Forestry and Macroeconomic Accounts of Nigeria:

The Importance of Linking Ecosystem Services to Macroeconomics

Full report

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Dr Jackie Crafford, Mr Joseph Mulders, Mr Nuveshen Naidoo, Ms Dineo Maila,
Mr Valmak Mathebula and Mr Kyle Harris
Prime Africa, South Africa
j.crafford@primeafrica.net

Dr Thomas Fameso
National Consultant
tomfamesco@ymail.com

PREAMBLE AND ACKNOWLEDGEMENTS

This report summarises work conducted by UN-REDD Programme during 2016 to guide the development of policy instruments for the Government of Nigeria in order to combat deforestation within the country.

The work conducted comprised economic modelling and analysis with the purpose of linking the drivers of economic behavior, as it relates to deforestation, to the benefits of forest ecosystem services.

The work was highly reliant on data collection within Nigeria. The UN-REDD Programme, UNEP and the authors wish to sincerely thank our colleagues in Nigeria who participated in and supported this study.

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.

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ACRONYMS AND ABBREVIATIONS

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
FME	Federal Ministry of the Environment
FRA	Forestry Resource Account
GDP	Gross Domestic Product
GEF	Global Environmental Facility
Ha	Hectares
M	Million
m	meters
MAI	Mean Annual Increment
MEA	Millennium Ecosystem Assessment
MSY	Maximum Sustainable Yield
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

GLOSSARY / DEFINITIONS

Forest	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).
Mangrove	Area of forest and other wooded land with mangrove vegetation. This occurs on the muddy banks of creeks and in tidal channels in the upper portion of the zone of saturator influence where the water is brackish (FAO 2015).
Other Regenerated Forest	Naturally regenerated forest where there are clearly visible indications of human activities (FAO 2015).
Plantations	Forest predominantly composed of trees established through planting and/or deliberate seeding (made up of forest plantation and Teak/Gmelia plantations) (FAO 2015).
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 (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 Nigeria (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).

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. UNEP 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 and, in this study, Nigeria.

The purpose of this study is to analyse the economic value of Nigeria's forest resources, where possible, placing added focus on resources found in the CRS, 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 Nigeria'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 Nigeria; 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 Nigeria is highly unique because of the scale of deforestation. From 2000 to 2015, the FAO estimates that forest area in Nigeria has decreased from 13.1 million ha to less than 7.0 million ha.

This is a rapid and severe rate of deforestation, equivalent to an annual average forest cover loss of 409,600 ha/a.

The Cross River State (CRS) contains approximately 31% of Nigeria's remaining primary forest (Fon et al 2014). It represents the highest density and largest continuous and undisturbed area of primary forests in Nigeria providing comparatively significant regional and national ecological benefits.

Much of these forests are managed within protected areas with approximately 40% in the Cross River National Park, 38% found within the fourteen forest reserves and 22% are managed by local communities. With this being said however these resources are no exception to pressures and overexploitation. Anthropogenic impacts have resulted in loss of these resources in scattered regions in the state over the past few years (approximately 4.5% Tropical High forest between 1991 and 2001).

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 Nigeria's natural ecosystems are important production factors to various economic sectors. Thus, 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 469,000 Naira/ha (in 2015). The FAO 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 164,000, 178,000 and 159,000 Naira/ha respectively. The health service, resulting from regulating malaria incidence, is 33,000 Naira/ha while the other (still highly significant) services display values below 10,000 Naira/ha (these include water provisioning, water yield available for hydro-power generation, effects on aquaculture and inland fishing and natural disaster mitigation by mangrove swamps. The total value of forest ecosystem services based on valuations done between 2000 and 2015 is approximately 1,000,000 Naira/ha. Although value is derived through forest use, the unsustainable exploitation thereof and subsequent deforestation results in a net loss to the economy of Nigeria.

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 Nigeria. Nigeria has put in place institutional arrangements in preparation for the implementation of UN REDD PROGRAMME.

Thus, in order to address the unique deforestation challenges faced by Nigeria, this study not only uses accounting and valuation of natural capital, but also makes significant progress towards designing and testing policy instruments that goes 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 PROGRAMME 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, 220% 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 Nigeria 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, agroforestry and industrialisation 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 Nigeria 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 2000, 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 Nigeria 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 Nigeria, 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 Nigeria would be.

The three preliminary policy options tested are:

1. Carbon trade
2. Certified plantation forestry
3. 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.

Carbon trade: The United Nations' REDD PROGRAMME 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 in the Eastern Littoral basin in the Cross River State (CRS). In this scenario the CRS returns 25% of the area deforested since 2000 (i.e. 285,000 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 70% and a net positive ecosystem services value of 16,540 M Naira would be returned to the economy, the net direct economic effects are negative. On its own, this is therefore not a workable policy instrument.

Certified plantation forestry: One of the key challenges central to a successful deforestation policy instrument for Nigeria relates to the productivity of land. The usable roundwood (or weighted average mean annual increment (MAI)) of the total forest estate of Nigeria is estimated at 2 m^3/ha/a. Planted forests in Nigeria however can achieve MAIs of up to 15 m^3/ha/a. Thus, a planted forest can yield up to 8 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 100,000 ha, comprising a fast growing species of at least 15 m^3/ha/a. We further assume that the relevant authority establishes a project implementation office at a cost of 1,000 million Naira 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.

Agroforestry: FAO round wood production data for Nigeria 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. 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 Nigeria. 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 100,000 ha, comprising a fast growing species of at least 12 m^3/ha/a. We further assume that the relevant authority establishes a project implementation office at a cost of 1,000 million Naira per year. The output of the analysis shows that the deforestation would be reversed. The net direct economic effects are all positive.

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

The challenge for the Government of Nigeria 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 PROGRAMME to develop and implement suitable policy instruments as may be developed by the relevant authorities in Nigeria.

KEY MESSAGES

1.	Deforestation in Nigeria is continuing at a rapid rate. The most recent estimates by the FAO indicates a rate that exceeds 400,000ha/a in forest losses, since 2000. This results in severe losses of ecosystem services. These losses is 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 91 900 million Naira in 2013. The total marginal value of these ecosystems services plus the sustainable timber harvest and non-timber forest products collections, was equivalent to 650,000 Naira/ha.
4.	The incentives for deforestation clearly far outweighs the value of losses in ecosystem services. Moreover, the ecosystem services losses are borne elsewhere in the economy. Nigeria 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 agroforestry. Additional policy options, such as eco-tourism, industrialization or other options, may be designed and tested by Nigeria.
6.	It is recommended that further work be conducted by the relevant authorities in Nigeria 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 programme has a key role to play in facilitating these processes. This includes applying the carbon income to the bouquet of policy instruments.

1. INTRODUCTION

As natural features in the landscape, ecosystems provide environmental, social and economic benefits to communities. The value of ecosystems in providing these services are 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.

Nigeria has one of the world fastest rates of deforestation having lost over 90% of its original forest resources (FME 2010). The loss is a result of long term pressures being placed on the resources through agricultural development, uncontrolled forest exploitation and urbanisation.

The Cross River State (CRS) contains approximately 31% of Nigeria's remaining primary forest (Fon et al 2014). It represents the highest density and largest continuous and undisturbed area of primary forests in Nigeria. Much of these forests are managed within protected areas with approximately 40% in the Cross River National Park, 38% found within the fourteen forest reserves and 22% are managed by local communities. This forms a significant proportion of the countries forest resources but with this being said are no exception to pressures and overexploitation. Anthropogenic impacts have resulted in loss of these resources in scattered regions in the state over the past few years (approximately 4.5% Tropical High forest between 1991 and 2001).

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 Nigerian forest resources have never been determined. As a rapidly growing and developing country with the largest economy 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 Nigeria's forest resources, placing, where possible, added focus on resources found in the CRS, 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 Nigeria'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 Nigeria; 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 Nigeria, 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 Nigeria. 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 Food and Agricultural Organisation of the United Nations (FAO), focussing on the period of 2000 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 basin (See Annex 1). A series of production functions[1] 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 Nigeria (See annexure 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 instruments aimed at mitigating against deforestation and forest degradation in Nigeria.

For a detailed methodological description refer to Annexures 1, 2, 3, 4 and 5.

Please note: All values in parenthesis indicates losses.

[1] The value of regulating services is best determined through an economic-ecological production function approach, which derives the value of regulating services as intermediate inputs into the production of final economic goods and services.

2. THE NIGERIAN ECONOMY AND THE ROLE OF FORESTS

2.1. Overview of the Economy

Although 2016 has been a difficult year from an economic growth perspective, Nigeria remains the largest economy in Africa, and is forecasted to rapidly grow and develop (Figure 1).

During 2015 and 2016, the Nigerian economy has been adversely affected by a fall in the global price of crude oil. Oil production remained low and growth of the non-oil sector weakened as the government cut spending due to lower oil revenues. While the oil sector contributes only about 10% of total GDP, it makes up about 90% of exports and 75% of government revenue. This situation has been aggravated by an inadequate supply of foreign exchange and exacerbated further by foreign exchange restrictions which has resulted in production and labour losses in some sectors.

Nevertheless, the 2017 outlook by the AfDB is positive, for economic recovery, albeit at a slow rate, as various reforms are expected to take effect. Such reforms include:

- Increased spending on infrastructure;
- Rationalisation of the public sector in order to cut the costs;
- Enforcement of a single treasury account to block financial leakages;
- Renewed efforts at enforcement of tax compliance;
- Preparation for zero-budgeting starting in 2016; and
- Increasing the ratio of capital to recurrent expenditure to 30:70.

A large factor in the commodity price decline is a marked decline in investment in China. However, this is associated with a so-called rebalanced growth, which can be expected to stimulate diversification of African economies in the medium to long term. The AfDB expects a medium to long term shift away from a traditional focus on natural resources towards a more exploratory focus on opportunities for a manufacturing and economic diversification.

Nigeria in particular, has seen a significant diversification of its economy with agriculture and primary sectors' relative contribution to GDP reducing by 16-17% and services sectors' relative contribution increasing by 24%.

Nigeria also faces a rapidly increasing population due to very high birth rates (Figure 2). At the same time this growth is largely skewed by migration to urban areas with the rural population now standing at approximately 53%.

Security remains a major challenge, in the north-east in particular. While the military has stepped up the fight against the Boko Haram insurgency the humanitarian situation has continued to deteriorate. The number of internally displaced persons is estimated at over 2 million, located mainly in the cities where conditions are safer.

Associated with economic diversification, population growth and migration resulting from security concerns, is a rapid rate of urbanisation and fast-growing mega-cities, especially Lagos and Kano. It is envisaged that Nigeria will have a strong focus in future on developing sustainable cities, which will be driven by structural transformation and integrated urban planning in order to minimise risk of unemployment and income inequality often associated with rapid urbanisation. The AfDB has identified

Lagos in particular as one of the mega-cities in Africa that has a high potential for innovation and job creation opportunities in sectors such as construction, information communications and technology (ICT) and retail trade.

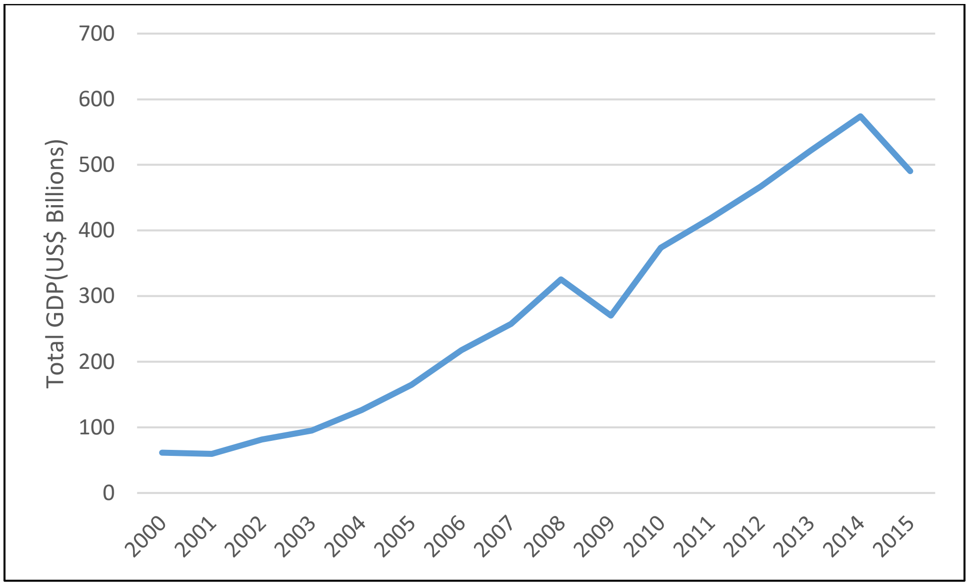

Figure 1: Growth of Nigeria's Gross Domestic Product (GDP) between 2000 and 2015 (Source: World Bank)

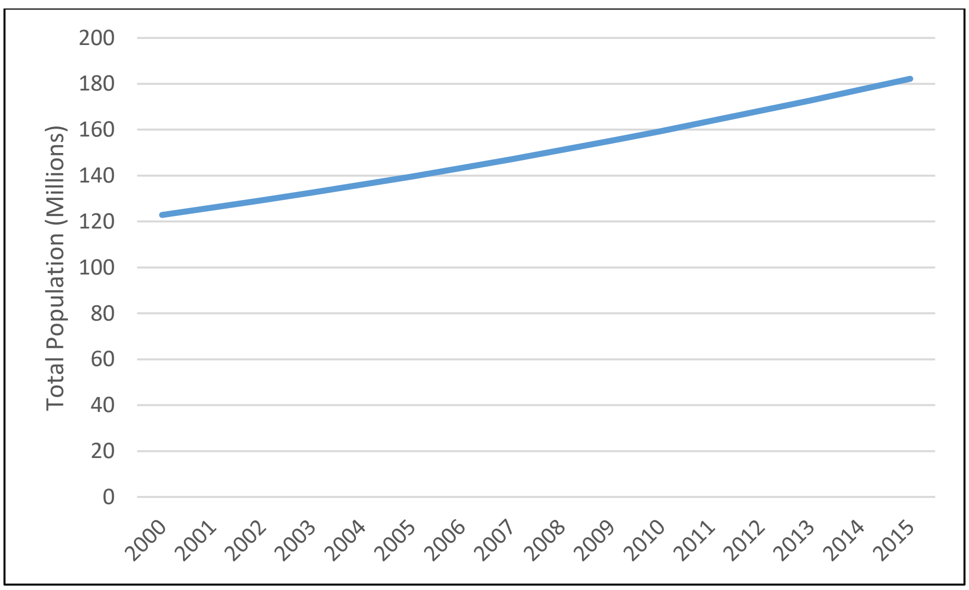

Figure 2: Growth of Nigeria's population between 2000 and 2015 (Source: United Nations)

2.2. Role of Forests on the Nigerian Economy

The macro-economic and demographic trends have several impacts on the forest sector.

Firstly, the commercial forest sector is small (0.25% of GDP), about 100 times smaller than the agricultural sector. However, it must be noted that forests supply approximately 30 million tons of firewood per year.

Secondly, it is often the case that as developing economies shed formal jobs during times of economic downturn, people seek livelihoods in subsistence or informal economic activities. It is thus likely that forests face increasing cumulative anthropogenic pressure as a resource for agricultural land, timber and fuelwood. For a description of drivers of deforestation in Nigeria refer to section 3.4.

Pressure on forest resources result in a reduction in forest cover, i.e. destruction of forest habitat, which in turn leads to losses of forest ecosystem services.

As an example, the forests in the CRS form a significant proportion of Nigeria's forest resources and as a result provide the region with a greater magnitude of ecosystem services that provide benefits to the local economy. Benefits include providing timber and fuelwood, medicinal plants, agricultural land, food provisioning and ecotourism (Cross River State Forestry Strategy 1994, Fon et al 2014). 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.

In addition to the effect of agriculture on forest habitat, unplanned urban expansion can also endanger wetlands' ecosystems, in the case of Nigeria mangroves and freshwater swamps. Urban expansion around Lagos, Nigeria, caused losses of wetlands in four local government areas of 38- 100% between 1986 and 2006 (Adelekan, 2009).

Nevertheless, well-planned development help to reverse forest ecosystem service losses. In Nigeria, significant investments in infrastructure, labour reform policies, national poverty reduction policies, expenditure and revenue-sharing frameworks seeks to drive equitable and inclusive growth in cities. Good health outcomes are pursued, and access to water and sanitation services remain a priority.

Nigeria has outlined several strategies such as the National Economic Empowerment and Development Strategy (NEEDS) and Nigeria Vision 20: 2020, to obtain goals that include guaranteeing the well-being and productivity of the people, optimizing the key sources of economic growth and fostering sustainable social and economic development.

UNEP defines a green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities." Key green economy focus areas for Nigeria, which would also shape policy instruments for combating deforestation, would include:

- Agriculture: Sustainable farming techniques can increase productivity, facilitate access to international supply chains, and respond to the global demand for more sustainable and organic produce.
- Forestry: sustainable trade in timber and non-timber forest products can significantly increase transparency and ensure traceability in the forestry sector, in particular through certification schemes.

- Fisheries: sustainable exploitation, and subsequently by certifying fish products for sustainability can improve the overall fishery management systems in Nigeria.
- Manufacturing: Cleaner production methods are essential to increase earnings, profitability, output growth and subsequently employment generation.
- Energy: Taking advantage of renewable energy sources can lead to increased energy security, reduced energy costs and reduced pollution externalities.

In the longer-term, climate change and environmental degradation caused by urban growth have different impacts on various African cities and regions. Flooding risks in low elevation coastal zones: 50% of African settlements with 1-5 million inhabitants lie at low elevation coastal zones (Kamal-Chaoui and Robert, 2009). Flooding increases in cities because they have more impervious surfaces (Paulais, 2012). The populations and assets of port cities are vulnerable to sea level rise. Mangrove forests and swamps play a key role in mitigating such risks and therefore provide an insurance value to the economy.

Figure 3 provides a visual representation of the chains of causality linking forests and the economy in Nigeria.

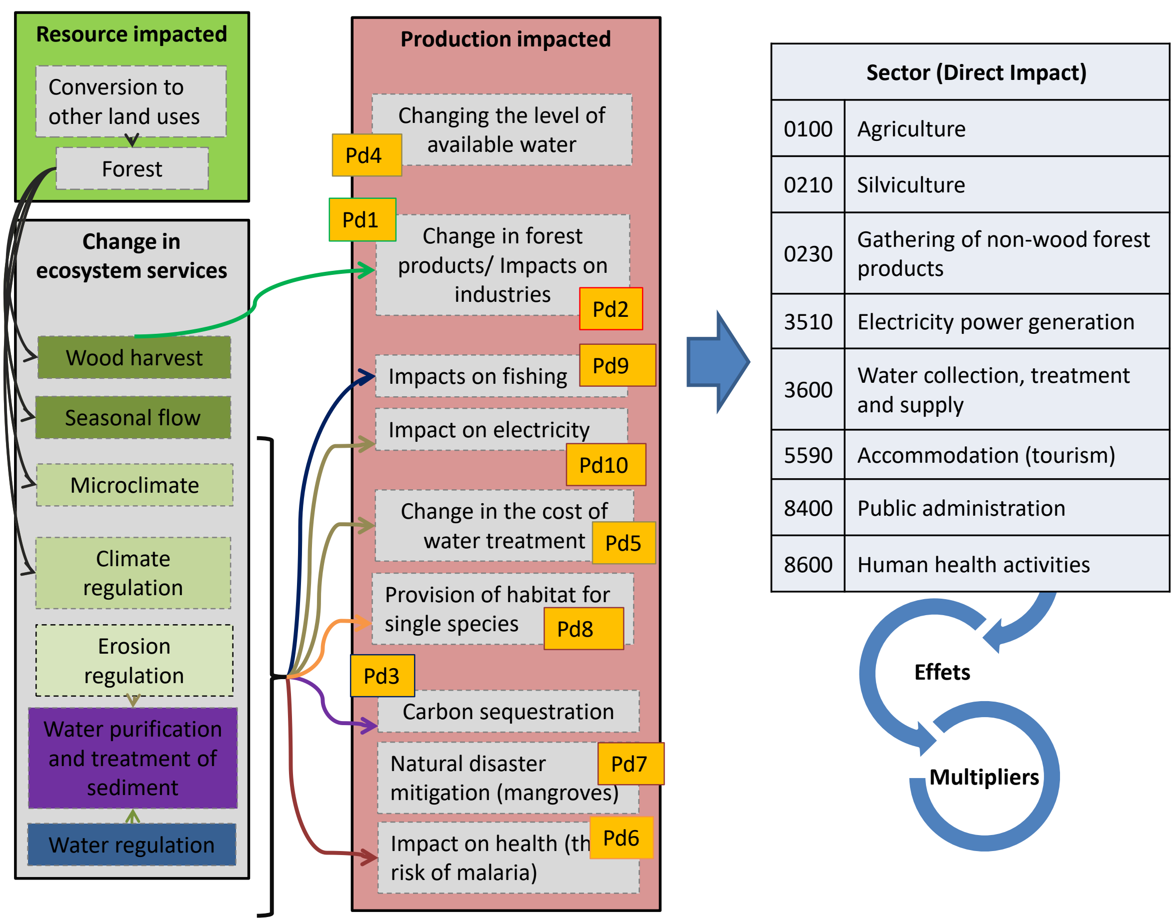

Figure 3: Visual representation of the chains of causality linking forests and the economy in Nigeria. The labels Pd1 – Pd10 denotes the production function developed (described in the Annexes below).

2.3. Deforestation in Nigeria and its drivers

The past 15 years has shown a significant decrease in the Nigeria's forest resources (Figure 4). The total rate of loss in terms of area (especially primary, and other naturally regenerated forests) has remained consistent at just above 400,000 ha /a between 2000 and 2015 (Figure 4) (FAO 2015) and can be seen across basins in Figure 16[2]. The corresponding loss in biomass was 42% which equates to almost 2 billion tonnes of carbon.

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 fortes management. Furthermore, the economic development of the country places added pressures on these resources in the form of infrastructure development and urban expansion. The drivers of forest loss in the CRS similarly include commercial logging and agricultural expansion with further impacts arising from urbanization. Poor management, enforcement of laws and regulations result in continuous pressure on these systems.

A review of the direct and indirect factors driving forest loss in the country in general is presented by the Nigerian Federal Ministry of the Environment (FME) (2010) (the data to follow is largely sourced from this document).

Direct drivers of deforestation and degradation include:

- Agricultural expansion (including pasture development);
- Unsustainable wood extractions (timber and fuelwood);
- Infrastructure extension (roads, settlements, pipelines, mining and hydroelectric dams); and
- Forest fires.

The extent and intensity of these pressures do vary across the country with over grazing and wood removals for fuelwood occurring more predominantly in the north and small scale logging occurring mainly in the southern regions (FME 2010).

The expansion of various land use activities at an economic and spatial scale may reveal more clues into the source of direct gains and losses to forest resources. As an example, although industrial wood removals and the rate of burning has remained relatively stable over the years, the extent of removal of wood for fuel purposes has increased by an average of 366 000 m^3 per year since the year 2000 (FAO 2015) (Figure 5).

More indirect drivers of deforestation and degradation are included in

[2] It is clear from the FAO results that the annual rate of deforestation is based on an estimate. It is strongly advise that

Table 1. These risks have placed cumulative pressure on forest resources in Nigeria. The loss to date has been extensive resulting in a large-scale loss of natural benefits from forest ecosystems to the socio-economic wellbeing of the country. The benefits arising from these resources need to be quantified and understood before measures can be put in place to stimulate their preservation and conservation toward preventing further loss of the countries valuable resources.

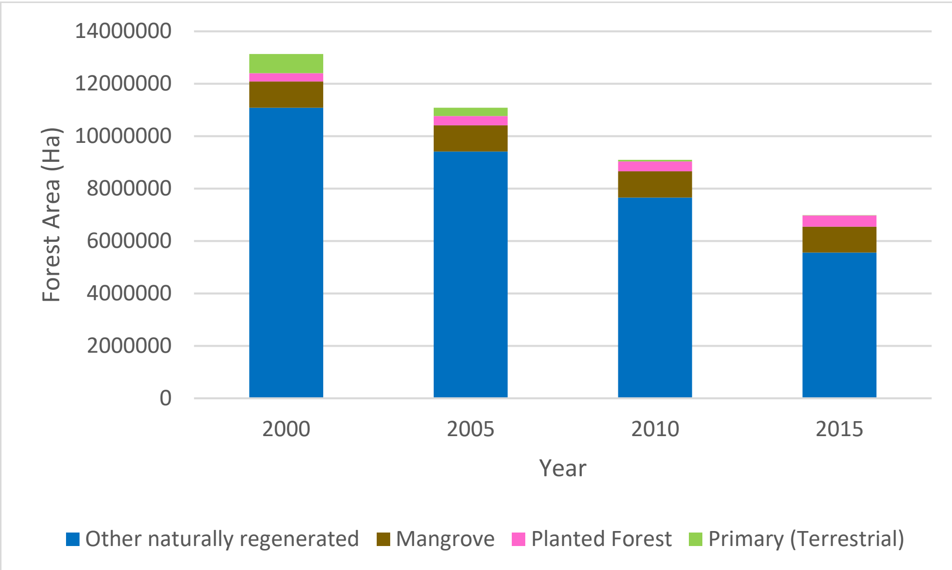

Figure 4: Nigerian forest cover and type by year (FAO 2015)

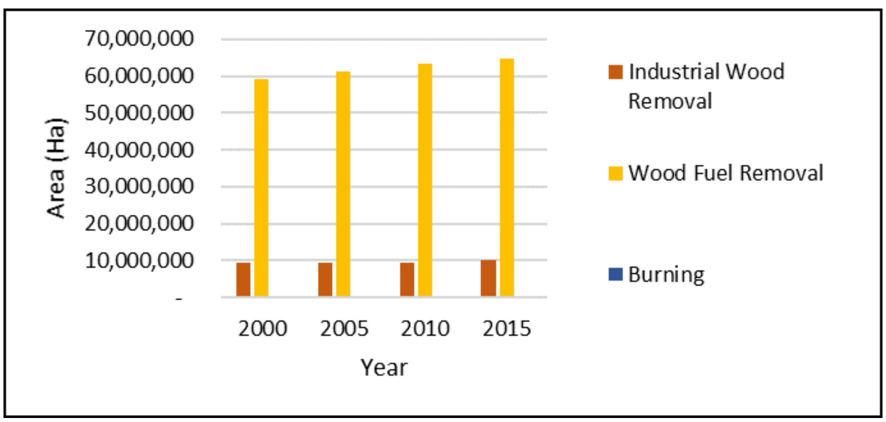

Figure 5: Direct losses to forest resources for the periods of 200, 2005, 2010 and 2015 (Provided by FAO 2015)

Table 1: Indirect drivers of deforestation and forest degradation in Nigeria (FME 2010).

Sector	Indirect Driver	Description
Macro-Economic Factors	Profitability of agriculture	High profitability of agriculture compared to that of sustainable utilization of forest resources is a major economic driver of deforestation and forest degradation.
Governance Factors	Outdated forest laws	The National Forest Policy (1988) fails to effectively provide the enabling environment for sustainable wood production and expansion of forest protection. It also fails to recognise the relationship that rural communities have with forest resources and the role they play in forest management.
	Lack of integration of relevant ministries	Although mechanisms that integrate biodiversity into the economy are present, the national planning processes do not effectively consider the impact of developments on the greater environmental and forestry sectors.
	Land tenure laws are not appropriately focused	The tenure of land by communities is not formally recognized thus removing any sense of responsibility toward utilized land.
	Capacity limitations	The Federal Department of Forestry has had a lack of capacity development and this has influenced a lack of funding and capacity for forest management at a state level.
	Absence in forest management planning	Forest management in forest reserves by state forestry departments has been seen to be virtually non-existent. There is a lack of policies which effectively regulate the use of these resources in a sustainable manner.
	Lack of communication from the top down	Timber removal forms a large part of various states annual revenue. The low cost of timber has resulted in the over-exploitation of forest resources to achieve revenue targets. Furthermore, annual revenue targets are set at an administrative level from where there is a gap in understanding of the state and extent of remaining forest resources.
	De-reservation of forest resources	Pressures by economic role players on governments result in various forest reserves being de-reserved. These occurrences create the impression that this is a potential option for land utilization and development.
	The ban on timber export	The ban on timber exports from Nigeria has prevented timber from realizing international competitive prices. Low prices of timber have been shown to contribute to both inefficient use of timber in industry and massive losses in appropriate revenue.
Other Factors	Demographic drivers	Rapid population growth has increased demand for resources and ultimately places pressure on available land and remaining natural resources. Further migration to subsistence agriculture places increased pressure on forest resources.
	Technologic drivers	Advances in extensive agricultural technologies affects the rate of deforestation.
	Cultural drivers	Communities are often compromised by timber extractors which negatively effects the resources ability to provide benefits. Once the benefits from forests is reduced, agriculture often becomes the alternative to supporting communities which further impacts the resource. A lack of knowledge of sustainable utilization methods is also a limitation within local communities.

2.4. The impact of deforestation on the economy

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.

A list of ecosystem services provided by forests is given in Table 2 below.

The growth in the Nigerian 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 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). Having increased harvest by 9%/a between 2000 and 2015 the sector draws direct value from forest resources in the form of timber provisioning, it also however has the potential to directly impact the ability of forests to provide other ecosystem services. In other words, 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 566,000 Naira/ha (Figure 9). The sustainable harvesting of timber is valued at 87,000 Naira/ha meaning the cumulative benefits of other services outweigh the value received by sustainable timber extraction (Figure 9).

Currently, however timber harvest is unsustainable with a current value of 469,000 Naira/ha (530% over harvested) still indicating that the value gained through over-exploitation is still below the value of other services (Figure 6). 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). Note in Figure 6 as the current unsustainable harvest continues there is a subsequent decrease in the value of timber that can be sustainable harvested.

The total stock of Nigeria's existing forests has decreased by 42% since 2000 (through a variety of impacts). This means that the total available yearly sustainable harvest has decreased from approximately 26 mil m^3/a (in 2000) to approximately 14 mil m^3/a (in 2015). This is a 47% decrease in the yearly timber available to be sustainably harvested in the last 15 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.

Table 2: Ecosystem services provided by various forest types in Nigeria (Adapted from MEA 2010, TEEB 2013 and Adeka and Mitchell 2011)

Ecosystem Service Category	General ecosystem services	Description	References
Provisioning	Food	Sustainably produced/harvested crops, fruit, wild berries, fungi, nuts, livestock, semi-domestic animals, game, fish and other aquatic resources etc.	Davies et al., 2009, Fentiman 1996, Nwadiaro 1984
	Fresh water	Agricultural and tree crops (cassava, yam, cocoyam, rice, maize, ogbono, cocoa, etc.).	Omofonmwan and Odia 2009, Umoh 2008, World Bank 1995
	Raw Materials	Sustainably produced/harvested wool, skins, leather, plant fibre (cotton, straw etc.), timber, cork, firewood, biomass etc.	Alogoa 2005, McGinley 2008, NDDC 2006, World Bank 1995
	Genetic materials	Forests and their biodiversity provide many plants used as traditional medicines as well as providing the raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources	Ndukwu and Ben-Nwadibia 2005
	Other products	Bush meat, and other products including raffia, snail, spices, mangrove salts, reeds and sedge.	Luiselli 2003, Luiselli et al., 2006, UNDP 2006, World Bank 1995
Regulating	Climate regulation	Carbon sequestration, maintaining and controlling temperature and precipitation	Brooks et al. 2000
	Water regulation (hydrological flows)	Regulating surface water runoff, aquifer recharge, river and stream recharge etc.	Cugusi and Piccarozzi 2009
	Water purification and waste treatment	Decomposition/capture of nutrients and contaminants, prevention of eutrophication of water bodies etc.	Abam 2001, Uluocha and Okeke 2004
	Erosion regulation	Maintenance of nutrients and soil cover and preventing negative effects of erosion (e.g. impoverishing of soil, increased sedimentation of water bodies)	Dupont et al. 2000
	Biochemical control	Forests are important for regulating pests and vector borne diseases that attack plants, animals and people. Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls.	Arimoro and Ikomi 2009
	Natural hazard regulation	Flood control, drought mitigation.	Abu and Dike 2008, Benka-Coker and Ekundayo 1995
Supporting/Habitat	Habitat for species	Habitats provide everything that an individual plant or animal needs to survive: food; water; and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements	USAID 2008
	Maintenance of genetic diversity	Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots'	USAID 2008
Cultural	Recreational and tourism	Hiking, camping, nature walks, jogging, canoeing, rafting, recreational fishing, diving, animal watching etc.	Jonathan 2006
	Aesthetic (Spiritual and inspirational)	Amenity of the ecosystem, cultural diversity and identity, spiritual values, cultural heritage values etc.	Anderson and Peek 2002, Bisina 2006, Isichei 1982
	Educational	Education, art and research	Ebeku 2004World Bank 1995

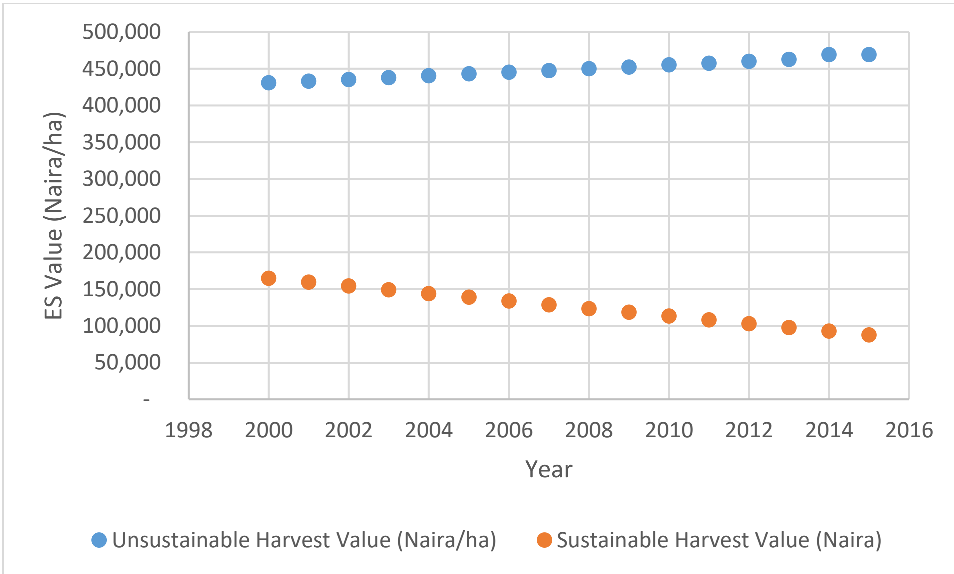

Figure 6: Value/ha of current timber harvest (unsustainable) and sustainable timber harvest in Nigeria between 2000 and 2015

2.5. The value of Nigeria'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 annexure 3).

Ecosystems are highly complex systems of which Nigeria'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 Nigerian 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 7).

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 8).

Note in Figure 17 and in Figure 8 the marginal value of ecosystem services provided by a hectare of forest gradually decreases between 2000 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 shown to be the single largest ecosystem service at a value of 469,000 Naira/ha (Figure 9). It is this value, combined with the use value of the deforested land, which is the fundamental economic driver of deforestation.

The values resulting from sustainable collections (i.e. collection of non-timber forest products (NTFP)), carbon losses and support by habitat are 164,000, 178,000 and 159,000 Naira/ha respectively. The health service reflects a value of 33,000 Naira/ha while the other (still highly significant) services display values below 10,000 Naira/ha (Figure 9). The total value of forest ecosystem services based on valuations done between 2000 and 2015 is approximately 1 million Naira/ha (Figure 9).

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. In the case of Nigeria, although this service does have a comparatively large value.

Of particular interest is the ecosystem service multiplier effect of carbon. The analysis show that for every 1 Naira of carbon sequestration value, there is a multiplier of 2.25 Naira (1+1.25) 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 Nigeria 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 2000 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 2000-2015 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 Nigeria as well as the communities who depend on the forest ecosystem.

Figure 3 below describes the relationship between ecosystem services and the economy and presents a simplified visual summary of the integrated bio-economic modelling done as part of this study.

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

Summary results of the FRA and ecosystem service mapping analysis and ecosystem service valuation are presented per basin including Niger North (Table 3), Niger Central (Table 4), Upper Benue (Table 5), Lower Benue (Table 6), Niger South (Table 7), Western Littoral (Table 8), Eastern Littoral (Table 9) and Chad Basin (Table 10).

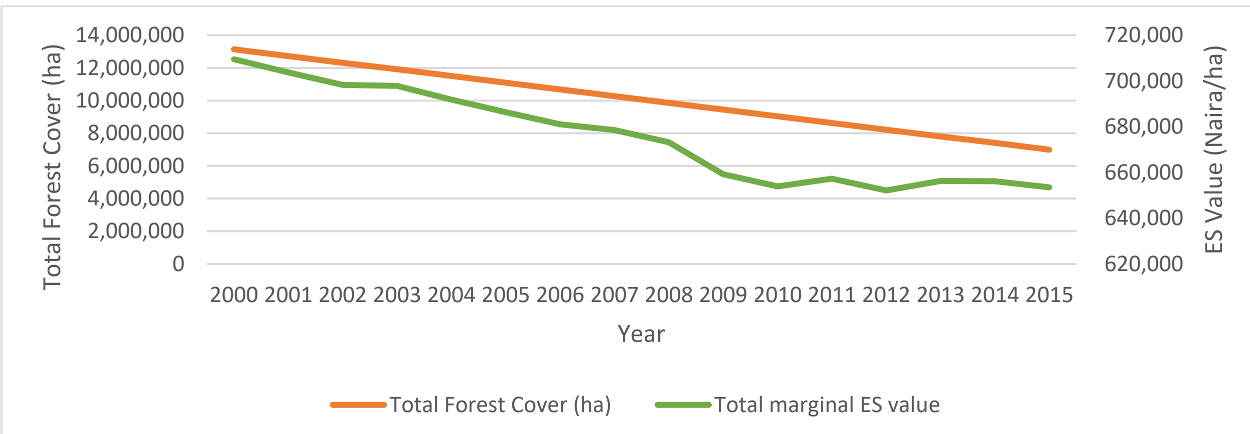

Figure 7: Forest area and corresponding ecosystem service value per ha in Nigeria between 2000 and 2015

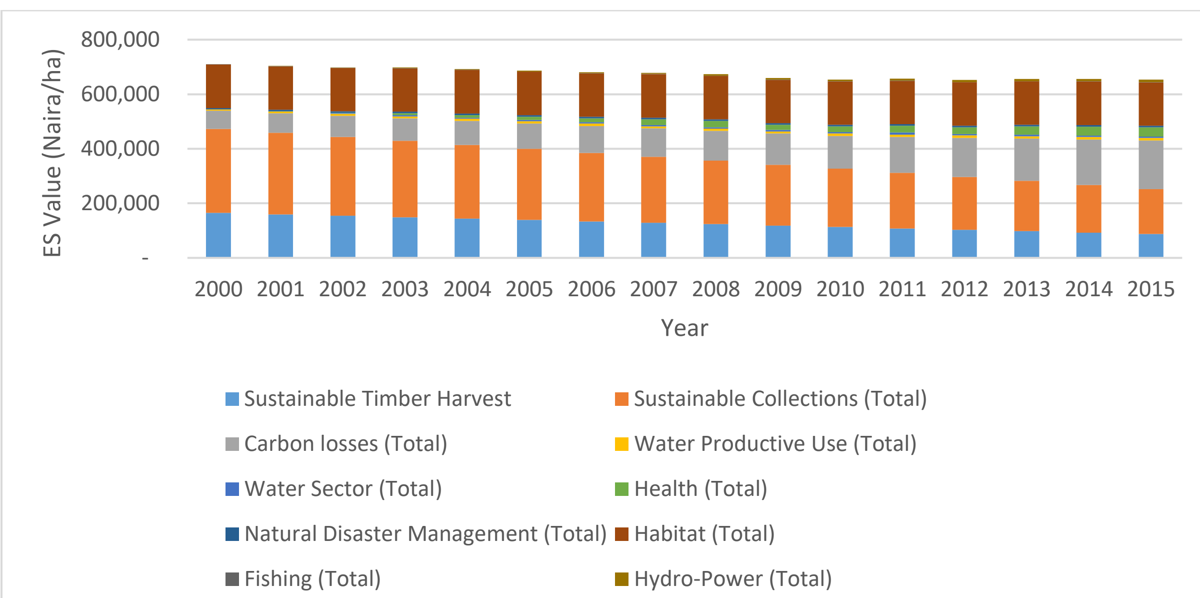

Figure 8: Marginal forest ecosystem service value per Ha between 2000 and 2015

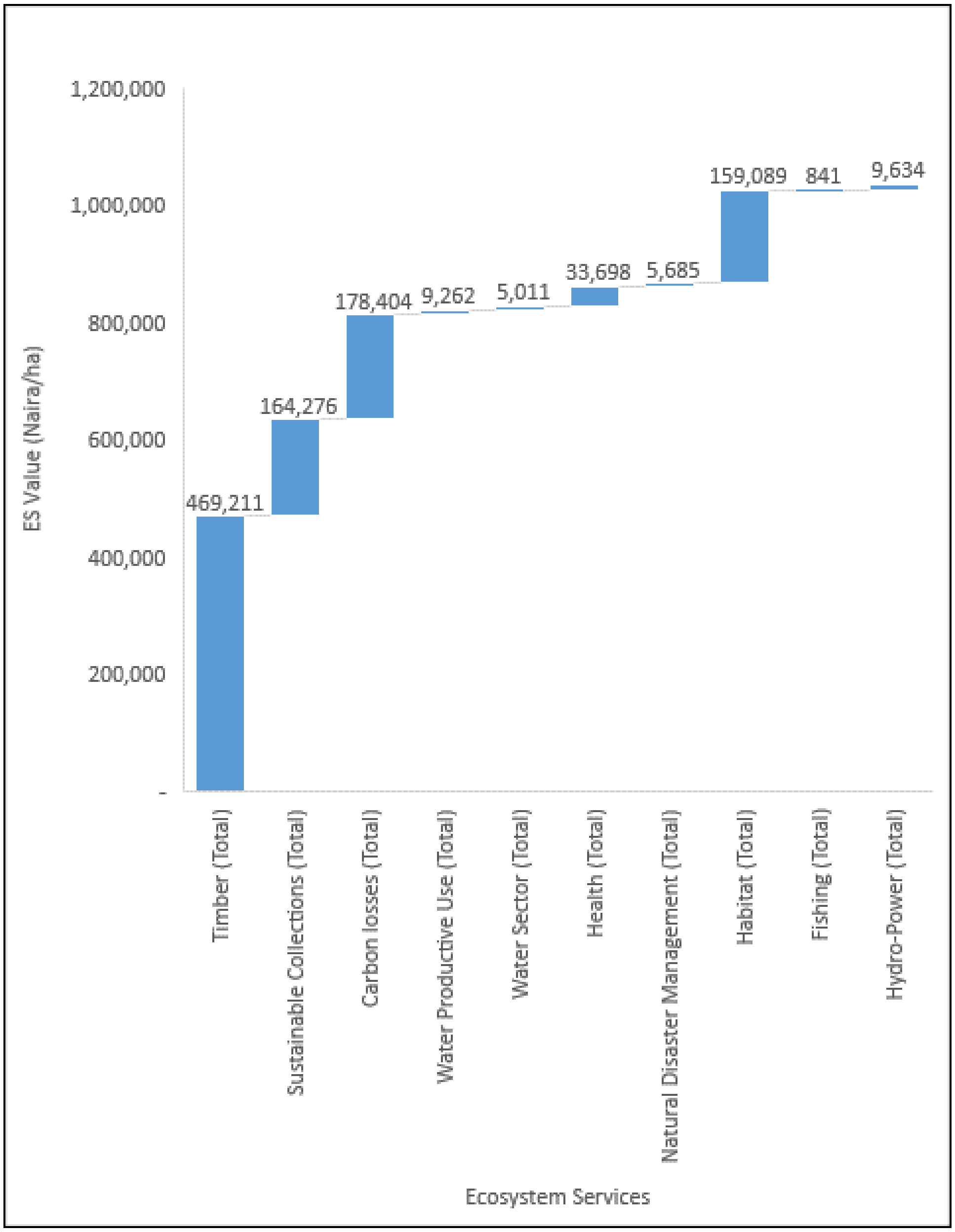

Figure 9: Forest ecosystem service value per Ha in 2015 in Nigeria

2.6. Deforestation in the CRS

Forest resources in the CRS (Tropical high, open, freshwater swamp and mangrove forests) covered a total area of 860 000 ha in 2001 (40.8% of CRS) (FME 2010) (Please note that this figure does not directly correspond to FAO data).

Up to date forest cover data (latest was 2001) within the CRS was not available at the time of this study. Data was available at a basin level however and given that the CRS falls within the Eastern Littoral basin, the data limitations resulted in this basin being used as a surrogate for changes in the CRS. Currently total forest cover in in the Eastern Littoral basin is approximately 1.4 million ha of which 4 109 ha is primary, 184 000 ha mangrove and the rest other regenerated forests (See annex 2). It is assumed that a large proportion of this can be found within the CRS.

The rate of forest loss in CRS between 1991 and 2001 has occurred at a slower rate of a loss of 4.5% Tropical High forest (FME 2010). Between 2000 and 2015 deforestation has occurred at a much greater rate in the Eastern littoral basin with a total loss of forest cover at 47%. This indicates as it does for the rest of Nigeria, the need for improved management to reduce deforestation and the loss of valuable forest infrastructure. Further research is needed to determine a more accurate up to date indication of the specific forest loss in the CRS.

Table 3: Preliminary ecosystem service mapping of the forest resources in the Niger North basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Niger North (14 211 145)	Terrestrial Forest	421 986	Timber and Fuelwood 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)	-Agricultural expansion -Over exploitation -Over grazing -Drought and desertification	-Kainji Lake National Park (Northern portion)	-Kainji Reservoir -Kainji Hydroelectric Power Station (800 MW) -Zamfara Hydroelectric Power Station (100MW)	Total ES losses = (17 663) -Crop Production -Forestry -Wood and wood products -Electricity -Arts, entertainment and recreation -Human health

Table 4: Preliminary ecosystem service mapping of the forest resources in the Niger Central basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Niger Central (15 399 394)	Terrestrial Forest	573716	Timber and Fuelwood Other Products (T) Carbon Sequestration Water regulation (hydrological flows) (F) Water purification and waste assimilation (F) Biological Control (Malaria/Water borne disease) (F) Habitat (Biodiversity Support) Recreational and tourism Erosion regulation	-Pollution from industries (Kaduna) -Urbanisation (Abuja) -Over exploitation -Agricultural expansion -Deforestation	-Kainji Lake National Park (central and southern portion) -Kamuku National Park	-Kaduna City -Abuja City -Zaria City -Jebba Hydroelectric Power Station (540 MW) -Shiroro Hydroelectric Power Station (600 MW)	Total ES losses = (21 195) -Crop Production -Forestry -Wood and wood products -Pulp, paper and paper production -Electricity -Arts, entertainment and recreation -Human health

Table 5: Preliminary ecosystem service mapping of the forest resources in the Benue Upper basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Upper Benue (11 395 783)	Terrestrial Forest	898818	Timber and Fuelwood 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)	-Timber extractions -Agricultural expansion -Deforestation	-Gashaka-gumti National Park -Yankari National Park	-Mambilla Hydroelectric Power Station (3000MW proposed)	Total ES losses = (20 912) -Crop Production -Forestry -Wood and wood products -Pulp, paper and paper production -Electricity -Arts, entertainment and recreation -Human health

Table 6:Preliminary ecosystem service mapping of the forest resources in the Benue Lower basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Lower Benue (7 340 413)	Terrestrial Forest	275928	Timber and Fuelwood 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)	-Timber extractions -Agricultural expansion -Deforestation	-Kashimbila Nature Reserve	-Makurdi City -Kashimbila Hydroelectric Power Plant (40MW proposed)	Total ES losses = (5 977) -Crop Production -Forestry -Wood and wood products -Pulp, paper and paper production -Arts, entertainment and recreation -Human health

Table 7: Preliminary ecosystem service mapping of the forest resources in the Niger South basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Niger South (15 587 029)	Terrestrial Forest	1 177 231	Timber and Fuelwood	-Timber extractions -Agricultural expansion -Deforestation	-Orashi Forest Reserve -Bayelsha Forest Reserve -Southern Adoru Forest Reserve -Edumanom Forest Reserve	Awka City	Total ES losses = (166 068) -Crop production -Forestry -Fishery -Wood and wood products -Pulp, paper and paper products -Chemicals, chemical products and pharmaceuticals -Arts, entertainment and recreation -Human health
			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)				
	Mangrove Forests (Marine)	653	Timber and Fuelwood	-Timber removal -Agriculture (Nipa Palms) -Navigational Canals -Oil production activities -Drainage -Deforestation -Industrial/ urban waste			
			Fishing (Marine)				
			Genetic materials (Medicinal) (S/M)				
			Other Products (M)				
			Carbon Sequestration				
			Water regulation (hydrological flows) (M)				
			Water purification and waste assimilation (M)				
			Biological Control (Malaria/Water borne disease) (M)				
			Erosion regulation				
			Natural hazard regulation (Oceanic surge control)				
			Recreational and tourism				
			Spiritual and inspirational (S/M)				
			Habitat (Biodiversity Support)				
	Mangrove Forests (Freshwater) (Niger Delta)	723	Fishing (Freshwater)	-Salt water Intrusion (Removal of barriers from mangroves) -Timber removal -Oil and gas exploration -Invasive plants -Drainage -Industrial/ urban waste -Deforestation			
			Fresh water provision (S)				
			Timber and Fuelwood				
			Genetic materials (Medicinal) (S/M)				
			Other Products (S)				
			Carbon Sequestration				
			Water regulation (hydrological flows) (S)				
			Water purification and waste assimilation (S)				
			Biological Control (Malaria/Water borne disease) (S)				
			Erosion regulation				
			Natural hazard regulation (Flood control)				
			Recreational and tourism				
			Spiritual and inspirational (S/M)				
			Habitat (Biodiversity Support)				

Table 8: Preliminary ecosystem service mapping of the forest resources in the Western Littoral basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Western Littoral (33 288 033)	Terrestrial Forest	2 010 221	Timber and Fuelwood	-Pollution from industries -Urbanisation over-exploitation -Agricultural expansion -Deforestation	-Old Oyo National Park -Okomu National Park	-Lagos City -Ibadan City -Benin City -Oyan River Dam (9 mw)	Total ES losses = (259 647) -Crop production -Forestry -Fishery -Wood and wood products -Pulp, paper and paper products -Chemicals, chemical products and pharmaceuticals -Water supply -Arts, entertainment and recreation -Human health -Real estate
			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)				
	Mangrove Forests (Marine)	655	Fishing (Marine)	-Deforestation -Urban development -Timber removal -Navigation canals -Industrial/ urban waste -Agriculture -Drainage			
			Timber and Fuelwood				
			Genetic materials (Medicinal) (S/M)				
			Other Products (M)				
			Carbon Sequestration				
			Water regulation (hydrological flows) (M)				
			Water purification and waste assimilation (M)				
			Biological Control (Malaria/Water borne disease) (M)				
			Erosion regulation				
			Natural hazard regulation (Oceanic surge control)				
			Recreational and tourism				
			Spiritual and inspirational (S/M)				
			Habitat (Biodiversity Support)				
	Mangrove Forests (Freshwater)	166	Fishing (Freshwater)	-Extensive abstraction -Timber removal -Oil and gas exploration -Invasive plants -Overburden system -Agriculture -Drainage			
			Fresh water provision (S)				
			Timber and Fuelwood				
			Genetic materials (Medicinal) (S/M)				
			Other Products (S)				
			Carbon Sequestration				
			Water regulation (hydrological flows) (S)				
			Water purification and waste assimilation (S)				
			Biological Control (Malaria/Water borne disease) (S)				
			Erosion regulation				
			Natural hazard regulation (Flood control)				
			Recreational and tourism				
			Spiritual and inspirational (S/M)				
			Habitat (Biodiversity Support)				

Table 9: Preliminary ecosystem service mapping of the forest resources in the Eastern Littoral basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/ Risks/ Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Eastern Littoral (19 955 888)	Terrestrial Forest	2 958	Timber and Fuelwood	-Timber extractions -Deforestation (Food crop agriculture, Increases hunting/ poaching	-Cross River National Park -Afi Mountain Wildlife Sanctuary -Mbe Mountain Wildlife Sanctuary	-Port Harcourt -Aba City -Calabar City	Total ES losses = (142 715) -Crop production -Forestry -Fishery -Wood and wood products -Pulp, paper and paper products -Chemicals, chemical products and pharmaceuticals -Water supply -Arts, entertainment and recreation -Human health -Real estate
			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)				
	Mangrove Forests (Marine)	436	Fishing (Marine)	-Deforestation -Urban Development -Agriculture (Nipa Palms) -Navigational Canals -Oil production activities -Industrial/ urban waste			
			Timber and Fuelwood				
			Genetic materials (Medicinal) (S/M)				
			Other Products (M)				
			Carbon Sequestration				
			Water regulation (hydrological flows) (M)				
			Water purification and waste assimilation (M)				
			Biological Control (Malaria/Water borne disease) (M)				
			Erosion regulation				
			Natural hazard regulation (Oceanic surge control)				
			Recreational and tourism				
			Spiritual and inspirational (S/M)				
			Habitat (Biodiversity Support)				
	Mangrove Forests (Freshwater)	85	Fishing (Freshwater)	-Drainage Salt water - Intrusion (Removal of barriers from mangroves) -Timber removal -Oil and gas exploration -Agriculture Invasive plants			
			Fresh water provision (S)				
			Timber and Fuelwood				
			Genetic materials (Medicinal) (S/M)				
			Other Products (S)				
			Carbon Sequestration				
			Water regulation (hydrological flows) (S)				
			Water purification and waste assimilation (S)				
			Biological Control (Malaria/Water borne disease) (S)				
			Natural hazard regulation (Flood control)				
			Erosion regulation				
			Recreational and tourism				
			Spiritual and inspirational (S/M)				
			Habitat (Biodiversity Support)				

Table 10: Preliminary ecosystem service mapping of the forest resources in the Chad basin in Nigeria

Basin (Pop 2006)	Ecological Infrastructure	Cover Area 2015 (Ha)	Ecosystem Services (TEEB 2013)	Impacts/Risks/Threats	Protected Areas	Economic features	Ecosystem service value losses (Naira/ha) and beneficiaries affected
Chad Basin (23 189 748)	Terrestrial Forest	416 269	Timber and Fuelwood	-Agricultural encroachment -Deforestation (over utilisation) -Overgrazing -Drought and desertification	-Chad Basin National Park -Lame Burra Game Reserve -Sambisa Forest Reserve	-Kano City -Maiduguri City -Jos City -Tiga Dam (6 Mw)	Total ES losses = (24 045) -Crop production -Forestry -Fishery -Wood and wood products -Pulp, paper and paper products -Water supply -Arts, entertainment and recreation -Human health
			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)				
	Lake Chad		Fishing (Freshwater)	-Population growth (Over utilisation) (400% increase in 50yrs) -Climatic Changes -Water Pollution (Industries) -Bad management -Overgrazing			
			Fresh water provision (C)				
			Water regulation (hydrological flows) (C)				
			Water purification and waste assimilation (C)				
			Erosion regulation				
			Natural hazard regulation (Flood control)				
			Recreational and tourism				
			Spiritual and inspirational (C)				
			Habitat (Biodiversity Support)				

3. 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 Nigeria.

Policy is described by UNEP 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 Nigeria, 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 Nigeria, 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 Nigeria would be.

The three policy options tested are:

1. Carbon trade
2. Certified plantation forestry
3. 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 409,600ha/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.
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 Nigeria's national balance sheet increases.
6. The fiscal effect measures the effect on the income of the Government of Nigeria. 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. Carbon Trade as a policy instrument

The United Nations' REDD PROGRAMME 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 in the Eastern Littoral basin in the Cross River State. In this scenario the CRS returns 25% of the area deforested since 2000 (i.e. 285,000 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 4US$/ton carbon, and this revenue is invested into the programme. Secondly, it assumes that the 285,000 ha can be made available and rehabilitated at a cost of 150,000 Naira/ha. Thirdly, it assumes that the required funding is raised through a corporate income tax.

The output of the analysis (

Table 11) shows that although the annual rate of deforestation would be curbed by 70% and a net positive ecosystem services value of 16,540 M Naira would be returned to the economy and the net direct economic effects are negative. Therefore not a workable policy instrument is used in isolation.

Of interest in this analysis is the Total GDP effect, which is positive. This indicator is positive as a result of the indirect effects of ecosystem services in the economy. The challenge would therefore be to find one or more policy instruments that is affordable and has positive direct effects, which would then be further supported by the positive externalities of forest ecosystem services (the Total Effect).

Table 11: This scenario demonstrates a pure carbon mechanism applied in the Eastern Littoral basin (Cross River State), where the CRS returns 25% of the area deforested since 2000 (i.e. 285,000 ha) to forest area through a long term rehabilitation programme.

Macro biophysical indicators		
Net ecosystem service value gained	*Million Naira/a*	16,540
Sustainability frontier		70%

Macro-economic impacts		**Direct Effect**		**Total Effect**	
Indicator	**Unit**	**Change**		**Change**	
GDP	*Million Naira/a*	-2,901	-0.01%	6,653	0.01%
Compensation of employees	*Million Naira/a*	-1,507	-0.01%	1,602	0.01%
Balance of payments	*Million Naira/a*	399	0.00%	-2,539	-0.03%
Fiscal effect	*Million Naira/a*	1,665	0.19%	7,169	0.84%

3.4. Certified plantation forestry as a policy instrument

One of the key challenges central to a successful deforestation policy instrument for Nigeria relates to the productivity of land. The weighted average mean annual increment (MAI) of the total forest estate of Nigeria is estimated at 2 m^3/ha/a (Alderman and Abayomi, 1994). Planted forests in Nigeria however can achieve MAIs of up to 15 m^3/ha/a (FAO 2003). Thus a planted forest can yield up to 8 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.

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 Nigeria where annual rainfall exceeds 800mm/a. In this scenario a private investor establishes a plantation forest estate of 100,000 ha, comprising a fast growing species of at least 15 m^3/ha/a. This scenario assumes an average crop rotation of 15 years and an average timber value of 22,000 Naira/m^3. We further assume that the relevant authority establishes a project implementation office at a cost of 1,000 million Naira 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 12) shows that the deforestation would be reversed. The sustainability contribution indicator is 159% indicating that the natural forest estate increases in size and a net positive ecosystem services value of 134,614 M Naira would be returned to the economy which would serve to further strengthen GDP growth.

The net direct economic effects are all positive. The analysis only shows negative indicators for Balance of Payments indicating a reliance on imported products and services to make the project work.

Table 12: This scenario demonstrates a certified plantation forestry project implemented anywhere in Nigeria where rainfall exceeds 800mm/a.

Macro biophysical indicators		
Total ecosystem service value preserved	*Million Naira/a*	134,414
Sustainability frontier		159%

Macro-economic impacts		Direct Effect		Total Effect	
Indicator	**Unit**	**Change**		**Change**	
GDP	*Million Naira/a*	46,664	0.09%	100,716	0.18%
Compensation of employees	*Million Naira/a*	17,661	0.12%	36,871	0.25%
Balance of payments	*Million Naira/a*	-400	0.00%	-6,371	-0.08%
Fiscal effect	*Million Naira/a*	5,794	0.68%	21,045	2.46%

3.5. Agroforestry as a policy instrument

FAO round wood production data for Nigeria 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 develops 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 Nigeria. In this scenario a the relevant authority implements a large scale Agroforestry initiative comprising distribution of fast-growing, wood producing tree species accompanies by extension services. It is assumes that the initiative is suitable certified as a sustainable forest management activity. The relevant authority establishes a timber-producing agroforestry estate of 100,000 ha, comprising a fast growing species of at least 12 m^3/ha/a. This scenario assumes an average crop rotation of 10 years and an average timber value of 11,000 Naira/m^3. We further assume that the relevant authority establishes a project implementation office at a cost of 1,000 million Naira per year. The analysis also assumes a steady state situation (as in the case of plantation forestry it is to be noted that agroforestry investment is a long term investment that may take many years to mature).

The output of the analysis (Table 13) shows that the deforestation would be reversed. The sustainability contribution indicator is 122% indicating that the natural forest estate increases in size and a net positive ecosystem services value of 103,395 M Naira would be returned to the economy which would serve to further strengthen GDP growth.

The net direct economic effects are all positive. As in the plantation forestry case, the analysis only shows negative indicators for Balance of Payments indicating a reliance on imported products and services to make the project work.

Table 13: This scenario demonstrates a certified agroforestry project implemented anywhere in Nigeria.

Macro biophysical indicators		
Total ecosystem service value preserved	*Million Naira/a*	103,395
Sustainability frontier		122%

Macro-economic impacts		**Direct Effect**		**Total Effect**	
Indicator	**Unit**	**Change**		**Change**	
GDP	*Million Naira/a*	35,478	0.06%	78,763	0.14%
Compensation of employees	*Million Naira/a*	9,393	0.06%	23,841	0.16%
Balance of payments	*Million Naira/a*	12,560	0.15%	-3,611	-0.04%
Fiscal effect	*Million Naira/a*	7,149	0.83%	19,280	2.25%

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 Nigeria 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.

4. 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 PROGRAMME and UNEP 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 PROGRAMME'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 Nigeria 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 PROGRAMME to develop and implement suitable policy instruments.

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6. ANNEXURE

6.1. Annex 1: Basins as Management Units

The 8 major Nigerian hydrological basins were thus chosen as management units for the investigation. The delineation of the study area into these units provided a logical approach to increasing the resolution of ecosystem services and their value to local (and national) beneficiaries in Nigeria. The nature and distribution of forest resources are largely driven by hydrological patterns. Hydrological basins form a geographic area of which all water systems, including surface and groundwater, are included. Water enters a basin through precipitation or flow from another basin and converge into streams or rivers and exit the basin through a common waterway (i.e. stream, river, estuary or ocean). Hydrologically, basins form a logical unit and as a result are commonly used as water management units. Furthermore, the natural water cycle within a basin influences the nature of ecological systems found within the boundaries of the watershed. The 8 basins (management units) with corresponding total populations can be seen in the figure below.

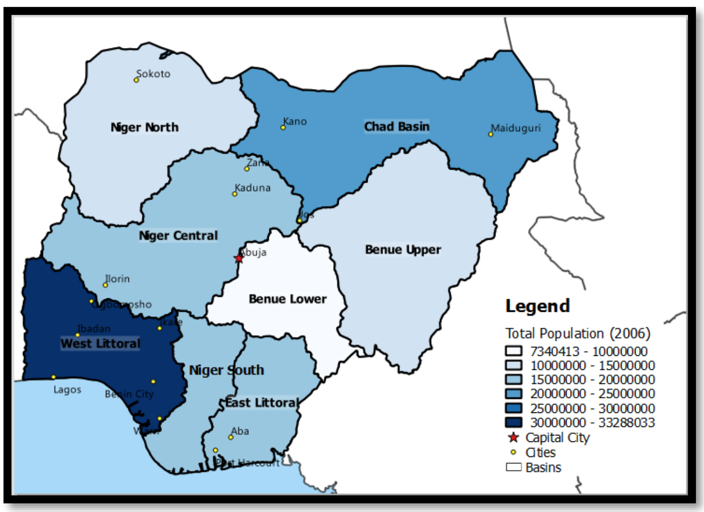

Figure 10: The major Nigerian basins with corresponding total populations and cities

6.2. Annex 2: Ecological Drivers of Forest Type and Distribution

Nigeria is characteristic of a range of ecological zones (Figure 11). The southern region along the coastline is situated within a tropical climate receiving approximately 2500 mm per year. The region is characterized by mangrove along the coast, fresh water swamp moving north towards a rainforest belt along the south-central region. North of the rainforest belt precipitation is approximately 1000 mm per year resulting in predominantly tropical savannas in central Nigeria stretching towards the north. Densities and sizes of trees reduce gradually within these savannas. Effects of encroachment of the Sahara Desert can be seen in the northern regions with rainfall being reduced to 470 mm per year. The region is characteristic of marginal savanna and contains the lowest density of forest resources in the country.

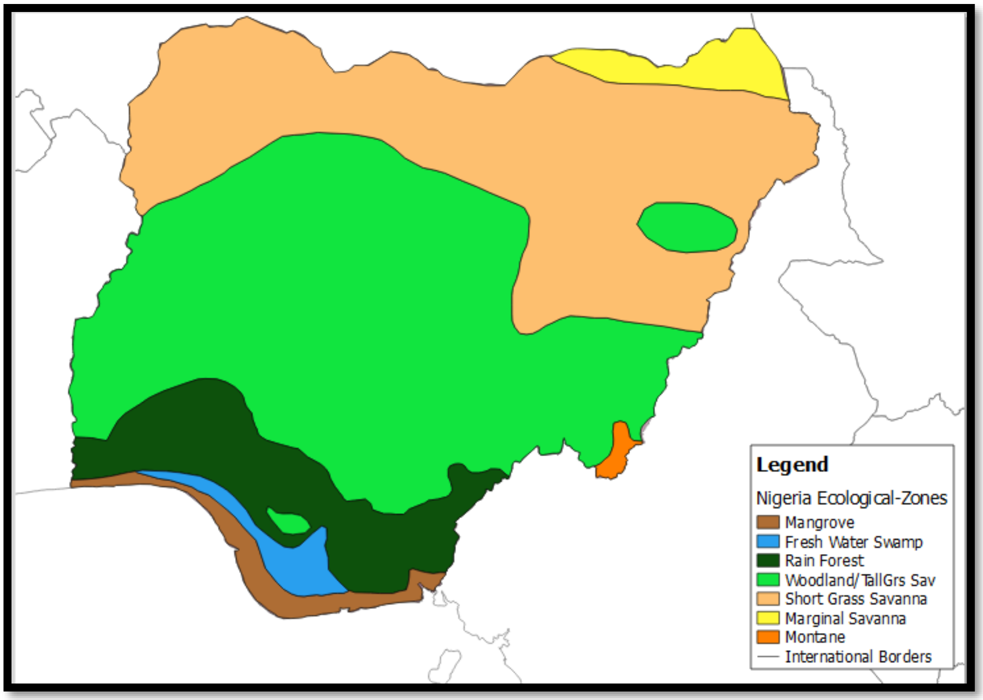

Figure 11: Nigerian ecological zones.

The climatic patterns and spatial distribution of hydrological and geological features has resulted in 6 broad types of forest resources (Table 14).

Table 14: General forest types found in Nigeria (Adapted from USAID 2008).

Forest types	Description
Lowland Forest	Lowland forests are characteristic of the rainforest ecological zone stretching from west to east Nigeria. These forests are characteristic of high biodiversity with complex ecological structures. Land use activities and deforestation have greatly reduced this forest type in Nigeria.
Fresh water Swamp Forest	Fresh water Swamp Forests are characteristic of the fresh water swamp ecological zone where portions of the forests are both seasonally and permanently flooded. The occurrence of mangrove species reduce upstream of the delta toward more fresh water where these forests are formed. In comparison to adjacent forest loss, these forests are not as heavily impacted on.
Savanna Woodlands	Savanna woodlands are characteristic of the tropical savanna regions north of the rainforest belt. These woodlands are not as dense as lowland forests, however nonetheless have been highly impacted on through land use activities.
Riparian Forests	Riparian forests include a variety of forest types along water features and water resources in the landscape. These forests function as both buffers and valuable ecotones.
Mangrove Forest	Mangrove forests are found along the mangrove ecological zone stretching across the Nigerian coastline. The forests are characteristic of saline and brackish conditions where mangrove species and other saline tolerant species can be found. The major threat is from agricultural encroachment and direct destruction by communities.
Montane Forests	Montane Forests are characteristic of the Montane ecoregion which is limited in Nigeria found in the East bordering Cameroon. These are highly diverse forests with unique geographic conditions resulting in the presence of endemic species.

The major water resources include lakes, rivers and wetlands. The major rivers are the Niger and Benue which drain much of northern Nigeria from the west and east respectively (Figure 12). They join in a series of tributaries to form the Niger Delta in the south. In the north, various rivers as well as the Hadejia-Nguru wetland drains into Lake Chad. Kainji Lake, a large artificial lake is situated in the west.

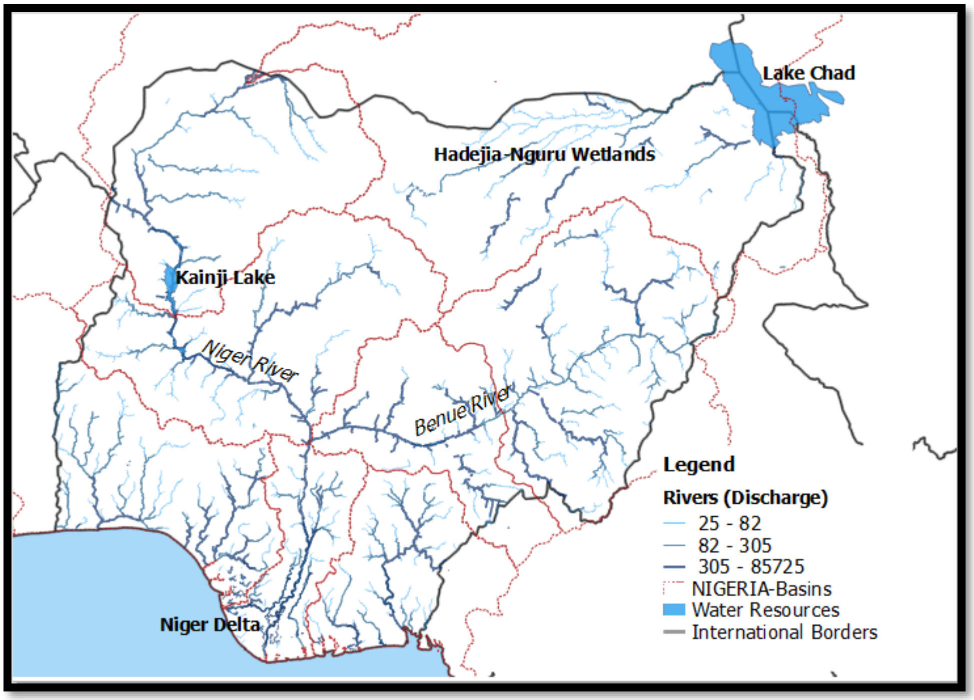

Figure 12: Major Nigerian rivers and water resources

There are many protected areas found throughout the country (of which 455 are gazette) (FAO 2015) consisting of 8 National parks, 23 Game reserves and numerous forest reserves (Figure 13). These areas are spread throughout the country across the various ecological zones. The trend in forest loss across the country has resulted in a pattern of protected areas containing a large proportion of the remaining forests resources.

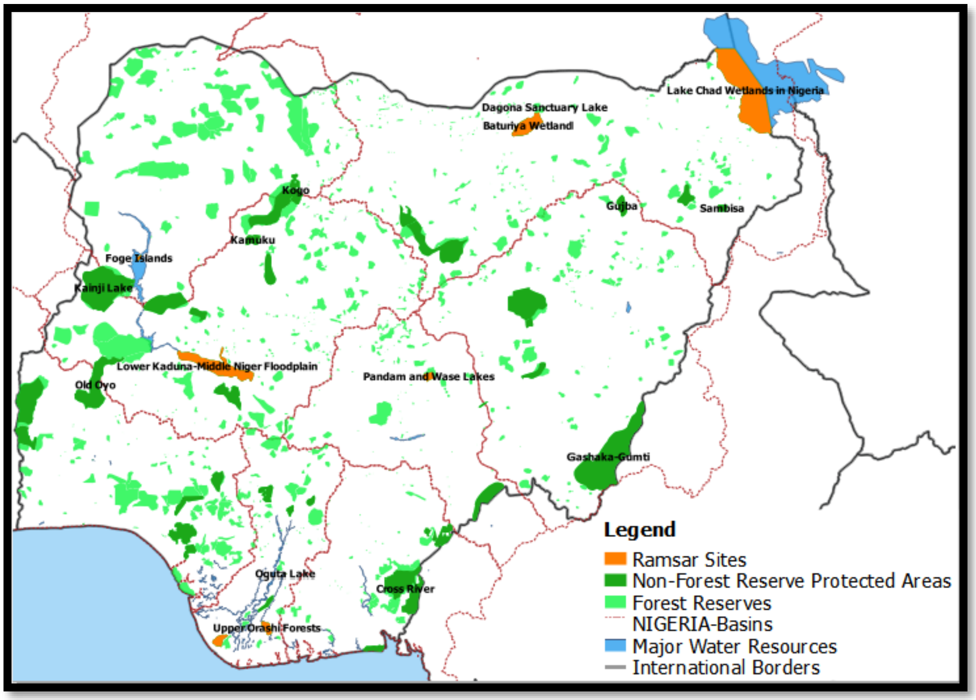

Figure 13: Protected areas and Ramsar sites found in Nigeria

6.2.1. Forest Extent

Total forests in Nigeria currently amount to 7 million ha (FAO 2015) consisting of 20 000 ha of primary forest, 420 000 ha of plantations, 997 000 ha mangrove forests and 5.5 million ha other non-primary but naturally regenerated forests (Figure 14). Mangrove forests include both marine (along the coast) and freshwater (inland) systems (See Figure 11 for a general idea of this distribution).

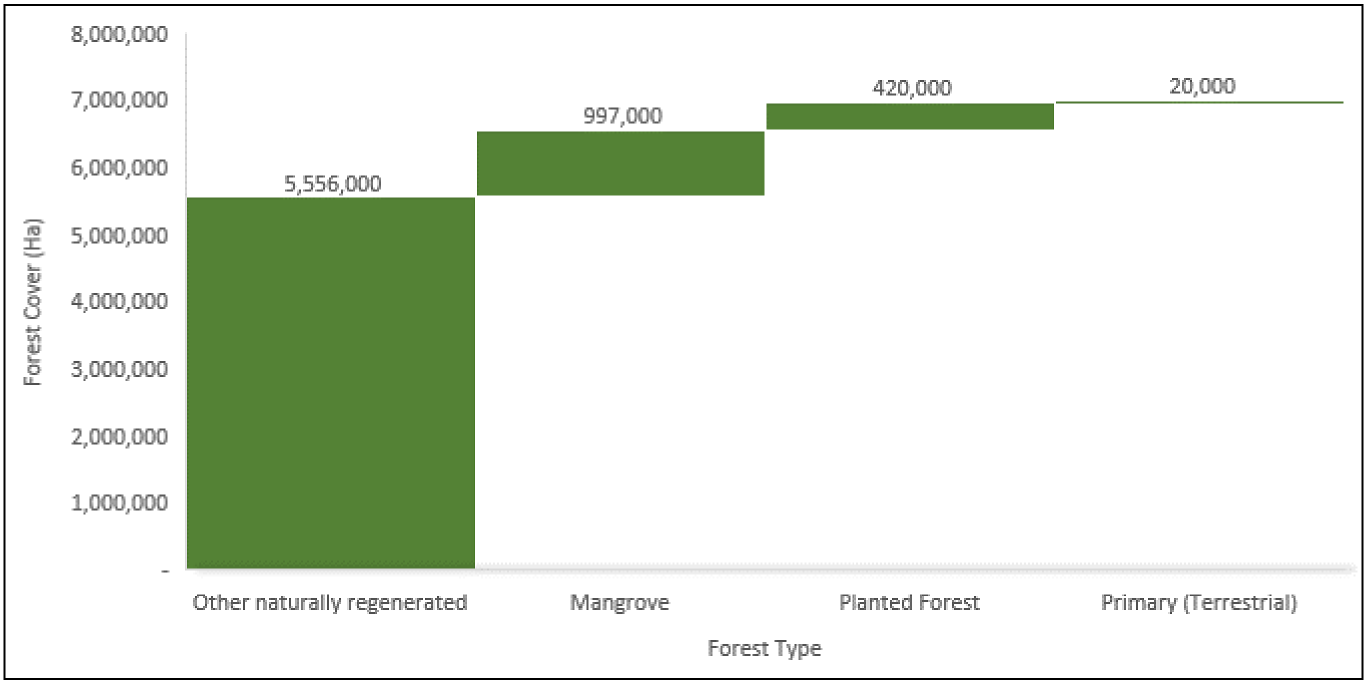

Figure 14: Total 2015 forest cover by type in Nigeria (FAO 2015)

The forest resources are most dense in the south of the country in the wetter climate and reduce northward as the climate becomes drier (Figure 15). The climatic variation together with land use impacts has resulted in 76% of total forests being found in the southern three basins of the country with highest density in the south-east (CRS) (

Table 15, Figure 15). These forests contain all mangrove forest types. 17% and 8% of the remainder of forests are situated in central and northern Nigeria respectively (

Table 15, Figure 15).

The CRS's entire forest resources (Tropical high, open, freshwater swamp and mangrove forests) covered a total area of 860 000 ha in 2001 (40.8% of CRS) (FME 2010). Please note that these figures do not directly correspond to FAO data (They likely include primary and other naturally regenerated forests). Of the total forests in the CRS in 2001, approximately 74% was tropical high forest, 14% open forest, 6% freshwater swamp forest and 5% mangrove which are found along the coast of the state (FME 2010).

Table 15: Total forest cover by type and basin in Nigeria (2015)

Hydro-logical Area	Basin	Total Forest	Primary (Terrestrial)	Mangrove (marine and freshwater)	Other naturally regenerated (excluding mangroves)	Planted Forest	Percentage of Total
	Units	*ha*	*ha*	*ha*	*ha*	*ha*	%
1	Niger North	263,576	754	-	209,414	15,830	4%
2	Niger Central	383,258	1,096	-	304,502	23,019	5%
3	Upper Benue	646,824	1,850	-	513,908	38,848	9%
4	Lower Benue	198,901	569	-	158,029	11,946	3%
5	Niger South	1,371,260	3,922	445,185	1,089,478	82,358	20%
6	Western Littoral	2,418,375	6,917	367,426	1,921,420	145,248	35%
7	Eastern Littoral	1,436,746	4,109	184,389	1,141,507	86,291	21%
8	Chad Basin	274,059	784	-	217,742	16,460	4%
Total	**Nigeria**	**6,993,000**	**20,000**	**997,000**	**5,556,000**	**420,000**	**100%**

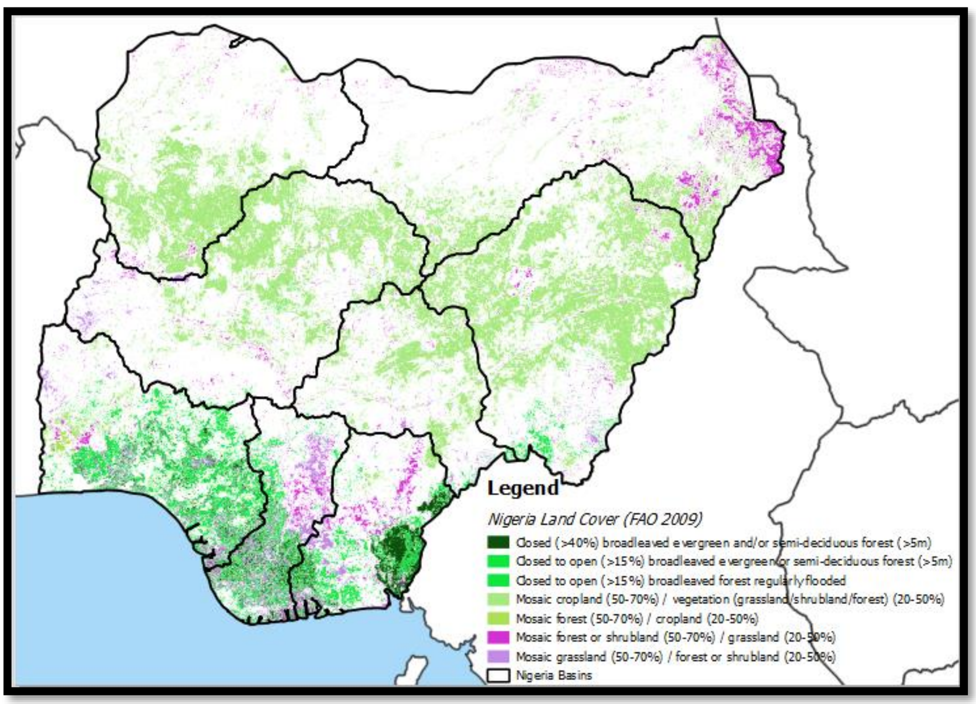

Figure 15: Land cover focussing on forest resources in Nigeria (FAO 2009)

6.2.1.1. Southern Region

The southern region of Nigeria namely the Western Littoral, Niger South and Eastern Littoral basins are characterised by a variation in climatic characteristics. This together with the locality on a geographic scale has resulted in the presence of three forest types including freshwater swamp forest (freshwater mangroves), band of marine mangrove forests along the coast in the south and the rest being largely terrestrial forests (Figure 15). Historically, the region contained dense and widespread forest ecological infrastructure but has been subjected to increasing populations and development. The region is highly utilised by local populations and increased urbanisation has resulted in the presence of many major cities towns and villages throughout of which the impacts have caused major loss in these natural systems resulting in fragmentation and discontinuity. Compared to many other regions in Nigeria however, the forest ecological infrastructure remains relatively in-tact.

The Niger Delta found in the Niger South basin forms a major ecological feature in the region containing 55% of all freshwater wetlands in Nigeria (Umoh 2008). The Cross River State found in the east contains the highest density of primary forest resources of any state in Nigeria containing approximately 31% of Nigeria's remaining primary forest (Fon et al 2014). This represents a significant proportion of the countries resources.

6.2.1.2. Central region

The central region includes Niger Central, Lower Benue and the Upper Benue basins. This region is highly heterogeneous in terms of forest ecological infrastructure with the largest portions of forests occurring in the south (Figure 15). The forest ecological infrastructure has been highly impacted throughout the catchment with seemingly less impacted pockets forming within many (but not all) of the protected areas. These areas remain under threat through increasing fragmentation. This is especially true in the central regions towards the Kaduna city. The remaining riparian forests play an increasingly vital role in buffering the river resources from land use impacts. Services provided by the forest resources have been seen to include the provisioning of timber and fuel wood to local industries and communities. The southern eastern portion of the catchment is drained by the Donga River which flows through the Gashaka-Gumti National Park and contains expansive forest cover along the foothills of the Mambilla Platteau. The region consists of a vast expanse of dense forests of which is also seen in the Yankari National Park to the North and other scattered occurrences throughout the basin.

6.2.1.3. Northern region

The northern region includes the Niger North and Chad Basins is situated within a region of predominantly dry climate and thus naturally contains a lower proportion of forest resources (Figure 15). The forest resources are mainly distributed within a few areas in the southern regions and within protected areas scattered across the basins. Informal wood extraction and grazing of livestock are two of the major impacts on forest resources in the area. A significant ecological feature is Lake Chad which provides a range of benefits to communities and economy.

6.2.2. Trends in Nigerian Forest Cover

Primary forest decreased by 97% between 2000 and 20015 (FRA 2015) (Figure 4) of which distributional changes can be seen in Figure 17. Mangroves have been seen to remain stable over this period (Figure 4, Figure 18). Other naturally regenerated forests have reduced by 50% (FRA 2015) (Figure 4) of which the loss across basins can be seen in Figure 19. Plantations on the other hand have increased by 33% over the same period (Figure 4) of which distributions can be seen in Figure 20.

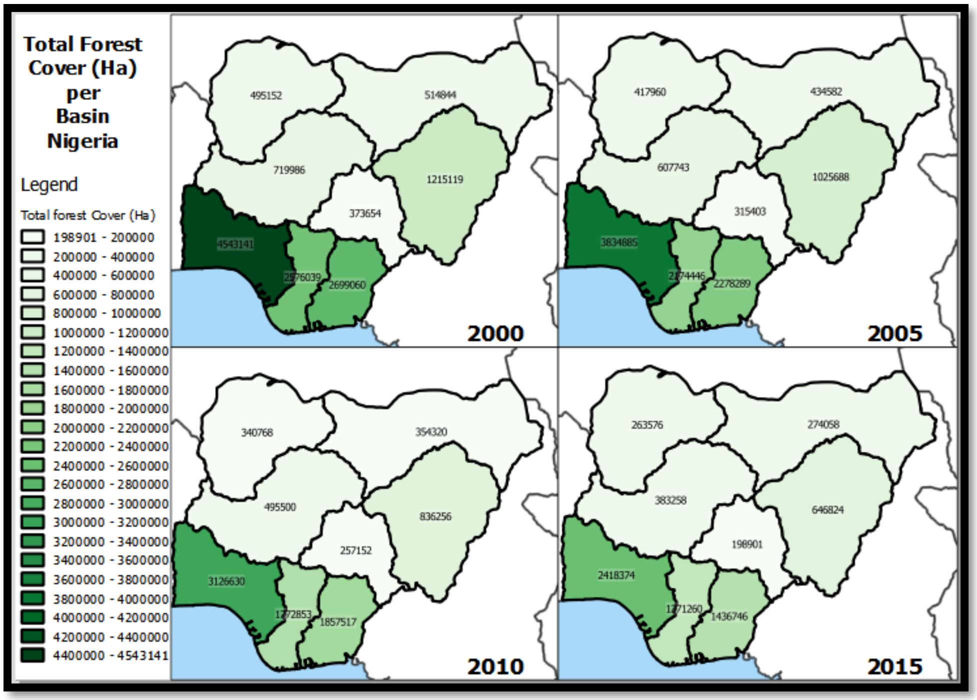

Figure 16: Total forest cover (Ha) in Nigerian basins for the years 2000, 2005, 2010 and 2015

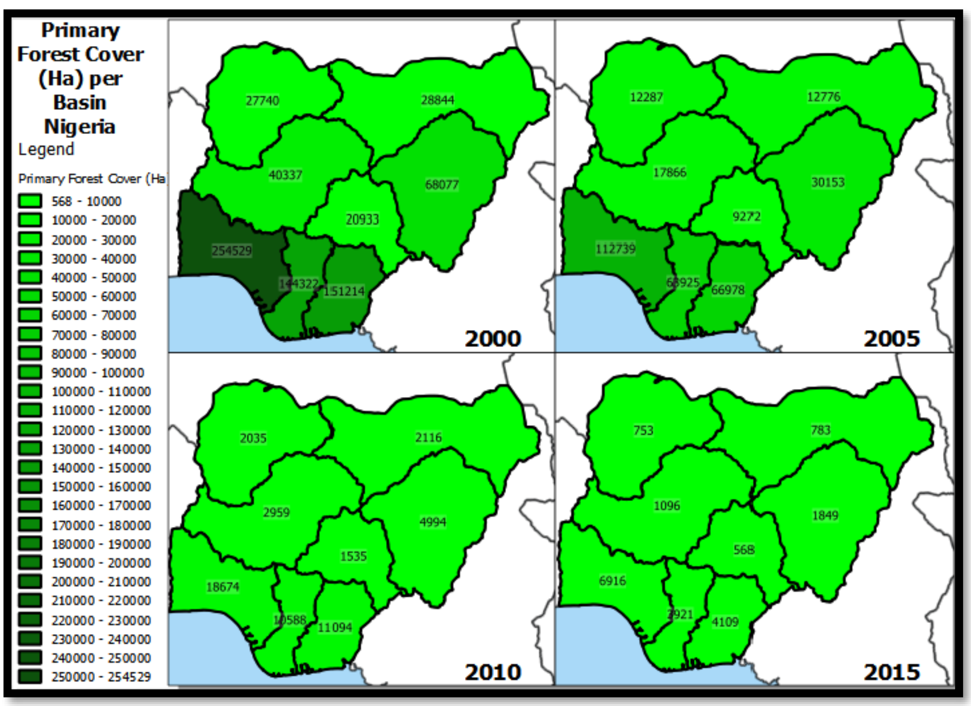

Figure 17: Primary forest cover (Ha) in Nigerian basins for the years 2000, 2005, 2010 and 2015

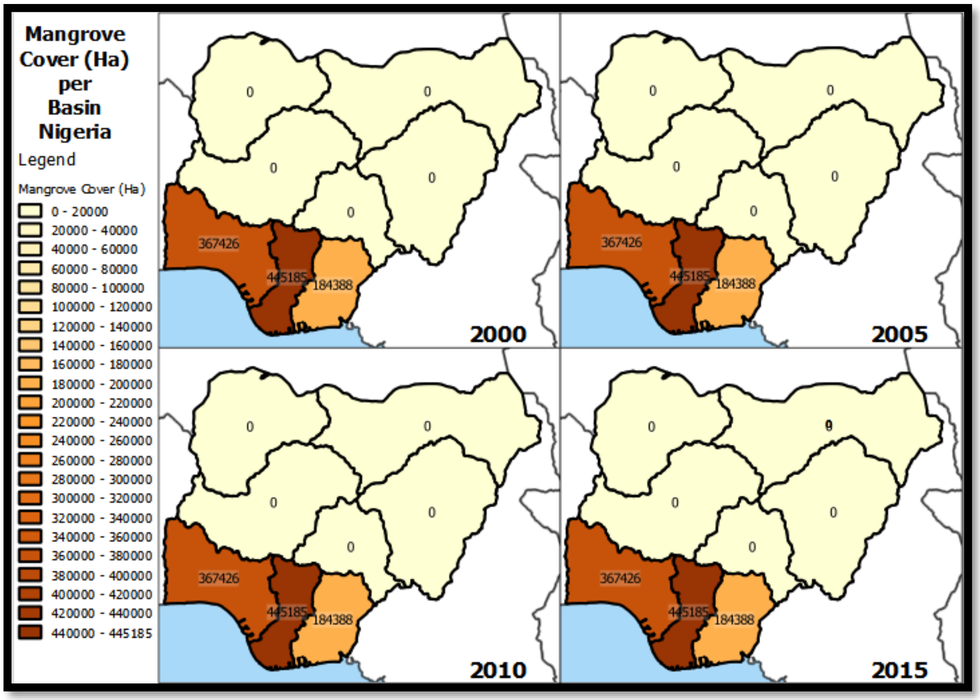

Figure 18: Mangrove forest cover (Ha) in Nigerian basins for the years 2000, 2005, 2010 and 2015

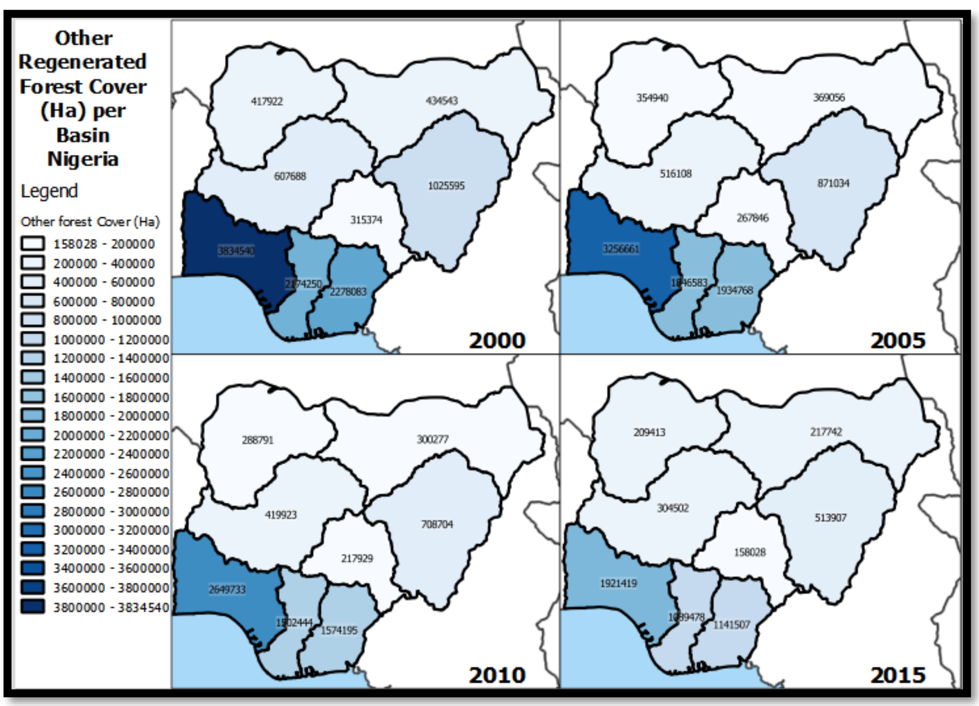

Figure 19: Other naturally regenerated forest (excluding mangroves) cover (Ha) in Nigerian basins for the years 2000, 2005, 2010 and 2015

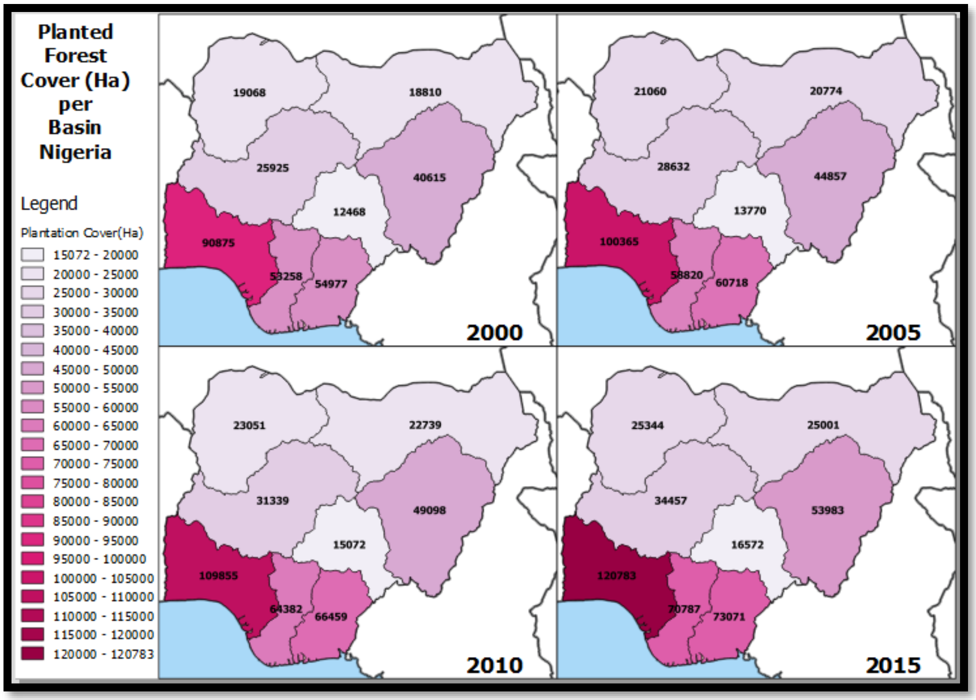

Figure 20: Plantation forest cover (ha) in Nigerian basins for the years 2000, 2005, 2010 and 2015

6.3. Annex 3: Regional Distribution of Nigeria's Forest Ecosystem Services and Beneficiaries

6.3.1. Demographic Distribution

Nigeria covers a land area of 92,377,000 ha which is sub-divided into 36 states and one territory. In 2006, the total population was 140.4 million and was projected to be over 182 million by 2011 (Census 2006). The Lagos State has the highest population density (2 602 per Km^2) in the country with 6% of the population and only 0.4% of the land area. The following most dense states are Anambra, Imo, Akwa Ibom, Abia and Rivers all found in the southern regions and Kano found in the North (Figure 21).

Nigeria is characterized by 4 major water basins, namely The Greater Niger, Lake Chad, Gulf of Guinea West Coast and Africa West Coast basins. These are further subdivided into 8 basins (Figure 22). Demographic descriptions are given for each basin in Table 16.

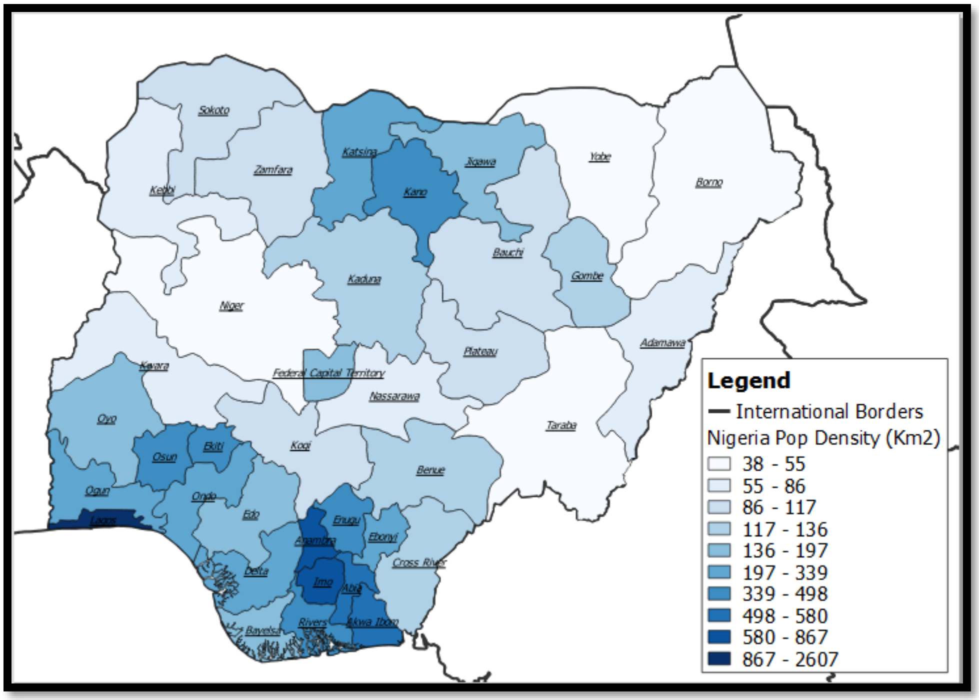

Figure 21: Nigerian states with corresponding population density (Census 2006).

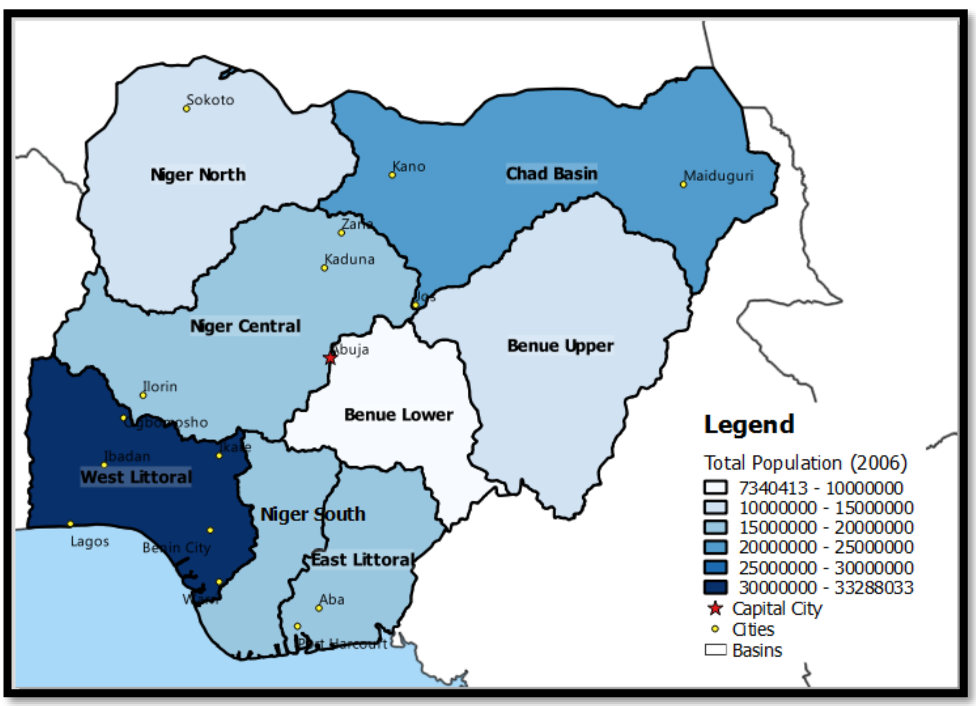

Figure 22: The major Nigerian basins with corresponding total populations and cities.

Table 16: Demographic descriptions of hydrological basins in Nigeria.

Basin	Demographic Description
Niger North	The Niger North basin also known as the Sokoto-Rima River basin is in the north-western part of Nigeria. It comprises of four states including Sokoto, Kebbi, Katsina and Zamfara. The basin has a population of 14 211 145 (2006 census) and includes the major cities of Sokoto, Katsina and Gusau.
Niger Central	The Niger Central Basin also known as Kaduna Basin is found in western central Nigeria. It comprises of the states of Kwara, Niger, Kaduna and the Federal Capital Territory. The region is home to a population of 15 399 394 (Census 2006) individuals as well as the capital city of Abuja and highly industrialized city of Kaduna.
Upper Benue	The Upper Benue Basin which is also known as the Gongola and Donga basins are found in eastern central Nigeria bordering Cameroon. As one of the larger basins in Nigeria it generally contains the states of Taraba, Adamawa, Plateau, Bauchi and Gombe including the major cities of Bauchi, Gombi, Jalingo and Yola. The total population size is 11 395 783 within the basin (Census 2006).
Lower Benue	The Lower Benue basin, also known as the Benue River basin, is found on the eastern central side of Nigeria. It consists (generally) of the states of Benue and Nassarawa and the city of Makurdi and town of Lafia. The total population within the basin is 7 340 413 (Census 2006). Rain-fed agriculture is the main economic activity in the basin. The basin is home to over 40 ethnic groups suggesting a huge diversity in cultures, beliefs and practices.
Niger South	The Niger South basin, also known as the Anambra basin, is situated in southern central Nigeria. It is the basin which contains the central Nigerian coastline and the Niger Delta. It generally includes the states of Bayelsa, Delta, Rivers, Anambra, Enugu and Kogi. Comparatively to other basins it has relatively small cities with the largest being Awka city. The population size however is relatively dense with 15 587 029 (Census 2006). Population growth is highly rapid in this area. Over the period of 15 years (1991-2006) there was a 50% increase in population (Census 2006).
Western Littoral	The West Littoral basin is also known as the Anambra Basin is situated on the south-western boundary of Nigeria. The state of Lagos is found within this basin which is the economic center of Nigeria accounting for 70% of the country's commercial establishments. This has driven the states rapidly increasing development and population influx and resulted in the largest city in Nigeria, Lagos. Other states include Edo, Ondo, Ekiti, Osun, Oyo and Ogun which are home to other major cities such as Ibadan, Benin City, Ikare and Ogbomosho. The total population in the basin is 33 288 033 (Census 2006).
Eastern Littoral	The Eastern Littoral basin which is also known as the Cross River Basin is situated in the south eastern corner of Nigeria. It generally includes the states of Imo, Abia, Akwa Ibom, Cross River State (which includes the highest density of primary forest of Nigerian states) and Ebonyi which include the major cities of Port Harcourt, Aba, Enugu, Uyo and Calabar. The total population is relatively high compared to other basins with 19 955 888 individuals (Census 2006).
Chad Basin	The lake chad basin is situated in the north-west corner of Nigeria and includes a portion of Lake Chad (Shared with Chad). It includes the states of Borno (Lake Chad), Yobe, Jigawa and Kano. The basin includes the major cities of Kano, Maidguri, Jos and Damaturu and has the second largest population of 23 189 748.

6.3.2. Ecosystem Services Distribution

The distribution and nature of Nigeria's forest resources provide a variation of ecosystem services both over space and between type of forest. The spatial distribution of forests result in a spatial variation of benefits received. With forests occurring more densely in the southern regions of the country, these basins will receive greater forest benefits compared to the northern drier basins. Furthermore, although most forest types provide a very similar range of services, the magnitude and nature of these services vary based on structural characteristics of forests.

Forest systems both terrestrial and aquatic play a role in climatic regulation, providing a sink for carbon dioxide and thus offering a carbon sequestration and storage service (Brooks et al. 2000). The storage of sequestered carbon further allows a net loss of carbon from the atmosphere proving beneficial at a global scale.

The presence of both terrestrial and mangrove forests in the southern regions thus alters the nature and magnitude of services provided compared to that of northern regions where only terrestrial forests occur. Additionally, the presence of major ecological features such as the forests in Cross River State, Niger Delta, and Lake Chad also provide valuable services to the socio-economic wellbeing of the region.

Extensive cultural services are also present throughout these areas with various protected areas being found within these regions which provide the benefits of conservation, tourism and recreational opportunities.

6.3.2.1. Southern Region

The Southern region (

Table 15) contains the bulk of the countries forest resources at 5.2 million ha (including all mangrove forests). The Niger Delta and CRS is also situated within this region and is thus is the majority beneficiary of the ecosystem services provided by the countries forest resources.

For starters, the presence of mangrove forests (both freshwater and marine) provide a valuable source of fish resources. In fact, fishing and agriculture are the two major traditional occupations in the south especially for the people of the Niger Delta. Salt water fishing activities predominantly occur along the coastal region and the brackish water swamps and lagoons while freshwater fishing activities occur more within small reservoirs and the major freshwater swamps and rivers. These provide an important source of food to local communities. In addition to the fish resources there are also major non-fish aquatic sources of food. The presence of these resources support large commercial fishing industries (World Bank 1995).

The timber, fuel and material provisioning service is also significant to the regional economy. The use is both commercial and for household use such as building materials and fuelwood. The timber industry sourced directly from the delta was estimated to be in the order of US$ 22.8 mil per year in 1995 (World Bank 2005).

Many medicinal plants are sourced from mangrove forests (both freshwater and marine). In the region as many as 24 species have been found to be used in traditional healing or other applications (Nkudwu and Ben-Nwadibia 2005).

Regulating services form a major component of the services provided by these systems. For instance the mangrove systems provide many of the services that are associated with wetland systems. For instance, water quality and quantity regulation. Slowing and retaining water in the wet season and releasing it slowly in the dry season and through this retention allowing for water purification by processing and assimilating contaminants through various bio-physical processes (Uluocha and Okeke 2004). The retention of water influxes further allows for a buffer for oceanic storm surges (in marine mangrove forests) and floods (in freshwater mangrove forests) (Uluocha and Okeke 2004). These water quantity regulation services together with the soil stabilising characteristics of forests prevent extensive erosion and loss of valuable sediments.

The forest systems form major sources of both terrestrial and aquatic habitats supporting a variety of fauna and flora (Uyigue and Agbo 2007). The freshwater swamp for instance provide important breeding ground for aquatic species and birds (Eleazor 2002). The delta specifically has been seen to inhabit approximately 200 species of fish (Nwadiaro 1984) of which 16 are endemic and 29 near endemic (Ebuku 2004). Thus, it has been said that the delta has the richest biodiversity in Nigeria (Ebeku 2004).

The CRS is a national biodiversity hotspot, containing a high degree of endemic biological species at a regional and international scale (Davis et al 1994, Myers et al 2000, Oates et al 2004). This is especially true for the plant, bird (26 endemic) and primate species found there.

Various cultural services have been seen to occur within this region. Within the delta various faunal species are seen as holy animals (Akani and Luiselli 2002). There are also many areas which are of spiritual significance and are sacred to various communities (Anderson and Peek 2002).

6.3.2.2. Central Region

Moving Northwards are regions more characteristic of tropical savannah. This region only contains terrestrial forests and a much smaller proportion of the countries forest resources at 1.2 million ha (

Table 15). This results in the region receiving a smaller proportion of benefits from forest resources compared to the south. This does not mean however that the services received from the terrestrial forests are any different in nature to those received in the south.

The forests that are present in the region provide many valuable services to the socio-economic wellbeing of the basin. This is especially true for larger tracts of uninterrupted forests.

For starters, the provisioning of building and fuel material to local communities and industries provides a major benefit to the region. In fact, many forest reserves have been established for the purposes of providing timber and fuelwood to communities.

Forests provide a water quantity service to the basin like what is described above where the systems capture excess runoff and allow for aquifer and stream recharge. The regulation of water in this way also improves water quality as it passes through these ecological systems.

In the west, water pollution is a prominent impact on ecological systems. The region of Kaduna city is one of the most highly industrialised cities in Nigeria. The industries in the area discharge large volumes (165,000 m^3 / day) (Yusuf 2004) of untreated effluent into the Kaduna River. The forest ecological infrastructure in the area provide a degree of quality regulation of contaminated water.

The forest resources within the region, especially those that remain spatially intact, predominantly within protected areas, provide important habitats for biodiversity. The bird life in the Donga basin for instance is of significant importance with over 190 species recorded in the areas (Birdlife.org). This provides a key tourism and recreational opportunity to the region.

6.3.2.3. Northern Region

The northern regions contain the least forest resources with 0.8 million ha (

Table 15) and thus logically benefits to a lesser degree from forest ecosystem services. The disconnected nature of the forest cover further suggests that the ecosystem services would be at a reduced level compared to that of a fully connected system. Although the ecosystems have been heavily impacted on, the pockets forests that remain, would still provide a degree of valuable services to the socio-economic wellbeing of the basin.

The sourcing of timber and fuelwood from the existing resources will still play a large role in local industries and communities. Furthermore, a highly beneficial service is the water regulating services. This basin is characteristic of a rainfall events which are short but intense in nature (Odjugo 2010). Thus a major environmental risk is that of flooding, erosion, sedimentation and siltation of water resources. Forests act as a buffer against these impacts however the loss in of forest resources in the area has resulted in a loss of the natural ability to mitigate against these risks.

The importance of the quality regulation, especially in the west, is intensified due to the nature of the land use. With 53% of land area (Niger North) being used for agriculture and the catchment playing a large role in sourcing water for the Niger River downstream, water quality becomes a key issue.

Forest habitats further provide a supporting service to fauna and flora. More specifically the forest resources within the protected areas provide a stronghold in the preservation of the local biodiversity. These protected areas are also sources of tourism and recreational interest to the area.

Lake Chad is a predominant ecological feature in the north-east of Nigeria (Chad Basin). Within the context of a dry climate it plays a major role in the local economy providing fresh water to wildlife, livestock and communities in the area. Its presence has allowed fishing and agriculture to have become a key source of livelihood. The lake further provides a source of hydrological regulation receiving influxes of water, mitigating against floods and erosion and provide alleviation from droughts. Water quality is also regulation through waste assimilation by trapping nutrients and sediment pollution (Baxter 1977, Donnely 1993). The lake has a large biodiversity maintenance role, providing ecological support to a range of fauna and flora. It forms an important feature for migratory birds, terrestrial wildlife and fish species (up to 176 species).

6.4. Annex 4: Methodological Approach

6.4.1. Forestry Resource Account (FRA)

Requirements for conducting the FRA for Nigeria 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 Food and Agricultural Organisation of the United Nations (FAO).

6.4.1.1. Temporal Scale

Data at a temporal scale was sourced from numerous reports published by the FAO representing FRA's for the years of 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, mangroves and planted forests of which definitions are provided in Table 17.

Table 17: Descriptions of forest type provided by the FAO (FRA 2015)

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.
Mangrove	This occurs on the muddy banks of creeks and in tidal channels in the upper portion of the zone of saturator influence where the water is brackish.
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.

6.4.1.2. 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 (

Table 18).

Table 18: Forest cover indicators and percentage thereof by LCCS regional legend

LCCS Regional Legend (Forest Indicators)	Percentage forest (%)
Closed (>40%) broadleaved evergreen and/or semi-deciduous forest (>5m)	100
Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)	100
Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water	100
Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	20
Mosaic forest (50-70%) / cropland (20-50%)	60
Mosaic forest or shrubland (50-70%) / grassland (20-50%)	35
Mosaic grassland (50-70%) / forest or shrubland (20-50%)	20

It was important that the total forest cover in the 2009 spatial data corresponded to that of the total forest cover reported in the Nigerian FRA for 2010 conducted by the FAO.

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 FAO) across basins. This provided an overview of where the forest resources were located throughout the country and how the extent varied across time (2000-2015). 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 2000, 2005, 2010 and 2015.

6.4.1.3. 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. Examples of these forest types in Nigeria include terrestrial and mangrove (aquatic forests).

As the distribution of aquatic forest types were not presented by the FAO spatial data, their distributions were inferred using ecological zones (freshwater swamp and mangrove ecological zone).

Total mangrove forests were presented by the FAO FRA (2015) and these were assumed to only occur within the freshwater swamp and mangrove eco-zones. The total mangroves were disaggregated into each southern basin based on the proportion of area of each eco-zone within each southern basin.

6.4.1.4. Forestry Losses

Forest losses were accounted for by identifying wood production statistics and losses through forest burning. Wood production statistics for Nigeria were sourced from FAOStat for the period of 2000 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).

6.4.2. 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 Nigerian 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.

6.4.3. 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.

6.4.3.1. 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.

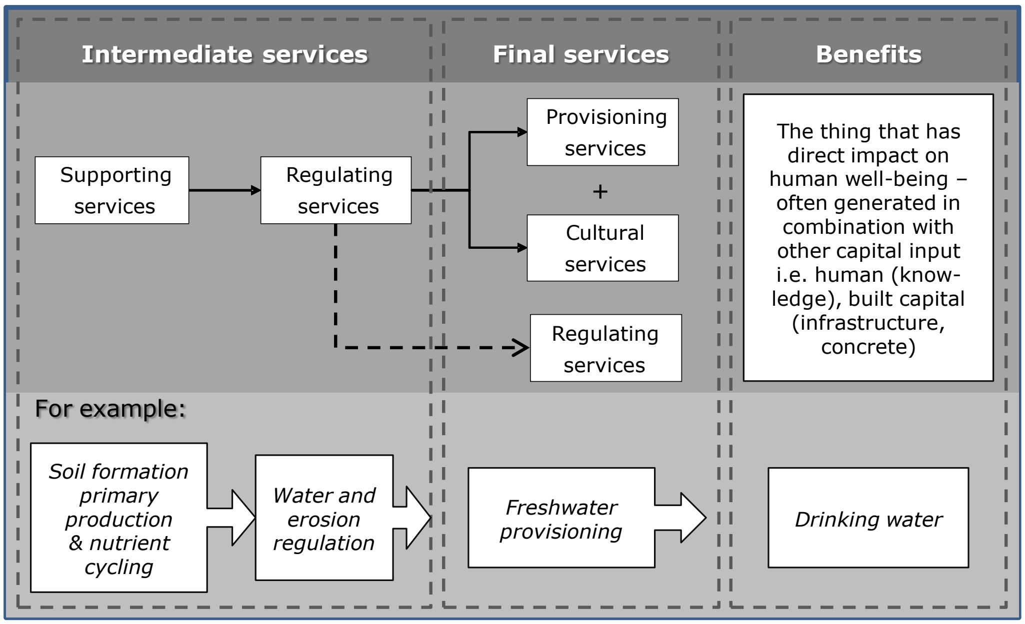

Figure 23: The distinction between intermediate services, final services and benefits (adapted from Fisher et al. 2008) illustrated by the stylised relationship between supporting, regulating, provisioning and cultural services as defined by the Millennium Ecosystem Assessment.

6.4.3.2. 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.

6.4.3.3. 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 24*). 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).

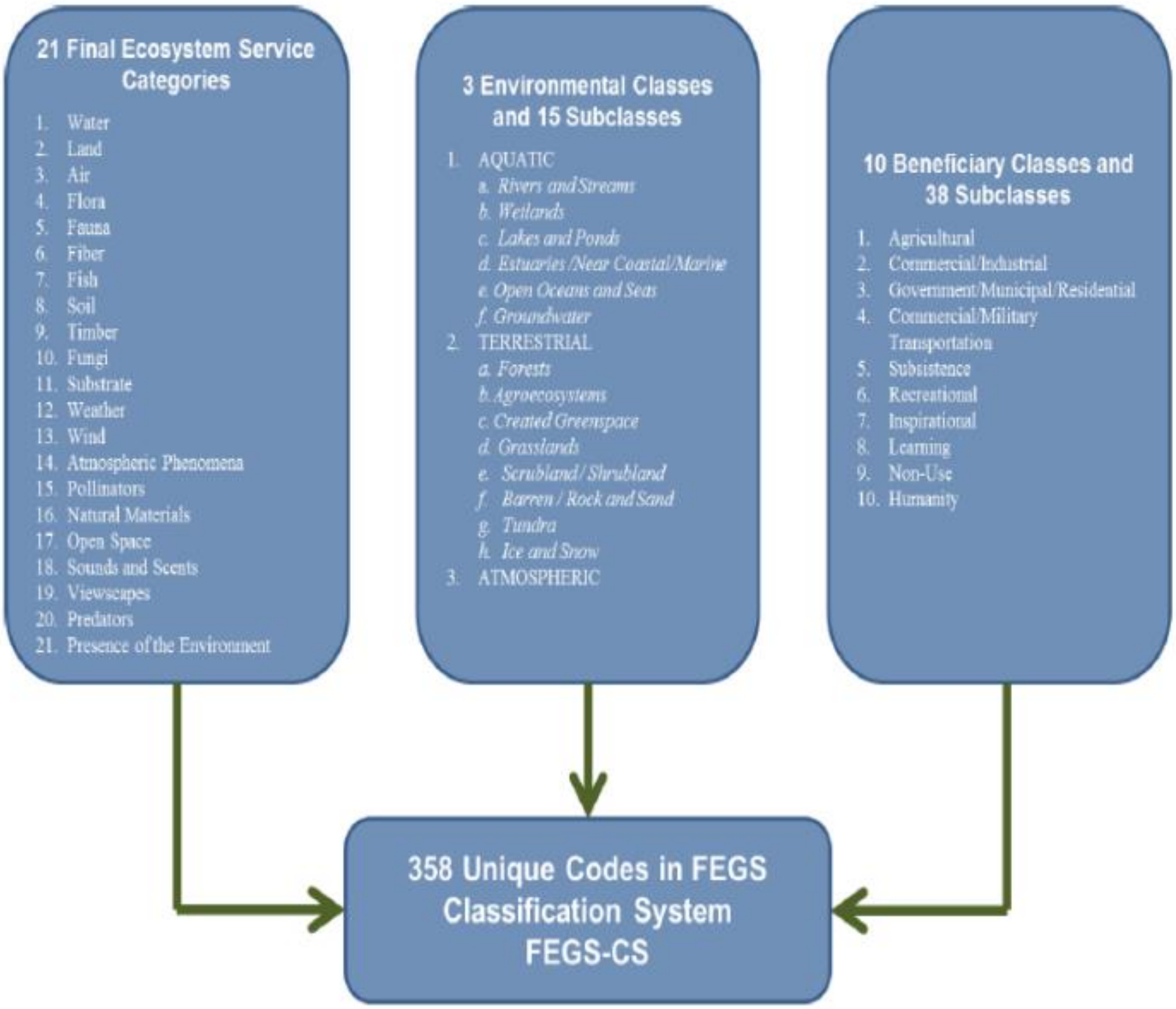

Figure 24: Final Ecosystem Goods and Services Classification System (FEGS-CS) (Landers and Nahlik 2013)

6.4.3.4. 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 25). 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).

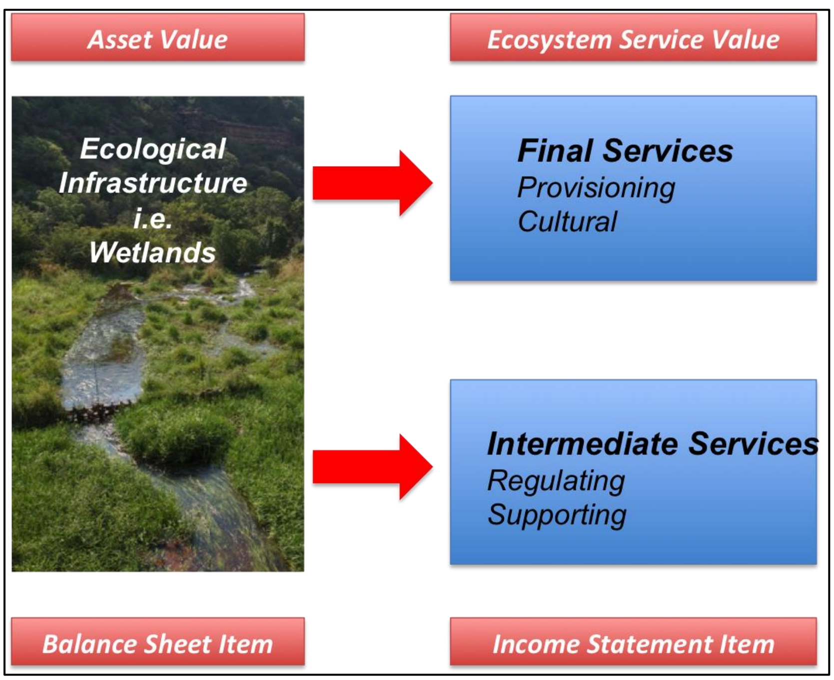

Figure 25: The relationship between ecological infrastructure and the delivery of ecosystem services

6.4.4. Ecosystem Service Valuation

6.4.4.1. 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.

6.4.4.2. Water Quantity

<u>Health</u>
Significant clinical evidence exists of the negative effect of deforestation on malaria infections in Nigeria. There estimated 300 thousand deaths per year in Nigeria. According to National Malaria Control Program (NCMP), the financial loss due to malaria annually was estimated to be about 132 billion Naira in the form of treatment costs, prevention, loss of man-hours, etc. Public health data was collected from World Bank and WHO for estimating health cost per person, affect population respectively.

<u>Sediment yield model</u>
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 Nigeria. 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).

6.4.4.3. 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.

6.4.4.4. Natural Disasters

<u>Storm Surges/ Tsunamis</u>
Data on the previous tsunamis that had a measurable impact on countries was collected with an objective to derive the costs of recovery after such event took place. The data collected indicate that most, if not all, major tsunamis resulted from earthquakes and thus in Nigeria, all earthquakes, regardless of the distance from the sea will be taken as potential events. A limited number of tsunami events had reported measured cost values in the literature and thus all available cost values became material.

Where data availability is not limited, a full insurance model would be constructed using a Poisson distribution on Number of Claims and the Bayesian probability on the probability of a tsunami occurrence. In this case, classical probability:

Probability = Number of potential events / Total number of potential events (P=N/T)

is used and an assumption that the Number of Claims follow a Poisson distribution with only one claim is used. We further assumed that there is only one claim paid at the end of a constant duration and also that since there was only one potential event which could have given rise to a claim, the claim would occur at the end of the entire duration.

The duration chosen here was the period between the first known and recorded potential event (1905- first seismic event in Nigeria) to the last known and recoded seismic event of Nigeria (2009), the difference resulted into 104 years (2009-1905).

The basic Insurance risk model formula used is (from Ruin Theory - CT6 Actuarial Statistical Models):

Premium= $(1 - \Theta)\ \lambda\ E(X)$

Where:

- Θ represent a percentage of insurer's profit (mark-up value)
- λ represent the expected number of claims, which is 1 in our case but can vary.
- $E(X)$ represent the expected aggregate claim, the amount of claim.

The resulting value can be multiplied by the probability of a claim in the cased of pooled insurance where not all events will result in a claim.

6.4.4.5. 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. Nigeria has 309 species on the IUCN Red List and these were given the average value.

6.4.4.6. 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.

6.4.4.7. Hydro-electric

Hydropower produces around 38% (World Bank) of electricity in Nigeria and its generation is entirely 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 Nigeria.

6.5. Annexure 5: Description of Methodology Inputs and Outputs

6.5.1. 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.

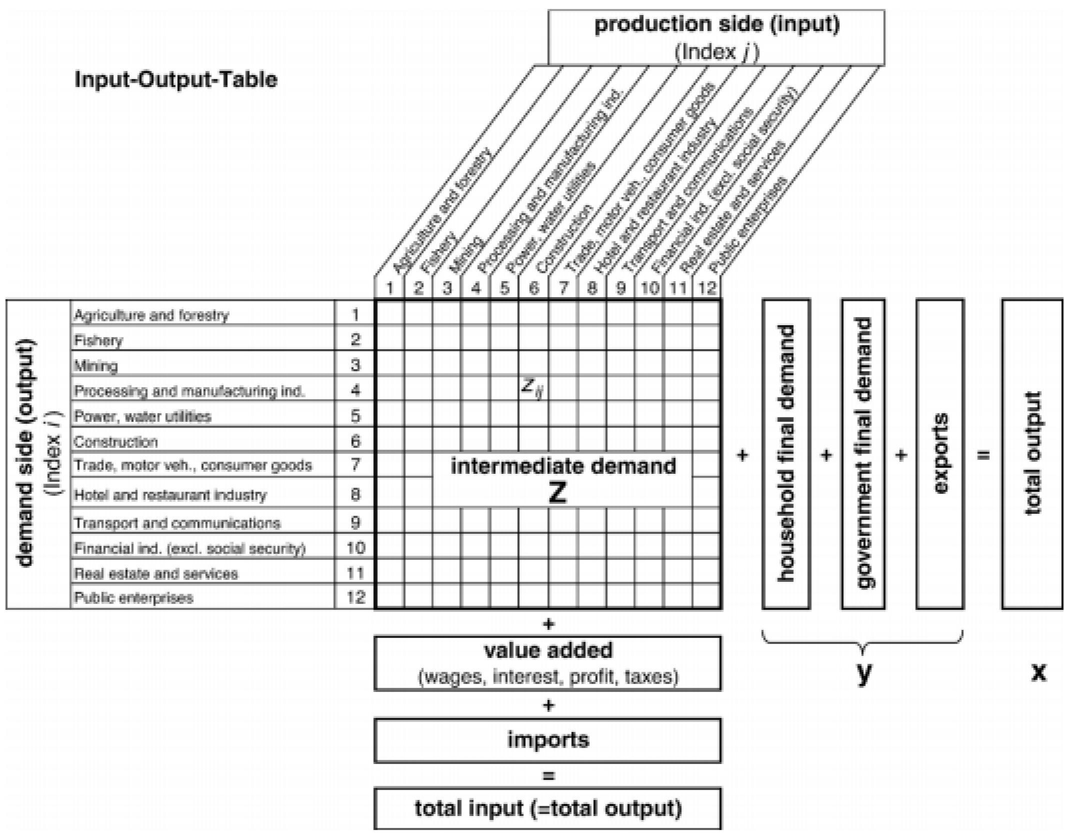

Figure A 1: Illustrative Input-Output Table (Sporri et al 2007)

Table A2 provides the technical specifications for the Nigerian 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 Nigerian economy. If x_i the total production of sector *i* and f_i 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:

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

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

$$\mathbf{x} = \mathbf{Zi} + \mathbf{f} \qquad (2)$$

With *i* designating a column vector.

We represent the matrix n *x* n of the technical coefficients in a compact matrix form as follows:

$$\mathbf{A} = \mathbf{Zx}^{-1} \qquad (3)$$

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,

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} \qquad (4)$$

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,

$$\mathbf{I}=\begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix} \text{ so that } (\mathbf{I}-\mathbf{A})=\begin{bmatrix} (1-a_{11}) & -a_{12} & \cdots & -a_{1n} \\ -a_{21} & (1-a_{22}) & \cdots & -a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ -a_{n1} & -a_{n2} & \cdots & (1-a_{nn}) \end{bmatrix} \quad (5)$$

The system represented in equation (4) is then

$$(\mathbf{I}-\mathbf{A})\mathbf{x}=\mathbf{f} \quad (6)$$

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

$$\mathbf{x}=(\mathbf{I}-\mathbf{A})^{-1}\mathbf{f}=\mathbf{L}\mathbf{f} \quad (7)$$

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

6.5.2. 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

6.5.3. The Multipliers

The multiplier of production :

$$(Multiplerof\ \mathrm{Pr}oduction)_j = \sum_i L_{ij}$$

Or :

*Lij c*onstitutes all the productions of each national industry necessary for the production of an additional unit of production

The Income Multiplier :

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

Or:

*v i*s the ratio of employment to output of each industry.

Effect on Income :

$$(EffectonIncome)_j = \sum_i v_i L_{ij}$$

Job Multiplier :

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

Or:

*w i*s 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.*