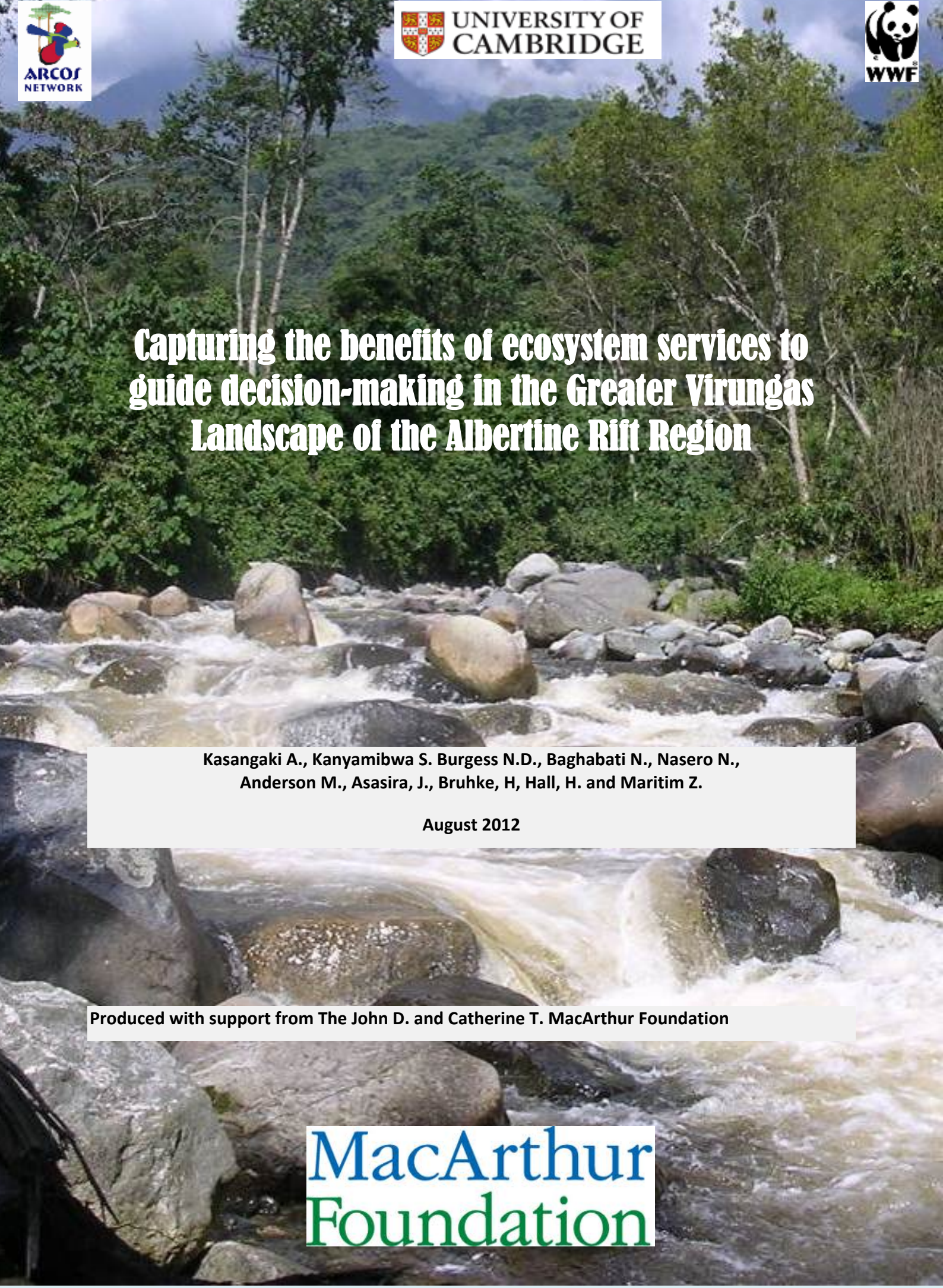

Capturing the benefits of ecosystem services to guide decision-making in the Greater Virungas Landscape of the Albertine Rift Region

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Cover photo: River Mubuku from Rwenzori Mountains, by Sam Kanyamibwa ©July 2003

Copies are available on-line at:
www.arcosnetwork.org
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Contents

i. Acronyms

ACNR	Association pour la Conservation de la Nature au Rwanda
AFED	Amis de la Forêt et de l'Environnement pour le Développement
ARCOS	Albertine Rift Conservation Society
ARECO	Association Rwandaise des Ecologistes
AWF	African Wildlife Foundation
CDM	Clean Development Mechanism
CFM	Collaborative Forest Management
CGIS/NUR	Centre for Geographical Information System /National University of Rwanda
CI	Conservation International (TEAM),
DRC	Democratic Republic of Congo
ES	Ecosystem Services
GAI	Global Action Initiatives,
GIS	Geographical Information System
GVL	Greater Virunga Landscape
GVTC	Greater Virunga Transboundary Collaboration
ICCN	Institut Congolais pour la Conservation de la Nature
IGCP	International Gorilla Conservation Program
InVEST	Integrated Valuation of Environmental Services and Tradeoffs
JGI	Jane Goodall Institute,
MUIENR	Makerere University Institute of Environment and Natural Resources
MUST-ITFC	Mbarara University of Science and Technology, Institute of Tropical Forest Conservation
NAHI	Nature Harness Initiatives
NTPFs	Non Timber Forest Products
PES	Payment for Ecosystem Services
PWS	Payment for Watershed Services
RDB	Rwanda Development Board
REDD	Reducing Emissions from Deforestation and Forest Degradation
SWOT	Strengths, Weaknesses, Opportunities and Threats
TNC	The Nature Conservancy
URP	Uplift the Rural Poor
UWA	Uganda Wildlife Authority
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund for Nature

ii. Acknowledgements

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iii. Executive Summary

The Greater Virunga Landscape (GVL) is a biodiversity rich area located within the Albertine Rift and hosts several protected areas. The high human population within the GVL depends to some extent on goods and services derived these protected areas. These ecosystem goods and services include water, non timber forest products such as fuelwood, medicinal plants and handicraft materials, honey, and bush meat. The landscape also serves regulatory functions such as water purification, carbon sequestration, and climate moderation.

With support from the MarcArthur Foundation, The University of Cambridge in partnership with the Albertine Rift Conservation Society and WWF US, implemented a three year project to map and quantify ecosystem services within the GVL, with the aim of providing information on the status of ecosystem services and how these will likely change under different development scenarios in the future. The information generated aims to guide decision makers on how to manage these ecosystem services and work towards improving the livelihood of communities within the GVL.

The project was implemented through a participatory process that involved generating information from several stakeholders knowledgeable about the landscape and on various different ecosystem services. The working approach involved information exchange and case study investitation, computer modelling and training in the use of a specialised ecosystem services mapping software called InVEST (Integrated Valuation of Environmental Services and Tradeoffs), as well as vital group discussions and workshops. A land cover/land use map was specially developed for use in during project implementation. Future development scenarios were developed though group work to include, Business As Usual, Market driven, and Green future scenarios. These storyline scenarios were coded into GIS (Geographical Information Systems) and three future landcover maps were created using modelling based on the three different scenarios. For each of the different future landcover maps that were developed the InVEST programme was used to assess how ecosystem services flows are likely to change in the future taking the year 2008 as the base year and the future as the year 2050.

The major ecosystem services identified for the GVL are maintenance of biodiversity, food provision, water supply, purification and regulation, and fuelwood provision. Most of these services are under stress from land fragmentation, over exploitation, pollution and general ecosystem degradation. The results show a high concentration of ecosystem services such as carbon, water, and non- timber forest products inside protected area systems. For example the Rwenzori Mountains National Park and the Virunga and Volcanoes National Parks yield high quantities of water annually. Areas of high carbon stocks also coincide with protected area networks in the region as this is where most of the high carbon natural forest is found. Since there is no likely change in landuse within the protected area systems, the forests will continue sequestering carbon from the atmosphere, and providing other ecosystem services and functions within the GVL. Other ecosystem services such as sediment retention and removal occurred both inside and outside protected area systems thus providing an essential service of removing pollutants before they get into water bodies.

Ecotourism as an ecosystem service within the GVL has high potential especially those based on Gorilla viewing in the mountains and viewing the diversity of other large mammals that are found in the lowland savannah woodlands. We observed that over 99 % of tourism income, in Volcanoes National Park, and in other NPs of Virunga Landscape generally, comes from foreign tourists, which explains why during a period of instability, the tourism sector is generally heavily affected. There is need for promoting tourism based on local population to try and fill up the shortfall during the off-peak seasons.

The main drivers of ecosystem services change differ in the different countries within the GVL. The main drivers in DRC are agriculture intensification, forestry practices, and mining. In Rwanda these main drivers are regarded as agriculture development and environment management practices such as restoration of

degraded landscapes. W hile, in Uganda, infrastructure development, tourism development and oil and gas exploration will affect ecosystem services change in that country.

Under the business as usual scenario, land use is likely to change in favour of small scale subsistence agriculture expanding into previously un cultivated shrubland and woodlands. This change is likely to result in degradation of ecosystem services such as fuelwood provision and pollution of water sources. While under the market driven scenario, large scale agriculture is expected to increase resulting in much greater degradation of ecosystem services such as carbon sequestration as most forests outside protected area systems will be converted to agricultural land. Under the green future scenario, plantation forestry is expected to increase, and adoption of sustainable landuse practices will generally result in improved ecosystem services flow.

Despite the high importance if ecosystem services for people well-being and national economies in the Greater Virungas Landscape, there is still poor awareness understanding among the general public, lack of policies and there are fewer attempts on valuating ecosystem services in the region. Given this situation and based on the results of this study, we recommend the following:

1. While there is a fairly conducive statutory policy environment for PES in the GVL due to decentralization and reform of environment, water, forestry & land policies, there isn't specific provision for PES. There is a need to mainstream ecosystem services in development, including in EIAs. Ecosystem management principles and integrated water resources management approaches need to be adopted in the GVL if the water resource is to be sustainably managed.
2. Each country of the Albertine Rift should develop policies compelling beneficiaries to pay for the ecosystem services they benefit from. Payment for watershed services a market based approach to ecosystem management needs to be explored within the landscape.
3. There is a need to develop capacity of the service providers-in terms of finances, technical services, to better appreciate the monetary value of their service.
4. There is a need to develop understanding and awareness among the political leadership and the general public and provide information platforms for environmental practitioners to guide decision making in the recognition of ecosystem service.
5. There is a need for quantifying and valuing ecosystem services in terms of their contribution to national economy and to assess the potential impacts of climate change on various resources such as water resources within the region or relate water to other development aspects such as human health, agriculture and fisheries.
6. There is a need to develop sustainable resource use models for ecosystem services, to avoid rapid decline of resources where this is allowed.
7. Measures to regulate harvest of resources should be put in place in areas that already show stress in ecosystem services such as firewood and bamboo. Agroforestry practices and establishment of woodlots to provide alternative sources of fuelwood should be supported in communities surrounding protected areas.
8. Landscape approaches such as ecosystem based management need to be promoted within the GVL to ensure maintenance of ecosystem services flow to the communities and restore ecosystems where these have already been degraded. Participatory natural resource management approaches such as Collaborative Natural Resource Management should be encouraged where these do not exist so as to encourage communities to be responsible environmental stewards in their respective areas.

1. Introduction

1.1. The Greater Virunga Landscape and its ecosystem services

The Greater Virunga Landscape (GVL) covers 13,800 km^2 of some of the most biodiverse habitats in Africa (Plumptre *et al.* 2003; 2007) (Figure 1). This landscape straddles the borders of Uganda, Democratic Republic of Congo (DRC) and Rwanda. It comprises the Virunga National Park in DRC and the contiguous protected areas in Rwanda (Parc National des Volcans) and Uganda (Semuliki, Rwenzori, Queen Elizabeth, Kibale, Bwindi Impenetrable and Mgahinga Gorilla National Parks; Kasyoha-Kitomi and Kalinzu Forest Reserves; and Kigezi and Kyambura Wildlife Reserves). The GVL was identified as one of six important conservation landscapes in the Albertine Rift during the Albertine Rift strategic planning process undertaken in the early 2000s (ARCOS 2004).

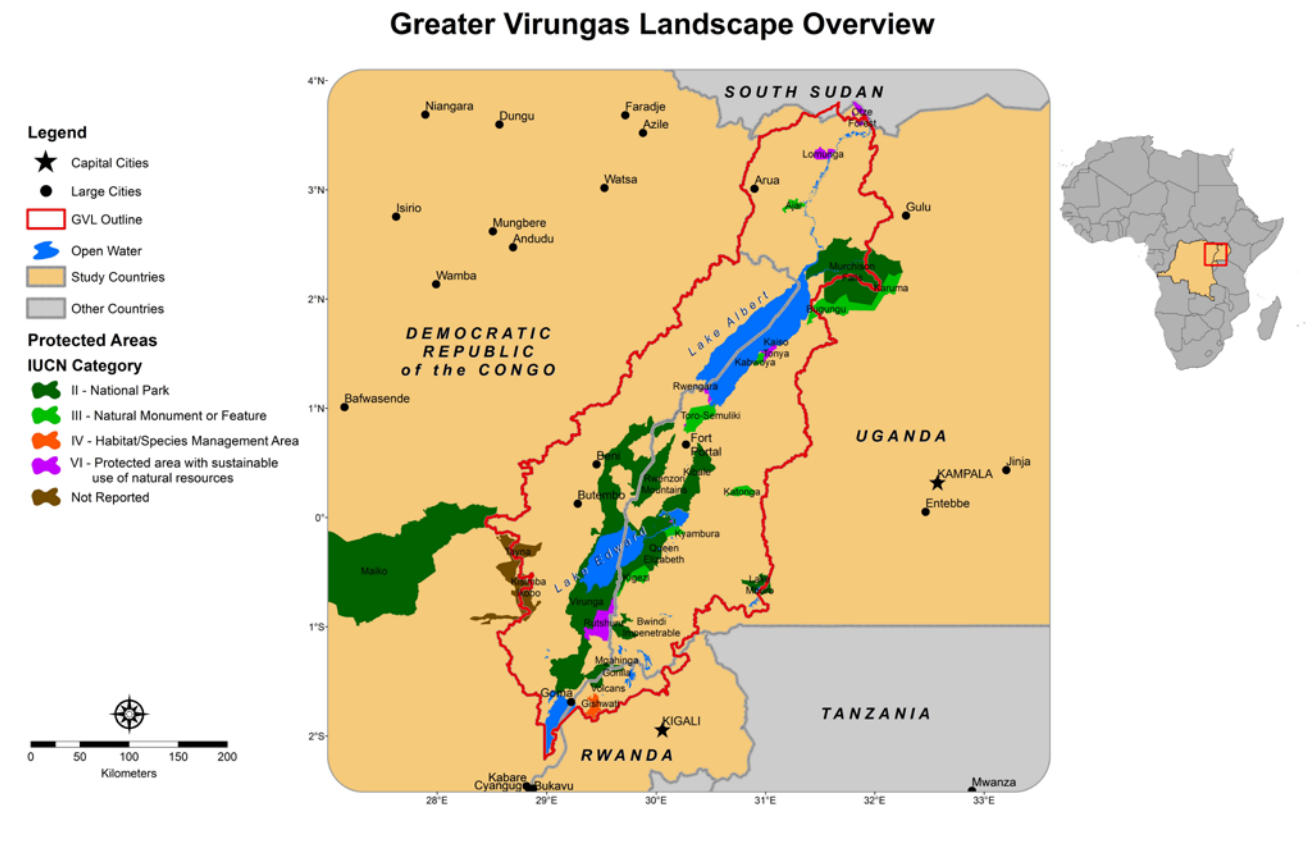


Figure 1: Overview landscape map of the Greater Virungas

The Albertine Rift has more vertebrate species and more endemic and threatened species than any other region in Africa. Containing a wildlife-rich network of mountains, lakes, forests, and savannahs, the Greater Virunga landscape has the highest biodiversity of vertebrate species in

Africa. ARCOS was established in 1995 to promote thansboundary collaboration at regional level in the Albertine Rift. Several initiatives such as the Greater Virunga Transboundary Collaboration (GVTC), and the International Gorilla Conservation Program (IGCP) are also in place, aimed at harmonising conservation efforts within the Greater Virunga Landscape. More recently the Wildlife Conservation Society has started a programme to support transboundary collaboration further north in the landscape so that all contiguous protected areas are working together. Mountain gorilla numbers have on the whole increased during the past 25 years despite civil wars in the region, which can largely be attributed to their ability to generate income from tourism but also to enhanced transboundary collaboration between Congo, Rwanda and Uganda (Plumptre et al 2007).

Figure 2: Bamboo harvesting in Echuya Forest

Ecosystem services are "the benefits of nature to households, communities, and economies." The importance of ecosystem services like carbon storage and sequestration, water supply and regulation are issues of global relevance as they link to efforts to reduce climate change to alleviate global poverty. The Millennium Ecosystem Assessment Report (2005) recognises four different categories of ecosystem services: provisioning services, regulating services, supporting services, and cultural services.

Most communities living around protected areas depend on them for livelihoods by accessing resources such as firewood, medicinal plants, handicraft materials and water because these resources have increasingly become scarce outside protected area systems. A recent scoping report on the status of ecosystem services in Uganda and Rwanda (Wong et al. 2005) found that most ecosystem services were

stressed; these included maintenance of biodiversity, food and fibre provision, water supply, purification and regulation - all of which have a bearing on human well-being. Several collaborative approaches (such as Community Forest Management -CFMs and Multiple Use Zones) have been created to allow communities to sustainably access resources from reserves. However, despite regulating resource access within protected areas, the harvested resources continue to decline due to natural causes and overharvesting. For example bamboo and firewood have become increasingly scarce in Echuya Forest Reserve, south western Uganda.

1.2 Objectives and scope of the report

There is growing evidence that many ecosystems have been degraded to such an extent that they are nearing critical thresholds or tipping points, beyond which their capacity to provide useful services may be drastically reduced. The quantifying and mapping of ecosystem services can be used to guide policy formulation aimed at sustainable management of ecosystems. In addition, governments and their development partners need to design more finely-tuned intervention strategies that would seek to promote the reduction of poverty and improve well-being while protecting and enhancing vital ecosystem services.

The report aims at sharing lessons learned from implementing a three-year project *'Capturing the Benefits of Ecosystem Services to guide Decision-making in the Greater Virungas Landscape of the Albertine Rift Region'* that was implemented by the University of Cambridge in collaboration with ARCOS and WWF US, with financial support from the MacArthur Foundation. The report shows the distribution of mapped ecosystem services within the landscape and recommends how best they can be harnessed to stimulate sustainable development in the region. The report further gives suggestions on how ecosystems should be managed to in order to maintain a steady flow of ecosystem services to the surrounding communities. The report also discusses how some ecosystem services are likely to change under different development scenarios such as the Business as Usual, Market Driven and the Green Future.

The project had the following objectives:

1) To quantify and value ecosystem services derived from the Greater Virunga landscape, including the Rwenzori Mountains.

2) To assess how amounts and values of services will change under future climate change and development scenarios.

3) To inform and engage decision-makers and other stakeholders on values of ecosystem services.

Three main limitations and constraints of the study are related to the lack of credible data on the impacts of conflicts on the environment in the region, short time period and limited funding to undertake this important study. This is why this report should be considered as a preliminary, to be reviewed by further studies and in depth assessments.

1.3 Structure of the report

After a general chapter looking at the introduction to the Greater Virungas Landscapes, its ecosystem services and a chapter presenting briefly the methodology and data used, the third and fourth chapters present the findings with regards to ecosystem services and the drivers of change respectively. The following chapters five and six then discuss the potential for payment for ecosystem services in the Greater Virungas and highlight some practical actions and policy decisions in the region that would benefit biodiversity and community livelihoods and sustainable development in general. Finally, these two chapters lead to a last chapter on conclusions and recommendations.

2. Methods and data acquisition

2.1. Stakeholders consultations and training

Methods used in implementing the project were mainly through participatory workshops that brought together stakeholders from within the GVL. The first stakeholder workshop was held in September 2009 in Kampala. The main goal of the workshop was to introduce the project to stakeholders, build capacity in valuation and quantification of ecosystem services and to conduct a participatory assessment of ecosystem services in the Greater Virungas Landscape.

A total of 30 participants from government and non-government organizations, the private sector and research institutions attended this workshop. They included decision makers, ecosystem services beneficiaries or users and data managers active or interested in the GVL. The workshop was facilitated by experts from ARCOS, WWF-US and University of Cambridge. It involved information and case study exchange, computer demonstrations and training in the use of a specialised ecosystem services mapping software developed by Stanford University, WWF-US and TNC called InVEST (Integrated Valuation of Environmental Services and Tradeoffs), as well as vital group discussions.

InVEST is a suite of modelling tools incorporated within ESRI ArcGIS software which can be used to assess and quantify the availability of a multitude of terrestrial and marine environmental services even in study sites where minimal spatial data are available. This tool was introduced and used by participants during the workshop. Given that InVEST has a number of input requirements, participants were requested to assess and validate available data. Ecosystem services were discussed at both the district and local level, involving local government and non-government institutions. The first workshop was also an opportunity for the participants to identify the source of datasets needed for modelling in InVEST.

During the first stakeholders' workshop, the participants conducted two related exercises in terms of analysing current drivers of ecosystem services and different factors that are likely to affect them:

1. SWOT analysis on issues affecting ecosystem services both positively and negatively, which allowed for the identification of threats and opportunities.
2. Identifying drivers of change affecting ecosystem services and proposed actions to address them
3. Paramaterizing future scenarios of landuse change.

A second stakeholders' workshop was also held in Kampala in 2010. Twenty-five participants from governments, universities, research institutions and non-governmental organisations involved in the Albertine Rift took part in the workshop, which brought together professionals from the region to discuss ecosystem services.

The participants defined ecosystem services as the benefits that people derive from ecosystems and which are used to support daily life in the region. A main component of the workshops was to determine key ecosystem services in the GVL. Draft maps of the distribution of these services were produced using the GIS tool InVEST by incorporating available data into the models. The need for obtaining improved local data was clarified and data gathering continued after that workshop to increase the precision of the models. An updated Land Use and Land Cover Map of the region was developed during this process. Under an assumption of different development/land use patterns by 2030, different future Land Use and Land Cover scenarios were developed, to show the possible increase / decrease in vegetation and cultivation, and the impacts on the provision of ecosystem services. Also, participants discussed the project challenges, especially where to get local data to run the InVEST model more accurately. Furthermore, a special session was dedicated to eco-tourism to discuss challenges and opportunities for promoting Payment for Ecosystem Services (PES) in the region.

A third and final workshop was held in 2012 that brought back to the region improved versions of all the ecosystem services maps and to showcase the policy relevance of the findings. Twenty five decision makers in Rwanda and DRC, and then in Uganda reviewed the products and made comments and assessed the policy relevance. The comments of these stakeholders allowed further changes to the models and mapped outputs, which were then worked on into 2012 to finalise the products.

2.2. InVEST Tool set

Mapping and modelling of the various ecosystem services was accomplished in the GIS based tool Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) that was developed by the Natural Capital Project (www.naturalcapitalproject.org). Geospatial data was collected in order to run the following InVEST modules within the ARCGIS environment: Carbon storage, water yield and sediment retention and NTFP (non-timber forest products).

Initially the AfriCover land cover map created by FAO was used, but due to a number of inconsistencies across the national boundaries, the project developed its own map of current land use/ land cover map (LCLU) (Figure 2).

Non Timber Forest Products (NTFP) include charcoal, medicinal plants, mushrooms, bushmeat, etc. These are not just products taken from the forest, but can also include informally harvested timber (not managed plantations).

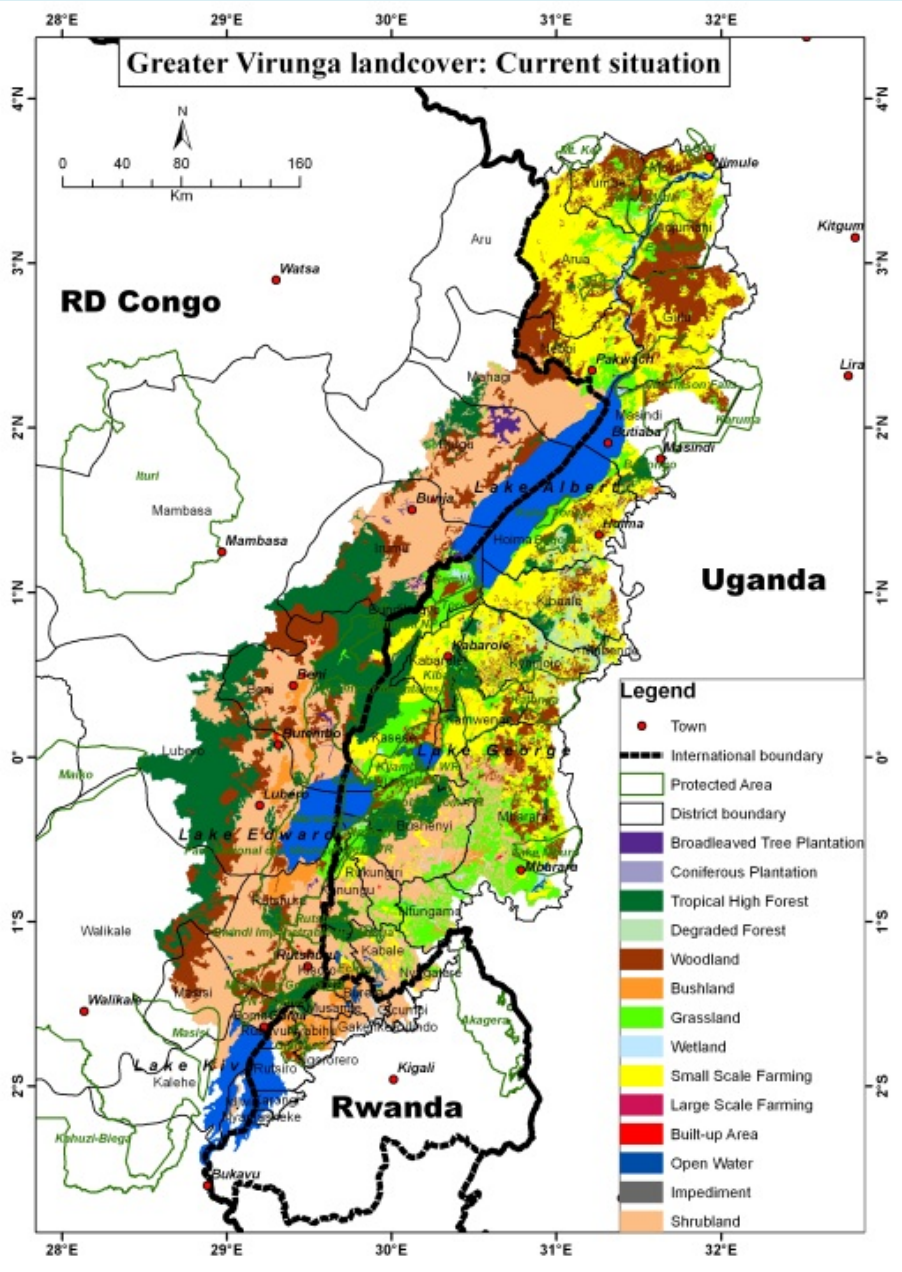


Figure 3: Landcover map from base year of 2008

In this report, we highlight preliminary modeling results for timber, mushrooms and charcoal stocks, based on harvest pressure, access and availability. Relative units (or stock estimates) were

estimated between 0 and 1. We have only used the first InVEST beta version of the NTPF model and hence all results should be regarded as preliminary.

Tourism Analysis: InVEST does not have provision for ecotourism modeling. In this project, we have assembled data on tourism parameters like visitor numbers per year to some protected areas within the Greater Virunga Landscape. We assume that different possible future scenarios could alter the flow of visitors and hence the profits generated, which in turn would affect the value of ecosystem services.

2.3 Data collection and Limitations

The following GIS datasets were used (Table 1). There are some gaps in what would have been ideal to have run the InVEST models, but not all required data were available and hence we only used the data below for creating the ecosystem service and scenario maps.

Carbon module	**Avoided reservoir sedimentation**
Land use land cover	*Land use land cover*
	Soil erodibility
NTFP	**Reservoir hydropower production**
Land use land cover	*Annual average precipitation*
Harvested product stocks	*Annual average evapotranspiration*
Habitat quality	*Soil depth*
Population centres and sizes	*Plant available water content*
Road locations and sizes	*Land use land cover*
Harvest pressure	*Model coefficients table*
Maximum travel distances	*Digital elevation model*
	Watersheds/sub watersheds

Table 1: Datasets used in INVEST Modelling

3. Mapping Ecosystem Services in the GVL

In this section, we discuss the distribution and quantities of the mapped ecosystem services within the GVL. The major ecosystem services modelled in InVEST were carbon, water yield, sediment retention and NTFPs. We also assembled data on tourism. Key ecosystem services in the region were identified through a consultative process involving stakeholders from the region including from governments, NGOs and experts from academic institutions (Table 2).

Table 2: Major ecosystem services identified in the GVL and their threat levels

Services	Causes of Stress	Threat Level	Comments
Maintenance of Biodiversity	Fragmentation Deforestation Hunting Poaching Overexploitation	High	High Socio-economic impact
Food Provision	Ecosystem, Land and soil degradation	High	Increasing food insecurity
Water Supply, Purification and regulation	Wetland degradation Water Pollution	Moderate	Limited hydrological data
Fuel (energy)	Wood deficiency	High	In DRC the situation is alarming

3.1. Carbon Storage

In the carbon model, high stocks of carbon were predicted to occur in tropical forested areas. The carbon stocks are high within the Ruwenzori mountain blocks both in DRC and Uganda, Kibale National Park, Kalinzu and Kashoha-Kitomi and Maramagambo Forest Reserves, Bwindi Impenetrable National Park in Uganda, Volcanoes and Virunga National Parks in Rwanda and DRC respectively. Areas of high carbon stocks coincide with protected area networks in the region. Since there is no likely change in landuse within the protected area systems, the forests will continue sequestering carbon from the atmosphere, and providing other ecosystem services and functions within the GVL.

The carbon stocks have a high potential for use in Payment for Ecosystem Services schemes especially under the Clean Development Mechanism (CDM) and the REDD+ mechanisms. A key challenge for institutions wishing to take part in the expected REDD+ mechanism will be to design operational, protected area/regional forest monitoring systems to support the Measurement, Reporting and Verification (MRV) requirements of the decisions. Different countries in the region are in the process of developing national REDD strategies aimed at harmonising REDD activities.

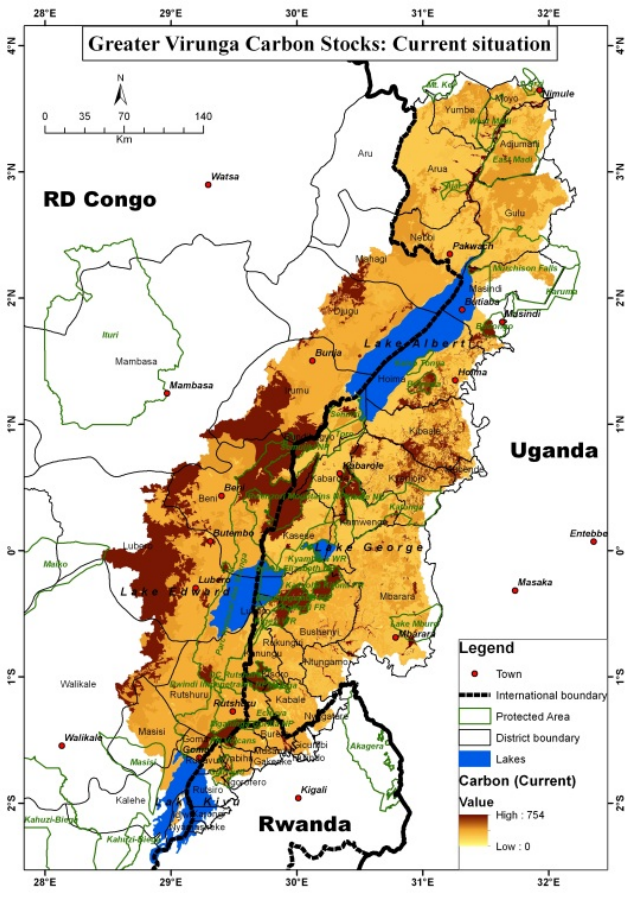


Figure 4: Map of the carbon stocks across the Greater Virungas Landscape (on a scale from high to low on a scale of brown to white)

Several REDD related projects are already operational in some parts of the GVL e.g. the Trees for Global Benefits program being implemented by ECOTRUST-Uganda in Rubirizi, Kasese and Hoima districts in Uganda. The Trees for Global Benefits Program uses the Plan Vivo System which is a standard for designing and certifying community-based payments for ecosystem services (PES) programmes (www.planvivo.org). Plan Vivo is ethical and pro-poor. It puts people at the heart of the solution to threats posed by climate change and loss of ecosystem services. Also operating in the Districts of Kanungu, Bushenyi and Kabale is the International Small Group and Tree Planting Program (TIST) that promotes tree planting by community groups who are later assisted in selling their carbon credits accumulated on the international market.

3.2. Water yield

We define the annual average water yield on a landscape as all precipitation that does not evapotranspire. While all of the water yield is not available to downstream users, its relative distribution across the landscape, and change across scenarios, can offer insights into the current availability of, and potential changes to, water supply for human uses. The InVEST Tier 1 water yield model is designed to evaluate how land use and land cover affect annual water yield across a landscape. This water balance model can accommodate areas with minimal access to data, and can be used with globally available data sources on annual precipitation and dryness indices (Zhang et al. 2001, Budyko and Zubenok 1961, Milly 1994). We summarize water yield for each watershed and sub-watershed as annual average runoff depth (mm / year).

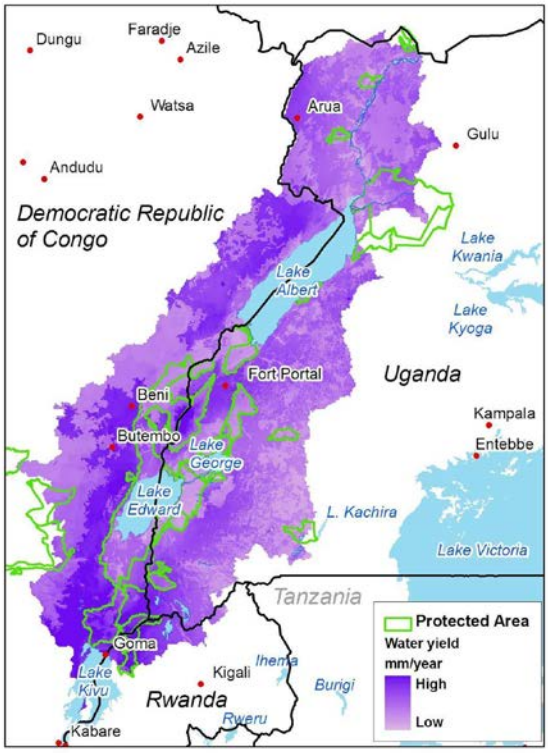


Figure 5: InVEST Tier 1 map showing concentration of water yield within the GVL. Areas with high water yield are coloured blue and are typically located in montane forests (water towers).

Watershed supplied water resources are vulnerable to extreme variation caused by land use and land cover (LULC) changes. LULC changes can alter hydrologic cycles, affecting patterns of evapotranspiration, infiltration, and water retention, and changing the timing and volume of water that is available for hydropower production. Changes in the landscape that affect annual average water yield upstream can increase or decrease water supplies. Maps of where water yield is used can help avoid unintended impacts on water supplies or help direct land use decisions that wish to maintain sufficient water supply, while balancing other uses such as conservation or agriculture. Such maps can also be used to inform investments in restoration or management that downstream stakeholders, make in hopes of improving or maintaining water yield for this

important ecosystem service. Maps of how much water each parcel of land contributes can help managers avoid developments in the highest water yielding areas, understand how much water will be lost or gained as a consequence of different management options, or identify which water users have the largest stake in maintaining water yield across a landscape. Areas predicted to have high water yields are on mountainous terrain that are forested. They include blocks of mountains in the DRC, the Volcanoes Mountains on the western side of Lakes Albert and Edward, and the Ruwenzori Mts. The area between Beni and Goma in DRC appears to have the highest water yield. In Uganda, areas around Fort Portal, and the Maramagambo and Kasyoha-Kitomi forests on the eastern side of Queen Elizabeth National Park in Uganda are predicted to have high water yield. The high water yield originating from the Rwenzori mountain block is depicted by the numerous streams and rivers originating from the mountainous region. The high water yield from the mountainous region has been targeted for Hydroelectric power generation. For example, there are three hydroelectric power plants on River Mubuku alone. These are Kilembe Mines (Ibanda HEP station), KCCL (Kasese Cobalt Company Ltd) hydropower (Mubuku 3) and Bugoye Power station owned and operated by Tronder Power Limited and produces 7.4 MW that is incorporated into the national grid. A 6.6 MW hydro power plant (Kanungu Power Station has already been commissioned on river Ishasha with its source in the Kigezi highlands including Bwindi Impenetrable National Park.

The water from the mountains is also targeted for irrigated agriculture such as in the Mubuku Valley Irrigation scheme and the prison farms in Kasese district in Uganda. Although the water yield from the GVL is quite high, the resource seems to be underutilised or harnessed to benefit the communities. Several industries in the region have targeted water from the GVL. These include water bottling companies, Hima Cement Factory, Kasese Cobalt Company in Uganda, Nyange and Bralirwa soft drinks and beer companies respectively in Rwanda. There is need for coordinated management of the water resources if sustainable utilisation is to be achieved. Integrated water resources management approaches need to be adopted in the GVL if the water resource is to be sustainably managed. Payment for watershed services a market based approach to ecosystem management needs to be explored within the landscape. Water service companies and HEP generating companies can be approached to incentivise upstream communities to engage in sustainable management of watersheds for the continuous flow of water downstream.

3.3. Sediment retention and export

The InVEST Tier 1 sediment retention model focuses only on sheetwash erosion processes, and is based on the Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978). The USLE predicts erosion based on the energetic ability of rainfall to move soil and cause erosion, the erodibility of a given soil type, slope, erosion protection provided by the presence of vegetation, and management practices (Roose 1996). The model also routes the sediment originating on each pixel along its flow path, with vegetated pixels along the path retaining some of this sediment based on their sediment retention efficiency, and exporting the remaining sediment to the next pixel in the flow path. We report the total sediment load exported to streams from each watershed and sub-watershed per year (tons / year), as an annual average.

Final output of sediment retention model. Shows the relative role of landcover in reducing soil erosion. In darker green sub-watersheds, landcover is keeping a greater amount of soil from reaching waterways.

Figure 6: InVEST Tier 1 map of total sediment retention in given sub-watersheds. Dark green areas show areas of high sediment retention

The sediment retention model quantifies the amount of sediment or soil loss from a given watershed and as such is a measure of the ability of landscapes to retain soil or prevent sediment from reaching water ways.

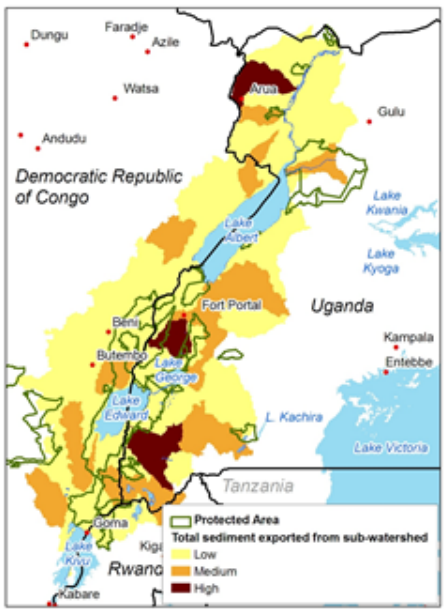
Areas where high sediments are retained on the Ugandan side of the GVL include forests north of Fort Portal town, i.e. Matiri, Bugoma and generally in areas at low elevations (low lying areas); Kibale National Park, and the tea plantations around Kibale Forest to the East of Fort Portal Wetland systems such as around Ntungamo and Kabale also retained loads of sediment compared to forested landscapes. In DRC, community forests near Goma such as the Domane de Chasse de Rutshuru are relatively intact retaining lots of sediment from the catchment. As a result, little sediment reaches the water ways, for example river Rutshuru that drains the watershed carries water that is not turbid. Tayna and

Kisimba_Ikobo community forests are the forests retaining sediments near Butembo and Beni. But because the forests are degraded due to charcoal making and timber extraction, a lot of sediment often ends up in rivers draining the landscape. For example rivers such as Tayna, Lindi and Lubero usually carry turbid water all year round. Wetland systems and low lying grassland areas seem to hold more sediment compared to forested landscapes.

Total sediment exported

Most of the rivers draining into the Lake Edward- George system on the eastern side of the rift are usually turbid throughout the year. They include Ishasha, Ntungwa, and Ncwera, but those originating from the Ruwenzori Mountains only become turbid during the wet seasons. Rivers such as Nyamwamba, Mubuku, Mpanga and Rwimi all having their sources in mountain Rwenzori usually carry clear water during the dry seasons. This illustrates the importance of forests in sequestering or filtering contaminants out of water. Thus montane forests are important in providing clean water to the surrounding communities downstream. For example, over 46 Gravity Flow Schemes (GFS) currently supply water to the downstream communities around Rwenzori National Park in both rural and urban centres. Most urban water supply systems in the Greater Virunga landscape derive their water from the mountain watersheds, e.g. Fort Portal town gets water from Mpanga river, while Kasese town from River Nyamwamba.

The dark brown areas show zones with high potential for soil erosion, and these coincide with areas of steep gradients such as on the slopes of mountain Rwenzori and the Kigezi Highlands in Rukungiri, Kabale and Kanungu Districts.



Sediment exported from each sub-watershed.. In darker brown sub-watersheds, a greater amount of soil is reaching streams and rivers. When comparing to the previous map, you can see that some of the same watersheds have high sediment retention as well as export (i.e., erosion). That's because if there's more erosion, there is also potentially more loose sediment that is available to be trapped by a downstream pixel.

Figure 7, *Total sediment exported from sub-watersheds. The sub-watersheds of high sediment export are predicted to occur in areas within Uganda*

3.4. Non-Timber Forest Products (NTFPs)

The importance of natural resources in supporting rural livelihoods is increasingly being recognized in national and international policy. For example, achievement of all the Millennium Development Goals will depend on maintaining the environmental goods and services that are key to human productivity (MA 2005). Approaches to development are therefore required that enable incomes to be derived from natural resources, while supporting the effective conservation of these resources. It is therefore suggested that policies geared towards increasing the economic return of NTFPs will lead to an internalization of forest resource values and an increased incentive for conservation through local resource management (Cottray et al. 2006). Several NTFPs were modelled during the project and details on each NTFP are presented below:

3.4.1. Charcoal Production within the GVL

According to Wong et al. (2005), firewood, charcoal and agricultural wastes are the primary sources of energy in Uganda and comprises 93 per cent of energy consumption. The situation is not different in other GVL countries. Rapid deforestation coupled with an ever increasing human population has resulted in over-exploited forest areas. Charcoal is the primary fuel among urban dwellers and charcoal making accelerates deforestation more than firewood collection. If the deforestation rate has to be controlled, energy-efficient interventions have to be promoted in the heavily deforested areas and urban dwellers should be encouraged to use energy efficient stoves and electricity or gas for cooking. Charcoal production shows high concentrations in the unprotected forests of DRC and in some areas inside Virunga National Park. Rampant charcoal making in the

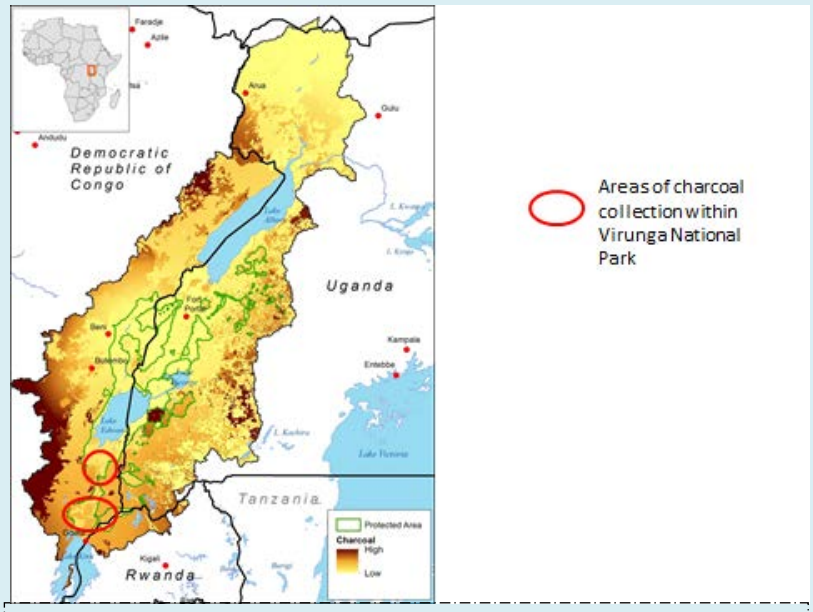


Figure 8. *Map of GVL showing concentration of charcoal making within the region. Note that in Virunga National Park, charcoal making is carried out inside the park.*

DRC may be attributed to the civil strife and lack of government structures in place aimed at protecting the forests. However, there are some pockets of charcoal making around Matiri Forests and unprotected forests in Kyenjojo, Kibaale and Kyegegwa Districts in Uganda. With the prevailing economic conditions in the region, the price of charcoal has more than doubled in recent times and this has put more pressure on the forests as more people engage in charcoal making to make quick profits. Some interventions are already in place e.g. in DRC by WWF to combat rampant charcoal making through making of briquettes from charcoal dust and promoting the use of energy efficient stoves.

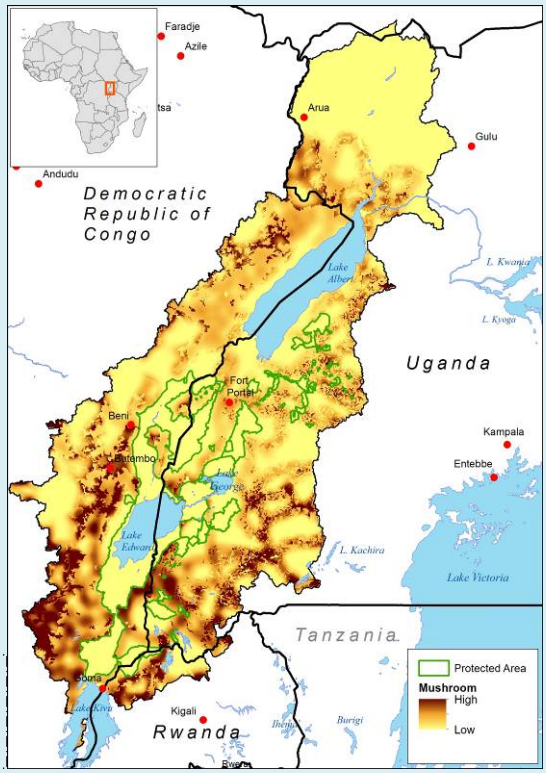


Figure 9. *Preliminary map of the distribution of mushroom harvesting in the Greater Virungas Landscape*

3.4.2. Mushroom

High stocks are predicted in forested protected area systems e.g. Kibale, Bwindi, Queen Elizabeth, and Rwenzori Mountains National Parks and Forest Reserves such as Kalinzu, Maramagambo, Matiri etc. Mushroom is important both for local consumption and for income generation as the surplus is often sold. The quantities of mushroom both in protected areas and community land may be problematic to estimate as their occurrence is usually seasonal and often predated upon by wild animals before people can access them.

3.4.3. Bamboo

Bamboo is an important NTFP within the GVL. The communities use it to make handicraft such as chairs and coffee sets, construction of tourist bandas and homes, fencing of homes and as bean stakes and firewood when dry. In the past, communities used to access bamboo from forests without restrictions but this has since stopped as most bamboo stocks are within national parks and forest reserves. The African mountain bamboo is a key food for several animals. The young bamboo shoots are favoured by several primate species such as the endangered mountain gorilla *Gorilla gorilla beringei*, the Golden and Blue monkey monkeys with the former two primate species being restricted to the GVL (Bitariho & McNeilage 2007). Most bamboo within the GVL is mainly the African montane bamboo of the species *Arundinaria alpina* or *Sinarundinaria alpina* or *Yushania alpina*.

Access to the bamboo resource is currently restricted in most protected areas, but because of its high demand by the communities, some protected area authorities have allowed controlled access to the resource under a regulated regime. For example in Echuya Forest reserve in South –western Uganda, bamboo is under threat from overharvesting from both licensed harvesters and the local communities who are allowed to collect the dried bamboo for firewood and bean stakes. If the unsustainable harvest is not regulated, bamboo might soon disappear from the forest. In Bwindi and Mgahinga Gorilla National parks, communities were allowed to harvest seedlings to plant on their own farms under a substitution planting program aimed at reducing pressure on the bamboo inside the forest. Access to bamboo in national parks in Uganda is run under the community conservation approach that allows local communities around the protected area to share some benefits accruing from the protected areas. In Rwanda, a similar bamboo planting exercise has been promoted outside Volcanoes National Park.

3.4.4. Firewood

High stocks of firewood still exist in forested and woodland areas outside protected areas. High stocks of firewood are abundant in unprotected forests and woodlands in DRC, near Butembo and Beni. Firewood appears in high quantities in areas with wooded vegetation outside protected areas. Firewood collection is rampant in areas outside protected areas and it is also done illegally

in protected areas. According to Wong et al. (2005) most areas in Uganda that are located within the GVL are already stressed for fuelwood. The number of hours people spend looking for firewood has increased dramatically in recent years and that there is wood deficit in most districts located within the landscape such as Kasese, Kabale, Bushenyi, Kanungu etc. If this negative trend is to be reversed, communities need to engage in agroforestry practices that will eventually increase the available wood. Recent trends suggest that, in urban centres, fuelwood is gradually being replaced by charcoal, which is considered a 'transition fuel' on the road towards the greater integration of electricity and LPG (Arnold et al., 2006).

3.4.5. Poles

The map output represents the access routes in protected area systems. The road network would influence quantities of poles harvested from a given forest. Easy to access poles would readily be overharvested. Harvesting for poles is only possible outside protected areas and community forests. However, some forest reserves in Uganda do allow harvest of poles by surrounding communities.

3.4.6 Timber

Sources of timber from the Ugandan side of the Greater Virungas is mainly from outside protected areas such as from commercial plantation forestry and private forests but also from forest reserves with a license. Timber harvesting is also practiced by small holder farmers who own some trees onfarm. With a boom in the construction industry, the demand for timber is expected to rise resulting in the depletion of forests outside protected areas.

3.4.7. Honey

Honey production is predicted to be high in areas associated with forests or in forested landscapes. Honey production was predicted to be high in areas around the Volcanoes national Park in Rwanda and Mgahinga Gorilla National Park in Uganda. In DRC, honey production is predicted to be high in areas around Beni and Butembo Towns. Honey production appears to be concentrated in areas close to protected areas. This could be attributed to the availability of

foraging grounds for the bees inside the protected areas. Protected areas in Uganda allow communities' access to the reserves for placement of beehives in designated areas termed Beekeeping Zones. The protected areas include, Bwindi, Kibale, Queen Elizabeth, and Rwenzori all located within the GVL. In beekeeping zones around Bwindi Impenetrable National Park, Bitariho (*in Prep*) reports that Beekeeping for honey is the most lucrative forest resource use with a mean annual income of 298,000ushs for each beekeeper.

Because of the lucrative nature of beekeeping several development agencies and NGOs are encouraging beekeeping as an income generating activity for the communities around protected areas. For example, Nature Uganda around Echuya Forest, Bwindi Mgahinga Conservation Trust supports beekeeping activities around Bwindi and Mgahinga National Parks. As a result, several beekeeping associations have been established within the GVL of Uganda and they include Rwenzori Beekeepers Association; Kisoro Beekeepers Association, and Bunyangabu Beekeeping Community all aimed at harmonising the beekeeping activity so as to improve community livelihoods through enhanced incomes. Packaged honey and other bee products are already on the market by these organisations, e.g Bushenyi Honey and Mgahinga Honey. In many societies, honey is regarded as an important ingredient in diet and is also used as medicine (chemotherapy) to treat ailments such as cough.

Honey has also been identified as an important ecosystem service in the baselines and indicators identification process under the Enhancing Ecosystem Services Resilience and Sustainable Benefits to Local communities in the Albertine Rift (ESLOC) project funded by the MacArthur Foundation.

3.4.8. Bushmeat

High stocks of bush meat are predicted mostly on the DRC side of the greater Virunga. Because of the cultural differences in the GVL, bush meat tends to be popular in the DRC compared to other areas in the landscape. For example, in DRC people freely eat bush meat from primates but few communities in Uganda and Rwanda enjoy primates' meat. Olupot et al (2009) studied patterns of illegal bushmeat off take and drivers of illegal hunting in and around Murchison Falls Conservation Area (MFCA), Queen Elizabeth Conservation Area (QECA) (Queen Elizabeth National Park, Kyambura Wildlife Reserve, and Kigezi Wildlife Reserve), Rwenzori Mountains National Park

(RMNP), and the Kafu River Basin. They found out that except for households headed by hunters, bushmeat was a less important source of protein than domestic livestock and fish for the households in the study sites. Hunters however heavily depended on bushmeat as a source of both income and food. Poverty and cultural attachment were cited as the main reasons for bushmeat exploitation (Olupot et al 2009). Bushmeat-eating households regard bushmeat as more tasty and medicinal than livestock meat and fish. Animal parts are also valued for spiritual uses and this is what in part drives hunting of some species. In Rwenzori National Park in Uganda, the population of primates was almost wiped out during the Allied Democratic forces insurgency, and it is now rare to sight any species of monkey as one walks through the forest.

3.4.9. Handicraft material

Stocks of NTFPs are not shown in protected areas even where access is allowed e.g Bwindi, Kibale and QENP. We expect high concentrations of handicraft material in wetlands that are still unconverted. Such chunks of wetlands exist around Ntungamo, Rukungiri, and very few in Bushenyi district in western Uganda. Several protected areas in the GVL side of Uganda allow communities access to handicraft material such as thatching grass from QENP, bamboo from Echuya Forest Reserve and Rwenzori Mountains National Park. People request for access to resources within protected areas because the stocks have already been overharvested outside the reserves. Even within, protected areas some handicraft material are already dwindling especially for the slow growing species such as *Loeseneriella apocynoides* (Bitariho 2004) and as such a ban has been placed on extracting the species until the population recovers. If harvesting for handicraft material from protected areas is to be sustainable, there is need for systematic assessment of the stocks in order to determine sustainable harvest levels as has been done in Multiple Use Zones/resource use zones in Bwindi, QENP, and Rwenzori Mts. National Parks in Uganda. For example in Echuya Central Forest Reserve located in the GVL, the bamboo is already under threat from overharvesting by both licensed and firewood collectors in addition to the bamboo being invaded by colonising forest tree species of *Macaranga kilimandsharica* and *Nuxia congesta*. There is thus an urgent need for reviewing the process of bamboo harvesting in Echuya forest with aim of placing a temporary ban to allow it recover from overexploitation. According to a survey carried out around Bwindi National Park by Bitariho (in prep), economic benefits from

harvesting handicraft material were found to be higher in communities allowed access to the resources compared to where resource access is not allowed (Uganda shillings 138,750 vs, 51,500 is earned annually).

In the Volcanoes National Park in Rwanda, no access to handicraft material is allowed. In protected areas where resource access is not yet legalised, this policy option needs to be explored with the aim of allowing access. In the DRC part of the GVL people are allowed to harvest resources from community reserves but there is still some discussions and conflicts between forest and indigenous peoples like pygmies, Lese, Bila despite all promises to apply the National Strategy of Community Conservation and Eco tourism as an alternative (Biffumbu, pers, comm).

3.4.10. Medicinal plants

Medicinal plants are mostly used by the rural folks although it makes its way to the urban markets too. Several national parks on the Ugandan side have Multiple Use Programs that allow communities to access plants of medicinal value from the protected areas e.g. Bwindi NP, Ruwenzori, and Kibale National Parks. Medicinal plants seem to be concentrated near protected areas where patches of natural forests and wetlands still exist and it is in these areas that herbal medicine is commonly used. Medicinal plant collection is done by recognised traditional healers who sell the products to the local people at a small fee. Regulation of harvest is done through signing of MOUs between protected area authorities and the resource user groups. With the advent of modern medicine, the use of traditional medicine is slowly declining.

3.5. Ecotourism model

The money flowing to developing countries from ecotourism activities is substantial, providing an enormous financial incentive against habitat loss and exploitation. The revenue for tourism is three times bigger than the combined spending on conservation projects in the developing world by official aid agencies and the GEF (Global Environment Facility). The Greater Virunga Landscape is one of the top destinations for nature tourism. However, economic services valuation strategies are limited and do not provide insight into the economic viability of ecotourism businesses, nor of the businesses incentives to conserve biodiversity. Capturing even a fraction of those revenues can aid in the sustainable development of conservation activities. Invest Program does not have provision for tourism ecosystem service modelling, but we assumed that different possible future scenarios could alter the flow of visitors and hence the profits generated, which in turn would affect the value of ecosystem services in the landscape. Considering the total annual number of tourists, we found that tourism is a fast growing sector and number of tourists has grown continuously in most of the Uganda National Parks during the last 15 years and this is probably a result of political stability in the visited areas during the last 15 years. Considering the data on visitors' number for 2010 from the protected areas within the landscape, Volcanoes NP in Rwanda was the best destination choice in the Landscape with nearly 190,000 tourists per year, followed by Queen Elizabeth NP and Murchison NP. While political stability plays a significant role, this may also be linked to the increase in number of Mountain Gorillas, increased tourism marketing, improvement of infrastructure and special events like Gorilla naming ceremony in Rwanda. However, in the DRC tourism based on gorillas is currently under threat due to rebel insurgency as park staff is often driven out of the protected areas and sometimes killed by the rebels.

Finally, we observed that over 99 % of tourism income, in Volcanoes National Park, and in other NPs of Virunga Landscape generally, comes from foreign tourists, which explains why during a period of instability, the tourism sector is generally heavily affected. There is need for promoting tourism based on local population to try and fill up the shortfall during the off-pick seasons.

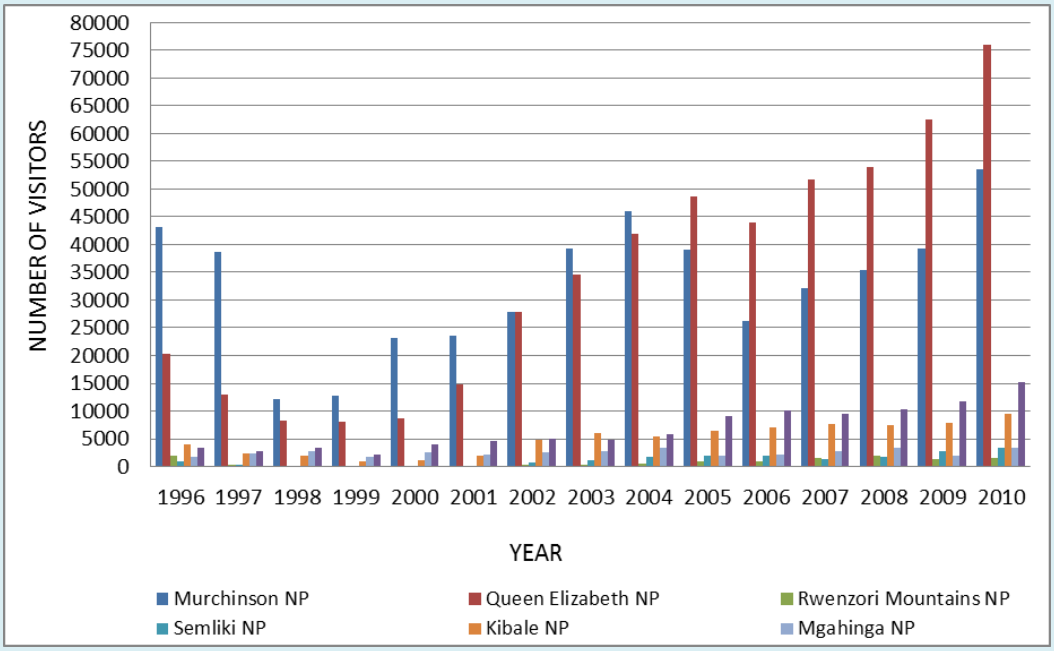


Figure 10. *Number of tourists in selected National Parks within the GVL in Uganda over a 15yr period. The graph shows that the number of tourists has grown continuously in most of the Uganda national parks during the last 15 years.*

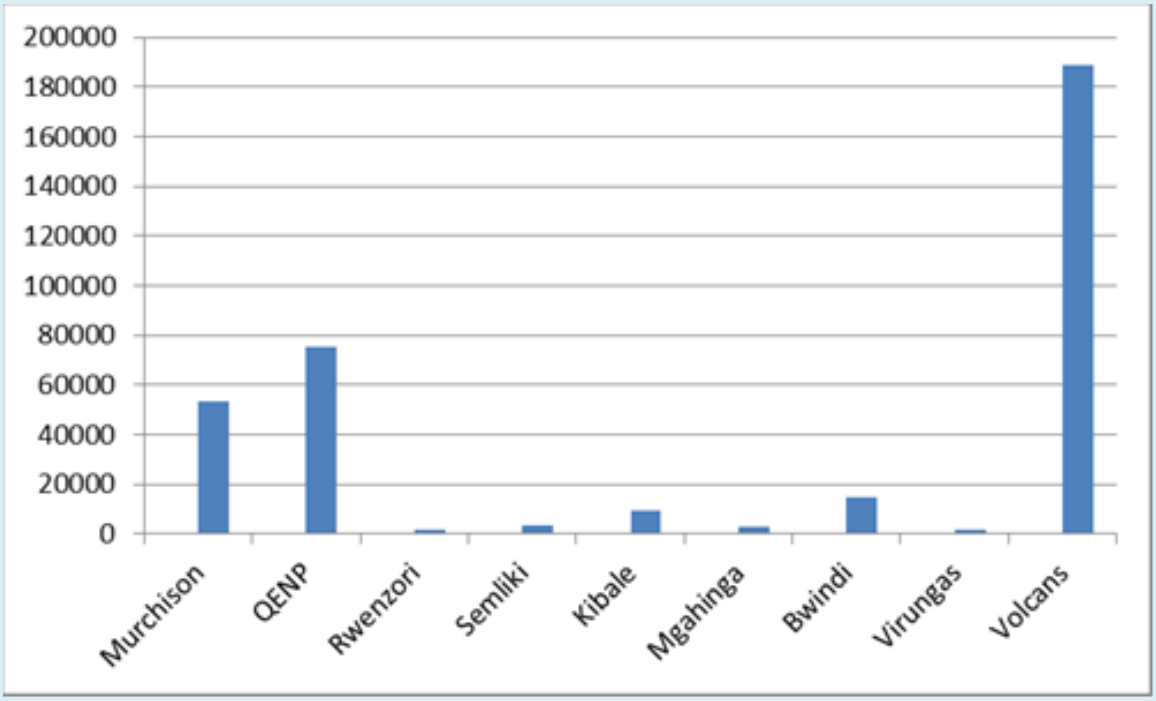


Figure 11. *Tourists' numbers in 2010 showed that Volcanoes NP in Rwanda was the best destination choice in the region with nearly 190,000 tourists per year, followed by Murchison NP and Queen Elizabeth NP.*

4. Drivers of Change for Ecosystem Services in the GVL

The potential drivers of change in ecosystem services within the GVL are summarised in the table 3 below. These were specified for the different countries basing on the countries' development plans and projections up to 2030. In DRC, the main drivers of ecosystem services change are agriculture, forestry, mining, energy, environment and agri-business. Agriculture is likely to expand in the DRC through the promotion of large-scale agriculture; this will be made possible by creating incentives such as loans to potential investors. However, clearing of large expanses of land will likely negatively impact ecosystem services flow. Expansion of agriculture is likely to affect water quality and quantity within the affected watersheds through pollution and increased evapotranspiration. There is a program in the DRC for strengthening the forestry sector e.g. through developing a forestry sector program, strengthened forestry monitoring, industrialization of wood production with domestic processing, support to concessions and national certification. Commercialisation of the forestry sector is likely to cause rampant deforestation in the region and a reduction in ecosystem services such as hydrological functions and wood biomass.

DRC is very rich in valuable minerals such as gold and coltan. The mining processes are often detrimental to water quality and human health by polluting the water sources with chemicals used in the mining processes. This is also likely to reduce on the forest cover. With the discovery of oil and gas in the Albertine Rift Graben, exploration and production of the resource will take place within the GVL in DRC. The consequences for ecosystem services will be enormous especially on water resources and wildlife.

In Rwanda, agriculture development, environmental management, population initiatives, land policies are the likely drivers of ecosystem services change. Rwanda is currently promoting organised agriculture by settling people in gazetted places and leaving the land to agriculture. This kind of development will likely favour some ecosystem services such as water as a result of practicing conservation agriculture and landscaping. The country is also undertaking massive restoration of degraded landscapes through tree planting to provide wood fuel and fodder to livestock. Reproductive health initiatives in the country aimed at curbing the ever increasing human population will probably reduce pressure on ecosystem services.

In Uganda the national development plan predicts extensive development of infrastructure such as roads and railway networks across the country. This will likely impact ecosystem services negatively e.g. through clearing of large expanses of land and forests. In addition, the drive to increase hydro-electric power generation will negatively impact freshwater resources through the reduction of environmental flows in the affected rivers. This is already being witnessed on the river Mubuku that drain the Rwenzori Mts. where three dams have been constructed leaving the river with no flowing water during the dry seasons and complete blockage to fish migrations along the river.

The major threats identified include over dependency of local communities on natural resources, high population density, poverty, natural disasters and insecurity and increasing land acquisition by international companies/individuals is a major problem.

Table 3: Examples of drivers and rules which will affect ecosystems in the region. The rules differ in the different countries represented within the GVL.

Country	Drivers	Rules
DRC		
	Agriculture: Increased contribution of agriculture to national economy, increased mechanization, removal of tariffs on inputs, promotion of micro credit	Agriculture increases
	Forestry: Developing forestry sector program, strengthened forestry monitoring, industrialization of wood production with domestic processing, support to concessions and national certification	More wood production can accelerate deforestation unless certification is done properly. With improper governance, this can result in more forest loss and conversion of natural areas to plantations
	REDD: Programme operational	Possibility to slow down forest loss
	Mining: Development of mining expertise, promotion of traditional mining	Possible reduction forest cover
	Energy: Promotion of increased access to energy, oil exploitation	Immigration in oil areas
	Environment: Development of national landuse plans	National land use plan if well done and followed can control land cover change
	Agro-business: Bio-fuel and palm oil	Likely to increase in future if no

	plantations	sustainable measures taken
Rwanda		
	Agriculture development: Intensification of sustainable production systems, promoting commodity chains and agribusiness, strengthened institutional framework	Increased agriculture (intensive, slight expansion because no space, but shift from dispersed settlement to communal villages)
	Environment management priorities: Rehabilitation of degraded lands, increased land tenure security and improved registration, special attention to biodiversity conservation	Plan for restoration of forests etc. Erosion control and agroforestry
	Population initiatives: Strengthen reproductive health services	Reduced population, communal villages
	Land policies: Policy on grouped settlement, land organized for modern viable farming	Plan for communal villages, afforestation in state-owned land, operationalization of identified agro-ecological zones
Uganda		
	Infrastructure development: Increased infrastructure; build more roads and rail	More and improved roads, possibly leading to more conversion along roads
	Tourism development: Build more tourism hotels and grow ecotourism	Depending on how this is done, can increase settlement in conservation areas
	Energy policies: Build oil refinery, pipelines, build more HEP dams, scale up oil and gas	Possible conversion (and degazettement) in mining areas, immigration
	Agriculture: Irrigation development	More agriculture
	Mining: Develop phosphate mining in Tororo, Iron ore	Habitat destruction/loss

5. Projected Future Scenarios for Ecosystem Services in the GVL

During the second workshop the project developed three scenarios of possible futures for the GVL and the parts of the countries that make up this area. These scenarios were used to create new landcover maps for the area that can then, via the InVEST software, be turned into new maps of ecosystem service provision across the area and into the future.

The different scenarios used here were developed in a participatory manner during a workshop that brought together stakeholders familiar with the GVL. From a baseline Scenario which corresponds to current land use, three future development scenarios were proposed: Business as Usual', 'Green Future' ad Market Driven' Scenarios and results are discussed below. Scenario development was based on probable land cover change as a result of national development policies and strategies (Table 3). The table highlights the possible development trajectories for the three GVL countries and likely drivers of land-use change. In terms of timescale, the first projections are based on the year 2030 (corresponding to the end of current Albertine Rift Strategic Framework).

Business as Usual Scenario

The Business as Usual Scenario assumes that development and environmental governance and politics will continue in the same trends as today. This scenario envisages a future where there is a degradation of ecosystem services and a depletion of natural resources. This might bring relatively higher economic growth of 7-10% in the three countries sharing the greater Virunga landscape. It will also lead to an increased gap between the rich and poor. Population growth slows as is typical with increased awareness and mortality and fertility rates drop. The increasing access to a global and regional market fosters growth in agricultural outputs for exports such as tea, livestock and encourages large private estate formation. Relatively cheaper fertilizers lead to an increase in

agricultural productivity, and global market for bio-fuels encourages large plantations to meet this market.

Lack of pro-poor development approaches mean less alternatives for people depending directly on the ecosystems for their livelihoods, and this increases illegal harvesting of timber and NTFPs from protected areas and wildlife trade targeting unique species from the region. The region is still a very important place for the global nature-based tourism market and in 2030 record numbers of people will fly to the region to spend time in parks and reserves. International tourists are increasingly joined by more affluent nationals, and by 2030 national tourism is more important than international tourism. This leads to village growth near parks and reserves.

Market driven scenario

The Market Driven Scenario outlines a future where development focuses on economic growth without much regard for changes in land use and consequences for ecosystem services and biodiversity. This scenario considers the influences and impacts on the environment caused by a market driven development. This is reflected in an increase in infrastructure, an increase in pollution and land degradation, and as well as in rising agricultural land area and consequent decline in area of natural forests. The cause might be a further increase in economic growth (>/= 10 %) and a political focus on development without considering rules which might be tangent to economic growth. As seen with the recent lobbying by the oil industry on oil exploitation in the Albertine Rift, there will be more emphasis on economic gains and job creation than the environmental services.

Green future scenario

The Green Future Scenario is based upon the assumption that environmental destruction will decrease and future land use will be more sustainable. Under the green scenario, the income growth is slower, but more equitable than in Scenario 1. Due to global health care efforts, mortality is down, but fertility rates are still high leading to continued population growth, but at a lower rate than in the year 2008. People will continue to move to cities, but also regional centres

become more important and the number of small cities increases greatly. These cities are networked for regional trading with some infrastructure improvements. A focus on good practices in catchment management and transboundary collaboration will encourage forest protection initiatives. A global market for carbon credits adds to the incentive to manage forests and a well-functioning plantation certification scheme means that in some areas there is an increase in forest cover. On the energy front, efficient charcoal burners and cooking briquettes made from agricultural waste greatly decrease demand for wood fuels. Small scale wind and hydro installations also supply villages with sustainable electricity. Fertilizer management and organic techniques mean less agricultural pollution to waterways, and husbandry education means that livestock densities can be reduced without a corresponding loss of product for market. Additionally, the global concern for the environment means that less people are flying internationally, but more people are flying to experience nature. For the region, this means that nature-based tourism visitors stay at the same level as the year 2000, but revenues from this sector continue to increase due to increased willingness-to-pay for these experiences. This ethic and demand also find result in increased protected areas and the creation of large wildlife corridors connecting reserves. The table below shows the different drivers of ecosystem services and the rules applicable in the different countries under the different development scenarios.

5.1 Landuse change under different scenarios

Under the Business as Usual scenario, it is expected that landcover will change mostly from shrub land to small scale agriculture. As the population increases, people will expand agricultural land into previously uncultivated lands in order to boost food production for the burgeoning human population. Under BAU scenario, protected area systems are expected to remain unchanged but with a slight increase in exotic tree plantations as the population struggles to meet the shortfall in timber supply. Under the market driven scenario, moderate expansion of small scale agriculture is also expected to occur in marginal areas such as shrubland. Under the Green Future Scenario, the expansion of small scale agriculture is expected to be minimal. However, people are expected to engage in sustainable forestry practices resulting in an increase in forest cover in most areas. The restoration of previously degraded landscapes will further increase.

This scenario assumes that development and environmental governance and politics will continue in the same trends as today. This scenario envisages a future where there is a degradation of ecosystem services and a depletion of natural resources. This might bring relatively higher economic growth of 7-10% in the three countries sharing the greater Virunga landscape. It will also lead to an increased gap between the rich and poor. Population growth slows as is typical with increased awareness and mortality and fertility rates drop. The increasing access to a global and regional market fosters growth in agricultural outputs for exports such as tea, livestock and encourages large private estate formation. Taking 2008 as the base year landcover is expected to change under different development scenarios as shown below (Figure 11).

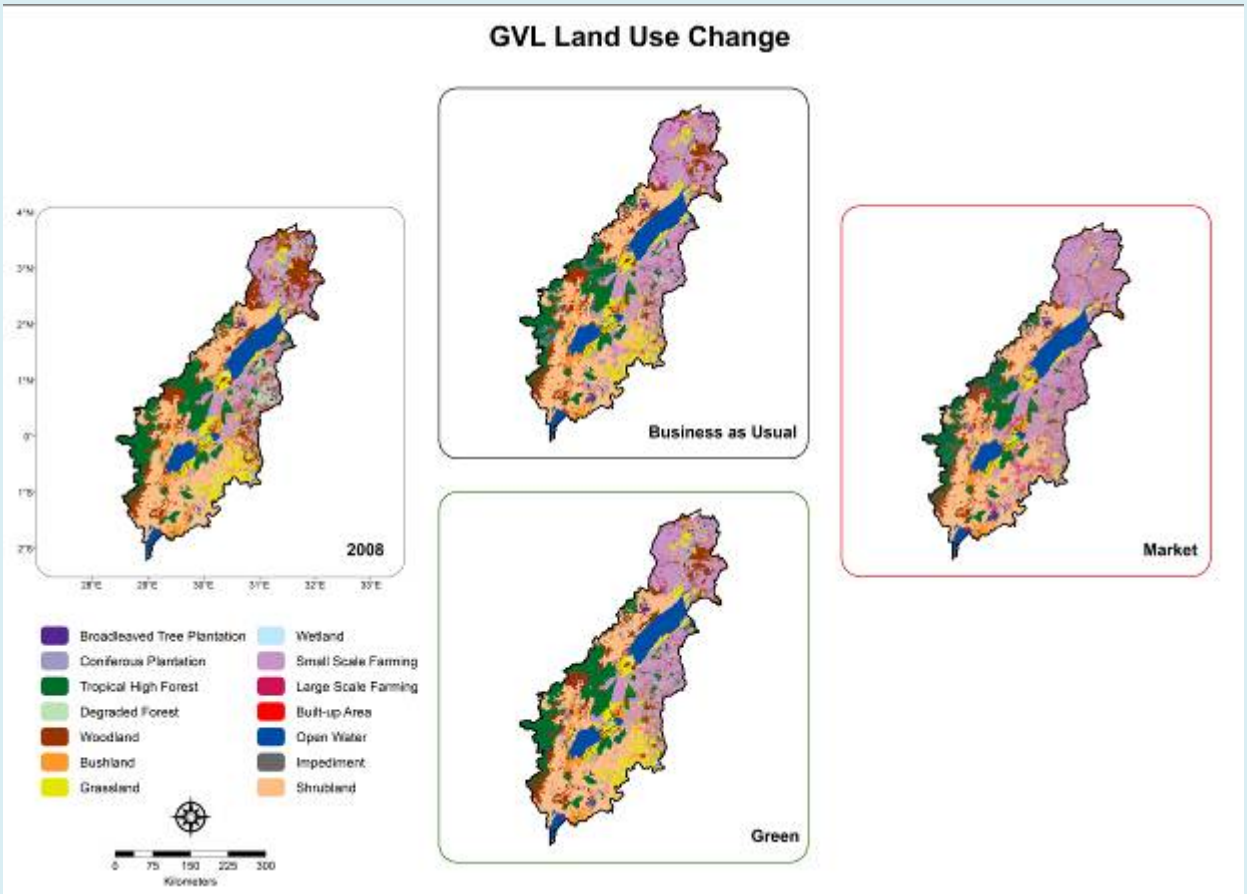


Figure 11: Landcover map for the Greater Virungas landscape and future landcover scenarios as developed during this project

The detail of the kinds of land use changes that are expected to occur can be seen better when the maps are zoomed to higher resolution, in this case to an area in Uganda (Figure 12).

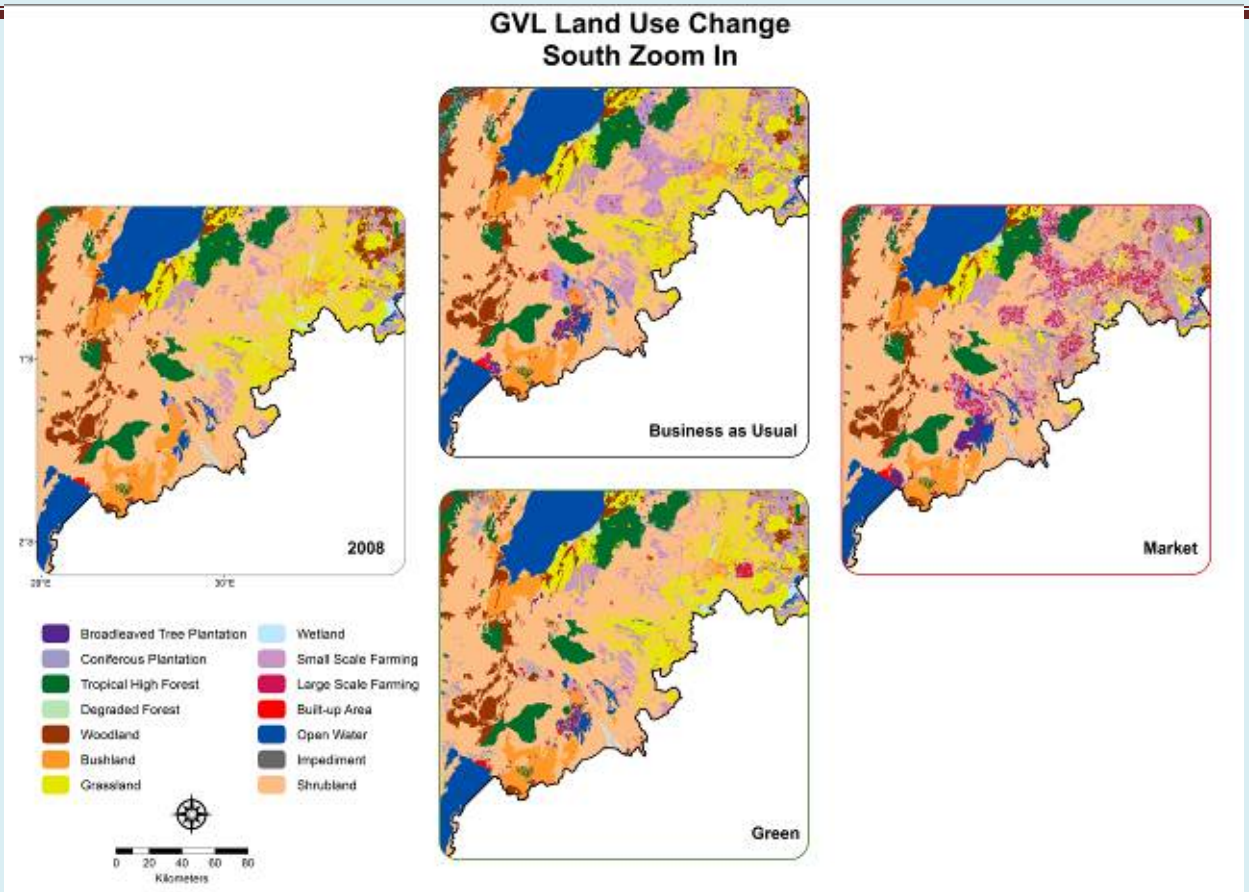


Figure 12: Zoomed landcover map showing additional detail of landcover in part of the project area

5.2. Carbon balance under different scenarios

Under the BAU scenario carbon storage is expected decline by -15 to -35% in sub-watersheds 1, 8, 10, 15, 1nd 16 that are mostly located within the Ugandan part of the GVL. This will be as a result of people opening up virgin land for agriculture and plantation forestry resulting into depletion of carbon stocks previously stored in forests, woodlands and shrubland. However, carbon stock is expected to change little under the same scenario in protected area systems such as National parks and forest reserves as shown in Figure 13. The assumption here is that the current state of protection will remain and that no encroachment or degazetment will affect the protected areas. Under the Market scenario, changes in carbon stock mirror those under the BAU scenario except that in the DRC, a lot of forests outside protected areas will be cleared for timber and agriculture expansion. Under this scenario forests and wooldlands will be futher depleted especially outside protected area systems. These expansions will be occasioned by commercialisation of agriculture and industrialisation especially on the Ugandan side of the GVL. The massive clearing of forests

and woodlands will likely exacerbate the climate change situation in the region and reduce the resilience of the population to disasters such as flooding and landslides. Under the green future scenario carbon storage and sequestration is expected to change minimally in sub-watersheds 1, 4, 5, 10 and 15. Under this scenario, it is expected that the population will engage in sustainable landuse practices such as agroforestry that will increase tree cover on the landscapes. In addition, governments will encourage plantation forestry that will increase carbon stocks in the GVL. Governments e.g. under the clean development mechanism will support initiatives aimed at greening their economies. Under this scenario adverse effects of climate change are likely to be abated as the increased forest/tree cover will sequester more carbon from the atmosphere.

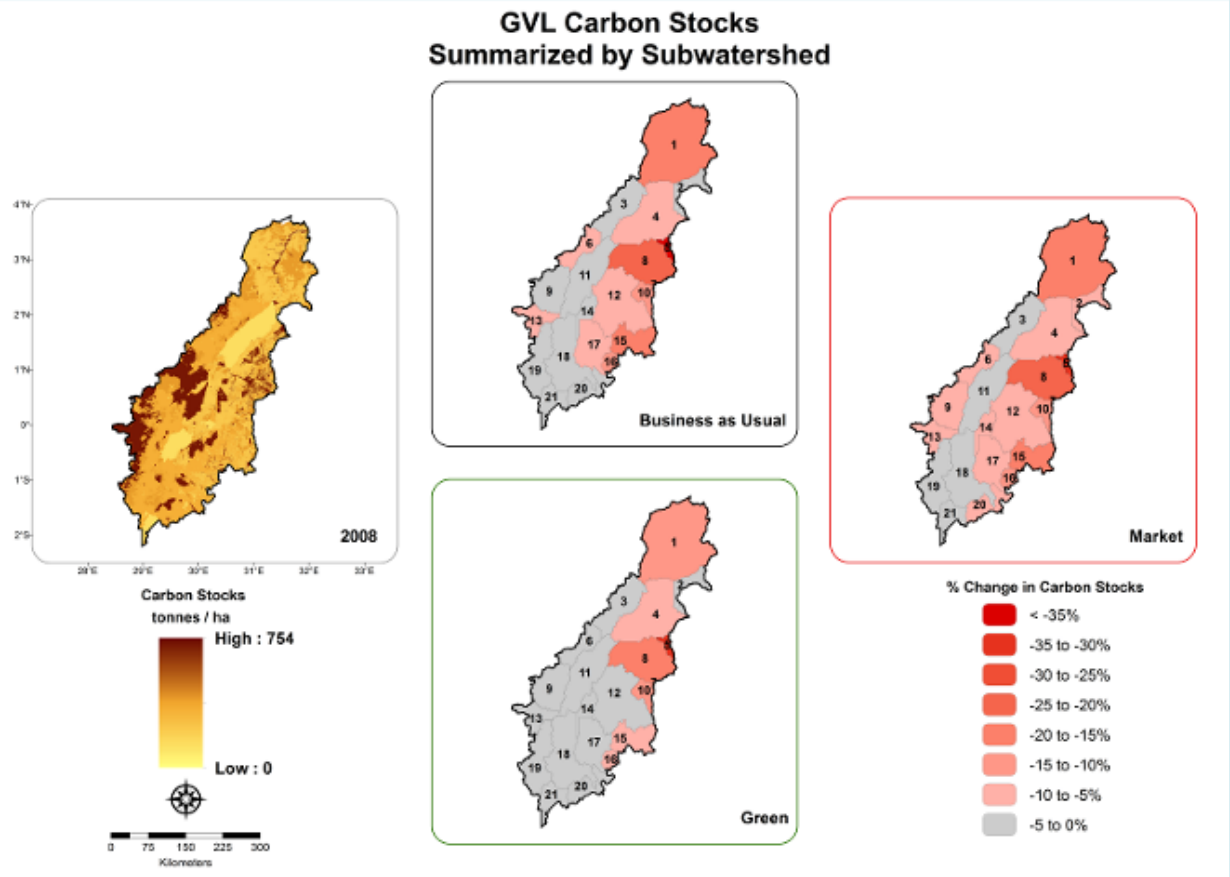


Figure 13: Carbon changes across the Greater Virungas Landscape

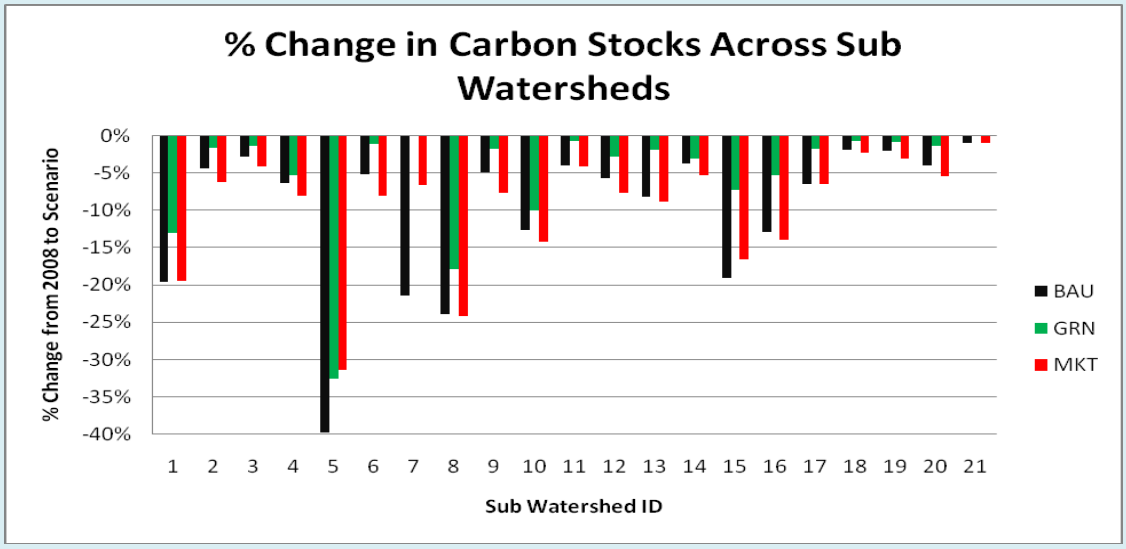


Figure 14: Carbon changes per sub-catchment / sub-watershed across the Greater Virungas landscape

5.3. Water yield under different scenarios

Under the BAU scenario, some watersheds are expected to have an increase in runoff from their landscapes. The relative increase in runoff is expected to range from -2% to 20%. The watersheds that are expected to experience increased runoff may tap into the opportunity to reserve the water for use in agriculture and fish farming. However, watersheds located in savannah grasslands (two sub-watersheds) are expected to experience a reduction in the amount of water yield of -5 to -2.5%. The increase in water yield may result in increased HEP generation by dams located within the watersheds. Watersheds within Uganda are expected to have appreciable increases in water yield under this scenario. In sub-watershed 5 in Uganda covering districts of Kyenjojo and Kibale, the increase in water yield under this scenario maybe attributed to the rampant deforestation taking place in the landscape caused by timber exploitation, charcoal making and clearing of land for cultivation and human settlements. As such the increased runoff may be only for short time periods becoming scarce soon after the rains.

Under the market scenario, watersheds mostly within Uganda are expected to have an increase of 2 to over 20% in water yield. These are sub-watersheds located mostly outside protected areas. The likely increase in water yield could provide opportunities for irrigated agriculture and other

water related development activities in the region. Little or no change in water yield would occur in most forested protected areas.

Under the Green future scenario, six sub-watersheds will experience an increase in water yield of between 2 to 20% thus increasing the availability of water in the landscape. This will happen mostly in watersheds within Uganda. The increased water abundance under this scenario would likely trigger development that requires water as an input. Under the scenario, hydropower generation will likely increase and fisheries productivity in the receiving water bodies will increase too. However, the likely increase in water yield may result in some negative impacts such as flooding and landslides, and the spread of waterborne diseases. Since, most of the watersheds are transboundary in nature, this calls for collaboration across the borders in order to sustainably manage the freshwater resources.

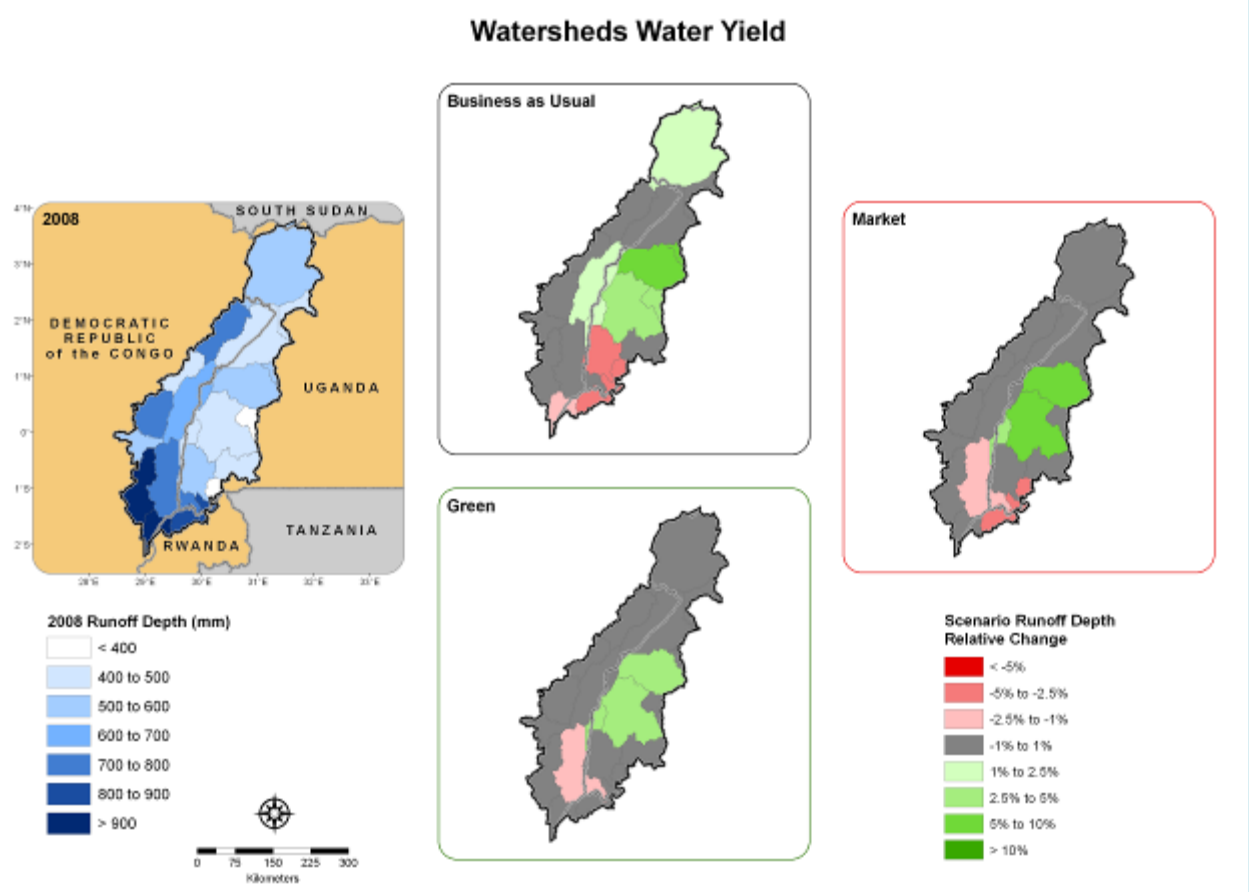


Figure 13: Change in water yield expected under different development scenarios

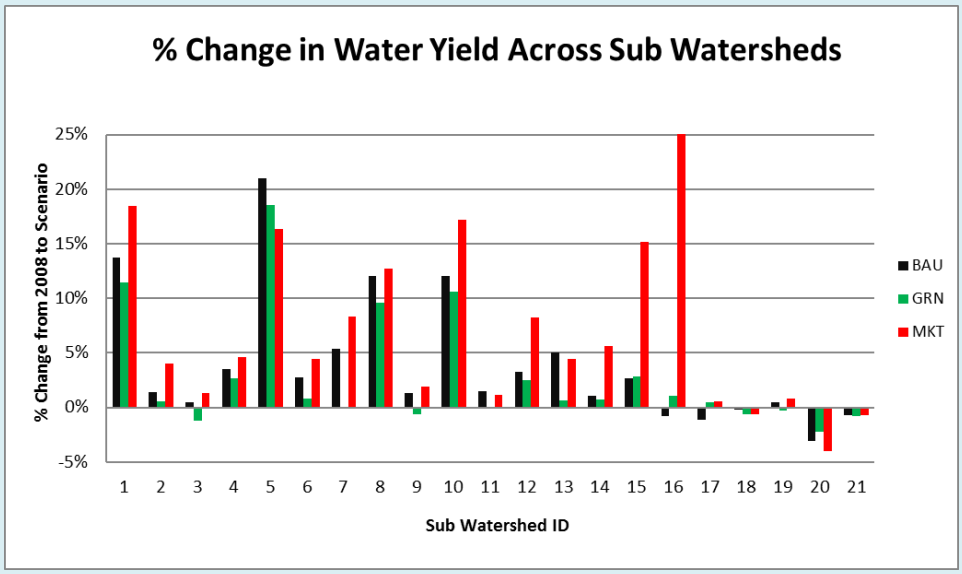


Figure 14: Change in water yield across sub-watersheds / sub-catchments

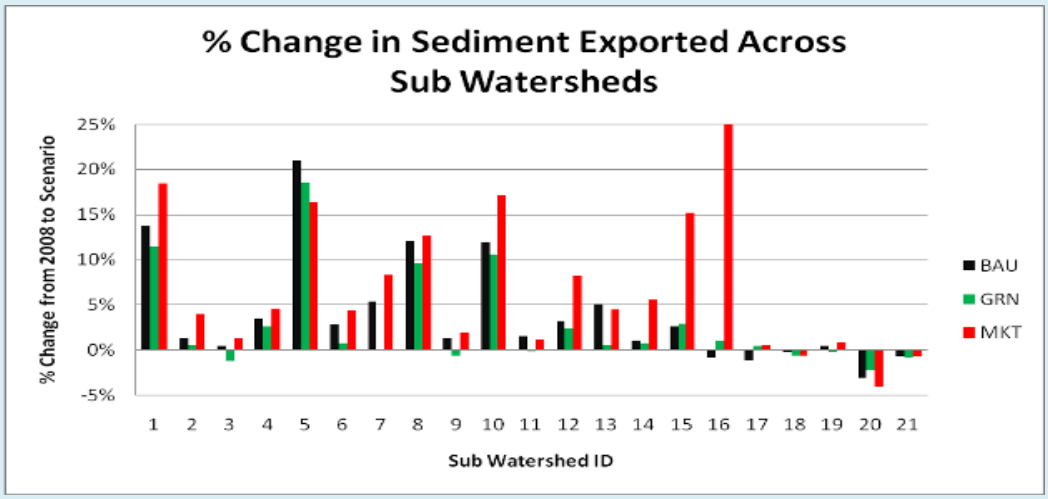
5.4. Water sediment retention under different scenarios

In terms of sediment exported, sub-watersheds 13, 1, 5, 10, 15, and 16 will experience an increase of over 10% of sediment exported acros the sub-watersheds under the BAU scenario (Figs 15 and 16). For example, in sub-watershed 13 around Tayna community forest, deforestation is likely to increase the amount of sediment getting into water bodies. Secondly, the expansion of agriculture into previously uncultivated woodlands and shrubland in the above sub-watersheds will further increase sediment export. The consequence will be increased turbidity (lowered water quality) and loss of aquatic biodiversity in the receiving water bodies. This may negatively impact on the health of the communities that depend on water from these sources.

Under the market scenario, sub-watersheds 1, 5, 10, 15, and 16 are expected to experience an increase of over 15% in sediment exported across the sub-watersheds. Sub-watershed 16 around Bushenyi and Ntungamo Districts in Uganda will experience sediment export of over 25% from the 2008 baseline. This may be as a consequence of wetland clearance for agriculture under this scenario. This increased sediment export will result in pollution of water sources within the sub-watershed.

Under the Green future scenario, sediment export across watersheds is expected to decrease due to the increase in vegetation cover across the landscape. However in sub-watershed 5 sediment export is likely to increase due to forest clearance for agriculture expansion, human settlement, and the lack of government initiatives to restore previously deforested landscapes.

Figure 15: Change in sediment exported under different development scenarios.



6. GVL Ecosystem Services and Policy Implications

Throughout the project duration, stakeholders that included policy makers such as ministers and local government representatives were involved in workshops that generated and disseminated information on ecosystem services within the GVL. Two policy workshops that brought together stakeholders from the three GVL countries of Rwanda, DRC and Uganda were held in Kigali (Rwanda and DR) and Kampala (for Uganda). Objectives of the policy workshops were the following:

a) To show to policy makers concentrations of key ecosystem services in their areas of operation and suggestions on how to harness them to support community livelihoods.
b) To introduce to policy makers the potential for market-based approaches in the region.
c) To encourage policy makers to include ecosystem services intolocal and national policy, and into consumer behaviour through the valuation of ecosystems and biodiversity.
d) To explore the management implications for the mapped ecosystem services inside and outside protected area systems.

Round table discussions were held at the end of the workshops on how to improve and make use of the GREVIRES outputs. Examples of market-based incentives for conservation namelyPES in the different countries were presented. What emerged from the presentations is that Uganda seems to be ahead in terms of PES schemes such as carbon trading and prospecting for REDD+ projects. It is followed by Rwanda with some PES examples, but no examples were presented from DRC. The Re-Direct project has been implementing a PES services project around Nyungwe National park in Rwanda. Under this project communities living around the park were given payments in return for not carrying out illegal activities such as poaching and firewood collection inside the park.

Based on the ecosystem services mapped within the GVL, market based incentives for conservation has high potential for application within the landscape. Governments, civil society and the private sector should together devise incentive systems for market-based funding mechanisms so as to encourage the restoration of its degraded lands (GTZ, 2008). Environmental markets—such as regulatory and voluntary carbon markets—and payments for ecosystem services (PES) are giving value to carbon storage, flood protection, as well as clean, reliable flows of water and other ecosystem services. The result is that formal environmental markets now exist and self-organized “payments for ecosystem services” are increasingly emerging.

7. Conclusions and recommendations

The report provides an initial assessment of ecosystem services within the GVL. It provides a starting point for site specific analyses such as at district or provincial level or protected area setting. Despite the high importance of ecosystem services for human well-being and national economies in the GVL, there is still limited awareness and understanding among the general public, lack of policies and there are fewer attempts on valuating ecosystem services in the region Based on findings from the report, we recommend the following

While there is a fairly conducive statutory policy environment for PES in the GVL due to decentralization and reform of environment, water, forestry & land policies, there is no specific provision for PES. There is a need to mainstream ES in development, including EIAs. Ecosystem Based Management principles and Integrated water resources management approaches need to be adopted in the GVL if the water resource is to be sustainably managed.

The mapped ecosystem services such as carbon have high potential for application in market based incentives especially under the Clean Development Mechanism (CDM) and the REDD+ mechanisms for conservation within the landscape. Environmental markets and payments for ecosystem services (PES) are giving value to carbon storage, flood protection, as well as clean, reliable flows of water and other ecosystem services. The information generated has potential for being used in the revision of benefit sharing arrangements around protected area systems in the region.

Areas that already show stress in ecosystem services such as firewood and bamboo; measures to regulate harvest of resources should be put in place. Agroforestry practices and establishment of woodlots to provide alternative sources of fuelwood should be supported in communities surrounding PAs. Substitution planting of NTFPs collected from PA systems should be explored and encouraged outside PAs. This is already being done in some areas such as around Echuya Forest Reserve; around Mgahinga and Bwindi Impenetrable National Parks in Uganda.

PES projects should be initiated to enhance the benefits that local communities derive from protected area systems. Payment for Watershed Services (PWS) is very feasible in areas downstream of sources of water. Downstream users of ecosystem services such as water can give

incentives to upstream communities for engaging in best management practices that maintain good water quality and quantity.

There is a need for developing understanding and awareness among the political leadership and the general public and to provide information platforms for environmental practitioners to guide decision making in the recognition of ecosystem services. Governments, civil society and the local communities should work together to develop projects that enhance benefits from ecosystem services without compromising their quality and quantity.

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