UN-REDD PROGRAMME

République Démocratique du Congo
Ministère de l'Environnement, Conservation de la Nature et Tourisme
Direction des Inventaires et Aménagement Forestiers

Multiple Benefits in the Democratic Republic of the Congo: Valuation and Mapping Feasibility Study

UN-REDD PROGRAMME

Technical report 23/02/2015

The National REDD Coordination of the Democratic Republic of the Congo (Coordination Nationale REDD, CN-REDD) is leading the REDD+ process in the Democratic Republic of the Congo. It is part of the Ministry of Environment, Nature Conservation and Tourism.

The UN-REDD Programme is the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in September 2008 to assist developing countries prepare and implement national REDD+ strategies, and builds on the convening power and expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

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Prepared by Blaise Bodin, Ulf Narloch, Ralph Blaney, Agnes Hallosserie
Supervised by Kate Trumper

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UNEP WCMC

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EXECUTIVE SUMMARY

1. Background:

The objective of this study is to scope out existing data, and information more widely, on forests in the DRC for the mapping and valuation of environmental services, both in terms of indirect (soil, water) and direct (Non-Timber Forest Products, tourism, high value timber) use benefits. Based on these findings it then offers a way forward for the DRC to proceed to a valuation of forest multiple benefits.

2. Overall findings:

Economic valuation of environmental services is a relatively young field. It was very difficult to find studies with robust methodologies, especially in a country like the DRC where data is so scarce. Moreover, for some services it is not only the economic analyses that are lacking but also a clear scientific demonstration linking forest cover to the provision of a given service, which is crucial in making the economic case for the multiple benefits of REDD+.

Indirect benefits are difficult to map and value and the only studies that have attempted to do so at the country level are not robust or precise enough to support land use planning. Direct benefits are much easier to quantify and value (but not necessarily to map). Here the main difficulty is determining maximum sustainable rates of extraction.

A brief summary of the main findings for the five benefits considered (soil, water, NTFPs, tourism and high value timber) is provided below:

2.1. Soil:

A draft report by WWF from 2009 (Shapiro et al. 2009) could provide a good basis for an InVEST type modelling of erosion control services at the watershed scale. The impact of this erosion could be valued through estimation of avoided costs of dredging in waterways or in dam reservoirs. Soil fertility seems more difficult as the link to forest cover is only relevant in complex mosaic landscapes. Slash-and-burn is an obvious case but with issues of compatibility with carbon benefits. Agroforestry does not appear to be practiced very much in the DRC (an economic case could be made for it based on a comparison of the overall agricultural productivity/carbon storage budget with slash-and-burn systems).

2.2. Water:

Valuing water quality through market prices would be problematic given the high proportion of the population not connected to a formal water distribution system. At best, soil erosion control to avoid siltation could be prioritized in populated areas. As for water quantity, the scientific evidence that forest cover in a given watershed increases runoff is controversial. The role of forest in the regulation of water flows is better established, but would require data on the occurrence of floods, landslides and local drought events (which is not available from the literature).

2.3. Non-Timber Forest Products (‘NTFPs’):

The terms of reference for this study included bush meat and fuelwood as part of the NTFPs to be considered. These forest products indeed appear to be the two biggest in terms of trade value. However, presenting them as multiple benefits of REDD+ is problematic. The reduction of fuelwood consumption is a priority of the national framework REDD+ strategy, as part of reforestation and integrated agriculture and forest landscapes activities. This makes it difficult to describe fuelwood (at least at the levels currently harvested) as a “Multiple Benefit” of standing forests stocks. As for bush meat, beyond the lack of consistent data, valuing it as a multiple benefit of forests would require establishing Maximum Sustainable Yields for each species. The mapping of bush meat as a benefit is also very difficult if based on species distributions, due to the complexity of dispersion and population dynamics of animal species.

2.4. Recreational value/tourism:

The DRC has the potential to support two main kinds of recreational activities: nature tourism and recreational hunting. Both remain largely underdeveloped to this date due to poor tourism infrastructure, the country’s perceived insecurity, and the relative inaccessibility of many sites of interest. In view of these difficulties, a valuation of these benefits can only be of their potential should the situation improve, rather than a picture of their actual worth. Gorilla tourism seems to be, by far, the most significant and most researched source of benefits in terms of recreational value. The potential of the country is easy to estimate from levels previous to the civil war and similar gorilla ecotourism parks in Rwanda and Uganda. Wilkie and Carpenter (1999) have also established a set of criteria for successful ecotourism sites which could be used for mapping of areas with potential.

2.5. High value timber:

Mapping and valuation of this service would require a clear view on how to make exploitation compatible with REDD+ carbon benefits, through systems for low-impact logging in community forests or industrial concessions. This is made difficult by the very high proportion of the logging sector that remains informal. Moreover, the current management model of logging companies in the DRC already consists of ‘creaming off’ the best species in the best patches. As infrastructure and security improve it may become more profitable to exploit less valuable species and to go further away from the rivers, which increases the impact of logging.

2.6. Interdependencies:

An additional difficulty to a valuation exercise is the extent to which the multiple benefits can be superimposed without taking into account the interactions between them, i.e. whether they are completely independent, or if in some cases their use conflicts, or can provide synergies. One example is that of high value timber logging and keeping bush meat hunting within sustainable levels, because loggers will often rely on bush meat for their food supply. Logging might also have a broader impact on NTFPs of importance for subsistence livelihoods (Ndoye & Tieguhong 2004). On the other hand, this interdependence between ecological processes could open up new avenues for the valuation of certain services.

3. Conclusion:

This study has found that the tangible value of the multiple benefits from forests in the DRC to the country’s people and economy are likely to be substantial. Deforestation results in a loss of these benefits, and over time this can become a significant loss. However, the data available is insufficient for anything much beyond awareness-raising. Where there is a shortage of existing data to use for mapping and valuation of forest benefits, as in this case, there is really only one way forward if REDD+ planners wish to utilise such information in their decision-making; this is commissioning further data collection. Although this can be an expensive process, work can be prioritised on the most important benefits. The potential outcome is that the long-term net benefits to the DRC from REDD+ would be fully exploited.

4. Recommendations:

The report ends with recommendations of how a (least-cost but sufficient) valuation process can be taken forward in terms of a plan for pilot studies. These can be used to inform a forest-wide spatial valuation. The activities that would need to be undertaken to deliver this are laid out, along with estimates of the resources required.

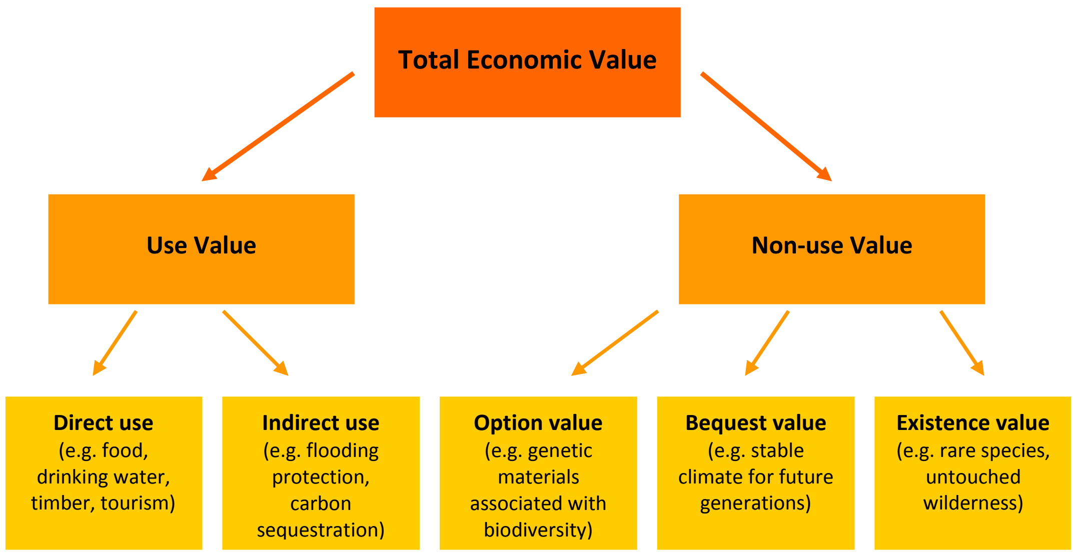
INTRODUCTION

The concept of multiple benefits (sometimes also referred to as ecosystem services) is helping decision-makers realize that forests are more than just a place where trees grow. In the past it has been the case that decisions about land use were made on very partial economic considerations, with many of the values of forests being ignored. However, the multiple benefits of forests are now starting to be recognized. Nevertheless, since markets currently do not exist to reflect many of the functions that forests perform, it is important to ensure that mechanisms are in place to recognize and maximize the value of forests to national wellbeing. If natural assets, such as forests, are constantly eroded then the economy will not be on a sustainable footing.

This is where the processes of valuation and mapping are aligned. For there is a need to both value and map the benefits of forests in order to inform land use planning. Areas can then be prioritised for conservation, under REDD+ for instance, on the basis of where benefits exceed costs (opportunity and transaction). Generally the process of valuation precedes that of mapping, although it may be iterative in some instances, and for some decisions mapped functions (qualitative or quantitative) without valuation will be adequate.

This study attempts to take forward the valuation of multiple forest benefits process in the DRC as far as possible based on the current literature available. It also identifies methods for valuation where the current data is missing or of poor quality. It identifies the information available for mapping benefits, and what further information is required.

There are different approaches to valuation of the environment; some adopt a non-economic approach. This study utilises an economic approach, with valuation referring to monetary figures. Economic valuations of forests (and the environment more generally) are based on the view of ecosystems as a source of goods and services for human benefit. Valuation is therefore essentially about human utilisation of these natural assets. In this approach, it is the summed value of the perceived functions for human well-being that determines their total economic value. The framework of Total Economic Value is set out in the diagram below.



Total Economic Value (TEV) recognises that there are two main sources of value: use value and non-use value. Use value can be divided into direct use (which refer to ecosystem goods and services that are used directly by human beings) and indirect use. Non-use values refer to the value that people derive from goods and services independent of any present use (or use value to them in their lifetime). Non-use values can be subdivided into option, bequest, and existence (though whether option value is use or non-use is debated).

A number of economic valuation methods have been developed to estimate the value of changes in the provision of environmental (including forest) goods and services. These methods are divided into direct market price, revealed preference and stated preference methods. Different valuation methods are suited to valuing different aspects of the environment. No single method is necessarily the best for valuing all resources - the selection of which method to apply will be context specific and dependent on whether or not the environmental service is traded (directly or indirectly) in a market, the availability of existing information on the value of similar resources, as well as the budget available for conducting a new valuation study.

If economic studies have been undertaken previously on the environmental asset (forests in this case) then the resulting valuations can be used as part of a TEV calculation. Sometimes valuations at other locations where the underlying resource is similar can be utilised (value transfer). However, such valuations should ideally be adjusted for socio-economic differences between locations (function transfer), though often the reported methodology in the report or journal paper will not have sufficiently detailed information in to enable such adjustments to be made. The values should also be up-rated by a price index to be reported in current (i.e. the most recent) prices.

In general, provisioning ecosystem services (i.e. direct use values) are normally valued using market price; regulating ecosystem services (i.e. indirect use values) by revealed preference values (such as costs avoided or replacement costs); and cultural ecosystem services (mainly non-use values, apart from tourism/recreation which falls under direct use) by stated preference values (such as contingent valuation and choice modelling).

This feasibility study of valuation of multiple benefits tries to assess the data available and gaps, as well as the issues involved. One important aspect is the link between the services under valuation and the presence of forests. If the link between the service and forest is not established, or not quantifiable, then there is no justification for the valuation of forest cover in the context of REDD+ implementation.

Before considering the five focus areas in turn, it is useful to briefly look at two previous attempts that were identified to value forest ecosystem services in the region, as they provide valuable insights in terms of the methodology used and the acknowledgement of its caveats.

PREVIOUS STUDIES ON THE VALUATION OF DRC FOREST BENEFITS

Only two studies have previously attempted to value the total value (or a range) of ecosystem services associated with the forests of the DRC. Neither of them linked this valuation to a spatial analysis of the services.

1. Nlom (2011)

Using a TEV framework the author finds that for the overall forest area in the Congo Basin:

> Direct values – formal timber sector, informal timber sector, fuelwood, bushmeat, non-wood forest products, and gorilla tourism – are estimated at US$ 13,885 million/year.
> Indirect values – watershed protection, additional annual value of carbon retained in forests, and option/existence values – are estimated at US$ 3,622 million/year.

Based on Nlom's data the relative sizes of the main DRC values are shown in the graphic below:

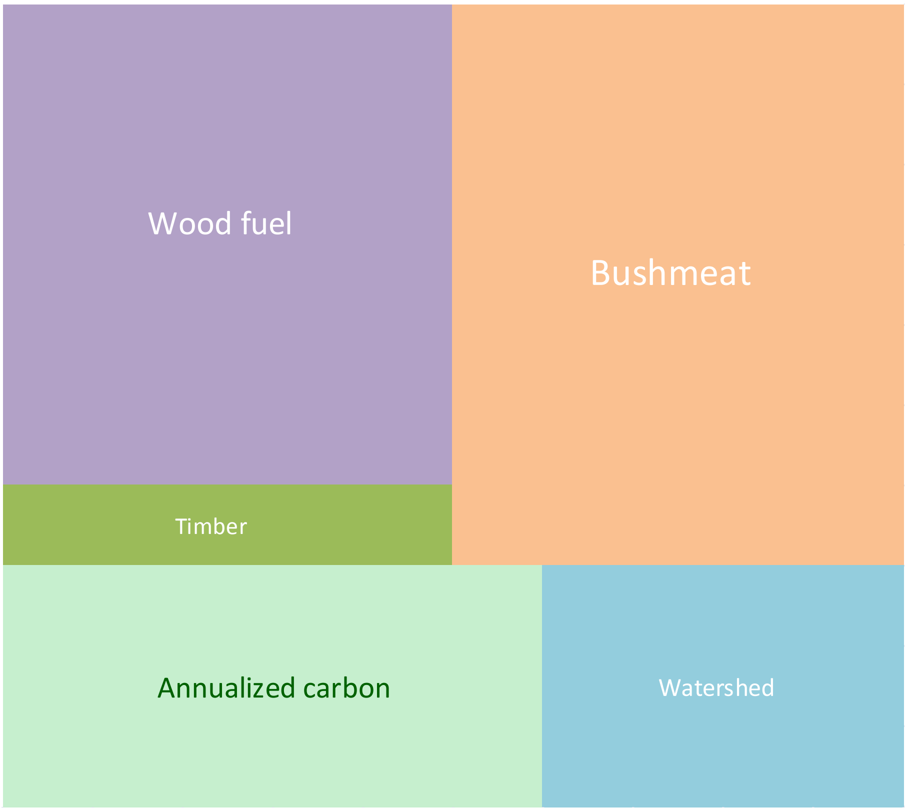


Figure 1. Visualization of the relative sizes of the main monetised values of the DRC's forests, UNEP-WCMC, based on data from Nlom (2011).

Nlom obtained the valuation figures by combining estimates from studies on the quantification of ecosystem services (e.g. the volume of NTFP harvested) with estimates from other studies on the value of those services (e.g. the market price of NTFP). The value estimates are mainly derived from an earlier study by Debroux et al. (2007), and are not up-rated to current values in any way (though the impact of this will be relatively small). Some of the sources are now quite dated; for example the bushmeat harvesting data is taken from a 1999 paper, so it is possible that the volume harvested has increased over the last 14 years. The paper otherwise contains useful references to more specific papers on the different components of the TEV.

Nlom makes clear that these (gross) values are indicative only and include potential values as well as realised values. Although described in the title as a study of the value of protected areas, in fact the geographical scope of this study goes beyond protected areas to include all forests. The study is across the whole Congo Basin and not just in the DRC, although some figures for DRC are reported (and of the figures provided for both DRC and the entire Congo Basin, DRC contains nearly all of the value). It is also worth noting that the option/existence values are estimated by using the proxy of donor assistance for nature conservation provided to the protected areas, which excludes any option value to the people of the DRC (including future value of genetic resources).

2. Debroux et al. (2007)

This detailed report carried out by CIFOR, The World Bank and CIRAD, examines the forest sector of the DRC in early 2006, the impact of post-2002 reforms, and recommends priorities for the remainder of the decade. One section of the report attempts to assess the orders of magnitude of the economic value of forest goods and services in the DRC. The authors note that, in addition to bushmeat, the forests provide the Congolese people with hundreds of forest plants that are used for food and medicines, but that little detailed data exists on these benefits.

The results of the study are introduced by a detailed disclaimer on the caveats of such an economic valuation, requiring any citation of the results to reproduce the disclaimer. In addition, they highlight the fact that in this war-torn country datasets are piecemeal and uncertain. The results for the different forest products are broadly in line with the findings of Nlom, just slightly lower.

With regard to both studies, the final values attributed to various ecosystem services are estimates of annual total (gross) flows, which imply that:

I. They overestimate benefits (because estimates are gross not net);
II. The fact that the estimates are of current flow means that, to the extent that there are unexploited potential benefits, they *underestimate* future flows, but to the extent that current patterns are probably not sustainable they *overestimate* future flows;
III. The distribution of benefits amongst the population is unclear;
IV. The estimates cannot explain what the impacts of deforestation would be – a reduction in forest cover may not reduce total benefits by an equivalent proportion.

INDIRECT USE BENEFITS (LOCAL LEVEL)

Within a TEV framework, the value of ecosystem-based goods and services is classified into two categories: use values and non-use values. Use values include direct use (such as food), and indirect use (e.g. regulating services such as climate control and water quality). In this study only the *local level* indirect use benefits from forests are included, under two interrelated thematic areas, soil and water.

1. Soil

1.1 Mapping

A draft report by WWF from 2009 (Shapiro et al. 2009) contains useful proxy variables for the mapping of soil erosion control services. The analysis is built upon a database of river basins over the DRC at a 250km^2 resolution. The report contains datasets that could be of use to determine the relative importance of each river basin for soil erosion control such as discharge flowing through, basin dominant land cover, wetland/no wetland, low slope/high slope (greater than 15% in more than 30% of the basin), type of forest cover and the delineation of the river basins themselves.

A map of soil erosion values in the DRC was produced by UNEP-WCMC in 2012 using similar data and methodology. A more detailed description can be found in the technical report.

1.2 Value

The most obvious ecosystem service that could be valued here is the soil erosion control that forests provide. Soil erosion control avoids topsoil being carried away by rainfall runoff, thereby reducing the fertility of eroded land. Soil erosion control also avoids the same sediments eroded being deposited in rivers or dam catchments downstream (which results in potential disruption to economic activity or costly remediation).

1.2.1 Fertility

In order to value soil fertility accurately data is needed on:

- Areas of agricultural production
- Types of crops
- Economic value of agricultural output by regions and crop type
- Soil fertility levels and their impact on agricultural outputs
- Links between soil fertility and forest cover

Both the overall volume and value of agricultural outputs at the country level for the main agricultural products are available through FAO STAT[1]. The spatial distribution of agricultural areas could be determined through existing land use cover maps.

With regards to the link between soil fertility and forests, a number of difficulties arise. There are very few studies linking soil fertility levels and forest cover, and most are in South American countries. Moreover, the main problem with valuing forests through soil fertility is that the economic advantage of soil fertility is most relevant in agricultural areas, not in forested ones.

The improvement or preservation of soil fertility levels through avoided deforestation would require an

[1] http://faostat.fao.org/

assessment of the contribution of the forests in the regeneration of soils in complex and unpredictable rotating slash-and-burn farming systems. Slash-and-burn agriculture does depend on forests to reconstitute soil fertility, but the effect is highly variable and situation-specific. The number of variables to take in account - soil type, topography, rainfall, and human agro-ecological factors – seems to make this assessment unrealistic at this stage.

The contribution of forests to soil fertility could be more relevant in a mosaic of forested and agricultural land, or for agro-forestry systems. The agricultural output of current slash-and-burn could then be compared with that of an agro-forestry system where the forest contributes more directly to soil fertility. It does not seem that agro-forestry has taken off in the DRC, as reflected by the absence of publications on the topic relevant to the region, meaning that proxies from agro-forestry systems in other countries would have to be used.

Doing this would also raise the question of where those agroforestry systems would take place – as a replacement of slash and burn areas or in areas of primary or secondary forest – and to what extent this “limited deforestation” or “limited afforestation” is compatible with REDD+, and thus whether the resulting benefits for soil fertility can be counted as “REDD+ multiple benefits”.

There are some projects in Southern and Eastern DRC to convert the Miombo (dryland forest) and mountain ecosystems into agro-forestry systems that could maintain levels of soil fertility while providing fuelwood and timber to local populations. Yet, these projects could raise concerns about whether such conversion could be considered compatible with REDD+. The UN-REDD Programme Social and Environmental Principles and Criteria (SEPC) specify that REDD+ activities ought “not cause the conversion of natural forest to planted forest, unless as part of forest restoration”.

In conclusion, the valuation of forests for soil fertility is compromised because of (i) the lack of a clearly established contribution of forests to soil fertility in the current state of agronomical science and (ii) the question whether agro-forestry systems are compatible with REDD+.

One study that may be useful in developing a way forward explores a different avenue tangentially relevant for valuation by assessing the potential for intensification of agriculture to release the pressure on forests. It points at the declining productivity of soils in the Virunga region and the fact that soil fertility and lack of land are the main constraints on local landholders to improve their productivity, which could be remediated through agricultural intensification methods (Hatfield 2005).

1.2.2 Sedimentation removal

Sedimentation caused by soil erosion could cause several types of damage (in addition to loss of life), all of them allowing the valuation of soil erosion control services provided by the forests through avoided costs methodologies.

These types of damage could be:

I. The submersion of crops or arable lands under sediments caused by mudslides or landslides (valued through avoided cost of sedimentation removal, avoided cost of lost crops and avoided opportunity cost of agricultural potential).
II. The interruption of roads, rail tracks, buildings or other infrastructure (e.g. power lines) due to mudslides (valued through the avoided cost of rebuilding)
III. The siltation of navigable waterways (valued through avoided cost of dredging or avoided cost of the impact on the economy)
IV. The sedimentation of dam catchments (valued trough avoided cost of sediment removal or

avoided cost of the impact on electricity production).

With regard to estimating these:

(i – ii) For damages caused by landslides or mudslides, data on previous such events (frequency, incurred costs) would be necessary. Looking at such data would help calibrate a model to calculate avoided costs resulting from deforestation, using variables such as slope, occurrence of extreme rainfall and presence of communication/transport networks and human settlements.

(iii – iv) It is important to note that siltation and sedimentation are controlled not only by soil erosion but also by water flow. The potential for valuation of controlling these processes is assessed in the water section, but an accurate model will need to take an integrated view of soil erosion control and water flows at the relevant scale.

A recent study by WWF/Dalberg (2013) estimates erosion control to be worth US$ 6.9 million annually in the Virunga National Park, with potential to increase this value to US$ 7.8 million annually. This is based on the restoration cost of deforested watersheds. Applying the latter value to the forested area of the park is equivalent to $22.41 per hectare.

2. Water

2.1. Mapping

As mentioned previously, the 2009 WWF report (Shapiro et al.) goes a long way in identifying critical catchments in terms of several parameters and their relation to forest cover. Much of the data required (land cover, forest types, slope, discharge, presence of cascade) is included, but the criteria for “critical” basins (in terms of the relation between forest cover and hydrology) must be defined (e.g. proximity to cities (quality), dams and waterways (flow)).

To be accurate, the model should take into account not only the criteria for each river basin but also the relation between different basins. In other words, the occurrence of forest cover in a given basin has an influence not only on that basin, but also on all downstream basins, and is similarly affected by all upstream basins. This may be technically challenging to model.

There is a reasonable amount of literature exploring the links between forest cover and water discharge (proxy for the overall water quantity) in river basins. The generally accepted fact that forests “provide water” has been challenged as not built on factual evidence, for the relationship appears to be specific to each site. Some studies point to a reduction in water discharge following deforestation whilst others state that discharge increases after removal of the forest (Andreassian 2004; Oudin et al. 2008).

A more recent paper models the effect of land use and land use changes in the Congo Basin on hydrological flow regimes of the watersheds (Batra & Kumar 2008). It finds that deforestation causes a reduction in evapotranspiration which will ultimately lead to reduced precipitation, which will reduce the soil moisture and hence agricultural productivity. Conversely, surface runoff and river discharge tend to increase with deforestation (Batra & Kumar 2008).

What seems to be established is that: forests act as regulators on water flow by slowing runoff in periods of intense rainfall (Brummet et al. 2009); in the Congo, a large portion of rainfall comes from recycling moisture from the region’s forests (Brummet et al., 2009); large forest basins, such as the Amazon or Congo, influence climate (e.g. rainfall patterns) at the local, regional (Matae, 2008) and global level (Andreassian 2004); even localized forest loss might flip the Congo region to arid conditions (Sheil and

Murdiyarso 2009).

Total valuations of the generic value of hydrologic services have been made in various places such as Hawaii, the Yangtze River catchment and for native forests in Chile. The value of watershed services is apparent, but the functionality and value of an ecosystem is likely to be highly variable, so site-specific assessment remains crucial (Brauman et al. 2007). In consequence, in the absence of any detailed study of forest watershed services in the Congo, a gross value (over the whole basin) will be possible to estimate, certainly in terms of an order of magnitude. However, it will be extremely challenging to express this value spatially in relation to certain areas of forest cover with a high degree of confidence in the accuracy of the mapping.

There is a further complicating factor in that the Congo River has the world's second highest daily freshwater discharge and is the second largest exporter of terrestrial organic carbon into the oceans. This fresh water plume can be traced hundreds of kilometres from the river mouth, and plays an important role in the ocean carbon cycle (functioning as a carbon sink) (Hopkins et al., 2013). Identifying spatial determinants of this function will be difficult. The value of this role could be set aside, though, if the focus is on primarily local benefits of the DRC's forests.

2.2. Value

There are two components of water that are of interest: water quantity (availability) and water quality. Aspects that need to be determined in order to estimate the value for both of these are as follows:

2.2.1. Quality

Value for drinking water. The price of water, using water bills, could be used as the basis for estimating this. It could be problematic, though, given the high proportion of the population that does not get their water through any formal system. Therefore, the value for drinking water could probably be looked at for Kinshasa only.

Value for fisheries. A reasonable amount of data exists on the value of fish for the economy of the DRC, but the link with forests in water catchments is not so obvious, as there is probably a higher tolerance to increased sediment levels, at least for some species. Further investigation of this topic would be required (and as a result possibly some ecological field research).

A study by Bagalwa (2012) examines the linkages between land use types in a catchment in the DRC and water quality measures. This could prove useful for determining functions within the land use/hydrological/soil erosion model.

2.2.2. Quantity

Information would need to be collated on:

- Water flow in dam catchment areas
- River flow along individual waterways

Ideally, further research to establish the functional link between forests and specific rivers in the Congo basin would inform any valuation. However limited resources are likely to preclude such a study in the near term.

The current data available includes the location of dams (Shapiro et al. 2009). However, also required would be:

- Location of projected dams (International Rivers Network and the DRC government are

possible sources for this information);
- Capacity of dams (including consideration of the proposed building of the world's largest hydropower plant at Inga Falls);
- Losses in power generation incurred from sedimentation (such data could be requested from the national electricity company);
- What are the important waterways in terms of transportation of goods and people, what is the difference in time and price of travelling by other means (where possible, and if not, what are the consequences for economic activity);
- What are the minimum levels of river flow required for navigation, and current seasonal flows.

Some other existing information that could be utilised when developing the valuation approach includes the following:

2.2.3. Dams

One paper was identified which makes a comprehensive examination of water and soil erosion control (Lee, Yoon, & Shah 2011). The model has been applied only to the Aswan dam catchment in Egypt, which is far removed from the climatic conditions in the DRC. A similar study for a dam catchment in Cambodia also valued the watershed services that would need to be paid to land users in the catchment area. The estimated net present value of forest conservation is US$ 4.7 million when using average annual climate values over 100 years, or US$ 6.4 million when considering droughts every eight years (Arias et al. 2011). A simpler valuation would calculate the loss of power outputs from existing and projected dams and model sedimentation and deforestation in the catchment areas of those dams. There are some studies on the Lom Pangar dam in Cameroon which could be useful (Hathaway & Durrel 2005).

2.2.4. Navigation

The Congo down to Kinshasa (but no further) and the Oubangui River form the two main routes for commercial traffic. Yet traffic has substantially decreased due to a reduction in water levels in the Oubangui over the last 30 years. An 18% reduction has been noted in discharge since 1985. Shallow water levels on the Oubangui during the dry season prohibit the use of barges for navigation for five months of the year. Convoy barges take 21 days roundtrip between Bangui and Kinshasa (Brummet et al. 2009).

The port of Matadi, which is DRC's main sea port, suffers from chronic siltation problems caused by sediments brought by the Congo River. The already limited capacity of the port is worsened by the sedimentation and reinforces the "bottleneck effect" on external trade of timber products. This is an interesting "hotspot" of sedimentation having a country-wide effect on one sector of the economy (export timber). But depending on the perspective, this is also one of the reasons why deforestation has been slow to recover even after the end of the hostilities (a possible 'negative' feedback loop from deforestation).

2.2.5. Watershed protection services

The existing watershed protection services studies in the DRC (Debroux et al. 2007; Ninan & Inoue 2013) are both based on valuation work by Ruitenbeek, who examined the value of flood prevention by rainforests. The difference between the two studies in terms of total value is significant. The much higher latter value appears to be due to applying Purchasing Power Parity up-rating (which takes into account inflation in the original country over the last two decades and then currency conversion that equalizes the purchasing power of different currencies by eliminating the differences in price levels), as well as a 10% greater forest area in DRC. The higher of the two figures appears more likely to reflect the correct magnitude of value, since the global median annual value for forest watershed protection services is US$ 174/ha (Ninan & Inoue 2013). However, since the relevance to the DRC of the original study on which these valuations are based is open to question, even the most recent study offers an unsatisfactory order of magnitude estimate of value.

Benefit	**Study**	**Value**	**Reference level**	**Estimation procedure**
Watershed services	(Debroux et al., 2007)	US$ 0.5 billion	Value per year (country level)	Ruitenbeek (1989) estimates the value of watershed services in rainforests in Cameroon. This value of US$ 3/ha is applied to the DRC forest area.
Watershed services	(Ninan & Inoue, 2013)	US$ 24.8 billion	Value per year (country level)	Also based on Ruitenbeek (1989), but up-rated to 2010 Purchasing Power Parity US$ 153/ha. Applied to the forest area in the DRC - a more recent estimate of area of 162 million ha (de Wasseige 2009).

DIRECT USE BENEFITS

In this study the direct use benefits have been identified as: non-timber forest products (NTFPs), recreation (i.e. paid recreation, thus covering tourism and hunting), and selective logging of high value timber. For those direct use benefits, the main caveat to any valuation is the question of sustainable harvest rates. Estimating accurately sustainable yields will be crucial in order to determine not only the current market value, which may be the results of an unsustainable harvest rate, but a Maximum Sustainable Yield (MSY) market value. Note that this MSY is not absolute, as it will be influenced by land-use patterns and planning decisions favouring one service over another.

1. NTFP

NTFP can be an important source of household income and some in the DRC earn more than a school teacher as a result; whilst NTFP traders can earn more than a qualified medical doctor (Ndoye et al., 2007). Bushmeat and fuelwood represent a scale of trade significantly larger than other categories of NTFPs (which are fragmented between dozens of species of plants, insects and other products). However, the inclusion of bushmeat and fuelwood as NTFPs is open to question. It is important to note that the 2002 Forest Code defines NTFPs as "all other forest products such as rattans, barks, roots, leaves, fruits, seeds, resins, gums latex and medicinal plants" (although fuelwood and its derivatives are classified as NTFPs in the legal framework in Gabon, CAR and Cameroon). As a result, it may be better to include fuelwood in a "wood products" category, together with high value timber.

In this instance the question of value is explored first, as it will help determine which are the priority NTFPs to map.

1.1. Value

As one would expect by the scale of trade, the most important NTFPs appear to be, by far, fuelwood and bushmeat, followed by caterpillars, and Gnetum (*Gnetum africanum*), a wild plant. Bushmeat provides a cheap source of nutrition for rural households (Bowen-Jones et al., 2002) and consumption has been estimated at between 1.1 and 1.7 million tonnes a year in the DRC (Debroux et al., 2007). Both caterpillars and Gnetum are important sources of protein in the diet of poor households, but also a delicacy, hence their high market value.

A market value for fuelwood is available, and there is also consumption and population data for Kinshasa, Kisangani and Goma. From the data it is possible to extrapolate the value in other significant cities and an estimate for the country.

In addition to those studies that give a monetary value for all or certain NTFPs, many studies contain quantitative data that could be useful, such as volume of trade or proportion of household income that is derived from NTFPs. Other quantitative data may be more difficult to translate into monetary valuations (e.g. the fact that more than 90% of the DRC population use medicinal plants sourced from forests to alleviate their medical ailments (Ingram, 2009)).

Benefit	Study	Value	Reference level	Estimation procedure
Charcoal	(Schure, Ingram, & Akalou-Mayimba 2011)	US$ 132 million	Market value in Kinshasa	For the supply of Kinshasa, most charcoal comes from within 200km from the city, with an average distance of 135 km. 42% comes from the eastern located Bateke Plateau, 34% from the southern located Bas-Congo province and 24% enters the province via the Congo river from more distant provinces including Bandundu, Equateur and Orientale up to 1000km away. 52% of the fuelwood harvested for the market in Kinshasa comes from agricultural land, 29% from uncultivated forests and 16% from other sources such as village plantations.
Charcoal/ fuelwood	(Schure, Ingram, & Akalou-Mayimba 2011)	US$ 143 million/year in Kinshasa US$ 2.5 million/year for Kisangani	Market value in Kinshasa and Kisangani	Total fuelwood consumption is 4.8 million m^3 in Kinshasa and 200,000 m^3 in Kisangani. That represents 12 times the official volume of wood production (400,000 m^3).
Charcoal	(Schure, Marien, de Wasseige, Drigo, Salbitano, Dirou, & Nkoua 2011)	US$ 15-25 per faggot	Market value in Goma	In 2007 Goma's annual timber consumption was 59,434 tons with 80% coming from illegal logging in the adjacent Virunga National Park.

Fuelwood/ charcoal	(Schure, Ingram, & Akalou-Mayimba 2011)	Kinshasa 300,000 Kisangani 40,000	Employment in number of people	Data on income by sector of the fuelwood economy could be found in order to calculate overall value: Kinshasa: 290,000 are involved in production, 900 in transport, 21,000 in retail and sales. Kisangani: 10,000 in production, 1600 in transport, 12,000 in retail and sales.
Fuelwood/ charcoal	(Debroux, Hart, Kaimowitz, Karsenty, & Topa 2007)	> US$ 1 billion	Market value + replacement cost (country level)	The annual fuelwood consumption is estimated at 72 million cubic metres. The average market price is 30 dollars per cubic meter, in faggots or equivalent charcoal. It is assumed that the price applies to the whole production including the share used by farmers and charcoal makers for their subsistence. In fact, this estimate is a mix of market value (for the share of fuelwood that is traded) and replacement cost (for the share that is consumed locally). This latter estimate is a theoretical one since in many cases there are no alternative sources of energy to replace fuelwood. Note: a similar order of magnitude comes out when using a replacement cost methodology, calculating the price of the oil needed to produce energy equivalent to 72 million cubic metres of wood.
Fuelwood/ charcoal	(Nlom 2011)	US$ 2.3 billion	Market value for the whole country	Production volumes taken from FAOSTAT, values calculated using average price for DRC of US$ 30 per m^3 of firewood/charcoal.
Charcoal	(Hoare 2007) citing (Ndoye and Awono 2005)	US$ 12.7	Net monthly household revenue from trade	Estimate from 57 traders in 2 markets in the Equateur province.
Bushmeat	(Nlom 2011)	US$ 2.7 billion	Market value for the whole country	Harvesting data from Inamdar et al. (1999) and value average for the DRC from Debroux et al. (2007).

Bushmeat	(Debroux, Hart, Kaimowitz, Karsenty, & Topa 2007)	> US$ 1 billion	Market value + replacement cost (country level)	Bushmeat consumption estimated at between 1.1 and 1.7 million tonnes per year (Wilkie and carpenter 1999, Fa et al., 2003). The average market price is estimated about 2.5 dollars per kg. It is assumed that the price applies to the whole production including the share used by farmers and bushmeat hunters for their subsistence. In fact, this estimate is a mix of market value (for the share of bushmeat that is traded) and replacement cost (for the share that is consumed locally). This latter estimate is a theoretical one since, in many cases there are no alternative sources of protein.
Caterpillars	(Debroux, Hart, Kaimowitz, Karsenty, & Topa 2007)	US$ 8 million	Market value (country level)	13,440 tonnes per year, at average market price of US$ 0.6 per kg.
Caterpillars	(Hoare 2007) citing (Ndoye and Awono 2005)	US$ 25.6 (Equateur) US$ 20.6 (Bandundu) US$ 355 (Equateur) US$ 2055 (Bandundu)	Net monthly household revenue from trade Value traded over 6 months (Equateur) and 4 months (Bandundu)	Estimate from 57 traders in 2 markets in the Equateur province. Estimate from 152 traders in 2 markets in the Bandundu province.
Gnetum	(Hoare 2007) citing (Ndoye and Awono 2005)	US$ 14.7 (Equateur) US$ 1.3 (Bandundu) US$ 21,904 (Equateur) US$ 507 (Bandundu)	Net monthly household revenue from trade Value traded over 12 months (Equateur) and 4 months (Bandundu)	Estimate from 57 traders in 2 markets in the Equateur province. Estimate from 152 traders in 2 markets in the Bandundu province.

1.2. Mapping

1.2.1. Fuelwood

The provenance of fuelwood for the Kinshasa market has been studied and possibly defines a replicable pattern for fuelwood harvesting around cities in the DRC. Mapping fuelwood harvest from rural populations could prove more difficult, but assumptions could be made, based on case studies, about populations, distance to harvest and average fuelwood use.

Fuelwood sold in Kinshasa comes from 50 to 300 km on three principal routes (Route nationale no1 du Bas Congo, Route nationale no1 du Plateau Batéké, and down the Congo River). The average distance is 135 km for charcoal and 102 km for unprocessed fuelwood. The city of Kisangani has six main areas of provenance, but distances in this forested region are much shorter, spanning a maximum of 50 km, with an average of 37 km for charcoal and 25 km for fuelwood (Schure, Ingram, & Akalou-Mayimba 2011).

1.2.2. Bushmeat

Around 80% of the meat eaten in the Congo Basin comes from wild animals (Biodiversity Support Program, 2001). But it will be very difficult to obtain any spatially relevant information about where bushmeat is sourced. Very rough proxies could be used such as habitat types and species range from IUCN. However, some studies show that the least perturbed areas of the forest are not necessarily the ones with the highest concentration of bushmeat species, and that patches of secondary forest harbour the greatest quantity and diversity. An alternative approach is to enquire from bushmeat hunters as to how far and which locations they travel to seek different animals. Sustainable harvest rates are also extremely difficult to estimate, due to dispersion and complex population dynamics.

1.2.3. Caterpillars

No data has been found on spatial distribution. One noteworthy fact, though, is that logging activity seems to have a detrimental impact on caterpillar availability, especially for taxa associated with certain species of trees of high value timber, which hints at a potential conflict between those two benefits (Hoare 2007). Once again, direct enquiry from harvesters may be the only option available at a reasonable cost to gain the data required.

2. Recreational value

2.1. Mapping

The DRC has the potential to support two main kinds of paid recreational activities: nature tourism and recreational hunting. Both remain largely underdeveloped to this date due to poor tourism infrastructure, the country's perceived (and real) insecurity, and the relative inaccessibility of many sites of interest.

Nature tourism would mostly be linked to the main charismatic species in the DRC; the foremost of these is the gorilla. There are two species of gorilla in the DRC, the mountain gorilla in the East and the lowland gorilla in the West. No study has been found on the lowland gorilla and its potential for ecotourism seems largely untapped (although it is much closer to Kinshasa and therefore easier to access). Yet, mountain gorillas are more popular because the climatic conditions in the mountains are preferable for tourists (less hot and humid). Other flagship species of the DRC are hard to spot and are present in the lowlands, where the conditions are not as pleasant.

The potential of other areas and species for nature tourism should nevertheless be assessed. Wilkie and

Carpenter (1999) estimate that tourism is only likely to be a major source of revenue when a protected area fulfils the criteria listed below:

I. Contains charismatic species. Charismatic animals that are likely to attract tourists include okapi, gorilla, mandrill, bongo, forest elephant and leopard;
II. Guarantees wildlife viewing;
III. Is close to an international airport or major tourist centre, other attractions, beaches and cultural centres;
IV. Offers easy (short), comfortable and safe access;
V. Provides internationally acceptable standards of food and accommodation;
VI. Offers unique landscapes;
VII. Is moderately inexpensive.

These criteria are useful for ranking protected areas in order of potential for nature tourism. Note that chimpanzees can also generate a profitable tourist activity, especially if they are close to a gorilla viewing zone, so allowing for a combined trip. Therefore, when assessing the location of potential high-value nature tourist areas the presence of chimpanzees also needs to be considered.

Mapping the potential value of trophy hunting would take a similar approach to that for nature tourism.

2.2. Value

Given current circumstances, a valuation of recreation would focus on potential rather than (non-existent) actual benefits. Gorilla tourism seems to be by far the most significant and most researched source of benefits in terms of paid recreational value. The potential of the country is easy to estimate from levels previous to the civil war and similar gorilla ecotourism parks in Rwanda and Uganda. The number of tourists visiting Rwanda's National Parks rose from 417 in the year 2000, to 20,000 in 2008 (WWF/Dalberg 2013). Most of these visits were to see the mountain gorillas. There is also some data from within the DRC. In the Virunga National Park the annual growth rate in the number of tourists was 200 per cent between 2009 and 2011 (WWF/Dalberg 2013). Other flagship species include the chimpanzee, the bongo and the okapi. Tourism around these species appears to be underdeveloped, because of the current lack of investment in the infrastructure and personnel necessary to access them (Wilkie & Carpenter 1999).

This can be explained in large part by the high price tourists are willing to pay to sit with a family of gorillas. Gorilla tourism is very high value: the mountain gorillas in Rwanda generated half of Amboseli National Park's revenues, and in Kenya are responsible for a quarter of the visitors. There is also a spill-over effect on aid received by the region. Complementary activities and projects get funding from international development agencies and have benefited the local job market. These projects usually integrate forest conservation with rural development (Weber 1998).

If this form of tourism is to expand, safeguards should be implemented to make sure that the gorillas' habitat is not overly disturbed, and that a larger proportion of benefits is captured at the local level. The latter is not only a question of social justice but also a question of sustainability for the gorilla parks. The benefits of gorilla tourism need to make up for the opportunity costs of those that cannot exploit the resources and the land protected for the gorillas. If not, the long-term sustainability of the parks will be jeopardized.

Another potentially large source of local income could be found in trophy hunting. Trophy hunting may provide a significant source of revenue for wildlife management in areas of forest endowed with trophy-quality bongo and elephant, if well regulated. It is easier to achieve profits because the investments necessary are less than for ecotourism, since hunters are often much more willing to "rough it" than are most tourists. Sustained demand over time does not seem to be a problem: Safari Club International asserts that one-third of its core membership travel to Africa to hunt at least once every 2 years (5,000 per year). However, a significant concern is the ecological sustainability of the activity. There is a large body of literature about the role of trophy hunting in conservation, and the debate about the gains for species protection as this hunting currently exists has not yet been settled (Lindsey et al. 2007). Valuing trophy hunting would involve a similar approach to that for nature tourism.

Benefit	Study	Value	Reference level	Estimation procedure
Gorilla	(Hatfield 2005)		For all 3 parks in the Virunga Region (Rwanda, Uganda and DRC)	This assumes the renovation and rebuilding of tourist infrastructure and a return of international confidence in the DRC as a tourist destination, but it is based on actual pre-war tourism figures and on gorilla tourism to neighbouring countries and PAs, and may therefore be a realistic estimate.
		US$ 7.75 million	Annual gorilla viewing expenditures	The study aims at estimating the overall value of the protection of this area for gorilla conservation, taking into account benefits from ecotourism but also opportunity costs for agriculture.
		US$ 4.48 million	Benefits in secondary income generation	An array of methodologies is used to calculate, direct, indirect and existence value. The figures for existence value are ignored in this summary.
		US$ 3.10 million	Tax generation	The opportunity cost of the protected areas for local populations was estimated using net farm income figures in the same regions and assuming that 50% of the existing park areas are cultivable. A shortcoming is that it does not include the opportunity cost of timber activities.
		US$ 15 million	Opportunity costs	
		US$ 9.9 million	AGGREGATE BENEFITS AND COSTS	
Gorilla	(Wilkie & Carpenter 1999)	US$ 1 million	Entrance fees in 1998 (Uganda)	Bwindi and Mgahinga National Park
		US$ 1 million	Entrance fees for 1998 (Rwanda)	Volcanoes National Park, Rwanda (Mountain Gorilla project)

		US$ 300,000	Entrance fees (DRC)	Only for Ozdala National Park. Projections suggest that if annual visitation rose from zero to 480 tourists and each paid US$ 1700 to visit the park for a week, over US$ 300,000 would be generated for park management and the treasury.
Gorilla	(Weber 1998)	US$ 400,000 US$ 418,000	Kahuzi-Biega National Park (DRC) Entrance fees for 1990 Virunga National Park (DRC) Entrance fees for 1990	The article does not pretend to do a global assessment of the value of Gorilla tourism, but different values presented amount to this formula: Number of tourists per year*(Park entrance fee + other expenses) + ((park ranger salary - median local salary)*number of park rangers.
Gorilla	(WWF/Dalberg 2013)	US$ 30 million	Direct potential value in Virunga National Park (DRC)	The report notes that current tourism value is zero, since the park was closed to tourists in 2012 due to the security situation.
Chimpanzee	(Weber 1998)	US$ 14,000	Entrance fees for 1990 in the Tongo chimpanzee reserve (DRC)	Social benefits included the creation of 25 jobs (15 in the park and 10 in a lodge). A hospital was built and access roads improved, all of that being direct or indirect impact of Chimpanzee tourism.
Trophy hunting	(Wilkie & Carpenter 2009)	US$ 30,000 – 100,000	Per trophy hunting concession Note: this is potential, not actual	Those figures are for Central Africa and Cameroon, giving a good idea of what it could be in the DRC (for which there are no figures at this time because of the insecurity).

3. High Value Timber (low-impact logging)

3.1. Mapping

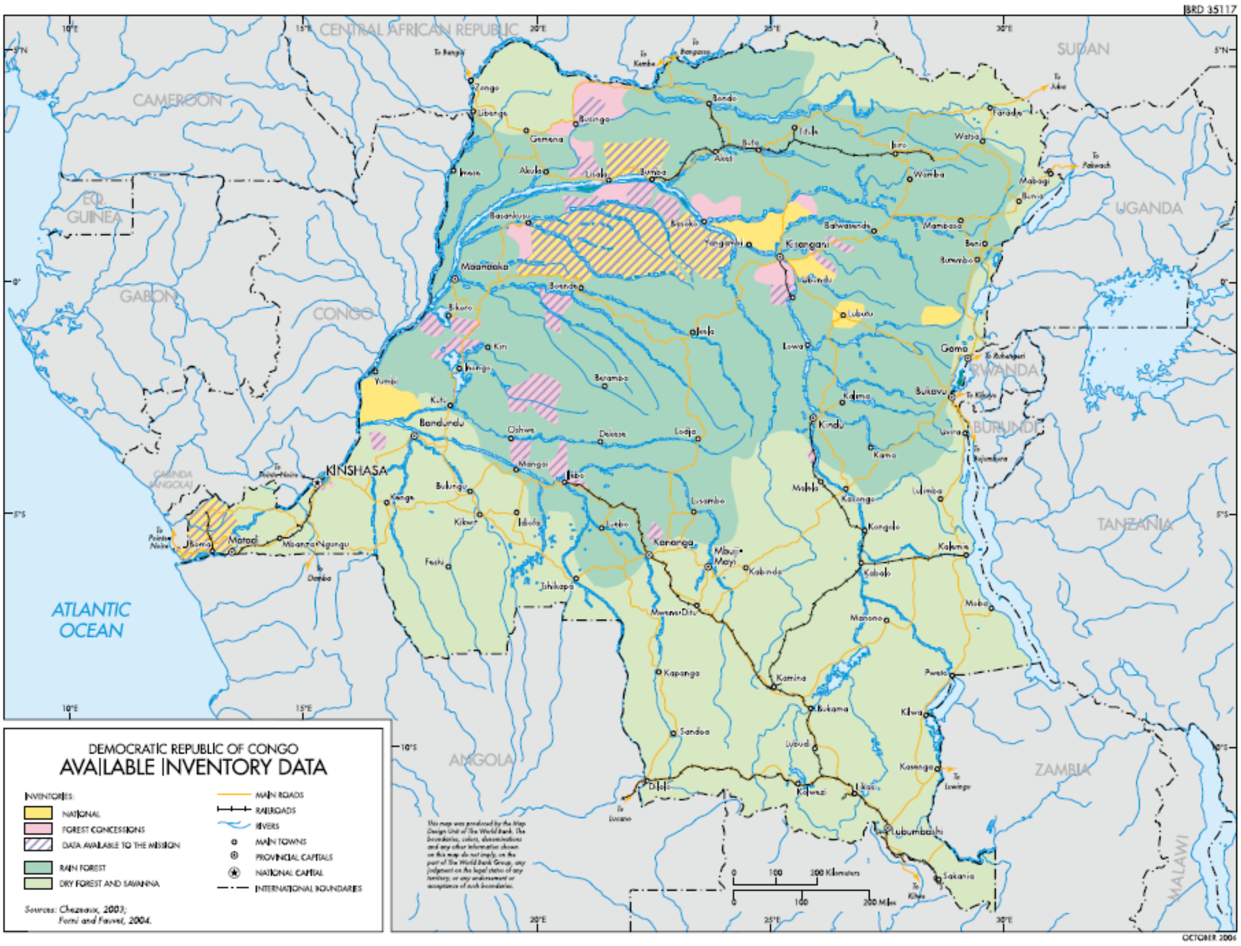
The forests of the DRC are very heterogeneous. Within the same province, dominant species can vary greatly from one concession to the next. Broad concentrations can nevertheless be described for the most valuable species. Wenge is mainly found in Bandundu, afromosia in Orientale and Equateur provinces, and dibetou is quite abundant south of the Congo river but almost absent north of it (Chezeaux 2003).

More detailed information can be found in the study for the World Bank by Chezeaux, summarized in the table below.

Principales essences exploitées par province de 1995 à 1999 (source DGF)

Essences	Total exploité	Bandundu	Bas Congo	Equateur	Orientale
Classe 1					
Acajou	67 396	11	770	62 374	4 240
Afromosia	65 955	0	0	38 267	27 687
Doussié	2 287	291	648	1 065	284
Iroko	74 162	2 752	16 638	46 926	7 846
Kosipo	15 692	5 560	1 676	8 379	77
Limba	30 776	0	29 393	1 383	0
Sapelli	256 314	6 518	1 355	199 391	49 050
Sipo	162 550	4 432	1 063	117 777	39 278
Tiama	59 513	4 109	1 166	40 646	13 593
Wengé	23 694	19 240	310	4 145	0
Total Classe 1	**758 340**	**42 913**	**53 018**	**520 353**	**142 056**
	69%	32%	43%	81%	68%
Bossé clair	27 122	12 852	678	9 714	3 879
Dibétou	7 332	436	608	5 797	491
Tola	194 897	45 709	20 352	76 943	51 892
Cl1 + 3 essences	**89%**	**77%**	**60%**	**96%**	**95%**
Autres essences	**118 886**	**30 870**	**49 449**	**28 067**	**10 501**
	11%	**23%**	**40%**	**4%**	**5%**
TOTAL	**1 106 577**	**132 780**	**124 105**	**640 874**	**208 819**

Inventory data is available for certain areas only, as highlighted on the following map. However, the DRC government may have more recent data available.



Map 6. Map of available inventory data in the DRC. *A small portion of the forest was inventoried in the 1970s and 1980s.* Source: Adapted from Chezeaux (2003); Forni and Fauvet (2004).

Debroux (2007) confirms that the DRC's forests of the Central Basin are rich in wenge and afromosia, two high-value species that tend to grow in clusters. As with other direct benefits, the main challenge with logging is that of its sustainability and compatibility with other benefits (especially carbon). A recent paper reviewing the literature on the direct and indirect impact of logging on different groups of species, found that for some species it was beneficial to some extent, but for others detrimental. It also contains proposed planning and active management guidelines for logging companies to limit the impacts of their activity (road design, staff policies to limit bushmeat consumption, etc) (Nasi, Billand, & van Vliet 2012).

A paper by Putz et al (2012), looks at the effects of "low impact logging" in the long-term on timber yields, carbon, and species richness (Putz et al. 2012). The results are encouraging but it should be borne in mind that they are preliminary and that little research has been conducted on the issue. An alternative view of the impact on carbon storage from selective logging may be inferred from the paper by Slik et al (2013), which finds that large trees account for an average of 44 percent of African forests' biomass.

3.2. Value

The Direction General des Forets collate the yearly figures of formal log production for the country. Figures are also reported in Eba'a Atyi & Bayol (2009), and the OFAC report from 2010 also contains figures on the production by species individually, but over the whole Congo Basin.

In 2003, the forestry sector's contribution to the Gross Domestic Product (GDP) of the DRC was 1%, and in

2007 it provided employment to 15,000 people.

A valuation could be made on the basis of selective, low-impact logging only, to ensure compatibility with REDD+. Fortunately, the management model of logging companies in the DRC already consists of 'creaming off' the best species in the best patches. As infrastructure and security improve, however, one can expect that it will become more profitable to exploit less valuable species and to go further away from the rivers (Debroux, Hart, Kaimowitz, Karsenty, & Topa 2007). In the medium term, though, the majority of the logging in the DRC is likely to remain selective, with average harvests of around 5 cubic metres per hectare (Debroux et al. 2007). The Debroux report also gives estimates of the value of both formal and informal timber sector:

Formal timber	**Informal timber**
40 million US$ per year in gross added value 60 million US$ per year in terms of market value	50 million US$ per year in gross added value 100 million US$ per year in market value

4. Interdependencies

The above analysis has identified a number of benefits that are delivered by forests. One thing that should be kept in mind is the extent to which the multiple benefits can be superimposed without taking into account the interactions between them. Whether they are completely independent, conflict, or work in synergies.

An example is the relation between fuelwood, other fuels and soil fertility (Bush 2009). As fuelwood becomes scarce households will turn to crop residues or grass for fuel. The result will be a loss of crop residues and nutrients to the agricultural system. Further degradation of the soil and declining crop residues will result in the use of animal manure as fuel. Should there be no other options for the extensification of agriculture; the result is a further decline in soil fertility.

Another example is that of high value timber logging and keeping bushmeat hunting within sustainable levels, because loggers will often rely on bushmeat for their food supply. Logging might also have a broader impact on NTFPs of importance for subsistence livelihoods (Ndoye & Tieguhong 2004)

Therefore, a caveat of any valuation will be the inability to capture the complex relationship between several services, and there could be non-linear effects. With sedimentation and water flow for example, it might not be possible to assert that more water flow can counterbalance the effect of more sedimentation. It may also be that water flow peaks have long-term effects on navigability because they remove sediments from riverbeds (so that the river may remain navigable with low discharge levels after a peak flow).

Yet, this interdependence between ecological processes could also open new avenues for the valuation of certain services. Bush (2009) estimates that the damage cost of the diversionary use of farm manure when forests fuelwood reserves have been depleted can by calculated through the replacement cost of nutrients in farm yard manure with chemical fertiliser which is available in local markets. Bush calculated a replacement cost of manure per household in a region of Uganda, and then extrapolated the value of an adjacent protected area.

This means valuing fuelwood not through its market price but through the avoided replacement cost of manure that would be used as fuel if wood was not available anymore. Therefore, in some instances ecosystem services valuation could be achieved through looking at such chain effects. By taking into account these interdependencies the valuation may also better gauge the actual value of forest benefits. However, further work is required in this area to identify the relationships between the different benefits.

CONCLUSIONS

This study has explored the available relevant literature, and identified how mapping and valuation of forest benefits in the DRC might be undertaken in the future. However, to improve the accuracy of both, new data (ideally both ecological and socio-economic) would need to be collected in the field. Where there is a dearth of existing studies the data will only allow a very limited assessment of benefits, as laid out below. The collated information does, however, provide a sound basis for further forest benefits valuation work in the DRC and should be used as the starting point for such studies.

Using the most relevant and up-to-date values from the literature reviewed it appears that the total value of the main forest benefits that have been assessed (watershed protection services, fuel wood, bushmeat, and soil erosion control) is currently around US$ 34,000 million a year (the majority of which relates to watershed protection services). This converts to an average annual value of US$ 207/ha of the DRC forest, which is less than half the global forest median value of US$ 441/ha (Ninan & Inoue 2013). However, many forest benefits in DRC have not been included in this figure (e.g. water quality, education, local climate, recreation, crop pollination, plant foods and medicines), whereas the global median includes some of these, along with values for carbon. Therefore, it would be no surprise if, when these other benefits are included, the actual average per hectare value, excluding carbon, in the DRC is similar to the global median. The carbon value of the DRC's forests has previously been estimated at US$ 1,211/ha (Maniatis 2008), giving a total average value of at least US$ 1,418/ha.

Such a general value is important for an indicative order of magnitude of the Total Economic Value of the forest, in terms of awareness raising amongst decision-makers (see Appendix I), but not so useful for land use planning purposes. It should be noted that the 'per hectare' value only represents a *notional* average for forest across the DRC. The actual value of an individual hectare of forest will vary greatly around this, where for instance in some places the forest provides (or could provide) significant benefits locally (e.g. tourism associated with gorillas, or water quality in fishing grounds). This value also does not indicate whether the extraction rates for fuel wood and bushmeat are sustainable (which is not the case in the DRC - it might be that only a percentage of the current extraction could be provided sustainably for example). It should also be noted that the values are also only the more tangible benefits that can be monetised. Thus, spiritual, cultural, aesthetic and option values to the DRC population are ignored. Sometimes these values, in terms of wellbeing, can be very large for certain individuals or groups.

Although this study has focussed on benefits to the DRC from forests, there are other benefits forests can deliver, i.e. existence values to the world beyond the DRC have not been taken into account. The forest's function as a global carbon store and the carbon benefits of reducing deforestation and forest degradation are acknowledged through REDD+, however many people beyond the DRC would recognise that the forests have a value to wider humanity as an important habitat containing many rare species not found elsewhere on the planet. Thus, as global citizens these people would attach a value to retention of the DRC's forests. The recent study (WWF/Dalberg 2013) of Virunga National Park in the DRC found that the value to global society of just conserving the gorillas in the park was very high. It equates to an annual value there for forests of around US$ 2,000/hectare.

Therefore, moving beyond indicative values for awareness raising, there is then a further task to identify the specific values of forest benefits and their relative importance at different scales. In some instances it will not be possible to derive monetary valuation figures, and so values will have to be assessed using a non-economic approach. These maps of the value of different forest benefits can be combined with those showing costs (opportunity, transaction, and implementation) to produce decision support material on the potential for REDD+ interventions to deliver multiple benefits. In terms of REDD+ planning a number of tools have been developed and applied for a REDD+ opportunity costs analyses, which are static (including the World Bank Opportunity Costs workbook), land use change models, or economic simulation models. The REDD Abacus Software, developed by the World Agroforestry Centre, is an example of a land use change model. Statistical software (such as STATA) and geospatial tools (such as ArcGIS) can also be used to analyze cost-related data and present results.

Mapping areas suitable for different interventions on the basis of current land uses, designations, and the safeguards is important. Detailed spatial analysis, which may involve collecting additional ecological or socio-economic data, is required in order to have greater confidence in identifying the best options and locations for multiple benefit delivery. The DRC does not have the resources, desire, or need, to measure everything though. Therefore, the detail of analysis using the above tools will depend on REDD+ priorities. Ultimately it is where the forest multiple benefits are likely to exceed the costs that the net gain to the DRC of implementing REDD+ will occur. By using spatial planning for forest multiple benefits the positive consequences of REDD+ to the DRC can be enhanced.

In terms of next steps, the recommendations section below sets out an action plan for delivery of pilot valuation studies, which could be used as the basis for a more accurate estimation of forest multiple benefits in the DRC. The plan is based on the findings of this feasibility study. It aims to provide a least-cost approach for spatial valuation of the main (non-carbon) forest benefits.

RECOMMENDATIONS

1. A plan for pilot valuations and mapping

This approach harnesses local knowledge from forest communities. As such it conforms to the Ecosystem Approach, which promotes engagement of local stakeholders in assessments of ecosystem service values. It requires data to be collected in the field and then applied with other existing data-sets to perform a spatial analysis of forest values. From the study areas it will be possible to extrapolate these values, taking into account underlying variations in key factors, to map local values across the DRC, and also produce a more accurate assessment of the multiple functions of the DRC's forests. The five multiple benefits that are identified to be prioritised for assessment (though the fifth is most difficult in terms of monetary valuation so may be postponed for future research) are set out below. They differ from the five set out at the start of this study. It makes sense for all wood removal to be looked at together, whatever the final usage of that wood, in order to establish total harvest sustainability. A new heading of damage avoidance has been created to brigade the various, but related, negative impacts of soil and water interaction. A new cultural benefit heading has been added, since these were largely overlooked, not just in the remit of this study, but from studies more widely. Such values stray from traditional economic territory into the field of social studies; however, increasingly it is being recognized that they need to be taken into account if human wellbeing is to be maximised. Finally, recreational values have been excluded from valuation since in the current security climate they are only potential values at this stage and little further progress might be made in terms of valuation than presented in this study. Potentially important areas for nature tourism should be included in any forest benefits mapping though.

2. Damage avoidance (landslides, siltation and flooding)

To assess damages caused by mudslides, siltation and flooding, data (frequency and impacts on crop production, houses, roads, dams etc) relating to previous such events should be collected in the study area by surveying local communities as well as government officials and dam managers. Data on topography, slope, and rainfall patterns can be collated and mapped along with presence of transport networks, dams and human settlements. The damage information can be used along with cost and market data to estimate value and hydrological-soil erosion models used to link costs to amount of forest cover spatially. Ideally more detailed soil data should be collected from the study area; however, this is not essential.

3. Water quality

This can be briefly examined to determine whether there are downstream uses in the study area that will be impacted by deforestation in terms of water quality – namely drinking water supplies and fisheries. Where market price data is not available/appropriate then local communities can be surveyed to determine the importance to them of being able to access clear drinking water. Relevant values can then be mapped based on the soil erosion model used in 1.

4. NTFPs

These could be important values; therefore time should be taken to collect adequate survey data from forest communities in order to fill existing data gaps. Information should be collected on the quantity, the value (either market value or the perceived importance to the household), and the area of forest utilised (obtaining this may require careful design of the questionnaire) in order to collect (a) bushmeat, (b) caterpillars and (c) fuelwood. Interviewees should also be asked about the perceived availability of these products, i.e. whether they have become less available over recent years/do they have to travel further to collect them. The association of particular NTFPs with certain tree species should also be recorded. Ideally ecological data on the sustainability of current harvest levels should be collected in order to estimate the impact of harvesting on populations of different species. However, in order to at least identify whether these species populations are noticeably declining, the survey question about NTFP availability could be used.

5. Wood

The quantity of timber harvested in addition to fuelwood for own use by local forest communities would be needed, along with the area of forest utilised for such a purpose, so that an estimate can be made as to whether local selective logging is sustainable. Questions on this would be included in the survey. Views can also be sought from local forest communities on the main reasons for forest conversion to other land uses. It would also be useful to briefly explore with experts on the ground the current state of the commercial timber industry.

6. Cultural

These social values are more difficult to place monetary valuations on and at this stage it may be decided that recording such values in monetary terms is not important for current decision-making. Any spiritual/cultural/aesthetic values associated with forests may be recorded by adding some further questions to the local surveys. This can be semi-quantitative in nature (e.g. no/some value; not so important/very important, in addition to the reasons for the importance, and the physical characteristics of the site). The specific area should be recorded on a map by the interviewer. However, as such values relate closely to specific sites, it would not be possible to extrapolate any findings from the pilot areas to the wider forest area. Nevertheless, this survey work could help determine the relative importance of such values and thus indicate whether these values should be collected more comprehensively for their mapping. If an attempt is made to value them in monetary terms then a more complex questionnaire will be required, which compares the importance of social values against goods that have market values.

7. Activities required:

Therefore, in order to deliver on the above (with just non-monetary assessment of cultural values, and excluding the further ecological research), a survey of local forest communities will be required, which will mainly collect quantitative data, and be based on an interview questionnaire. This should aim for sample size of 250-500 individuals in total, at a minimum of three representative (i.e. of the forest nationally) locations in the study area. The interviews should be conducted face-to-face with the interviewer reading out the pre-determined questions and writing down responses (the interviewers will need some training but can be recruited locally within the DRC). A separate questionnaire will be required for interviews with officials, which could be conducted via telephone or face-to-face. Most of the field work can be undertaken by a DRC-based consultant. However, international expertise will be required in order to undertake the ecological and valuation modelling and mapping (and this will take longer than the field work). Project oversight by the international consultant is also likely to be required.

Such a project would likely take around 6-8 months, with international consultant input of around 50 days, DRC consultant 20-25 days, data entry clerk in the DRC 4-5 days and 6-8 local interviewers (undertaking 10+ interviews per day) for 4-5 days. Note that other expenses include a further day for all employed in the project for running/attending the training workshop for local interviewers, as well as travel and subsistence expenses (including for the local interviewers when working in the field). The exact number of days input in the DRC will depend upon the sample size chosen. Data analysis for the valuation would be undertaken jointly between the consultants.

The above approach is envisioned as the least-cost way forward, which would deliver spatial valuation of forest multiple benefits. However, more detailed analyses would provide a greater degree of accuracy in spatial valuation (this may be important for particular locations which are contentious and where the benefits of a proposed REDD+ project are contested). These may be rare cases though, so that the value maps resulting from the work outlined above would in most instances be adequate for REDD+ planning purposes in the DRC. Finally, it should be noted that this approach differs from a standard economic impact analysis - if a more accurate estimation of the total value of DRC's forests to the economy is required then a sectoral analysis will be required.

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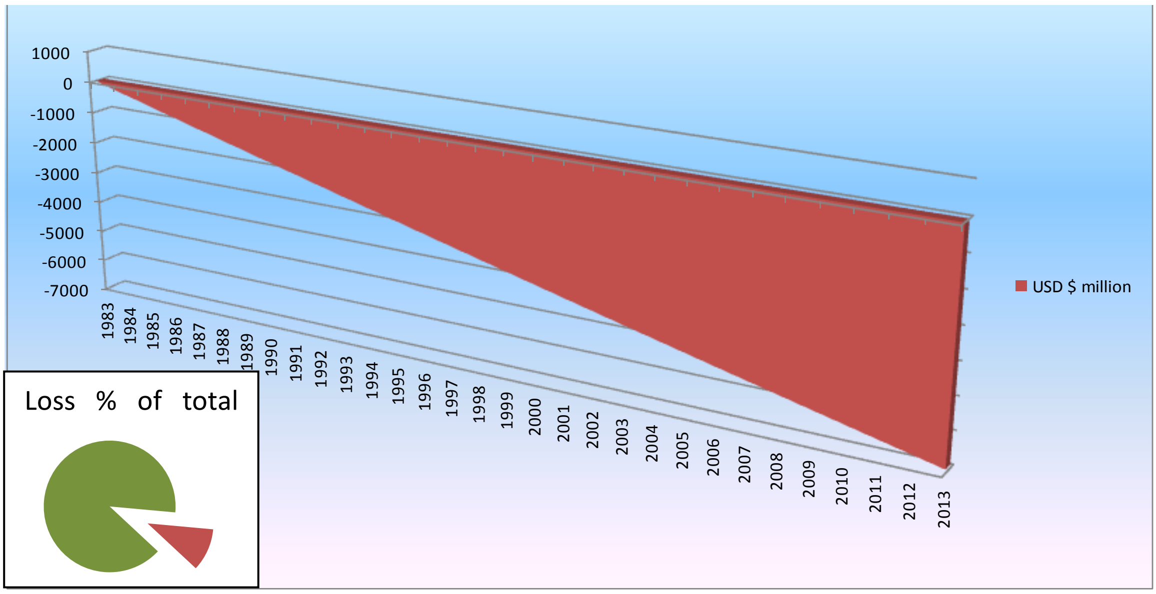
APPENDIX I

Even with only the existing data, an order of magnitude estimate of the total value of non-carbon multiple benefits of all the DRC forests can be made. This can be useful in highlighting the importance of forest benefits to decision makers in finance ministries who may not have thought about the forest in these terms. The value for the national economy, and how its use determines the sustainability of the current economic approach, can be demonstrated quite simply. The following chart uses a forest value of US$440/ha. This is a realistic, possibly conservative, value, since most deforestation will occur near urban areas and rivers, where the hydrological benefits of forests are likely to be greatest. Deforestation and degradation rates are projected backwards from data available for the last two decades. The annual deforestation rate is assumed to average 0.2% (degradation is estimated conservatively, with most assumed to be transitory before full deforestation; the impact of degradation on forest benefits is assumed to be half the deforestation impact). As can be seen, over the last three decades the DRC's forest benefits have been reduced, with lost annual in-country benefits now totalling almost US$ 7,000 million. If a lower deforestation rate is adopted over the last decade (0.1%), as some evidence suggests†, then the lost annual in-country benefits now total almost US$ 6,000 million. This indicates how policies that make a small reduction in deforestation rates can deliver substantial benefits over time. The inset pie chart shows the higher rate of loss in relation to the total remaining value of the DRC's forest benefits. Note that this estimate is based on changes since 1983; however, deforestation will have taken place before that time. Even a loose definition of sustainability maintains that liquidated natural capital (e.g. forests) should be off-set by investments in long-term built capital. Consistently running down natural (or any other form of) capital for current consumption cannot be maintained indefinitely, resulting in eventual economic decline. The green economy concept offers a sustainable alternative.



Graph 1: Losses (in USD $ million) in the value of the DRC's annual benefits from rainforests since 1983; UNEP-WCMC

† For instance, see the paper by Zhuravleva et al. 2013, Satellite-based primary forest degradation assessment in the Democratic Republic of the Congo, 2000–2010. Environ. Res. Lett. 8 024034