEB 2010, de Groot et al. 2012).

The "values" of the ecosystem services provided by forest ecosystems can be expressed in a number of ways and methods. The values can be expressed qualitatively i.e. which cities benefit from which forest for biodiversity support or flood control) or quantitatively i.e. the number of people benefitting from clean water.

They can also be expressed in monetary terms i.e. the monetary value of sequestered carbon, avoided costs of water pre-treatment and supply or avoided costs of potential flood damage (TEEB 2013). When interpreting ecosystem service values, it is important to note that it is only tool of analyzing trade-off options and decisions should not be made in isolation of other societal values and needs.

6.2.3.1. The Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (2005) defines ecosystem services as the benefits that people receive from ecosystems and makes the link between ecosystem services and human well-being (2005). The MA classifies ecosystem services into supporting (basic ecosystem functions and processes that underpin all other services),

regulating (covering the absorption of pollutants, storm buffering, erosion control and the like), provisioning services (covering the production of foods, fuels, fibre etc.), and cultural services (covering non-consumptive uses of the environment for recreation, amenity, spiritual renewal etc.).

It is important to recognize that the utilitarian values (the benefits consumed, used or enjoyed) of these services are not additive. Supporting and regulating services can be considered to be similar to intermediate consumption in the economic sense. Provisioning and cultural services are those that enter final consumption. In order to avoid double accounting, only the final consumption services should be valued.

That is, the services inventory for a given evaluation case must be benefit specific, and the service units that depend on these services must be mutually exclusive and expressed in "final ecosystem service units" (Boyd and Banzhaf 2007). To achieve this, we begin with the definition of ecosystem services employed by Boyd and Banzhaf, in turn developed from the MA definition: "Ecosystem services are components of nature, directly enjoyed, consumed or used to yield human well-being.

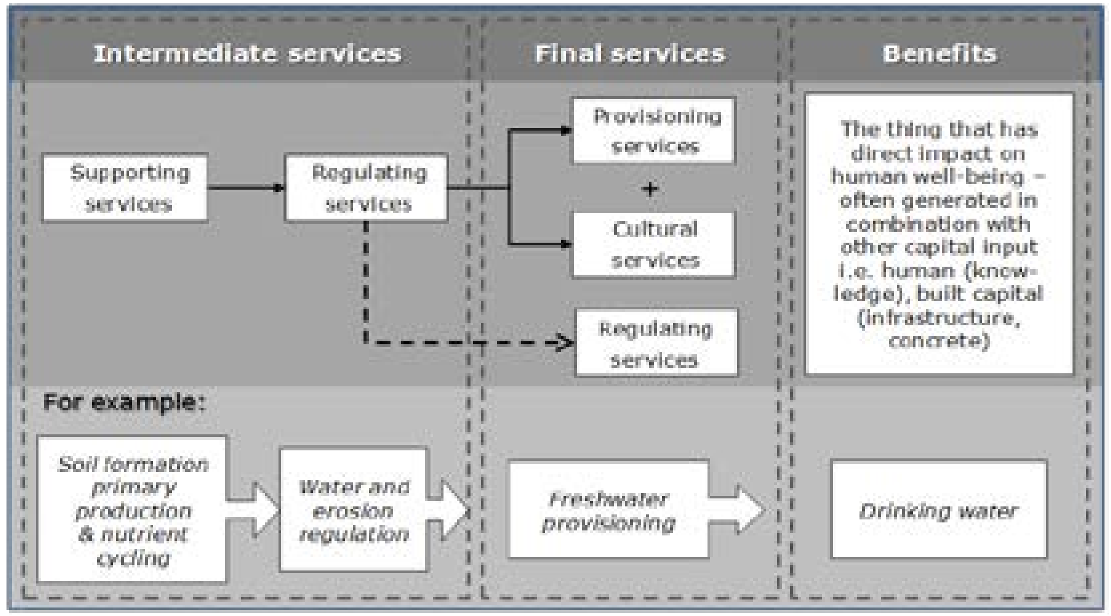


Figure 8: The distinction between intermediate services, final services and benefits (adapted from Fisher et al. 2008) illustrated by the stylised relationship between supporting, regulating, provisioning and cultural services as defined by the Millennium Ecosystem Assessment.

6.2.3.2. The Economics of Ecosystems and Biodiversity

The Economics of Ecosystems and Biodiversity (TEEB) is an international initiative to draw attention to the benefits of biodiversity. It focuses on the values of biodiversity and ecosystem services, the growing costs of biodiversity loss and ecosystem degradation, and the benefits of action addressing these pressures. The TEEB initiative has brought together over five hundred authors and reviewers from across the continents in the fields of science, economics and policy (TEEB 2013).

The TEEB initiative can be viewed as the next step in ecosystem service understanding and builds on the MA by providing a focussed approach for dealing with the costs of biodiversity loss and how this impacts society.

6.2.3.3. Final Ecosystem Goods and Services – Classification System (FEGS-CS)

The Final Ecosystem Goods and Services Classification System (FEGS-CS) is developed by the US Environmental Protection Agency (US EPA) towards providing a comprehensive framework for the evaluation of ecosystem services (Landers and Nahlik 2013). The FEGS-CS builds on the MEA and similarly defines Final Ecosystem Goods and Services FEGS as "components of nature that are directly enjoyed, consumed, or used to yield human well-being.

" The goal of FEGS-CS is to "Identify, measure, and quantify FEGS in a scientific, rigorous, and systematic way that can be aggregated from local to regional and national scales" (Landers and Nahlik 2013). In other words, it attempts to accurately identify and value contributions of ecosystem services toward economic well-being. To this end,

FEGS-CS takes one step forward from the MEA as it classifies natural resources into FEGS which have corresponding environmental classes (which indicate the source components of nature) and beneficiary classes (which indicate the beneficiaries of well-being) (Figure 9). Various combinations of these classes depending on the beneficiary will result in 358 unique FEGS codes which will ultimately all be valued, thus identifying an ecosystems contribution towards a range of specific beneficiaries.

The premise is that specific sectors can be attributed with the benefits received from ecosystems and these benefits be quantified and valued. This would allow for the understanding of environmental contributions toward socio-economic wellbeing.

By taking this comprehensive approach the FEGS-CS contributes threefold: 1) by avoiding double counting of ecosystem services (as only final goods and services are categorised) and 2) by providing a common language among stakeholders when evaluating ecosystem services 3) by attributing ecosystem services with beneficiaries.

The FEGS-CS provides for linkages between economic benefits and environmental risk of which can be compared using environmental and economic accounting (E and EA).

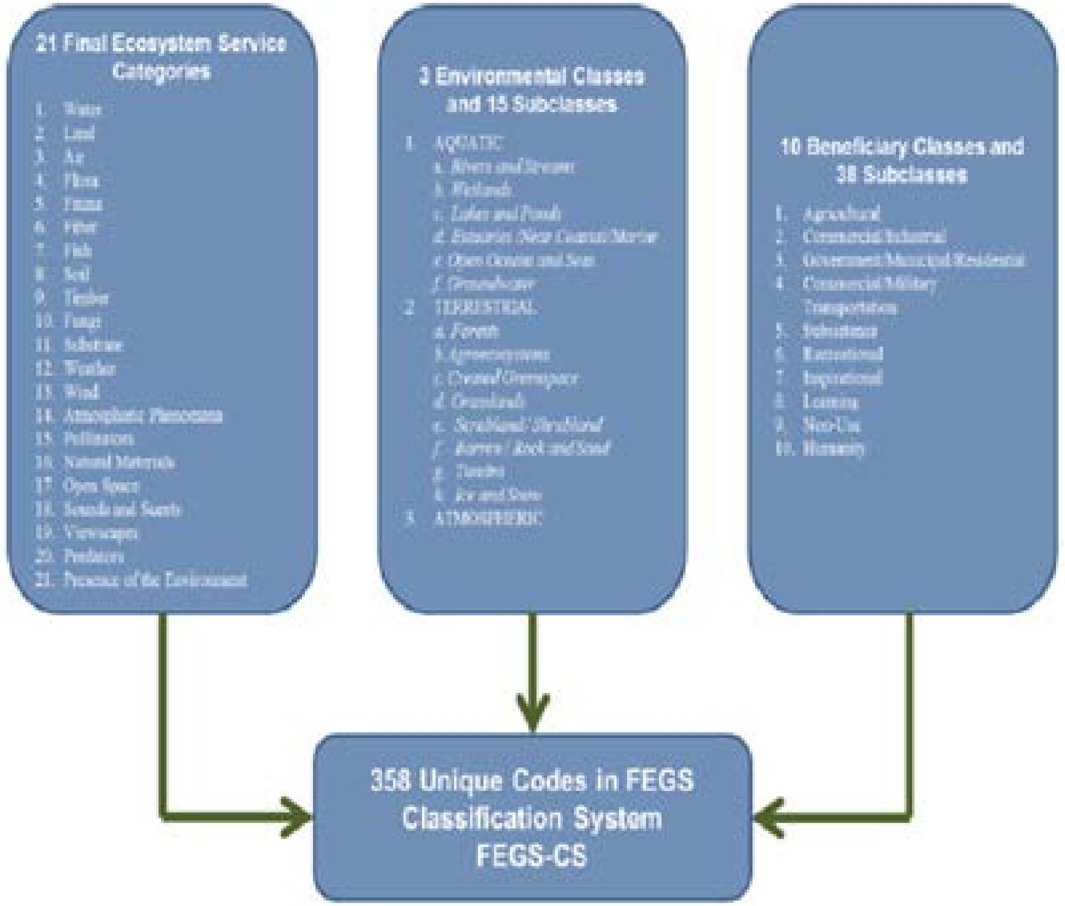


Figure 9: Final Ecosystem Goods and Services Classification System (FEGS-CS) (Landers and Nahlik 2013)

6.2.3.4. Valuation of Forests and Ecological Infrastructure

The concept of ecological infrastructure has recently gained traction among conservation biologists and can be seen as an additional lens in which to view the valuation of forest ecosystem services. According to SANBI (2012), ecological infrastructure refers to functioning ecosystems that deliver valuable services to people such as fresh water, climate regulation, storm protection and soil formation. It is the nature-based equivalent of built or hard infrastructure.

The SANBI definition goes further and describes five attributes of ecological infrastructure:

1. Ecological infrastructure is a public good;
2. Ecological infrastructure enhances built infrastructure;
3. Ecological infrastructure supports rural development;
4. Ecological infrastructure helps us cope with climate change; and
5. Ecological infrastructure creates jobs.

With the addition of ecological infrastructure, one can develop a forest valuation model that takes the value of natural assets into consideration and is not constrained by ecosystem service valuation only. When ecosystem service valuation is added to the model, we have the beginnings a fully integrated model, which is in line with conventional economic balance sheet and income statement thinking.

The relationship between the ecological asset (balance sheet item) and the delivery of ecosystem services (income statement items) can be described as the annual rent received from an asset i.e. a house for example (Figure 10).

The forest ecosystem services are delivered every year (more or less in the same quantity) and are dependent on the condition of the ecological infrastructure as well as external factors such as rainfall, land use change etc. If the condition of the ecological infrastructure is modified, there may be a corresponding change in delivery of ecosystem services.

In subsequent sections a valuation is given for the ecosystem services as well as an ecological infrastructure value (asset).

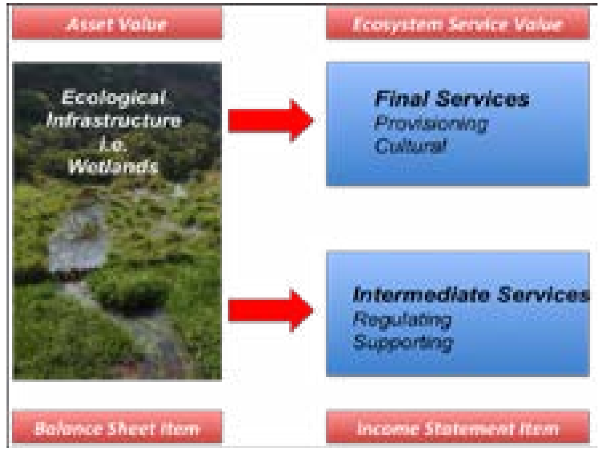


Figure 10: The relationship between ecological infrastructure and the delivery of ecosystem services

6.2.4. Ecosystem Service Valuation

6.2.4.1. Carbon Sequestration

The carbon sequestration service was valued by utilising current best practise for the development of national green-house gas inventories presented by the International Panel on Climate Change (2006). Volume 4 of the guidelines as well as Annex 1 (specifically Tables 3B1) were used to develop the inventory.

The inventory looked at annual natural change in carbon stocks based on results of the FRA to establish the impact analysis model for natural regeneration, harvesting and other. The process included the natural capacity of existing forests to sequester carbon. Removal activities such as harvesting (Roundwood and fuelwood removal) and disturbances (fire) was included to indicate the effects on sequestration capacity.

6.2.4.2. Water Quantity

Health
Significant clinical evidence exists of the negative effect of deforestation on malaria infections in Uganda. Uganda has the world's highest malarial incidence rates, and malaria id the leading cause of mortality (27%). Reports estimate that the incidence rate is 478 cases per 1,000 population, and approximately 70,000 to 100,000 Ugandans die each year from the disease.

According to the Ministry of Health's National Malaria Control Program, the socio-economic impact of malaria includes out-of-pocket expenditure for consultation fees, drugs, transport and subsistence at a distant health facility. These costs are estimated to be between USD 0.41 and USD 3.88 per person per month (equivalent to USD 1.88 and USD 26 per household). Household expenditure for malaria treatment is also a high burden to the Ugandan population, consuming a larger proportion of the incomes in the poorest households.

Sediment yield model
The account is using sediment yield model to estimate the effect of deforestation of forest natural hedge on the total production of the creation of suspended solids in Uganda. Erosion and sedimentation reduce soil fertility, cause siltation of channels, reservoirs and dams and increase turbidity of water supplies This model estimate cumulative nitrate and phosphate load as a result of deforestation. Taking results from various small scale studies we assume that poor management collectively will result in higher peak flows and on average cause additional sediment (and thus nutrient losses).

6.2.4.3. Water Quality

The average water treatment cost was estimated by calculating water collection, treatment and supply and volume (m3/yr) based on projected demand. The model derives a cost function for the water treatment based on the size of the sewage plant wastewater. The model is based on the load reduction fraction of water to be treated with excess nutrients to water with allowable nutrient concentrations.

6.2.4.4. Natural Disasters

Data on the disasters due to landslides, floods and drought was collected through datamining. The data included the cost or evaluated loss in monetary terms for each disaster. To develop the necessary mitigation strategy we used the Actuarial Statistics techniques which calculates the ruin of a portfolio. Taking the whole country as a single portfolio and the disaster cost as the claim to the country, we were able to calculate the premium which can be put aside every year to cover for the losses.

6.2.4.5. Habitat and Species

The value of the biodiversity within various areas was estimated as the value of conservation efforts or willingness to pay for preservation of species. A database of Red Data species was developed to quantify the value of species conservation by project funding. Uganda has 200 species on the IUCN Red List and these were given the average value.

6.2.4.6. Fishing

The fishery production model looks at the effect of water pollution on the production of fishes. Fishing production data was collected from FAOstats. Nutrient enrichments of water bodies do have a positive effect on fishery productivity in nutrient-limited environments. However, excess nutrients affect fish productivity through changes in the amount of food available and the quality of the habitat.

6.2.4.7. Hydro-electric

Hydropower produces 84% of the total installed capacity of 822 MW. The actual total electricity capacity is 550 MW and the country's peak demand is about 489 MW. Electricity generation is thus highly dependent on river flow. The hydropower model was used to demonstrate the impact of water pollution on the efficiency of hydropower plants. The data was collected from various hydropower studies in Uganda.

6.3. Annex 3: Description of Methodology Inputs and Outputs

6.3.1. Construction of the Input-Output Model

An input-output table is a representation of national or regional economic accounts that records how industries produce and trade between themselves (ie, flows of goods and services). These flows are recorded in a matrix, simultaneously by origin and destination (OECD 2006). An input-output analysis is the standard method for measuring the propagation effects of changes in final demand for a product in an industry or sector (Surugiu 2009).

A standard input-output table is shown in Figure A 1. The flows for inputs are recorded in the columns of the table and the outputs are included in the rows (Sporri et al 2007). The intermediate demand (Z) represents the table of inter-industrial transactions, a matrix of transactions between sectors of production. Final demand (y) includes households, government and the rest of the world. The value added to the production sector consists of capital and labor, it also obtains a share of interest and wages. An input-output analysis is generally used to calculate the economic impacts resulting from exogenous changes at y.

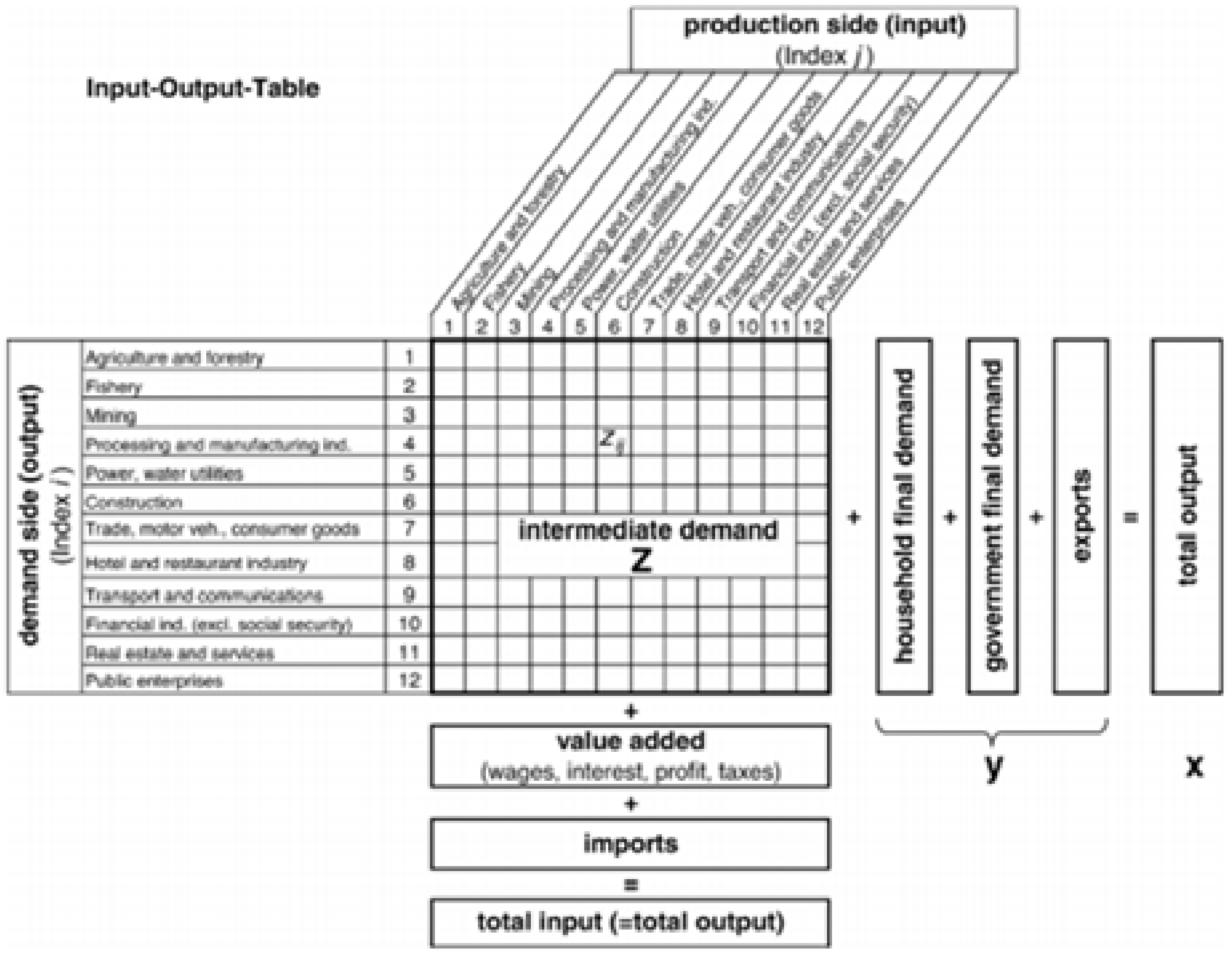


Figure A 1: Illustrative Input-Output Table (Sporri et al 2007)

Table A2 provides the technical specifications for the Ugandan input-output model.
Table A 1: Input-output aggregate table

Exits / Entrance	Inter-industrial Flow			Total Final Demand	Total Outputs
	Primary	Secondary	Tertiary		
Primary	z_{11}	z_{12}	z_{13}	f_1	x_1
Secondary	z_{21}	z_{22}	z_{23}	f_2	x_2
Tertiary	z_{31}	z_{32}	z_{33}	f_3	x_3
All primary entries	y_1	y_2	y_3		
Total Entries	x_1	x_2	x_3		

Looking at n sectors of the Ugandan economy. If xi the total production of sector i and fi final demand of output of sector i, the equation relating to the distribution of sales and the final demand for the other industries is written as follows:

$$x_i = z_{i1} + \ldots + z_{ij} + \ldots + z_{in} + f_i = \sum_{j=1}^{n} z_{ij} + f_i$$

The terms zy indicate inter-industry sales by sector i for all other sectors j with fi the total final demand for output in sector i. We can summarize the distribution of sector sales for each sector of the Ugandan economy in matrix form as follows:

$$\mathbf{x} = \mathbf{Zi} + \mathbf{f}$$

With i designating a column vector.
We represent the matrix n x n of the technical coefficients in a compact matrix form as follows:

$$\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$$

The operational forms of the technical coefficients are as follows:

$$z_{ij} = a_{ij} x_j$$

Rewrite equation 2 considering the operational form of the technical coefficients,

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f}$$

Now let I be the identity matrix n x n whose diagonal elements have a value of 1 and the others a value of 0,

$$\mathbf{I} = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$$ so that $$(\mathbf{I} - \mathbf{A}) = \begin{bmatrix} (1-a_{11}) & -a_{12} & \cdots & -a_{1n} \\ -a_{21} & (1-a_{22}) & \cdots & -a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ -a_{n1} & -a_{n2} & \cdots & (1-a_{nn}) \end{bmatrix}$$

The system represented in equation (4) is then

$$(\mathbf{I} - \mathbf{A})\mathbf{x} = \mathbf{f}$$

For equation (6) to have a unique solution (I-A) must not be singular. If (I-A)-1 exists, then equation (6) can be expressed as follows:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{Lf}$$

$$(\mathbf{I} - \mathbf{A})^{-1} = \mathbf{L} = l_{ij}$$

is the inverse matrix of Leontief or the matrix of total needs.

The technical coefficients (equation 3) and the Leontief matrix (equation 7) can be used to estimate the direct and indirect economic benefits of various scenarios. Once the input-output model is built, multipliers can be computed and the model can be customized to add value to the larger UN Environment project and answer specific questions that are not normally part of a standard evaluation of the socio-economic impact of input-output. These improvements are discussed below.

6.3.2. Multipliers and impact depth estimation

The Leontief inverse matrix can be used to calculate the output multiplier, the income multiplier and the income effects (D'Hernoncourt, Cordier and Hadley 2011)

- The multiplier of the output of a given industry can be defined as the sum of all the outputs of each national industry necessary for the realization of an additional production unit.
- The income multiplier indicates the increase in

employment income as a result of a change in employment income of 1 currency unit for each industry.

- The income multiplier shows the impact on employment income across the economy resulting from an increase of one unit of final demand for industry output j.
- The employment multiplier shows the total employment increases across the economy as a result of an employment change.

Multiplier formulas are provided in Section 8.3.
The analysis estimates the direct and indirect impacts. Table A-3 provides definitions of direct and indirect impact. It differs between GDP (economic growth) and employment. The principle of multiplier analysis depends on the impression that an exogenous change of the elements has an initial effect as well as a total effect on the economy.

Table A 2: Definitions of direct and indirect impact. Source: own compilation

GDP (Economic Growth)	
Direct Impact	Indirect Impact
The direct economic impact is the change in economic activities that are directly related to the simulated scenario	The indirect economic impact seeks to capture the ripple effect to the host economy (eg, additional money spent in the region by saying an increase in eco-tourism) Indirect impact, also known as the multiplier effect, includes the spending of revenues in the local economy.
Professional Experience	
Direct Impact	Indirect Impact
Total employment created / destroyed directly according to the simulated scenario	Indirect employment is the total of jobs created / destroyed according to the simulated scenario. Local businesses that provide goods and services to the eco-tourism sector increase / decrease the number of their employees as eco-tourism is on the rise / fall, thus creating a multiplier of employment

6.3.3. The Multipliers

The multiplier of production :

$$(Multiplerof\ Production)_j = \sum_i L_j$$

Or :
Lij constitutes all the productions of each national industry necessary for the production of an additional unit of production

The Income Multiplier :

$$(IncomeMultiplier)_j = \sum_i \frac{v_i L_j}{v_j}$$

Or:
v is the ratio of employment to output of each industry.
Effect on Income :

$$(EffectonIncome)_j = \sum_i v_i L_j$$

Job Multiplier :

$$(JobMultiplier)_j = \sum_i \frac{w_i L_j}{w_j}$$

Or:
w is equal to a full-time job by wage bill of the total production of each industry.
Employment effects determine the employment impact across the economy resulting from a change in final demand for an industrial production unit j.

For More Information Contact:
Ministry of Water and Environment,
Uganda National REDD+ Secretariat,
Forest Sector Support Department,
Plot 10/20 Spring Road
Tel: +256 414 347085
Email: Mwe@mwe.go.ug; Ps@mwe.go.ug
Website: www.mwe.go.ug

THE REPUBLIC OF UGANDA
Ministry of Water and Environment.