Estimation of the Economic Value of Natural and Environmental Resources within Uganda

Prepared for the Ministry of Finance, Planning & Economic Development Uganda by IDEEA Group

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1. Introduction

The estimation of the economic value of natural and environmental resources serves to highlight and quantify the variety of benefits that are provided by the environment to society and the economy. The intent is to quantify values in a way that enables effective decision-making. This can include monetisation of values to bring them into a common currency (e.g. USD) that allows benefits to be compared across different policy and investment plans. This can clarify the benefits across different development paths and show the importance of specific projects to a society and the economy.

The stock of renewable and non-renewable natural and environmental resources is collectively referred to as the natural capital. Natural capital should be considered spatially, and the stocks described in terms of their extent (geographical size) and condition (quality in terms of abiotic and biotic characteristics). Once an understanding of the natural capital stocks (the asset base) is developed, the flows of ecosystem services from the environment, recognised ultimately as benefits to people, can be understood. This representation of the environmental-economic system is the core natural capital model (Figure 1).

Figure 1: Core natural capital model.

This approach to understanding natural capital can be underpinned by natural capital accounting, the process of structuring and representing data on natural capital (stocks) and ecosystem services (flows) in an organised manner. The United Nations System of Environmental-Economic Accounting (SEEA) provides internationally accepted concepts and definitions which underpin a consistent and comparable approach to natural capital accounting. The use of the SEEA as the framework by which this is done has the benefits of both its status as an international standard and its compatibility with the System of National Accounts (SNA) in terms of alignment of concepts, definitions, and principles.

The SEEA can be considered in terms of two constituent and entirely compatible frameworks. The SEEA-Central Framework (SEEA-CF) covers practices on individual environmental assets, such as energy and water. The SEEA-Ecosystem Accounting (SEEA-EA) serves as a framework for the organisation of biophysical data, the measurement of ecosystem services, and the tracking of changes in ecosystem assets in terms of both their extent and condition in a way that can be linked to economic and other human activity information.

1.1. Purpose of this project

The purpose of this project was to perform a valuation of Uganda's natural and environmental resources. It builds on existing work that has been undertaken in Uganda, given the Government of Uganda has already adopted natural capital accounting and launched a national plan. This project is part of a broader body of work under the contract to Update the Uganda National Parameters and Commodity Specific Conversion Factors and Construction of New National Parameters. The objective is to demonstrate how the economic value of natural and environmental resources can be estimated to provide the Government of Uganda with a more holistic view of the value of the country's non-tradable commodities.

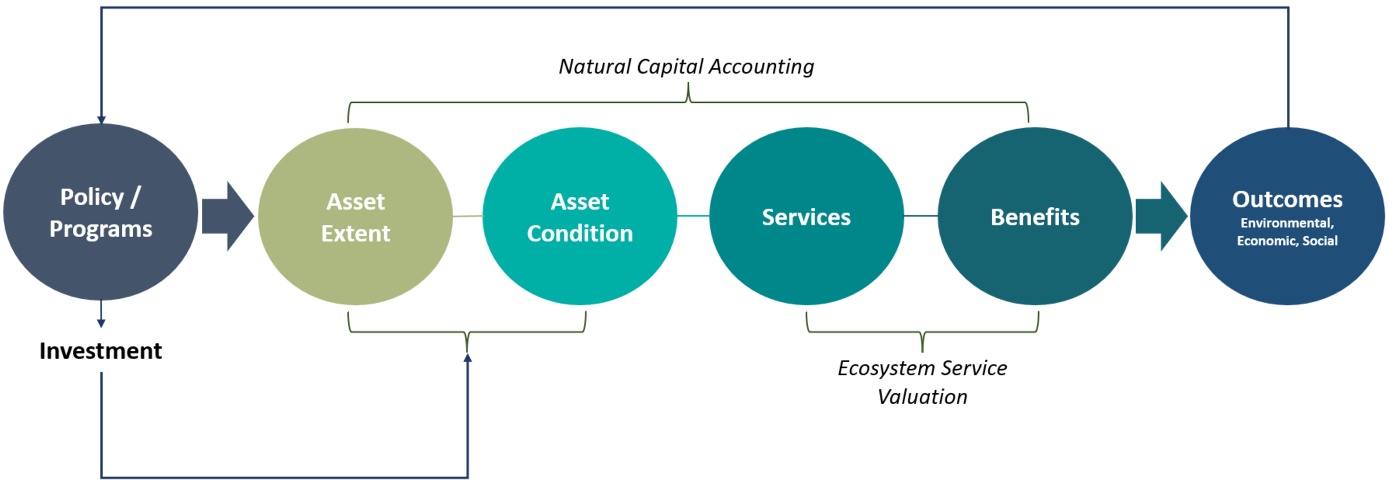
This document contains an introduction to natural and environmental resource valuation, a set of estimated valuation data, a discussion of the results of this valuation, and a discussion of how the results of this project can be used practically.

1.2. Investing in natural and environmental assets

To ensure that natural and environmental resource valuation can be effectively used in decision making it is important for a consistent investment model to be adopted. The investment model is a framework for considering how natural capital can be invested in and/or otherwise altered through policies and programs to drive environmental, economic, and social outcomes.

Figure 2 demonstrates a natural capital investment model. It illustrates how policies and programs that seek to change outcomes can act by changing the natural capital stock (via direct or indirect investments that influence the extent or condition of the stock, e.g., increasing the size of wetlands or making grasslands more productive). In influencing the stock, changes in the supply of ecosystem services and ultimately the benefits society receive can be realised. The focus of the natural capital program logic is on policies and programs that lead to investment (directly and indirectly) in the stock of natural capital. The model also acknowledges that the outcomes of investments in natural capital influence future policies and programs.

Figure 2: Model for investment in natural capital and how it can be used to influence environmental, economic, and social outcomes.



Investments in natural capital are effectively payments to manage the environment and natural resources so that society can be provided with benefits via ecosystem services. These investments in natural capital can add new assets, change the composition of existing assets, or maintain or enhance assets to secure future flows of ecosystem services. These ecosystem services can be:

- Inputs to economic activities (e.g., provisioning of food and fibres for use in agricultural industries).
- Consumed directly by households (e.g., wild food and materials provisioning services).
- Consumed by the environment itself (e.g., water regulation services by a wetland may reduce the impact of flood events on a grassland or forest).

The services and benefits that are provided by natural capital can also ultimately be tied to a user such as a business, household, or government. Ecosystem service valuation in terms of monetisation enables the conversion of ecosystem services into benefits in per dollar terms. This can be used to understand the outcomes of investments in natural capital from a monetary perspective where possible.

1.3. Our approach to natural and environmental resource valuation

The approach taken here is to quantify the variety of benefits that natural and environmental resources provide to society and the economy by means of assigning monetary values to ecosystem assets. This will be done in a top-down nature using standard values per hectare per year for each ecosystem type. The total values of assets will incorporate different types of use and non-use values.

In general, it is recommended that a bottom-up approach of understanding specific ecosystem flows in the relevant context and then applying a valuation technique to the resultant dataset is followed. However, that was not possible here due to scoping and data availability so an initial view of the value of specific ecosystem assets is being developed to provide guidance on the approach and inputs that can inform at a high level where high value ecosystem assets may exist. This approach is considered appropriate when valuation is performed at a large geographical scale, such as over a whole country.

In order to quantify the natural and environmental resource values the following steps are taken:

1. Compile a register of Natural and Environmental Resource (NER) assets in Uganda that classifies these assets based on relevant land cover classes.

2. Develop outputs of maps showing the locations and configuration of these assets; and tables summarising the area and changes in the area of different NER types over time.

3. Assign monetary values to ecosystem services and ecosystem assets via the value transfer approach. Values should reflect both market and non-market resource values and will encompass both use and non-use values to the extent possible.

4. Compile a balance sheet of monetary values for all asset types. Where possible and appropriate data will be presented:

    a) on a per annum income basis;

    b) on a per hectare basis; and

    c) in maps showing the distribution of values across Uganda.

5. Summarise the results and document the methods and data sources used. This will include a set of accounts developed following the structure outlined in the SEEA and a set of recommendations on future areas of focus.

2. Asset Register of Natural and Environmental Resource Assets

Developing an asset register of natural and environmental resources for Uganda involves the classification of all the ecosystem types within the country. Where this is done spatially ecosystem assets can then be defined. The definitions of ecosystems, ecosystem types, and ecosystem assets used here are those that align with the guidance in the SEEA-EA. Here ecosystem assets are synonymous with natural and environmental resource assets.

Ecosystems: An ecosystem is "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (Convention on Biological Diversity, article 2, entitled "Use of terms").

Ecosystem Types: Ecosystem types represent a distinct set of abiotic and biotic components and their interactions (SEEA-EA, 2021).

Ecosystem Assets: Contiguous spaces of a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions (SEEA-EA, 2021).

In order to develop an asset register for Uganda a set of extent accounts for the country were developed via the ARIES for SEEA tool. ARIES for SEEA classifies occurring ecosystem types in accordance with the level 3 Ecosystem Functional Groups of the IUCN Global Ecosystem Typology 2.0. The use of the IUCN Global Ecosystem Typology is consistent with the guidance contained within the SEEA-EA. However, the classification of ecosystem types varies depending on the methodology that is used. It is possible that other datasets with competing information on ecosystem types are more reliable.

We identified a set of national land-cover statistics for Uganda from the Uganda Bureau of Statistics for the year 2015. We have compiled an additional asset register based on these land-cover statistics as a means of comparison, however, note that there were no spatial representations of this data publicly available.

To simplify the asset registers, given the high level of detail on different ecosystem types, they were aggregated into overarching groups that align more closely with the groupings often used in valuation studies. The mapping of detailed ecosystem types to these aggregate groupings can be seen in Appendix 1.

2.1. Natural and environmental asset register for Uganda derived from ARIES for SEEA

The natural and environmental asset register based on ARIES for SEEA data demonstrates that there has been changes in the extent of all ecosystem types over the period of 2012 to 2018 except 'Bare Land' (Table 1). The largest losses noted were in cropland ecosystems whilst the largest gains were in tropical forests. A version of the table which details more granular ecosystem types can be seen in Appendix 2.

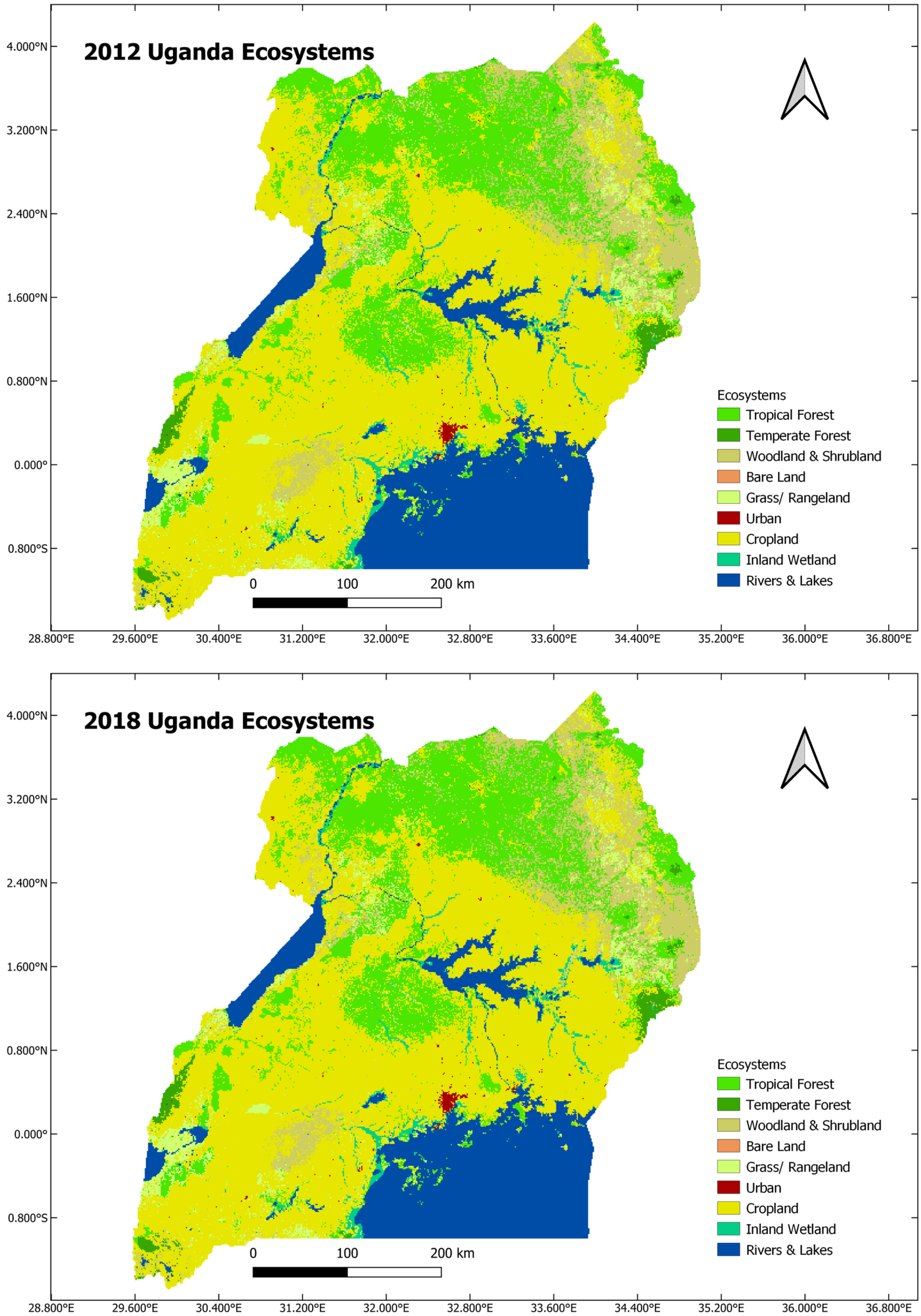
Table 1: Natural and environmental asset register derived from ARIES for SEEA for the years 2012 and 2018.

Extent	Cropland	Bare Land	Grass-/Rangeland	Inland Wetlands	Rivers & Lakes	Temperate Forests	Tropical Forests	Urban	Woodland & Shrubland
Extent 2012 (ha)	11887800	447	965216	376107	3714742	257391	4747434	53772	2247106
Extent 2018 (ha)	11762530	447	943618	374916	3715040	261115	4954032	59879	2178439
Net change (ha)	-125270	0	-21598	-1191	298	3724	206598	6107	-68667

2.2. Map of natural and environmental assets of Uganda derived from ARIES for SEEA

Mapping of the extent data suggests that changes in extent between 2012 and 2018 have been relatively minimal given little difference can be seen in the distribution of ecosystem types (Figure 3). Proportionally, the largest changes in extent have occurred in the Urban and Tropical Forest Ecosystem Types. However, even for these ecosystem types only subtle differences in distribution can be seen.

Figure 3: Maps of ecosystem type (categories of natural and environmental assets) across Uganda in the years 2012 and 2018.



2.3. Natural and environmental asset register for Uganda derived from Uganda Bureau of Statistics data

The natural and environmental asset register based on data from the Uganda Bureau of Statistics was only able to be compiled for the year 2015 (Table 2). Given differences in the way ecosystem types are classified, tropical and temperate forests were not shown as separate groupings in this data. A version of the table with details of more granular ecosystem types can be seen in Appendix 3 along with a breakdown of the data by districts.

Table 2: Natural and environmental asset register derived from Uganda Bureau of Statistics land-cover statistics for the year 2015.

Extent	Cropland	Bare Land	Grass- /Rangeland	Inland Wetlands	Rivers & Lakes	Forests	Urban	Woodland & Shrubland
Extent 2015 (ha)	10530819	7780	5097372	715481	3749581	738711	135567	3180185

3. Monetary Valuation of Natural and Environmental Resource Assets

The economic value of natural capital measured in monetary terms provides a means of demonstrating the importance of a project in a given socio-economic context. Benefits of monetary valuation include that it:

- Allows the benefits provided by nature to be directly compared to other economic costs and benefits.
- Provides a tool for communicating the benefits of nature in an understandable way.
- Highlights important areas for conservation and/or restoration where further analytical work may be required to enable effective decision making regarding policies and investments.

This value can be interpreted in a number of ways depending on the type of valuation technique applied. In a broad sense it provides an indication of the overall use and non-use values of a given natural capital asset. Some different types of value that can underpin this monetary value are demonstrated in Table 3 below.

Table 3: Taxonomy for the components of total economic value of natural and environmental resources.

Total Economic Value				
Use Values			**Non-use Values**	
Direct Use	**Indirect Use**	**Option Value**	**Bequest Value**	**Existence Value**
Outputs directly consumable	Functional benefits	Future direct and indirect values	Value of environmental legacy	Value from continued existence
• Food • Biomass • Recreation • Health • Increased living comfort	• Flood control • Storm protection • Nutrient cycles • Carbon sequestration	• Biodiversity • Conserved habitats	• Habitats • Prevention of irreversible change	• Habitats • Species • Genetic • Ecosystem

Source: EFTEC/RIVM, 2000.

In this study values for the following services were included:

- Climate regulation services
- Erosion prevention services
- Existence-related services
- Food provisioning services
- Recreation-related services
- Raw materials provisioning services
- Waste treatment services
- Water provisioning services

Types of valuation techniques that can be applied to natural and environmental resources include:

Revealed Preference Methods: Imputing values directly via markets or through behaviour.

Stated Preference Methods: Compiling data on willingness to pay and/or willingness to accept.

Value Transfer Methods: Using studies completed elsewhere to inform valuation.

Here the focus has been on the value transfer method (AKA benefit transfer method) as a means of completing the valuation without needing to obtain primary data. This approach has the benefit of being flexible and informative without being too resource and/or time intensive. The advice of the SNA and the SEEA-EA is that “where directly observed market prices are not available, they may be estimated by prices from similar markets; from related markets or using costs of production” (SEEA-EA, Chapter 9).

Value transfer tends to be more reliable when there is similarity between the two sites. The source-data settings for the value transfer are referred to as 'study sites' and the settings receiving estimates the 'policy sites'. In general, when applying the value transfer method it is important to recognise that the variation in values depends on the location and context in which the ecosystem services are supplied and used. This is important for a number of reasons including:

- The physical levels of service provisioning may vary spatially (e.g. carbon sequestration may vary depending on environmental variables such as soil condition and incidence of solar irradiation).
- The value of services may vary depending on proximity to human populations and their economic situation (e.g. recreation-related services are likely to be more relevant when a natural capital asset is close to a large population centre and is easily accessible).
- The value of services may be spatially heterogenous given underlying preferences are unlikely to be uniform across geographies (e.g. existence values may be linked to cultural connection to given natural capital assets and so are likely to vary between different sites and population groups) and institutional context may be different (e.g. rights of access to and use of ecosystems may differ across sites).

The value transfer approach can be considered in terms of two main approaches: unit transfers and value function transfers. Unit transfers refer to the use of a single estimate of the monetary value of an ecosystem service or a measure of the central tendency of multiple estimates to estimate ecosystem service values in other locations. Value function transfer adjusts values from primary study sites and applies a function to tailor the values to the transfer site based on existing research or understanding.

3.1. Deriving per hectare per annum ecosystem service values for Uganda

The monetary valuation was completed based on the asset register discussed in Section 2 above that was compiled from data obtained from ARIES for SEEA. Where previous valuation studies were completed within Uganda they were prioritised as the source of the value transfer. Values are all presented in 2018 int$ terms. Values based on studies in Uganda were found for the following:

Wetlands: Previous studies on the value of water provisioning, food provisioning, raw materials provisioning, and waste treatment services were identified. These were based at the Pallisa district wetlands, southwestern farmlands, the Kyoga plains, Lake Victoria crescent, Nakivubo wetlands, and the Doho rice irrigation system in Butaleja district. A mixture of different valuation techniques was used across these studies (Angella et al. 2014; Emerton et al. 1998; Kakuru et al. 2013; Nalukenge et al. 2009).

Fish Provisioning Services: The value of fish provisioning services at various lakes within Uganda is based on the value of the provisioning service per hectare of lake and river ecosystems at a national level. These values are based on 2018 numbers from the Fisheries Resources Accounts for Uganda. The approach to valuation in these accounts was the resource rent approach, whereby the costs of inputs and wages related to the production of fish for sale is subtracted from the market price so the value of the fish that is contributed directly by natural capital can be established (National Environment Management Authority 2021).

Crop and Livestock Provisioning Services: The value of crop and livestock provisioning services, which are inputs to valuing cropland and grassland ecosystem assets respectively, were based on the value of the provisioning service per hectare of cropland and grassland ecosystems at a national level. These values are based on 2018 numbers from the Land and Soil Improvement Accounts for Uganda. The approach to valuation in these accounts was to use market prices, as opposed to the resource rent approach due to data availability. As such, it is likely the values are an overestimate of the contribution of natural capital. However, they provide a useful indicator of the natural capital value and are more likely to be representative than taking values from other countries (National Environment Management Authority 2021).

Where specific values for Uganda were not available values were taken from the studies in the Ecosystem Services Valuation Database (ESVD) from across Africa. 508 values from studies across Africa were identified. The values were then adjusted by the relative gross national income of the study countries to Uganda based on gross national income data taken from the World Bank Data Explorer. This adjustment was made as value transfers with income adjustments have often been shown to perform better than function transfers in international contexts in terms of their validity and reliability (Johnston et al. 2021; Bateman et al. 2011; Czajkowski et al. 2017; Artell et al. 2019). Values were also converted to 2018 equivalent values wherever necessary.

There is not yet a consensus on specific variables that should be included in value transfer studies, however, adjusting for income and taking values from the same continent or region is likely to improve the results of the value transfer compared to cases where they are taken from different regions. Whilst it may have been beneficial to take values from only a set of neighbouring countries the trade-off in this instance to include all of Africa was employed to increase the sample size of study sites, as an increased sample size has also been associated with improvement in the results.

In order to derive total per hectare ecosystem service values for each ecosystem type, the values from all included services were added together (Table 4). In some cases, there were no values for a given service for a specific ecosystem type available in the ESVD dataset for African countries. In order to ensure that all relevant ecosystem service values were being included in the total for a given ecosystem type, the global average values were used to interpolate missing values. This was done by calculating the relative size of the Ugandan values calculated so far to global values where possible and using this proportion to infer values for the missing services relative to the known global values where necessary.

Table 4: Calculated per hectare per annum ecosystem service values by ecosystem type for Uganda.

Ecosystem Service Values (int$/ha/year)	Cropland	Bare Land	Grassland /Rangeland	Inland Wetlands	Rivers & Lakes	Temperate Forests	Tropical Forests	Urban	Woodland & Shrubland
Climate regulation	$12	$0	$337	$185	$310	$595	$566	$0	$110
Erosion prevention	$6	$0	$0	$0	$0	$0	$22	$0	$0
Existence	$0	$0	$0	$335	$0	$5	$14	$137	$0
Food	$484	$0	$690	$335	$13	$1	$52	$0	$0
Recreation	$12	$0	$54	$9	$198	$1	$5	$0	$0
Raw materials	$89	$5	$76	$835	$3	$2	$9	$0	$5
Waste treatment	$92	$0	$0	$4,715	$0	$0	$28	$0	$0
Water	$8	$81	$45	$675	$6	$0	$8	$0	$0
Sum of Service Values	$704	$86	$1,203	$7,090	$529	$604	$705	$137	$117

Another noteworthy point is that ecosystem service values may not simply be additive within a given ecosystem, and also are likely to vary depending on the distribution and quality (extent and condition) of neighbouring ecosystems. It is possible that gains in some ecosystem services are negatively associated with gains in others, given the interactions that may occur between ecosystem services. This is best addressed through understanding the relationships between different ecosystem services from the perspective of a set of condition accounts. However, the exact nature of such interactions is not yet fully understood (Smith et al., 2017).

We did not develop condition accounts given the scope of the piece of work and data availability. This should be considered where values are implemented for decision making. For example, when looking to conserve an area of wetlands it would be beneficial to consider the current condition of the wetlands and ensure that it is of an appropriate level already or is improved to increase the flow of ecosystem services it provides and optimise the benefits received.

3.2. Values of ecosystem assets on a per annum income basis

To calculate the values of ecosystem assets on a per annum income basis the ecosystem service values per hectare per year are multiplied by the extent values of each ecosystem type (Table 5).

Table 5: Calculated ecosystem asset values on a per annum income basis for Uganda.

Value per annum ($int)	Cropland	Bare Land	Grass-/Rangeland	Inland Wetlands	Rivers & Lakes	Temperate Forests	Tropical Forests	Urban	Woodland & Shrubland
Value 2012 ($)	8371103219	38378	1160898751	2666580715	1966739043	155507855	3345573528	7360271	261970018
Value 2018 ($)	8282891094	38378	1134922088	2658136582	1966896817	157757783	3491165610	8196192	253964745
Net change ($)	-88212125	0	-25976663	-8444133	157774	2249928	145592082	835922	-8005272

3.3. Values of ecosystem assets on a per hectare basis

To calculate the values of ecosystem assets on a per hectare basis we consider the net present value of each ecosystem asset (Table 6). The net present value is based on the value per annum of the ecosystem assets (Table 5). Net present value is calculated with respect to a 100-year asset life and a discount rate of 5%. These asset life and discount rate values are a rule of thumb extensively used across natural and environmental resource asset valuation.

To demonstrate the sensitivity of the values to the assumed discount rates the asset values under a 4% and 7% discount rate are also presented in Table 7 given values within this range are commonly applied. Where valuation is used for decision making the appropriateness of these different discount rates and the implications for the total values should be taken into consideration.

Table 6: Calculated ecosystem asset values on a per hectare basis for Uganda using a 100-year asset life and a 5% discount rate.

Value per hectare ($int)	Cropland	Bare Land	Grass-/Rangeland	Inland Wetlands	Rivers & Lakes	Temperate Forests	Tropical Forests	Urban	Woodland & Shrubland
Value 2012 ($)	13976	1704	23872	140721	10508	11992	13987	2717	2314
Value 2018 ($)	13976	1704	23872	140721	10508	11992	13987	2717	2314
Net change ($)	0	0	0	0	0	0	0	0	0

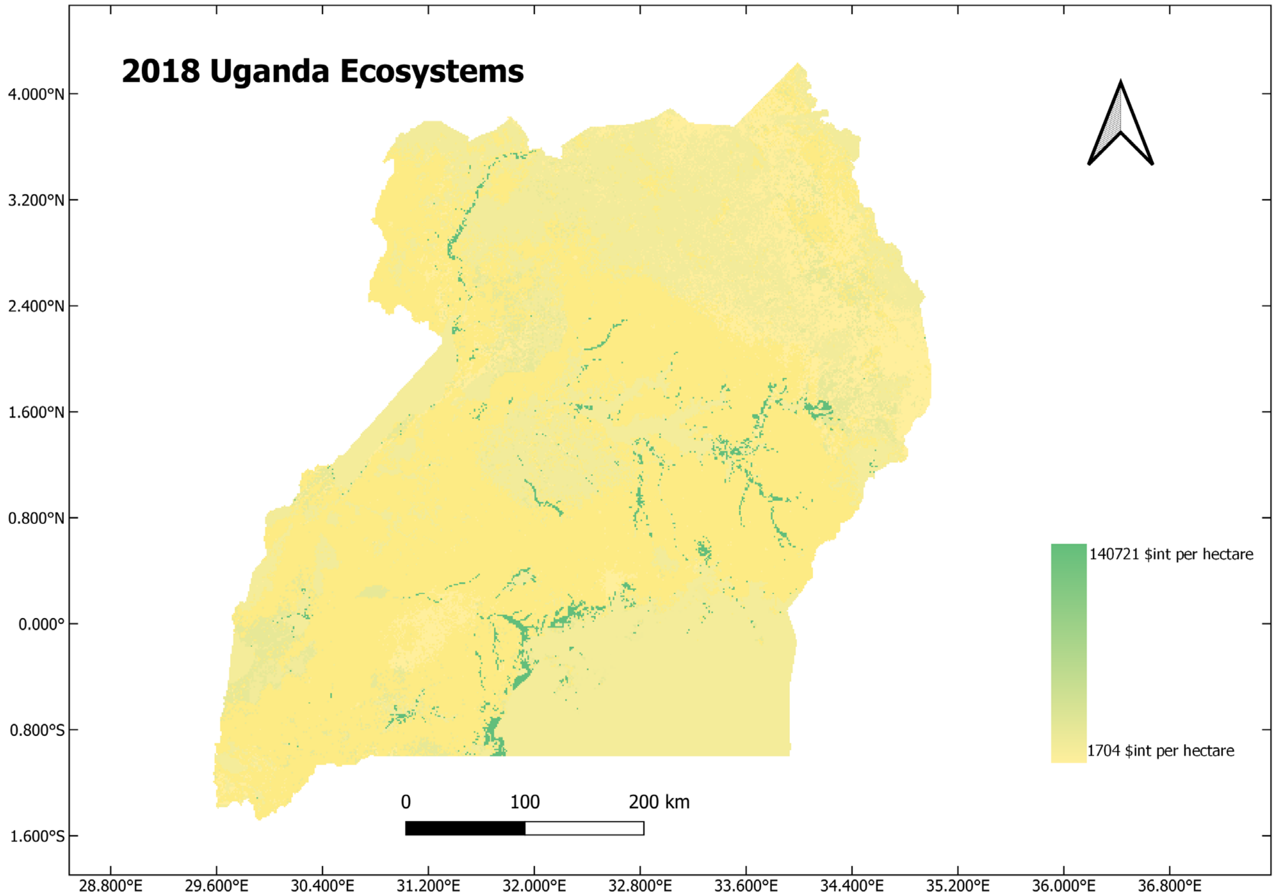
Table 7: Sensitivity check of ecosystem asset values on a per hectare basis for Uganda using a 100-year asset life and a 4%, 5%, and 7% discount rate.

Value per hectare ($int)	Cropland	Bare Land	Grass-/Rangeland	Inland Wetlands	Rivers & Lakes	Temperate Forests	Tropical Forests	Urban	Woodland & Shrubland
2018 ($) (4%)	17256	2104	29473	173739	12974	14805	17269	3354	2857
2018 ($) (5%)	13976	1704	23872	140721	10508	11992	13987	2717	2314
2018 ($) (7%)	10048	1225	17162	101168	7555	8621	10056	1953	1664

3.4. Values of ecosystem assets in maps showing the distribution of values across Uganda

Figure 4 shows a map of ecosystem asset value in Uganda. Given the minimal change in extent between 2012 and 2018, maps of the two time periods are indistinguishable so only the map for 2018 is included here for brevity. The map clearly outlines areas where wetlands exist as being of high value and suggests that the main discernible distinction outside of wetlands is whether the ecosystem type is cropland or non-cropland given the large proportion of Uganda that is taken up by cropland ecosystems, as visible in Figure 3 above.

Figure 4: Maps of ecosystem asset value across Uganda in the years 2012 and 2018 based on the determined values of the underlying ecosystem types. Given the similarity between the maps only the 2018 map is shown here.



4. Discussion and Future Directions

4.1. Data sources, references, and summary of methods

As discussed above, the estimation of the economic value of natural and environmental resources is dependent on the collation of data on multiple parameters. To apply the value transfer method the primary data needs are ecosystem extent for each relevant ecosystem type and a per hectare ecosystem service value for each relevant ecosystem service in each relevant ecosystem type. Where these data are collected the general method is to:

1. Compile an asset register at a scale that is relevant to your use case.
2. Adjust per hectare ecosystem service values to be context relevant wherever possible.
3. Apply total per hectare ecosystem service values to the asset register data.
4. Calculate asset value on a per hectare basis

Ecosystem extent data by ecosystem type can often be obtained from national statistical offices, as well as a variety of other public sources. The data used in this study is from ARIES for SEEA and the Uganda Bureau of Statistics. Links to these sources, along with some other optional sources for future reference are included below. In addition, the United Nations have published a recording of a webinar held for the Africa Natural Capital Community of Practice that provides some useful context on the use of ARIES for SEEA in natural capital accounting. A link to this webinar is also provided below.

- Uganda Bureau of Statistics – Land Statistics
- ARIES for SEEA
- Copernicus
- Esri
- USGS
- Africa Natural Capital Accounting Community of Practice Webinar

Per hectare ecosystem service values data for value transfer is data sourced from pre-existing valuation studies. In general, this data can be taken from a wide variety of sources often including academic papers, government reports, and reports by international financial institutions such as multilateral development banks. The ESVD provides a compiled dataset of many studies that can be used for value transfer. ESVD can be used to identify specific studies by searching in the database or provide aggregate datasets for estimation of representative measures. Data in this study was taken from the ESVD data on studies performed within Africa and existing sets of accounts for Uganda. The Environmental Valuation Reference Inventory represents another useful information source that can be used in future work.

- Ecosystem Services Valuation Database (ESVD)
- Environmental Valuation Reference Inventory
- Fisheries Resources Accounts for Uganda
- Land and Soil Improvement Accounts for Uganda

Where possible, adjustments should be made to per hectare ecosystem service values to make them as context relevant as possible for a given application. As noted above, when value transfer is occurring in international contexts there is evidence that adjustments on a per-income basis can increase performance. Here adjustments were made using Gross National Income data sourced from the World Bank Data Explorer and applying it to values taken from studies in the ESVD.

- World Bank Data Explorer

4.2. Discussion of results

This study employed the value transfer method to obtain a set of per hectare ecosystem service values to enable a national scale valuation of Uganda's natural and environmental resources. As with all value transfer studies, which is often the only feasibly available approach when completing studies on a national scale, it is important to consider the appropriateness of the values for use in making decisions on specific investments. The values provide a guide as to what ecosystem types are most and least valuable, where future work on valuation may be beneficial, and where high value ecosystem assets are likely to be concentrated.

The total magnitude of the values for each ecosystem type that were obtained in this study differs quite significantly relative to the global average values. However, this is to be expected given the global average values are based on a large number of studies and are based on averages across the database, which includes a disproportionately large number of European studies given the maturity of natural capital accounting within Europe. As values are dependent on economic variables such as income, which is above global averages across much of Europe, this inflates the global average values. This is particularly evident in that the country with the most values in the ESVD is the United Kingdom. The ESVD Global Update Report 2020 advises that global values should not be used for value transfers, given "they reflect the underlying ecological and socio-economic contexts of diverse (but not necessarily representative) study sites." Hence, the focus here was on adjusting values to be as context appropriate as possible.

The valuation performed here suggests that the highest value ecosystem type within Uganda is wetland ecosystems. This is followed by grass-/rangeland ecosystems. In general, the suggestion that wetland ecosystems are particularly high value is reasonable given the important role of wetlands in regulating water and nutrient flows, as breeding grounds for diverse groups of species, and as hotspots of carbon sequestration. However, the values used here are from a small set of wetlands within Uganda and may not necessarily be representative of wetland values across Uganda overall. The lowest value ecosystem type identified here within Uganda is bare land ecosystems, this also aligns with general expectations given the low productivity of these ecosystems.

Future work focussed on obtaining new values in Uganda from a variety of valuation methods would increase the level of confidence in the values that have been obtained here. However, given resource constraints this is not always possible. Where specific investments are to be made more granular value transfer approaches could be applied where details on the specific context of the site of interest are taken into account and a set of particularly suitable studies for value transfer are identified and adjustments are made to the values provided here. Particular focus should be given to rivers and lakes and tropical forests as the values obtained here appear low relative to expectations for these generally highly productive and important ecosystems.

As identified in Section 2 above there is also not an appropriate publicly available set of data on ecosystem types across Uganda that is spatially defined. ARIES for SEEA provides a useful dataset, however, comparisons with other datasets and validation of the data to agree on a set of values would increase confidence in the results obtained.

4.3. Applying natural and environmental resource valuation in decision making

The Government of Uganda has adopted natural capital accounting and launched a national plan. Part of this national plan involved the development of the first sets of natural capital accounts within Uganda, data from which was utilised as part of this study. Next steps should be focussed on expanding the role of natural capital accounting within Uganda and utilising natural and environmental resource valuation in decision making. This should be considered in line with the natural capital investment model discussed in Section 1.2 above. Key areas of focus where the values calculated in this study could be useful include initiatives related to environmental management, tourism, project appraisal, and risk analysis.

Environmental Management and Tourism: Using the results of this study, important areas that contain multiple high value ecosystem types should be identified. If this is overlayed with considerations from other relevant data, such as population data, the identification of important areas could be further improved. Identifying these areas will provide a view of where environmental management, tourism, and other nature-related activities could be targeted. By adjusting values to be more context specific clearer recommendations on activities that should be undertaken can be made with data to back the decision-making process.

Risk Analysis: In addition to identifying high value areas, natural and environmental resource valuation can be used to understand nature-related risks in a given area and how they can be transmitted into financial risks. This line of thinking is similar to that employed in the Taskforce on Nature-related Financial Disclosures (TNFD); a private sector initiative focussed on understanding nature-related risks to organisations. By understanding these risks, specific investment activities targeted at de-risking a given landscape can be identified. Some benefits that could be obtained can also be directly linked to disaster risk reduction initiatives, for example where flooding and storms pose risks to communities and businesses protective ecosystem services can materially change the risk profile in a given area.

Project Appraisal: As noted, valuation of natural and environmental resources can assist in the identification and understanding of risks. Conversely, it can also assist in the identification of opportunities and the appraisal of projects. This could involve, for example, drawing linkages directly to the Sustainable Development Goals to ensure links to development initiatives are clear.

Application of environmental valuation to the appraisal of projects can be informative even where the projects are not inherently seen as nature-related. For example, where a piece of infrastructure is proposed for development and its construction would require the removal of natural ecosystems if these ecosystems were high value the risks associated with their removal, and the economic and social impacts that could occur as a result of their removal, should be considered in depth as part of the project appraisal process. Alternatively, projects could be nature focussed green infrastructure solutions (e.g., planting vegetation for erosion control).

Consider that a natural and environmental resources valuation approach extends the basic model of the economy to focus on the value derived from ecosystem services. Ultimately, ecosystem services affect total welfare, and can be considered as part of a cost-benefit or cost-effectiveness analysis. Consider the following examples:

- A project is considering the replacement or repair of a stormwater pipe that releases outflow into a lake. The reason for the project is to mitigate the risk of the stormwater runoff reducing the quality of the water in the lake, which could ultimately have impacts on the environment and people's health and wellbeing. An understanding of the value of the ecosystem services provided by the lake (e.g., water provisioning, fish provisioning, etc.) would help inform the priority of the project. Possible alternative solutions to the problem could include planting of vegetation that would provide water purification services. If the value of these services is higher than the costs of planting the vegetation, this may represent a cost-effective manner of improving the water quality. Depending on the specific situation, this planting may be able to reduce the costs of the project by either negating the need for replacement of the stormwater pipe or reducing overall repair costs.
- Consider a housing development where regular flooding events are a known risk. These floods may lead to damage to properties, which both increases costs for the owners and tenants of the properties and increases risks to financing institutions (i.e., lenders and insurers). In trying to reduce the risk associated with flooding, some solutions that could be suggested could include creating artificial wetlands and/or putting in physical drainage infrastructure. By understanding the ecosystem services that could be provided by the wetlands, the value the wetlands could provide less their installation and maintenance costs could be compared with the physical drainage infrastructure installation and maintenance costs. This would enable a cost-effectiveness analysis to be undertaken that will assist in identifying the project that will use funds most efficiently.

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Appendix 1: Mapping of aggregate groupings used in this study to ARIES for SEEA and Uganda Bureau of Statistics Classifications

Aggregate Groupings	ARIES for SEEA Classifications	Aggregate Groupings	Uganda Bureau of Statistics Classifications
Cropland	Cropland	Cropland	Farmland small scale
		Cropland	Farmland large scale
Bare Land	Rocky pavement lavaflow scree	Bare Land	Impediments
Grass/Rangeland	Temperate subhumid grassland	Grass/Rangeland	Grassland
Grass/Rangeland	Tropical subtropical savanna		
Inland Wetlands	Intertidal forest shrubland	Inland Wetlands	Wetland
Inland Wetlands	Episodic arid floodplain		
Inland Wetlands	Tropical flooded forest peat forest		
Inland Wetlands	Boreal cool temperate palustrine wetland		
Inland Wetlands	Warm temperate tropical marsh		
Rivers and Lakes	Aquatic	Rivers and Lakes	Open water
Temperate Forests	Temperate forest	Forests	Hardwood plantation
Temperate Forests	Subtropical warm temperate forested wetland		
Tropical Forests	Tropical subtropical lowland rainforest		Softwood plantation
Tropical Forests	Tropical subtropical montane rainforest		Tropical High Forest normal stock
Tropical Forests	Tropical subtropical dry forest thicket		Tropical High Forest low stock
Urban	Urban industrial ecosystem	Urban	Built up areas
Woodland & Shrubland	Temperate woodland	Woodland & Shrubland	Woodland
Woodland & Shrubland	Seasonally dry tropical shrubland		
Woodland & Shrubland	Cool temperate heathland		Bushland
Woodland & Shrubland	Seasonally dry temperate heath shrubland		

Appendix 2: Detailed natural and environmental asset register for Uganda derived from ARIES for SEEA (2012-2018)

	Ecosystem Type									
Extent	**Aquatic**	**Boreal cool temperate palustrine wetland**	**Cool temperate heathland**	**Cropland**	**Episodic arid floodplain**	**Intertidal forest shrubland**	**Rocky pavement lavaflow scree**	**Seasonally dry temperate heath shrubland**	**Seasonally dry tropical shrubland**	**Subtropical warm temperate forested wetland**
2012 (ha)	3714742	1490	1192	11887800	104267	5958	447	2004313	211364	9384
2018 (ha)	3715040	1490	1192	11762530	103969	6107	447	1931922	211662	9235
Net change (ha)	298	0	0	-125270	-298	149	0	-72391	298	-149
Extent	**Temperate forest**	**Temperate subhumid grassland**	**Temperate woodland**	**Tropical flooded forest peat forest**	**Tropical subtropical dry forest thicket**	**Tropical subtropical lowland rainforest**	**Tropical subtropical montane rainforest**	**Tropical subtropical savanna**	**Urban industrial ecosystem**	**Warm temperate tropical marsh**
2012 (ha)	248007	149	30237	1192	2760995	1623589	362850	965067	53772	263200
2018 (ha)	251880	149	33663	1192	2927078	1648315	378639	943469	59879	262158
Net change (ha)	3873	0	3426	0	166083	24726	15789	-21598	6107	-1043

Appendix 3: Detailed Natural and environmental asset register for Uganda derived from Uganda Bureau of Statistics land-cover statistics (2015)

Region/Subregion/ District	2015 Extent by Ecosystem Type (ha)												
	Hardwood plantation	Softwood plantation	Tropical High Forest normal stock	Tropical High Forest low stock	Woodland	Bushland	Grassland	Wetland	Farmland small scale	Farmland large scale	Built up areas	Open water	Impediments
CENTRAL	13,836	32,212	70,889	36,697	278,478	444,610	669,963	253,570	2,047,944	53,109	73,140	2,164,464	1,498
CENTRAL NORTH	4,940	30,462	1,607	6,272	222,214	322,561	330,020	112,091	1,004,894	12,642	11,261	55,738	255
KAYUNGA	5	197	95	2,111	8,026	14,326	13,281	17,787	96,928	3,497	1,355	12,632	
KIBOGA	43	679		83	15,892	30,483	32,543	10,763	62,197	26	765	57	
KYANKWANZI	517	9,914		64	16,924	65,360	41,444	7,911	107,273	67	1,437	74	35
LUWEERO	445	713	221	107	19,122	17,329	27,366	12,545	140,199	1,332	2,678	82	30
MITYANA	1,643	721	514	1,402	3,883	10,348	2,994	6,989	114,757	2,535	1,420	9,873	53
MUBENDE	2,088	11,597	778	2,193	13,817	47,579	37,128	15,012	321,107	3,050	1,688	6,523	82
NAKASEKE	200	3,588		116	76,052	83,795	75,510	19,941	85,574	1,120	1,020	303	5
NAKASONGOLA		3,053		196	68,497	53,340	99,753	21,142	76,860	1,015	899	26,194	50
CENTRAL SOUTH	8,896	1,749	69,282	30,425	56,264	122,049	339,943	141,479	1,043,050	40,468	61,879	2,108,726	1,242
BUKOMANSIMBI	34				1,305	969	1,651	4,480	51,703		67		
BUTAMBALA	288	56	819	2,621	1,064	1,894	2,619	4,124	26,379		590		31
BUVUMA				2,120	4,230	714	5,727	745	15,177		119	809,977	23
BUYIKWE	343	353	17,518	8,673	2,054	2,679	8,355	2,005	62,730	15,788	1,927	23,033	17
GOMBA	291	54	259	758	18,452	28,434	28,639	11,435	76,877	407	344	1,645	79
KALANGALA			10,058	4,096	6,050	915	5,617	2,370	6,232	8,175	291	863,027	36
KALUNGU	343			20	413	2,440	8,342	12,551	54,409	18	868	4,217	8
KAMPALA	17				88	257	491	706	773		15,582	1,768	18
LWENGO	221				160	6,744	6,166	1,871	76,795		312	31	
LYANTONDE				58	1,824	11,710	36,731	409	36,323		141	54	110
MASAKA	449		8,928	2,578	1,302	5,655	29,041	6,696	68,356	15	1,032	108,693	290
MPIGI	2,112	533	1,556	2,165	3,087	4,548	9,526	26,323	67,369	1,011	1,612	32,518	44
MUKONO	2,033	342	12,748	5,108	5,613	6,026	8,361	19,967	105,165	9,903	8,105	97,744	160

Region/Subregion/ District	2015 Extent by Ecosystem Type (ha)											
	Hardwood plantation	Softwood plantation	Tropical High Forest normal stock	Tropical High Forest low stock	Woodland	Bushland	Grassland	Wetland	Farmland small scale	Farmland large scale	Built up areas	Open water	Impediments
RAKAI	411	26	17,396	1,117	1,010	14,167	116,422	20,176	155,722	580	657	75,819	16
SEMBABULE	27	3		422	5,451	27,174	63,049	4,448	130,778		282	179	104
WAKISO	2,327	382		689	4,163	7,723	9,206	23,173	108,262	4,572	29,952	90,021	306
EASTERN	4,945	12,359	58,635	13,015	19,263	148,918	214,954	262,899	2,201,166	29,979	15,883	965,910	13
EAST CENTRAL	3,968	10,264		2,950	2,583	22,647	9,982	73,630	855,918	17,172	8,573	849,867	
BUGIRI	2,827	312				2,895	518	8,394	85,012	1,584	858	2,677	
BUSIA	53	23		2,590	78	1,258	160	4,654	63,938	0	295	2,891	
BUYENDE	8	6			595	7,405	1,506	13,355	107,043		255	57,635	
IGANGA		98				1,496		5,853	93,013	101	1,365		
JINJA	793	2,330		237	20	333	597	472	48,728	10,658	2,977	5,121	
KALIRO		0				344	242	12,975	63,878		243	9,171	
KAMULI		125			952	5,759	2,544	5,377	134,341	163	793	5,441	
LUUKA		91				219	197	1,893	62,024	452	163		
MAYUGE	212	6,830			770	1,412	2,021	4,409	85,998	4,214	1,216	356,779	
NAMAYINGO		431		123	168	556	1,677	2,203	46,850		164	409,850	
NAMUTUMBA	75	17				971	519	14,045	65,092		245	304	
ELGON	890	1,719	58,467	10,065	11,090	36,013	75,632	19,946	376,074	11,821	2,981	68	10
BUDUDA	66		8,638	549	398	842	2,027		14,863		6		
BUKWO	111	801	14,506	2,454	2,788	6,939	6,317		16,825	1,789	29		
BULAMBULI			5,757	2,248	3,407	10,072	21,864	945	20,838	8	124		
BUTALEJA		2				20		12,402	46,532	6,411	154	25	
KAPCHORWA			10,355	1,087	1,285	2,189	2,693		20,297		330		10
KWEEN	11	855	5,508	542	2,165	11,276	39,527	157	20,715	1,474	140		
MANAFWA	0		7,986	1,292	306	517	18		47,828		129		
MBALE	575		1,188	1,132	348	465	34	81	46,688	210	1,096		
SIRONKO			4,528	760	388	1,266	3,005		33,809	55	316		

Region/Subregion/ District	2015 Extent by Ecosystem Type (ha)												
	Hardwood plantation	Softwood plantation	Tropical High Forest normal stock	Tropical High Forest low stock	Woodland	Bushland	Grassland	Wetland	Farmland small scale	Farmland large scale	Built up areas	Open water	Impediments
TORORO	127	62			6	2,429	146	6,362	107,679	1,874	657	43	
TESO	87	376	168		5,590	90,258	129,340	169,324	969,173	986	4,329	115,974	3
AMURIA					91	25,943	22,015	14,559	194,092		1,323	276	
BUDAKA					8	188	114	1,421	38,636	653	41		
BUKEDEA		68			1,354	7,927	11,682	7,388	76,847		138	62	
KABERAMAIDO	18	11	168		2,235	5,746	1,935	11,627	109,296		616	30,746	
KATAKWI					478	32,066	82,101	28,609	89,785	66	760	9,287	
KIBUKU						424	302	9,532	38,084		115	543	
Pivot	69				733	4,507	2,713	14,026	79,764		114	5,400	
NGORA					9	1,785	963	22,211	40,060		24	6,969	3
PALLISA						1,147	2,513	23,969	74,731		135	6,619	
SERERE		297			629	4,414	3,513	22,834	113,451	267	313	50,973	
SOROTI					53	6,110	1,490	13,147	114,428		751	5,101	
NORTHERN	5,548	5,357	314	2,131	533,265	1,006,051	3,045,334	82,616	3,554,141	96,814	32,885	173,113	1,851
ACHOLI	777	838			173,389	229,352	893,724	6,601	1,407,745	88,904	14,035	11,972	792
AGAGO	8				10,177	50,520	78,333	88	209,338	58	1,626		96
AMURU	167	137			34,310	25,519	123,776	3,231	208,724	33,152	1,595	3,418	263
GULU	534	701			20,183	11,253	36,330	1,099	253,574	1,028	3,606	394	160
KITGUM	5				34,239	31,300	177,448		165,814		2,580	7	
LAMWO	7				23,794	39,216	263,851	10	186,383	36,672	1,874	251	20
NWOYA	38				45,346	22,949	150,238	2,006	161,650	17,787	908	7,398	250
PADER	18				5,341	48,596	63,747	168	222,261	208	1,844	505	2
KARAMOJA	71		45		191,357	498,666	1,733,463	1,484	331,236	74	2,769	292	351
ABIM					7,851	41,886	136,862	288	47,127		1,226	26	6
AMUDAT			45		15,001	20,107	118,546		10,037		134		
KAABONG	28				58,898	158,701	442,395		66,119		42	154	37

Region/Subregion/ District	2015 Extent by Ecosystem Type (ha)												
	Hardwood plantation	Softwood plantation	Tropical High Forest normal stock	Tropical High Forest low stock	Woodland	Bushland	Grassland	Wetland	Farmland small scale	Farmland large scale	Built up areas	Open water	Impediments
KOTIDO					8,175	61,409	233,802	0	59,469			12	24
MOROTO	43				64,360	78,926	170,999		38,733		596	36	144
NAKAPIRIPRIT					27,361	67,382	277,288	1,196	46,221	74	23		
NAPAK					9,711	70,255	353,570		63,529		749	64	140
LANGO	328	3,324	93	523	28,223	118,067	80,101	49,697	959,678	409	6,462	127,054	254
ALEBTONG	5				617	12,124	6,607	1,184	131,572		362	483	
AMOLATAR					2,825	5,553	8,173	7,167	68,264		846	78,116	
APAC	22	386	93	432	14,766	24,668	26,343	13,079	209,411		1,606	37,651	43
DOKOLO		2,938			811	7,944	2,971	7,189	76,908		271	9,699	
KOLE	15				777	13,790	2,923	1,320	85,933		241	26	21
LIRA	212				716	12,480	3,777	40	113,886		1,107	288	55
OTUKE					2,780	23,399	22,050	497	105,276		662	222	4
OYAM	74			91	4,931	18,109	7,258	19,220	168,427	409	1,365	570	131
WEST NILE	4,372	1,195	177	1,607	140,295	159,966	338,046	24,834	855,483	7,427	9,620	33,795	454
ADJUMANI			177	1,607	52,922	50,999	73,329	7,151	107,919	6,521	782	7,292	3
ARUA	1,644	362			24,629	27,103	89,114	6,250	272,482	119	3,057	5,001	156
KOBOKO	397	40			6,251	3,927	4,851	14	58,947	11	1,124		60
MARACHA	868	4			403	4	177		42,050		1,082		4
MOYO	4				30,468	42,372	38,658	8,167	57,539	85	384	11,264	131
NEBBI	17				6,252	16,371	46,275	1,700	117,906	392	1,447	9,114	34
YUMBE	319	92			14,201	17,400	76,232	1,399	128,322	289	954	1,089	4
ZOMBO	1,124	697			5,170	1,790	9,409	153	70,319	12	788	33	63
WESTERN	19,907	13,559	399,287	50,021	381,945	367,655	1,167,122	116,395	2,471,718	75,948	13,658	446,094	4,418
SOUTH WESTERN	7,779	9,592	127,786	8,849	54,207	122,881	704,346	37,482	1,014,834	5,962	4,690	69,851	300
BUHWEJU	206		13,674	1,681	601	1,591	22,422	20	26,993		6		
BUSHENYI	1,178	83	19,068	1,612	2,248	1,542	12,601	1,058	44,672	2,401	241	149	14

Region/Subregion/ District	2015 Extent by Ecosystem Type (ha)												
	Hardwood plantation	Softwood plantation	Tropical High Forest normal stock	Tropical High Forest low stock	Woodland	Bushland	Grassland	Wetland	Farmland small scale	Farmland large scale	Built up areas	Open water	Impediments
IBANDA	314	44	3,386	424	1,102	4,692	12,904	154	73,316	51	662	72	47
ISINGIRO	75	798			1,193	21,401	146,337	8,552	82,639		113	3,979	3
KABALE	1,545	2,524	8,654	118	5,535	9,214	10,204	2,320	124,901	1,874	277	5,801	
KANUNGU	1,370	2,245	19,819	529	3,524	6,674	16,970	109	75,608	329	110	1,929	
KIBINGO	300	77			1,185	2,201	36,601	2,217	27,543		165		5
KIRUHURA	334	23		6	14,860	26,616	219,980	8,352	184,876		416	4,652	152
KISORO	116	74	9,956	206	754	1,614	724	398	55,719	213	124	3,071	
MBARARA	454	1,359		33	1,845	10,613	69,486	5,212	88,562	59	1,692	78	
MITOOMA	421	15	2,828	128	1,834	1,666	2,948	303	47,391	218	18	38	7
NTUNGAMO	304	1,820			835	12,968	96,005	7,230	84,685	773	389	531	10
RUBIRIZI	556	381	32,645	3,049	13,101	12,719	26,716	788	19,337	44	171	37,524	53
RUKUNGIRI	606	150	17,755	1,061	5,589	9,368	30,447	770	78,591		307	12,027	7
WESTERN	12,129	3,967	271,501	41,172	327,738	244,774	462,776	78,914	1,456,884	69,986	8,968	376,244	4,119
BULIISA			31,495	1,176	44,027	30,079	76,496	7,886	19,939	25	123	76,679	51
BUNDIBUGYO		67	38,275	1,484	4,908	2,098	3,791		34,365		565	124	
HOIMA	1,002	387	37,578	5,835	15,478	48,587	32,449	5,433	215,008	2,912	1,000	227,536	80
KABAROLE	1,169	63	40,760	5,605	6,546	3,604	11,863	1,727	100,563	8,793	705	991	58
KAMWENGE	1,046	252	25,143	3,363	10,627	19,502	20,854	7,060	148,664	65	660	6,604	104
KASESE	375	39	38,160	5,768	33,325	12,150	83,282	12,742	85,542	21,087	1,712	42,049	2,734
KIBAALE	71	46	14,869	5,062	11,110	27,143	4,843	12,539	345,173	1,198	1,449	214	892
KIRYANDONGO		35	597	2,551	125,128	39,833	80,310	4,985	99,009	5,460	863	4,032	4
KYEGEGWA	3,957		3,434	4,683	5,223	12,833	8,781	2,880	132,547		205	51	133
KYENJOJO	4,247	1,685	24,334	2,730	2,044	16,776	10,708	7,680	153,556	6,494	405	12	44
MASINDI	263	149	16,647	2,914	55,304	28,282	41,800	7,383	115,752	23,952	994	72	19
NTOROKO		1,243	208	0	14,020	3,888	87,599	8,600	6,767		288	17,880	