

Ecosystem services of the Congo Basin forests

Including a case study of the Democratic Republic of Congo

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EXECUTIVE SUMMARY

- Taking into account population growth, road density, logging concessions and forest fragmentation, the Congo Basin could continue to shrink towards the interior over the next 50 years and may fragment into three blocks.
- The Congo Basin loses some 1.49 million hectares a year to agriculture, logging, road development, oil exploitation and mining.
- The annual rate of deforestation has been estimated at an average of 0.425.
- The Republic of Congo loses at least 7,000 hectares of forest each year to logging for firewood.
- The most rapidly changing area in terms of logging is in the northern Republic of Congo, where the rate of road construction increased from 156 km $year^{-1}$ for the period of 1976–1990 to over 660 km $year^{-1}$ after 2000. Furthermore, evidence for a new frontier of logging expansion was documented within the Democratic Republic of Congo.
- The greatest amount of forest disturbance due to logging (15%) occurred in Cameroon and Equatorial Guinea, compared with just 1% within the Democratic Republic of Congo.
- The number of trees being felled for sale is a maximum of 4 per hectare.
- Conflicts in the region have been financed to a large degree by logging, ivory trade, diamond, gold and coltan mining.
- In 2005, an agreement was signed between Cameroon, Gabon and Republic of Congo to protect 14.6 million hectares of forest, or approximately 7.5% of the entire Congo Basin.
- Africa's tropical rainforest zone is the driest in the tropical rainforest region and has become drier in recent decades.
- Deforestation of the Congo Basin has the potential to decrease precipitation by approximately 5-15% in the U.S. Great Lakes region. It also affects Ukraine and Russia where in May precipitation is reduced by as much as 25%.
- There exists a natural see-saw oscillation across the Atlantic Ocean: floods in the Amazon tend to coincide with droughts over the Congo Basin and *vice-versa*. Deforestation and degradation could hence have an important effect on this natural oscillation.
- A large part of the rainfall in the Congo Basin comes from recycling of moisture by the forest. 75-95% of rainfall is recycled within the Congo Basin.
- Evaporation from the region contributes about 17% of rainfall in West Africa.
- The impact of total deforestation on rainfall in the Congo Basin is spread over the entire year, with the dry season (June-July) mostly suffering from deforestation with a decrease of precipitation around 30% during this period, versus a decrease of 10-20% during the wet season.
- Replacement of tropical rainforest vegetation with savannah vegetation in the basin would result in decreased averaged rainfall throughout the year: this ranges between 2 to 3 mm^{d-1} during the northern hemispheric summer months, when the region experiences the driest conditions (July to September), and less than 1 mm^{d-1} during the wettest months (autumn and spring). Over southern Africa deforestation results in substantial rainfall reduction over Mozambique and rainfall increase over Botswana, Zambia, the southern region of the Democratic Republic of the Congo, and parts of South Africa.
- Deforestation in timber concessions reduced rainfall in bordering undisturbed national parks by 15%. This rainfall reduction is large enough to shift the vegetation of some parks across the transition zone from forest to woodland or savannah with a consequent crash in biodiversity.
- The hydroelectric potential of the Congo Basin amounts to about $1/6^{th}$ of the known world resources.
- The per hectare value of the Congo Basin forests was calculated at US$ 1152.9.
- Using the FAO 2007 statistics, 65.9 million tonnes of carbon are released per annum in the Congo Basin.
- The region's forests are a sink of an estimated 24-39 Gt of C and current deforestation rates are estimated to be releasing 0.02 – 0.44 Gt of C per year.
- The CBFP priority landscapes with regard to biodiversity and ecosystems cover about 38% of the forests in the Congo Basin and contain around 30 important protected areas.
- Assuming annual growth of 5.3% per year, it would take until 2060 for the GDP per capita in the Democratic Republic of Congo to return to its level of 1960.
- The Democratic republic of Congo has the potential to produce 150,000 Megawatts of power through hydroelectric potential. There are plans to raise the production from the Inga hydroelectric power station to 44,000 Megawatts by 2010, twice as much as the Three Gorges Dam in China.

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1. INTRODUCTION

The Stern Report on climate change, published in October last year, highlighted the fact that deforestation is responsible for 18 % of the world's greenhouse gas emissions (GHG), and stated that prompt action to tackle deforestation is a critical part of the global response to climate change (Stern, 2006). If current trends continue, tropical deforestation will contribute 3 billion tonnes of carbon each year (Chomitz, 2006), with emissions from deforestation throughout the world expected to total 40 billion tonnes of carbon between 2008-2012. This alone will raise atmospheric CO_2 levels by about 2 parts per million (ppm) - greater than the cumulative total of aviation emissions since the invention of aeroplanes (Stern, 2006).

The question on tropical forests, climate, human-induced climate change and land-use and land-cover change (LULCC) is a complex one, encompassing several scientific disciplines and cutting both ways. Firstly, the question could be posed as follows: *how do climate and climatic variations, human-induced climate change and LULCC affect tropical forests*? Secondly, one might ask: *what role do tropical forests play in regulating the local, regional and global climate, how does this effect LULCC and human-induced climate change*? The second question can be roughly delineated as the local, regional and global ecosystem services tropical rainforests provide.

It is well-known that deforestation, forest degradation and climate are coupled. Drier regions are more likely to be deforested/degraded while deforestation/degradation contributes to altering local, regional and global climate. The fate of many of the world's tropical rainforests is unlikely to be mostly determined by climate trends but rather by human actions on forest use or protection (Malhi & Wright, 2005).

As the avoided deforestation/compensated reductions scheme is gaining momentum and is being debated at the UNFCCC in Bonn another question arises. While the international community is struggling to work out the details of how to pay developing countries to keep forests intact for their carbon values, an important gap in knowledge is becoming increasingly apparent: what are the ecosystem services forests provide (locally, regionally and globally), to whom do they provide them and what is their potential economic value?

This report sets out to provide a preliminary overview of the following key questions:

1. What are the major threats to the Congo Basin forests in the next 5-30 years?
2. Who are the best stakeholders acting in the region on forest issues to work with, why and what actions are being considered to counter threats?
3. What is the most convincing existing model of delivering benefits to local people which have reduced deforestation rates?
4. What are the ecosystem services provided by Congo/DRC forests, who benefits from them and can we place economic values on these and to whom they are provided?
5. How do the above questions apply to the Democratic Republic of Congo?
6. What are the main gaps identified and future outlooks?

The report will follow these questions by means of sections. It is by no means exhaustive and aims to provide a preliminary overview of the issues raised and highlight some major gaps that future research could focus on.

2. THE CONGO BASIN FORESTS

Africa accounts for about 17% of the world's forests but for about 50% of net recent global deforestation (Cropper, 2006) and has already lost more than two-thirds of its original forest (Wilkie & Laporte, 2001). Overall 4 million hectares of African forests are destroyed each year due to growing human population, illegal logging and conversion of forest land to other uses (WWF, 2005).

The Congo Basin forests extend over the following six countries: Equatorial Guinea, Cameroon, the Central African Republic (CAR), the Democratic Republic of Congo (DRC), the Republic of Congo and Gabon. Being the richest ecosystem of the continent and harbouring more than half of Africa's fauna and flora, it is an important tropical forest region in Africa. It has the second largest contiguous area of humid tropical forests after the Amazon, or approximately 20% of the world's remaining tropical forest (figure 1) (Achard *et al.*, 2002; FAO, 2001; Mayaux *et al.*, 2004). Large blocks of intact natural forest still remain in DRC, Gabon and the Congo (Bryant *et al.*, 1997). As well as endangered wildlife, central African forests also harbour vast reserves of minerals which still remain to be tapped. Furthermore, there is a huge potential for the generation of hydroelectric power.

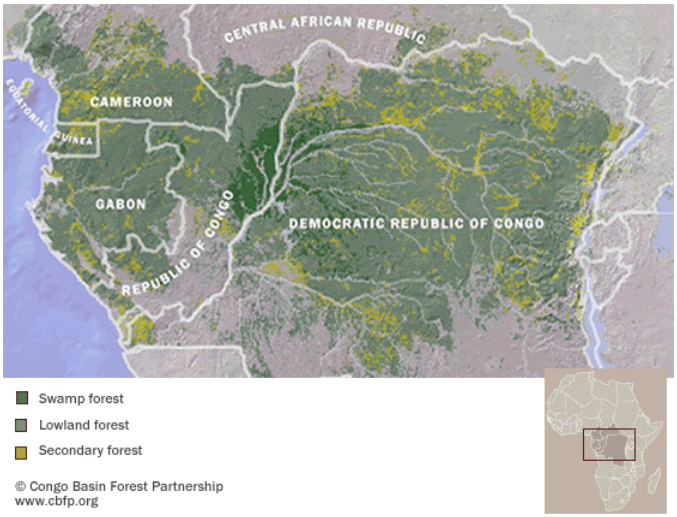

Figure 1. Location of the Congo Basin forests on the African continent and its extent.

Zhang *et al.* (2006) examined the vulnerability of the Congo Basin's forest using a Geographical Information System (GIS) platform, taking four variables into consideration: population growth, road density, logging concession and forest fragmentation. Their results indicate that the **Congo Basin forest will continue to shrink towards the interior over the next 50 years**. Furthermore, the current contiguous forests **will fragment into three large blocks**, including one on the west side of the Congo River and two in the Democratic Republic of Congo, while a large number of small forest patches will remain on the periphery of the large blocks.

Compared to the other two main tropical forest regions (Amazon Basin and South-East Asia) the Congo Basin has received little funding research and conservation wise and scarce attention in the media other than in war-torn areas. However, more recently there has been a growing interest in the region which is a necessary and much welcomed development (Appendix 1).

3. THREATS TO THE CONGO BASIN FORESTS

Land-use change and land-cover changes are so pervasive that, when aggregated globally, they significantly affect key aspects of Earth System functioning (Lambin *et al.*, 2001). The primary cause of deforestation in Africa as a whole since 1980 is direct conversion from forest to small-scale permanent agriculture, accounting for 60% of the forest area changes (Kelatwang & Garzuglia, 2006). The two major threats to primary forests in Africa are logging and commercial hunting to meet a growing urban demand for bush meat (Kelatwang & Garzuglia, 2006). The **Congo Basin loses some 1.49 million hectares a year to agriculture, logging, road development, oil exploitation and mining** (WWF News, 2005). Appendix 2 provides a regional overview of the main direct and indirect threats and the main underlying causes as outlined by the Congo Basin State of the Forests document (2006).

Table 1 shows, for each country, the forest area in 2005 and the annual change rate based on calculations made by the author from the FAO (2007) forest assessment.

Table 1. Forest area in 2005 and the annual change rate (FAO, 2007). Total forest* includes forest plantations.

	Forest area (2005)				Annual Change rate			
	Total forest* area	% of land area	Area per capita	Forest plantations	1990 - 2000		2000 – 2005	
Country	(1000 ha)	(%)	(ha)	(1000 ha)	(1000 ha)	(%)	(1000 ha)	(%)
Cameroon	21245	45.6	1.3	-	-1.9	-3.7	-9	-5.2
Central African Republic	22755	36.5	5.8	5	-30	-0.1	-30	-0.1
Republic of Congo	22471	65.8	5.8	51	-17	-0.1	-17	-0.1
Democratic Republic of Congo	133610	58.9	2.4	-	-532	-0.4	-319	-0.2
Equatorial Guinea	1632	57.2	3.2	-	-15	-0.8	-15	-0.9
Gabon	21775	84.5	15.8	36	-10	n.s.	-10	n.s.
Total	**223488**	**56.12**		**92**	**-613**	**-0.27**	**-400**	**-0.18**

3.1 Deforestation

Human causes of deforestation[1] in the Congo Basin are multiple, ranging from illegal logging and agricultural encroachment in Cameroon, to fuel wood supply and urban expansion around refugee migrations and major cities in Liberia and eastern Democratic Republic of Congo (Mayaux *et al.*, 2005). Shifting cultivation has been the primary cause of deforestation (FAO, 2001; Justice *et al.*, 2001). However, through the build up of local road networks, logging will open large blocks of presently inaccessible forests to small-farm holders and generate a secondary wave of land-use change, as deforestation is related to local forest accessibility (Wilkie *et al.*, 2000; Zhang *et al.*, 2005).

Zhang *et al.* (2005) estimated tropical deforestation in the Congo Basin during the 1980s and 1990s. They found that the **annual rate of deforestation**, *i.e.* conversion of dense and degraded forests to non-forest, ranged from 0.0 – 2.7% with an **average of 0.42%**. Furthermore, image interpretation confirmed a hypothesised relationship between deforestation and forest accessibility. Using a case study in southern Cameroon, Mertens & Lambin (2000) found that roads mostly increased the accessibility of the forest for migrants rather than providing incentives for a transformation of local subsistence agriculture into market-orientated farming systems. Although the annual deforestation rate of 0.42% in the Congo Basin is on the low side compared to West Africa and other tropical regions, this is increasing as this region is slowly improving its infrastructure, new logging concessions are being allocated and there is an increasing pressure from population growth (Justice *et al.*, 2001; Zhang *et al.*, 2002). In conflict areas, especially on the eastern DRC border with Rwanda, refugees have played in important role in deforestation processes.

Many rural people also depend on wood and charcoal for heating and cooking. The Central African Forestry Commission (COMIFAC) estimated that the **Republic of Congo loses at least 7,000 hectares of forest each year to logging for firewood** (POWER: Congo, 2006).

A recent study by Laporte *et al.* (2007) showed that industrial logging is expanding rapidly in the Congo Basin. They found that **the most rapidly changing area was in the northern Republic of Congo, where the rate of road**

[1] Deforestation in this research will be referred to as the depletion of tree crown cover to less than 10% (see Mayaux *et al.*, 2005).

construction increased from 156 km year^{-1} for the period of 1976–1990 to over 660 km year^{-1} after 2000. Furthermore, evidence for a **new frontier of logging expansion was documented within the DRC**, which currently contains 63% of the total remaining forest of the region and has the lowest measured logging road density (0.01 km km^{-2}) of all Central African nations. Rates of logging road construction increased within DRC, particularly in a 50,000 km^2 region of north-central DRC, where the rate of road development progressed from 336 km year^{-1} (1986–1990) to 456 km year^{-1} (2000–2002). The authors also estimated that 5% (89,715 km^2) of the total forested area as disturbed and 29% (567,782 km^2) as more likely to have increased wildlife hunting pressure due to easier access and local market opportunities offered by new logging towns. **The greatest amount of forest disturbance (15%) occurred in Cameroon and Equatorial Guinea, compared with just 1% within the DRC**.

3.2 Degradation and fragmentation

The Congo Basin has a different history and different trajectories of disturbance compared to the Amazon Basin. For example, the 'fishbone' disturbance patterns often evident from images of South America are not apparent in the Congo Basin (figure 2). Furthermore, our knowledge of forest fragmentation and the large-scale distributions of fragmentation in the region are limited. Generally speaking and in comparison to areas such as the Amazon forest, deforestation in the Congo Basin remains limited to relatively few areas and clear-cutting on a large scale or agricultural expansion is not expected to take place in the near future (Mayaux *et al.*, 2005).

Nonetheless, the forest has recently been subject to significant human-induced changes (Zhang *et al.*, 2005). Considerable areas of dense forest have been (1) deforested by conversion into agricultural land and other non-forest cover or (2) degraded into areas with low tree-cover (Mertens & Lambin, 2000). The key factor driving forest fragmentation and degradation, and thus the key to near-term management of forests in the Congo Basin, is logging. Industrial logging in the basin currently affects about half of the forest block. It is generally of low intensity, the **number of trees being felled for sale being around 0.5 to 3 per hectare, with a maximum of 4 per hectare** (CBFP, 2006), **to reach an average wood productivity of 5-6 m^3/ha** (Estève, 1983; Jonkers, 2000 cited by Nasi, 2005). This process is very selective, with the degree of selectivity being much higher inland (DRC, northern Republic of Congo) than in the coastal regions (Gabon, Cameroon) because companies can only harvest species whose commercial value exceeds the cost of transport to the ocean (CBFP, 2006). In many regions only the very highest value specimens are taken which is not ecologically sustainable (CBFP, 2006). Despite laws and regulations, this practice continues because of current political and social uncertainties and fluctuations in the international market (CBFP, 2006).

Intensifying this is that increased pressure on these forests can be expected in the foreseeable future due to population growth, increasing demands on forest resources (Justice *et al.*, 2001) and the opening of new road networks by governments and logging companies (Wilkie *et al.*, 2000). Based on the application of a calculated 'vulnerability' index, countries most likely to suffer future forest degradation and loss of forest cover include Equatorial Guinea, Cameroon and CAR (Laporte *et al.*, 1998). In particular, with the end of the war in DRC, concerns have been raised about the allocation of logging permits and fear exists of rapid deforestation growth in DRC within the next years (Debroux *et al.*, 2007; Greenpeace, 2007).

3.3 Conflict and displaced people

Some countries in the region (CAR, Republic of Congo, DRC) have been ravaged by wars and/or civil disturbances that have led to large numbers of refugees and displaced persons (CBFP, 2006). Despite United Nations assistance, these populations have had to depend on the country's natural resources and live in places where their impact has been very severe, both on natural ecosystems and on local populations. This problem is particularly acute in eastern DRC, in the Virunga Landscape and the Maiko-Tayna-Kahuzi-Biega Landscape (CBFP, 2006). Furthermore, **the conflicts have been financed to a large degree by logging, the ivory trade or diamond, gold and coltan mining** (CBFP, 2006).

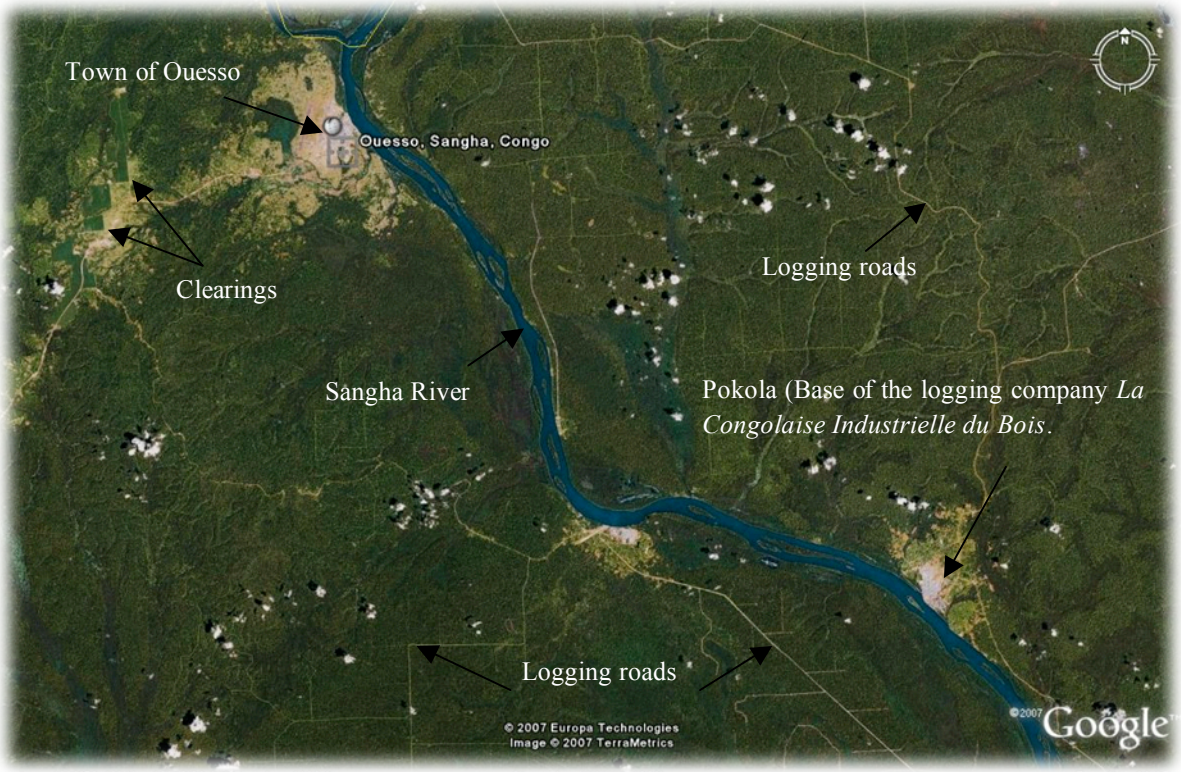

Figure 2. Google Earth Image showing an area in the northern Republic of Congo where extensive logging roads can be observed, yet not the typical fish-bone pattern as one finds in the Amazon Basin.

3.4 Non-renewable natural resource exploitation

This section is based on a report by Reed & Miranda (2007).

The countries of the Congo Basin forests are home to an important economic wealth of mineral resources including oil, gold, diamonds, uranium, copper and manganese. Striking a balance between the exploitation of these resources and conserving biodiversity is a challenge in countries with highly developed corporate social responsibility and environmental standards, and is even more difficult in this region.

As with logging, the development of infrastructure associated with mining poses a substantial threat to the Congo Basin forests. The indirect impacts from these activities can be more harmful than direct impacts through natural resource degradation, pollution and deforestation. High mineral prices in the region are encouraging the further development of various mineral deposits, including previously unviable deposits. As the profits are high, exploitation companies are increasingly willing to invest significant resources into developing mineral fields, often in inaccessible areas, requiring major infrastructure development.

Some governments (especially Gabon and Equatorial Guinea) that rely on oil revenues may be facing shortages that will encourage the development of non-oil minerals or increase logging or agricultural output. A significant infrastructure development will be the construction of the Chad-Cameroon oil pipeline. However, according to World Bank estimates, the underground pipeline will produce minimal deforestation (10-15 km^2), will cause little resettlement and will adhere to appropriate standards of environmental protection (World Bank, 2007).

To my knowledge, there have been no estimates on either the forest areas affected by mining and the infrastructure development that accompanies it, nor the environmental impacts in both the scientific or non-scientific literature in the Congo Basin.

4. PLAYERS IN THE REGION AND ACTIONS CONSIDERED

In 1999 the first Central African Heads of State Summit took place in Yaoundé, Cameroon marking an important turning point in the political agenda of the sub-region. The outcome was the 1999 Yaoundé Declaration where the Heads of State of the countries present expressed their commitment to work towards sustainable management and conservation of the Congo Basin Forests. In the meantime, there have been remarkable changes in the forestry sector: (1) the establishment of a central sub-regional institution, the Central African Commission of Forests (COMIFAC); (2) the adoption of a sub-regional 'convergence plan'; (3) the establishment of a partnership for the Congo Basin forests (CBFP) and (4) adhesion to the principles of good governance in forestry matters (AFLEG) (Brazzaville Summit, 2005). At the Brazzaville Summit in 2005, the commitments to the Yaoundé Declaration were reinforced and **a trilateral agreement** (TRIMOD) **was signed between Cameroon, Gabon and Congo to protect 14.6 million hectares of forest, or approximately 7.5% of the entire Congo Basin**.

COMIFAC[2] now brings together ten Central African states. Headed by the Council of Ministers, it is the political and technical body for orientation, coordination and decision-making with respect to conservation and sustainable management of the forest ecosystems of Central Africa. It harmonises and coordinates the forest and environment policies of its Member States. The COMIFAC 'Plan de Convergence', adopted by the Council of Ministers, defines the common intervention strategies of the States and partners in the development of Central Africa as related to conservation and sustainable management of forest ecosystems and savannahs. The strategic priorities are: (1) harmonisation of forest and taxation policies; (2) knowledge of the resource; (3) management of ecosystems; (4) conservation of biological diversity; (5) sustainable exploitation of forest resources, combating poverty, socioeconomic development, monitoring timber sector and sub-regional timber market; (6) strengthening of capacities, participation of players, information, training, consciousness-raising; (7) research-development; (8) development of financing mechanisms; (9) cooperation and partnerships. COMIFAC works in close cooperation with other regional and/or African institutions, including: African Timber Organization (ATO), *Agence intergouvernementale pour le développement de l'information environnementale* (ADIE), *Organisation pour la conservation de la faune sauvage en Afrique* (OCFSA), *Réseau des aires protégées d'Afrique centrale* (RAPAC), *Conférence sur les ecosystèmes de forêts denses et humides d'Afrique centrale* (CEFDHAC).

Other important and influential players in the Congo Basin region are listed below.

- The Congo Basin Forest Partnership (CBFP): this association brings together some thirty governmental and non-governmental organisations. It was established in September 2002, at the World Summit on Sustainable Development (Johannesburg, South Africa). The goal of CBFP is to improve communication between members and coordination between their projects, programmes and policies in order to enhance the sustainable management of the Congo Basin forests and improve on the standard of living of the inhabitants of the region (CBFP website: http://www.cbfp.org/en/index.htm) .
- Central African Programme for the Environment (CARPE): is a United States Agency for International Development (USAID) initiative aimed at promoting sustainable natural resource management in the Congo Basin. Recognising the important role of the Congo Basin forest and amidst the increasing pressures facing the Congo Basin forest, CARPE works to reduce the rate of forest degradation and loss of biodiversity by supporting increased local, national, and regional natural resource management capacity (CARPE website: http://carpe.umd.edu/) .
- WWF: WWF is very active in the region and appears to have a good relationship with many of the influential partners. It was WWF that organised the Yaoundé summit in 1999. On the ground, WWF and its partners have habituated gorillas for research and ecotourism, control the bushmeat problem, help indigenous groups such as the Ba'Aka pygmies hold onto their traditional way of life, search for solutions to the Ebola outbreaks that are killing villagers and devastating gorilla populations, and work with logging companies to halt poaching and reduce deforestation (WWF website: http://www.worldwildlife.org/wildplaces/congo/).

[2] This section on the COMIFAC is based on the Box 7.1., page 49 of the CBFP (2006) report citing Nagahuedi (2005), Hakizumwami & Ndikumagenge (2003) and COMIFAC (2006). See the COMIFAC website for more information: http://www.comifac.org/

5. DELIVERING BENEFITS TO LOCAL PEOPLE AVOIDING DEFORESTATION

The Congo Basin is home to more than 24 million people, most of whom depend on the forest for their livelihoods. The livelihoods of these people are under threat by the continued loss of the forest. The hunting of wildlife to supply urban and commercial forestry settlement markets may represent a more immediate and significant threat to the forest than deforestation itself (USAID-CBFP). Furthermore, the industrial harvesting of timber, natural population growth, immigration, commercial hunting, the production of palm oil, road construction and growing access to distant markets have driven traditional systems of natural resource management to the breaking point (CBFP, 2006). Unfortunately, very few populations retain control over the resources on which they traditionally depend and which are being quickly depleted. Local populations are also often marginalised from the decision-making processes. Hence, one of the main challenges for natural resource management in the Congo Basin is the re-establishment of systems where local populations retain control over land use on an ethical self-regulating basis (CBFP, 2006). According to CBFP (2006) experiments on local management of the forests' natural resources are being conducted in several areas, however, refraining from marketing forest products raises an additional problem: how are local populations going to generate the necessary financial means to meet their basic needs, for example healthcare and education?

There are two answers to this question: (1) Either increased production from agriculture and/or local stock farming can provide a solution (which requires that products be taken away and marketed) or (2) deliver benefits to local people that avoid deforestation for agriculture and firewood collection. Mertens & Lambin (2000) created a model to look at land cover trajectories in southern Cameroon. Returns of forest conversion and costs of forest conversion are important aspects. According to the authors, these depend on the following:

- Returns of forest conversion:
    - Farmgate prices of outputs as a function of the transportation costs and the price at the market;
    - Farmgate price of inputs as a function of the transportation costs and the price at the market;
    - Agroclimatic conditions which are represented by classes of land aptitude for agriculture, describing the influence of soil, climate and topography on the potential yield of the main crops of the local farming systems.
- Costs of conversion:
    - Physical accessibility to the forest: which in turn depends on the road network and the number of openings in the forest cover that facilitates access to the forested areas. This can be measured by the distance of any forest location to the nearest forest/non-forest edge and by the forest-cover fragmentation;
    - Forest clearing cost which is related to the density of the vegetation cover and to the technology used for forest clearing;
    - Social accessibility to forested land which is related to human pressure on the land and is dependent upon the population density relative to non-farm employment opportunities in the region and, as a proxy variable, on the average income level of the local population (low average income level is assumed to generate greater demand for land);
    - Land tenure and especially the degree of tenure security of the forest occupants.

A forest plot is assumed to be converted to non-forest if it has a positive rent (*i.e.* if the returns to conversion are positive). If benefits are to be provided to local people for avoiding deforestation, they will have to outweigh the benefits of 'normal' forest conversion. These benefits will most likely have to be both economic and other (healthcare, access to clean water, electricity, etc.). It would be feasible to conduct a few simple case studies mapping the returns and costs of conversion of certain forest communities and calculating the positive rent. One could then examine how much these communities would need in terms of economic compensation for not undertaking these activities and what kind of non-economic benefits they would see as priorities to be developed. This would allow the development of a basic model and in a more sophisticated model access to micro-credits could play a role in giving local people the opportunity to have more control over their livelihoods. It is important, however, to acknowledge the case-specificity of each community.

6. ECOSYSTEM SERVICES

Rainfall patterns are affected by forests on a local, regional and potentially global scale. Avissar & Werth (2005) and Maynard & Royer (2004) found that complete deforestation in tropical Africa would result in a decline in rainfall and increase in surface temperatures within the affected region. The forests of the Congo Basin play an important role in maintaining the local, regional and global climate. The region's forests are a sink of an estimated 24-39 Gt of carbon, and current deforestation rates are estimated to be releasing 0.02- 0.44 Gt of carbon per annum (Hoare, 2007). Furthermore, they are an important driver of atmospheric circulations, the exchange of energy and water between the forests and atmosphere influencing regional and global weather systems (Hoare, 2007).

6.1 Rainfall

Deforestation of tropical regions significantly affects precipitation at mid and high latitudes through hydrometeorological teleconnections (Avissar & Werth, 2005). Land-cover scenarios have shown that tropical rainforest conversion will probably lead to a weakening of the Hadley circulation over much of the world and to significant changes in the Asian monsoon circulation (Feddema *et al.*, 2005). **Heating** of the atmosphere above the African and South American continents **results in 5,600 km^3 of rain over the Congo** and 12,000 km^3 over the Amazon, annually. Therefore, rainfall and atmospheric movement over these two basins have a huge influence over global climate (Eltahir *et al.*, 2005). The Congo Basin has received little attention in the field of climate research despite its important position as the third largest deep convection centre, globally, after the West Pacific warm pool region and the Amazon Basin (Shem & Dickinson, 2006). Tropospheric heating related to this convection is a primary driver of general tropical circulation, yet our understanding of the climate processes in this region is limited and represents a notable gap in our understanding of the tropical climate system (Todd & Washington, 2004). In a study by Malhi & Wright (2005) examining the mean climate and climate trends of tropical forest regions over the period 1960-98, evidence was presented that **Africa's tropical rainforest zone is the driest tropical rainforest region and has become drier in recent decades**. The extent of African tropical rainforest appears to be especially vulnerable to small shifts in the ocean-atmosphere circulation. Furthermore, the authors suggested that a study of how surviving African forests have responded to the drying trends of recent decades may yield useful insights into how tropical rainforests in general may respond to future drying. This strong drying trend suggests that Africa's tropical rainforest zone should be a priority study region for understanding the impact of drought on tropical forests. Moreover, African tropical rainforests have also experienced a significant increase in dry season intensity.

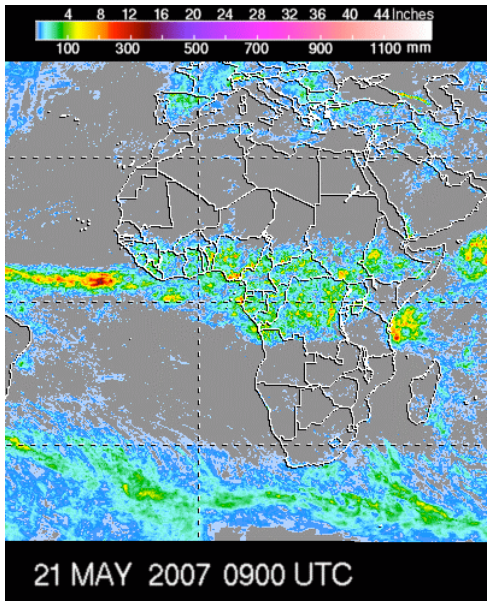

Figure 3. NASA TRMM (Tropical Rainfall Measuring Mission) image showing a week of accumulated rainfall over the African continent.

6.1.1 Global effects

On a global level, a strong link has been found between rainfall in the Congo Basin and circulation patterns over the North Atlantic during the Northern hemisphere's spring and winter (Todd & Washington, 2004).

Deforestation of the Congo Basin causes a **decrease in precipitation of approximately 5-15% in the Great Lakes region**, mostly centred in Illinois, with a peak decrease of about 35% in February. It also affects the **Ukraine and Russia (north of the Black Sea), where in May precipitation is reduced by as much as 25%.** Deforestation of Amazonia and the Congo Basin severely reduces rainfall in the lower U.S. Midwest during the spring and summer seasons; in the upper U.S. Midwest during the winter and spring, respectively, when water is crucial for agricultural production in these regions (Avissar & Werth, 2005).

There also exists an important interplay between African and Asian land-cover change which affects the Asian Monsoon. The Indian Ocean experiences a significant reduction in surface pressure, resulting in warmer surface temperatures and increased cloud cover and precipitation, and these effects extend over most of the Indian subcontinent (Feddema *et al.*, 2005).

A study by Eltahir *et al.* (2005) used satellite observations on tropical rainfall distribution and historical river flow observations to document a **natural see-saw oscillation across the Atlantic Ocean** (figure 4). **The results showed that floods over the Amazon basin tend to coincide with droughts over the Congo Basin and *vice-versa***. They found that the phenomenon is most significant during the Southern hemisphere summer and was observed more clearly during the decades of 1945-1955, the 1960s and 1970s. **Deforestation and degradation could hence have an important effect on this natural oscillation** as large variations in rainfall over the continental centres of convection and rainfall of the Amazon and the Congo are likely to have significant impacts on the hydrology and climate of surrounding regions.

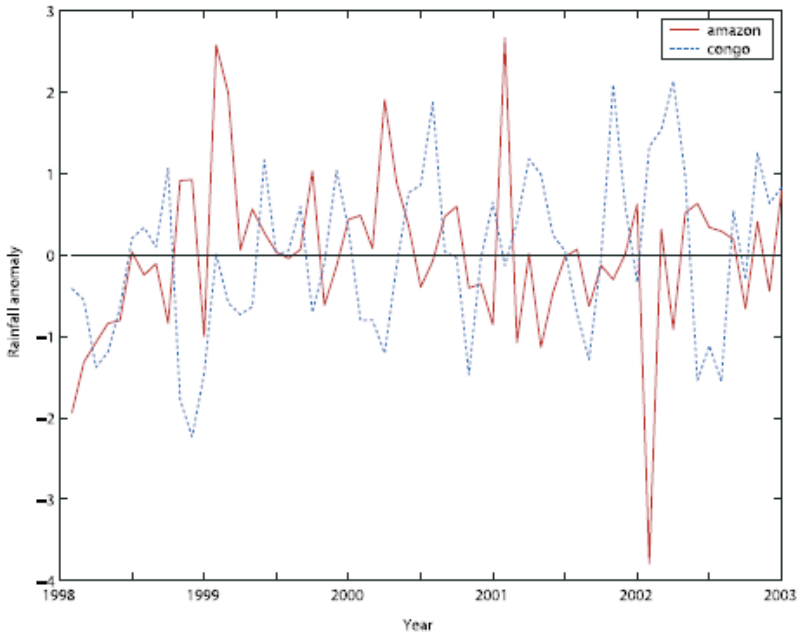

Figure 4. Rainfall anomalies over the Amazon and Congo basins. Figure was taken from Eltahir *et al.* (2005).

6.1.2 Local & regional effects

It is believed that deforestation in the Congo Basin would have a particularly strong effect on local rainfall (Hoare, 2007). Cadet & Nnoli (1987) showed that **a large part of the rainfall comes from the recycling of moisture by the forest**, whereas in other monsoon regions most rainfall comes from water vapour accumulated from the oceans. Although the estimate is somewhat old, Brinkman (1983) found that as much as **75-95% of rainfall is recycled within the Congo Basin** while the figure was put at 50% for Amazonia.

Gong & Eltahir (1996) found that **evaporation from the region contributes about 17% of rainfall in West Africa**. Moisture supply from the Congo Basin is strongly regulated and limited by the westerly flow associated with the monsoon circulation. Therefore, the large-scale monsoon regulation exerts significant control on where moisture reaching West Africa comes from.

Using a global climate model (GCM), Werth & Avissar (2005) simulated the effects of the total deforestation of equatorial Africa. More specifically, they examined local and remote precipitation changes caused by such a land-use change. The authors found a strong local effect, **the impact of deforestation on rainfall in the Congo Basin is spread over the entire year, with the dry season (June-July) mostly suffering from deforestation with a decrease of precipitation around 30% during this period, versus a decrease of 10-20% during the wet season**. The remote effect is caused by the African geopotential changes being spread beyond the deforested area by the large-scale winds.

Furthermore, Semazzi & Song (2001) showed that replacement of tropical rain forest vegetation with savannah grassland vegetation would results in the following climate changes over Africa: (1) over the deforested region, the model results indicated a significant reduction in area averaged rainfall throughout the year. The **decrease ranges between 2 to 3 mm^{d-1} during the northern hemispheric summer months, when the region experiences the driest conditions (July to September), and less than 1 mm^{d-1} during the wettest months** (autumn and spring) and (2) Over **southern Africa deforestation results in substantial rainfall reduction over Mozambique and rainfall increase over Botswana, Zambia, the southern region of the Democratic Republic of the Congo, and parts of South Africa**. Changes in the trapped Rossby wave train activity generated by the mid-tropospheric latent heating over the tropical forest region are responsible for the continental-scale teleconnection climate response.

Baidya Roy *et al.* (2005) used regional-scale atmospheric simulation experiments to investigate how deforestation in timber concessions could affect precipitation inside bordering, undisturbed national parks in the Republic of Congo and Gabon. Results showed that **in some parks rainfall reduced as much as 15%**, while others showed slight increases. Moreover, the study revealed that inside parks, rainfall was especially sensitive to upwind deforestation along the path of airborne moisture travelling inland from the ocean. The simulations clearly suggest that extensive logging in timber concessions in the western Congo Basin could affect the rainfall in adjacent protected areas and national parks, it is important to further assess the potential impact of logging on the regional climate as a whole. This study also has important conservation issues given that **the magnitude of rainfall reduction observed in the simulations is large enough to shift the vegetation of some parks across the transition zone from forest to woodland or savannah with a consequent crash in biodiversity**.

6.2 Watershed – hydroelectric power

During the high rainy seasons of May and December, the Congo River which drains the Congo Basin, discharges some 1.2 million $feet^3$ of water per second into the Atlantic Ocean (Washington Post, 2001). It has been estimated that the **hydroelectric potential of the Basin amounts to about 1/6th of the known world resources**, yet only a fraction of this potential has been harnessed (Encyclopedia Brittanica, 2007). Considering that the section on rainfall has shown that deforestation can have considerable effects on rainfall and moisture recycling within the Basin, protecting the watershed and thus hydroelectric power potential for the future with huge economic returns is crucial. DRC is the country with the largest potential and more details are given in the case study.

6.3 Carbon Storage

Carbon storage and carbon dioxide emissions of tropical forests have recently gained much political interest with regards to avoided deforestation/compensated reductions. Below follow two tables with the most important information extracted (1) from the Food and Agriculture Organisation (FAO) forest assessment 2007 with calculations by the author (table 2) and (2) from the peer-reviewed literature (table 3). This is also the only ecosystem service in the Congo Basin on which we can place a value at this present time. Using the information from table 1, we can calculate that according to the FAO 2007 data, the Congo Basin loses 65.9 million tonnes of carbon per annum.

Table 2. Information regarding growing stock, biomass and carbon in biomass based on FAO (2007). Using an average figure of US$ 7 / tC (Chomitz, 2006) the author calculated per hectare value of carbon.

Country	Growing stock			Biomass		Carbon in biomass		Per hectare value
	Per hectare (m^3/ha)	Total (million m^3)	Commercial (% of total)	Per hectare (tonnes/ha)	Total (million tonnes)	Per hectare (tonnes/ha)	Total (million tonnes)	US $ / t C
Cameroon	61.8	1313	10.1	179.1	3804	90	1902	630
Central African Republic	167.0	3801	-	246.3	5604	123	2801	861
Republic of Congo	202.5	4551	30	461.1	10361	231	5181	1617
Democratic Republic of Congo	230.8	30833	-	346.9	46346	173	23173	1211
Equatorial Guinea	65.6	107	-	141.5	231	70	115	490
Gabon	222.5	4845	-	334.6	7285	167	3643	1169
Total	**203.4**	**45450**		**329.5**	**73631**	**164.7**	**36815**	**1152.9**

Table 3. Showing most important peer-reviewed literature dealing with biomass and carbon in Central Africa and the Congo Basin.

Authors	Subject examined	Important results
Gaston *et al.* (1998)	State and change in carbon pools in the forests of tropical Africa.	Aggregating their data for the Congo Basin, the total carbon pool (above – and underground) can be estimated at ~ 30850 Tg[3] which is equivalent to ~ 60.7% of the total carbon pool of African tropical forests. However, it is suggested that the reduction in the aboveground carbon pool attributable to deforestation and biomass reduction by human activities (degradation) between 1980 and 1990 was 4433 Tg (of the original 25291 Tg aboveground carbon pool).
Zhang & Justice (2001)	C emissions and sequestration potential of Central African Ecosystems.	In 1980, aboveground carbon stocks were 28.92 Pg and were reduced to 24.79 Pg by 1990. Improved forest management could sequester 18.32 Pg of carbon.
Justice *et al.* (2001)	C and climate change.	Carbon emissions equivalent to 0.14 Pg/yr. Over the next 60 years emissions from the Democratic Republic of Congo would total 8.5 to 9.4 Pg. At present the forests of the Congo Basin serve as a large reservoir of carbon, which is equivalent to approximately 5 years of total global carbon dioxide emissions.
Zhang *et al.* (2002)	Impacts of simulated shifting cultivation in deforestation & carbon stocks of Central African forests.	Shifting cultivation under projected rates of rural population growth would increase the annual rate of deforestation to 1.3%, converting 94% of the land area into cropland, fallow and secondary forests by 2050. At that time, only 40% of the potential above-ground biomass carbon (i.e. assuming all the simulated area is occupied by dense forests) will remain, compared to 85 and 74% in 1950 and 1990, respectively.

Forests are often cleared for agricultural land which may only be worth a few hundred dollars per hectare and perhaps generating up to US$ 1000 from one-off timber sales (Hoare, 2007). The opportunity costs of forest conservation can be calculated based on the profitability of the particular land-use system that replaces a forest (Hoare, 2007). One estimate placed this at between US$ 3-11 / t C (Chomitz, 2006). Furthermore, Chomitz (2006) calculated that relatively modest carbon prices, of perhaps US$ 5-10 could deter forest conversion of 1-2 million km^2 of forest by 2050, preventing the release of 8-15 Gt C, while a price of US$ 100 would promote the conservation of 5 million km^2 of forest, equivalent to 47 Gt C.

[3] $Tg = 10^{12}$ g

6.4 Regional Biodiversity

The Congo Basin forests hold some 400 mammal species, 1300 bird species, 336 amphibian species, 400 reptile species and 20,000 inventoried plant species, of which approximately 8000 are endemic (COMIFAC website).

This section is based on the CBFP (2006) report.

On the initiative of the CARPE program, priority sites were grouped into large fairly intact areas, called 'Landscapes', based on their representativeness, the viability of their populations, the sustainability of their ecological processes, and their integrity and the resilience of their ecosystems. The CARPE program chose 11 of the Landscapes to serve as their basic units for conservation planning and implementation (figure 5).

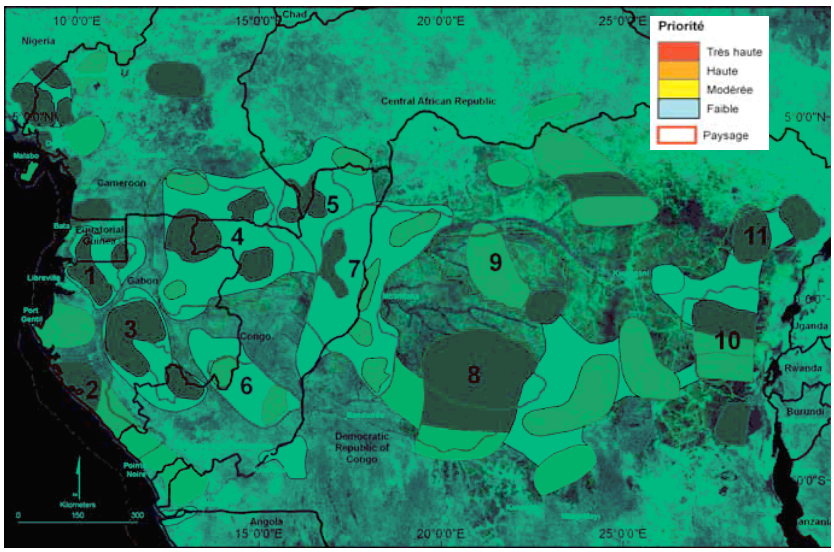

Figure 5.Priority areas for conservation and the 11 landscapes (source: CBFP, 2006)

Overall, the **CBFP Landscapes cover about 685,400 km^2, covering approximately 38% of the forests in the Congo Basin, and contain around 30 important protected areas** (national parks and wildlife reserves). The Landscape network is therefore approaching the threshold of 50% 'protected' land considered necessary to stop extinctions due to human actions. Every Landscape is centred on one or more core zones (generally protected areas) where biodiversity conservation takes priority over other forms of land use. If possible, these zones are linked by corridors so as to combat fragmentation. Around the core zones, most Landscapes include industrial extraction areas (forest concessions and/or oil concessions) and rural areas with community forests. With an **average area of 62,314 km^2**, these Landscapes are sufficiently large to cover the territories used by species such as the forest elephant, large hornbills or the giant tigerfish and to conserve viable populations of rare species or species needing large spaces. In effect, each Landscape corresponds to a vast 'ecosystem' consisting of intact core zones, comprised of priority areas for conservation, with extraction and human impact zones increasing towards the edge. The threats to the core zones, which mainly come from the peripheral areas around the Landscapes, can be systematically identified and mitigative measures can be planned.

7. CASE STUDY - THE DEMOCRATIC REPUBLIC OF CONGO

The DRC is selected as a small case study as it is the country which holds most of the Basin's forests and where the political context is evolving rapidly after the end of the war. The Congolese population is approximately 60 million, of which an estimated 90% is poor and 70% lives in rural areas (Debroux *et al.*, 2007). The country's huge forest area is a major source of food, energy, medicine and building materials for the estimated 40 million people who live in rural areas and depend on forests for their livelihoods. As the country emerges from several years of war, its forests face both opportunities and risks. The problem facing DRC today is not whether increased exploitation of forests will occur, but rather how it will happen. Several opportunities exist such as logging, mining, biofuels or compensated reductions or a combination of the aforementioned.

Assuming **annual growth of 5.3% per year, it would take until 2060 for the GDP per capita to return to its level of 1960** (Debroux *et al.*, 2007). DRC ranks last in the world in quality of its business environment (IFC, 2006). Widespread corruption and misuse of public resources, both natural and financial have been widely recognised as major obstacles to the country's development (Debroux *et al.*, 2007).

Progressive collapse of the road system, although resulting in a decline in trade in agricultural produce and other raw materials, has proved a boon for conservation, preserving some of the largest remaining blocks of intact tropical forest anywhere in the world from exploitation (Wilkie *et al.*, 2000). One of the current risks is that with improved road infrastructure, logging is going to expand and in the absence of enforced regulation, it could do so in a destructive way to serve short-term private interests. At this stage, the DRC government, in collaboration with international donors and conservation organisations have a unique opportunity to prioritise segments of the network for reconstruction. If done properly, this could effectively dictate the direction of development, resource use and conservation for the next 50 years and optimise short-term economic returns while avoiding areas of unique ecological value that are vulnerable to overexploitation (Wilkie *et al.*, 2000). Up to 60 million hectares of forest could be opened up to mostly new industrial logging activities, potentially releasing an additional 3 to 6 Gt of carbon into the atmosphere over the period in which the forest was logged (Hoare, 2007). A further similar amount could be released if these logged forests are eventually completely cleared (Hoare, 2007).

Wilkie and colleagues (2001) correctly highlight that the indebted nations of the Congo Basin are not only incapable of contributing significantly to cover the recurring costs of protected area management, the growing opportunity costs of setting aside protected areas is increasing incentives to local communities and national governments to 'illegally' exploit economically valuable resources within parks and reserves.

7.1 Who to contact?

Several international NGO's are active in the country although their work has been complicated by the political unrest over the last few years. Local NGO and institutions have also kept working, however with very limited resources.

Organistion	Description
WWF (Belgium)	International NGO with good experience in the country
Greenpeace (Belgium)	Idem as above
DFID (United Kingdom)	Involved with looking at payments for ecosystem services.
Africa Museum Tervuren (Belgium)	Museum with a research component to it. Their experience and work in the region extends back to colonial times.
CNONGD	*Conseil National des ONG de Développement du Congo* (National Board of Development NGO's in Congo)
REPEC	*Réseau des Partenaires pour l'Environnement au Congo* (Network of partners for the Congo environment)
GTF	*Groupe de Travail Forets* (Forests working group)
ICCN	*Institut Congolais pour la Conservation de la Nature* (Congolese Institute for Nature Conservation)

7.2 Ecosystem services in the country

This section will briefly examine the hydroelectric potential, biodiversity and will provide a tentative economic assessment. Carbon calculations can be found for the DRC under section 6.3.

7.2.1 Hydroelectric potential

The DRC has the largest **freshwater resources in Africa and its hydroelectric potential ranks fourth in the world** (Debroux *et al.*, 2007): **it has the potential to produce 150,000 Megawatts of power**, approximately three times

Africa's present consumption (SADC, 2006). The DRC could become the hub of a pan-African power grid, with exports to Europe and the Middle East as a realistic option (Power: Africa, 2007).

The single site of Inga, just upriver from Matadi, has a power potential estimated at more than 30,000 Megawatts (Encyclopaedia Brittanica online, 2007), a potential generating capacity that equals that of all Southern African countries put together (SADC, 2006). Since the independence of the country, two hydroelectric projects have been completed there called Inga I and Inga II. Although the combined installed capacity of Inga is only a small fraction of the total potential, it is greater than the present power consumption of the DRC. There are plans to raise the generation capacity of the Inga hydroelectric power station to 44,000 Megawatts by 2010 (SADC, 2006), nearly **twice as much as the Three Gorges Dam in China**.

Although the DRC has 60% of Africa's hydroelectric potential, only 7% of the country's population has access to electricity (SADC, 2006). Almost 95% of the electricity produced is consumed in the Kinshasa and Katanga provinces leaving a huge potential for domestic and industrial purposes. Currently, the DRC exports electricity to 6 African countries including Zimbabwe, which buys more than half of the total exported capacity (Washington Post, 2001).

This resource, of which the future use depends largely on the state of the forests should be taken into careful consideration.

7.2.2 Biodiversity

Our knowledge of DRC's biodiversity is embryonic, several forest areas remain unexplored, large taxonomic groups have barely been investigated and the biodiversity is already endangered (Debroux *et al.*, 2007).

The country's biodiversity ranks fifth in the world for animal and plant diversity, on the African continent it ranks first for mammal and bird diversity and third for floral diversity after Madagascar and South Africa (Debroux *et al.*, 2007). DRC contains 5 Natural World heritage Site and contains 12 of Africa's 30 'Centres of Plant Endemism' as identified by IUCN and WWF. It also contains two of the 'Endemic Bird Areas' identified by BirdLife International (Mittermeier *et al.*, 1997; Demey & Louette 2001). **Officially, 60 protected areas, including seven national parks, cover approximately 18.5 million hectares, i.e. about 8 % of the country**. Many of the protected areas were created along the Albertine Rift in the east—biologically the most diverse part of the country, but also the most populated, and the area most exposed to the recent conflict. The *Institut Congolais pour la Conservation de la Nature (ICCN)* has the responsibility for managing protected areas of the DRC. Despite its dedicated staff, the ICCN is affected by the DRC's overall institutional collapse, including insufficient salaries, lack of training, and the fact that more experienced staff are nearing retirement.

Desire to have access to natural resources has been an important factor in recent military conflicts. These mostly involved minerals, although access to timber and land was also involved. There were large scale speculative attempts to claim forests during the war with the hope that they would be worth more after the conflict ended (Debroux *et al,* 2007).

7.2.3 Tentative economic assessment (Debroux et al., 2007)

Table 4 below is a copy of a table in Debroux *et al.*, 2007.

Disclaimer and method. All figures mentioned in this section are to be taken as tentative approximations of orders of magnitude. In this war-torn country, databases are piecemeal and uncertain. There are few quantitative studies on the economic value of forests. They rarely cover representative samples at the national level, and extrapolations therefore cannot be robust. Uncertainty ranges are obviously high, yet difficult to assess in statistical terms. Methodologies used in various studies may not be comparable. Some estimates are based on assumptions and simplifications that are open to debate and could be inaccurate. All figures mentioned in this section must therefore be treated with the greatest care. This initial effort will need to be further improved and updated as better data become available. Additional studies are needed to that end. ***Any reference to this section will need to carry this disclaimer***.

Table 4 **Estimated orders of magnitude of the economic value of annual flows of forest goods and services.** *The economic value is approximated by the market value for traded goods and services, by the replacement cost for other goods and services, and by the willingness to pay for existence values.* Source: Adapted from Bravi (2005). ***Due to the piecemeal nature of databases for the DRC, these orders of magnitude are highly approximate. Any reference to this table will need to carry the methodological disclaimer given in the text.***

Good/Service	**Estimated order of magnitude of the economic value of current annual flows for selected forest products and services, in US dollars (market value, replacement value, or willingness to pay)**
Formal timber	Approximately 60 million
Informal timber	Approximately 100 million
Fuelwood	Tentatively estimated over 1 billion
Bushmeat	Tentatively estimated over 1 billion
Other foods	No figures available
Medicines	No figures available
Materials, implements	No figures available
Watershed protection	Tentatively estimated 0.1-1 billion
Ecotourism	Marginal
Carbon	Zero
Option, existence values	Approximately 18 million
Cultural, political dimensions	No figures available

We have identified the importance of the Congo Basin forests and DRC forests and the ecosystem services they provide. However, there have been no studies looking to evaluate the value of these ecosystem services. As I understand, DFID is in the process of writing such a report for the DRC.

8. RESEARCH GAPS & FUTURE OUTLOOKS

This report has provided an overview of the questions raised at the very beginning. However, it is very clear that there is an immense lack of information, good and up to date information regarding almost each one of the questions raised, especially with regards to local people and ecosystem services and values. Having said this, we can identify some further research topics, the list could be long and I will just highlight what I believe are the most important ones.

- What is the impact on the forest of removing mammals and avifauna (For example, the work by Dr. Carlos Perez in Brazil)?
- What are the CO_2 emissions attributed to creation of logging roads and infrastructure;
- What are the CO_2 emissions from forest degradation and selective logging;
- What are the CO_2 emissions from infrastructure development for mining;
- What is the area impacted by infrastructure development for mining;
- What are the values of ecosystem services in general or per hectare;
- Can we place a value on the rain generation of the Congo Basin in other regions (*e.g.* crop outputs)
- Can we place an ecosystem value on each of the 11 landscapes;
- What would the economic returns be of large-scale hydropower and what would the environmental impacts be?
- What models can be applied to develop schemes for bringing benefits to local people for avoiding deforestation?

Continuing, data gathering should be funded to fill in the gaps of the table with the tentative economic assessment for the DRC (Debroux *et al.*, 2007) and a similar assessment should be extended to all the countries of the Congo Basin.

On a broader scale, one needs to stop and ask a few basic questions. What about the ethics behind avoided deforestation/compensated reductions and payments for ecosystem services? How will this affect forest communities? Will the money filter down for infrastructure development and the general good of the countries or will it remain in the hands of the rich and powerful as has often been the case in this region? Furthermore, According to Debroux *et al.* (2007), if peace and infrastructure increase value of forests, greater conflict could result, unless the rights to use and benefit from forests are better defined, gain legitimacy and effective mechanisms are developed to resolve disputes. This is without mechanisms in place such as compensated reductions and payments for ecosystem services. Thus, it is necessary to think carefully about the consequences such schemes may have in terms of conflict or fuelling conflict in the region and particularly DRC.

When dealing with this region, one needs to be aware that anything happening will be a slow process, will require large investments and a great deal of patience to guide the governments of this region. One also needs a realistic approach, these countries need to develop and come out of poverty and developing their natural resources is one of the first things they will and should do. It is the responsibility of the international community not to point a finger of blame at what is going wrong or could go wrong, but to highlight the opportunities and work towards putting these into reality together with the governments, organisations and people of these countries. The opportunities exist, it is now time to value them and make them valuable.

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APPENDIX 1. A TIMELINE OF RECENT DEVELOPMENTS

In the last six months attention on the Congo Basin forests and the forests in the Democratic Republic of Congo particularly has suddenly rocketed up. A timeline of the most recent noteworthy developments is presented below.

- December 2006: the Wildlife Conservation Fund (WWF) brings out a report saying that two-thirds of the forests in the Congo River Basin could disappear within 50 years if logging and mineral exploitation continues at current rates.
- 2007: CIFOR, the World Bank and CIRAD launch a report on the forests in post-conflict DRC[4].
- January 2007: WWF publishes an assessment report of the mining sector and infrastructure development in the Congo Basin with a strong emphasis on impacts on the forests and environment (Reed & Miranda, 2007)[5].
- February 2007: A conference in Brussels on the DRC forests is held including governments, international NGO's and agencies[6].
- February 2007: The Rainforest Foundation produces a report on the Congo Basin's Forests and Climate Change (Hoare, 2007)[7].
- March 22, 2007: Gordon Brown announces an £800m Environmental Transformation Fund to help developing countries cope with environmental changes such as global warming. The first major grant is for the Congo Basin and accounts for £50 million. This will form the basis of a new Congo Basin rainforest conservation fund, to be set up under the aegis of 10 African countries surrounding the forests (area of 700,000 square miles). The fund will be overseen by Nobel Peace Laureate Wangaari Maathai and Canada's former Prime Minister, Paul Martin. The aim? To ensure that local people's livelihoods and rights are protected while helping them to better manage the forest and find livelihoods consistent with forest conservation. Although this is nothing novel it is very welcome in a region which has suffered detournement des fond and political instability: the fund will strengthen the work of donors already active in the region, including Belgium, Canada, France, Germany and the US, and it will open a channel for new donors to add their support. The 10 regional countries are seeking US$ 2 billion from foreign donors to fund a conservation plan agreed two years ago in Brazzaville and due to run until 2013. So far donors have raised just US$ 300 million[8].
- April 11, 2007: Greenpeace releases a damning report 'Carving up the Congo' (Greenpeace, 2007), exposing how international logging companies operating in the Democratic Republic of Congo (DRC) are causing environmental degradation, social tensions and how the World Bank's efforts to control the logging industry are failing[9].
- April 12, 2007: Mr Benn, the International development secretary, says the World Bank needed to develop pilot projects that get enough money to poor people living in forests to give them alternative ways to improve their lives, other than deforestation. He said logging in the DRC had the potential to destroy not only livelihoods but hugely damage the world's climate: 34 billion tonnes of carbon could be released if the country's forests were destroyed - equivalent to the UK's entire carbon output since 1946[10].
- April 27, 2007: the Director-General (DG) of UNESCO, Mr. Matsuura wrote to President Kabila and to Mr. Guehenno, the United Nations Under-Secretary-General for Peacekeeping Operations, asking for measures to stop the poaching and killing of endangered animals in the five World Heritage sites of the DRC. The DG's initiative follows reports that several hundred hippopotami and at least two mountain gorillas have been killed in recent months in the Virunga National Park, inscribed on the World Heritage List in 1979 and on the World Heritage List in Danger in 1994. DRC's four other World Heritage sites - the nationals parks of Garamba, Kahuzi-Giega, Salonga and the Okapi Wildlife Reserve - are all inscribed on the Danger List. While recognising the quality of the conservation work carried out by the Congolese Institute for Nature Conservation, Mr Matsuura notes that urgent and systematic action is required to prevent the irredeemable loss of the outstanding universal value that warranted the inscription of DRC's five sites on the World Heritage List (World Heritage News Archive).

[4] See following website to access document: http://www.cifor.cgiar.org/publications/pdf_files/Books/BCIFOR0701.pdf
[5] See following website to access document: http://assets.panda.org/downloads/congobasinmining.pdf
[6] See conference website for more information: http://www.confordrc.org/view.php
[7] See following website to access document: http://www.rainforestfoundationuk.org/s-Clouds%20on%20the%20Horizon
[8] See Article in *The Independent*, March 22 (2007) 'Rainforest Protection: New fund to conserve Congo Basin' at: http://news.independent.co.uk/environment/article2381081.ece and Article in *Reuters Alernet*, March 28 (2007) 'Britain gives $98 million to protect Congo Basin forests' at: http://www.alertnet.org/thenews/newsdesk/L2864549.htm
[9] See following website to access document: http://www.greenpeace.org/international/campaigns/forests/africa/congo-report
[10] See Article in *The Guardian*, April 12 (2007) 'World Bank must lead on Climate Change, says Benn' at: http://politics.guardian.co.uk/development/story/0,,2055736,00.html

APPENDIX 2. REGIONAL OVERVIEW OF THREATS

The State of the Forest report for the Congo Basin published by the Congo Basin Forest Partnership (CBFP, 2007) sheds some light on land-use and land-cover changes in the Basin, of which a brief summary is presented below. In the Congo Basin, the loss of biodiversity and resources is driven by three processes, which are not necessarily linked but whose effects often accumulate: (1) deforestation, (2) fragmentation and (3) degradation. Several direct and indirect threats were highlighted.

Main direct threats:

- Poaching and the bushmeat trade: As many tree species are dispersed by animals (birds, primates, ungulates, rodents, etc.), the disappearance or rarefaction of this fauna may significantly disturb the re-growth of forest formations.
- Shifting agriculture: this form of agriculture only becomes a problem when the fallow period becomes shorter (Maniatis, 2005) and more primary forests are cleared, generally occurring along main roads and on the outskirts of urban centres.
- Permanent or intensive agriculture: In densely populated mountainous regions and high plateaus of western Cameroon and eastern DRC, a form of virtually permanent agriculture is developing with very short or none existent fallow periods. These mountainous areas are considered hot spots of biodiversity (for endemic species), in particular the high altitude forests of western Cameroon and those of the Albertine Rift.
- Unsustainable industrial logging: Industrial logging in the forests of the Basin currently affects about half of the forest block and is generally of low intensity (number of trees felled for sale are around 0.5 to 3 per hectare, with a maximum of 4 per hectare).
- Informal logging: these forms of logging supply local markets with construction timber and firewood. Surveys carried out in Cameroon suggest that these forms of logging involve larger volumes of timber than those from industrial logging.
- Mining: A large part of gold and diamond mining is conducted by small scale artisanal operators. In recent years the mining of coltan (a vital mineral for manufacturing cell phones and other electronic appliances) has increased significantly and has attracted international attention due to the severe environmental degradation caused by current practices.

Main indirect threats:

- Population growth: Throughout Central Africa the human population is expected to grow from 76 million in 2005 to over 185 million in 2050. In the least populated countries, this may not cause any main concerns, but in Cameroon, Equatorial Guinea and DRC demographic pressures will become very intense. This is important since human pressure is at the root of many of the above-mentioned threats.
- Road construction: Although roads are absolutely essential for development, but they fragment the forests, favour the advance of agriculture and facilitate hunting and trade in bushmeat. The construction or rehabilitation of roads is an ambiguous problem requiring an objective, rational and multidisciplinary approach (Wilkie *et al.*, 2000).
- Urbanisation: Generally speaking, human populations in Central Africa are highly urbanized (up to 80% in Gabon). This urbanization has led to an exodus from the forests to the urban centres, reducing the rural populations and their impacts on the forests. Nonetheless, urban populations continue to depend on available forest resources. All towns and cities have large game markets and consume enormous quantities of firewood.
- Displaced populations and conflicts: Several countries in the region (CAR, Republic of Congo, DRC) or neighbouring regions (Angola, Uganda, Rwanda, Burundi) have been ravaged by wars and/or civil disturbances that have led to large numbers of refugees and displaced persons. Despite UN and international assistance, these displaced populations have been forced to depend on the country's natural resources and live in places where their impact has been very severe, both on natural ecosystems and on local populations. This problem is particularly acute in eastern DRC.

Main identified underlying causes:

- Corruption and lack of good governance: These two issues undermine progress towards conservation and sustainable management of forest resources in Central Africa. Corruption and bad business practices are causing or maintaining a lack of transparency and good governance in the awarding of forest concessions, often in contravention of the laws and regulations in force.
- Lack of institutional capacity.
- Insufficient long term funding.
- Lack of understanding problems of scale.
- Lack of data, monitoring and evaluation.