UNEP-WCMC & IDEEA **Technical report**

Experimental Ecosystem Accounts for Uganda

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Key messages

The experimental ecosystem accounts for Uganda presented in this report follow on from a recent publication which explored approaches to accounting for species-level biodiversity and a feasibility study of applications using existing data in Uganda. The accounts compiled respond to policy entry points for biodiversity and ecosystem related concerns in Uganda, identified in the feasibility study (UNEP-WCMC 2016b). The feasibility study established five clear policy entry points and applications for accounting, namely:

1. To inform the ongoing debates surrounding the gazettement and de-gazettement of protected areas.
2. To make the case for increased budget allocation and investment in biodiversity rich sectors for conservation and management (e.g., forestry as it maintains relatively high levels of biodiversity).
3. To establish the extent of ecosystem degradation and where declining biodiversity threatens the delivery of ecosystem services and implications on economic growth and human well-being.
4. To increase awareness and appreciation of biodiversity as a natural capital asset amongst decision makers and the public.
5. To assess national progress towards the objectives of Uganda's National Biodiversity Strategy Plan (NBSAP II) and National Development Plan (NDP II) and associated international commitments (i.e., the Aichi targets and SDGs).

Given these entry points, this report describes the first attempt to rapidly develop the required underlying spatial-data infrastructure and the compilation of key ecosystem and biodiversity related accounts using the System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA) framework. The accounts compiled for Uganda concern land cover, ecosystem extent, three non-timber forest products (Gum Arabic, Shea butter tree nuts and *Prunus africana*) and two flagship mammals (Chimpanzees and Elephants) species. Collectively, these accounts provide significant insights into the state and trends in ecosystems and biodiversity for Uganda.

At the broadest level, the accounts reveal:

- Substantial reductions in the extent of natural ecosystems in Uganda, particularly for Forest (29% remaining) and Moist Savanna (32% remaining) ecosystems. The degradation[1] of forest ecosystems has been particularly notable in the sub-regions of Western, Central 1, East Central and Teso (see Figure 7 for

[1] In this report the term 'degradation' includes the loss of natural ecosystems to land conversion, as described in Uganda's NBSAP II National Target 3.2

location of sub-regions). For Moist Savanna ecosystems, degradation has been greatest in the Acholi, Lango and Teso sub-regions. These losses will impact on the delivery of a broad range of ecosystem services and on ecosystem resilience, including the ability of the landscape to adapt to climate change.

- Large areas of ecosystems have been subjected to changing land cover since 1990, with only the Karamoja sub-region retaining a significant area of consistent natural vegetation cover between 1990 and 2015 (77% of remaining natural land cover). The potential drivers for the changes in land cover include intermittent farming and plantation use with up to 3 to 4 million ha subject to change. These changes in land cover are significant because the areas subject to change will not be able to support the delivery of the range of ecosystem services that could otherwise be expected if there had been a stability in ecosystem type.

Overall, the rich spatial data and spatial infrastructure underpinning the accounts is demonstrated to be very flexible and further analysis of the data is possible.

Using the richness of the data and the accounting structure, a number of key policy findings have been identified:

1. The **protected areas estate** has performed well by preventing the loss of natural ecosystems and the benefits they confer to Uganda. With respect to **wildlife-watching tourism opportunities**, a large majority of remaining fully-suitable chimpanzee habitat is protected in the South Western (96%) Western (84%) and West Nile (74%) sub-regions. However, substantial habitat still exists outside of protected areas in the Western sub-region (51,000ha) providing **opportunities to target areas for future protection and tourism development**.
2. For elephants, **a large majority of fully-suitable habitat is protected in the Karamoja (94%), South Western (97%) and Western (94%) sub-regions** but only a small proportion is protected in West Nile (12% out of 143,000 ha) and a substantial area exists outside of the protected areas in Acholi (approx. 67,000 ha). As such there may be **opportunities to develop wildlife watching tourism** in locations in West Nile and Acholi sub-regions.
3. For *Prunus africana* **the protected area estate has been effective in covering the remaining highest quality range of this species,** with 89% of the extent of these areas protected at the national scale.
4. Large areas of potentially suitable natural vegetation for harvesting **non-timber forest products (NTFPs)** have been identified in Acholi, Central 2, Karamoja, South Western, West Nile and Western sub-regions. In addition to smaller areas in Lango and Teso. Specifically, there are **opportunities for developing areas for sustainable harvesting for Gum Arabic and Shea butter tree nuts and butter production**, particularly in Acholi (approx. 496,000 ha), Karamoja (approx. 352,000 ha), West Nile (approx. 241,000 ha),

Teso (approx. 47,000 ha) and Lango (approx. 35,000 ha) that are not in conflict with Uganda's protected area estate.

5. There are potentially **significant species conservation benefits** from conserving natural areas in Acholi, Karamoja and West Nile, as these areas are associated with relatively **high bird and large mammal species richness**.
6. The accounts presented in this document present information in a way that can assist **reporting on a range of policy commitments**, including: National strategic objectives for biodiversity specified in Uganda's NBSAP (II) and corresponding Aichi Targets (e.g., 4, 5, 11, 12, 13 and 15) and National development plan (II) objectives for Environmental and Natural Resources (ENR) and associated SDGs (e.g., 1, 12 and 15).

The ecosystem accounts developed in this report establish a basis for regular updates on the trends in the extent of natural ecosystems and implications for key species. The timely provision of this information is essential for engaging decision-makers and providing timely communication about national and sub–national trends to the public. There are multiple ways decision-makers and researchers can use the information presented in the accounts to analyse trends in natural capital in Uganda. The spatial data infrastructure developed by this project can readily be employed to support such work and is equally relevant to other countries facing similar policy challenges.

Opportunities for developing and improving the accounts that have not been possible within the constraints of this project, include:

- The accounts for flagship species (elephants and chimpanzees) could be improved using species distribution modelling approaches and the incorporation of primary monitoring data.
- The accounts should be expanded to include information on biodiversity and associated benefits in agricultural and plantation areas to illustrate further the trade-offs that exist between conservation and expansion of activities such as agriculture.
- The accounts should be harmonised with other spatial statistics produced for the country (e.g., land cover statistics generated by the NFA). This should include integrating information on soil water seasonality and seasonal wetlands.
- Given there will be other drivers of ecosystem degradation that are not revealed by the accounts presented (e.g., over grazing or charcoal production), the compilation of ecosystem condition accounts should be extended beyond those presented in this report. This is likely to require the collation of primary monitoring data.

- Extensions to incorporate accounts for fisheries, water, carbon, ecosystem condition and ecosystem services supply and use should be completed. This should include the integration of information on biomass and wood fuel resources collated via the National Biomass Survey. Ultimately, these accounts should move from physical to monetary accounting and make links to measures of economic activity recorded in Uganda's System of National Accounts.

More generally, it must be recognised that these accounts have been developed over a short period of time using specialist expertise such that the potential value of accounts can be quickly assessed. Moving forward, it will be important to establish the institutional arrangements and technical capability to compile accounts on a long term basis. To this end, it will be necessary to engage across ministries and agencies and to collaborate with programs of work on natural capital accounting in southern Africa. These programs include the current planning for the implementation of the SEEA in Uganda led by the Ugandan Bureau of Statistics with support from the UN Statistics Division; the work on natural capital accounting under the Gaborone Declaration led by Conservation International; and the World Bank's Wealth Accounting and Valuation of Ecosystem Services (WAVES) partnership.

Glossary

Aichi Biodiversity Targets: A set of 20 targets for biodiversity to be achieved by 2020 by parties to the Convention on Biological Diversity (CBD).

Biological diversity (Biodiversity): The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (CBD 1992)

Community: Assemblages of plant and animal populations that live in a particular area or habitat and interact to form a system with its own emergent properties.

Ecosystem condition: The condition of an ecosystem asset based on measurements of various characteristics at a given point in time (UN et al. 2014).

Ecosystem-level biodiversity: The variety of ecosystems in a given place.

Ecosystem extent: The size of an ecosystem asset in terms of spatial area (UN et al. 2014).

Ecosystem asset: A spatial representation of ecosystems as contiguous areas of a single ecosystem type that form the conceptual base for accounting and the integration of relevant statistics (UN et al. 2015).

Ecosystem resilience: The ability of an ecosystem to tolerate shocks and disturbance but still maintain the same level of functioning (Mori et al. 2013).

Ecosystem services: The contribution that ecosystems make to the benefits received by economic units and people from the environment (UN et al. 2015).

Gaborone Declaration for Sustainability in Africa: A commitment amongst 10 African countries to incorporate value of natural capital in public and private policies and decision making.

Natural capital: Natural capital includes land, minerals and fossil fuels, solar energy, water, living organisms and the services provided by the interactions of all these elements on ecological systems (UNEP 2012).

NBSAP (II): Uganda's second National Biodiversity Strategy and Action Plan sets out an action plan for achieving seven strategic national biodiversity objectives by 2025. The vision of the NBSAP (II) is to "maintain a rich biodiversity benefiting the present and future generations for socio-economic development" (NEMA 2016a). The NBASP (II) provides the framework for implementing the CBD's Aichi Targets in Uganda.

National Development Plan (II): A planning framework for 2015 to 2020 towards Uganda's vision to achieve "A transformed Ugandan society from a Peasant to a Modern and Prosperous Country within 30 years". The NDP(II) provides the framework for implementing the UN Sustainable Development Goals in Uganda (NPA 2015).

Ecosystem Accounting Area (EAA): The geographical extent for reporting species or ecosystem information defined by, for example, sub-region boundaries, protected areas or national boundaries.

System of Environmental-Economic Accounting – Central Framework (SEEA-CF): The internationally adopted, multipurpose, statistical framework for understanding the interactions between the environment and the economy (UN et al. 2014b).

System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA): An experimental, multipurpose, statistical framework that aims to reinforce and quantify the importance of the relationship between people and their environment (UN et al. 2014).

System of National Accounts (SNA): The internationally adopted standard for compiling national statistics on economic activity.

Species-level biodiversity: Diversity at the species-level, often combining aspects of species richness, their relative abundance, and their dissimilarity (MA 2005a).

Species richness: The number of a species within a given sample, community or area (usually from a particular taxa, e.g. plant species richness) (MA 2005b).

Sustainable Development Goals (SDGs): A set of 17 goals adopted by countries of the United Nations in 2015 to end poverty, protect the planet, and ensure prosperity for all.

Taxon (plural taxa): A taxonomic category or group, such as phylum, order, family, genus or species.

Threatened species: Any species vulnerable to endangerment in the near future. Comprises the IUCN Red List categories of 'Vulnerable Species', 'Endangered Species' and 'Critically Endangered Species'. Global Red Lists have are produced by the IUCN and a National Red List exists coordinated by the Wildlife Conservation Society (WCS)

WAVES: A World Bank-led global partnership that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts.

1 Introduction

Natural capital is used in combination with other capitals and human inputs to produce flows of goods and services that are used, consumed and experienced across economies and societies. Several definitions for natural capital are promoted in the literature. UNEP (2012) identifies specific components "natural capital includes land, minerals and fossil fuels, solar energy, water, living organisms and the services provided by the interactions of all these elements in ecological systems". In this context, ecosystems and biodiversity are important components of a country's overall natural capital stock. High profile studies, such as The Millennium Ecosystem Assessment (MA 2005b) and The Economics of Ecosystems and Biodiversity (TEEB 2010), demonstrate that the sustainable use of ecosystems and biodiversity is fundamental to maintaining economic progress and human well-being over the long term.

The National Development Plan II (NDP II) for Uganda (NPA 2015) explicitly recognises the need for sustainable use, development and effective management of Environmental and Natural Resources (i.e., natural capital) in the pursuit of sectoral growth and socio-economic development. This includes explicit objectives for the Environmental and Natural Resources (ENR) sub-sector, which include restoring and maintaining the integrity and functionality of degraded ecosystems; increasing the sustainable use of ENR; increasing wetland coverage and reducing degradation; increasing Uganda's resilience to climate change; and, increasing afforestation, reforestation, adaptation and mitigating deforestation for sustainable development (NPA 2015).

The second National Biodiversity Strategy and Action Plan for Uganda (NBSAP II) will provide key contributions towards these objectives and the NDP (II) generally, via strategic objectives to (amongst others): strengthen frameworks for biodiversity management, facilitate and build capacity for monitoring and information management for biodiversity; reduce negative and enhance positive impacts on biodiversity; and, promote the sustainable use and equitable sharing of costs and benefits of biodiversity (NEMA 2016a).

The sustainable use of ENR is also echoed in the recent 2014 State of the Environment Report for Uganda (NEMA 2016b), which calls for innovative management approaches to ensure the environment continues to support human development and well-being. Natural capital accounting can contribute to achieving the objectives for ENR (including ecosystems and biodiversity) in Uganda, by providing detailed and regularly updated information on the state and trends of ecosystems and biodiversity and the benefits they provide.

International guidance on natural capital accounting is provided by the System of Environmental-Economic Accounting (SEEA) Central Framework (CF), which describes how to account for environmental resource assets (UN et al. 2014b). The

SEEA CF is extended to consider ecosystems and biodiversity in the SEEA Experimental Ecosystem Accounting (SEEA-EEA) framework (UN et al. 2014). Within the SEEA-EEA, ecosystems are characterised as assets on the basis of their type, extent and a range of condition characteristics (including biodiversity) that are relevant to processes and functioning of the ecosystem. Ecosystems are then linked to the economy and human well-being via the basket of ecosystem services they provide.

Several related studies have been undertaken to establish the state (i.e. the extent and condition) of ecosystems in Uganda and the ecosystem services and benefits that they deliver. This includes the National Biomass study undertaken by the National Forest Authority (NFA), which combines national land cover mapping and land change analysis with ground-truthing to establish biomass values per hectare (Diisi 2009). The NFA study provides the information required by decision makers for optimising the use of biomass energy resources (wood fuel), where biomass energy is a key ecosystem service for many Ugandans. The National Environmental Management Authority (NEMA), with support from the World Bank, has also compiled national forest accounts (NEMA 2011). The accounts identified that the economic contribution of forests in terms of forest products, other ecosystem services and biodiversity protection was as high as 8.7% of GDP, highlighting the case for investment in the maintenance of forest assets.

UNEP-WCMC (2016b) provides a summary of these and other studies and an assessment of the feasibility of undertaking ecosystem and thematic species accounting in Uganda using the SEEA framework. The feasibility assessment included a roadmap for compiling Species Accounts based on UNEP-WCMC's (2016a) publication *Exploring Approaches for Constructing Species Accounts in the Context of SEEA-EEA* that has informed the development of the Species Accounts presented herein.

This report builds on the above work by presenting a set of experimental ecosystem accounts for Uganda relevant to biodiversity and related policy and decision-making. This work draws on existing approaches and the large body of analytical work on environmental assessment completed for Uganda. The work shows how existing data can be collated and adapted to produce informative sets of accounts. The objective is to demonstrate how the SEEA framework can be employed rapidly and cost effectively to compile a set of integrated accounting tables that can assist policy and decision making in a consistent and coherent manner at the national and sub-national level. This is intended to support decision makers so they can understand the trade-offs and connections relevant to the sustainable management of ecosystems and biodiversity in Uganda.

The accounting tables are also intended to provide a foundation for the wider implementation of the SEEA framework in Uganda, for instance via extensions to incorporate accounts for fisheries, water, carbon, biomass, ecosystem condition and services. The remainder of this report is structured as follows:

- Section 2: Sets out the intended uses of the accounts and summarises the approach employed.
- Section 3: Introduces the proposed set of accounts to be compiled for Uganda and the underlying data sources.
- Section 4: Provides a set of selected land and ecosystem extent accounts and presentations.
- Section 5: Provides a set of selected Species Accounts and presentations
- Section 6: Presents the conclusions and recommendations for further work

The technical methodology for compiling the accounts is described in full in Appendices A and B. The accounts presented comprise a small proportion of the possible accounts that could be compiled using the spatial data infrastructure developed by this project. Practitioners and researchers interested in constructing accounts using the spatial data employed by this project are invited to contact UNEP-WCMC to access this data.

2 Ecosystem accounts: Uses and measurement approach

2.1 Uses of ecosystem accounts

SEEA accounts should be designed to provide the most relevant information to decision makers in the most useable format (Vardon et al. 2016). In order to establish a set of policy uses for the accounts, a desktop study of policy entry points and a stakeholder engagement exercise were undertaken in Uganda (as reported in UNEP-WCMC, 2016b). This work established that there are clear policy entry points and applications, providing a basis for the use of information from accounts compiled using the SEEA framework to inform decision making.

Specifically, the following set of key policy applications have guided the selection and development of the accounts presented in this report:

1. **Inform the ongoing debate surrounding the gazettement and de-gazettement of protected areas.** The accounts presented organise information on the trends of ecosystem and species habitat loss within the current protected area estate. This allows for the assessment of the performance of the protected estate in terms of ecosystem protection but also in terms of securing important economic benefits, such as maintaining flagship species and associated tourism opportunities. The accounts also provide spatial information about the areas or land that could be targeted for gazettement to provide the greatest level of economic and biodiversity benefits.
2. **Making the case for increased budget allocation and investment in biodiversity rich sectors for conservation and management (e.g., forestry as it maintains relatively high levels of biodiversity**). The accounts provide information on the extent of ecosystems that could potentially support commercially viable harvesting of non-timber forest products and expanded wildlife watching opportunities for tourism.
3. **Establishing the extent of ecosystem degradation and where biodiversity trends threaten the delivery of ecosystem services and implications on economic growth and human well-being.** The accounts organise information on the extent of loss of different ecosystem types in Uganda (i.e., degradation due to land conversion), both at the national scale and spatially disaggregated to sub-regional scale. This provides spatially disaggregated information on trends in the potential of these ecosystems to provide provisioning services from non-timber forest product species, cultural recreational services associated with flagship species watching and the ability of ecosystems generally to deliver services and contribute to providing climate change resilient landscapes.

4. **Increasing awareness and appreciation of biodiversity as a natural capital asset amongst decision makers and the public.** The accounts link trends in ecosystem loss to potential ecosystem services, such as non-timber forest product yields and wildlife watching tourism opportunities. This can be used to engage both the public and sector level decision-makers.
5. **Assessment of progress towards the strategic objectives of Uganda's NBSAP (II) and National Development Plan (II) and associated international commitments (i.e., Aichi targets and SDGs).** The accounts will yield key indicators relevant to several policy commitments in Uganda. This includes metrics on the rate and trends in habitat loss, progress towards protecting ecologically representative areas with high biodiversity importance, progress towards protecting the range and conservation status of threatened species and identifying areas where tourism and NTFP production possibilities can contribute to local economic development

The accounts have been developed to assist decision making with respect to land use, development and conservation. To this end, the accounts can support the National Planning Agency in identifying where potential opportunities for protection of natural land may also realise development co-benefits from tourism and non-timber forest product harvesting. The accounts also provide important information to planners interested in analysing trade-offs in different land-use options with respect to avoiding degradation of key ecosystems. The accounts will also support the National Environmental Management Authority in reporting on progress towards strategic objectives for biodiversity, protection of threatened species ranges and identifying where ecosystem degradation is occurring and where restoration or protection should best be targeted.

More generally the accounts are intended for use by multiple users in the public sector, researcher institutes and NGOs who are interested in understanding the trends in ecosystem and species level biodiversity. The accounting tables are also intended to provide a foundation for the wider implementation of the SEEA framework in Uganda. As noted previously, practitioners and researchers interested in constructing accounts using the spatial data employed by this project are invited to contact UNEP-WCMC to access this data.

2.2 Overview of the measurement approach

An overview of the approach employed to develop the set of Experimental Ecosystem Accounts for Uganda is provided in Figure 1. The first stage in the process was to construct accounts of the extent of land cover classes for 1990, 2005, 2010 and 2015 using land cover maps produced for Uganda by the National Forest Authority (NFA) (as described in Diisi 2009). Using this information, accounts have then been created for the extent of natural and non-natural land cover based on aggregations of relevant land cover classes. With these aggregated accounts in place, accounts of ecosystem extent have been compiled by intersecting areas of natural cover in 1990, 2005, 2010 and 2015 with a distribution of the original extent of vegetation in Uganda (as proposed by Langdale-Brown et al. 1964).

Finally, Species Accounts describing the extent of suitable habitat for individual species have been compiled. For Non-Timber Forest Product (NTFP) species this has been achieved using expert knowledge to associate key NTFP species with the discrete vegetation classes proposed by Langdale-Brown et al. (1964). The accounts are then constructed on the basis of the extent of these classes remaining in areas of natural cover for 1990, 2005, 2010 and 2015. For the flagship Species Accounts, IUCN and historic data on area of occupancy have informed the maximum potential range of these species in Uganda. Habitat preferences for flagship species proposed by the IUCN have then been matched to suitable land cover classes to generate accounts of the extent of suitable habitat for 1990, 2005, 2010 and 2015 within these ranges.

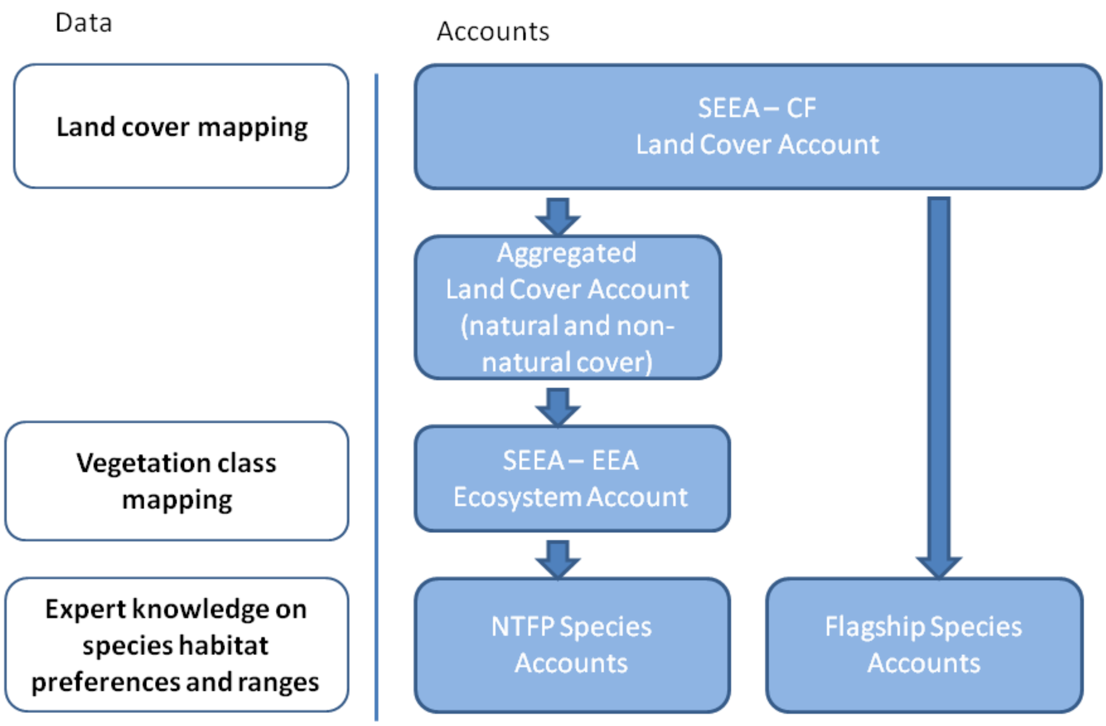


Figure 1: Approach to developing Experimental Ecosystem Accounts for Uganda

The various accounts outlined in Figure 1 were determined in discussion with stakeholders in Uganda, including the NPA, NEMA and UBoS. The approach for developing the accounts is summarised in Section 3, with expanded methodological documentation provided in the appendices.

3 Getting the data together

3.1 Introduction

The SEEA is a multipurpose framework for understanding the interactions between the environment and the economy, thereby extending the established System of National Accounting (SNA) used for the measurement of economic activity and related stocks and flows. The SEEA CF was adopted as an international standard in 2012 to describe the stocks of environmental assets and environmental flows into the economy (natural inputs) and from the economy to the environment (residuals). Thus the SEEA CF includes accounting for certain aspects of biodiversity, such as stocks of fish and other aquatic resources. The SEEA-EEA extends this framework to consider ecosystems, their condition and the services they provide. This includes accounting for biodiversity, both as a management theme and as an important element in the measurement of ecosystem condition (Remme et al. 2016). The relationship between these accounts is shown in Figure 2.

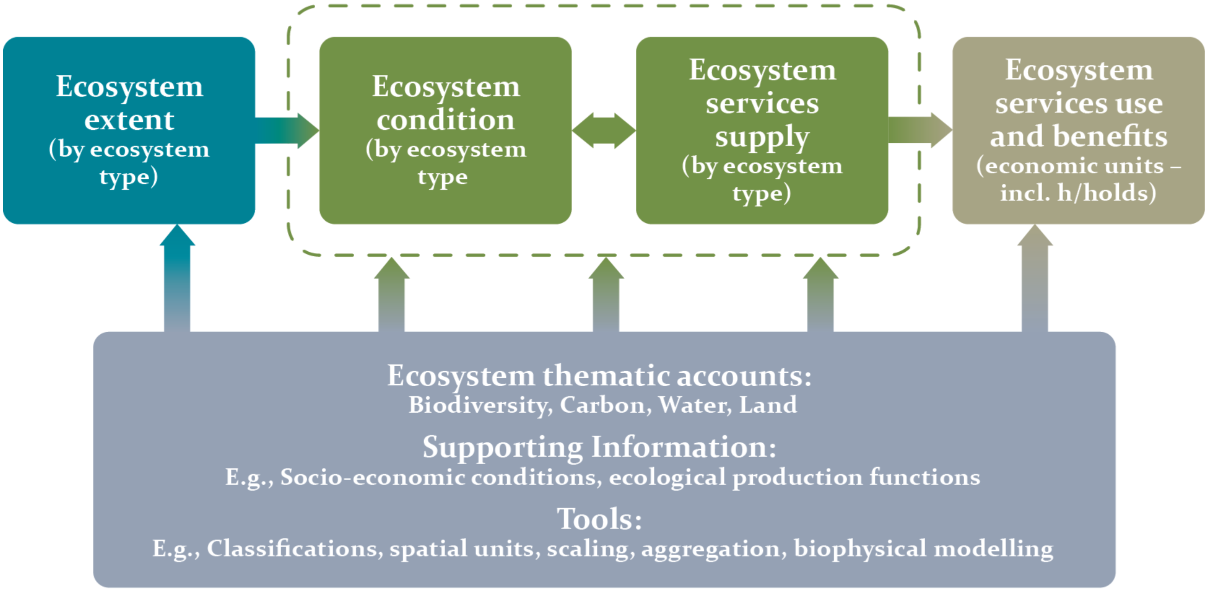


Figure 2: Relationship between thematic accounts and other SEEA-EEA accounts (adapted from Chow 2016)

The definition of biodiversity used within the SEEA-EEA follows that adopted by the Convention of Biological Diversity (CBD 1992), which emphasizes diversity between ecosystems, species and genetic information. An important observation here is that the CBD definition identifies ecosystem diversity as a component of overall biodiversity, whereas the SEEA-EEA proposes biodiversity accounting as a thematic component of ecosystem accounting (as shown in Figure 2). A second observation is that the CBD definition for biodiversity emphasises variability, whereas, it may often be the case that the stock of certain aspects of biodiversity (e.g., abundance of an iconic species) is also of interest to users of 'biodiversity accounts' (Vardon et al. 2015).

The approach proposed here is to develop a set of accounts relevant to biodiversity in Uganda. This includes accounts of land cover (a coarse approximation of potential ecosystem-level biodiversity) and ecosystem extent (providing more ecologically relevant information on ecosystem-level biodiversity). Species-level biodiversity accounts are also presented for the extent of potentially suitable habitat (a proxy for stocks) of species that are most policy relevant, namely *Vitellaria paradoxa* (which produces Shea butter tree nuts from which Shea butter and other Shea-based products are made), *Acacia senegal* (which produces Gum Arabic), *Prunus africana* (a traditional medicine) and chimpanzees and elephants (iconic flagship species important for tourism). The estimation approach reflects the habitat-based approach proposed in UNEP-WCMC (2016a) for compiling Species Accounts. These accounts are intended to be analysed with other sources of information to communicate a coherent picture of the environment, ecosystems and biodiversity to decision makers in the context of the uses defined in Section 2.1.

3.2 Land Accounts and data

The SEEA-CF defines land as " a unique environmental asset that delineates the space in which economic activities and environmental processes take place..." (UN et al. 2014b, pp. 174). It identifies land as central to economic and environmental accounting. The availability of regularly updated remote sensing data on land cover has allowed the development of time series observations for land cover that can inform the compilation of land cover accounts in most countries. For example, the Land Cover Classification Systems (FAO LCCS 3, FAO 2009) allows the biophysical characteristics of land to be systematically recorded (UN et al. 2014b pp. 177).

In Uganda, the National Biomass Study (NBS) started in 1989 to monitor the dynamics of woody biomass in Uganda. The project provides national land cover maps, originally based on the NBS Classification system developed from the original study (1990). From 2005 onwards land cover maps were generated based on the FAO LCCS and cross referencing this system to the original NBS Classes. The land cover maps were produced in combination with ground-truthing, to establish biomass values per hectare for different land cover classes (Diisi 2009). The project outputs also provide information for understanding the delivery of other key forest and woodland ecosystem services, such as provision of fruit, building materials, natural hazard protection and erosion control. Land cover maps have now been produced for 1990, 2005, 2010 and 2015.

Figure 3 presents the extent of the NBS classes in 2015. Given the familiarity of these NBS classes to potential users of the accounts, these higher level classes have been adopted for the land accounts presented in this report (rather than the land cover classes proposed in the SEEA-CF, noting that both can be aligned to the detailed FAO LCCS). The land accounts have been compiled following the logic set out in Chapter 5.6 of the SEEA-CF. It is noted that land cover accounts and associated land cover change analysis has already been undertaken in Uganda for 1990 to 2005 by the NFA (presented in Diisi 2009). As such, the land accounts presented herein are intended to extend this analysis to 2010 and 2015 and facilitate the integration of land cover information with wider biodiversity data on ecosystems and species.

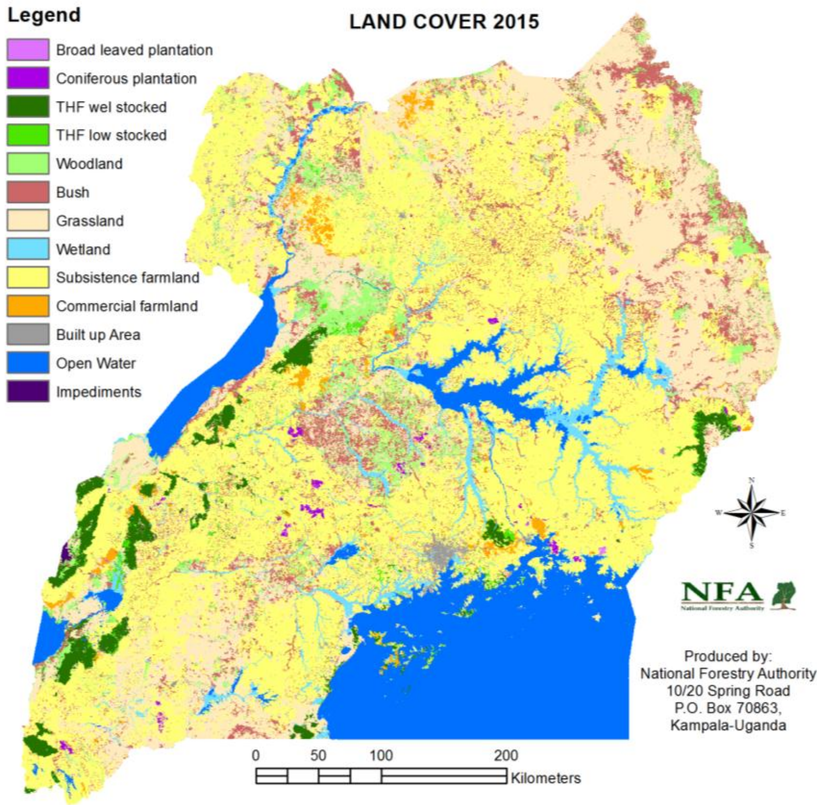


Figure 3: Extent of NBS Classes in Uganda 2015 (source NFA)

With reference to Figure 3, the key features of the Ugandan landscape are the extent of subsistence (a.k.a. small scale) farm land throughout the country, the large lakes (Lake Victoria in the south-east and Lake Albert in the west) the large river and wetland systems (especially in the centre of the country) and the extensive grasslands in the north east. Tropical forests can be found in the south west and areas of bush can be found scattered across the country.

In order to support the analysis, accounts derived from these land cover data have been compiled to summarise changes in the extent of natural and non-natural (i.e., converted for production) land cover. This has been achieved by assigning different NBS classes to natural and non-natural cover types, as summarised in Table 1. This follows the approach set out in Pomeroy et al. (2002). In Table 1, built up areas are also represented as a separate class to reflect urbanisation as a distinct driver of land conversion. Open water is considered as a separate class as it is generally not associated with significant land conversion (although the potential for impoundments to be generated for hydropower provision exist). At this broad level, the land accounts provide a framework for exploring the potential impacts of urbanisation, agricultural expansion, deforestation and other land uses on ecosystems, protected areas and biodiversity. This can inform progress towards national and international policy commitments such as NBSAP (II) target 3.5 (corresponding to Aichi Target 5, by 2020 at least halving the rate of loss of natural habitats and where feasible brought close to zero) and NBSAP (II) target 3.1 (corresponding to Aichi Target 11, by 2020 at least 17% of terrestrial and inland water, especially areas of biodiversity importance, are conserved through ecologically representative protected areas).

Table 1: NBS Classes and derived classes

NBS Code	NBS Class	Derived Class
3	Tropical high forest well stocked	Natural
4	Tropical high forest low stocked	Natural
5	Woodland	Natural
6	Bush	Natural
7	Grassland	Natural
8	Wetland	Natural
1	Broad leaved plantations	Farmland and plantations
2	Coniferous plantation	Farmland and plantations
9	Small scale farm land	Farmland and plantations
10	Commercial farmland	Farmland and plantations
11	Built-up area	Built up area
12	Open water	Open water
13	Impediments	No data
	No data	No data

3.3 Ecosystem Extent Accounts and Data

Within the SEEA-EEA, ecosystems are spatially delineated assets that are characterised on the basis of their type, extent (in terms of area), a range of condition metrics (e.g., species richness) and their ability to deliver ecosystem services. An ecosystem asset is conceptually characterised as contiguous areas of a single ecosystem type (UN et al. 2015). Whilst land cover classes may align with ecosystem types in some cases, land cover is also an artefact of its historical and current use. This implies land cover classes may not always be ecologically meaningful representations of ecosystems.

Driver et al. (2015) discuss this in the context of producing integrated land cover and ecosystem extent accounts using the SEEA framework for KwaZulu-Natal province in South Africa. In their application, they employ maps of biomes for South Africa and a regional vegetation map for the province. Changes in the extent of ecosystems (i.e., using biomes or component vegetation classes) are derived by intersecting the historic baseline of the distribution of biomes or vegetation class (c.1840) with 'Natural' classes as presented in time series maps of land cover (e.g., the extent of the derived 'Natural class' presented for 2015 in Table 1). Given the focus of the accounts presented here is to inform on the potential implications of natural ecosystem loss for biodiversity, ecosystem extent accounts have been compiled following the approach employed by Driver et al. (2015). However, following UN et al. (2015), it is acknowledged that ecosystems range from fully natural to managed systems and follow on work should be considered to develop disaggregated accounts for areas such as farmland and plantations.

As discussed in the feasibility study, the approach outlined above is conceptually similar to that employed by Pomeroy et al. (2002). In their analysis, Pomeroy et al. (2002) use the vegetation classes proposed by Langdale-Brown et al. (1964) and associated biome level aggregations for Uganda. The Langdale-Brown et al. (1964) map was created on the basis of an ecological survey of Uganda, carried out between 1957 and 1960. The final mapping was based on a combination of this field work and aerial photograph interpretation. It was compiled at a scale of 1:250,000. In total, 22 different vegetation classes were determined on the basis of species present and their cover-abundance; physiognomy; soil type and depth; topography and drainage conditions. Each of the 22 classes were further disaggregated to individual vegetation units (or mixtures where more than one vegetation type occurs). For example, vegetation type A2 – *Ericaceae-Stoebe Heath* – is part of the vegetation class A –High Altitude Moorland and Heath, which is part of the Forest biome. Using this approach, Langdale-Brown et al. (1964) mapped a total of 2,697 individual vegetation units across Uganda, identified by the class letter and a number for the vegetation type that can be readily aggregated as vegetation classes or biomes.

The Langdale-Brown et al., (1964) vegetation classes and biomes are presented in Table 2. As part of their analysis, Pomeroy et al. (2002) digitised these units as polygons, Figure 4 presents the associated distribution of the original extent of the biomes in Uganda (i.e., assuming no conversion of land) from this digital map. Pomeroy et al. (2002) then determine the extent of vegetation classes remaining by intersecting the original distribution with the extent of natural land classes (Table 1) from the 1990 NBS Land Cover map. They find very large reductions in forest and savannah ecosystems (~75%) due to conversion to agriculture and also reductions in wetlands (~25%) due to drainage. This approach is updated herein to provide contemporary results for the 2005, 2010 and 2015 using NBS land cover maps. This has informed the development of a set of ecosystem extent accounts similar to those presented by Driver et al. (2015). These accounts present the extent of natural ecosystems in terms of the 22 vegetation classes proposed by Langdale-Brown et al., (1964) and their associated aggregations, which are termed biomes following Pomeroy et al. (2002).

Table 2: Ecosystem Extent Accounts Biome and Vegetation Classes

Vegetation Class Code	Vegetation Class	Biome
A	High Altitude Moorland and Heath	Forest
B	High Altitude Forests	
C	Medium Altitude Moist Evergreen Forests	
D	Medium Altitude Moist Semi-Deciduous Forests	
F	Forest/Savanna Mosaics	
G	Moist Thickets	Moist Savanna
H	Woodlands	
J	Moist Acacia Savannas	
K	Moist Combretum Savannas	
L	Butyrospermum Savannas	
M	Palm Savannas	
N	Dry Combretum Savannas	Drylands
P	Dry Acacia Savannas	
Q	Grass Savannas	
R	Tree and Shrub Steppes	
S	Grass Steppes	
T	Bushlands	
V	Dry Thickets	
W	Communities on Sites with Impeded Drainage	Wetlands
X	Swamps	
Y	Swamp Forests	
Z	Post-Cultivation Communities	No data*
	No data	

*In the ecosystem accounts presented areas of open water for which vegetation classes are not available are recorded as 'No Data' as are areas of Post-Cultivation Communities.

In order to understand the richness and diversity of vegetation types within the landscape, summary statistics have been calculated based on the extent of vegetation classes retained in the landscape. These discrete units of vegetation class can be considered as supporting different communities of species in the landscape. As such the variation (turnover) of these classes in the landscape can also be considered to provide an indication on the likely species turnover in an area (i.e., species level biodiversity).

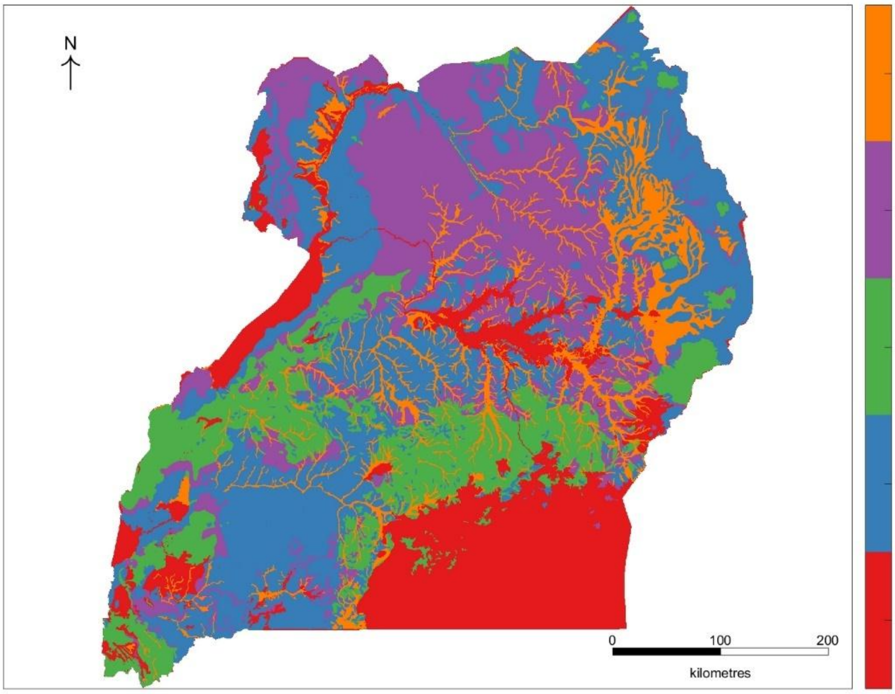


Figure 4: Original Extent of Langdale-Brown Biomes in Uganda

3.4 Ecosystem Assets

The SEEA-EEA is a spatially based framework, with ecosystems represented as spatially distinct assets characterised by their extent, condition and ability to provide ecosystem services. A requirement of any classification for ecosystem assets is that it satisfies the principles of being Mutually Exclusive and Collectively Exhaustive (MECE). Essentially, this implies that there are no overlaps between differently classified areas and the combined extent of all classified areas covers the landscape of interest in its entirety. Both the NBS land cover classes and the Langdale-Brown vegetation classes (with the assumption the no data is indicative of open water and post cultivation communities) satisfy this requirement.

Figure 5 shows the classes for both Langdale-Brown classes and the NBS land cover classes. The Langdale-Brown asset classes start at the vegetation type and are then aggregated to classes and biomes. The NBS assets start at the class level and are then aggregated to derived classes (see Table 1). Since there is only a single time period for the Langdale-Brown vegetation classes, an intersection was done between the NBS aggregate 'Natural" and the Langdale-Brown classes for each year. Each intersection represents a Langdale-Brown extent for each year.

As shown in the right-hand side of Figure 5, the Langdale-Brown extent data is organised via the ecosystem extent accounts at the scale of individual vegetation classes or at the aggregated scale of national biomes. On the left-hand side of Figure 5, NBS Land Cover classes can be organised via the land cover account. This account can then be linked to production units (e.g., farms) and associated economic statistics by land ownership, ultimately providing a pathway for integration with the standard system of national accounts. In order to integrate ecosystem services via this approach, a spatial intersection between the NBS land cover classes and Langdale-Brown classes is required, as shown in the middle of Figure 5. As noted in Section 3.3, this study focuses on natural ecosystems but developing accounts for managed ecosystems (i.e., the NBS aggregates other than 'Natural' in Figure 5) would be useful follow-on work for informing on wider assessments of ecosystems in Uganda.

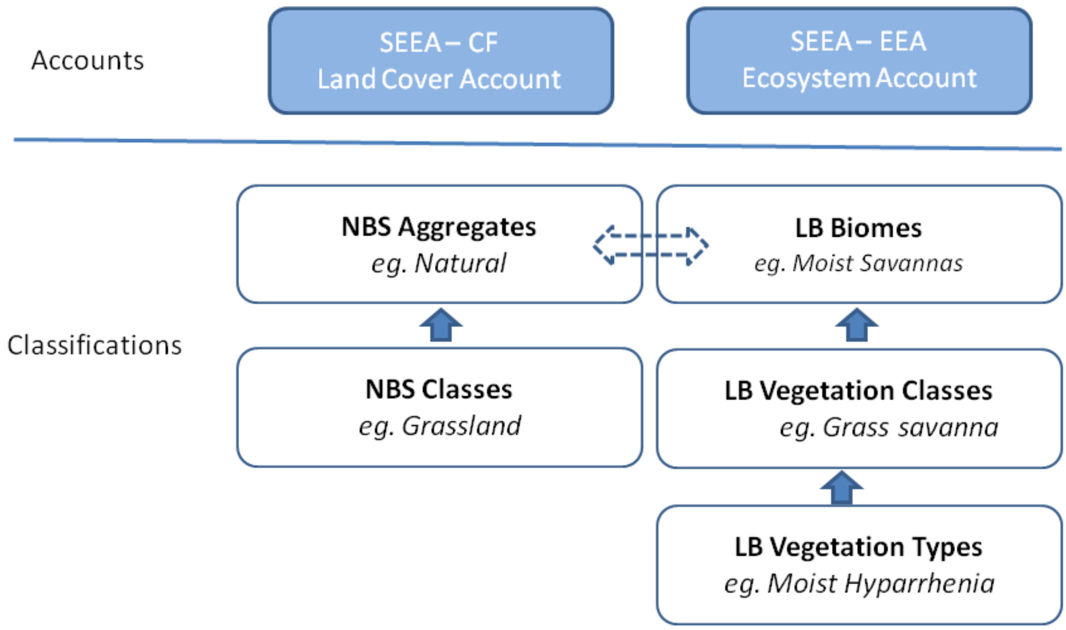


Figure 5: Hierarchy of Ecosystem Classes for Uganda (adapted from Eigenraam & Ivanov 2015)

3.5 Species Accounts and Data

The feasibility study identified several characteristics to guide the selection of species (species of special concern) for this report. These included species that are hunted or harvested for household and commercial purposes (including non-timber forest products, NTFPs), the threat status of species (including Red List status) and the iconic status of species (for example large mammals). The set of species of special concern was determined in consultation with NEMA and NPA and with consideration to the key applications listed in Section 2.

3.5.1 NTFP Species Accounts

The 22 mapped Langdale-Brown et al. (1964) vegetation classes presented in Table 2 can also be used to infer the distribution of discrete community classes of species (UNEP-WCMC 2016a). This requires the assumption that the vegetation classes broadly reflect the distribution of species or species groups. Changes in the extent of habitat suitable for specific community classes can then be inferred using maps of land cover change. This approach has been used to generate a set of Species Accounts in Uganda for NTFPs, as described below.

Baldascini (2002) identifies a set of potentially income generating species occurring in forest, savannah and wetland ecosystems of Uganda. Of these, *Prunus africana*[2] , *Vitellaria paradoxa* (which produces Shea butter tree nuts)[3], *Acacia senegal* (which produces Gum Arabic)[4], have been selected as important NTFP species in Uganda. Pomeroy et al. (2002) link the occurrence of these species to the Langdale-Brown et al. (1964) vegetation classes using expert knowledge. These associations are summarised in Table 3 below.

Table 3: Suitable Langdale-Brown vegetation classes for NTFP species

NTFP Species	Suitable Langdale-Brown classes		Notes
Prunus africana	B	High Altitude Forests	This species occurs at altitude in montane forests. This distribution is reflected by the medium to high altitudes associated with the stated vegetation classes.
	C	Medium Altitude Moist Evergreen Forests	
	D	Medium Altitude Moist Semi-Deciduous Forests	
Shea Butter Tree	L	Butyrospermum Savannas	Pomeroy et al., (2002) identify the species to commonly be in the North, North East and North West of Uganda*
	N	Dry Combretum Savannas	
Gum Arabic tree	K	Moist Combretum Savannas	This species is assumed to occur throughout Uganda.
	L	Butyrospermum Savannas	
	M	Palm Savannas	
	N	Dry Combretum Savannas	
	P	Dry Acacia Savannas	

*This area is assumed to comprise of the West Nile, Acholi, Lango, Karamoja, Teso, Elgon sub-regions, generally matching the distribution presented in Cottray, Miles, & Newton, (2006).

In order to generate spatial accounts for species of concern, a deductive modelling approach is employed (as described UNEP-WCMC, 2016a). To generate an historic distribution of these species it is assumed that *Prunus africana* and the Gum Arabic tree occur in all the suitable Langdale-Brown classes (i.e., the discrete community classes) across the country as described in Table 3. For the Shea butter tree, it is assumed their range is restricted to the West Nile, Acholi, Lango, Karamoja, Teso and Elgon sub-regions following the note provided by Pomeroy et al. (2002). The extent of potentially suitable habitat remaining for each species is then determined by intersecting the original distribution of the relevant Langdale-Brown classes and the

[2] The bark of *Prunus africana* is a traditional medicine that may also be useful for treating prostate cancer and Benign Prostatic Hyperplasia (BHP)

[3] The nuts of the Shea Butter tree are used in cosmetic products

[4] *Acacia senegal* can be tapped for gum that is used in the food and pharmaceutical industries, notably as a stabilising or emulsifying agent

areas of natural land cover identified in the time series of land cover maps for 1990, 2005, 2010 and 2015.

3.5.2 Flagship Threatened Species Accounts

The SEEA-EEA describes an account for threatened species based on the IUCN Red List. Table 4 draws on the information presented in Uganda's recent National Biodiversity Strategy and Action Plan (NBSAP) II (NEMA 2016a) to illustrate such an account for Uganda

Table 4 Example Red List Account for Uganda (2004 to 2008)

Classifications >>	Extinct or Extinct in the wild (5)	Critically Endangered (4)	Endangered (3)	Vulnerable (2)	Near Threatened (1)	Least Concern * (0)	RED LIST INDEX
Opening Stock	38	27	31	72	64	18	0.521
Closing stock	38	28	36	67	66	18	0.518

The Red List account shows a decrease in the Red List Index in the final column, indicating that the threat status of the set of species considered in Table 4 has increased overall between 2004 and 2008. The threat status categories are based on global assessments, but WCS et al. (2016) have recently compiled National Red List of species. This will provide a nationally more relevant set of criteria for compiling a Red List account for Uganda in the future (the only observation is currently for 2016).

Red List data is not amenable to spatial disaggregation beyond national or coarse sub-national scales. Therefore, in order to generate spatial species accounts, *Loxodonata africana* (African Elephant) and *Pan troglodytes* (Common Chimpanzee) have been selected as iconic flagship threatened species[5] for accounting. Flagship species are generally charismatic species whose presence can be used to attract visitors to raise revenues and that resonate with public conservation concerns. They also provide proxies for species-level biodiversity generally because maintaining the viability of habitat for flagship species will, at the same time, maintain habitat for many other species (a.k.a the umbrella effect[6], Caro 2010). Megafauna such as elephants and chimpanzees play important roles for ecosystem dynamics by their interaction with other organisms especially plants, and by maintaining habitat diversity. As such, they can also provide a useful proxy to monitor the maintenance of ecosystem functions and associated services delivery.

[5] *Loxodonta africana* global threat status is vulnerable and national threat status is critically endangered. *Pan troglodytes* threat status is endangered both globally and nationally (WCS et al. 2016).

[6] where maintaining the range of a viable population of one species maintains viable populations of many others

For well-studied species, digital range maps provide a coarse approximation of distribution. For both chimpanzees and elephants a conservative range of occurrence has been assumed based on IUCN expert range assessments. In addition, a wider historic range of occurrence has been estimated for elephants based on digitising the range of elephants for 1960 presented in Lamprey et al. (2003). These ranges have been refined via deductive modelling to exclude areas that are outside of the altitude ranges that the flagship species would be expected to occur in (e.g. the *schweinfurthii* subspecies of chimpanzee present in Uganda are thought not to occur above 2,790m).

The habitat classes reported as suitable for elephants and chimpanzees, as proposed by IUCN (2016), have then been associated with NBS land cover classes on the basis of being either fully or partially suitable (described in full in Appendix B). These associations are summarised in Table 5, where unsuitable classes (e.g., small-scale farmland for Chimpanzees) are omitted from the table.

The flagship Species Accounts are then compiled on the basis of the extent of fully suitable, partially suitable and unsuitable habitat remaining within the IUCN-based range estimates for chimpanzees and elephants (following UNEP-WCMC 2016a). A further account is compiled for elephants based solely on the extent of fully suitable, partially suitable and unsuitable habitat within their historic range. The information on extent has been generated using the time series of NBS land cover class observations for 1990, 2005, 2010 and 2015 and the flagship species associations summarised in Table 5. This provides a proxy for the status of each species and where, potentially, elephants and chimpanzees could occur and associated benefits (e.g., tourism) could be realised.

The NBS land cover classes necessarily cover a range habitat types, for example areas defined as woodland classes will have locations that are similar to forests and others that are more akin to bush. The classes therefore have a range of suitabilities for species. In addition, there are a range of other factors that determine a location's suitability for a particular species, such as bush meat hunting intensity or distance from disrupting transport infrastructure. Nonetheless, habitat is a key component of a location's suitability for a species, therefore, the habitat based approach represents a relevant, albeit coarse, view of a key factor.

3.5.3 Species Richness Data

WCS are currently coordinating a project with the Government of Uganda and the National Biodiversity Data Bank (NBDB) to establish the areas of high value for species conservation. This project comprises an extensive collation and conditioning of geo-referenced species occurrence / observation data for Uganda from multiple sources, largely covering the period from the 1990s to the present day. The identification of high value was partially informed by the 2005 National Biomass Report, using the same system for identifying natural areas discussed in Section 3.2. This data is analysed in the context of the wider set of accounts in order to provide a more holistic picture of the environment to decision-makers.

Table 5: Suitable NBS Classes for flagship species.

Flagship species	NBS Code	NBS Class	Suitability of NBS Classes
Chimpanzees	3	Tropical high forest well stocked	Fully
	6	Bush	Fully
	4	Tropical high forest low stocked	Partially
	5	Woodland	Partially
	7	Grassland	Partially
Elephants	3	Tropical high forest well stocked	Fully
	5	Woodland	Fully
	6	Bush	Fully
	7	Grassland	Fully
	8	Wetland	Fully
	13	Impediments	Fully
	1	Broad leaved plantations	Partially
	2	Coniferous plantation	Partially
	4	Tropical high forest low stocked	Partially
	9	Small scale farm land	Partially

3.6 Spatial infrastructure and reporting procedure

The Ecosystem Assets described in Section 3.4 comprise the conceptual spatial unit for accounting purposes. In order to use these units for reporting and accounting it is necessary to attribute information such as soil type, ownership, and protection status to the same spatial boundaries. However, in practice, these other spatial data sets will have a different spatial boundaries and resolutions.

In order to overcome the spatial boundary and resolution issues, a basic spatial unit (BSU) is created for accounting and analytical purposes (UN et al. 2015). The BSU is not an accounting unit, per se, but it is used to provide a consistent spatial layer for data integration. The approach adopted to generate BSUs for the Ugandan accounts is to create a master grid of 100m grid cells (each representing a BSU) that covers the entire country. This set of BSUs (grid cells) satisfies the mutually exclusive, collectively exhaustive requirement for spatial ecosystem accounting.

By converting all spatial data layers, whether in grid or vector format, to a master grid, the information can be aggregated and combined to present different data referring to comparable spatial areas, including for ecosystem assets. Appendix A provides further technical description of the approach and how grid, raster and vector types of data have been harmonised.

With this spatial infrastructure in place, it is then possible to aggregate data attributed to the BSUs to generate accounts for various accounting areas. Thus, ecosystem accounts can be developed for each individual Ecosystem Asset, such as a contiguous area of grassland or grass savanna, as discussed in Section 3.4. However, in most cases, larger areas will be most relevant for analysis and users' needs. These larger aggregations are defined as Ecosystem Accounting Areas (EAA) (see Figure 6).

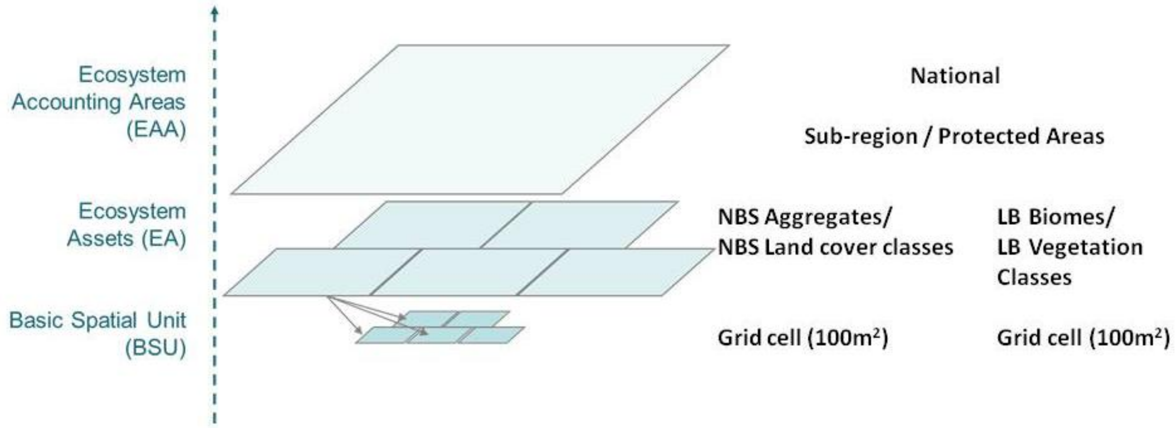
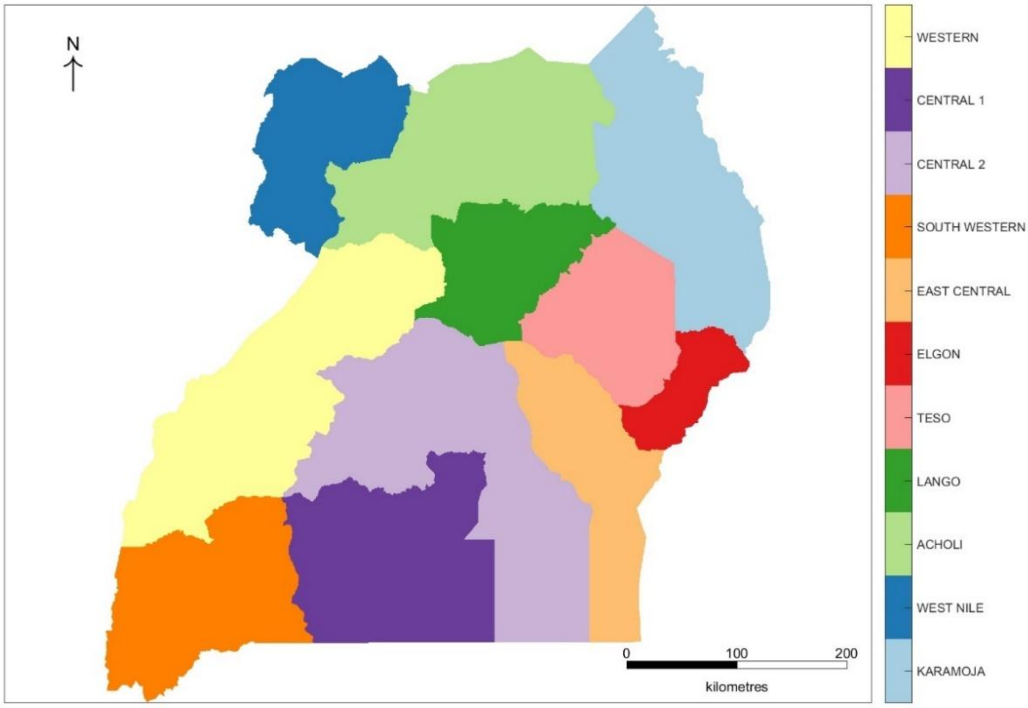


Figure 6 Basic Spatial Units (BSU) hierarchy and aggregations

The EAAs for the project were determined in consultation with NPA, NEMA and UBoS. In order to align with national statistics, a national scale account is required. In addition, in order to inform management and policy responses, a degree of disaggregation is necessary. As such, accounts have been produced for the sub-regions shown in Figure 7. The area and population for these sub-regions are provided in Table 6. Given that the methods proposed rely on the changes observed in the land cover maps for Uganda, accounts for each of these mapped years have been produced (i.e., 1990, 2005, 2010 and 2015) nationally and for sub-regions. Finally, in order to inform the debate on gazettement and de-gazettement, the accounts have been compiled with reference to the extent of protected areas in Uganda in 2015. The GIS shapefile for the protected area system has been obtained from the World Database on Protected Area (IUCN & UNEP-WCMC 2017).



produced using EnSym

Figure 7 Sub-regions in Uganda

Table 6: Sub-region areas (hectares) and populations

	Total Area	Population*	Population density (no./ha)
ACHOLI	2,822,809	1,513,277	0.5
CENTRAL 1	2,621,333	5,862,240	2.2
CENTRAL 2	3,627,334	3,681,788	1.0
EAST CENTRAL	1,736,805	3,893,688	2.2
ELGON	602,099	2,544,489	4.2
KARAMOJA	2,752,774	989,321	0.4
LANGO	1,392,432	2,069,618	1.5
SOUTH WESTERN	2,170,710	4,312,378	2.0
TESO	1,485,292	2,616,933	1.8
WEST NILE	1,577,532	2,669,348	1.7
WESTERN	3,356,278	4,626,977	1.4
GRAND TOTAL	24,145,398	34,780,057	1.4
Adjusted Grand Total (net of Open Water areas)	20,479,953	34,780,057	1.7

*Population data based on http://data-energy-gis.opendata.arcgis.com/. Population growth rates for Uganda as a whole are estimated at 3.3% / year in 2015 (World Bank n.d.)

4 Compiling the Land and Ecosystem Extent accounts

The compilation stage requires collating, cleaning and adapting the source data into a suitable format and then populating the accounting tables proposed in Figure 1. This Section presents the various accounting results for the land and ecosystem extent accounts and derived data presentations to inform the key applications determined in Section 2.1. The technical methods are described in full in the appendices following the report text.

4.1 Land Cover Accounts

Table 7 presents a summary National Land Cover Account for Uganda based on the observed changes in the extent of NBS classes in 1990, 2005, 2010 and 2015 revealed by the land cover maps.[7] The general trends observed are increases over all years in areas of small scale farmland, commercial farmland, broad leaved plantations, coniferous plantations and built - up areas (except broad leaved plantations between 1990 and 2005). The increase in the area of small-scale farmland between 1990 and 2015 is particularly notable, comprising approximately 2 million hectares or 8% of Uganda's territory.

The corollary of land conversion is a reduction in the extent of natural land cover between 1990 and 2015. In particular, the extent of woodlands has declined substantially (approx. 2.9 million ha), with Tropical High Forest (well and low stocked) (approx. 265,000 ha) also experiencing reductions in extent over this period. Whilst, the extent of grassland appears to exhibit only a minor net change between 1990 and 2015, there is a significant drop between 1990 and 2005, which is then recovered in 2010. The drop between 1990 and 2005 of 1.1 million ha, is associated with a corresponding increase in the extent of bush of 1.5 million ha. Between 2005 and 2015, the extent of bush is then shown to decrease by approximately 1.1 million

[7] Diisi (2009), presents the same data for 1990 and 2005, here it is extended to include the more recent land cover mapping data for 2010 and 2015. A comparison between the land cover statistics reported in Table 7 and those presented by Diisi (2009) identifies some small discrepancies across classes (<1%) that are believed to be an artefact of the difference in which the GIS data has been processed. The notable exception is the differences in the areas of Tropical High Forest – well stocked for the 2005 land cover map (the value in Table 7 is 57,000ha higher than that presented by in Diisi (2009). However, this difference is largely accounted for by differences in the similar natural classes of Tropical High Forest – low stocked (approximately 10,000ha lower in Table 7) and Woodland (10,000ha lower in Table 7). The remainder of the differences are <1% for 2005. As such these differences have low implications for the approach set out in the previous Section, with the exception of potentially marginally overestimating the extent of habitat suitable for chimpanzees. Nonetheless, this information implies that some further harmonisation of the data is required to bring it in line with the statistics produced by the NFA.

hectares, while grassland recovers to its previous extent. This substitution of bush and grassland areas may be associated with reclassification of these areas using different mapping approaches in 1990 and 2005. Another potential explanation for part of these observations could be reduced grazing practiced in 2005, compared with 2005. In the absence of grazing animals, bush and woody vegetation may have had the opportunity to grow in these areas, leading to a reclassification of grassland as bush in 2005. A driver for reduced grazing may be the internal displacement of people in the north of the country during conflict in the latter part of the 20th century (this is discussed further in Section 4.2.1). Alternatively the spread of *Lantana camara* (a shrub considered an alien invasive species in Uganda, NEMA 2016a) in the 1980s and 1990s (Plumptre, A., pers comms.) may have led to reclassification of grassland as bush where it had become established in these areas.

The changes in grassland and bush between 1990 and 2005 presented in Table 7 suggest some inconsistency in classifications between these periods. In this regard, Diisi (2009) provide a detailed explanation of the 1990 and 2005 mapping approaches. Notably, the digital map from 1990 was created from interpretation of hardcopy images, whereas the 2005 map was directly produced from digital satellite imagery and employed the FAO LCCS. There are also differences in the levels of generalisation in interpretation of images between these two approaches, with more generalisations implicit in the LCCS for the 2005 maps. These differences in methodology and classification are likely to have contributed to some of the unexpected trends noted in Table 7 (e.g., the increase in wetlands between 1990 and 2005).

Table 7 National Land Cover Accounts for Uganda (hectares)

Land Cover	1990	2005	2010	2015
Broad leaved plantations	18,736	14,740	18,779	43,900
Built up area	36,553	97,266	100,056	134,884
Bush	1,417,678	2,965,292	2,365,727	1,877,278
Commercial Farmland	68,456	106,494	137,363	259,102
Coniferous plantation	16,244	18,661	39,032	55,428
Grassland	5,109,964	4,057,838	5,000,112	5,126,140
Impediments	3,750	7,817	12,964	14,626
Open Water	3,663,772	3,680,264	3,709,407	3,665,445
Small scale farm land	8,396,117	8,841,450	9,723,790	10,461,271
Tropical high forest low stock	272,835	191,678	114,872	143,448
Tropical high forest well stocked	650,679	600,161	551,220	516,129
Wetland	483,561	752,140	762,570	755,958
Woodland	3,970,470	2,774,971	1,586,190	1,078,131
Other	36,583	36,626	23,316	13,658
Grand Total	24,145,398	24,145,398	24,145,398	24,145,398

A final observation with respect to Table 7, is that wetland extent appears to be relatively stable between 2005 and 2015 but shows an unexpected and substantial increase in extent from 1990 to 2005 (approx. 269,000ha). This is understood to be due to permanently wet grassland areas being mapped as grassland in the 1990 map only but included in the wetland class in mapping from 2005 onwards. This is supported by spatial analysis of wetlands in Uganda undertaken by Wetlands Management Department et al. (2009), which provides shapefiles for wetland extent in Uganda. These identify approximately 732,500 ha of permanent wetland in Uganda, in broad accordance with the figures presented for 2005, 2010 and 2015 in Table 7.

However, it is important to note that in addition to permanent wetlands, there exists a substantially larger extent of seasonal wetland in Uganda. These areas are only flooded for part of the time and, in many locations, the dry period may comprise most of the year. The shapefiles associated with the Wetlands Management Department et al. (2009) study identify that the total extent of seasonal wetlands in Uganda is approximately 2,408,100 ha. This area is in addition to the extent of permanent wetlands presented in Table 7 for 1990, 2005, 2010 and 2015.

These areas of seasonal wetlands can be found in several of Uganda's main land cover classes, with the largest extents associated with seasonally wet grasslands (approx. 1,532,600 ha, classified as Grassland in Table 7); and woodlands (approx. 513,600 ha) (Wetlands Management Department et al. 2009). As described in Diisi (2009), information on soil water seasonality is captured by the Land Cover maps. This could be used to provide information on the extent and condition of seasonal wetlands in different land cover classes in future iterations of the accounts.

4.2 National Aggregated Land Accounts

Table 8 to Table 10 (below) provide an analysis of land change using the accounting structure proposed in the SEEA-CF (UN et al. 2014b, Table 5.13, pp.179). As described in Section 3, NBS cover classes have been aggregated to reflect natural[8] and converted land to classes that reflect land use. Compilation of these accounts reflects the interest in understanding potential impacts of habitat loss on biodiversity and the benefits it provides. This approach will also mitigate some of the uncertainties surrounding classifications of bush, grassland and wetland discussed above.

As expected Table 8 to Table 10 reveal a trend of increasing conversion of natural land, with the extent of natural land reducing by approximately 2.4 million hectares between 1990 and 2015. Conversion of land for farming and plantation uses is the principle driver of the observed reduction in natural land, increasing in extent by approximately 2.3 million hectares between 1990 and 2015. Significant urban expansion is also noted, with the extent of built up areas increasing from approximately 36,500 ha in 1990 to approximately 134,900 ha in 2015, a rise of 370%.

[8] Natural = Bush; Grassland; Tropical high forest low stocked; Tropical high forest well stocked; Wetland and Woodland.

Table 8 Aggregate land account 1990-2005 (hectares)

Classifications >>	Built up area	Farmland and plantations	Natural	Open Water	Other	TOTALS
Opening Stock (1990)	36,553	8,499,553	11,905,187	3,663,772	40,333	24,145,398
Additions to stock						-
Total additions to stock	72,921	2,207,479	1,703,122	60,646	7,297	4,051,465
Reductions in stock						-
Total reductions in stock	(12,208)	(1,725,687)	(2,266,229)	(44,154)	(3,187)	(4,051,465)
Net change in stock	60,713	481,792	(563,107)	16,492	4,110	-
Closing stock (2005)	97,266	8,981,345	11,342,080	3,680,264	44,443	24,145,398

Table 9 Aggregate land account 2005-2010 (hectares)

Classifications >>	Built up area	Farmland and plantations	Natural	Open Water	Other	TOTALS
Opening Stock (2005)	97,266	8,981,345	11,342,080	3,680,264	44,443	24,145,398
Additions to stock						-
Total additions to stock	49,718	2,341,090	1,410,080	61,170	23,912	3,885,970
Reductions in stock						-
Total reductions in stock	(46,928)	(1,403,471)	(2,371,469)	(32,027)	(32,075)	(3,885,970)
Net change in stock	2,790	937,619	(961,389)	29,143	(8,163)	-
Closing stock (2010)	100,056	9,918,964	10,380,691	3,709,407	36,280	24,145,398

Table 10 Aggregate land account 2010-2015 (hectares)

Classifications >>	Built up area	Farmland and plantations	Natural	Open Water	Other	TOTALS
Opening Stock (2010)	100,056	9,918,964	10,380,691	3,709,407	36,280	24,145,398
Additions to stock						-
Total additions to stock	67,274	2,033,691	1,148,214	25,187	21,737	3,296,103
Reductions in stock						-
Total reductions in stock	(32,446)	(1,132,954)	(2,031,821)	(69,149)	(29,733)	(3,296,103)
Net change in stock	34,828	900,737	(883,607)	(43,962)	(7,996)	-
Closing stock (2015)	134,884	10,819,701	9,497,084	3,665,445	28,284	24,145,398

In addition to net trends, Table 8 to Table 10 reveal substantial gross changes to natural land cover. The tables clearly reveal a scenario of large areas of natural land being converted to farmland or plantation and reverting to natural land between periods. For example, Table 8 shows the reduction in farmland and plantations between 1990 and 2005 is around 1.7 million ha, matched with similar increases in natural land cover. The converse is also observed. The picture that emerges is that the gross changes (i.e., additions plus reductions) in natural land cover and farmland and plantations are around 3 to 4 million hectares in each period. This suggests there are areas of natural land that are being systematically brought into agricultural and plantation production and then abandoned to regenerate.

The ecosystems in these areas that are intermittently being used for production are likely to be significantly altered from their natural state. This will have impacted on the species assemblages present. In turn, there are implications with respect to ecosystem functioning and the capacity of these areas to provide ecosystems services beyond the provisioning services of agricultural or plantation land uses. One way to determine the extent of natural land most likely to retain its original condition is to identify those areas that have remained permanently natural cover since 1990. A map of these areas is provided in Figure 8. This reveals significant areas of natural land cover to have remained unconverted in the north east and the west of the country and centrally around the Murchison Falls area.

Between 1990 and 2015, approximately 14.6m ha have been classed as natural at some time. From this total approximately 7.3m ha has been permanently natural, 2.3m ha has been classified as natural in 3 out of 4 of the 1990, 2005, 2010 and 2015 land cover maps, 2.2m ha has been natural in 2 out of 4 of the land cover maps and, finally, 2.8m ha has been classified as natural in only one land cover map.

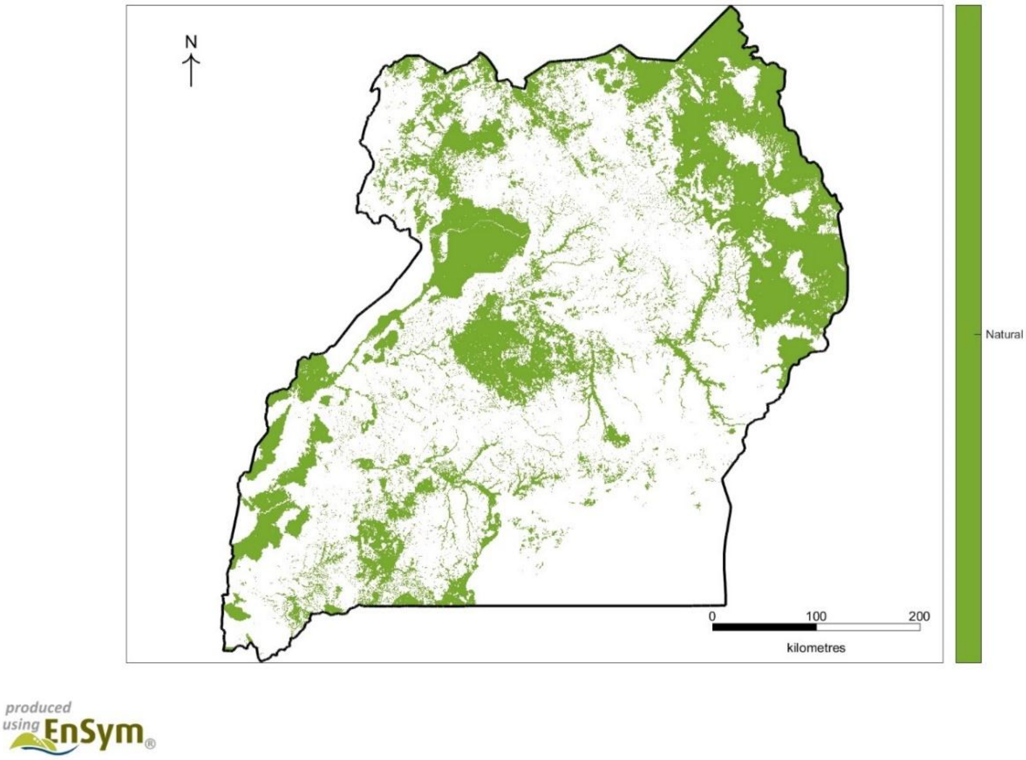


Figure 8 Extent of permanently natural land cover 1990 to 2015

4.2.1 Sub-Regional Aggregated Land cover accounts

Figure 9, provides the trends in natural land cover at a sub-regional scale. Acholi is of note, with substantial increases in the extent natural land cover observed from 1990 to 2005, followed by substantial decreases between 2005 to 2010 and 2010 to 2015. The increase in natural land cover between 1990 and 2005 may well reflect the displacement of people as a result of the conflict between the Uganda Peoples Defence Forces and the Lord's Resistance Army that began in 1985/86 (Nampindo et al. 2005). This is believed to have resulted in the abandonment of large tracts of farmland during the period of conflict and substantial expansion of farming activity following the conflict.

Outside of Acholi, Figure 9 reveals ongoing general trends of conversion of natural land in the following sub-regions: Central 1; Central 2; Lango; and Western. Natural land cover loss appears to have been arrested in recent years in East Central; Elgon; Karamoja; and South Western.

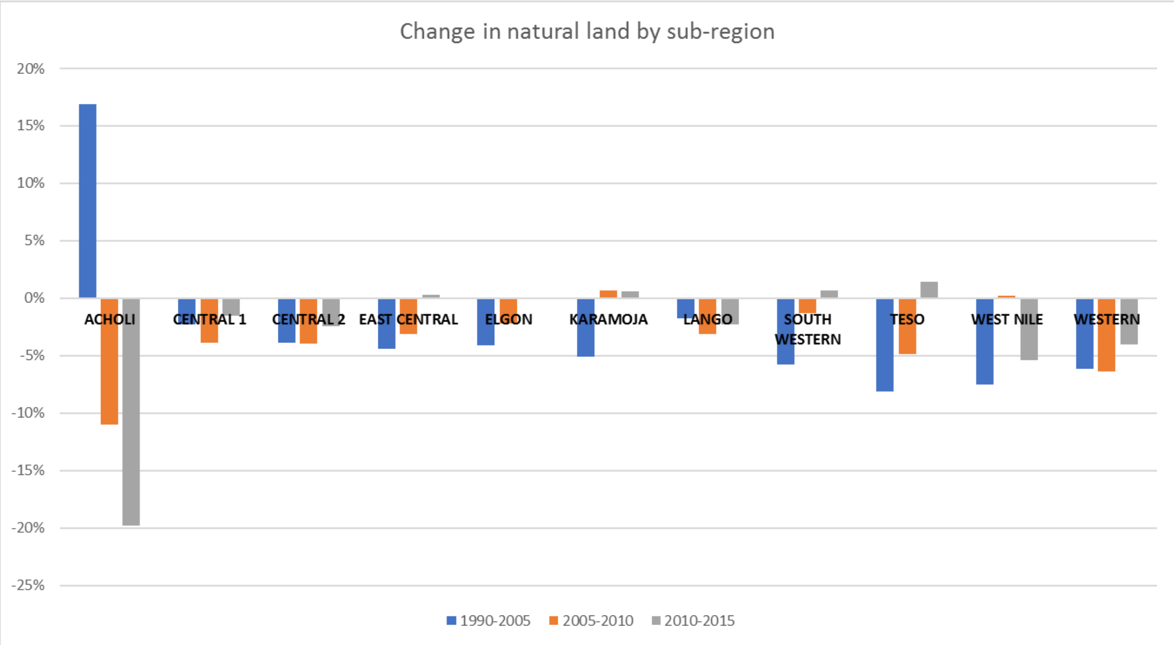


Figure 9: Chart of natural land cover by Sub-region.

Table 11 presents the information in Figure 8 in tabular form at the national and sub-regional scale. Table 11 reveals 30% of Uganda's land cover has remained natural cover consistently between 1990 and 2015. Karamoja shows the highest proportion of such land (77% of total land area), with the remaining sub-regions showing shares of 35% or less. In East Central, almost all land is identified to have been under agricultural, plantation or urban use at some point between 1990 and 2015 (only 4% of natural land in 1990 remained unchanged).

Table 11 Area (hectares) and percent of sub-regions that have remained natural land cover 1990 to 2015

	Always natural land cover 1990 to 2015	Total Area	% Always natural cover
ACHOLI	949,036	2,822,809	34%
CENTRAL 1	400,398	2,621,333	15%
CENTRAL 2	816,796	3,627,334	23%
EAST CENTRAL	68,312	1,736,805	4%
ELGON	179,493	602,099	30%
KARAMOJA	2,128,624	2,752,774	77%
LANGO	139,735	1,392,432	10%
SOUTH WESTERN	635,189	2,170,710	29%
TESO	269,423	1,485,292	18%
WEST NILE	492,115	1,577,532	31%
WESTERN	1,171,949	3,356,278	35%
GRAND TOTAL	7,251,070	24,145,398	30%

4.3 Ecosystem extent accounts

Table 12 to Table 14 present the national ecosystem extent accounts at the biome level. They present changes in extent of biomes in areas of natural land cover between 1990 and 2015.[9] It is believed the approach of integrating the Langdale brown and NBS data will provide a more accurate picture of trends in the extent of natural ecosystems, such as savanna, wetlands and forests than solely relying on the land cover data. In this regard, the accounts reveal an increase in the extent of moist savanna (approx. 220,000ha) [10] between 1990 and 2005 but large reductions in subsequent periods of approximately 432,000ha between 2005 and 2010 and approximately 495,000ha between 2010 and 2015. For the other biomes, dry savannas, forests and wetlands, Table 12 to Table 14 reveal decreasing trends in extent across all periods.

[9] Total natural land cover in this section is slightly smaller than presented in earlier accounts as only those natural areas classified to dry savannas, forest, moist savannas and wetlands have been included (post cultivation communities and 'no data' mapped by Langdale-Brown et al. (1964) are captured under 'Aggregated Other'). These constitute 96% of the total natural land cover according to NBS. The category 'Aggregated Other' also represents an aggregation of the Built-up Areas, Farmland and Plantations, Open Water and Other land cover classes reported in Table 8 to Table 10.

[10] A slight increase in moist savvana is noted between 1990 and 2005 but this should be interpreted with caution given the differences in the approaches employed for constructing the land cover maps for 1990 and 2005.

Table 12 Langdale-Brown Biomes accounts 1990-2005 (hectares)

Classifications >>	Dry Savannas	Forest	Moist Savanna	Aggregated Other	Wetlands	TOTALS
Opening Stock (1990)	5,533,957	1,532,155	2,488,469	12,635,427	1,955,390	24,145,398
Additions to stock						-
Total additions to stock	513,081	214,459	755,603	2,128,137	141,506	3,752,786
Reductions in stock						-
Total reductions in stock	(949,925)	(407,551)	(536,075)	(1,624,649)	(234,586)	(3,752,786)
Net change in stock	(436,844)	(193,092)	219,528	503,488	(93,080)	-
Closing stock (2005)	5,097,113	1,339,063	2,707,997	13,138,915	1,862,310	24,145,398

Table 13 Langdale Brown Biomes accounts 2005-2010 (hectares)

Classifications >>	Dry Savannas	Forest	Moist Savanna	Aggregated Other	Wetlands	TOTALS
Opening Stock (2005)	5,097,113	1,339,063	2,707,997	13,138,915	1,862,310	24,145,398
Additions to stock						-
Total additions to stock	599,020	189,432	371,535	2,266,713	146,504	3,573,204
Reductions in stock						-
Total reductions in stock	(864,275)	(349,489)	(803,603)	(1,306,491)	(249,346)	(3,573,204)
Net change in stock	(265,255)	(160,057)	(432,068)	960,222	(102,842)	-
Closing stock (2010)	4,831,858	1,179,006	2,275,929	14,099,137	1,759,468	24,145,398

Table 14 Langdale Brown Biomes accounts 2010-2015 (hectares)

Classifications >>	Dry Savannas	Forest	Moist Savanna	Aggregated Other	Wetlands	TOTALS
Opening Stock (2010)	4,831,858	1,179,006	2,275,929	14,099,137	1,759,468	24,145,398
Additions to stock						-
Total additions to stock	462,669	141,505	281,798	1,957,614	157,879	3,001,465
Reductions in stock						-
Total reductions in stock	(758,013)	(254,815)	(777,002)	(1,043,851)	(167,784)	(3,001,465)
Net change in stock	(295,344)	(113,310)	(495,204)	913,763	(9,905)	-
Closing stock (2015)	4,536,514	1,065,696	1,780,725	15,012,900	1,749,563	24,145,398

Figure 10 presents the information on biome extent in natural areas in Table 12 to Table 14, relative to the original extent mapped by Langdale-Brown et al. (1964). This reveals substantial reductions in forest (29% of original extent remaining in 2015) and moist savanna (32% remaining in 2015). This implies a reduction in the benefits derived from ecosystem services associated with these biomes, which is driven by reduced extent and, most likely, an unfavourable spatial configuration of these assets with respect to access for beneficiaries.

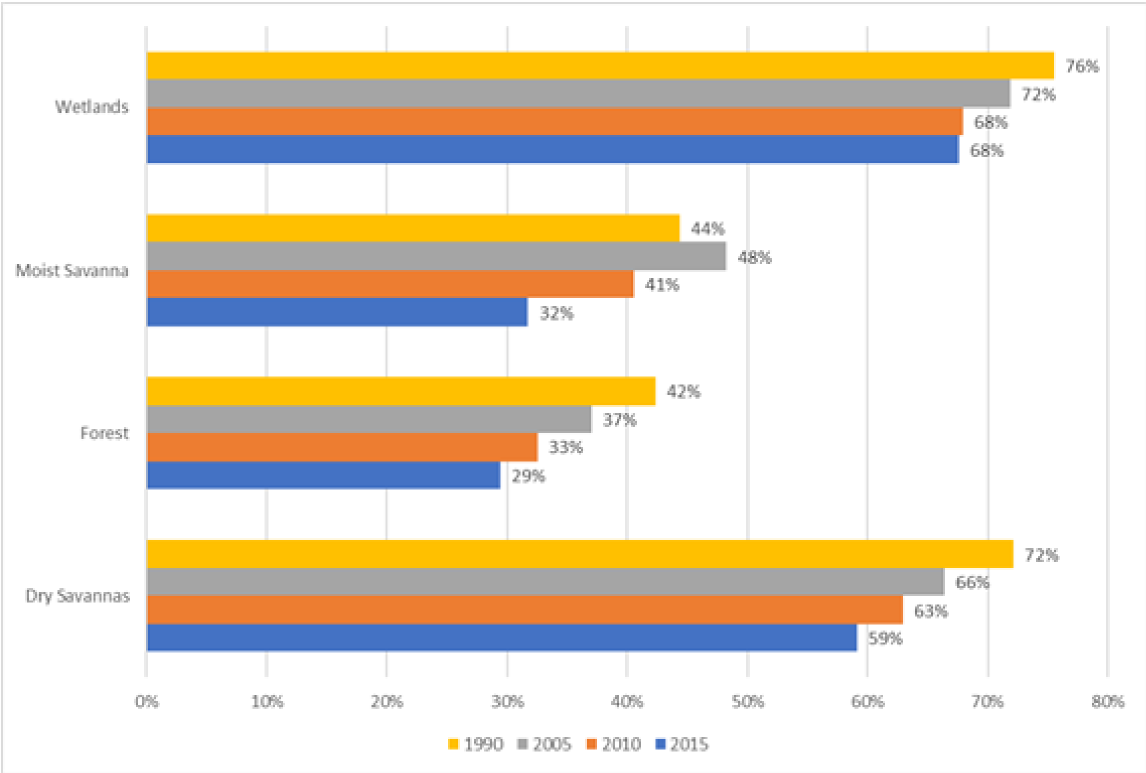


Figure 10: Chart of the biome extent remaining in natural land cover classes.

From the perspective of ecosystem function, biodiversity and service provision, it may be more useful to understand the changing extent of ecosystems at the disaggregated scale of the 22 vegetation classes considered by Langdale-Brown et al. (1964). For example, changes in forests may be usefully analysed by distinguishing between high and lower altitude forests depending on the policy question at hand.

Table 15 presents the information of the extent of those vegetation classes remaining in natural areas in 2015 in absolute terms and relative to their original extent as mapped by Langdale-Brown et al. (1964) (excluding Post Cultivation communities). Table 15 reveals reductions exceeding 50% in the extent of: Forest/savanna mosaic (13% of original extent remaining); Moist Combretum savanna (21%); Moist Acacia savanna (24%); Butyrospermum savanna (34%); Palm Savanna (43%); and, Woodland (48%). With respect to Table 15, the substantial area of the 'Aggregated Other' class reflects the same class presented in Table 12 to Table 14. This is included in Table 15 in order to maintain the internal consistency of the accounts (i.e., so the grand total in this column matches the total area of Uganda). Using the spatial data infrastructure developed for this project, accounts could readily be developed for vegetation classes at sub-region scale, which may be of interest to users of the data.

Table 16 provides the extent of biomes in natural areas in 2015 by sub-region. As shown in Figure 10, nationally losses in biomes are greatest for forest and moist savannas. For forests, Table 16 identifies that the greatest loss in absolute terms is in Western (with only 34% remaining of the original 1.2 million ha extent), Central 2 (with only 16% of the original 718,000 ha remaining), Central 1 (22% of the original 497,000ha remaining) and East Central (4% of the original 400,000 ha remaining). For Teso only 3% of the original (albeit much lower) extent of approximately 18,000ha remains. Whilst large proportions of forests have been retained in Acholi (97% of the original 27,000ha) and Karamoja (91% of the original 104,000 ha), other sub-regions retain greater areas of natural cover in forest areas in absolute terms. Specifically, in Western approximately 409,000 ha remain, in South-western approximately 190,000 ha, in Central 2 approximately 115,000 ha, in Central 1 there are 110,000ha and in Elgon 103,000 ha remain.

Table 15 Extent of vegetation classes in natural areas in 2015 (hectares)

Langdalebrown Classes		Dry Savannas	Forest	Moist Savanna	Wetlands	Grand Total	Original Extent	% Original extent remaining
A	High altitude heath and moorland		60,065			60,065	67,527	89%
B	High altitude forest		261,863			261,863	307,612	85%
C	Medium altitude moist evergreen forest		165,132			165,132	291,264	57%
D	Medium altitude moist semi-deciduous forest		256,738			256,738	514,545	50%
F	Forest/savanna mosaic		321,898			321,898	2,439,157	13%
G	Moist thicket			128,902		128,902	251,558	51%
H	Woodland			196,548		196,548	412,561	48%
J	Moist Acacia savanna			147,030		147,030	613,728	24%
K	Moist Combretum savanna			319,433		319,433	1,496,722	21%
L	Butyrospermum savanna			876,317		876,317	2,569,789	34%
M	Palm savanna			112,495		112,495	263,927	43%
N	Dry Combretum savanna	2,052,452				2,052,452	3,773,426	54%
P	Dry Acacia savanna	733,602				733,602	1,431,718	51%
Q	Grass steppe	79,390				79,390	79,759	100%
R	Tree and shrub steppe	132,754				132,754	157,219	84%
S	Grassland savanna	807,912				807,912	1,363,311	59%
T	Bushland	369,498				369,498	423,104	87%
V	Dry thicket	360,906				360,906	444,839	81%
W	Communities on Sites with Impeded Drainage				1,279,012	1,279,012	1,851,995	69%
X	Swamp				445,965	445,965	711,569	63%
Y	Swamp forest				24,586	24,586	25,662	96%
	Aggregated Other					15,012,900	4,654,406	N/A
	Grand Total	**4,536,514**	**1,065,696**	**1,780,725**	**1,749,563**	**24,145,398**	**24,145,398**	**N/A**

With respect to the Moist Savannas biome, Table 16 reveals the greatest loss in Acholi (38% of the original 1.8 million ha remains), in Lango (16% of the original 937,000ha remains) and Teso (13% of the original 638,000ha remain). The largest proportionate loss is observed in Elgon, with only 4% of the original extent remaining. The largest proportions of original moist savannas extent retained are in Karamoja (77% of the original 164,000ha), Western (49% of 623,000ha) and West Nile (42% of 607,000ha).

The largest reductions in Dry Savannas biome are observed in South Western (57% of the original 1,091,000 ha remain), Central 2 (58% of the original 977,000 ha remain) and Central 1 (44% of the original 758,000 ha remain). Whereas, the proportionate reductions in Dry Savannas biome are greatest in East Central (8% of original 164,000ha extent remaining), Teso (17% of original 273,000 ha remaining) and Lango (19% of the original 144,000 ha remaining) and least in Karamoja (87% of original 1.8 million ha extent remain), Acholi (59% of original 778,000ha remain), Western (59% of original 936,000 ha remain), Central 2 (58% of 977,000 ha remain) and South Western (57% of 1,091,000 ha remain).

For Wetlands, Table 16 shows the largest losses in absolute terms have occurred in Teso (61% of the original 382,000ha remain), Central 2 (70% of the original 420,000ha remain) and East Central (35% of the original 180,000ha remain). Large proportionate decreases in wetland extent are also noted in Lango (45% of the original 171,000ha remains)

Table 16 Extent of biomes in natural areas by sub-region in 2015 (hectares)

Sum of Area (ha)	Langdalebrown_Biomes											
Subregion	Dry Savannas			Forest			Moist Savanna			Wetlands		
	Original Extent	Current Extent 2015	% of Original	Original Extent	Current Extent 2015	% of Original	Original Extent	Current Extent 2015	% of Original	Original Extent	Current Extent 2015	% of Original
ACHOLI	777,655	457,035	59%	27,477	26,579	97%	1,842,369	692,643	38%	146,303	87,862	60%
CENTRAL 1	757,532	333,267	44%	497,487	109,714	22%	103,541	18,690	18%	188,594	145,146	77%
CENTRAL 2	976,599	564,238	58%	718,102	114,927	16%	219,705	70,466	32%	420,039	295,535	70%
EAST CENTRAL	164,458	13,059	8%	399,695	14,673	4%	191,083	11,431	6%	179,920	62,926	35%
ELGON	113,229	39,415	35%	204,421	103,307	51%	71,027	3,141	4%	109,084	58,041	53%
KARAMOJA	1,837,976	1,605,141	87%	103,573	94,740	91%	163,994	126,439	77%	622,503	564,141	91%
LANGO	144,467	27,233	19%	-	-	-	937,189	151,436	16%	170,877	76,616	45%
SOUTH WESTERN	1,090,973	619,838	57%	445,458	189,706	43%	211,473	64,112	30%	77,573	52,122	67%
TESO	273,045	46,786	17%	17,864	505	3%	637,940	80,155	13%	382,301	232,519	61%
WEST NILE	601,940	275,405	46%	4,711	2,315	49%	607,074	255,894	42%	113,654	76,436	67%
WESTERN	935,502	555,097	59%	1,201,317	409,230	34%	622,890	306,318	49%	178,378	98,219	55%
Grand Total	**7,673,376**	**4,536,514**	**59%**	**3,620,105**	**1,065,696**	**29%**	**5,608,285**	**1,780,725**	**32%**	**2,589,226**	**1,749,563**	**68%**

4.4 Ecosystem diversity

At the finest level of granularity, the Langdale-Brown et al. (1964) disaggregates the 22 vegetation classes to 86 plant communities/vegetation types that are represented as distinct mapping units (of at least approximately 1 mile square). Langdale-Brown et al. (1964) also map intricate vegetation patterns by mapping two or more of these units together. Analysis of the Langdale-Brown et al. (1964) map indicates this resulted in a total of 211 different mapped unit combinations. Table 17 reveals how the number of different mapped units in each sub-region has changed over time. This is considered to be an indicator of ecosystem richness within each sub-region. As Table 17 shows, due to land conversion there has been a reduction in the number of different unit combinations originally mapped by Langdale-Brown et al. (1964) from 211 originally to 206 in 2015 for Uganda as a whole. The reduction in ecosystem richness is largest in Elgon and Teso, with 7 distinct units lost to land conversion by 2015, compared to those mapped originally by Langdale-Brown et al. (1964).

The information on the extent of these vegetation types has also been used to construct a natural ecosystem diversity metric (based on the Bray-Curtis similarity index (Bray & Curtis 1957), as described in Appendix B). This index is sensitive to reductions in both the overall richness and the extent of the units mapped by Langdale-Brown et al. (1964). The original Langdale-Brown map provides the baseline index measure of 1.0. Table 18 provides the trends in natural ecosystem diversity overtime revealed by this index. This reveals that losses of ecosystem diversity are greatest in East Central (with a score of 0.178 in 2015), then followed by Lango (0.264 in 2015) and Teso (0.402). Low index values arise when the absolute and relative coverage of natural ecosystems is very different to the original case. Natural ecosystem diversity is high, relative to the National index value (0.609), in Karamoja (0.937) and South Western (0.637). The high value in Karamoja is particularly important as this sub-region is associated with the highest ecosystem richness reported in Table 17 (106 different vegetation type units).

Table 17 Ecosystem richness account 1990-2015

Ecosystem Richness	Original	1990	2005	2010	2015
ACHOLI	40	38	39	38	37
CENTRAL 1	27	27	27	27	27
CENTRAL 2	42	42	41	42	40
EAST CENTRAL	28	28	28	27	26
ELGON	35	33	31	30	28
KARAMOJA	106	105	106	106	106
LANGO	40	38	39	36	37
SOUTH WESTERN	38	37	35	37	37
TESO	38	35	33	33	31
WEST NILE	35	34	32	32	31
WESTERN	60	60	58	58	57
UGANDA	**211**	**208**	**208**	**207**	**206**

Table 18 Ecosystem diversity account 1990-2015

Ecosystem Diversity Metric	1990	2005	2010	2015
ACHOLI	0.742	0.868	0.788	0.601
CENTRAL 1	0.662	0.639	0.559	0.534
CENTRAL 2	0.733	0.686	0.626	0.594
EAST CENTRAL	0.336	0.251	0.176	0.178
ELGON	0.576	0.539	0.507	0.507
KARAMOJA	0.958	0.929	0.932	0.937
LANGO	0.387	0.372	0.318	0.264
SOUTH WESTERN	0.705	0.655	0.630	0.637
TESO	0.560	0.459	0.399	0.402
WEST NILE	0.730	0.660	0.651	0.586
WESTERN	0.777	0.727	0.639	0.601
UGANDA	**0.722**	**0.703**	**0.653**	**0.609**

4.5 Ecosystems and core protected areas

One of the proposed uses of the accounts is to inform the debate on gazettement and de-gazettement of protected areas in Uganda. One way to contribute to this debate is to evaluate the role that protected areas have played in protecting natural biomes from land conversion. Figure 11 presents the extent of the 'core' protected area system in 2015 and the extent of this core also included in the protected area system in 1990, 2005 and 2010. [11]. As Figure 11 shows the current protected area system includes additional areas that were not designated as protected in 1990, this is reflected by the 20% increase noted between 1990 and 2005. However, the large majority of the 2015 extent of the protected area system (approx. 80%) has been protected since at least 1990. This reveals the current system benefits from a continuity and legacy of protection. Figure 11 also shows the 2015 protected areas estate was essentially established by 2005, with only 2% change noted between in 2005 and 2015.

[11] The information on protected areas has been obtained from the WDPA (IUCN & UNEP-WCMC 2017). This comprises of all categories of protected areas recorded in the WDPA database for Uganda.

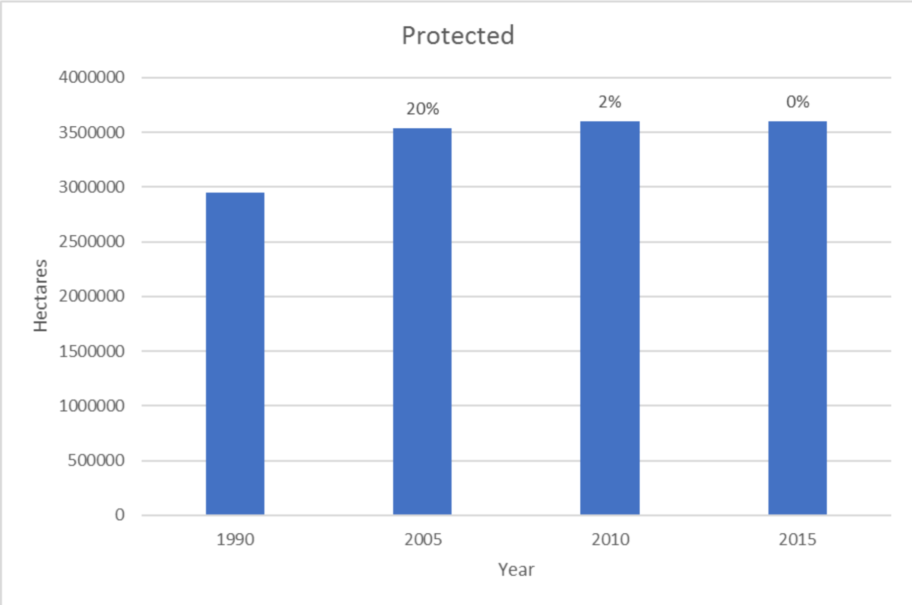


Figure 11 Extent of the 2015 protected area system protected in 1990, 2005 and 2015 (hectares)

With respect to Figure 11, it is important to note that this does not provide any data on areas lost to degazettement. A significant extent of the 1990 protected area system in Uganda was subject to degazettement between 1990 and 2005. The development of the Wildlife Protected Area System Plan (WPASP) during the 1990s was a significant driver of this (Lamprey et al. 2003). Lamprey et al. (2003), identify that prior to the implementation of the WPSAP, 'Controlled Hunting Areas' were a protected area category and the extent of these areas was approximately 280,000 ha. However, this category was abolished under the WPSAP and only a small proportion of these areas were re-retained under a new 'Community Wildlife Areas' protection category. Makumbi (2001) also identify specific instances of degazzetment for the Wabisi-Wajala forest reserve and excision of approximately 1,000ha off the Namanve forest reserve during the 1990s. These losses are not captured in Figure 11.

Table 19 summarises the extent of different Langdale-Brown biomes included in the 2015 protected areas system, and the extent that was also protected in 1990, 2005, and 2010. The extents of biomes protected reflect those areas of land that have not been converted, for example for agriculture, plantations or built up areas in protected areas. For forests, Table 19 reveals over two-thirds (68% or approx. 730,000ha) of the remaining extent of this biome is covered by protected areas in 2015 (with approx. 656,000 hectares protected since 1990). The proportion of remaining wetlands protected in 2015 is approximately one-quarter (26% or approx. 462,000ha) in 2015 (with approx. 316,000 hectares protected since 1990). For dry savanna, 33% (or approx. 1.5 million hectares) of the remaining extent of this biome is protected in 2015 (with approx. 1.3 million hectares protected from 1990). Finally, for moist savanna 23% (or approx. 409,000ha) are covered by the protected areas estate in 2015 (with approx. 399,000 hectares protected from 1990).

As shown in Figure 10 and the second column of Table 19, there has been a trend of decreasing extent of natural biomes in Uganda. This underlines the importance of the protected areas estate in maintaining the integrity of these ecosystems. In this regard, Table 19 reveals the protected areas estate has secured an increasing proportion of the remaining extent of natural biomes since 2005, when the 2015 configuration was largely established. This confirms continuing loss of these biomes outside of protected areas. However, in the absolute terms, moist savanna and forest do show negative trends in protected areas between 2005 and 2015. Between 2010 and 2015, Table 19 reveals a reduction of approximately 25,000ha for forests and 10,000ha for moist savanna. Conversely, modest increases in dry savanna (approx. 7,000ha) and wetlands (approx. 2,000ha) are noted in the protected areas estate between 2010 and 2015. However, these observations of small changes in extent may be artefacts of mapping data and the compilation procedure employed.

Table 19 Langdale-Brown Biomes – Protected Area Account

Sum of Area (ha)			
Langdalebrown Biomes 1990	**Total**	**Protected**	**% Protected**
Dry Savannas	5,533,957	1,328,508	24%
Forest	1,532,155	656,275	43%
Moist Savanna	2,488,469	399,251	16%
Other	12,635,427	248,797	2%
Wetlands	1,955,390	316,311	16%
Grand Total	**24,145,398**	**2,949,142**	**12%**
Sum of Area (ha)			
Langdalebrown Biomes 2005	**Total**	**Protected**	**% Protected**
Dry Savannas	5,097,113	1,542,282	30%
Forest	1,339,063	778,926	58%
Moist Savanna	2,707,997	434,751	16%
Other	13,138,915	358,794	3%
Wetlands	1,862,310	419,799	23%
Grand Total	**24,145,398**	**3,534,552**	**15%**
Sum of Area (ha)			
Langdalebrown Biomes 2010w	**Total**	**Protected**	**% Protected**
Dry Savannas	4,831,858	1,495,618	31%
Forest	1,179,006	754,915	64%
Moist Savanna	2,275,929	421,876	19%
Other	14,099,137	468,933	3%
Wetlands	1,759,468	459,456	26%
Grand Total	**24,145,398**	**3,600,798**	**15%**
Sum of Area (ha)			
Langdalebrown_Biomes 2015	**Total**	**Protected**	**% Protected**
Dry Savannas	4,536,514	1,503,048	33%
Forest	1,065,696	729,660	68%
Moist Savanna	1,780,725	409,017	23%
Other	15,012,900	497,505	3%
Wetlands	1,749,563	461,568	26%
Grand Total	**24,145,398**	**3,600,798**	**15%**

The category 'Other' represents areas of non-natural land cover, post cultivation communities, open water and areas where data is missing.

Table 20 presents the ecosystem richness and diversity metric discussed in Section 4.4 for protected areas. This reveals that the protected area estate has been effective in covering a diversity of different mappable vegetation units, with 162 out of the possible 206 units protected in 2015. However, there remain opportunities for expansion to cover the full remaining set of these vegetation units. The diversity metric is also consistently high for the protected area estate, suggesting the estate is doing well at preserving natural ecosystem diversity within its boundaries, although some reduction is observed.

Table 20 Ecosystem Richness and Diversity in Protected Areas

	1990	2005	2010	2015
Ecosystem Richness	145	168	166	162
Ecosystem Diversity Metric	0.970	0.960	0.943	0.938

5 Compiling the Species Accounts

This Section presents the various accounting results for Non-Timber Forest Products (NTFPs) and flagship Species Accounts and derived data presentations with which to inform the key applications determined in Section 2.1. for these accounts. The technical methods for compiling the flagship Species Accounts are described in full in Appendix B, following the report text.

5.1 Species Accounts for NTFPs

Langdale-Brown et al. (1964) present 22 different vegetation classes. There are various perspectives through which the implications of change in the extent of these classes can be viewed. Following the spatial approach of Cottray et al. (2006), the accounts presented here link the extent of classes remaining in natural land cover change to key non-timber forest products (NTFPs) species, that could support local livelihoods and generate foreign exchange revenues (specifically Shea butter tree nut and gum arabic harvesting) or may be may be at risk of overharvesting (specifically *Prunus africana*). The accounts are based on the associations proposed by Pomeroy et al. (2002) as described in Section 3.3.

5.1.1 Shea butter tree nuts

There is significant interest in Shea butter tree nut harvesting and the development of local shea butter production as a means of supporting livelihoods in Northern Uganda. For example, The Shea Project has engaged with over 400 community groups in the area as part of an integrated conservation and development project (The Shea Project n.d.). Similarly, the Beadforlife project has brought together 760 women to improve processing and market opportunities for shea nuts and butter (CNN 2011). There is also interest in increasing production beyond the current subsistence levels in order to realise national economic benefits associated with a strong international market, currently catered for by other countries including Senegal and Ghana (Daily Monitor 2016). However, the plant is classified as vulnerable on the Global and National IUCN Red List (WCS et al. 2016).

Table 21 provides an account of the areas of suitable vegetation classes for the Shea butter tree (*Vitellaria paradoxa)* and, therefore, potentially suitable for supporting Shea nut harvesting and butter production. Table 21 reveals there has been a significant reduction in the extent of areas of suitable vegetation classes for the Shea butter tree nut harvesting in natural areas between 1990 and 2015 in all regions. However, substantial areas of potentially suitable habitat are identified in 2015 in Acholi (789,000 ha), Karamoja (703,000 ha) and West Nile (420,000). Cumulatively, these sub-regions contain 91% of the total extent of potentially suitable habitat for Shea butter tree nut harvesting within the remaining areas of natural land cover in Uganda. Table 21 also reveals that the vast majority of these areas lie outside of the protected area estate.

Table 21 Shea butter tree nut account 1990 to 2015 (hectares)

	ACHOLI	ELGON	KARAMOJA	LANGO	TESO	WEST NILE	Uganda
Original Extent	1,698,092	84,296	831,487	481,236	605,551	986,801	4,687,463
1990	1,021,071	25,823	742,697	132,093	187,845	596,956	2,706,485
% Original Extent	60%	31%	89%	27%	31%	60%	58%
% 1990 extent in Uganda	38%	1%	27%	5%	7%	22%	100%
2015	788,723	15,042	702,678	83,443	91,280	419,758	2,100,924
% Original Extent	46%	18%	85%	17%	15%	43%	45%
% 2015 extent in Uganda	38%	1%	33%	4%	4%	20%	100%
Regionally Protected 2015	72,230	50	302,280	5,689	2,410	59,807	442,466
Regional % Protected	9%	0.33%	43%	7%	3%	14%	21%

The Shea butter tree is a slow growing tree that can take 15 years to produce flowers and fruit production peaking between 45 and 50 years (Elias & Carney 2007). As noted in the Section 4.1, there appear to be large areas that have been intermittently farmed and between different periods. It is likely that the potential for viable Shea butter tree nut harvesting will be significantly reduced in these areas. Table 22 summarises the areas that have remained natural from 1990 to 2015 (based on Figure 8) and, therefore, provide a more realistic assessment of the extent of potential habitat for Shea butter tree nut harvesting.

Table 22 Revised Shea butter tree nut account 2015 (hectares)

	ACHOLI	ELGON	KARAMOJA	LANGO	TESO	WEST NILE	Uganda
1990 to 2015 stable extent	563,773	8,771	631,031	35,336	47,294	292,668	1,578,873
% of 2015 suitable extent	71%	58%	90%	42%	52%	70%	75%
% of 1990 to 2015 stable extent in Uganda	36%	1%	40%	2%	3%	19%	100%
Regionally Protected 2015	68,220	2	278,623	4,693	1,205	51,716	404,459
Regional % Protected	12%	0%	44%	13%	3%	18%	26%
Regionally Unprotected 2015	495,553	8,769	352,408	30,643	46,089	240,952	1,174,414

Given this context, Table 22 reveals that a majority of the natural areas suitable for Shea butter tree nut harvesting have remained unconverted since 1990 (71% in Acholi, 90% in Karamoja and 70% in West Nile). In Acholi and West Nile these areas are generally outside of the protected areas estate (approx. 496,000 ha in Acholi and approx. 241,000 ha in West Nile). In Karamoja, while a relatively higher area is protected, over half of the areas suitable for Shea butter tree nut harvesting are outside of the protected area estate (approx. 352,000 ha). Overall there is considered to be of significant potential for development of Shea butter tree nut harvesting in these sub-regions that is not currently in conflict with the protected areas estate. In addition, there also exists potential to develop Shea butter tree nut harvesting in locations in Teso (approx. 47,000 ha of suitable habitat) and Lango (approx. 35,000 ha habitat), the vast majority of which is not in conflict with the protected area system (3% in Teso and 13% in Lango). It should be noted that ground-truthing would be required to establish the condition of the most suitable areas for production given the possibility of localised activities, such as charcoal production, that may have impaired the ability of these ecosystems to support this provisioning service.

5.1.2 Gum Arabic

Gum Arabic is produced from tapping the *Acacia senegal* tree that grows in the wooded grasslands and deciduous bushlands of Uganda (Obua et al. 2006). Historically, Gum Arabic production and marketing has been a viable economic activity, notably in Karamoja during the 1960s and 1970s, up until trade collapsed due to security concerns and inadequate supplies in the 1990s (Obua et al. 2006). Table 23 provides an account of the areas of suitable vegetation classes for Gum Arabic production. As with Shea butter tree nut harvesting, Table 23 demonstrates there have been reductions in the areas of suitable habitat for Gum Arabic production in natural areas in all sub-regions between 1990 and 2015, particularly in the South Western, West Nile and Western sub-regions.

Table 24 presents the extent of areas of suitable vegetation classes for Gum Arabic production that have remained natural land cover consistently between 1990 and 2015 and are likely to best support this production. This reveals there is approximately 3 million ha that could still potentially support Gum Arabic production in Uganda. The highest percentages of this area are in the Karamoja (22%), Acholi (21%), Central 2 (15%), Western (13%) and West Nile (11%) sub-regions. Relatively large proportions of these areas also occur within the protected areas estate in the Western (51%) and Karamoja (46%) sub-regions, however, the extent of potentially suitably Gum Arabic habitat occurring inside protected areas is below 20% elsewhere.

In summary, there are substantial extents of potentially suitable vegetation for Gum Arabic production outside of protected areas in Acholi (approx. 536,000 ha), Central 2 (approx. 430,000 ha), Karamoja (approx. 361,000ha), West Nile (approx.275,000ha), South Western (approx. 212,000ha) and Western (approx. 190,000 ha). Again, ground-truthing would be required to confirm local activities have not impacted on ecosystem condition and the potential delivery of the Gum Arabic provisioning service.

Table 23 Gum Arabic Account 1990 to 2015 (hectares)

	ACHOLI	CENTRAL 1	CENTRAL 2	EAST CENTRAL	ELGON	KARAMOJA	LANGO	SOUTH WESTERN	TESO	WEST NILE	WESTERN	UGANDA
Original Extent	2,154,663	618,969	1,079,492	317,871	160,922	894,409	887,608	634,402	724,433	1,082,990	979,823	9,535,582
1990	1,209,420	360,844	762,681	71,009	41,417	795,463	199,798	505,906	210,191	648,687	689,138	5,494,554
% Original Extent	56%	58%	71%	22%	26%	89%	23%	80%	29%	60%	70%	58%
% 1990 extent in Uganda	22%	7%	14%	1%	1%	14%	4%	9%	4%	12%	13%	100%
2015	899,250	251,732	601,064	18,840	27,165	751,987	141,436	365,153	101,338	464,638	471,696	4,094,299
% Original Extent	42%	41%	56%	6%	17%	84%	16%	58%	14%	43%	48%	43%
% 2015 extent in Uganda	22%	6%	15%	0%	1%	18%	3%	9%	2%	11%	12%	100%
Regionally Protected 2015	106,059	12,553	40,810	600	312	336,532	6,308	28,407	3,124	63,004	215,558	813,267
Regional % Protected	12%	5%	7%	3%	1%	45%	4%	8%	3%	14%	46%	20%

Table 24 Revised Gum Arabic Account 2015 (hectares)

	ACHOLI	CENTRAL 1	CENTRAL 2	EAST CENTRAL	ELGON	KARAMOJA	LANGO	SOUTH WESTERN	TESO	WEST NILE	WESTERN	UGANDA
1990 to 2015 stable extent	635,992	135,489	461,193	6,362	19,111	671,394	64,013	237,782	52,877	329,482	392,196	3,005,891
% of 2015 suitable extent	71%	54%	77%	34%	70%	89%	45%	65%	52%	71%	83%	73%
% of 1990 to 2015 stable extent in Uganda	21%	5%	15%	0%	1%	22%	2%	8%	2%	11%	13%	100%
Regionally Protected 2015	99,498	5,230	31,065	287	193	309,913	4,894	25,774	1,528	54,601	201,875	734,858
Regional % Protected	16%	4%	7%	5%	1%	46%	8%	11%	3%	17%	51%	24%
Regionally Unprotected 2015	536,494	130,259	430,128	6,075	18,918	361,481	59,119	212,008	51,349	274,881	190,321	2,271,033

5.1.3 Prunus africana

The bark of *Prunus africana* is a widely used traditional medicine in Africa. More recently, bark extracts have been used by pharmaceuticals companies in treatments for benign prostatic hyperplasia (BPH) (an enlargement of the prostate that causes discomfort in older men) (Bodeker et al. 2014). This has led to a lucrative international market. However, the plant is classified as vulnerable on the IUCN Red List[12].

Table 25 provides an account of the extent of suitable vegetation classes in areas of natural land cover for *Prunus africana*. For Uganda as a whole, Table 25 reveals that 76% of the extent of suitable vegetation classes for the plant remained in areas classified as natural cover in 1990, however, this reduced to 61% by 2015. The drivers for this are land conversion in the Central 1 (47% of the original extent of suitable habitat remaining in 2015), Central 2 (34% remaining 2015) and East Central (6% remaining 2015) sub-regions. Table 26 presents the extent of the suitable vegetation classes for *Prunus africana* that have consistently been classified as natural cover from 1990 to 2015. This reveals that the protected area estate has been effective in covering the remaining highest quality range of this species, with 89% of the extent of these areas protected at the national scale (largely associated with the Elgon, Karamojoa, South Western and Western sub-regions). This likely reflects that protecting montane forest areas have been an important goal of the protected area system in Uganda. Despite previous losses, opportunities for further protection of *Prunus africana* species appear to exist in the sub-regions of Central 1 (approx. 21,000 ha outside protected areas), Central 2 (approx. 13,000 ha outside protected areas) and Karamoja (approx. 12,000ha outside protected areas).

[12] http://www.iucnredlist.org/details/full/33631/0

Table 25 *Prunus africana* Account 1990 to 2015 (hectares)

	ACHOLI	CENTRAL 1	CENTRAL 2	EAST CENTRAL	ELGON	KARAMOJA	SOUTH WESTER	WEST NILE	WESTERN	UGANDA
Original Extent	11,863	137,399	174,559	80,742	96,939	99,448	170,470	2,496	339,505	1,113,421
1990	11,503	91,366	106,320	26,464	76,431	97,709	140,541	2,496	295,541	848,371
% Original Extent	97%	66%	61%	33%	79%	98%	82%	100%	87%	76%
% 1990 extent in Uganda	1%	11%	13%	3%	9%	12%	17%	0%	35%	100%
2015	11,661	64,435	60,004	5,150	70,824	91,099	138,203	1,974	240,383	683,733
% Original Extent	98%	47%	34%	6%	73%	92%	81%	79%	71%	61%
% 2015 extent in Uganda	2%	9%	9%	1%	10%	13%	20%	0%	35%	100%
Regionally Protected 2015	10,883	28,807	38,853	2,574	68,989	76,152	132,841	443	217,876	577,418
Regional % Protected	93%	45%	65%	50%	97%	84%	96%	22%	91%	84%

Table 26 Revised *Prunus africana* Account 2015 (hectares)

	ACHOLI	CENTRAL 1	CENTRAL 2	EAST CENTRAL	ELGON	KARAMOJA	SOUTH WESTER	WEST NILE	WESTERN	UGANDA
1990 to 2015 stable extent	10,771	45,954	45,691	3,145	64,269	84,608	132,398	1,974	223,940	612,750
% of 2015 suitable extent	92%	71%	76%	61%	91%	93%	96%	100%	93%	90%
% of 1990 to 2015 stable extent in Uganda	2%	7%	7%	1%	10%	14%	22%	0%	37%	100%
Regionally Protected 2015	10,357	24,575	32,994	2,001	63,816	72,300	130,207	443	211,652	548,345
Regional % Protected	96%	53%	72%	64%	99%	85%	98%	22%	95%	89%
Regionally Unprotected 2015	414	21,379	12,697	1,144	453	12,308	2,191	1,531	12,288	64,405

5.2 Accounts for Flagship Threatened Species

The World Tourism Organisation (2014) provides an analysis of typical wildlife watching tours by international tourists in Africa. The study interviewed a range of tour operators for Africa, identifying wildlife watching tourism as representing 80% of the total annual trip sales amongst these operators. A key motivation for nature watching tourist arrivals in Uganda is the potential to observe iconic species, such as gorillas, chimpanzees, lions and elephants.

The majority wildlife watching tourism in Africa is associated with protected areas (WTO 2014). The Species Accounts presented in this Section identify the extent of potential habitat that could support wildlife watching opportunities for the selected IUCN threatened flagship species, chimpanzees and elephants, in different sub-regions. These accounts can help identify where economic opportunities could be expanded inside and outside of the current protected areas estate given substantial increasing international visitor trends in Uganda (WTTC 2015).

5.2.1 Chimpanzees

Table 27 presents the extent of fully suitable, partially suitable and unsuitable habitat in the three sub-regions within the IUCN extent of occurrence for chimpanzees in 2005 and 2015, as described in Section 3.5.2. Given the different approaches employed to generate the 1990 land cover map, it is considered more reliable to focus on changes between the 2005 and 2015 to infer recent trends. Overall, approximately 493,000ha of fully suitable chimpanzee habitat is estimated to remain in 2015, within the 2,032,000ha of the IUCN range of occupancy. Table 27 reveals that between 2005 and 2015, there has been a decrease in the area of fully suitable habitat in the Western sub-region (approx. 86,000ha). At the same time, the extent of fully suitable habitat appears stable and shows marginal increases in the West Nile (<. 5,000ha) and South Western (< 10,000ha) sub-regions. However, it should be noted that the overall extent of fully suitable habitat in West Nile is only approximately 21,000 ha, which limits potential carrying capacity for his species. In all three sub-regions associated with the IUCN range of occupancy, substantial decreases in partially suitable habitat are observed, particularly for Western (with a loss of approx. 71,000ha).

With respect to protected areas, a large majority of fully suitable chimpanzee habitat is protected in South Western (96%), Western (84%) and West Nile (74%). There remains a substantial extent of potentially fully suitable habitat outside of protected areas in the Western sub-region (since only around 265,000 out of 316,000ha is protected). As such there may be opportunities to develop wildlife watching tourism locations in expanded protected areas in this sub-region. Overall, the protected areas estate in Uganda in 2015 included approximately 431,000ha of fully suitable chimpanzee habitat. This is equivalent to 87% of the entire remaining fully suitable habitat within the IUCN extent of occurrence in 2015.

Table 27 Extent of Chimpanzee Suitable Habitat in IUCN Ranges 2005 to 2015 (hectares)

	SOUTH WESTERN	WEST NILE	WESTERN	UGANDA
Extent IUCN Range	497,896	117,290	1,416,963	2,032,149
Opening Stock (2005)				
Fully Suitable in IUCN Range	146,847	16,686	401,905	565,438
Partially Suitable in IUCN Range	104,573	50,866	375,625	531,064
Unsuitable in IUCN Range	246,476	49,738	639,433	935,647
Net Changes				
Fully Suitable in IUCN Range	9,493	4,335	-86,154	-72,326
Partially Suitable in IUCN Range	-18,765	-17,435	-71,016	-107,216
Unsuitable in IUCN Range	9,272	13,100	157,170	179,542
Closing Stock (2015)				
Fully Suitable in IUCN Range	156,340	21,021	315,751	493,112
Partially Suitable in IUCN Range	85,808	33,431	304,609	423,848
Unsuitable in IUCN Range	255,748	62,838	796,603	1,115,189
Extent of fully suitable habitat in IUCN Range protected (2015)	149,851	15,598	265,193	430,642
% of fully suitable habitat in IUCN Range protected (2015)	96%	74%	84%	87%
% of Uganda's total extent of fully suitable habitat in IUCN Range protected (2015)	35%	4%	62%	100%

5.2.2 Elephants

Table 28 presents the extent of fully suitable, partially suitable and unsuitable habitat in the seven sub-regions that lie within the IUCN extent of occurrence for elephants in 2005 and 2015. Table 28 reveals that between 2005 and 2015 there was a substantial reduction in the extent of fully suitable habitat for elephants in the Western sub-region (approx. 57,000ha), albeit there remained significant areas of fully suitable habitat in 2015 in this sub-region (approx. 623,000ha). In addition reductions in the extent of fully suitable habitat for elephants are observed in West Nile (approx. 24,000ha). These reductions appear to be characterised by a degradation of areas to partially suitable habitat (an increase of approx. 53,000ha observed in Western and 19,000 ha in West Nile). These were the principle drivers of the overall reduction in the extent of fully suitable habitat for Uganda as a whole between 2005 and 2015 (approx. 104,000ha).

The protected areas estate in 2015 included a majority of the remaining extent of fully suitable elephant habitat in Acholi (71%), Karamoja (94%), South Western (97%) and Western (94%) sub-regions. All of these sub-regions contained in excess of 100,000ha of fully suitable habitat in 2015. Elsewhere, West Nile includes approximately 143,000ha of fully suitable habitat, of which only 12% is associated with protected areas. As such there may be opportunities to develop wildlife watching tourism locations in expanded protected areas in this sub-region.

Table 28 Extent of Suitable Habitat in IUCN Elephant Range 2005 to 2015 (hectares)

	ACHOLI	CENTRAL 1	ELGON	KARAMOJA	SOUTH WESTERN	WEST NILE	WESTERN	UGANDA
Extent IUCN Range	245,525	10,857	727	104,549	248,708	184,364	744,161	1,538,891
Opening Stock (2005)								
Fully Suitable in IUCN Range	239,483	10,762	727	101,598	212,296	166,792	680,221	1,411,879
Partially Suitable in IUCN Range	1,102	41	-	2,623	31,605	16,639	41,432	93,442
Unsuitable in IUCN Range	4,940	54	-	328	4,807	933	22,508	33,570
Net Changes								
Fully Suitable in IUCN Range	-8,277	-229	-3	-564	-13,103	-24,176	-57,383	-103,735
Partially Suitable in IUCN Range	5,198	228	0	564	13,119	19,495	53,459	92,063
Unsuitable in IUCN Range	3,079	1	3	0	-16	4,681	3,924	11,672
Closing Stock (2015)								
Fully Suitable in IUCN Range	231,206	10,533	724	101,034	199,193	142,616	622,838	1,308,144
Partially Suitable in IUCN Range	6,300	269	-	3,187	44,724	36,134	94,891	185,505
Unsuitable in IUCN Range	8,019	55	3	328	4,791	5,614	26,432	45,242
Extent of fully suitable habitat in IUCN Range protected (2015)	163,024	6,177	646	94,816	194,014	17,279	588,067	1,064,023
% of fully suitable habitat in IUCN Range protected (2015)	71%	59%	89%	94%	97%	12%	94%	81%
% of Uganda's total extent of fully suitable habitat in IUCN Range protected (2015)	15%	1%	0%	9%	18%	2%	55%	100%

Table 29 presents the trends in the extent of suitable habitat within the historic range of elephants (circa. 1960 as proposed in Lamprey et al. 2003). Table 29 reveals this extent is substantially larger (approx. 8.0 million ha), than the IUCN extent of occurrence (approximately 1.5 million ha). Of this historic range, approximately 5.1 million hectares is identified as fully suitable habitat in 2005, falling to approximately 4.0 million in 2015. The highest losses are noted in the Acholi (approx. 525,000ha) and Western (approx. 349,000ha) sub-regions, with these losses characterised as a degradation to partially suitable habitat.

In comparison with the IUCN extent of occurrence, the figure of 4 million hectares of fully suitable habitat in 2015 is clearly overstating Uganda's capacity to support elephants. However, there may remain significant areas of potentially fully suitable habitat in 2015 within the historic range in Acholi (only 28% protected), Central 2 (only 6% protected) and West Nile (only 20% protected) that could provide future habitat for elephants in Uganda. This would require on the ground assessment to identify and mitigate any potential human wildlife conflict issues as human activities, such as hunting and collection of plant resources, which have been shown to effect the use of habitats by elephants in Uganda (Edward 2009)

5.3 Species Richness data (WCS provided data)

As discussed in Section 3.5.3, WCS and their partners have compiled a national map of discrete natural areas, to which they have assigned species richness metrics based on an extensive catalogue of observation data. For birds and large mammals (in addition to other taxa), WCS have ranked each discrete natural area in terms of species richness. These have then been weighted in order to account for variations in the availability of observations for different taxa for each natural area. Table 30 and Table 31 provide an example of how data collected on bird and large mammal observations could be integrated, or used in combined presentations, for more complete sub-regional accounts.[13] The approach adopted to organise the data presented in Table 30 and Table 31, was to normalise the weighted species richness ranks for birds and large mammals across Uganda. Then, sites were categorised based on high (top $80^{\%ile}$), medium – high ($60^{\%ile}$ to $80^{\%ile}$), medium ($40^{\%ile}$ to $60^{\%ile}$), low to medium ($20^{\%ile}$ to $40^{\%ile}$) and low (bottom $20^{\%ile}$) levels of species richness. It should be noted that this presentation is grounded in the discrete areas delineated by the WCS project and not grounded in the spatial infrastructure discussed in Section 3.6. Nonetheless, the observations of species richness are underpinned by the condition of Ecosystem Assets in each sub-region.

[13] In total, the WCS co-ordinated project collates data on 5 taxa and assesses this in multiple ways, including overall richness and threat status

Table 29 Extent of Suitable Habitat in Historic Elephant Range 2005 to 2015 (hectares)

	ACHOLI	CENTRAL 1	CENTRAL 2	ELGON	KARAMOJA	LANGO	SOUTH WESTERN	WEST NILE	WESTERN	UGANDA
Extent Historic Range	1,646,099	149,085	863,298	42,659	329,647	19,380	894,084	984,165	3,052,605	7,981,022
Opening Stock (2005)										
Fully Suitable in Historic Range	1,401,349	99,261	586,377	42,659	310,897	8,443	419,140	598,131	1,590,365	5,056,622
Partially Suitable in Historic Range	239,316	47,316	275,642	-	18,624	8,662	456,368	364,882	1,349,988	2,760,798
Unsuitable in Historic Range	5,434	2,508	1,279	-	126	2,275	18,576	21,152	112,252	163,602
Net Changes										
Fully Suitable in Historic Range	-525,523	-1,770	-90,511	-21	-2,955	-2,963	-57,595	-90,044	-349,495	-1,120,877
Partially Suitable in Historic Range	450,685	1,671	87,554	18	2,861	3,792	55,985	87,770	321,934	1,012,270
Unsuitable in Historic Range	74,838	99	2,957	3	94	-829	1,610	2,274	27,561	108,607
Closing Stock (2015)										
Fully Suitable in Historic Range	875,826	97,491	495,866	42,638	307,942	5,480	361,545	508,087	1,240,870	3,935,745
Partially Suitable in Historic Range	690,001	48,987	363,196	18	21,485	12,454	512,353	452,652	1,671,922	3,773,068
Unsuitable in Historic Range	80,272	2,607	4,236	3	220	1,446	20,186	23,426	139,813	272,209
Extent of fully suitable habitat in Historic Range protected (2015)	244,429	23,910	27,824	42,572	229,383	19	208,500	99,333	821,307	1,697,277
% of fully suitable habitat in Historic Range protected (2015)	28%	25%	6%	100%	74%	0%	58%	20%	66%	43%
% of Uganda's total extent of fully suitable habitat in Historic Range protected (2015)	14%	1%	2%	3%	14%	0%	12%	6%	48%	100%

Table 30 reveals there is a large area of sites associated with high bird species richness in Acholi (approximately 737,000ha or 49% of the total area in Uganda). Karamoja also has a similarly large area of sites with high bird species richness (approximately 600,000ha or 40% of the total area). East Central is characterised by limited natural areas for which bird species observations are available (less than 60,000ha overall). Table 31 reveals the sub-regions with the largest proportion of areas for high, large mammal species richness are in the Central 1 (approximately 36,000ha or 48% of the total areas) and Western (21,500ha or 29% of the total areas) sub-regions. However, these areas are revealed to be quite small, comprising 75,000ha in total. In comparison, the medium – high, large mammal species richness sites extend to approximately 1.44 million hectares, with Acholi containing approximately 864,000 ha (or 60%), Karamoja 201,000 ha (or 14%) and West Nile 177,000 ha (or 12%) of this area.

As noted in Section 3.3, ecosystem diversity is also high in the sub-regions of Karamoja (0.937), South Western (0.637), Acholi (0.601) and Western (0.601) in 2015. This indicates that there may be benefits for both ecosystem and species level biodiversity associated with conserving natural areas in these sub-regions. It also provides evidence to support the assertion that ecosystem-level biodiversity provides a useful approximation for species-level biodiversity in Uganda. The South-Western sub region is an exception to this and this might result disturbances to biodiversity through activities that do not show up in the NBS as changes in the land cover, for example, direct off-take of resources or resulting from infrastructure development.

Table 30: Area of WCS Ranked Bird Sites by Sub-region (hectares)

	ACHOLI	CENTRAL 1	CENTRAL 2	EAST CENTRAL	ELGON	KARAMOJA	LANGO	SOUTH WESTERN	TESO	WEST NILE	WESTERN	UGANDA
Low	173,493	96,788	571,663	28,099	111,342	294,281	86,665	469,114	57,510	2	879,356	2,768,313
Low - Medium	14,636	40,787	16,903			117,417		21,927		245,094	163,796	620,560
Medium		36,109	11,809	19,120	2,751	795,425		7,638	38,904	13,532	11,234	936,522
Medium - High	473,492	6,018	43,638	9,543		161,134	7,190	9,060	4,771	2,403		717,249
High	737,267	654	4,462	1,108		599,408	23,804		1,814	122,243	9,628	1,500,388
Total	1,398,888	180,356	648,475	57,870	114,093	1,967,665	117,659	507,739	102,999	383,274	1,064,014	6,543,032

Table 31: Area of WCS Ranked Large Mammal Sites by Sub-region (hectares)

	ACHOLI	CENTRAL 1	CENTRAL 2	EAST CENTRAL	ELGON	KARAMOJA	LANGO	SOUTH WESTERN	TESO	WEST NILE	WESTERN	UGANDA
Low	473,892	115,957		17,678	114,093	793,493	14,370	378,591	89,880	120,963	744,466	2,863,383
Low - Medium	24,703		581,793	10,421		261,014	73,141	117,949	6,534	57,336	180,843	1,313,734
Medium	34,834	21,618	271	3,007		712,187		7,401		18,737	30,271	828,326
Medium - High	864,373	5,746	53,178	26,764		200,971	26,180		1,814	177,350	86,872	1,443,248
High	1,086	36,109	8,329				3,968	3,798		196	21,562	75,048
Total	1,398,888	179,430	643,571	57,870	114,093	1,967,665	117,659	507,739	98,228	374,582	1,064,014	6,523,739

6 Discussion and Conclusions.

The set of accounts presented in this report is intended to inform national and sub-regional land use and land management policies in an integrated manner. To this end, the accounts and charts demonstrate the integration of several important initiatives, including:

- NFA National Biomass Study (Diisi 2009)
- Strategic Criteria for Rural Investments in Productivity (SCRIP) Program (Pomeroy et al. 2002; Cottray et al. 2006)
- vegetation mapping (Langdale-Brown et al. 1964)
- IUCN data on threatened flagship species
- national protected areas programme
- species observation data collated by WCS, the national biodiversity databank and partners.

The key insights that the set of accounts and data presentations provide with respect to the uses defined in Section 2.1 are summarised below. This is followed by a review of further work to improve and expand the accounts presented in this report.

6.1 Informing the ongoing debates on gazettement and de-gazettement of protected areas

At an aggregate level, the land cover accounts reveal an ongoing trend in the loss of natural land cover in Uganda. The impact of this on natural ecosystems is revealed in the ecosystem extent accounts. These accounts identify significant reductions in the extent of natural forest and moist savanna biomes in Uganda, with only 29% and 32% of their original extent remaining in Uganda in 2015 (Figure 10). The protected area estate has managed to secure an increasing proportion of the extent of these biomes over time as loss of natural ecosystems has continued outside of the protected area system between 2005 and 2015. The current protected area system also benefits from a legacy of protection, with 80% of the extent of the current system protected from at least 1990.

That the protected areas estate has performed well in preventing the loss of natural ecosystems and the benefits they confer in Uganda, is also reflected by the diversity of natural land cover within its boundaries. The calculated ecosystem diversity metric for protected areas in 2015 is approximately 0.94 (Table 20), compared to 0.61 for Uganda as a whole (see Table 18). This reveals that the protected area estate is maintaining a representative coverage of the diversity of vegetation within its extent, with 162 different vegetation units / combinations covered out the 206 identified in Uganda as a whole (see Table 17 and Table 20). Maintaining the variety of these ecological niches also helps to secure species-level biodiversity. This further implies that multiple ecosystem functions are being maintained by protected areas, with associated benefits in terms of the number of different ecosystem services that have the potential to be delivered.

Further evidence of the potential benefits of the protected areas program is revealed in considering prospects with respect to individual iconic flagship species and associated tourism opportunities. In Uganda, the tourism industry as a whole is the highest foreign exchange earner (NEMA 2016a). The total economic contribution of all tourism to Uganda was estimated to be UGX6,904.5bn (or 10.1% of GDP) in 2015 and is forecast to rise by 6.6% per annum to UGX13,083.2bn by 2025 (or 10.2% of GDP) (WTTC 2015). Wildlife tourism comprises an important part of this sector.

The majority wildlife watching tourism in Africa is associated with protected areas (WTO 2014). In total the National Parks of Uganda received 213,950 visitors in 2013 (MTWA 2014). These visits generate substantial revenues streams, in terms of park entrance fees, permits and associated expenditures on accommodation, meals, souvenirs and other services. The World Tourism Organisation (2014) study revealed the average length of stay associated with wildlife watching tours in Africa is 10 days, and average daily tour prices are US$433 per person per day (excluding flights). On top of this, individuals spend an additional US$55 on out-of-pocket expenses. As discussed in the feasibility study (UNEP-WCMC 2016b), the National Development Plan (NDP II) and the Tourism Policy for Uganda identify tourism as a vehicle for economic development by generating greater revenues. There are significant opportunities for Uganda in this regard, with international tourist arrivals forecast to increase from 1,292,000 arrivals in 2015 to 2,158,000 in 2025 (WTTC 2015).

A key motivation for tourists visiting Uganda is to observe iconic species such as chimpanzees and elephants. The Species Accounts for these flagship species can assist in understanding where these species and associated tourism potential can be best protected. For chimpanzees, a large majority of fully suitable chimpanzee habitat is protected in the South Western (approx. 150,000 out of 156,000ha) and West Nile (16,000 out of 21,000ha) sub-regions (see Table 27). As such the protected area system is performing well in maintaining habitat in these areas and associated tourism benefits. However, the limited extent of habitat in absolute terms in West Nile is likely to only support small populations of chimpanzees. In the Western sub-region, there remains a substantial extent of fully suitable habitat outside of protected areas (265,000 out of 316,000ha are protected). As such there may be opportunities to develop wildlife watching tourism locations through expanding protected areas in this sub-region.

For elephants, in excess of 90% fully suitable habitat within the IUCN range is protected in the Karamoja, South Western and Western sub-regions (Table 28). Again this indicates the protected area estate is performing well at maintaining habitat for these species and potential associated tourism benefits. However, for West Nile only 12% of the fully suitable habitat is protected. Expansion of the protected area system could support the establishment of viable elephant populations in this sub-region. In turn this would provide further opportunities to develop wildlife watching tourism

With respect to NTFP relevant species, the protected area estate encompasses a large majority of the potential *Prunus africana* suitable habitat in Uganda (89% of 612,750ha), largely associated with protected areas in the Elgon, Karamoja, South Western and Western sub-regions (see Table 26). *Prunus africana* growing in Uganda may also be particularly effective in treating prostate problems and potentially cancer treatments (NewVision 2011). As such maintaining the genetic diversity of the species via the protected area system may provide a source of significant pharmaceutical revenues in the future.

With respect to Gum Arabic, in excess of 200,000 ha of potentially suitable natural vegetation is identified in Acholi, Central 2, Karamoja, South Western, West Nile and Western Sub-regions with a maximum of 51% of this area currently protected in any one sub-region (see Table 24). Similarly for Shea butter tree nut harvesting and butter production, in excess of 290,000ha potentially suitable natural vegetation is identified in the Acholi, Karamoja and West Nile sub-regions with 44% or less of this protected (see Table 22). As such there are opportunities for conservation and development associated with these potentially commercially viable species, for example via sustainable harvesting programmes, outside of the protected areas estate.

The above discussion on NTFP is particularly relevant for the sub-regions of Acholi, Karamoja and West Nile, where commercial NTFP harvesting could be integrated with the development of tourism opportunities associated with elephant watching across all three sub-regions, with limited potential chimpanzee tracking in West Nile. This could support infra-structure development and create tourist demand for locally produced shea butter products. Such support would be particularly beneficial in Acholi and Karamoja, where low population densities may limit economic opportunities and the case for infrastructure investments that would benefit local communities. The Acholi, Karamoja and West Nile sub-regions also contain natural areas of high bird species richness and medium to high large mammal species richness (see Table 30 and Table 31) illustrating conservation co-benefits with respect to protecting the natural cover in these sub-regions.

6.2 Making the case for increased budget allocation and investment in biodiversity rich sectors for conservation and management.

Potentially, there are multiple economic benefits that can be realised from natural landscapes. The NTFP species accounts provide information on the extent of areas that could potentially support commercially viable Shea butter tree nut and Gum Arabic harvesting. The returns on any such activity will depend upon sustainable yield quantities, market access and local and international prices.

For the Shea butter tree nuts, Elias & Carney (2007) indicate that a mature tree will yield approximately 20 kg of nuts per year. In their study for Burkina Faso they find densities of trees to vary from 25 to 55 per hectare, equivalent to potential yields of 500 kg to 1,100 kg per hectare. In the context of Ghana, Hatskevich et al. (2011) identify a government price paid of US$0.25 per kilo for Shea butter tree nuts and US$1.45 per kilo for Shea butter to local harvesters and processors. This equates to potential revenues of US$125 / ha / year to US$275 / ha / year for Shea butter tree nut harvests. If the harvest is processed locally this could rise to US$239.25 / ha to US$ 526.35 / ha / year. [14] Based on prices for Nigeria reported by Tiamiyu et al. (2014), Shea butter tree nut harvests could achieve US$500 per ton (f.o.b) and processed Shea butter US$1,700 per ton (f.o.b) on the international market. For Gum Arabic, Obua et al. (2006) evaluate the potential yields of Gum Arabic in Karamoja. Their study identifies potential yields of 154 kg / ha of Gum Arabic per year. In 2015 the total exports from Sudan to the EU alone were 40,000 tonnes and achieved a price in early 2016 of €2,7000 / tonne (f.o.b)(CBI 2016). Accordingly if appropriate supply chains and market access can be established, sustainable NTFP harvesting could generate significant foreign exchange revenue.

As proposed by Cottray et al. (2006) sustainable harvesting of NTFPs can realise significant local and national development objectives, whilst delivering multiple co-benefits for conservation. This provides an opportunity for sectors associated with the management of these NTFP areas to make an economic case for investments in conservation and management. As noted above, in excess of 200,000 ha of potentially suitable natural vegetation for Gum Arabic production is identified per sub-region in Acholi, Central 2, Karamoja, South Western, West Nile and Western, with most of this area not in conflict with the protected areas estate (see Table 24). For Shea butter tree nut harvesting there exceeds 290,000ha per sub-region of potentially suitable natural vegetation in the Acholi, Karamoja and West Nile sub-regions, a majority of which is also outside of protected areas. In addition, there also exists potential to develop Shea butter tree nut harvesting in locations in Teso (approx. 47,000 ha) and Lango (approx. 35,000 ha), the vast majority of which is outside the protected area system (see Table 22).

As discussed with respect to protected areas, the tourism sector is a significant source of foreign exchange revenue for Uganda. The flagship species accounts provide information on the areas where infrastructure investments may be appropriate to support this sector. As highlighted with respect to protected areas, there is the potential to develop this sector in Acholi, Karamoja and West Nile in tandem with the sustainable harvesting of NTFPs. This will also yield conservation co-benefits via the protection of areas of high species richness identified in the work coordinated by WCS (see Table 30 and Table 31). There is also the opportunity to further integrate information on biomass and wood fuel resources collated and coordinated via the National Biomass Survey. This will help identify which areas will benefit from sustainable resource management that can also yield wider ecosystem service benefits and associated synergies for conservation and sustainable management.

[14] Assuming the on a manual production ratio of 0.33 proposed by Elias & Carney (2007)

6.3 Establishing the extent of ecosystem degradation and where biodiversity trends threaten the delivery of ecosystem services and implications on economic growth and human well-being.

The ecosystem extent accounts reveal substantial reductions in the extent of natural ecosystems in Uganda. As noted, the extent of forest and moist savanna ecosystems in natural areas has reduced to approximately 29% and 32% of their original extent by 2015 (see Figure 9). In particular, Forest/savanna mosaic (13% of original extent remaining); Moist Combretum savanna (21% remaining) and Moist Acacia savanna (24% remaining) ecosystems have been substantially degraded due to land conversion (see Table 15).

The degradation of forest ecosystems has been particularly notable in Western (only 34% of original extent remaining), Central 1 (22% remaining), Central 2 (16% remaining), East Central (4% remaining) and Teso (3% remaining) (see Table 16). Associated with this losses are implications for the loss of wider forest derived ecosystem services, for example wood fuel provision for local communities (as discussed in Diisi 2009)

The degradation of moist savvana ecosystems has been largest in Acholi (38% original extent remaining), Lango (with 16% remaining), Teso (with 13% reminng) and Elgon (4% remaining) (see Table 16). With respect to provisioning services, the NTFP accounts reveal this is has resulted in substantial reduction in the extent of moist savanna ecosystems that support Gum Arabic and Shea butter tree nut harvesting in certain sub-regions. For example, for Teso the extent of remaining habitat suitable for Shea butter tree nut harvesting is 15% of its original extent, for Lango it is 17% and Elgon 18% (see Table 21). With respect to Gum Arabic only 6% of the original extent of suitable habitat for supporting this provisioning service remains in East Central, 14% in Teso, 16% in Lango and 17% in Elgon (see Table 23).

The diversity of ecosystems within some sub-regions has been reduced significantly in comparison with original configurations. Specifically, ecosystem diversity is much lower in East Central (0.178), Lango (0.264) and Teso (0.402), compared to 0.609 for Uganda as a whole (see Table 18). As such, the ability of multiple ecosystem functions to be provided by the landscape in these sub-regions is reduced. This will have implications for the range and volume of ecosystem service benefits that could potentially be delivered to beneficiaries in these sub-regions and the resilience of those services to natural disasters and climate change.

The land accounts also reveal gross changes of approximately 3 million hectares between 2010 and 2015 in the stock of natural land cover (see Table 10). This indicates that in addition to the net losses in natural areas, there may also be large areas of ecosystems that have been subject to intermittent farming and plantation use (although the potential for part of these gross changes to be an artefact of some inconsistency in classification between periods is acknowledged). Such land use is likely to have impacted on the condition of ecosystems in these areas and their ability to support the delivery of the range and volume of ecosystem service benefits that could otherwise be expected.

With reference to Shea butter tree nut harvesting, only 42% of the remaining natural cover in 2015 in Lango and 52% in Teso associated with ecosystems that can support Shea butter tree nut harvesting have been consistently classified as natural cover since 1990 (see Table 22). Given the slow growth rate of the Shea butter tree, these are likely to be the main areas in these sub-regions capable of delivering this provisioning service in the medium term.

For Gum Arabic provision, only 34% of the remaining natural land cover in East Central, 45% in Lango, 52% in Teso and 54% in Central 1 associated with ecosystems capable of supporting Gum Arabic production has consistently remaining natural land cover between 1990 and 2015 (see Table 24).

The flagship species accounts also provide useful information to evaluate where ecosystem degradation has occurred as elephants and chimpanzees are umbrella species and protecting the range of these species will also protect the range of several others. Further, given that the maintenance of species assemblages is linked with ecosystem functions (Balvanera et al. 2006), the extent of suitable habitat for these species can also be considered a broad proxy for the potential multifunctionality of ecosystems in these areas. This provides a wider argument for conservation beyond altruistic and tourism concerns.

For chimpanzees, nationally only 21% of the IUCN range of occupancy is fully suitable for this species in 2015 (see Table 27). However, between 1990 and 2015 there has been an overall increase in the extent of fully suitable habitat in the South Western and West Nile sub-regions, although a small decrease is noted in the Western sub-region (see Table 27). For Elephants, there has been a significant decrease in the extent of fully suitable habitat in their historic range (approx. 50%, see Table 29). With respect to the IUCN range of occupancy, 85% of this area remains fully suitable habitat in 2015. However, in Western 57,000ha and in West Nile 24,000ha of fully suitable habitat was lost between 2005 and 2015 (see Table 28). This implies significant degradation of associated ecosystems in these areas.

6.4 Increasing awareness and appreciation of biodiversity as a natural capital asset amongst decision makers and the public

The accounts for NTFP and flagship species can be employed to demonstrate the potential national and sub-regional trends in these assets and identify the principle habitat loss drivers associated with their status both inside and outside of protected areas. As highlighted above, this information can be linked to potential economic benefits in terms of harvest yields and tourism opportunities that can engage both the public and sectoral decision-makers. More generally, the accounts could provide regular updates on the trends in the extent of natural ecosystems (via the ecosystem extent accounts and derived diversity metrics). The timely provision of this information will be essential for engaging decision-makers and allow prompt communication of these national and sub –national trends to the public. There are anticipated to be multiple ways decision-makers and researchers can use the information presented in the accounts to communicate wider stories around biodiversity and natural capital in Uganda.

6.5 Assessment of progress towards the strategic objectives of Uganda's NBSAP (II) and National Development Plan (II) and associated international commitments (i.e., Aichi targets and SDGs).

The set of accounts presented can yield multiple indicators that can help inform progress towards key policy goals. With respect to Uganda's NBSAP II and NDP II, these include:[15]

- **NBSAP (II) target 1.1, by 2020 biodiversity values integrated in to national and local development plans, budgets and policy statements (corresponds to Aichi Target 2):** The set of ecosystem and species accounts provide the first step in integrating biodiversity values into the national accounting system (a key mainstreaming target identified in the NBSAP II). Further integration can be achieved by making links to economic statistics related to tourism and provisioning ecosystem services. The development of ecosystem service accounts would allow for further integration of biodiversity values, albeit implicitly via monetary valuation of the service flows it supports.
- **NBSAP (II) target 3.1, b7 2020 at least 17% of terrestrial and inland water ecosystems in Uganda are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas for socio-economic benefit of the population (corresponds to Aichi Target 11)**: The flagship species and ecosystem extent accounts can reveal progress towards protecting an ecologically representative set of areas with high biodiversity importance in Uganda. They flagship and NTFP species accounts can also assist in identifying opportunities for conservation and socio-economic development, via activities such as sustainable harvesting and wildlife watching tourism.
- **NBSAP (II) target 3.1, by 2020 the extinction of known threatened species plants and animals inside and outside of protected areas has been prevented and their conservation status improved (corresponds to Aichi Target 12)**: The flagship species, Shea butter tree nut and *Prunus africana* accounts can inform progress towards protecting the range and conservation status of these species. There is also likely to be a number of other threatened species whose status would be improved via the umbrella effect of maintaining and improving the ranges of these specific species. The accounts presented allow for information to be organised in a manner that reveals trends at any

[15] This list is adapted from Vardon et al., (In Press.)

scale, including both within the protected area system (as presented) and outside of it.

- **NBSAP (II) target 3.2, by 2020 ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15% of degraded ecosystems (corresponds to Aichi Target 15):** In combination, the land cover and ecosystem extent accounts can identify areas that have been degraded and are characterised by high ecosystem diversity potential. This can inform selection of areas for restoration and improving biodiversity and resilience. The development of ecosystem condition accounts would also provide useful information to inform management actions and track progress in relation to this target. This also clearly aligns with the objectives of the NDP II for Environmental and Natural Resources by identifying degraded ecosystems for restoration and improving their integrity and functionality for the long-term. This will also help to address the objective of the NDP II to increase Uganda's resilience to climate change.

- **NBSAP (II) target 3.5, by 2020 the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero to reduce degradation (corresponds to Aichi Target 5 and 14)**: The flagship and NTFP species, ecosystem extent and land accounts provide information on the sustainable use of terrestrial ecosystems that can be used to monitor habitat conversion and degradation in absolute terms and with respect to maintaining safe operating distances from ecological limits.

- **NBSAP (II) target 4.1, by 2020 appropriate incentives for biodiversity conservation and sustainable use are in place (corresponds to Aichi Target 3):** The set of accounts presented provides the foundation for integrating biodiversity in the national accounting and reporting process, a proposed activity under the NBSAP (II). The accounts provide a framework that can be built upon to further evaluate the trade-offs between biodiversity benefits and different development options. This can contribute to informing the more sustainable use of ecosystems and biodiversity in Uganda. This can also inform against the objectives of the NDP II for Environmental and Natural Resources, specifically with respect to increasing the extent of wetland and forest ecosystems.

- **NBSAP (II) target 4.2, by 2020 a well established framework for implementing the Multilateral System of accessing and sharing of benefits arising from PGR in place (corresponds to Aichi Target 13):** The *Prunus africana* and NTFP species accounts can help monitor trends in the maintaining the genetically diversity of these species based on distributions of different communities in different sub-regions and associated access rights.

The NDP (II) also provides the framework for localising the UN Sustainable Development Goals (SDGs) in Uganda. The accounts presented also yield indicators to inform progress towards the SDGs, including:

- **SDG 1 (End poverty in all its forms everywhere):** The species accounts presented can help inform where tourism and NTFP production possibilities can contribute to local economic development and address poverty. The potential of the accounts to address this goal would be improved via the development of ecosystem service accounts.
- **SDG 12 (Ensure sustainable consumption and production patterns):** The land, ecosystem extent and NTFP species accounts can inform about sustainable production by tracking the degree of habitat conversion and degradation associated with different economic sectors and potential implications on NTFP harvests and the tourism sector.
- **SDG 15 (Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss)**: The land, ecosystem extent and species accounts can track whether ecosystems are being sustainable managed by identifying areas of land degradation and associated impacts on biodiversity.

6.6 Limitations and further work.

The set of experimental ecosystem accounts presented here is a first attempt to develop a spatial infrastructure for accounting for ecosystem and biodiversity related themes in Uganda using the SEEA-EEA framework. The accounts have largely focused on ecosystems and biodiversity associated with natural areas. It is important to note that the accounts have been created using remotely sensed observations on land cover change to infer impacts on ecosystems and species. There will be multiple drivers of ecosystem degradation that will not be revealed by this approach. This includes over-grazing and over harvesting (e.g., for charcoal production) of natural areas. For example, aerial surveys have identified livestock grazing in savvana areas in Uganda (Plumptre et al. 2010). This activity introduces disturbances to wildlife and creates conflict with the needs of wildlife, for example by reducing the availability of water and grazing fodder for non-domesticated species. As such the set of accounts would be improved by compiling ecosystem condition accounts, ideally based on ground-truthing and primary monitoring data or, potentially, more sophisticated remote sensing approaches.

The habitat based approaches employed in the development of the Species Accounts are acknowledged to relate to potential presence only. However, whilst habitat suitability is no guarantee of species occurrence and there are multiple other factors determining precise suitability, the accounts do direct attention to areas where ecological and economic returns on species may be most likely realised. The habitat based approach is coarse because habitat classes have a range of suitability within them and certain areas within one class might be suitable whilst other locations might not. For example, areas classified as low stocked tropical high forest, where they have not be overly disturbed by human activities, might be as suitable for a species as other areas classed as well stocked tropical high forest.

The habitat based approach could therefore be refined by considering more finely resolved habitat information, along with information about other pressures, such as human population and transport infrastructure. This could be achieved using species distribution modelling. Given information on locations in which a species has been observed and locations where it has been found to be absent, for example from animal movement or ecological census data, this would allow modelling of habitat suitability by incorporating the sensitivity of the species to human pressures. To achieve this would require a set of detailed primary biodiversity monitoring datasets as well as detailed spatial information on human activities (e.g. settlements, population and road densities) that could be relied upon to inform future updates of the accounts.

Outside of natural areas, biodiversity also underpins a range of important ecosystem services. The well cited example being the role of pollinators in maintaining and improving agricultural yields (Munyuli 2013). Establishing a set of species-level biodiversity accounts for areas of farmland will be very useful but will heavily depend on the availability of primary time-series monitoring data. As discussed in the feasibility study, determining how such data can be collected and maintained will require an extended stakeholder workshop involve multiple ministries, NGOs, and academia. This has not been possible within the constraints of this project.

With respect to the delineation and classification of ecosystem assets employed in this study, these have been derived using the combination of Langdale-Brown and NBS land cover classifications for natural areas. In order to achieve a more nuanced assessment of converted areas, such as farmland, and use them in the analysis, it is likely that further hybridisation of the land cover and Langdale-Brown classes will be required. However, expanding the information set to include agricultural and plantation areas will be important in order to understand further the trade-offs that exist between conservation and sustainable management of natural resources versus expansion of activities such as agriculture.

The accounts have been compiled using multiple datasets that have been integrated into a common spatial infrastructure. Whilst associated conversions and processing may have introduced slight errors these are not considered to have influenced the overall conclusions of the report. Nonetheless, there remains a need to harmonise the accounts with other spatial statistics produced for the country. Notably this includes achieving an exact concordance with the land cover statistics generated by the NFA. There is also noted to be a lot of 'noise' in the land cover data that should be further evaluated (i.e., the gross changes between periods are large compared to net changes). In addition, given the different approaches employed to generate land cover maps for 1990 and 2005 onwards, consideration should be given to investing in further harmonisation between periods (although this decision should be driven by a needs assessment). Integrating information on soil water seasonality in the land cover maps is also likely to be useful for supporting policy development and decision-making for wetland management.

Finally, one of the ambitions of the SEEA framework is to integrate information on ecosystems with the standard national accounts (UN et al. 2015). This will (most likely) start with the compilation of ecosystem extent and condition accounts, followed by the measurement of the supply and use of ecosystem services in physical terms and then monetary terms and, ultimately, the integration of ecosystem service and asset values into the standard economic accounts (UN et al. 2015). The accounts presented here provide a concrete step along this path.

Follow-on work should include integration of further information on ecosystem condition and key ecosystem services in Uganda (e.g., wood fuel provision), beyond those associated with the selected flagship NTFPs species. This should support the compilation of ecosystem service accounts for the supply and use of a set of key ecosystem service related benefits for Uganda.

Developing these accounts will require a coordinated approach across multiple ministries, authorities and organisations, with the aim of moving beyond physical to monetary accounting of ecosystem services flows, covering both the supply and use of ecosystem services where possible. In turn, this will require making explicit the links to economic and other use data for ecosystem service benefits such as tourism revenues, provisioning service benefits and benefits associated with key regulating services (e.g., erosion control, flood attenuation) that are important for communities and livelihoods in the country. This work should also include extensions to incorporate accounts for fisheries (and other benefits associated with open water ecosystems) water and carbon and, ultimately, integration with the system of national accounts.

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Appendix A: Ensym platform

This appendix sets out how data and modelling were undertaken for the project using the Environmental Systems Modelling Platform[16] (EnSym). EnSym is a decision support tool designed to provide:

- simple and intuitive access to complex science that helps prioritise natural resource investment;
- an understanding of the environmental benefits delivered by actions undertaken in the landscape; and
- a framework for scientists and researchers to test and apply empirical and process-based scientific models.

EnSym provides users with an evidence-based framework to support decision-makers on how and where to invest to maximise environmental outcomes. EnSym employs scientific models to understand the impact that actions such as revegetation, weed control and riparian management, have on the landscape. Users can visualise, test and interpret results of changes in climate, land use and land management practices through a single user-friendly interface.

Scientific models included in EnSym are peer reviewed, published and under continual refinement by researchers. Models are grouped into **five toolboxes** that relate to different sections of the landscape and have different analytical capabilities, as described below.

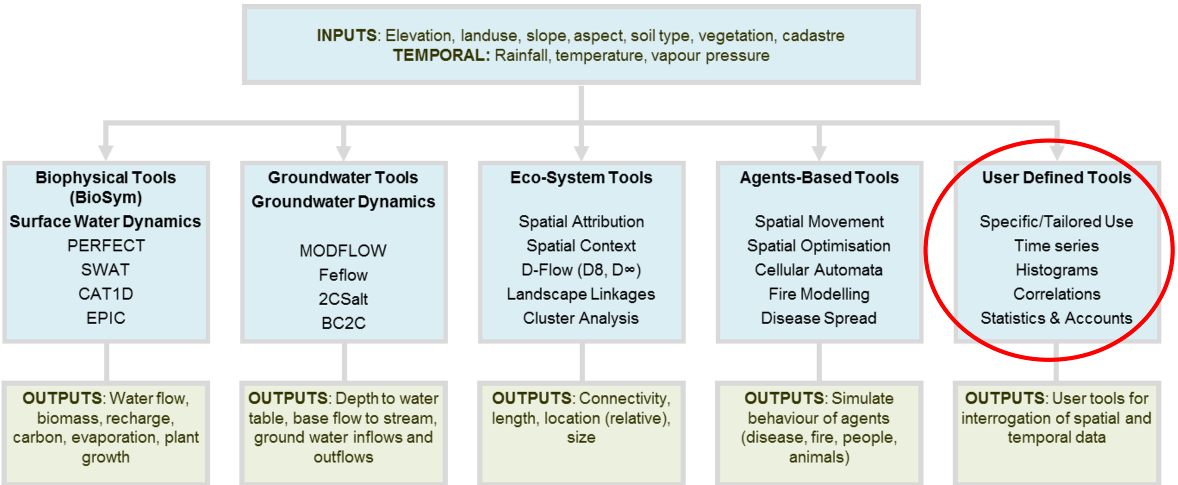

Figure 12 EnSym analytical tool boxes

These models utilise temporal (rainfall and temperature) and spatial (soil type, elevation, land use, vegetation and groundwater) data as inputs and other data sources can be added as required. The functionality of EnSym has been refined so that

[16] https://ensym.dse.vic.gov.au/cms/

environmental information can be combined efficiently to produce ecosystem accounts (see 'User Defined Tools' module in the above figure).

When using EnSym to construct ecosystem accounts the first stage is to build a scenario. A scenario is a file that contains multiple spatial layers in a common grid format suitable for rapid analysis and reporting. Figure 13 provides an overview of the links between the master grid (Basic Spatial Units, BSU), ecosystem assets and ecosystem reporting areas. The BSU is not an accounting unit, per se, but it is used to provide a consistent spatial layer for data integration. The approach adopted to generate BSUs for the Ugandan accounts is to create a master grid of 100m grid cells (each representing a BSU) that covers the entire country. This set of BSUs (grid cells) satisfies the mutually exclusive, collectively exhaustive requirement for spatial ecosystem accounting.

By converting all spatial data layers, whether in grid or vector format, to a master grid, the information can be aggregated and combined to present different data referring to comparable spatial areas, including for ecosystem assets and ecosystem accounting areas.

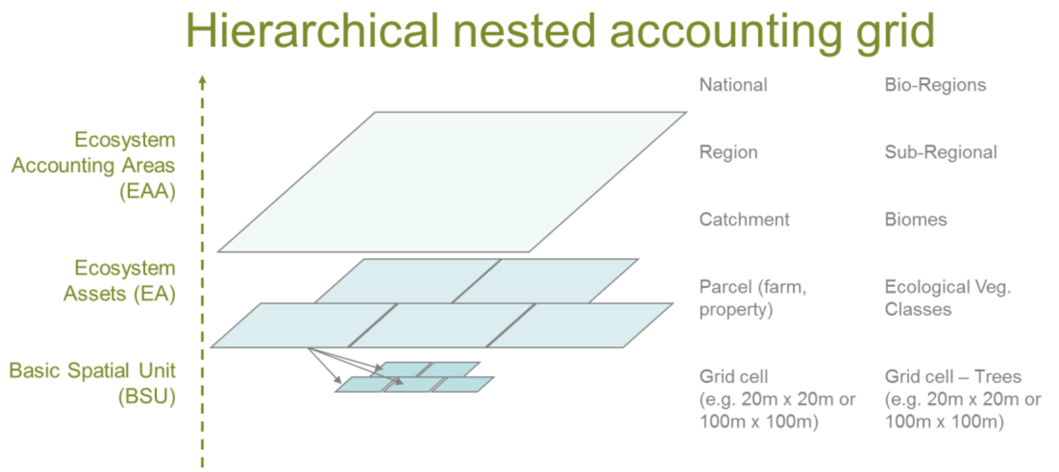

Figure 13 EnSym nested grid approach to integrating spatial data

The following data sets were used to build the scenario for this project.

- NBS Land Cover map 1990 (based on digitising hard copy images)
- NBS Land Cover map 2005, 2010 & 2015 (based on satellite imagery and FAO LCCS)
- National Biodiversity Data Bank (NBDB) Uganda digitised version of the Langdale-Brown et al., 1964 (The vegetation of Uganda and its bearing on land use.)
- WCS et al 'Map of critical sites for threatened species' (note this is draft)

- Bespoke habitat suitability maps produced for Chimpanzee and African elephant using habitat preferences (associated with NBS classes) and IUCN range data for chimps and elephants and historic range assessment for elephants only (presented in Lamprey et al., 2003 'A Study of Wildlife Distributions, Wildlife Management Systems, and Options for Wildlife-based Livelihoods in Uganda'). Produced for 1990, 2005, 2010 and 2015
- Extent of Sub-regions in Uganda based on data collated by the Energy Sector GIS Working Group Uganda (http://data-energy-gis.opendata.arcgis.com/)

The master grid for Uganda used the WGS 1984 UTM Zone 36N projection. The process of adding data to the scenario used the following steps:

1) Reproject the layer to WGS 1984 UTM Zone 36N
2) If the layer is a shape file it is then gridded to 100m. the process follows gridding to 10m and then resampling to 100m to ensure the greatest level of accuracy when moving for a vector format to a grid format. If the layer is gird (ie. say tiff format) then the layer is simply resampled.
3) Each layer is then loaded into EnSym and checked for consistency with the master grid. Checks include:
    a. The alignment to the master grid
    b. Data that may not be attributed in the new layer for the entire coverage of the master grid. If the loaded layer does not fully cover the extent of the master grid then cells (BSUs) that have not been attributed are assigned 'other', in general.

Figure 14 below shows an example of a layer that has been loaded and contains missing data when compared to the mater grid, indicated with a black cross.

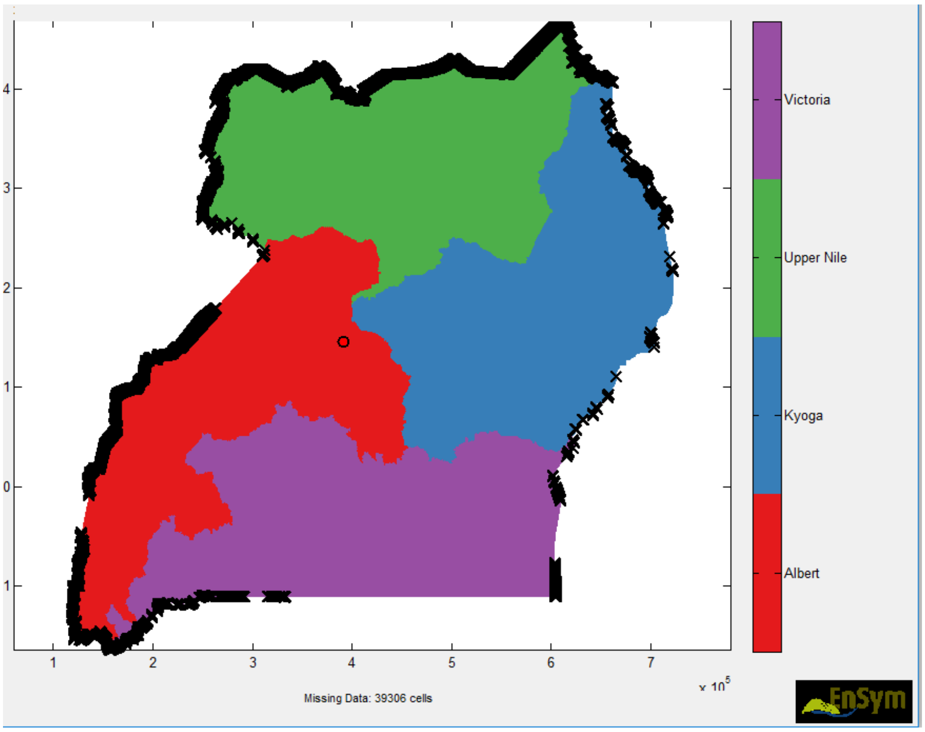

Figure 14 Example of a layer with missing data in grid format

With EnSym there is a dedicated menu item for "Accounting and Reporting" (See Figure 15). Within this menu, you can analyse layers for statistics (histogram of areas), report mean, sum, standard deviation, multiple layer summary, accounts tables and change tables. The last three functions were used predominantly for this project once all data had been loaded and validated.

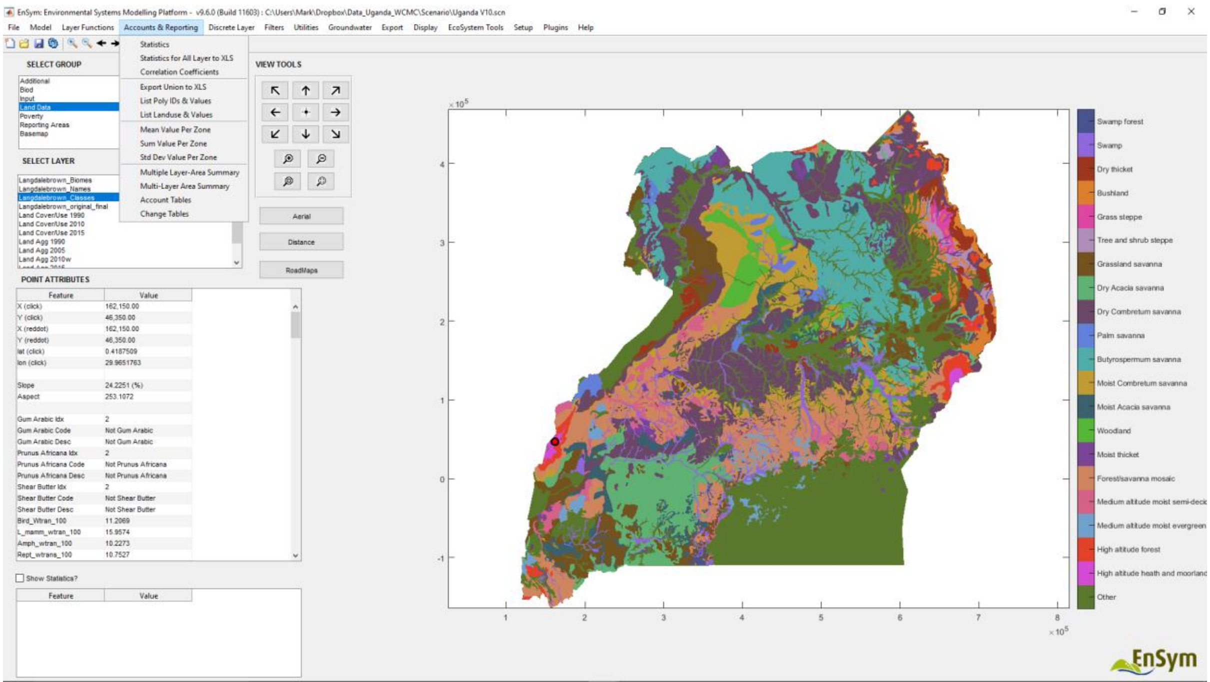

Figure 15 EnSym Reporting and Accounting menu

Appendix B: Methodology for Ecosystem Diversity and Flagship Species Accounts

Ecosystem diversity (Community class) accounts

Accounts for the change in diversity of community types were generated for two measures: the richness or number of different types within an Ecosystem Accounting Area; and, the similarity of the community types and extents within an Ecosystem Accounting Area to those of the unmodified, or pristine, ecosystems within the same area.

To capture the highest variation in community characteristics we used the vegetation code attribute from the Langdale Brown map of natural vegetation, which provided the highest resolution of vegetation types. To calculate the richness of community classes for each Ecosystem Accounting Area, we first intersected the Langdale-Brown vegetation code map with the habitat classes sensed for the National Biomass Study. We then counted the number of different vegetation types within each Ecosystem Accounting Area that remained in natural land cover classes. For the similarity measure we followed the same approach but in addition to counting the number of vegetation types existing as natural vegetation, we also took into account how the extent of each vegetation type had changed in comparison to the vegetation existing in a pristine state for the Ecosystem Accounting Area. We used a metric called a Bray-Curtis index (Bray & Curtis, 1957). The measure indicates how similar the vegetation types make up in the Ecosystem Accounting Area is to the pristine state, where an index value of 1 means it is identical, whilst an index value of 0 indicates there are no ecosystem types occurring in natural habitat classes.

Flagship Species Accounts

Species accounts were constructed for *Loxodonta africana* and *Pan troglodytes* using species distributions maps, coarse approximations of the geographic distributions of each species, which were then refined using deductive modelling based on expert based habitat suitability rules and remotely sensed information on habitat distribution in Uganda from the National Biomass Study (Diisi 2009).

Data sources

We used the species distributions from the 2016v1 IUCN Red List assessment as the best estimates for the contemporary distributions of *Loxodonta africana* and *Pan troglodites* (IUCN). For *Loxodonta africana*, we also used earlier distributions digitised from hard copy reports using the Ugandan national boundary to coordinate the maps. Specifically, we digitised an estimate of the species distribution in 1960 (Lamprey et al. 2003). We used estimated historic ranges to provide a baseline distribution predating the habitat distribution information derived from the National Biomass Study. In addition to the species and habitat distributions we also used a map of elevation to determine suitability according to upper elevation bounds for each species. To determine elevation we used the outputs from a digital elevation model (Lehner et al., 2006).

The coarse species distributions were used to define the area of occupancy for each species, in other words the area in which the species is likely to be observed. These were then refined to generate the area of suitable habitat within the areas of occupancy. For each taxa we used the expert rules for species habitat suitability generated by the IUCN Red List assessment exercise and used in previous conservation assessments (e.g. Rondinini et al. 2011; Visconti et al. 2016).

Approach

All layers were converted to rasters with a grid cell resolution of 1km by 1km to simplify the analysis. For those cells falling within the species area of occupancy, defined by the species distribution, we assigned each cell to one of three classes fully suitable, partially suitable and unsuitable, according to the suitability model for the species. Cells were deemed fully suitable where the remotely sensed habitat class was equivalent to a class with full suitability according to IUCN classification. Partial suitability was assigned to human modified classes (e.g. Tropical high forest – low stocked), since some disturbance in these land cover types and other NBS classes that had partial overlap with the IUCN classified suitable habitats (Table B1).

Pan troglodites

For the *Pan troglodites* accounts, we associated the forest classes assessed by IUCN as suitable with NBS class 3 (well stocked tropical high forest) and the dry savanna class with NBS class 6 (bush). NBS class 4 (low stocked tropical high forest) was not included in the fully suitable habitat classification since it includes some human impact and information on the human disturbance tolerance of *Pan troglodites* was not available from the IUCN assessment. We used NBS bush class to describe the IUCN's savanna habitat class because this was the closest match. The alternative, NBS class 7 (grasslands), incorporates grazing lands and improved pastures. Because NBS classes 4 (low stocked tropical high forest) along with 5 (woodlands) and 7 (grasslands) might also provide suitable habitat for *Pan troglodites*, we incorporated these classes as partially suitable.

We also limited suitability to sites below an elevation of 2,790m, which is the observed upper elevation limit for the subspecies *Pan troglodites schweinfurthii* found in Uganda according to the IUCN Red List Assessment.

Loxodonta africana

The habitats assessed by IUCN as suitable for *Loxodonta africana* are wide ranging covering forest, savanna, shrubland, grassland, wetland and desert. We associated the IUCN forest habitats with NBS class 3 (well stocked tropical high forest) and NBS class (5) woodland. Woodland was incorporated here because *L. africana's* is assessed to find temperate forests suitable. The IUCN habitats of savanna and shrubland were associated with NBS class 6 (bush) because as described above this was the closest matching NBS class that avoided explicit incorporation of human modification. NBS class 7 (grasslands) was associated with the IUCN grassland habitat class. For the IUCN habitat class Artificial/Aquatic - Seasonally Flooded Agricultural Land, NBS class 8 (wetland) was most assessed to be most aligned. Lastly, the NBS class 13 (impediments) represents bare rocks and soils without vegetation cover and so is the most closely aligned with the desert IUCN habitat class.

Since the human modified habitats represented by NBS classes 1 (broad leaved plantations), 2 (coniferous plantations), 4 (low stocked tropical high forest) and 9 (small scale farmland) are likely to also provide some suitable habitat we incorporated these as partially suitable habitat for *Loxodonta africana*.

Table B1: Expert derived habitat suitability for *Loxodonta africana* and *Pan troglodites* from IUCN (2016) and the mapping from IUCN habitat classes to NBS classes.

Species	IUCN Habitat class	IUCN Habitat description	NBS Class	Suitability
Pan troglodites	1.5	Forest - Subtropical/Tropical Dry	3	Full
Pan troglodites	1.6	Forest - Subtropical/Tropical Moist Lowland	3	Full
Pan troglodites	1.8	Forest - Subtropical/Tropical Swamp	3	Full
Pan troglodites	1.9	Forest - Subtropical/Tropical Moist Montane	3	Full
Pan troglodites	1.9	Forest - Subtropical/Tropical Moist Montane	4	Partial
Pan troglodites	1.9	Forest - Subtropical/Tropical Moist Montane	5	Partial
Pan troglodites	2.1	Savanna - Dry	6	Full
Pan troglodites	2.1	Savanna - Dry	7	Partial
Loxodonta africana	1.4	Forest - Temperate	3, 5	Full
Loxodonta africana	1.5	Forest - Subtropical/Tropical Dry	3	Full
Loxodonta africana	1.6	Forest - Subtropical/Tropical Moist Lowland	3	Full
Loxodonta africana	1.7	Forest - Subtropical/Tropical Mangrove Vegetation Above High Tide Level	3	Full
Loxodonta africana	1.8	Forest - Subtropical/Tropical Swamp	3	Full
Loxodonta africana	1.9	Forest - Subtropical/Tropical Moist Montane	3	Full
Loxodonta africana	2.1	Savanna - Dry	6	Full
Loxodonta africana	2.2	Savanna - Moist	6	Full
Loxodonta africana	3.4	Shrubland - Temperate	6	Full
Loxodonta africana	3.5	Shrubland - Subtropical/Tropical Dry	6	Full
Loxodonta africana	3.6	Shrubland - Subtropical/Tropical Moist	6	Full
Loxodonta africana	3.7	Shrubland - Subtropical/Tropical High Altitude	6	Full
Loxodonta africana	3.8	Shrubland - Mediterranean-type Shrubby Vegetation	6	Full
Loxodonta africana	4.4	Grassland - Temperate	7	Full
Loxodonta africana	4.5	Grassland - Subtropical/Tropical Dry	7	Full
Loxodonta africana	4.6	Grassland - Subtropical/Tropical Seasonally Wet/Flooded	7	Full

Loxodonta africana	4.7	Grassland - Subtropical/Tropical High Altitude	7	Full
Loxodonta africana	5.13	Wetlands (inland) - Permanent Inland Deltas	8	Full
Loxodonta africana	5.2	Wetlands (inland) - Seasonal/Intermittent/Irregular Rivers/Streams/Creeks	8	Full
Loxodonta africana	5.3	Wetlands (inland) - Shrub Dominated Wetlands	8	Full
Loxodonta africana	5.4	Wetlands (inland) - Bogs, Marshes, Swamps, Fens, Peatlands	8	Full
Loxodonta africana	5.8	Wetlands (inland) - Seasonal/Intermittent Freshwater Marshes/Pools (under 8ha)	8	Full
Loxodonta africana	5.9	Wetlands (inland) - Freshwater Springs and Oases	8	Full
Loxodonta africana	8.1	Desert - Hot	13	Full
Loxodonta africana	8.2	Desert - Temperate	13	Full
Loxodonta africana	14.1	Artificial/Terrestrial - Arable Land	9	Partial
Loxodonta africana	14.2	Artificial/Terrestrial - Pastureland	9	Partial
Loxodonta africana	14.3	Artificial/Terrestrial - Plantations	1	Partial
Loxodonta africana	14.3	Artificial/Terrestrial - Plantations	2	Partial
Loxodonta africana	14.4	Artificial/Terrestrial - Rural Gardens	9	Partial
Loxodonta africana	14.6	Artificial/Terrestrial - Subtropical/Tropical Heavily Degraded Former Forest	4	Partial
Loxodonta africana	15.8	Artificial/Aquatic - Seasonally Flooded Agricultural Land	9	Partial