Vital but vulnerable: Climate change vulnerability and human use of wildlife in Africa's Albertine Rift

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MacArthur Foundation
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Author Contributions

The authors of this report contributed in the following ways: WF conceived of, raised funds for and managed the project. TO coordinated the human livelihoods component. WF and JC coordinated collection of climate change vulnerability data. JC and WF conducted the climate change vulnerability assessments and subsequent analyses. TO and GG developed the methodological approach to gathering data on human use of species and GG carried out expert consultation to identify species of importance for human use. GG and WO collected human use data from the literature and analysed the results. JC and WO produced maps and figures. JC, WO, WF and TO wrote and edited the report.

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Foreword

The Albertine Rift region of East-Central Africa has received considerable attention in recent times, particularly from conservation organizations with a common interest in preserving the region's rich biodiversity. However, this is not a new topic, and the plight of many of the region's habitats and species (perhaps most famously the Mountain Gorilla) have long been household topics across the world. Human populations of the Albertine Rift have also often been prominent in matters of global affairs throughout recent decades, though sadly these have often reflected difficult times of conflict or poverty. While these two issues may, at a glance, seem unconnected, it is actually the case that the two are highly inter-related: As the region's already high human population density continues to grow, so will pressures on natural systems and their component species, particularly as land is converted and harvest levels of natural resources increase. As the people of the region are often highly reliant on these resources for their basic survival needs, and even more so during difficult times, this matter warrants the urgent attention of both conservationists, human development/welfare agencies and stakeholders in the region alike.

In more recent times, the emerging threat of climate change has added an additional level of complexity to both of these issues. Both humans and natural systems are expected to respond to projected environmental changes, though the specifics of how such responses will manifest remain a subject of much debate. Again, the subject of climate change impacts in the Albertine Rift has received some attention in recent years – not least thanks to the generous funding provided to a variety of organizations by the MacArthur Foundation. Such work has indicated a high vulnerability of the region to changes in climate, and has also highlighted a range of knowledge gaps that will require filling if successful adaptation to climate change is to meet the pressing needs of both biodiversity and human populations. In short, while much commendable work has been undertaken to assess the status and needs of the people and biodiversity of the Albertine Rift region, the need for further information upon which well-guided actions relating to biodiversity conservation, climate change adaptation and sustainable use of wild biological resources (and, of course, combinations of the three) may be based, still remains, and is perhaps now greater than ever.

The work presented in this document builds upon much of the work already undertaken in the Albertine Rift region, particularly efforts to catalogue the vast diversity of species present, as well as those to assess the risk of extinction faced by many species. In this timely and comprehensive assessment of 2,358 of the region's species, IUCN and TRAFFIC International have gathered a wealth of information relating to the ways in which naturally occurring species are important for humans, both at the subsistence level and for more commercial purposes. They have also applied newly developed methods which provide insights not only into which species might be most impacted by climate change, but also into the mechanisms through which such impacts could occur. When combined with available existing data on the status, trends and geographic distributions of these species, they have been able to paint a more holistic picture of how human utilization, climate change and other existing threats may, in combination, impact upon wild species, how such impacts may affect local human communities, and the broad geographic regions where such effects may be greatest.

This report, and its underlying data, will likely be of great value to a range of stakeholders, conservation practitioners and human development agencies with a vested interest in the Albertine Rift's biodiversity and/or its human populations. Armed with both species- and regional-level information on the factors listed above, either in isolation or in combination, it will be possible for them to make informed decisions about the severity and geographic variation of current and future impacts in the region. Based upon this work it will be possible to prioritize the species and regions most in need of conservation action, whether this relates to climate change adaptation, sustainable use of resources, existing threats to species, or any combination of the three. I urge all those concerned with the management and conservation of one of the world's most spectacularly diverse regions to not only read this report, but to use its findings when considering future courses of action for conservation of wildlife and human communities. In doing so, we will hopefully facilitate the preservation of a global treasure for the enjoyment of many generations to come.

Dr Sam Kanyamibwa
Executive Director, Albertine Rift Conservation Society (ARCOS)

Executive Summary

This report brings together a broad range of new and existing information on 2,358 plant and animal species of the Albertine Rift (AR) region of East and Central Africa. Through an exciting collaboration between IUCN and TRAFFIC, and with generous funding from the MacArthur Foundation, we have been able to assess the climate change vulnerability of all known Albertine Rift mammals, birds, reptiles, amphibians and fish, as well as a range of plants, whilst simultaneously gathering detailed information on their use by humans. This powerful combination of climate change vulnerability and use information provided a new tool for assessment of the possible impacts of climate change on the important provisioning services these species provide. These results have been combined with Red List assessments of species' extinction risk due to non-climate change driven threats, where available. Overall, this study presents the results of perhaps the most holistic assessment to date of the status of, threats to, and use by humans of the region's biota.

The AR has emerged as a priority region for our study for a number of reasons. Firstly, the region is believed to support more endemic mammals, birds and amphibians than any other in Africa, and it is estimated that over 50% of birds, 39% of mammals, 19% of amphibians, and 14% of reptiles and plants found in mainland Africa occur there. Secondly, the region's very large and growing human population is known to be heavily dependent on many of the natural biological resources that the region provides. If these resources are to continue to support the human population in a manner which is not detrimental to the survival of wild populations, it is vital that exploitation is carried out in a sustainable manner in the long term. Thus, it is essential to determine how people use wild resources and to what degree, and then to use this information to ensure future conservation strategies are effective and allow for a more sustainable management of resources. Thirdly, the climate in the AR has already been shown to be changing, and projections suggest that changes are set to continue. For these reasons, better knowledge of how species are likely to be impacted by climate change is fundamental for both biodiversity conservation and developing sustainable livelihood strategies.

Through a process of expert consultation and detailed literature reviews, we have identified the taxonomic groups and the species believed to be important to people's livelihoods in terms of subsistence and contribution to income. Freshwater fish, plants and mammals emerge as the most heavily utilized taxa, and contribute most to people's livelihoods. We found that 330 freshwater fish species (60% of all freshwater fish species present), 153 plant species (60%), 85 mammal species (24%), 83 bird species (9%), 57 reptile species (34%) and 49 amphibian species (45%) were

Tea plantations on the edge of Nyungwe National Park rainforest, Rwanda. ©Rachel Strohm

important for at least one use purpose (e.g. for food, medicine, fuel, etc.). Although it is likely that a much greater number of species are used to some degree, identifying those species which are most important means that conservation actions can be targeted at ensuring sustainability of their harvest and use.

Many of the AR's inhabitants earn a living through the harvesting, processing and selling of wild species for food, as well as relying on them for protein and nutrition. For some freshwater fish and mammal species, levels of exploitation are high, and trade occurs at local, national and international levels, thereby generating large sums of money. Some plant species are important as a food source for both rural and urban inhabitants and evidence suggests that plants can be a vital resource during periods of food insecurity. Generally the consumption of most species of amphibians, birds and reptiles seems to be relatively low, though there are some exceptions.

Plants provide an essential source of fuel, and the majority of the AR's population relies on wood and charcoal for heating and cooking needs. A variety of plant species also provide the timber and fibre used to create a broad array of products crucial to livelihoods, ranging from fence posts and house construction materials to blacksmiths' bellows and tea-pickers' baskets. The majority of people in the AR do not have access to modern medicine, and must rely on wild species for medicines both for themselves and their livestock. In this report, we illustrate the wide variety of species used to treat an astounding range of ailments, from life-threatening diseases such as malaria, to infertility and a sore throat. Wild species may also be traded as pets, hunted for sport, made into clothing and jewellery and may generate income through ecotourism, among other uses. It is evident that whilst some people use wild resources to make large amounts of money, others rely on them simply to survive.

Geographic patterns of use vary across the AR and are influenced by culture, wealth and preference. We compared the locations of highest concentrations of utilized species for birds, amphibians, fishes and mammals, and found that the far northern parts of the AR, particularly in and around Virunga National Park, Queen Elizabeth National Park and the areas surrounding Lakes Albert, Edward and George, contain high numbers of important species for all four (though more typically three) taxonomic groups. Regions in the far northeast and far northwest have high numbers of important species from two taxa (mainly amphibians and mammals), whilst in the southern half of the Rift, most of Lake Tanganyika and some areas on the periphery of the Rift boundary contain high numbers of important fish species only.

Despite the widespread use of wild species in the AR, with the exceptions of mammals and fish, there has been a dearth of recent documented information addressing which species are used and how. Data were especially lacking for plants, amphibians and reptiles. For most species and all taxonomic groups, there has been little focus on investigating the contribution that species make to peoples' livelihoods. A better understanding of the reliance of local people on wild species and how climate change may impact populations of important species will be vital in devising appropriate conservation and livelihood strategies that allow for adaptation to a changing climate.

We used IUCN's Climate Change Vulnerability Assessment Framework to independently assess three components of species' vulnerability, namely sensitivity (the ability to persist *in situ*), adaptive capacity (the ability to mitigate impacts by dispersing or undergoing micro-evolutionary change) and exposure (the degree to which the species will be subjected climatic changes). Sensitivity and adaptive capacity assessments were based on a combination of species' life history, ecological, physiological and genetic traits. Exposure was calculated by modelling the degree of changes in temperature and precipitation across species' ranges. For fishes, exposure was calculated as climatic changes across the water catchments in which species occur. By combining sensitivity, adaptive capacity and exposure, we calculated relative measures of overall climate change vulnerability for each taxonomic group. These results indicate the species likely to be at greatest risk from climate change within each group, but as they are not absolute measures, they cannot be interpreted to indicate which species are 'safe' from climate change, nor whether one taxonomic group is more climate change vulnerable than another.

We identified the 31 amphibians (28% of those assessed), 199 birds (20%), 31 freshwater fish (6%), 107 mammals (30%), 79 plants (39%) and 70 reptiles (42%) likely to be most vulnerable to climate change. The traits according to which these species qualified as vulnerable provide indications of the mechanism(s) through which climate change may impact upon a species, and thus can be used to guide management decisions and actions. Our approach also allows identification of species for which only one or two aspects of climate change vulnerability are of concern; although of lower conservation priority, these species may also warrant conservation interventions and/or monitoring.

We found that some of the traits according to which species qualified as climate change vulnerable were fairly consistent between taxonomic groups. These included heightened sensitivity due to habitat specialism, climatic triggers (e.g. for breeding, activity or migration), low population sizes and reliance upon specific fire regimes. Particularly common traits associated with low adaptive capacity were the presence of dispersal barriers (often due to habitat fragmentation, but also from natural barriers such as steep escarpments and altitudinal gradients) and low micro-evolutionary rates, typically due to low reproductive outputs and/or long generation times. The latter are likely to prevent species from accumulating novel adaptive characteristics at a sufficient rate to counteract negative climate change impacts.

Similar to spatial patterns for utilized species, we found that the northern parts of the AR contained greatest overlap in concentrations of climate change vulnerable species between taxonomic groups. Although no areas were priorities for all four groups, the central AR (close to and on the DRC border), the areas directly east of the Itombwe Massif, the region encompassing the southern extent of the Réserve naturelle des primates Kisimba Ikobo, Nyungwe National Park, the area surrounding Lake Kivu, and much of Virunga National Park contain overlapping priorities for three taxonomic groups. These patterns largely follow those of species richness. We found that greatest concentrations of climate change vulnerable fish species occur in the Lake Tanganyika region (excluding its far northern parts), where freshwater fish species richness is highest.

Our assessments of climate change vulnerability highlighted a number of key data gaps. For freshwater fish in particular, poor knowledge of species' possession of traits conferring potential for adaptation resulted in the highest degree of uncertainty for all groups considered. This knowledge gap was also present, to a lesser extent, across most other groups. Other significant knowledge gaps included global population sizes (birds), sensitivity to changing fire regimes, and specific dietary requirements (mammals). Although trait data for reptiles and plants were considered to be relatively robust, assessments of these groups were limited somewhat by a poor knowledge of the distribution ranges of many species. These knowledge gaps are priorities for research.

We then combined climate change vulnerability and use assessments to identify the human utilized species most likely to be negatively impacted by climate change. We found that 14 amphibians (13% of those assessed), 17 birds (2%), 19 freshwater fish (3%), 24 mammals (7%), 33 plants (36%) and 25 reptiles (15%) are of known importance for use and are also amongst those of greatest vulnerability to climate change impacts. In combination with other information sources, this information can be used to provide important guidance for those seeking to take appropriate adaptive action to ensure that provision of the important services these wild species provide is maintained in the face of climate change.

We have also presented the results of Red List assessments of species' extinction risk due to non-climate change related threats for all groups except plants and reptiles, and compare this with assessments of both human use and climate change vulnerability. We found that six amphibians (5.5% of those assessed), five birds (0.5%), 19 freshwater fish (3%) and eight mammals (2%) are both important for use and considered to be threatened with extinction. We also indicate the seven amphibians (6.5% of those assessed), 17 birds (2%), seven freshwater fish (1%) and 21 mammals (6%) considered to be both threatened with extinction and vulnerable to climate change. Finally, we indicate the five amphibians, four birds, five freshwater fish, four mammals, three plants and one reptile species that are important for use, vulnerable to climate change and considered to be threatened with extinction.

Key messages and recommendations

1. **People of the AR rely heavily on natural resources, yet we have found that many of the species of importance for human use are also climate change vulnerable and/or threatened with extinction due to non-climate change related threats.** Since climate

change is likely to lead to even greater reliance on wild species in the AR, it is essential that interventions for both human development and biodiversity conservation are promptly prepared and implemented. This report provides a non-exhaustive list of possible approaches (and their caveats) that we believe could help to promote sustainable use of wild species, enhance their potential to adapt to climate change impacts, and thereby continue to provide essential services for the people of the region.

2. **We emphasize the importance of maximizing species' inherent ability to adapt to climate change.** Our study identifies AR species that are of highest vulnerability overall, potential adapters, potential persisters and those of high latent risk. These categorizations are useful, firstly, for helping to identify the species for which conservation resources should be prioritized, and secondly, for broadly categorizing species according to the types of conservation interventions that are likely to be most effective in helping them to adapt to climate change. Accordingly, we also provide a list of potential adaption strategies that are likely to be useful for assisting species-level climate change adaptation for each of these climate change vulnerability types.
3. As the field of climate change vulnerability assessment advances, conservation practitioners are likely to be faced with multiple and potentially conflicting assessments. In such cases, we recommend conservative interpretation of all results and the use of 'no regrets' strategies, which aim to enhance species' capacity to adapt without reducing options for alternative strategies should species respond in unanticipated ways. The uncertainties discussed throughout this study underscore the need for new and continued efforts to monitor species' responses to climate change. **In conjunction with the establishment of baseline datasets with which to compare the coming changes, such monitoring is imperative for understanding mechanisms of climate change impacts, testing and improving vulnerability assessments and, hence, for the development of sound climate change adaptation strategies.**
4. Our results highlight species that are likely to decline in relative abundance and hence in their availability for human use in the future due to climate change. They broadly indicate the geographical regions at greatest risk of losing the important provisioning services wild species offer. Our findings are also valuable for prioritizing areas requiring further study, and can be used to guide those developing climate change adaptation strategies for both humans and biodiversity. However, as several notable knowledge-gaps exist, **it is recommended that further research is undertaken to determine the extent of human use and reliance on species across the AR, and the resulting impacts upon wild populations**.
5. **We highly recommend an increase in efforts to raise awareness of, and enforce laws surrounding, the legality of harvesting wild species.**
6. Harvesting of plants for fuel is significant within the AR, and increasing human populations and urbanization are likely to elevate demand further, particularly for charcoal. **We recommend investigating the potential of creating community-based fuel wood plantations of non-climate change vulnerable, native and non-invasive exotic plant species as a way to supply fuel wood.** Programmes focusing on reducing overall consumption of fuel should also be promoted. These could include introducing more fuel efficient household stoves and more efficient kilns for charcoal production, and the use of alternative cooking technologies.
7. Where feasible and appropriate, **we encourage the domestication of threatened and/or climate change vulnerable medicinal plants, in order to reduce pressures on wild populations**. We also encourage increased efforts to conserve crop wild relatives and traditional varieties of wild food plants as these could provide climate change adaptation opportunities through crossing with domesticated species to increase resilience.
8. **In order to ensure a sustainable supply of fish, we suggest increasing efforts to ensure protection of important wetland habitats and the species within them.**
9. **Levels of exploitation of some mammal species for food are high.** We suggest measures that may reduce pressure on wild species including increasing access to livestock, investigating possible alternative protein sources (e.g. other mammal species; invertebrates) and domestication of native wildlife.
10. In light of our study's findings, **some of the AR's strategies, regulations, laws and agreements may need re-evaluation:**
    - Spatial patterns of climate change vulnerability and use should be included in the identification of Key Biodiversity Areas and other conservation planning initiatives.

- Priorities for species-level monitoring and management both within and outside formal protected areas should be re-evaluated.
- REDD+ initiatives should consider climate change vulnerability and use both during planning stages and in long-term monitoring in order to ensure maximum biodiversity and human livelihoods co-benefits.
- Species' climate change vulnerability and the additional extinction risk this introduces should be considered when managing harvest and trade. Population monitoring to determine impacts of climate change will be particularly important when making decisions that export will be sustainable for CITES-listed species.
- As species shift their ranges due to climate change, they may cross borders into new countries, regions and/or protected areas. While such species may previously have been regarded as invasive aliens, in the newly emerging context of climate change, such migrations should be regarded as adaptive responses and potentially welcomed. Laws and policies typically define invasive species as those occurring outside their historical ranges, so amendments and updates may be needed.
- Should species' adaptive responses include changes in migration patterns or routes, particularly those across national boundaries, updates in agreements under the Convention on Migratory Species may be needed.

This study aims to provide information to assist in the management of wild species in the AR. We hope that the findings we present here will promote re-evaluation and, where necessary, refinement of current strategies and priorities to ensure that climate change and unsustainable use do not undermine the valuable advances made in conserving the AR's biodiversity.

A man carries timber to Birambo, Rwanda. The livelihoods of the people in the Albertine Rift region depend on the availability and use of wild species, including those from protected areas.
© Susan Novak

Chapter 1. Introduction and Background

1.1 Rationale and objectives of the study

Increases in crop failure due to climate change driven drought and crop diseases are likely to cause more people to become more reliant on wild resources.
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The Albertine Rift (AR) is world-renowned for supporting both extraordinary biodiversity and an extremely large human population. Climate change is expected to have severe impacts on the region, including on its biodiversity and people, who rely on the wild species for their livelihoods. Climate change adaptation strategies for both biodiversity and human development are therefore a clear and urgent priority.

Recognizing the need for sound assessments of vulnerability as an essential foundation for conservation strategies, IUCN established the Red List of Threatened Species in 1963. With the emergence of climate change as a 'new' threat to species since the 1980s, IUCN recognized the strong need to incorporate it into assessments of extinction risk. Traditional approaches to climate change vulnerability assessment such as those based on species distribution models were investigated, and although valuable in many cases, they were found to be inappropriate for a large proportion of the rare and threatened species about which we are generally most concerned (Foden *et al*. 2013; Dawson *et al*. 2010). Requirements for detailed distribution data covering relatively large geographic areas, as well as the technical complexities of the application of species distribution models, mean that widespread roll-out of the approach by those carrying out on-the-ground conservation is often impossible. Such approaches also fail to take into account aspects of species' biology and ecology that can significantly elevate or decrease climate change vulnerability Foden *et al*. 2013; Dawson *et al*. 2010). As a result, IUCN has developed a new biological trait-based approach for assessing climate change vulnerability, described in Foden *et al*. 2013 and the Methods section of this report.

The development of this new conservation practitioner-orientated approach provided an excellent tool to tackle an assessment of climate change impacts in the AR. Through an exciting collaboration between IUCN and TRAFFIC, we have been able to assess climate change vulnerability of all AR mammals, birds, reptiles, amphibians and fish, as well as a range of plants, while simultaneously gathering detailed information on their use by humans. This enabled a powerful new combination of results to provide an assessment of the impacts of climate change on the important provisioning ecosystem services these species provide.

In summary, this assessment has three overarching aims, which we hope will be informative and useful both individually and in combination. These are:

1. **To identify the species of importance for human use in the AR, and to gather available information describing this use.**
2. **To assess the relative climate change vulnerability of AR species.**
3. **To use these results to identify the use types, livelihoods, species and areas that are most likely to be negatively impacted by climate change in order to inform climate change adaptation strategies for both biodiversity conservation and human development.**

This study marks a number of firsts. No broad-scale compilation of human use information has previously been compiled for this region. The study provides the first climate change vulnerability assessments for almost all species covered, with the exception of the birds and amphibians. It represents the first use of IUCN's traits-based approach at a regional scale, and has also piloted its use for mammal, reptile and fish species. It is, to our knowledge, the first time that species-scale climate change vulnerability and human use assessments have been combined. The overall methodology, the modified use modules for IUCN's Species Information Service (SIS), and a suite of new species range maps are also all important products that have become available as part of this project. We are extremely grateful to the John D. and Catherine T. MacArthur Foundation for enabling us to carry out this work.

This report provides background information on the AR, including descriptions of the geography, biodiversity and human populations of the region, as well as information on climate change projections for the region and how these might impact upon natural systems. We then describe the methods that were used to collect and analyze our data (Chapter 2). Chapters 3 to 8 present our findings for each taxon individually, and species-level information can be found in the summary tables in Appendix 1. Finally, we summarize our findings and present a series of conclusions and broad recommendations relevant to AR species and their use and/or conservation (Chapter 9).

Background

1.2 Geographic description of the Albertine Rift

Africa's Great Rift Valley is the result of tectonic movements in which three plates (the Nubian, the Somalian and the Arabian) move away from each other. The Great Rift Valley itself can be divided into three main components (Figure 1.1): The Ethiopian Rift, the Eastern Branch and the Western Branch. The bulk of the Western Branch (excluding Lakes Rukwa and Malawi) is usually referred to as the AR. The AR is thought to differ from the Eastern Branch (or 'Gregory Rift) by having less volcanic activity and deeper basins (Wood and Guth 2009).

It is important, at the beginning stages of this document, to define the boundaries of our focal area. Definitions of the AR vary widely between sources, but consistently contain features such as the Virunga, Mitumba and Rwenzori mountain ranges, as well as lakes such as Tanganyika, Kivu, Edward and Albert (from which the region gets its name).

The Macarthur Foundation (2007) defines the geographical extent of the AR as "extending from just north of Lake Albert in northern Uganda down to the southern tip of Lake Tanganyika, including the escarpment and associated protected areas. The area encompasses varying portions of six different countries: eastern Democratic Republic of the Congo (DRC), western Uganda, Rwanda, Burundi and Tanzania, and northern Zambia." At a more detailed spatial scale, we use Conservation International's GIS polygon to delineate the boundaries of our project's focus (see Methods section 2.1.1), and to create the maps presented hereafter.

The remainder of this section describes, for each of the six AR countries, the major protected areas (PAs) (see Figure 1.2) and administrative districts (see Figure 1.3) within the AR Boundary. Details of the region's five major lakes are also provided.

1.2.1 Burundi

Approximately the western third of Burundi is considered to fall within the catchment zone of the AR. Districts falling within this zone include Cibitoke, Kayanza, Bubanza, Muramvya, Bujumbura, Mwaro, Bururi and the western half of the Makamba province. More than half of the country's western edge borders Lake Tanganyika.

Important PAs within this area include the Bururi Forest Nature Reserve (comprising 3,300 ha of high altitude damp forest), Kibira National Park (37,870 ha of evergreen rainforest, montane bog and bamboo) and Rusizi National Park (9,000 ha of forest (50%), artificial landscapes (23%), shrubland (18%) and grassland (7%)) (Saundry and Arce 2009; BirdLife International 2010a). Rusizi National Park is contiguous with Rwanda's Nyungwe forest.

1.2.2 Democratic Republic of the Congo (DRC)

Although small relative to the country's large size, the portion of the AR falling within DRC comprises the majority of territory falling to the west of Lakes Albert, Edward, Kivu and Tanganyika. Districts found within this zone include eastern Orientale, Nord-Kivu, Sud-Kivu and north-eastern Katanga.

Important PAs within this area include the Itombwe Mountains (1,190,000 ha of montane forest (71%), shrubland (18%), savannah (5%) and small amount of other habitat types), Kahuzi-Biéga National Park (600,000 ha of primary montane forest), Maiko National Park (Nord-Kivu and Orientale provinces–1,083,000 ha of evergreen lowland forest). Virunga National Park (780,000 ha of forest

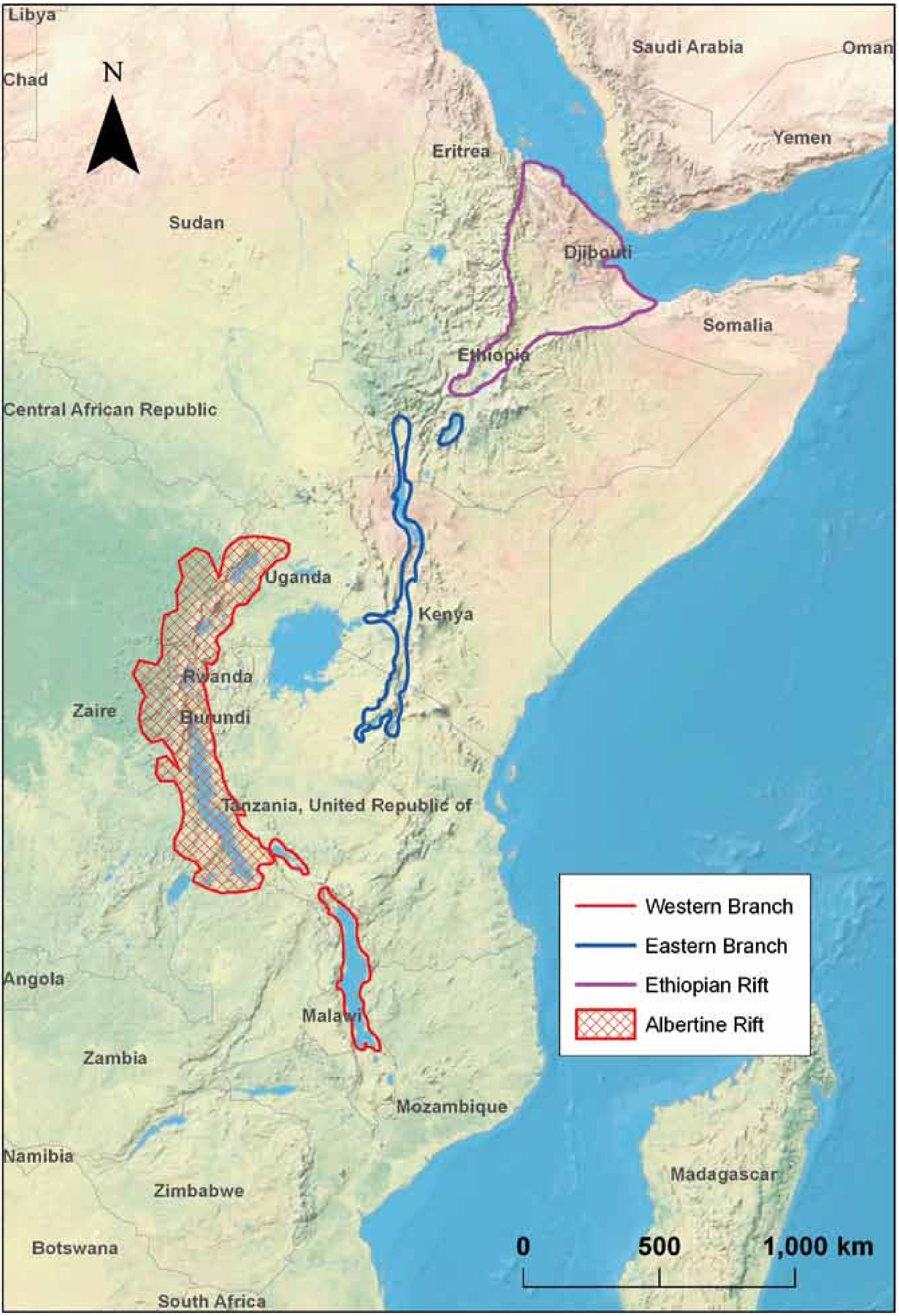


Figure 1.1 The major components comprising the Great Rift Valley. Adapted from Wood and Guth (2009).

(64%), grassland (9%), wetlands (4%) savannah (3%), shrubland (2%) and other artificial landscapes) (Saundry and Arce 2009; BirdLife International 2010a). Other biologically important, yet mostly unprotected, areas in DRC include The Marungu Highlands (770,000 ha of forest (57%), shrubland (31%) and small amounts of savannah, wetland and artificial landscapes), Mount Kabobo (10,000 ha of forest (65%), shrubland (17%) and savannah (15%)) and the forests west of Lake Edward (Nord-Kivu province – 100,000 ha of forest (47%), savannah (4%) and grassland (1%), the remainder comprising artificial and unknown habitats) (Saundry and Arce 2009; BirdLife International 2010a).

1.2.3 Rwanda

Approximately the western third of Rwanda is considered to fall within the catchment zone of the AR. Districts falling within this zone include Ruhengeri, Gisenyi, Kibuye, Gikongoro and Cyangugu. Important PAs within this area include Nyungwe Forest Reserve (97,000 ha with 98% forest cover), Volcanoes National Park (15,000 ha of varied habitats, including shrubland (31%), forest (28%), savannah (4%) and other artificial landscapes) and Mukura Forest Reserve (1,600 ha of forest cover) (Saundry and Arce 2009; BirdLife International 2010a). Another small yet important site is Cyamudongo forest (300 ha of relict forest).

1.2.4 United Republic of Tanzania

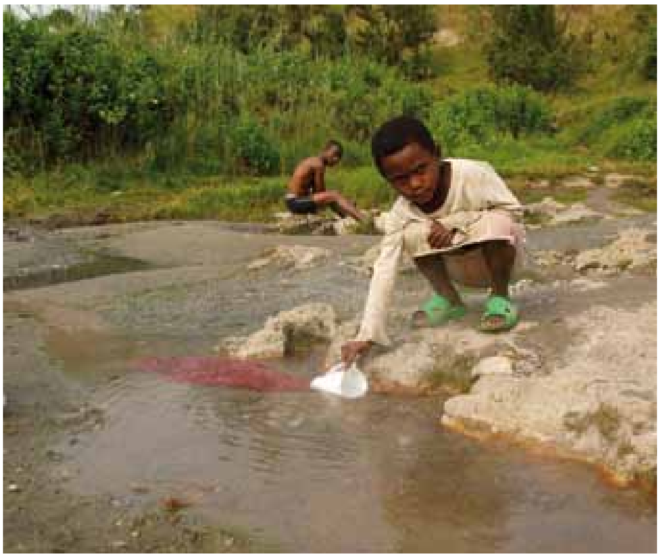
The portion of United Republic of Tanzania (hereafter Tanzania) that falls within the boundary of the AR occurs at the far west of the country and roughly encompasses the area bordering Lake Tanganyika. The two districts falling within this zone include Kigoma to the north and Rukwa to the south. Important PAs within this zone include Mahale National Park (323,000 ha of forest (87%), shrubland (7%) and wetlands (5%)) and Gombe National Park (5,200 ha of semi-deciduous and evergreen forest, grassland and shrubland) (Saundry and Arce 2009; BirdLife International 2010a).

1.2.5 Uganda

The portion of Uganda falling within the catchment zone of the AR occurs at the far west of the country. This area roughly encompasses the area bordering Lakes Edward, George and Albert, and includes the Victoria Nile and the southern section of the Albert Nile. Districts falling within this zone include Nebbi, Gulu, Masindi, Hoima, Kibale, Bundibugyo, Kabarole, Kasese, Bushenyi, Rukingiri, Kisoro and Kabale.

Important PAs within this zone include Budongo Forest Reserve (82,530 ha of forest (74%), savannah (2%) and other artificial and unknown habitats), Bugoma Central Forest Reserve (40,100 ha of forest (82%) and grassland (18%)), Bugungu Wildlife Reserve (74,830 ha, habitats unknown), Bwindi Impenetrable National Park (33,100 ha of 97% forest cover), Echuya Forest Reserve (4,000 ha of forest 61% and other artificial landscapes), Kasyoha-Kitomi Forest Reserve (39,464 ha of forest), Kibale National Park (76,600 ha of forest (83%), savannah (7%) and other artificial and unknown habitats), Kyambura Wildlife Reserve (15,510 ha of forest (68%), wetland (12%), grassland (8%), shrubland (7%) and other artificial habitats), Mgahinga Gorilla National Park (4,750 ha of forest (75%), savannah (4%), grassland (1%) and other artificial and unknown habitats), Murchison Falls National Park (39,000 ha of forest (37%), savannah (16%), wetland (10%), shrubland (4%) and other artificial and unknown habitats), Queen Elizabeth National Park (including Lake George) (223,000 ha of forest (51%), wetland (20%), shrubland (5%), savannah (4%), grassland (2%) and other artificial habitats), Rwenzori Mountains National Park (99,600 ha of forest (78%), savannah (11%), grassland (2%) and other artificial and unknown habitats), Semliki National Park (21,900 ha of forest (89%) and other artificial and unknown habitats) and Toro-Semuliki Wildlife Reserve (115,000 ha of forest (27%), grassland (15%), shrubland (4%), savannah (2%) and other artificial and unknown habitats) (Saundry and Arce 2009; BirdLife International 2010a).

Healthy streams are vital for delivering clean water to rural and impoverished communities such as this one in Rwanda.
© Martijn Munneke



1.2.6 Zambia

Only the most northern points of the districts of Luapula and Kasama (north-eastern Zambia) can be regarded as falling within the AR boundary. Important PAs occurring within this area include Mweru-Wantipa National Park (Luapula and Kasama districts – 313,400 ha of wetlands (47%), forest (46%) and shrubland (4%)) and Nsumbu National Park (including Tondwa Game Reserve to the west) (Kasama district – 256,000 ha of forest and wetlands (figures unavailable) (Saundry and Arce 2009; BirdLife International 2010a).

Table 1.1 Details of the five major lakes found in the AR, including countries of occurrences, size in hectares and altitude in metres (International Lake Environment Committee 2012).

Lake	Countries	Size (ha)	Altitude (m)
Lake Albert	DRC; Uganda	530,000	615
Lake George	Uganda	25,000	914
Lake Edward	DRC; Uganda	235,500	912
Lake Kivu	DRC; Rwanda	22,000	1,460
Lake Tanganyika	Burundi; DRC Tanzania; Zambia	3,200,000	773

1.2.7 The lakes

When describing protected areas and other important features of the AR it is important to give mention to the numerous lakes present, which are extremely important in terms of both biodiversity and the ecosystem services they provide. Table 1.1 provides details of the five major lakes occurring in the AR, all of which are freshwater lakes. Note that Lake Albert is the northernmost and is fed by Lake Edward, to the south (Plumptre *et al.* 2003). Northeast of Lake Edward lies the comparably smaller Lake George. Further south of Lake Edward is Lake Kivu, which runs, via the Rusizi River, into Lake Tanganyika – one of the largest and deepest lakes in the world. A map showing the locations of these lakes is presented in Chapter 5 (Figure 5.3).

1.3 Biodiversity of the Albertine Rift

The AR consists of a number of different habitats, each of which supports unique terrestrial and/or aquatic biological communities. At its highest points (e.g. Rwenzori Mountains, Virunga National Park: altitude ≤ 5,150m (Plumptre *et al*. 2007; BirdLife International 2010b)) one finds permanent glaciers and snow fields or bare rock, as well as active volcanoes and their associated specialist habitats. At the lowest altitudes (≤ 600m), meanwhile, one typically finds savannah grassland, savannah woodland and lowland forest. Between these two altitudinal extremes is a gradient of terrestrial habitats which include alpine moorland (3,400–4,500m), Giant Senecio and Lobelia vegetation (3,100–3,600m), giant heather (3,000–3,500m), raised bogs (3,000–4,000m), bamboo forest (2,500–3,000m) and montane forest (1,500–2,500m) (Plumptre *et al*. 2007). A number of wetland and aquatic habitat types are also present in the AR, including hot springs, sedge wetlands, and stream, river and lake associated habitats ranging from riparian to benthic habitats. Of particular biological relevance are the ‘Great Lakes’, which are some of the largest and deepest lakes in the world and are noted for their high biological diversity and endemism.

The AR is believed to support more endemic mammals, birds, and amphibians than any other region in Africa, and it is estimated that over 50% of birds, 39% of mammals, 19% of amphibians, and 14% of reptiles and plants found in mainland Africa occur in the AR (WCS 2012). The AR has been justifiably acknowledged by several large conservation organizations for its global biological importance. For example, Conservation International (2007) include the AR as part of its ‘Eastern Afromontane Biodiversity Hotspot’, BirdLife International (2003) recognize the area as a highly important ‘Endemic Bird Area’ or ‘EBA’, and the World-Wide Fund for Nature (WWF) include both the AR montane forests and the Rift Valley lakes in their list of priority ‘ecoregions’ for global conservation (Olson and Dinerstein 2002; WWF 2010).

Although numerous surveys of the region’s biodiversity have been, and continue to be, conducted, it is clear from published literature that there remain many further elements to be explored. To date, perhaps the most thorough review of species present in the region is that conducted by the Wildlife Conservation Society (Plumptre *et al.* 2003; 2007), which collates available literature and experts’ knowledge on seven major taxonomic groups. These data provided the starting point from which many parts of our assessments were based (see Methods, section 2.1.1). It is important to be aware, however, that much of this data is still considered preliminary, and that there are many areas that require further investigation. Small mammals, for example, are relatively poorly surveyed and there are likely many more species in the region than are currently recorded. The situation is similar for the

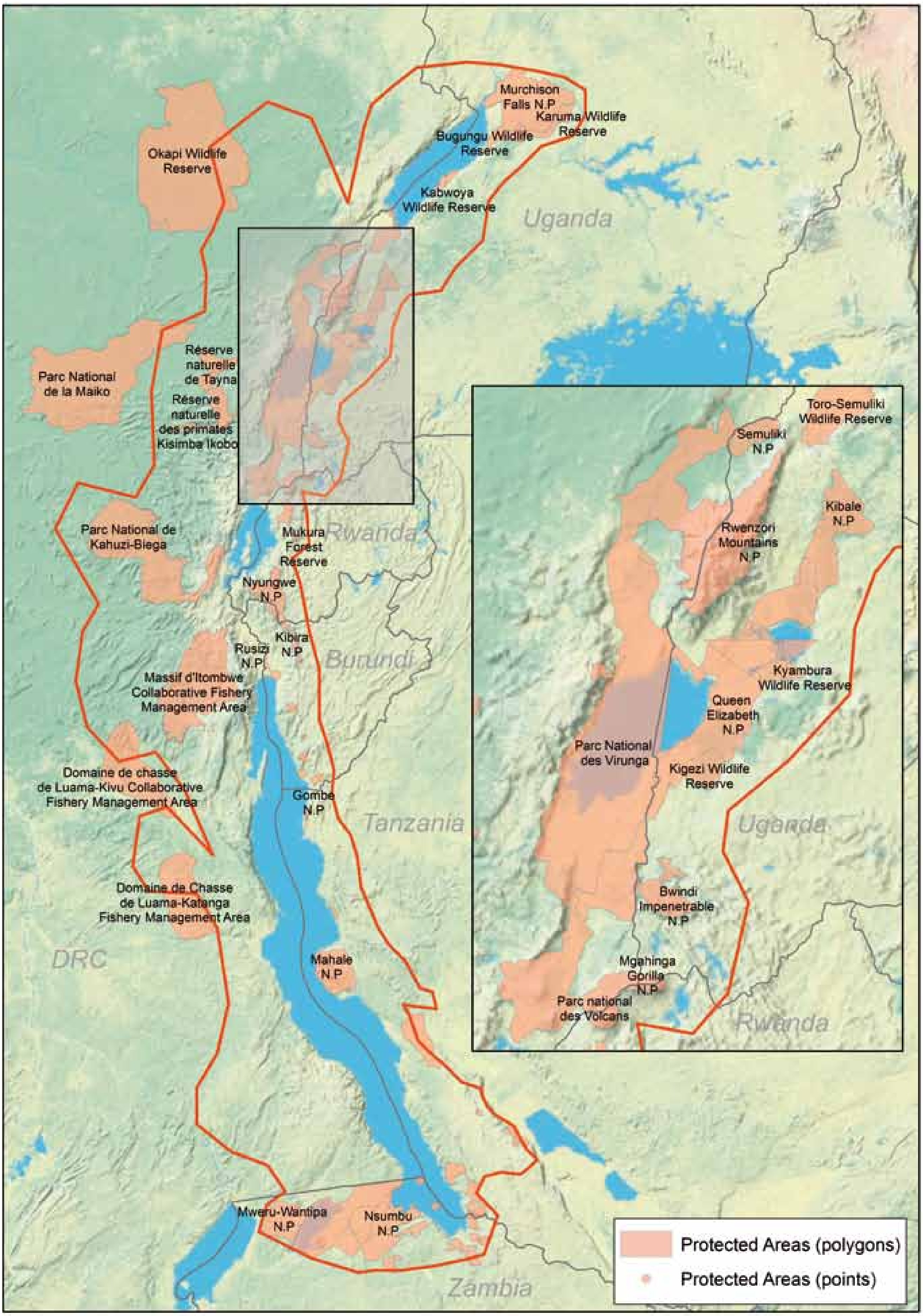


Figure 1.2 Major protected areas within the AR. Data from the WDPA (IUCN and UNEP-WCMC 2012).

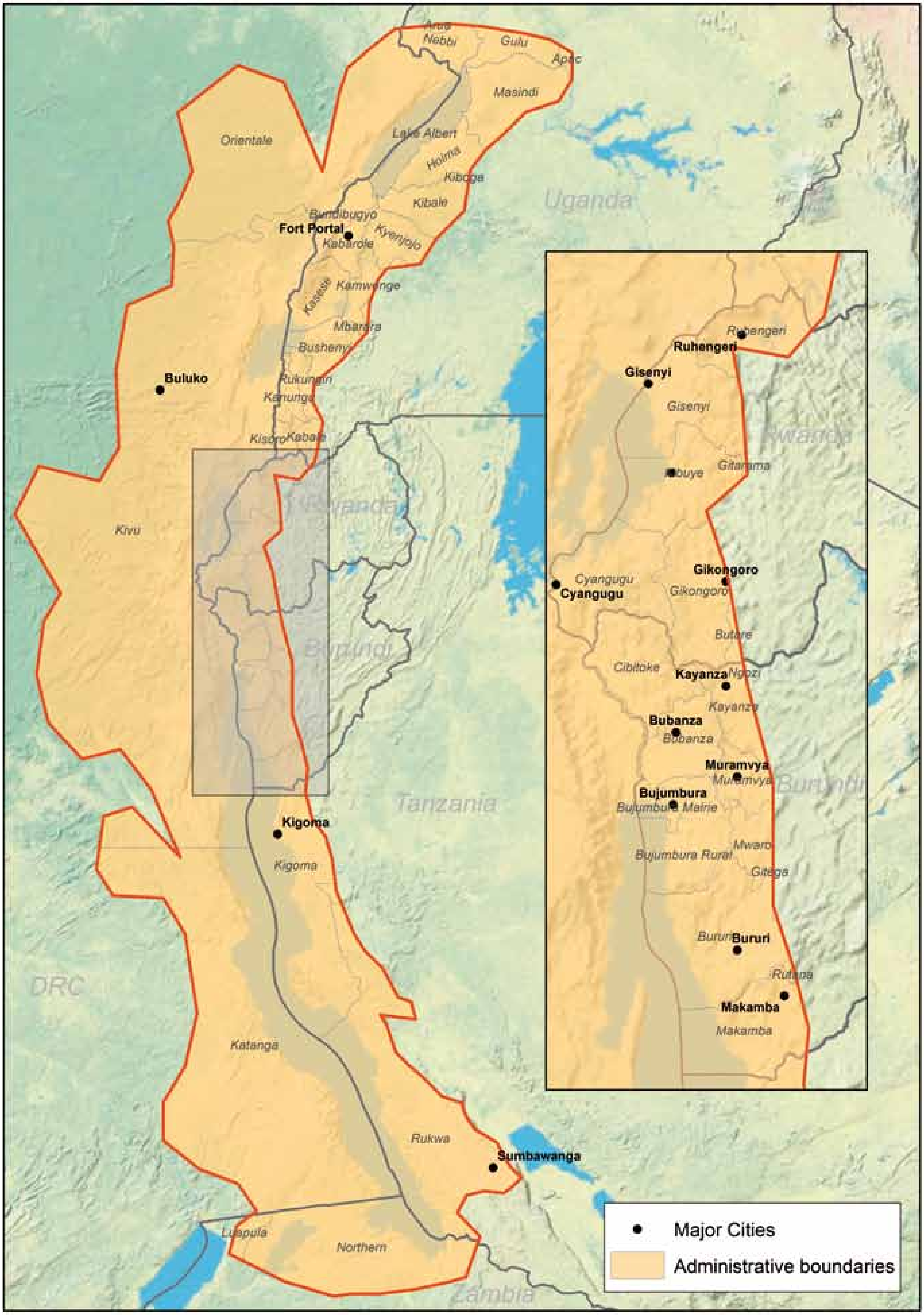


Figure 1.3 Administrative boundaries and major cities within the AR.

other taxa; new bird species are regularly reported in the area, while plant and invertebrate species counts are well recognized as being incomplete.

1.4 Historical climates of the Albertine Rift

A recent study by Seimon and Picton Phillips (2009) discusses the historical climate conditions in the AR as a pretext for providing climate predictions for the region. Seimon and Picton Phillips acknowledge uncertainties in data consistency and quality, a lack of long-term data for most areas and an associated loss of detail following application of interpolation techniques. Here we use this and other works to describe the climates of the AR region.

The climates of the AR region are complexly associated with altitude and other geographic factors, and can show high variability at varying temporal and spatial scales (Seimon and Picton Phillips 2009). Localized geographic factors interact with general and regional atmospheric circulation patterns in a number of ways. Among the most important of these are the Intertropical Convergence Zone (ITCZ) and El-Niño/La-Niña (ENSO) episodes. The ITCZ occurs where winds from the northern and southern hemispheres converge, forming a band of low pressure, leading to cloud formation and storm activity (Obasi 2005; Seimon and Picton Phillips 2009). The precise location of the ITCZ varies throughout the year, moving back and forth across the equator and forming 'wet seasons' as it passes. The alternating ENSO episodes are thought to be the most dominant perturbation responsible for inter-annual climate variability over eastern and southern Africa (Nicholson and Entekhabi 1986; Seimon and Picton Phillips 2009). The warm (El-Niño) periods typically bring above average rainfall around March–May, and below average rainfall in the months of June–September, while the cold (La-Niña) periods result in the opposite (Obasi 2005; Seimon and Picton Phillips 2009). Rainfall patterns associated with ENSO activity are further complicated by the interacting 'Indian Ocean Dipole', a phenomenon similar to ENSO, and whose timing is known to affect the severity of its effects (Seimon and Picton Phillips 2009).

Giant Lobelias (*Lobelia wollastonii*), here photographed in the Rwenzori Mountains (Uganda), characterize one of the more unusual habitats in the Albertine Rift.
© Clément Girardot

The main feature of the AR's annual climatic variation is levels of precipitation, with temperature variation being determined primarily by elevation. Overall, high altitude locations (i.e. > 2,000 m) are estimated as having typical daily mean temperatures of around 15–17°C with minima of 0°C and below; intermediate altitude locations (i.e. 1,500–2,000 m) have typical mean temperatures of 18–21°C; and lower altitude areas have temperatures regularly exceeding means of 21°C. While temperature may show high variability at a local scale, seasonal temperature differences within single locations are slight. The largest exception to this occurs in the southern regions, and particularly around Lake Tanganyika and the Mahale Corridors (Seimon and Picton Phillips 2009), where the (southern hemisphere) winter months are markedly cooler than the summer months, and are more typical of subtropical locations. At this location temperature maxima are usually reached in late September, just prior to the onset of the wet season.

In terms of precipitation, observations of temporal variation are largely in agreement with expectations associated with the movement of the ITCZ, described above. As such, locations nearer to the equator tend to have bimodal rainy seasons of relatively short duration, while as one travels poleward they encounter a gradient between bimodal and unimodal rainfall patterns. At locations situated near to the equator (e.g. the Greater Virunga Landscape), the two rainy seasons are centred around early May and September. North of the equator, around the areas of Murchison Falls and Semliki National Parks (approximately 0.5°–2°N), a bimodal rainfall pattern remains apparent, but the amplitude of shifts between wet and dry periods is far less pronounced. An unexplained reduction in rainfall, lasting for about a week in the centre of the October maximum period, demonstrates strong variability of the precipitation regimes and, perhaps more importantly, the underrepresentation of such phenomena in data given at low resolution temporal scales. At more southern locations, such as that encompassing Nyungwe Forest Reserve and Kibira National Park (approximately 2°S), one experiences a transition between bimodal and unimodal annual rainfall regimes. Here an 8.5 month wet season (early September – mid-May), with peaks at the beginning and end, is typically followed by a 3.5 month dry season with intermittent rains. At locations further south still, such as the Mahale National Park (approx. 6°S), rainfall patterns become even more unimodal in nature, with a distinct rainy period from October to mid-May.

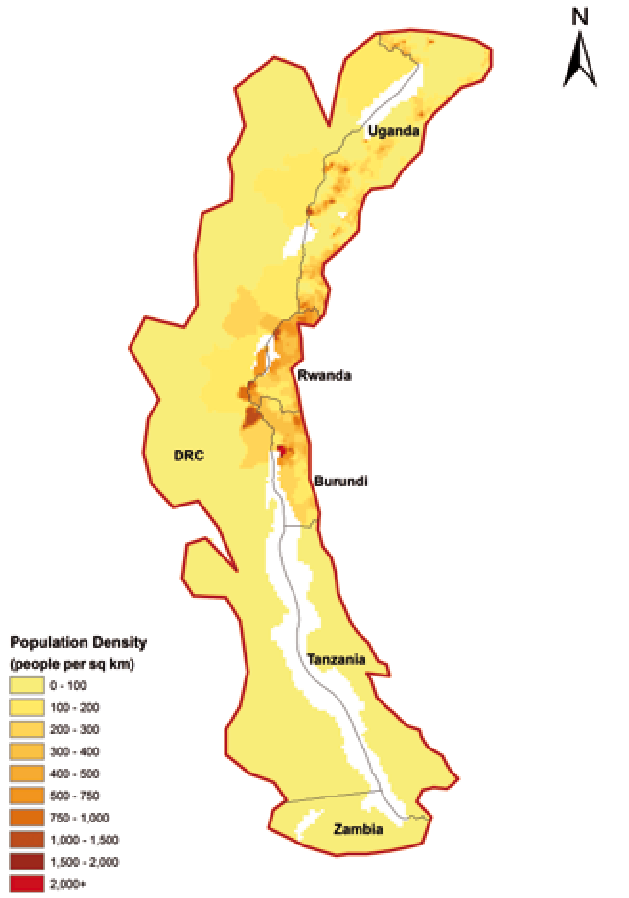
1.5 Human use of wild species in the Albertine Rift

The AR was estimated to be home to between 40 and 50 million people (Plumptre *et al.* 2003), and although a more recent figure is lacking, it can be assumed that this figure has only increased with time. People within the AR have a high diversity of histories, cultures and livelihood strategies, and are among the poorest in Africa (WCS 2012). Meeting the Millennium Development Goal of eliminating extreme poverty and hunger in the region, especially for the rural communities, is extremely challenging. Human population densities in the region can reach 1,000 people per km^2, or even more in places (WCS 2012; Figure 1.4). This number is known to have increased and is expected to continue to do so, escalating the already high pressures on land, water and other natural resources.

1.5.1 Global use of wild species

Globally, the economies, cultures and well-being of many people rely on their consumptive and non-consumptive use of wild living resources (IUCN 2000). The non-monetary contribution of biodiversity is often far greater than the cash contribution and the total income value derived from global forests, for example, was found to be one-fifth cash and four-fifths non-cash (FAO 2011). Some of the key non-cash products derived from wild sources are fuelwood, timber and other building materials, protein (typically wild meat and fish), fruit, vegetables and medicines. Worldwide, fuelwood was estimated to be the main source of household energy for 2.6 billion people (Sampson *et al*. 2005), though a more recent figure is lacking. In sub-Saharan Africa in 2004, 93% of people in rural areas and 58% in urban areas relied on biomass (predominantly fuelwood and charcoal) as their primary fuel for cooking (International Energy Agency 2006). Wild meat is often the primary source of animal protein, and though recent studies are lacking, it has previously been estimated that wild meat provides 30–80% of protein consumed by rural households in Central Africa (Koppert *et al*. 1996). An estimated 10–12% of the world's population rely on fisheries, aquaculture and related industries for at least part of their household income (FAO 2012). A vast array of edible plant products are collected from the wild, including seeds, nuts, leaves, fruits, roots, tubers and fungi. These often supplement agricultural crops as a source of vital nutrition, which is especially important during periods of reduced agricultural output (FAO 1995). Medicines derived from wild species are often the most accessible and affordable health care available to many people. It is estimated that on average 80% of people in African countries rely on biodiversity for their primary health care (WHO 2008), and wild sourced medicines are also used to treat livestock. Other uses of wild species range from pets to clothing fabric to musical instruments.

Figure 1.4 Estimated human population density of AR countries in 2005 (Data from CIESIN *et al.* 2005).



As well as being essential for subsistence, the trade in biodiversity generates cash. It has been estimated that around 40% of the world's economy is based on the direct and indirect use of biodiversity (WEHAB 2002), and it is thought that 20–30% of rural incomes are derived from natural resources, suggesting that use of biodiversity is intrinsically linked with poverty alleviation and development issues (Kamanga 2009; IUCN 2012; PEN 2012). Cash income can be generated in a range of ways, including from direct sale of products (e.g. wild meat or fuelwood), adding value by making the raw resource into a product such as furniture, and through industries serving ecotourism. Money generated can contribute significantly to household incomes, and provide a means to buy food and household goods, pay school fees and improve agricultural production systems (FAO 1998). Though the rural poor are likely to be more reliant on biodiversity, both for subsistence and as a means to generate an income, urban residents and people from all wealth brackets also use and derive benefits from wild resources.

Though exact figures illustrating the reliance of people within the AR upon natural resources are generally lacking, activities such as hunting (typically of large mammals, although other species too) and collection of wild animals and plants for food, medicine, fuel, building materials and even trade, are commonplace in the AR. Direct impacts of the region's human population on biodiversity include over-utilization of a variety of wild species for consumption and trade. Declines in the populations of many species and, as a result, the wider ecosystems in which they occur are apparent (Plumptre *et al.* 2004). In some areas the situation for both people and biodiversity has been made far worse by human conflicts (Hammil and Brown 2006). The resulting migration of hundreds of thousands of people has led to intensive pressure in certain areas due to the massive demand for basic necessities such as food, fuel and shelter (Plumptre *et al.* 2004). The high availability of guns in the region has also led to increased poaching of species such as African Elephant and Hippopotamus (Brown 2003).

1.6 Climate change and the Albertine Rift

It has been well documented that anthropogenic climate change is likely to have, and in some cases is already having, significant impacts upon the species that constitute the world's ecological communities and systems (Thomas *et al.* 2004; Fischlin *et al.* 2007; Foden *et al.* 2008). A review of literature on the effects of climate change on biological systems (Fischlin *et al.* 2007) concludes that, with an increased global temperature of 2–3°C (relative to pre-industrial temperatures), 20–30% of the species assessed are likely to be at increasingly high risk of extinction. However, uncertainties associated with this figure are high, and estimates range from 10% (with a 2°C rise) to 40% (with a 3°C rise). Existing and future anthropogenic pressures on ecosystems are likely to act synergistically with climate change (Fischlin *et al.* 2007) and will necessitate changes in the way much land is used, which could, in turn, impact greatly upon many species and ecosystems.

1.6.1 Mechanisms of climate change impacts on species

The ways that species may be affected by a changing climate are numerous, complex and often species specific, and potential impacts may be positive, negative or benign. Positive impacts are most likely to be felt by generalist species (e.g. see Rogers and McCarty (2000) and Thuiller *et al.* (2005)) which may, for example, experience reduced competition as competitor populations decline or be able to expand their ranges into newly climatically suitable areas. Pathogens and parasites are likely to benefit as physiological stress in hosts leads to decreased immune responses (Fischlin *et al.* 2007; AWF *et al.* 2011).

This study seeks to identify climate change vulnerable species, so focuses on the negative impacts, examples of which are shown in Figure 1.5. While these direct impacts are explored in detail in later chapters, it is also important to acknowledge indirect climate change impacts such as those caused by human responses to climate change. For example, the production of biofuels, which reduce consumption of fossil fuels, has already been shown to have changed land-use patterns in many regions including some of the most biodiversity-rich and sensitive ecosystems (Keeney and Nanninga 2008). The Mountain Gorilla (*Gorilla beringei*) which, although not considered in other studies to be highly vulnerable to direct climate change, is likely to be impacted by land use change and loss of natural habitats in its current distribution range (Masinde and Belfiore 2009; AWF *et al*. 2011).

1.6.2 Climate change predictions for the Albertine Rift

At present, the best available source of climate change projections is the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (hereafter AR4) (IPCC 2007), although this will be

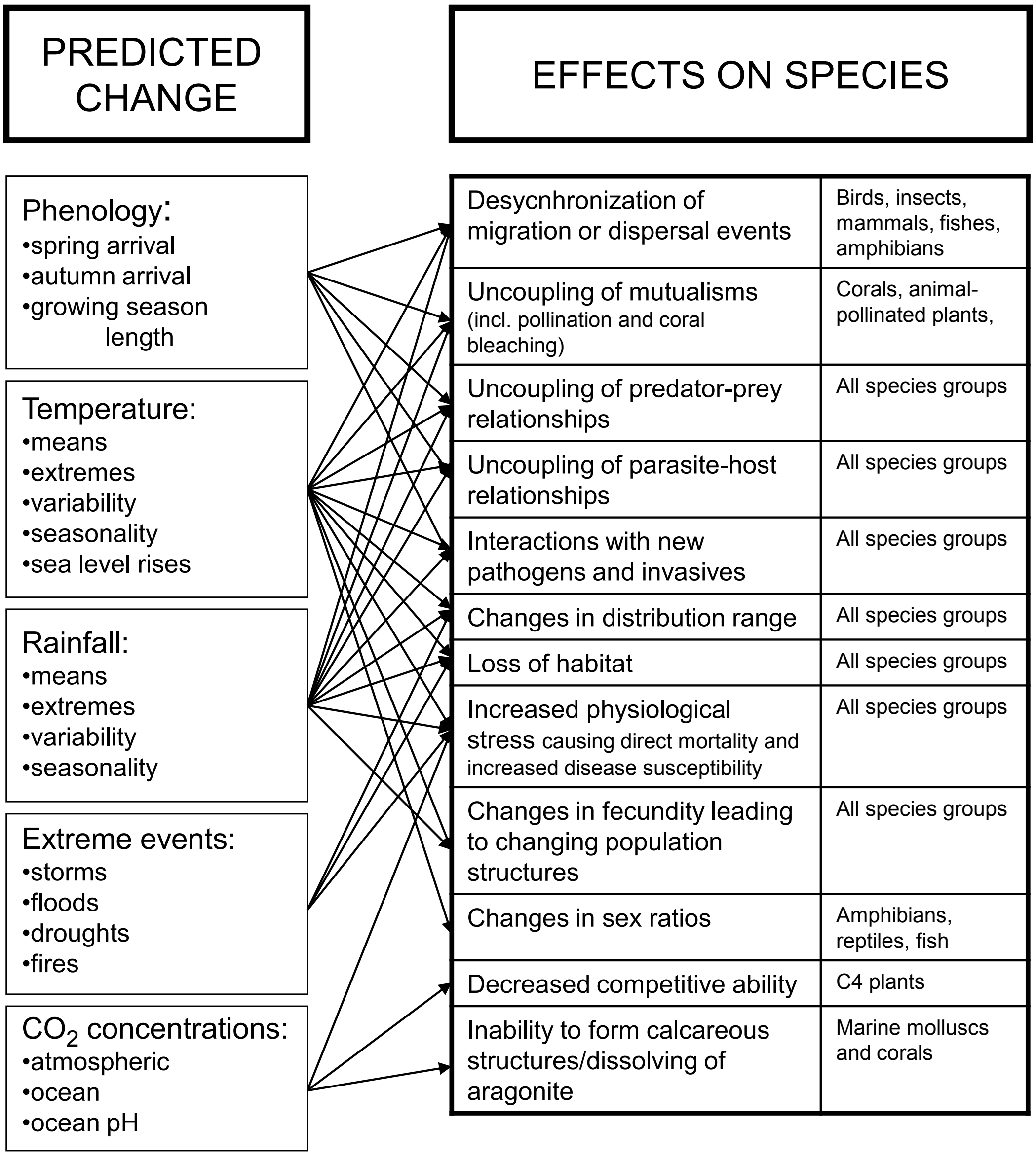


Figure 1.5 A summary of some of the predicted aspects of climate change and examples of effects on species (from: Foden *et al.* 2008).

superseded by the publication of the Fifth Assessment Report, due in 2014. The methods used therein involve the use of a multi-model dataset (MMD) that provides a range of possible future climatic values (temperature and precipitation) based on 21 different general circulation models (GCMs). From these models, the median and extreme values are typically provided, giving an indication of the changes in climate that may be expected within a specified timeframe.

Similarly, the models used may be run under the assumption of various future emissions scenarios, in which aspects such as greenhouse gas emissions and land use change, among others, may vary. Although numerous hypothetical scenarios or storylines exist (see IPCC SRES 2000 for a full description), three of the most commonly used, including for this study are the A1B scenario (often regarded as the most moderate), the A2 scenario (considered a more extreme scenario), and the B1 scenario (among those predicting the least extreme changes).

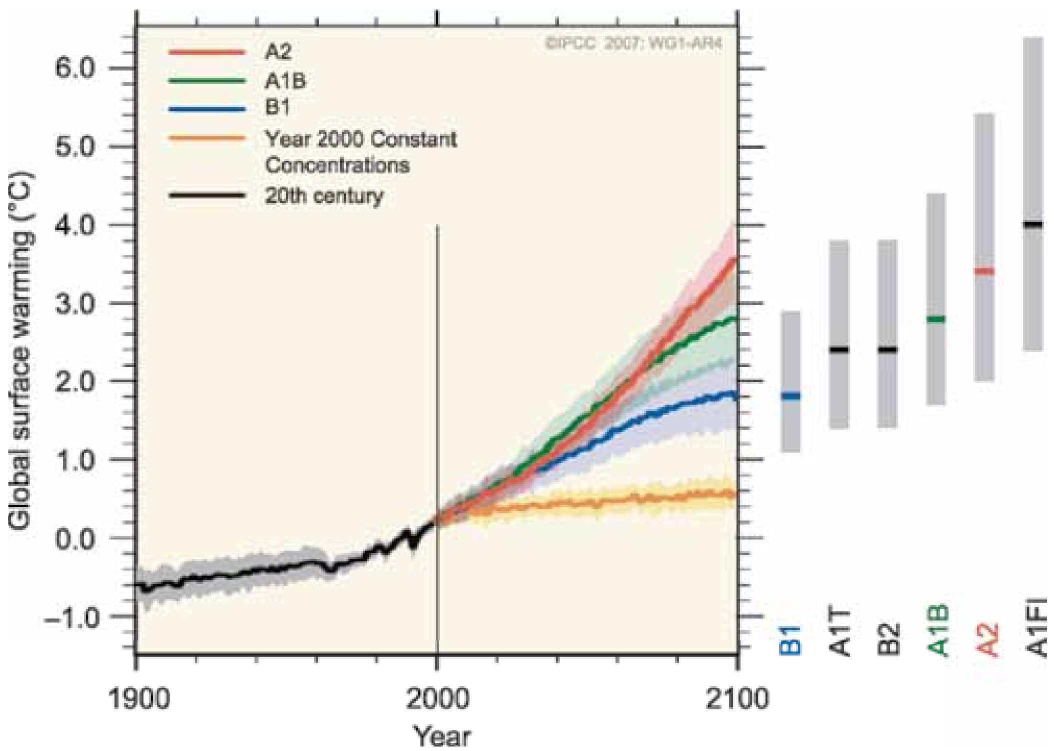
The climate change projections developed by the IPCC give estimates of global temperature rises of 1.8, 2.8 and 3.4°C by 2100 under the B1, A1B and A2 scenarios, respectively (Figure 1.6). The predicted changes are not spatially uniform; Figures 1.7 and 1.8 demonstrate the global variation in predicted temperature and precipitation changes respectively. Although the extent of changes in temperature varies between locations, a generally consistent warming trend is expected in most regions. In contrast, changes in precipitation vary not only in the extent, but also in the direction of change, with some locations expected to become wetter and others to become drier. Other climatic change related phenomena include rising sea levels, contracting snow and ice cover, increased frequency of hot extremes/heat waves, heavy precipitation events, and increased intensity of tropical cyclones (IPCC 2007).

The IPCC's Fourth Assessment Report provides regional assessments for Africa, with specific sections covering the north, east, south and west. Climate projections for East Africa (encompassing the AR) for the period 2080–2099 (derived using the A1B scenario) are shown in Table 1.2, which shows deviations from the mean, calculated for the period 1980–1999. At this scale, the projected temperature changes for East Africa are similar to those for southern and West Africa, but lower than for Saharan Africa.

Table 1.2 describes a general warming trend under all scenarios for East Africa as a whole. Furthermore, the same models project that, during the period of 2080–2099, all seasons will experience extremes of warmth (defined as warmer than the warmest summer of the control period of 1980 to 1999). Using similar calculations, models suggest that for the periods of December–January–February (DJF), March–April–May (MAM), September–October–November (SON) and annually, 25%, 15%, 21% and 30% of years respectively, will experience extremes of wetness, while 1%, 4%, 3% and 1% will experience extremes of dryness. While most of Africa will likely experience decreased levels of annual rainfall, East Africa is expected to experience an overall increase. It should be noted, however, that such rainfall predictions contain high levels of uncertainty (Solomon *et al.* 2007; Scholes *et al.* 2008).

In considering projected climate change at an even finer spatial scale for the AR, levels of uncertainty are even greater still, largely for two reasons: Firstly, the region's highly complex climate systems (described in Section 1.4), which can show high variability at varying temporal and spatial scales (Seimon and Picton Phillips 2009), often result in high variation (i.e. uncertainty) between modelled output values. Secondly, for the AR there is a general lack of long-term, robust climate data for the region coupled with an apparent bias in data availability towards specific regions within each country. Such knowledge gaps are especially problematic in regions of complex topography, where both climatic and ecological gradients are typically large (Haiden and Pistonik 2009; Seimon and Picton Phillips 2009).

Figure 1.6 IPCC projections of average global surface warming relative to 1980–1999 for the moderate (A1B), more extreme (A2) and less severe scenarios of greenhouse gas emissions (B1). A scenario at which greenhouse gasses are maintained at 2000 levels is also shown. Shading reflects the ±1 standard deviation range of individual model annual averages. (from: IPCC 2007).



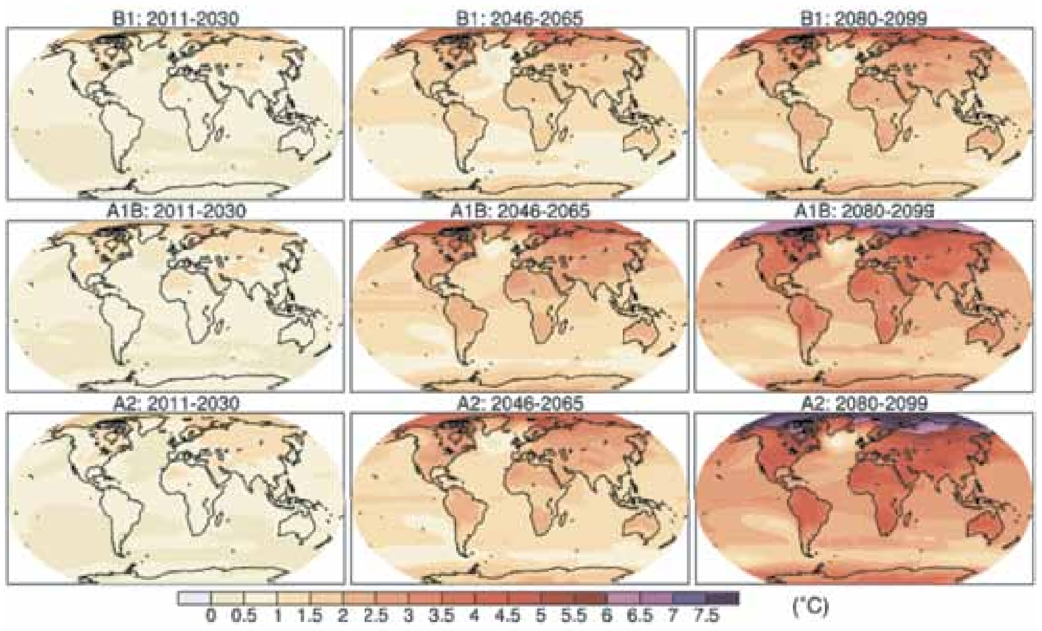


Figure 1.7 Predicted annual mean surface warming (surface air temperature change, °C) for low (B1; top), moderate (A1B; middle) and more extreme (A2; bottom) greenhouse gas emissions scenarios for 2011 to 2030 (left), 2046 to 2065 (middle) and 2080 to 2099 (right). Anomalies are relative to the average of the period 1980 to 1999 (from: Meehl *et al.* 2007).

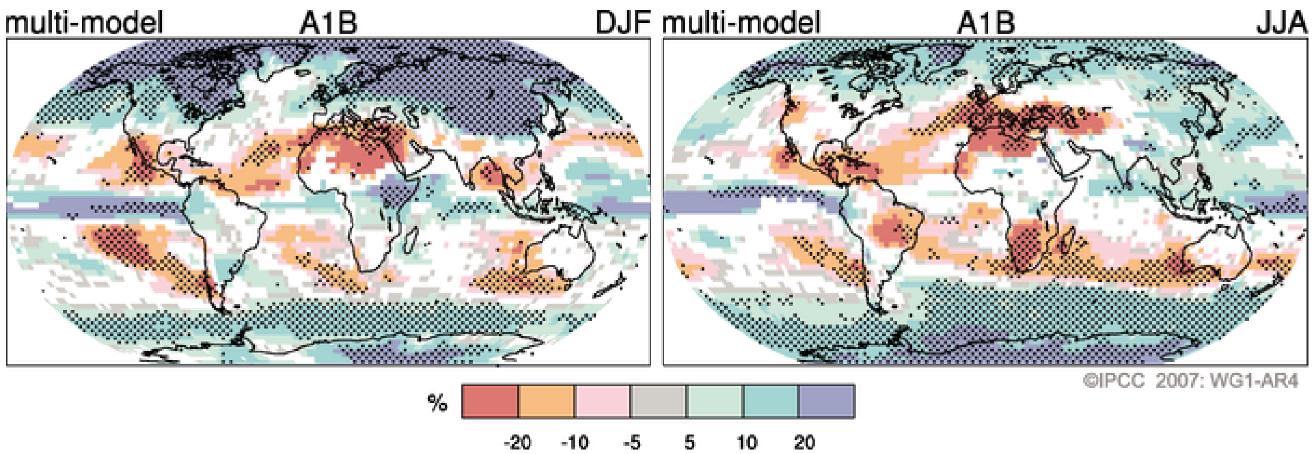


Figure 1.8 Predicted changes in precipitation for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December-January-February (DJF; left) and June-July-August (JJA; right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change (from: Solomon *et al.* 2007).

Table 1.2 Minimum, median and maximum projected changes (from the 1980–1999 average) in temperature and precipitation in East Africa for the period 2080–2099 under the moderate A1B scenario. Asterisks reflect values for which there is low agreement between models, and for which the middle 50% (i.e. 25–75%) of calculated values disagree in sign (i.e. increase or decrease) (from: Christensen *et al.* 2007).

	Temperature (°C)			Precipitation (% change)		
Season	**Minimum**	**Median**	**Maximum**	**Minimum**	**Median**	**Maximum**
DJF	2	3.1	4.2	-3	13	33
MAM	1.7	3.2	4.5	-9	6	20
JJA	1.6	3.4	4.7	-18*	4*	16*
SON	1.9	3.1	4.3	-10	7	38
Annual	1.8	3.2	4.3	-3	7	25

To date, only one assessment of predicted climate change effects specific to the AR has been conducted (Picton Phillips and Seimon 2009). This assessment compares projections under the extreme A2 scenario for the years 2030, 2060 and 2090, to 1990 baseline data for the entire AR and for seven sub-regions of high conservation importance. In contrast to other climatic assessments of the region, which typically quantify only temperature and precipitation, Picton Phillips and Seimon quantify additional (often indirect) variables including runoff, evapotranspiration and fractional cover of plant functional type, among others. Table 1.3 shows projections (for the whole region) of maximum, mean and minimum values for three variables: temperature, precipitation and runoff, for three future periods. Picton Phillips and Seimon note several limitations to their analysis, including inconsistencies in model outputs and other uncertainties that are often inherent to even lower resolution climate modelling. Furthermore, the paper's authors stress that their results should not be taken as an explicit forecast for the region. Nonetheless, as this is the most detailed assessment to date, we feel that it is constructive to make reference to these results, and, in the following paragraphs, present information extracted from this work. We also include additional relevant information from National Adaptation Programmes of Action (or NAPAs – prepared by least developed countries to describe their most urgent climate change adaptation needs) and UNDP Country Profiles (climate data summaries produced by the United Nations Development Programme, intended to address the climate change information gap for developing countries).

1.6.2.1 Projected changes in temperature

Picton Phillips and Seimon (2009) project a mean annual temperature increase of 3.6°C for the AR as a whole by 2090. From the sub-regional assessments conducted as part of this investigation, models suggest a small amount of spatial variability in thermal seasonality at regions further from the equator. This pattern is more pronounced to the south. Overall, however, all regions are projected to experience noticeably warmer conditions in future years. Such projections are reflected in the NAPAs and UNDP Country Profiles: climate predictions specific to Burundi (Republic of Burundi 2007) (based on high global GHG emissions) suggest a rise of 0.4°C every 10 years, resulting in a total increase of 1.9°C by the 2050s. In the DRC NAPA (République Démocratique du Congo 2006), modelling efforts were not focused on the region encompassing the AR. However, the geographically nearest two sites investigated (Lubumbashi -27.5°E, 7.5°–12.5°S and Bandundu -22.5°E and 2.5°–7.5°S), recorded/projected mean annual temperatures for the years 1990, 2050 and 2100 as 20.4°C, 23.7°C, 24.7°C and 24.9°C, 24.7°C, 28.4°C, respectively. These figures translate as suggested increases of 4.3°C and 3.5°C by 2100 for Lubumbashi and Bandundu respectively. In Tanzania, the currently observed temperature increase of 0.23°C per decade, is projected to result in overall increases of 1.0 to 2.7°C by the 2060s, and 1.5 to 4.5°C by the 2090s (McSweeney *et al.* 2008a). In Uganda, the currently observed temperature increase of 0.28°C per decade is projected to result in an overall increase of 1.0 to 3.1°C by the 2060s, and 1.4 to 4.9°C by the 2090s (McSweeney *et al.* 2008b).

1.6.2.2 Projected changes in precipitation

Picton Phillips and Seimon's (2009) projections of future precipitation regimes suggest that, on average across the AR, precipitation will increase, specifically by 3%, 7% and 17% increases for the years 2030, 2060 and 2090 respectively, compared with baseline data. However, such increases are

Table 1.3 Predictions of changes in three climatic variables across the AR under the A2 (extreme) emissions scenario for the years 2030, 2060 and 2090, compared with baseline data for the year 1990. (From: Picton Phillips and Seimon 2009).

		1990	2030	2060	2090
Mean Annual Temperature (°C)	Max	26	27	28.1	29.7
	Mean	22.7	23.6	24.7	26.3
	Min	15	16	17.1	18.7
Mean Annual Precipitation (mm)	Max	1,887	1,900	1,968	2,098
	Mean	1,199	1,233	1,287	1,406
	Min	821	875	938	1,057
Annual Runoff (mm)	Max	723	760	871	986
	Mean	264	286	327	433
	Min	43	28	50	127

expected to be highly varied between regions. The levels of increased precipitation suggested by models are not expected to be sufficient to counteract the effects of warming noted above. Therefore, an overall drying effect is likely to occur, which is likely to be more pronounced in the period of February–May. In contrast, the November–December wet season period is likely to experience the largest increases in precipitation. Such patterns have already been observed at Mahale on Lake Tanganyika, although it is currently unclear whether this is simply the result of normal climatic variability (Picton Phillips and Seimon 2009).

Thousands of streams such as this one in the Rwenzoris (Uganda) flow through the Albertine Rift. Streams are sensitive to changes in hydrological, precipitation and snowmelt regimes, which can also affect downstream habitats.
© Clément Girardot

As with temperature, Picton Phillips and Seimon's (2009) precipitation projections are similar to those of the NAPAs and UNDP Country Profiles. For Burundi, climate projections based on high global greenhouse gas emissions suggest an increase in rainfall in the range of 3 to 10%. The cyclic nature of rainfall in the country is predicted to continue more or less unchanged (Republic of Burundi 2007). In DRC, at a countrywide scale, models suggest an increase in total precipitation in the Congo Basin, with the opposite occurring everywhere else (République Démocratique du Congo 2006). Monthly predictions suggest a shortening of the rainy season, increasing in severity as one travels south. The total annual recorded and predicted rainfall (mm) for the years 1990, 2050 and 2100 in Lubumbashi and Bandundu (see above), are 1,262, 1,232, 1,147, and 1,440, 1,531 and 1,622 mm respectively, suggesting a total change of -115 mm and + 182 mm by 2100 for the two zones respectively. Tanzania's rainfall is largely projected to increase in future years (McSweeney *et al.* 2008a). Ensemble models suggest rainfall changes ranging from -4 to 30% by the 2090s, and ensemble median changes of 7 to 14%.

From a seasonal perspective, projected rainfall increases appear to correspond with the wet seasons of their respective areas. In Tanzania, for example, rainfall increases in January and February will affect most of the country but particularly the far south, while the opposite is expected for the March–May and September–November increases, which will affect northern regions to a greater extent. From June–September rainfall levels are projected to increase in the north while decreasing in central and southern regions. Uganda's mean annual rainfall is largely projected to increase in future years (McSweeney *et al.* 2008b). Ensemble models suggest rainfall changes ranging from -8% to +46% by the 2090s, with ensemble median changes of +7 to +11%. From a seasonal perspective projected rainfall increases are expected to be largest during the October–December wet season. These models further project that higher proportions (up to 15% increase by 2090) of rain will fall in 'heavy events' occurring throughout the year, and 1- and 5-day maxima increasing (particularly in the rainy seasons) by up to 27 and 37 mm, respectively.

1.6.2.3 Other projected changes

Picton Phillips and Seimon (2009) investigate projected changes to a number of other factors as a result of climate change. Net cloud cover throughout the AR is projected to remain largely unchanged although spatial changes are likely to become more apparent over time. By 2060 cloud cover in the north could be reduced by 3–5% in April and May, resulting in earlier onset of the dry season. This trend is predicted to continue and could be experienced by the whole of the AR by 2090. By 2090 the southeast is projected to experience cloud cover increases greater than 5% in the months of November and December, resulting in increased rainfall. Rising temperatures are also likely to result in rises to the mean altitude of orographic clouds. Under the A2 (extreme) scenario, projections suggest a lift in cloud cover of several hundred metres.

The levels of runoff in the AR are generally projected to significantly increase (see Table 1.3), although the extent of such increases varies greatly between locations, with areas in the north potentially experiencing decreases in the short term. These short term reductions in northern regions are likely to

The Rwenzori Mountains in Uganda are almost always covered with mist and clouds, especially during the spring and autumn rainy seasons. Mountain ecosystems are warming at rates above the average of those of other ecosystems (Beniston *et al.* 1997).
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result in reduced river flows and lake levels. By 2090, however, all regions of the AR are expected to experience increased levels of runoff, with a projected mean increase of 64% compared with 1990 levels. Increases to runoff, coupled with increases to evaporation rates, are likely to result in large scale fluctuations to the levels of most water bodies, both seasonally and inter-annually. Such increases may be slightly less noticeable along Lake Tanganyika. Further variables investigated by Picton Phillips and Seimon (2009) include effects to net primary productivity, relative cover of plant functional type and fire regimes, all of which are given further mention in section 1.6.4.

1.6.3 Observed recent climatic changes in Albertine Rift countries

Also included in NAPAs and UNDP country profiles are a number of observations and records of recent climatic changes, which are typically presented at a country level and are acknowledged as varying in source and reliability. The intrinsic variability of the region's climate has already been mentioned and it is important to note that although these changes are highly likely to be occurring in response to anthropogenic climate change, the levels and time frames of monitoring are relatively short compared with cycles of natural fluctuations, and ongoing monitoring is essential to confirm emerging trends.

Consistent throughout all NAPAs and UNDP country profiles are observations of increased temperatures. For Burundi, an increase in the mean annual temperature of about 0.7–0.9°C since the 1930s has been recorded, while for Tanzania temperature increases are thought to be occurring at an average rate of 0.23°C per decade. Also in Tanzania, increases in the extremes of maximum and minimum temperature have been noted in recent years. In Uganda, the mean annual temperature is believed to have increased by 1.3°C since 1960 (McSweeney *et al.* 2008b), with most rapid changes of 0.37°C per decade in the months of January and February. The fastest changing regions of Uganda are found in the southwest (including part of our focal area), which are warming at around 0.3°C per decade compared with an increase of 0.28°C per decade for the entire country. In DRC and Rwanda, anecdotal evidence (see NAPAs of République Démocratique du Congo (2006) and Republic of Rwanda (2006), and Twagiramungu (2006)) has indicated temperature increases in recent times, particularly in the dry seasons. In DRC, 94% of subjects in a survey of 2,800 people believed this to be the case (République Démocratique du Congo 2006).

In terms of precipitation and hydrology, the NAPAs and UNDP country profiles have described several recent trends. In all cases, increasingly long dry spells followed by periods of increased rainfall intensity have been observed. On balance, the overall annual levels of precipitation received by these countries is commonly noted as declining, often resulting in an increased frequency of drought and, in some cases, the loss and degradation of water resources, including an important fall in the level of Lake Tanganyika (Republic of Burundi 2007). The observed periods of extremely intense rainfall events have had several important effects, which include increased occurrences of flooding, soil erosion/degradation and landslides.

1.6.4 Impacts of climatic changes on the Albertine Rift's biological systems

This section provides information about the way many of the major habitat types found in the AR may be, and in some cases are already being, affected by climate change. Most of the examples presented here originate from literature assessing habitats similar to, yet not specifically from, the AR. Care should be taken, therefore, when using these examples to make inferences to the study region, as subtle differences in species composition, geographic location, topography and other abiotic factors may greatly affect an ecosystem's response to a changing climate. Where available, information on observed and anticipated effects to ecosystems and species specific to the AR is provided.

1.6.4.1 Mountain ecosystems

Worldwide, mountain ecosystems support some of the highest levels of endemism on record, and provide services that extend far beyond their geographical boundaries. This phenomenon holds true in the AR region, where alpine endemism is high and ecosystem services (particularly water provision) are provided to a wealth of ecosystems and communities. Mountain ecosystems have been observed to be warming at a rate above the average of other ecosystems (Beniston *et al.* 1997).

Potentially the greatest impacts of rising temperatures in AR montane areas are changes to the hydrological regime through shortening and earlier onset of the snow-melt period. This results in rapid release of water and subsequent downstream floods. At a later stage, ecosystems at a range of altitudes may experience water shortages following the premature depletion of reserves (Fischlin *et al.* 2007).

Climate change impacts on mountain ecosystems may result in a reshuffling of the species and communities that currently exist along an altitudinal gradient, with a general trend of the upward migration of species and communities to track warmer temperatures and other changing climatic and habitat conditions (e.g. cloud cover). Picton Phillips and Seimon (2009) estimate that a 3.6° rise in air temperature (as suggested by models for the AR) would require an upward shift of many species by around 600–720 metres. Such changes in altitude are typically coupled with a decrease in available habitat due to the ‘tapering’ nature of most montane landscape features. The overall limits to the upward migration of any species are defined by the maximum height of the mountain (or other landscape feature) upon which the migration is taking place. Non-motile species and other poor dispersers may be unable to relocate to new sites, including alternative mountains with greater upward-migratory potential, if they are unable to withstand conditions at intermediate (i.e. lower) locations. Examples from the reviewed literature of species observed to be undergoing such shifts include the Three-horned Chameleon (*Chamaeleo jacksonii*), Giant Senecio trees (*Dendrosenecio* sp.) and mosquitoes (Family: Culicidae) (Republic of Uganda 2007; Kulkarni 2009), with similar effects predicted for the Regal Sunbird (*Nectarinia regia*), and other bird species (see BirdLife International 2010b). Similar distributional shifts have been reported for other species, although reliable data to substantiate such reports are not available (Kulkarni 2009).

1.6.4.2 Forests and woodlands

Species-based modelling approaches (e.g. McClean *et al.* 2005) have suggested with medium confidence that climate change will result in decreased biodiversity within African forests. Forest types whose constituent species’ ranges are currently limited by minimum climatic conditions are likely to expand the leading edges of their ranges as the climate changes (Fischlin *et al.* 2007). For example, high altitude montane forest species of the AR may ultimately be replaced by lower montane or non-montane species, which may, in turn, begin to encroach (where space is available) upon even higher non-forest habitat types (UNEP-WCMC 2010). At lower altitudes increasing temperatures and changes to precipitation and hydrological regimes are likely to impact forest ecosystems. Picton Phillips and Seimon (2009) note that in areas such as those surrounding southern Lake Tanganyika, rising temperatures combined with increased precipitation may result in a major shift from ‘tropical broadleaf evergreen’ to ‘raingreen’ forest, resulting in a 30% loss of the former by 2090. Overall it is thought that a significant moistening of the climate in the southern AR may result in the diminishing of the current north-to-south/maximum-to-minimum coverage gradient, with ‘tropical broadleaved evergreen’ species being favoured at the expense of ‘broadleaved raingreen’ species (Picton Phillips and Seimon 2009).

Climate change driven changes in the AR’s precipitation and hydrological regimes are likely to affect the health of semi-deciduous closed-canopy forest systems (Picton Phillips and Seimon 2009), which have been demonstrated to be more sensitive to precipitation decreases than grasslands or savannahs (Hély *et al.* 2006). Such sensitivity is among the factors that are likely to be responsible for the observed encroachment of lowland ecosystems on mountain forests in other regions described by Fischlin *et al.* (2007). The importance of changes to the precipitation and hydrological regimes in determining forest ecosystem health cannot be overstated as, while drought conditions lead to forest degradation, increases to water availability coupled with warming temperatures may, in some cases, result in increased forest productivity. Picton Phillips and Seimon (2009) state that in the southern

Lake Tanganyika region, the riverine forest surrounding current drainage channels (a key habitat for chimpanzees) could be severely negatively affected should predictions that runoff will intensify to around 44% above 1990 levels by 2090 prove correct.

Further potential impacts of climate change on forest and woodland ecosystems involve alterations to communities of predators and pathogens, particularly phytophagous insects and fungal pathogens, which can show tendencies of increased abundance and vigour as a response to increased temperatures (Foden *et al.* 2008). Increases in the frequency and severity of fires, resulting as temperatures, fuel loads and periods of drought increase, are also known to affect forest ecosystems (Flannigan *et al.* 2000; Gitay *et al.* 2001; Fischlin *et al.* 2007). Species undergoing drought and other climate related stresses are often more vulnerable to other biological stressors. At present, however, the specific effects of climate change on predators, pathogens and fire regimes in East Africa are largely unexplored.

1.6.4.3 Grasslands and savannahs

Anticipating climate change impacts on grasslands and savannahs is challenging due to the complex interactions between plant functional types, fire and herbivores. While an increase in atmospheric CO_2 favours typically woody C_3 plants due to CO_2 fertilization, such effects may be counteracted by the benefits of increased temperature to C_4 grasses (Fischlin *et al.* 2007) and are further complicated by interactions with water availability, water use efficiency, fire and herbivores. However, as very few experiments have been conducted to investigate such specific factors and habitats, making informed predictions of habitat level effects is difficult. Picton Phillips and Seimon (2009) include an area of C_4 grassland from the Mahale Corridors (Tanzania) in their assessment of climate change impacts in the AR and suggest that, in terms of losses or gains to specific plant functional types, this area will remain largely unchanged.

1.6.4.4 Freshwater wetlands, lakes and rivers

Major climate change driven changes to freshwater ecosystems are likely to occur both directly, as a result of precipitation changes, rising temperatures and CO_2 concentrations, and indirectly, due to changes to upstream hydrological and precipitation regimes (Fischlin *et al.* 2007). Increased freshwater inputs following heavy rains and rapid snow melt can result in increased sedimentation and nutrient loading to all of the aquatic ecosystems described herein. Picton Phillips and Seimon (2009) note that near-term reductions in runoff, particularly in the north of the AR, may have important impacts on rivers and lakes such as Edward, George and Albert. By 2090, the contrasting increases in runoff (64%) will affect hydrology, erosion and siltation rates. The combination of increased runoff and greater evaporation will likely result in large magnitude fluctuations in the size of water bodies in the area at both seasonal and inter-annual time scales.

In lakes, increasing temperatures can lead to a deterioration of water quality as a result of reduced patterns of mixing, reduced oxygen levels in the hypolimnion and an increased release of phosphorous stored in sediments (Kling *et al.* 2003). Such effects have already been observed in Lake Tanganyika (O'Reilly *et al.* 2003; Kulkarni 2009), which has experienced a 20% reduction in net primary productivity and a 30% reduction in fishery yields as a result. Increasing temperatures are also likely to affect the health and distribution of many aquatic species, including fish, invertebrates and microorganisms. Those that cannot tolerate new conditions may either perish or migrate to new areas, typically polewards (Fischlin *et al.* 2007), whereas other species, including invasive species and 'toxic' blue-green algae may show an increase in prevalence, at the cost of other less adaptable and specialist species (Winder and Schindler 2004).

The potential effects of climate change on river systems are complex and usually depend upon the specifics of alterations to both precipitation and hydrological regimes. With current predictions we may expect to see periods of increasingly high water flow (increased frequency of heavy rains and earlier/faster melting of highland snow and ice) followed by periods of increasingly low water flow (periods of drought and prematurely depleted montane water reserves). Riparian habitats are also sensitive to fluctuations in water level, as noted above. Changes to melting regimes of glaciers in the Rwenzori Mountains have been attributed to a shift in the course of the Semliki River (Kulkarni 2009).

Wetlands could potentially experience an increase in primary productivity as temperatures and CO_2 levels increase (Megonigal *et al.* 2005). However alterations to precipitation regimes may negate such effects and, furthermore, those resulting in extended dry periods could lead to the drying out of expanses of wetland, with associated negative impacts to inhabiting species (Fischlin *et al.* 2007). Significant Hippopotamus (*Hippopotamus amphibius*) deaths in the nearby Katavi National Park, Tanzania, have been observed in years of extreme drought (Kulkarni 2009), which could provide an insight into possible future events.

1.6.4.5 Cross-biome Impacts

A number of climate change effects that may affect more than one biome have been suggested. Among these are changes in the relative abundances of habitat types such as the encroachment of broadleaved evergreen forest into areas currently supporting broadleaved raingreen habitat, described above. Similar interactions are likely to occur between other biomes, although predicting the precise nature of such changes is difficult and, therefore, poorly explored.

A general increase in the net primary productivity (NPP) of most ecosystems throughout the AR is expected, owing to the combined effects of warming and CO_2 fertilization. While such a change may have some positive outcomes including increased habitat/food opportunities for some species and increased carbon sequestration, increases in NPP have also been linked to problems such as negative changes to plant community structure, proliferations of problematic (particularly invasive) species and an increased frequency of fire (Picton Phillips and Seimon 2009).

The effects of a changing climate on migratory species are challenging to predict. While they tend to have high inherent dispersal capacity and hence be less vulnerable to climate change impacts, they may be dependent on specific conditions in multiple areas, habitats and resources at different stages in their migratory cycles. Migratory species are also susceptible to disruption of migration cues, making them more vulnerable to climate change. Within the AR, migratory species suspected to be climate vulnerable include elephants (*Loxodonta africana*) and a number of bird species (Hockey 2000; Kulkarni 2009). The sensitivity of elephants to climate change was highlighted by the ENSO event of 1997/1998, which killed a significant number of the acacia trees upon which elephants depend for food (Kulkarni 2009). Disruptions to migratory habits are expected to become one of the main drivers of the decline of African mammals, with a predicted loss of 10–20% of species by 2080 (Boko *et al.* 2007).

1.6.4.6 Human environments

Finally, in the AR and other areas, climatic changes have the potential to impact the socio-economic and physical well-being of its human inhabitants. Such impacts will undoubtedly instigate human adaptive responses that affect the wider environment, and in many cases this will result in further encroachment of urban and other artificial environments into existing natural habitats – a response that will be exacerbated by an ever increasing human population. Among the most important impacts of climate change to the region's human populations are likely to be increased water stress and the often associated changes in the productivity and viability of agricultural practices. The population of Africa at risk from increased water stress alone is projected to be between 75–250 million and 350–600 million people by the 2020s and 2050s respectively (Boko *et al.* 2007), while agricultural productivity across the African continent is expected to decrease by 17–28% by the 2080s as a result of climate change (Cline 2007). Likely responses to such impacts include increased water extraction from natural water bodies, as well as expansion (and intensification) of agricultural practices into previously unused areas. This is likely to have direct impacts on both species inhabiting these habitats and on migratory (or naturally dispersing) species that may depend on them as 'stopover points'. Changes in the viability of agricultural practices may also result in changes to the way that humans utilize natural resources, a subject discussed in greater detail in the concluding sections of this report.

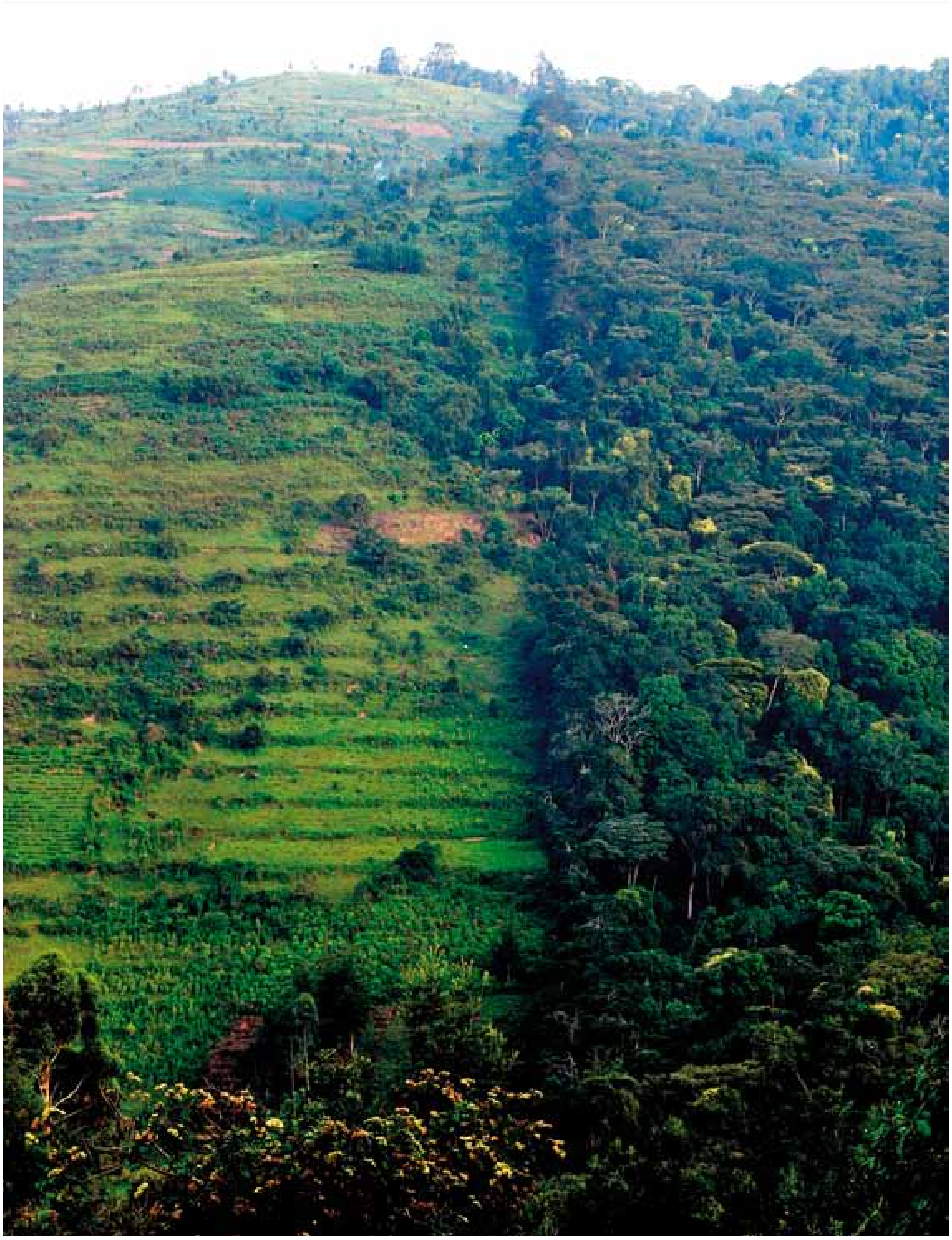
Flooding in Gatumba village, Bujumbura (Burundi) following a period of intense rainfall between February and March 2012. The frequency and intensity of such occurrences is likely to change due to climate change. © 350.org

Chapter 2. Methods

2.1 Compiling baseline species data

2.1.1 Compiling species lists for the Albertine Rift

The Wildlife Conservation Society (WCS) kindly provided preliminary species lists, which were regarded as the most authoritative for the region. Since IUCN has carried out comprehensive Red List assessments for amphibians, birds, mammals and fishes in the region, we cross-referenced the WCS lists with a list derived by carrying out a GIS exercise of overlaying a polygon of the AR boundary (derived from Conservation International's Biodiversity Hotspots shapefile[1]) with species' distribution range polygons. For fish, species were included if any part of the hydroshed (watershed) in which they



The stark contrast at this national park boundary (Uganda, 2008) highlights the enormous demand for agricultural land in the Albertine Rift. This demand is likely to increase markedly as the region's populations continue to increase and climate change exacerbates food security concerns.
© Douglas Sheil/CIFOR

occur falls within the AR. The majority of discrepancies between the WCS and IUCN lists arose due to taxonomic inconsistencies and these were investigated and resolved on a species-by-species basis, with the IUCN Red List taxonomy ultimately adopted. Where taxonomy was unresolved (e.g. not yet published), these species were excluded from our assessment. Due to updates (i.e. lumping or splitting) of some bird species in the period between data collection and data analysis, 81 assessed species were subsequently excluded from our analyses. With the exception of freshwater fish, for which some assessments were made at the sub-species level, all assessments were made at the species level, even where detailed information on sub-species was available.

For plants, comprehensive species lists were not available from either WCS or IUCN. As an assessment of all species occurring in the region was beyond the scope of this study, we compiled a non-exhaustive list of species known to be important for use and for which expertise was available. Development of lists of focal species proved challenging and not all species were considered under all components of the assessment. For example, of the 153 species investigated for their importance for human use, 93 were assessed for climate change vulnerability and only 13 had been previously assessed for extinction risk on the IUCN Red List. For this reason, we list the numbers of plant species considered wherever plant results are presented.

With the exception of butterflies, comprehensive species lists for invertebrates were unavailable. A brief expert consultation and literature review showed that some invertebrate groups are likely to be of importance in the region. The IUCN SSC Mollusc Specialist Group and the IUCN Freshwater Biodiversity Assessment Unit suggested that the harvest of molluscs was unlikely to be of significant importance. Given the general scarcity of information and expertise on this enormous group, we were unable to assess invertebrates in this study.

A range of experts on AR species were identified and, following email elicitation of inputs, further refinements to the AR species lists were made. Finally, the lists were reviewed at a four day trait collection workshop in 2010 (discussed in detail below). The resulting AR species lists provided the basis for subsequent work, and these are given in the species summary tables in Appendix 1.

2.1.2 Species distribution maps

For amphibians, birds, fish and mammals, species distribution range maps were available from the IUCN Red List database[2]. For plants, range maps were generated by London's Royal Botanic Gardens, Kew[3] based on descriptions of geographic distributions in floral accounts and other published sources (e.g. the World Checklist on Selected Families (WCSP 2012)). Where species were identified to be relatively narrowly distributed, herbarium specimen records were compiled from Kew Herbarium and electronic sources (e.g. GBIF) and were used to refine the range. Reptile distribution range maps were created by the University of Tel Aviv[4], based on published accounts of reptile distributions, from field guides and other accounts on reptile biodiversity, biogeography and taxonomy (including new species descriptions)[5]. Because the AR region straddles both East and Central Africa and field guides tend to cover only one or other of these regions, distribution maps for species that are not endemic to either region are generally incomplete. The implications of this are discussed in Section 2.5.3.

2.1.3 Endemism

WCS have produced lists of mammals, birds, amphibians and reptiles which are endemic to the AR and these were used to classify endemics in this study. The database Fishbase (www.fishbase.org) was used to identify endemic fish, but no list of endemic plants is available. Endemic species are discussed further in the relevant chapters on individual taxonomic groups (Chapters 3–8).

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1. Conservation International's Biodiversity Hotspots boundaries shapefile is freely available at: http://www.conservation.org/where/priority_areas/hotspots/Pages/hotspots_main.aspx
2. Spatial data associated with IUCN Red List assessments are available at: http://www.iucnredlist.org/technical-documents/spatial-data
3. Plant distribution polygons were compiled by Helen Chadburn, Alice Groom, Lynda Murray and Steven Bachman.
4. Reptile distribution polygons were compiled by Anat Feldman, Yuval Itescu, Shai Meiri and Oliver Tallowin.
5. Field guides: Spawls *et al*. 2002; Branch 2005. Other accounts include: Klaver and Bohme 1990, Bohme *et al*. 2005, Broadley *et al*. 2006, Wagner *et al*. 2008, Menegon *et al*. 2009, Krause and Bohme 2010, Lutzmann *et al*. 2010, Greenbaum *et al*. 2011.

2.1.4 IUCN Red List assessments of extinction risk

The majority of amphibians, birds, freshwater fish and mammals found in the region have been assessed for the IUCN Red List of Threatened Species[6]. For plants and reptiles, however, only a few species have been assessed, and many of these assessments were carried out more than a decade ago and are in need of updating. All relevant assessments are available from the IUCN Red List website (www.iucnredlist.org) and the measure of extinction risk they provide has been integrated into this assessment in an effort to paint a fuller picture of current state and future vulnerability of the region's species.

2.2 Assessing climate change vulnerability of AR species

2.2.1 IUCN's Species Vulnerability to Climate Change Assessment Framework

Thanks to funding from the MacArthur Foundation (2007–2011), IUCN has been able to explore the relationship between climate change and the biological traits that may increase or decrease its impacts on species. IUCN has developed an approach to assessing species' vulnerability to climate change that incorporates species' biological traits, and has successfully piloted it on the world's birds, amphibians and corals (Foden *et al.* 2008; Foden *et al.* 2013). The AR climate change vulnerability assessment project has provided an opportunity to adapt the approach for use at a regional level, and to apply it to additional taxonomic groups of species. This section, adapted from Foden *et al*. (submitted), gives an overview of our assessment approach and provides a background for the more detailed methods described in Section 2.2.2.

IUCN's approach, known as the Climate Change Vulnerability Assessment Framework, provides a series of 'rules' that are used to classify species according to three dimensions of climate change vulnerability (Figure 2.1):

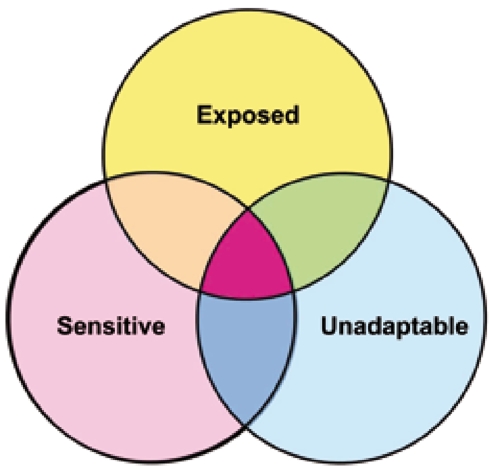
EXPOSURE: the extent to which a species' physical environment will change due to climate change

SENSITIVITY: the lack of potential for a species to persist *in situ*

LOW ADAPTABILITY: a species' inability to avoid the negative impacts of climate change through dispersal and/or micro-evolutionary change

Species that are most highly Exposed, Sensitive and Unadaptable are considered most vulnerable to climate change. These species, represented by the red triangle in Figure 2.1, are flagged as being of greatest conservation concern. Important information can also be gained from species scoring highly in other combinations of the framework's vulnerability dimensions, and this is discussed more fully in section 2.2.1.3.

Figure 2.1 Greatest climate change vulnerability occurs where species face highest exposure to climatic change, and also possess biological traits or characteristics that confer both Sensitivity and Unadaptability to such changes.



2.2.1.1 Assessing Sensitivity and Low Adaptability to climate change

Through two workshops and other consultations with experts, held during 2007, we identified more than 90 biological and ecological traits

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6. Amphibians were assessed as part of the Global Amphibian Assessment in 2004; birds were last assessed by BirdLife International in 2011; freshwater fish were assessed by Darwall *et al*. in 2011; mammals were assessed as part of the Global Mammal Assessment in 2004.

associated with Sensitivity and Low Adaptability to climate change (Foden *et al*. 2008). Those relating to Sensitivity have subsequently been classified into five ‘trait groups’ (Box 2.1) and those for Low Adaptability into two (Box 2.2). Guided by these trait groups, we conducted a second round of expert consultation and selected taxon-specific biological, ecological, physiological and environmental traits for each taxonomic group considered. These traits are presented and discussed in each of the taxon-specific chapters. Challenges in selecting traits included balancing selection of the most theoretically sound traits with the practicalities of data availability and collection. A further challenge was defining traits in objective and replicable ways and, as far as possible, developing quantitative measures for them.

Species were assigned scores of ‘unknown’, ‘not high’, ‘high’ or in certain cases ‘very high’ for each trait, based on a broad range of information sources (discussed in more detail below). While in some cases, thresholds of extinction risk were clear (e.g. ‘occurs only on mountain tops’), in most cases there was no *a priori* basis for setting a particular extinction risk threshold. For such traits (e.g. tolerance of exposure to projected temperature changes), we arbitrarily selected a threshold of the worst affected 25% and 10% of species; those ranked in this group were scored ‘high’ and ‘very high’, respectively, while the remaining species were assigned scores of ‘not high’, or ‘unknown’ where distribution data were lacking. Data on, for example, population sizes, temperature-tolerance thresholds and interspecific interactions were particularly sparse, necessitating frequent scores of ‘unknown’. In some cases where empirical data were unavailable, experts were able to provide information either from unpublished data, their own field knowledge or, where justified, through inference from similar species.

2.2.1.2 Assessing Exposure to climate change

We derive an estimation of species’ Exposure to climate change by calculating simple metrics of climatic change across refined species’ distribution ranges. Distribution ranges are mapped by experts as part of IUCN Red List assessments and are available at http://www.iucnredlist.org/technical-documents/spatial-data.

Conducting species conservation assessments using the IUCN Red List Categories and Criteria includes compiling species distribution maps. IUCN holds around 40,000 of such range maps, 22,000 of which are recorded electronically as GIS polygons at varying levels of precision. We removed areas

Participants from the climate change vulnerability assessment workshop, held in Entebbe, Uganda, in August 2010. From front left: Stephen Spawls (reptiles), Jamie Carr (IUCN Species Programme; workshop coordinator), Prince Kaleme (small mammals), Robert Kityo (small mammals), Gilbert Isabirye-Basuta (mammals), Muderhwa Nshombo (fish), Christine Kabuye (plants). From middle left: Alan Channing, Charles Msuya (amphibians), Reginald Mwaya (reptiles), Floribert Bujo (plants), Quentin Luke (plants), Gaspard Banyankimbona (fish), Florence Tumwine (IUCN Uganda; workshop organizer). From back left: Andy Plumptre (mammals; all AR species), Jos Snoeks (fish), Wendy Foden (IUCN Species Programme; workshop leader), Corey Roelke (reptiles). Missing from photograph: Robert Bagyenda (fish) and Winnie Nkalubo (fish).

Box 2.1 The five Sensitivity trait groups used in the Climate Change Vulnerability Assessment Framework (from Foden *et al*. 2013).

a) **Specialized habitat/microhabitat requirements:** Across many studies of both animals and plants, threatened and declining species include a disproportionate number of specialists compared to generalists and of species with extensive geographic ranges (Cardillo *et al.* 2005). Under a changing climate, most species are likely to face changes in their habitats and microhabitats and those less tightly coupled to specific conditions and requirements are likely to be more resilient. Sensitivity is increased where a species has several life stages, each with different habitat or microhabitat requirements (e.g. water-dependent larval amphibians), or when the habitat or microhabitat to which the species is specialized is particularly vulnerable to climate change impacts (e.g. mangroves, cloud forests or polar habitats). However, in some cases (e.g. deep sea fishes), extreme specialization may allow species to escape the full impacts of competition from native or invading species, so the interaction of such traits with climate change must be considered carefully for each species group assessed. This trait group is not independent of species' low adaptive capacity as habitat and/or microhabitat specialization also decreases the chances of successful colonization if species are able to disperse to new climatically suitable areas (e.g. plants confined to limestone outcrops; cave-roosting bats).

b) **Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle:** The physiology and ecology of many species is tightly coupled to very specific ranges of climatic variables such as temperature, precipitation, pH and carbon dioxide levels, and those with narrow tolerance ranges are particularly vulnerable to climate (Deutsch *et al*. 2008). Even species with broad environmental tolerances and unspecialized habitat requirements may already be close to thresholds beyond which ecological or physiological function quickly breaks down (e.g. photosynthesis in plants; protein and enzyme function in animals).

c) **Dependence on a specific environmental trigger that is likely to be disrupted by climate change:** Many species rely on environmental triggers or cues for migration, breeding, egg laying, seed germination, hibernation, spring emergence, and a range of other essential processes. While some cues such as day length and lunar cycles will be unaffected by climate change, others such as rainfall and temperature (including their interacting and cumulative effects) may be severely impacted. Species tend to become vulnerable to changes in the magnitude and timing of these cues when this leads to an uncoupling with resources or other essential ecological processes e.g. early spring warming causes the emergence of a species before its food sources are available. Climate change vulnerability is compounded when different stages of a species' life history or different sexes rely on different cues.

d) **Dependence on interspecific interactions which are likely to be disrupted by climate change:** Many species' interactions with prey, hosts, symbionts, pathogens and competitors will be affected by climate change, either due to the decline or loss of these resource species from the dependent species' ranges or loss of synchronization in phenology. Species dependent on interactions that are vulnerable to disruption by climate change are at risk of extinction, particularly where they have high degree of specialization for the particular resource species and are unlikely to be able to switch to or substitute other species.

e) **Rarity:** The inherent vulnerability of small populations to allee effects and catastrophic events, as well as their generally reduced capacity to recover quickly following local extinction events, suggest that many rare species will face greater impacts from climate change than more common and/or widespread species. We consider rare species to be those with small population sizes and those that may be abundant but are geographically highly restricted. In cases where only a small proportion of individuals reproduce (e.g. species with polygynous or polyandrous breeding systems or skewed sex ratios), we use an estimate of effective population size to assess species' rarity, and where species are known to be declining or subject to extreme (greater than ten-fold) fluctuations in population size, we set less conservative population size thresholds. Similarly, thresholds of larger population sizes were used for species with congregatory breeding systems, since they are more likely to experience catastrophic population declines.

Box 2.2 The two Low Adaptability trait groups used in the Climate Change Vulnerability Assessment Framework (from Foden *et al*. 2013).

a) **Poor dispersability:** In general, the particular set of environmental conditions to which each species is adapted will shift to increasing latitudes and altitudes in response to climate change. Species with low rates or short distances of dispersal (e.g. land snails, ant and rain drop splash dispersed plants) are unlikely to migrate fast enough to keep up with these shifting climatic envelopes and will face increasing extinction risk as their habitats become exposed to progressively greater climatic changes. Even where species could disperse to newly suitable areas, extrinsic barriers may decrease changes of dispersal success. Dispersal barriers may be geographic features such as unsuitable elevations (e.g. species confined to mountain ranges), oceans (e.g. for species on small islands or at the polar tip of a land mass), rivers, and for marine species, ocean currents and temperature gradients; unsuitable habitats and/or anthropogenic transformation may also act as dispersal barriers for habitat specialized species. In this context we describe species as having dispersal barriers both when suitable areas exist but extrinsic factors make them unlikely to reach them, as well as when no newly suitable areas are likely to exist (e.g. for polar species).

b) **Poor evolvability:** Species' potential for rapid genetic change will determine whether they will be able to undergo evolutionary adaptation at a rate sufficient to keep up with climate driven changes to their environments. Species with low genetic diversity, often indicated by recent bottlenecks in population numbers, potentially face inbreeding depression and generally exhibit lower ranges of both phenotypic and genotypic variation. As a result, such species tend to have fewer novel characteristics that could facilitate adaptation to the new climatic conditions. Where they exist, direct measures of genetic variability can be supplemented with information on naturalization outside species' native ranges and on the success of any past translocation efforts. Indirect measures of evolvability relate to the speed and output of reproduction and hence the rate at which advantageous novel genotypes could accumulate in populations and species (Chevin *et al*. 2010). Evidence suggests that evolutionary adaptation is possible in relatively short time frames (e.g. five to 30 years (Bradshaw and Holzapfel 2006)) but for most species with long life cycles (e.g. large animals and many perennial plants), such adaptation is unlikely to keep up with the rate of climate driven changes to their environments.

Box 2.3 The two Exposure groups used in the Climate Change Vulnerability Assessment Framework (adapted from Foden *et al*. 2013).

a) Changes in temperature	i) Absolute difference in **mean temperature** across the species' range between 1975 and 2050
	ii) Absolute difference in **temperature variability** (calculated as Average Absolute Deviation) across the species' range and seasonally between 1975 and 2050
b) Changes in precipitation	i) Absolute ratio of change in **mean precipitation** across the species' range between 1975 and 2050
	ii) Absolute ratio of change in precipitation variability (calculated as **average absolute deviation**) across the species' range and seasonally between 1975 to 2050

of unsuitable habitats and elevation from range polygons (see Section 2.2.2.2 for detailed description of methods). By overlaying projected changes in taxon-relevant climatic variables on these refined range maps, we obtained simple measures of species' exposure to four types or climatic change (Box 2.3) within their current ranges. For this study, we used the 1961–1990 climatic means as a reference for historical climates and considered projected changes to 2050 (mean of 2040–2060).

Once again, species were scored as 'unknown', 'not high, 'high' or 'very high' under this dimension of the framework, and because thresholds for exposure to climatic changes have seldom been established, scores were typically derived by ranking species and selecting the worst affected species as those with highest exposure.

2.2.1.3 Combining Sensitivity, Low Adaptability and Exposure scores into an overall assessment of climate change vulnerability

Sensitivity, Low Adaptability and Exposure scores for each species are then assembled and overall vulnerability scores calculated according to two simple logic steps (described in Figure 2.2): species are assigned a high score under each vulnerability dimension if they have *any* contributing trait (e.g. considered sensitive if a habitat specialist). They are considered highly vulnerable overall, however, only if they score as 'high' under *all* three of exposure, sensitivity and adaptive capacity (from Foden *et al*. 2013). To account for missing trait data, each of the previous steps was run twice; missing trait information was firstly assumed to represent a low vulnerability score and secondly to represent high scores. This provided best-case (or optimistic) and worst-case (pessimistic) scenarios respectively.

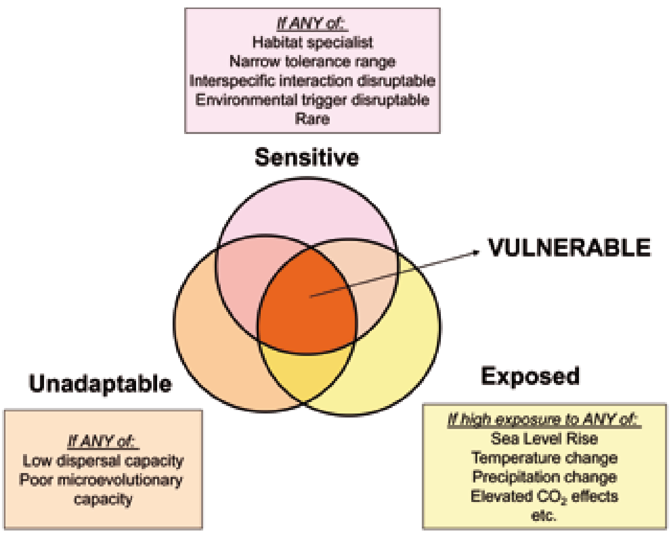
It is extremely important to note that, since many of the trait thresholds are simply relative cut-offs for continuous variables (e.g. 25% of species of greatest exposure to changes in mean temperatures), rather than empirically tested thresholds of vulnerability, **our approach provides a relative, not absolute, measure of climate change vulnerability**. The actual numbers and percentages of species emerging as vulnerable through this approach represent only the degree of overlap between the three vulnerability dimensions rather than a measure of vulnerability overall. **It is therefore not appropriate to use our results to compare degrees of vulnerability between different taxonomic groups.** Species identified as vulnerable to climate change should be regarded as estimates of the *most* vulnerable species, noting that in some taxonomic groups, all species may be at risk from climate change impacts while in others, far fewer than the most vulnerable species we identify may actually be seriously negatively impacted. Further caveats to interpreting our results are discussed in Section 2.5 at the end of this chapter.

2.2.2 Applying the assessment framework to Albertine Rift species

2.2.2.1 Compiling climate change trait data

We held a four day workshop in Entebbe, Uganda, from 17–21 August 2010 to build capacity for use of the IUCN Climate Change Vulnerability Assessment Framework in the region and subsequently to gather trait data for assessments of AR species. An initial list of traits used for previous application of the framework formed a starting point and, using expert opinion, these traits lists were refined for specific application to new taxonomic groups and to the AR. The specific traits used to assess climate change vulnerability for each taxonomic group are presented in the taxonomic chapters of this report (Chapters 3–8).

Figure 2.2 Schematic diagram showing the three dimensions of vulnerability (Exposure, Sensitivity and Low Adaptability), the biological and environmental trait groups contributing to them and the logic system used to classify species as high in each vulnerability dimension.



In some cases, species data collected for IUCN Red List assessments could be used directly to assess climate change vulnerability traits. For example, habitat data collected during Red Listing was used to identify species that are habitat 'specialists'. In most cases, however, data were collected from literature (peer-reviewed and grey), or from experts, based on their knowledge and opinions following field observations or by extrapolation from knowledge of closely related species. For birds, data gathered by BirdLife International and regional partners for the recent global climate change vulnerability assessment (Foden *et al*. 2013) were used and this group was not reassessed at the workshop. Biological and ecological trait data comprized a range of different data types, including continuous, categorical and binary types. Thresholds for each trait were based on known or inferred species tolerances or, where such knowledge was lacking, as percentiles of worst impacted species.

2.2.2.2 Modelling climatic niche breadths and exposure to future climatic changes

Because IUCN Red List range maps frequently represent species' extents of occurrence (often calculated by drawing a polygon around all known places that a species occurs), they may include areas not actually occupied by the species and for which climate projections differ (Foden *et al*. 2013). For example, a range polygon may have been drawn around a lowland amphibian's occupied range on either side of a mountain range, or similarly around a coral's range on either side of an ocean. Because the inclusion of unsuitable areas in these polygons is a particularly large potential source of error in calculations of climatic tolerances, we refined species' ranges for our assessments by excluding within-range habitats and elevations that are known to be unsuitable for the species. To do this, we rasterized IUCN range polygons to grids with a resolution of 10 minutes (species were considered present in any cell intersected by the original polygon to any extent), and carried out the following (methods are described in more detail in Foden *et al*. 2013):

1. Species-habitat association data, based on IUCN's habitat classification scheme, were cross-referenced with the spatially explicit Global Land Cover 2000 categories[7], and grid cells containing no suitable habitat were removed.
2. Using the US Geological Survey's GTOPO30 global digital elevation model[8], cells wholly comprising elevations believed to be outside of the species' tolerance range were excluded. This was based upon both Red Listing data, data gathered at the workshop and through other expert consultations.

Because empirical evidence of species' environmental tolerances (used to assess one aspect of Sensitivity) is sparse, we use the range of historical temperatures and precipitation levels tolerated by the species across its historical range as a proxy (Foden *et al*. 2013). Based on the Worldclim global dataset's 1950–2000 monthly means for terrestrial areas (excluding Antarctica) at 10 minute resolution (Hijmans *et al*., 2005; http://www.worldclim.org), we calculated the average absolute deviation across all cells in each species' refined range, for each of the 1975 (mean 1950–2000) monthly means, producing two measures, one for precipitation and one for temperature, that represent tolerance of variability both seasonally and spatially. The average absolute deviation (AAD) is a summary statistic of dispersion, and, for a data set {x1, x2, ..., xn}, AAD is defined (McGraw-Hill 2002) as:

$$\frac{1}{n}\sum_{i=1}^{n}|x_i - m(X)|.$$

In our calculations, each x represents a monthly mean for a cell in a species' refined range. Species were ranked according to their AAD scores and the 25% of species with the narrowest values for temperature and/or precipitation were regarded as of highest sensitivity (Foden *et al*. 2013).

Exposure modelling was conducted using a combination of ArcGIS 10 and Microsoft SQL Server 2005. The input data for this process was as follows: baseline (1975, i.e. 1961–1990 average)) climate values were obtained using historic projected monthly means, obtained from the Nelson Institute for Environmental Studies (http://ccr.aos.wisc.edu/model/ipcc10min/), downscaled to a resolution of 10 minutes following the protocol of Tabor and Williams (2010). Projections for 2050 (2041–2060 average) used 10 minute resolution projections under the moderate SRES A1B scenario, using means of four General Circulation Models (UKMO HadCM3, MPIM ECHAM5, CSIRO MK3.5 and GFDL CM2.1), which were obtained from the same source. The use of back-casted projections for the baseline data was deemed preferable to that of empirical climate records as anomalies between two datasets of differing sources could have been due to differences in the methods of derivation, rather than genuine changes, as projected by the models.

For all cells in a species' range, overall baseline means (OBM) for temperature and precipitation were calculated. The differences between the 1975 and 2050 OBM's were used as measures of projected change in the means of temperature across each species' current range. For projected changes in mean precipitation, the absolute ratio between the 1975 OBM and the projected mean change was used. In addition, the AAD was calculated for all species and for both climate variables. The differences between the 1975 and 2050 AAD's, and the absolute ratios of the 1975 AAD and the projected change by 2050, were used as measures of projected change in the variability of temperature and precipitation, respectively, across each species' current range. Species were then

7. Global Land Cover 2000 data is available from: http://ies.jrc.ec.europa.eu/global-land-cover-2000.
8. Data from the GTOPO30 global digital elevation model is available from: http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30_info

ranked under each of these four exposure measures and those within the 25% greatest projected change by 2050 for any were scored as of high exposure.

2.3 Use and livelihoods information

2.3.1 Identifying species of importance for human use

Due to time constraints, it was not possible to gather in-depth information pertaining to the use of species and their contribution to people's livelihoods for each of the species thought to be present in the AR. Therefore, with the aim of selecting a more manageable subset of 400–600 species, expert opinion was used to identify species used by people (see step A below). A detailed literature review was then carried out for these focal species, and where additional used species were identified from the literature, these were added to the focal species lists and further literature reviews were conducted (step B). Finally, based on the two previous steps, it was possible to identify species that are 'important' and 'most important' for use (step C). We describe how these steps were carried out in more detail below:

A: *Elicit expert opinion on species used by people of the Albertine Rift*

We identified a broad range of experts using various sources including literature reviews, IUCN SSC Specialist Groups, conservation organizations, government organizations and researchers. They included use, livelihoods and species experts, particularly those with knowledge of the AR region. Experts were sent species lists in a Microsoft Excel spreadsheet, and asked to assist by identifying species that they considered to be harvested for use and, where known, to specify the use type. Categorization of uses followed the IUCN Red List use types (Table 2.1). Experts were also asked to rate each species' importance in terms of direct use, and in terms of income generation or employment opportunities arising as a result of its harvesting. Experts were also asked to provide details of any supporting literature, as well as contact details of any other relevant experts.

In general, experts within the region responded well to our request; of the more than 260 people that were contacted, over 40% replied and provided some level of assistance either by providing data, further contacts or forwarding the email to other experts, and/or suggesting or sending relevant literature. Approximately 40 information requests were completed and returned. Information from responses varied in the degree of detail, with some specifying the type and importance of use, and others simply indicating a species as being used within the AR. There were more experts and a higher response rate for better known taxonomic groups such as mammals. Where expertise was lacking for certain taxa, a brief literature review was used to further identify or clarify those species which are important for use and livelihoods. International trade data for CITES-listed species were obtained from the UNEP-WCMC CITES trade database[9]. Other databases were also consulted; for fish in particular, Fishbase and The Lake Tanganyika Biodiversity Project Database (www.ltbp.org) were key resources.

A list containing a subset of AR plants (kindly supplied by WCS) was sent to experts who identified those thought to be important for use. Given the vast number of plant species utilized, only those species rated as being highly important for use by at least one expert or identified by two or more experts as being used, were selected. It is recognized that further species within the region may be important for use, but due to time constraints in data collection these were not included as focal species for this study. Known cultivated crops were later excluded from the lists as it was considered too difficult to discern level of reliance on wild-sourced versus cultivated specimens. Because of the necessity for the climate change vulnerability and human use data collection to begin simultaneously, a somewhat different species list emerged for each component. This meant certain species were only assessed for climate change vulnerability (111 species) or only for human use (60 species), and 93 species were assessed for both.

Based on the responses from experts and information collected from databases, a subset of species was selected for which further research could be carried out.

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9. International trade for some species is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prevents commercial trade in species considered to be threatened with extinction and regulates trade in other species to ensure that trade does not threaten their survival.

B. *Conduct detailed literature reviews for used species*
An extensive literature review to obtain the relevant use and livelihoods information was conducted through web searches, consultation of academic papers, databases and other published and grey literature as well as using information derived from experts. Wherever possible, the most recent studies were used, though it was not possible to exclude older studies due to the paucity of data in some areas and for some taxonomic groups/species. Where published articles were suspected to be out-of-date, efforts were made to contact the author to gauge their views on their current validity. We sought information specifically relevant to the AR region (as defined in section 1.2), but it was not always possible to discern the exact area upon which research was focused. This was particularly true for DRC, which has experienced significant changes in terms of area/region names and boundaries, and for which we encountered difficulties obtaining detailed maps of each area of the country's very large land mass. Furthermore, there are a number of areas, including national parks/forests such as the Ituri Forest that are only partially within the AR. It was decided that information pertaining to such areas should be included. Where information was not area-specific, or was based on an area close to, but not inside, the AR region, it was only included if very little other information was available for that particular taxonomic group, species or country, and all uncertainties were recorded.

C. *Based on the two previous steps, identify species that are important and most important for use*
A scoring system was devised on the basis of the experts' responses and other sources in order to identify 'important' species for human subsistence use and incomes from each taxonomic group. The 'most important' species were selected based on the researchers' expert opinions, having reviewed the available data. The resulting lists of important and most important species are discussed in more detail in each of the separate taxonomic chapters. It is recognized that species that are not included in these lists may also be used.

Table 2.1 IUCN Red List™ use types (as per the Species Information Service (SIS) Toolkit, rev. 2.0).

Use Type	Description
Food – Human	Food or beverages for human consumption e.g. wild pig (*Sus scrofa*) for meat for humans, shark fins for human food, brazil nuts for human food.
Food – Animal	Used as food for animals e.g. used for fish farming fodder or livestock feed such as Peruvian anchoveta.
Medicine – human and veterinary	Human and veterinary materials administered specifically to treat or prevent a specific illness or injury e.g. Bear bile, tiger bone, ginseng, Caterpillar fungus (*Ophiocordyceps sinensis*). Items administered as vitamins, tonics etc. should be included under food).
Poisons	For instance poisons, pesticides, herbicides, fish poisons
Manufacturing Chemicals	Solvents, dyes, adhesives, resins etc. whether for domestic or commercial/industrial use
Other Chemicals	For instance incense, perfumes, cosmetics
Fuels	Used as fuel including wood and charcoal production from wood, grasses etc.
Fibre	Fibre for weaving sewing, rope, paper, etc. e.g. Vicuna for its hair, Tibetan antelope for 'shahtoosh'. There may be some overlap here with wearing apparel, accessories.
Construction or structural materials	For instance timber trees or bamboo for building and grasses for thatching material.
Wearing apparel, accessories	Clothing footwear, belts, bags, trimmings etc. For example harvest of snake or crocodiles for skins in order to make leather items. There may be some overlap here with Fibre.
Other household goods	For instance containers, furnishings, etc. with primarily utilitarian functions, though potentially highly decorated
Handicrafts, jewellery, etc.	Finished goods with primarily ornamental/decorative rather than utilitarian function e.g. Elephant or hippo ivory, wild pearls, shells, feathers etc.
Pets, display animals, horticulture	Includes animals used as pets and for display (e.g. in zoos, circuses), plants used for re-planting for ornamental puposes, including private gardens and public display (e.g. botanical gardens) e.g. mantella frogs, orchids.
Research	Includes specimens used in or as the subject of any type of research (e.g. behavioural, medicine, propagation, disease resistance etc) e.g. *Macaca fasicularis* use in medical trials.
Sport, hunting/specimen collecting	Includes collection and preservation of dead specimens for personal pleasure, e.g. not for research; collection of live specimens should be included under pets/display animals, horticulture.
Establishing *ex-situ* production	Individuals harvested from the wild in order to establish captive or cultivated populations, which will then be harvested for any of the other end uses. For instance snakes harvested from the wild to establish ranching or captive breeding facilities with the aim of harvesting the offspring for skins destined for the clothing industry.

2.3.2 Database development for human utilization data

The Species Information Service (SIS), which is the information management tool of the IUCN Red List, contains two separate modules relevant to the human use of species. The first stores information on the uses of species, while the second focuses on information about the contribution a species makes to human livelihoods. Among this project's aims was to work with those developing the SIS database to revise these modules in order to: a) make them more user-friendly; and b) to encourage experts to complete this information during IUCN Red List assessments. Delays in the revision of SIS to include these modules resulted in the need to develop two standalone Microsoft Access databases used for storing the information on use and livelihoods gathered throughout this project. Additional information was stored in a document external to the database, and full references were recorded in a Microsoft Excel spreadsheet.

Both databases were designed to be compatible with the SIS database, and will facilitate the collection and storage of necessary use and livelihoods data for other projects in the future. Through this process we were also able to refine and adapt the design of SIS. These databases may be used by other researchers who do not have access to the online SIS database and, if sources can be verified, may assist in the gathering of use and livelihoods information for IUCN Red List assessments from a wider group of specialists.

The two databases hold the following information:

The **Use Database** was designed to capture information on what the species is used for (e.g. medicines, food, fuels, fibre etc.), the scale of this use (locally, nationally or internationally) and for what means (commercial (sold for cash) or subsistence (directly used/consumed)). It also captures information on what parts, life-stages and genders of the species are most commonly used and if harvesting for this purpose might negatively impact the species, or other elements of the ecosystem.

The **Livelihoods Database** captures information on the contribution of a species to local livelihoods. It was designed to include detailed case study information on those utilizing the species. This includes information regarding who harvests the species (i.e. demographic information such as gender, income level etc.), who uses the harvested species and who processes the species products. It also records information on the contribution to user's diet (if applicable) and income, and the level of dependence (e.g. opportunistically harvested; only utilized in emergency situations etc.).

An artisanal fish processor sells smoked and fried Tilapia and Nile Perch (Uganda). These species can be sold for a high price and are important for the livelihoods of local people. © Cambria Finegold, WorldFish

2.4 Combining use information, climate change vulnerability assessments and IUCN Red List threat statuses

For the six taxonomic groups considered, data on human use, climate change vulnerability and Red List categories were collated into a central spread-sheet and a yes/no score was calculated for each of these three components (i.e. important/not important for use; highly /not highly climate change vulnerable; threatened/not threatened). This provided a simple means to combine and compare outputs. It is important to note that for some taxonomic groups, most species would be used in some form by some people, even if only opportunistically.

For outputs of the climate change vulnerability analysis, species were considered vulnerable if they scored 'high' or 'very high' under all three dimensions of the assessment framework. Finally, species were considered threatened if they were recognized on the IUCN Red List as Vulnerable, Endangered or Critically Endangered, and all other categories were considered not threatened. We note that further research may show that Data Deficient species are actually be threatened or even extinct. Results are shown giving ‘optimistic’ and ‘pessimistic’ scenarios where climate change vulnerability assessments were incomplete.

2.4.1 Identifying emerging spatial patterns

To identify geographic regions containing high numbers of species recognized as important for use, climate change vulnerable and threatened, the total numbers of species of these types present in each cell were calculated. These were plotted as species density maps using the 10 minute resolution[10] refined species distributions. Colour ramps are based on Jenks’ Natural Breaks.

Bivariate plots are typically used to highlight geographic relationships between two variables of interest, and we used these to successively investigate how human use, climate change vulnerability and threat status co-vary across the AR. For each aspect, data on number of species per cell was divided into 10 classes based on Jenks’ Natural Breaks. These classes were used as coordinates on a 10 x 10 grid, with any two of the three variables on the y- and x-axes. Each grid cell was assigned a colour which graduated from muted colours for low frequencies to highly saturated colours representing extreme values. Each grid cell on the resulting maps was assigned a colour value according to the calculated frequency of species in these groups, thereby illustrating spatial covariation between the two variables of interest (Foden *et al. 2013*).

In Chapter nine of this report we provide maps indicating, for each of the three aspects investigated, areas containing high numbers of highlighted species. These maps combine data for each of the four taxonomic groups with distribution data (i.e. amphibians, birds, freshwater fish and mammals), and show areas where highlighted areas of two or more of these groups overlap. In order to avoid bias due to the high variation in the total numbers of species in each taxonomic group, we mapped, for each group, areas containing the upper 25% quantile (i.e. the last of four regular intervals based on the cumulative distribution of data) of total numbers of highlighted species.

2.5 Caveats and interpretation of outputs

Within each of the six chapters on specific taxonomic groups (Chapters 3–8), we present summaries of our results through a series of maps, tables and figures, as well as a breakdown of the findings for each species considered in Appendix 1. The final sections of this chapter provide recommendations for interpretation and use of the results. Since the results of this assessment are, at this stage, largely unvalidated, we note some important caveats to our methods. These are necessary to consider when interpreting the results, but also highlight important areas for future work in this field.

2.5.1 Interpretation of climate change vulnerability assessments

Further to providing an overall indication of species vulnerability to climate change, our approach highlights the individual mechanisms through which climate change may impact upon each species. This information is best interpreted at the species level using the species summary tables in Appendix 1. The climate change vulnerability data presented in the species summary tables should be cross referenced with the ‘trait codes’ given in the climate change vulnerability sections of each corresponding chapter.

While our study’s results focus most on species that are Exposed, Sensitive and Unadaptable, since they are of **highest vulnerability** to climate change, other combinations of these vulnerability components are also informative (see Figure 2.3). For example, for species recognized as Sensitive and Unadaptable but not Exposed (considered as of ‘**high latent risk**’) it may be prudent to monitor any climatic changes throughout its range, particularly as there is often high uncertainty associated with many future climate change projections, as well as with our own understanding of the levels of exposure to change that is actually biologically significant for each species. For a species recognized as Exposed and Sensitive, but believed to be capable of adapting (‘**potential adapters**’), it may be wise to monitor presumed adaptive responses to ensure that they are occurring, and to provide

10. In subsequent sections results often refer to number/proportions of ‘species per grid cell’ and readers should be aware of the resolution used (note that 10 minutes = approximately 18.5 kilometres at the equator).

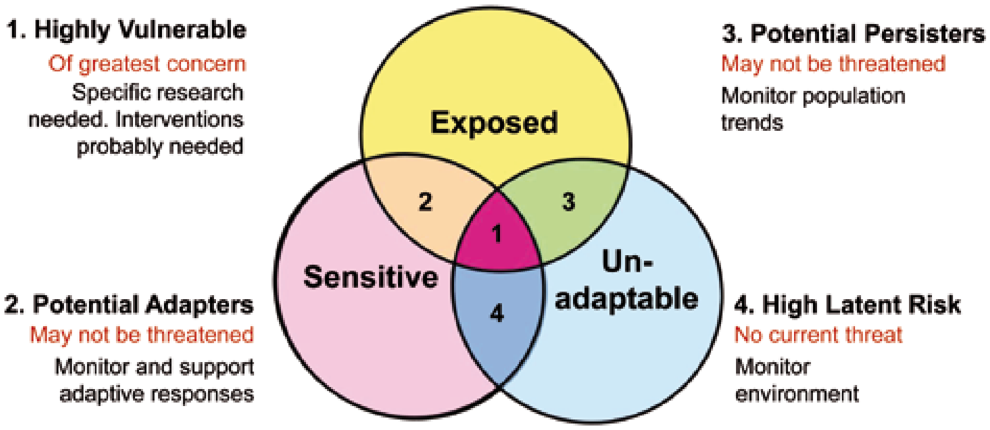
appropriate support (e.g. assisted breeding, translocation, corridor creation, etc.) for these wherever necessary. Finally, for species that are poor adapters and are highly Exposed but are not highly Sensitive (‘**potential persisters**’), monitoring of population trends is important in order to ensure that populations are showing the anticipated resilience; reduction of other threats to enhance persistence is likely to be an important and effective conservation strategy for this species type. Finally, species that score under only one vulnerability dimension, as well as those scoring under none, are of the lowest climate change vulnerability.

Upon identifying a species for which climate change-related conservation action(s) may be required, we hope that conservation practitioners will take into account the individual species traits identified in this assessment to inform their subsequent approach. A list of potential adaptation options and approaches are provided in Table 9.5 in the final chapter of this report.

A number of important caveats should borne in mind when interpreting the results of our climate change vulnerability assessments, and these are presented in the following paragraphs (from Foden *et al*. 2013):

a) We acknowledge that experts’ judgements can be subject to certain biases (Burgman *et al*. 2011a), but emphasize their value, particularly where timely decisions are needed in the face of novel, future or uncertain situations (Burgman *et al*. 2011b).
b) The selected trait threshold we chose (25%) is arbitrary and is unlikely to represent any real limit to species’ tolerances. It simply highlights the top scoring species as a basis for analysis. Ideally the threshold would be updated or validated through observations and or experiments of the way in which climate change and traits interact (e.g. Ozgul *et al*. 2010; Van Bocxlaer *et al*. 2010). When interpreting the absolute values of the percentages for each group, it is important to recognize that these simply represent the degree of overlap between sensitivity, low adaptive capacity and exposure within the taxonomic group. It is particularly important to emphasize, therefore, that comparisons between the percentages of high vulnerability species cannot be interpreted to represent any real differences in vulnerability between taxonomic groups.
c) Our framework’s scoring system is based on the assumption that species have multiple pathways to extinction; traits were selected and scores calibrated such that a ‘high’ score on any single e.g. sensitivity trait would result in the species being ranked as ‘sensitive’ overall. As anthropogenic climate change progresses, the range, species-specificity and frequencies of extinction pathways (no doubt including some not yet identified) will become apparent, but at this point, we believe it is premature to rank one trait as more important than another or exclude any that have been identified as possibilities. We acknowledge that this simple, equally-weighted combination of traits and trait groups fails to account for their potentially differing importance in conferring climate change vulnerability, but we are unable to quantify or justify relative trait weightings at this time.
d) In practice, the biological traits are likely to interact with each other and with environmental change in non-linear ways, and there will be thresholds and abrupt state changes as a result. These effects are likely to be very specific and context-dependent and the only way to develop an understanding will be through detailed field studies over many years with a great deal of relevant climate and

Figure 2.3 Responses associated with various combinations of the three framework dimensions.



environmental information. This is simply going to be impossible for many species, but the availability of a few such studies (Foden *et al*. 2007; Franks *et al*. 2007; Ozgul *et al*. 2010) and the deployment of more mechanistic models (e.g., Keith *et al*. 2008; Morin *et al*. 2008) should start to support more sophisticated approaches than the very broad brush approach we use here.

e) Our approach does not specify the relationship between vulnerability scores and the risk of extinction. Although Foden *et al*. (submitted) shows vulnerability to be correlated with extinction risk (as determined by the IUCN Red List Criteria) at a global scale, it is not possible to equate vulnerability with a specific level of threat, and the relationship between vulnerability and extinction risk may be different for different groups. Results may be interpreted, for example, to predict which species and geographic regions will be at relatively higher risk of climate driven extinction than others, but not to quantify this risk, nor to compare vulnerability between the broader taxonomic groups assessed.

f) We recognize that climate change will have positive effects on many species. In fact, many species are already benefitting from climate change, especially in temperate areas (Thomas *et al*. 2010), and to date most range shifts recorded have resulted in range expansions more than contractions (Walther *et al*. 2005). However, our framework does not attempt to incorporate this – we are interested in identifying species at risk from climate change.

2.5.2 Interpretation of human use and livelihoods information

a) The species lists were reduced following expert consultation, as it would not be possible to carry out a detailed literature review of all species present due to time constraints. However, species that occur in the region may still be used even if they are not discussed within this report. For many taxa such as fish or mammals, the vast majority of species present in the AR will be used by at least some people, even if they are only harvested opportunistically.

b) We note that, because more literature was available on certain use types (e.g. human food) compared with others (e.g. fibre), there may be a bias towards over-emphasizing these use types in our study. Further information was collected regarding the significance of each use type to subsistence or incomes (see Section 2.3.1), but again, data was not uniformly available when attempting to measure levels of importance, for example more data were available for assessing

Species that are dependent upon specialized habitats or microhabitats such as this freshwater stream (Bwindi) may have increased sensitivity and hence vulnerability to climate change.

the local or international value than for the national level. However, it is hoped that by both consulting with experts and the literature, the majority of important species were captured for at least one of their use types.

c) It must be remembered that the terms ‘important’ and ‘most important’ in the context of use are both relative, meaning that different taxonomic groups cannot be compared. For example, reptile species selected as being ‘most important’ are only considered so relative to other reptiles and, overall, reptiles were not an important group when compared with others such as plants and fish. These terms are also only valid within the context of this report.
d) Information on use of species was often derived from in-depth studies of precise geographic areas (e.g. particular forests or national parks) or specific groups of people (e.g. hunters). One must bear in mind that a species’ selection as ‘important’ or ‘most important’ may be based on information pertaining to only one country or geographic location, and does not mean the same is true throughout the species’ range. Levels of reliance are likely to vary geographically and to be influenced by a range of factors such as culture and wealth.
e) Quantifying levels of use is very difficult due to the unregulated, informal and sometimes illegal use of wild resources. The literature used within this report is likely to have some limitations, for example studies which used questionnaires to estimate levels of wild meat off-take may be hampered by unwillingness of respondents to admit carrying out illegal hunting whilst official fish catch volumes often over-estimate legal landings (Kaelin and Cowx 2002) but do not include illegal fishing. Where possible within this report, we have attempted to find multiple sources of data which identify important species, however we emphasize that use of some species may have been over- or under-estimated, or not included at all.

2.5.3 Interpretation of density maps

The various maps presented throughout the results sections of this document are intended to provide a broad overview of the regions containing proportionally high numbers/percentages of species highlighted through the various aspects of our assessment (human use, climate change vulnerability and/or threat, as well as general species richness). We have attempted, when describing these maps, to relate highlighted areas to specific areas of interest (e.g. protected areas given in Figure 1.2, major lakes or, less frequently, towns and districts).

When interpreting the maps presented, it is important to acknowledge that some degree of accuracy may have been lost during the various mapping processes described earlier. Similarly, there are inherent uncertainties associated with the production of the original species distribution polygons upon which these maps were based. For further information on the mapping standards used for IUCN Red List assessments (applicable in this report to amphibians, birds, freshwater fish and mammals) we direct readers to IUCN’s Red List mapping standards, which is available online[11].

In the case of reptiles, distribution data for many species was only available for four of the relevant countries (Uganda, Rwanda, Burundi and Tanzania), and this has two major implications. Firstly, when compiling distribution maps for reptiles it was necessary to exclude DRC and Zambia from the final images, as a lack of knowledge of reptile distributions within these countries would otherwise have resulted in misleading figures (e.g. species richness would have appeared lower in these countries than is actually the case). The second implication of this knowledge gap is that we were unable to calculate the climatic tolerances of many of the reptile species of interest (this requires knowledge of a species’ full range). Resultantly, it was decided to exclude this Sensitivity trait from our analysis of reptiles altogether.

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11. IUCN’s mapping standards are available from: http://speciesmapping.pbworks.com/w/file/50458779/Red%20List%20%20Mapping_standards.pptx

Chapter 3. Amphibians

3.1 Overview of amphibians considered in the assessment

Our assessment considered a total of 110 amphibian species from 13 families. The largest of the families represented were Hyperoliidae (35 species), Arthroleptidae (27 species) and Phrynobatrachidae (12 species). The vast majority of the species considered are frogs (99 species) and toads (10 species), the only exception being the caecilian *Boulengerula fischeri*. WCS (2011) recognize a total of 38 amphibian species as endemic to the AR. However, owing to differences in taxonomic references, and particularly our exclusion of taxa for which species status was unresolved at the time of data collection, we recognize a total of 30 endemic amphibians.

Amphibian richness is particularly high (supporting 33–38 species per grid cell) at the north-western limits of the AR boundary (within the DRC), in an area encompassing (and extending northwest from) the Virunga National Park and Lake Edward (Figure 3.1). This area of high richness extends south as far as the border with northern Rwanda, where it also extends eastward into south-western Uganda (around the areas of Bwindi Impenetrable and Mgahinga National Parks).

Other locations with visibly high amphibian richness include much of the Ugandan component of the AR (excluding the northern limits of the boundary), which typically supports 21–26 species in any given cell, and much of the Zambian portion of the AR, which typically supports 21–23 species.

Areas with noticeably lower amphibian richness include much of the central AR, particularly in areas near to the Domaine de Chasse de Luama-Katanga/Luama-Kivu (DRC) and stretching north/northeast into southern and western Burundi. The lowest number of amphibian species recorded in any cell is seven.

Of the 110 amphibian species considered in this assessment, 12 are known to be globally threatened with extinction according to the IUCN Red List (IUCN 2012). Figure 3.2 shows the distribution of

Fischer's African Caecilian (*Boulengerula fischeri*) at Nyungwe (Rwanda). This Albertine Rift endemic amphibian species from the Caeciliidae family was assessed as vulnerable to climate change. © Paul Freed

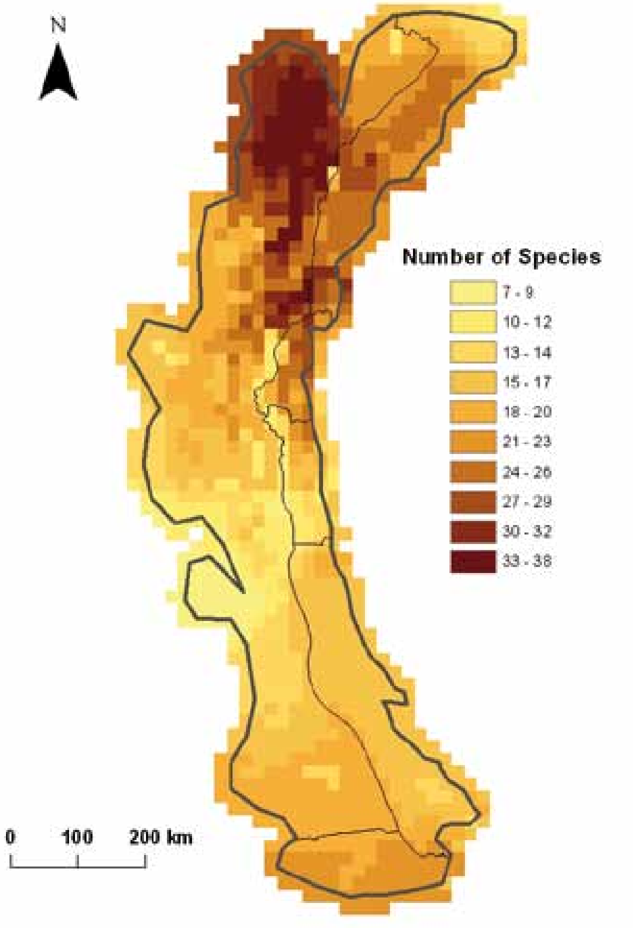


Figure 3.1 Species richness of amphibians in the AR.

Table 3.1 Most important amphibian species for subsistence use and/or incomes in the AR.

Species	Common Name	Endemic?	Uses
Afrixalus orophilus	Two-lined Leaf-gluing Frog	Yes	Pet trade
Amietophrynus superciliaris	African Giant Toad		Medicines; pet trade
Hoplobatrachus occipitalis	Crowned Bullfrog		Human food
Xenopus fraseri	Fraser's Clawed Frog		Human food; pet trade
Xenopus ruwenzoriensis	Uganda Clawed Frog	Yes	Human food
Xenopus vestitus	Kivu Clawed Frog	Yes	Human food
Xenopus wittei	De Witte's Clawed Frog	Yes	Human food

globally threatened amphibians in the AR region. Areas containing the greatest numbers of threatened species (Figure 3.2a) include regions in and around Virunga National Park (particularly the South) (DRC), Bwindi Impenetrable National Park, Gishwati Forest Reserve (Rwanda), Mukura Forest Reserve (Rwanda), Nyungwe National Park (Rwanda), and the eastern portions of Kahuzi-Biega National Park and the Itombwe Massif (both DRC).

Areas containing the highest proportions of threatened species (Fig. 3.2b) are similar to those described above, suggesting that, where applicable, the number of threatened species is well correlated with the total number of species present.

3.2 Importance for human use

Very little information was available on the use of amphibians in the AR area and the countries within it. Upon extensive consultation with experts, it became apparent that the absence of information available is likely to reflect the lack of human reliance on this taxonomic group within the area of study. This may, at least in part, be due to the large water bodies present in the region which can provide a rich supply of protein through fish. Mohneke *et al.* (2010) found an association between declining local fish stock levels and the increasing consumption of amphibians in Western Africa, which may suggest fish in the AR are still relatively abundant at this time.

Forty-nine amphibian species were specified by experts as being important for use[12], compared with other amphibian species within the AR, though the general consensus was that amphibians generally are not an especially important taxon for human use. Four of the forty-nine species are listed on the IUCN Red List as Vulnerable and two as Endangered. All six of these threatened species are endemic to the AR. A further five species are considered Data Deficient and 38 are Least Concern. In total 12 of the species found to be important for use are considered endemic by WCS. Seven species have been identified as most important for use (Table 3.1), mainly due to their use as food or in the pet trade. However, the use of amphibians does not appear to be as extensive as that of other taxa such as fish and mammals.

Of the 49 amphibian species identified as being important for use, the majority (92%) were selected due to their use in the pet trade. Six species were identified as being used for subsistence, though data to support this suggestion were extremely sparse. Only the African Giant Toad (*Amietophrynus superciliaris*) was identified through expert consultation as possibly used for medicinal purposes.

The greatest density of amphibian species recorded as important for use is in the north-west of the AR (DRC), particularly in the districts of Ituri and Nord-Kivu; in the northern part of Virunga National Park up to 19 utilized species can be found per grid cell (Fig. 3.3a). The density of important species

[12] The terms 'important' and 'most important' are relative only to other amphibian species in the AR when discussed in this chapter, meaning that the importance of amphibian species cannot be compared with species in different taxonomic groups.

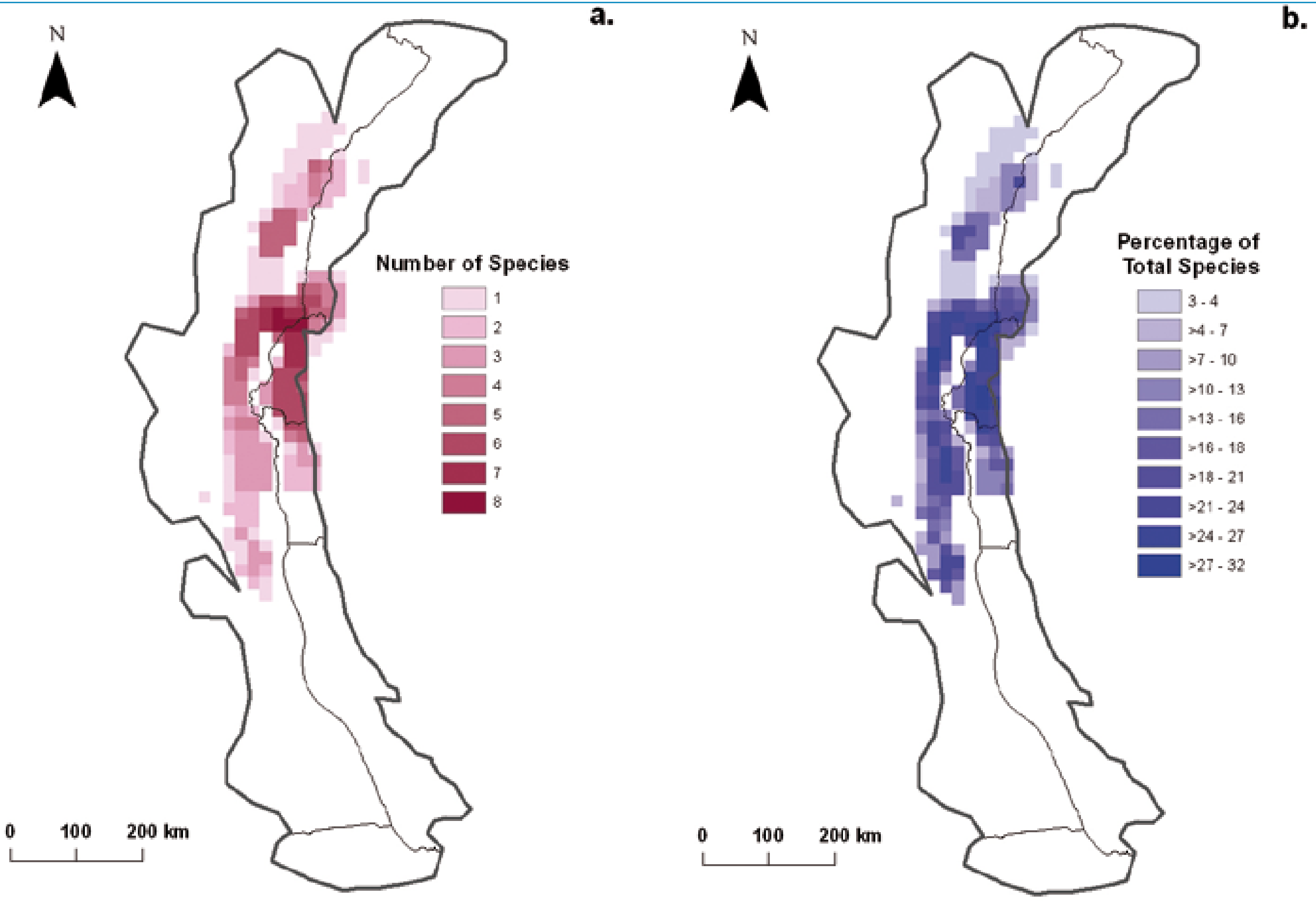


Figure 3.2 Distribution of globally threatened (IUCN 2011) amphibians in the AR. Map (a) shows *total numbers* of species known to be threatened with extinction. Map (b) shows the *percentage of the total species present* in each region that are threatened.

is much lower in the central part of the AR, particularly in and around the northern part of Domaine de Chasse de Luama-Katanga where the density was just three species per grid cell. The percentage of the total number of species that are important for use followed a similar pattern, though peaked in Sud-Kivu and to the south of Kahuzi-Biega National Park, with up to 81% of all species present being used (Figure 3.3b).

3.2.1 Harvest for human food

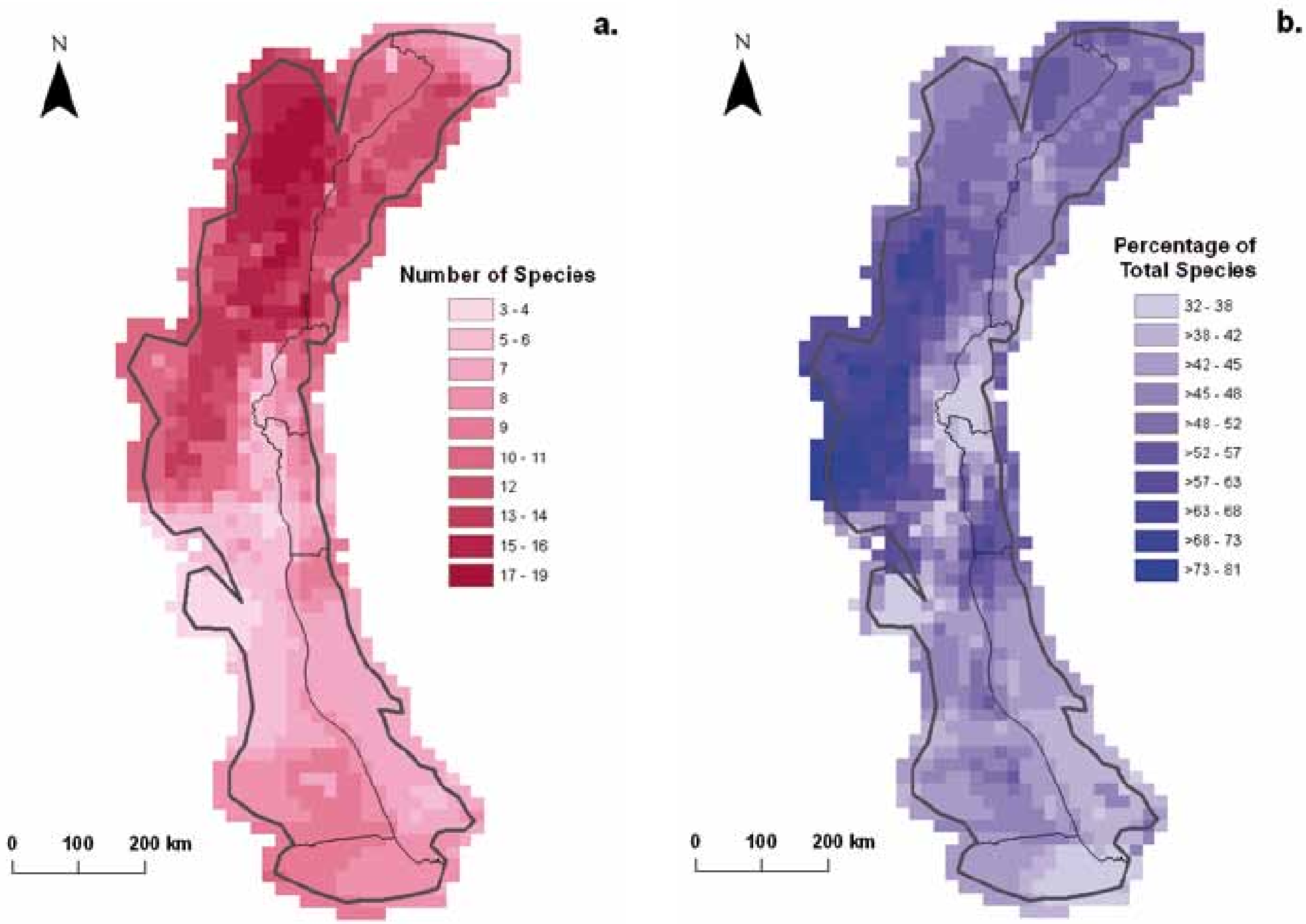
According to consulted experts, the Crowned Bullfrog (*Hoplobatrachus occipitalis*) and species in the genus *Xenopus* are most likely to be used for human food, which resulted in five species being selected as important for food. Information from the IUCN Red List supports this as Crowned Bullfrog and four of the five *Xenopus* species present in the area are specified as used, or likely to be used, for food. The Crowned Bullfrog is categorized on the IUCN Red List as Least Concern and has a wide distribution across Africa (Rödel *et al.* 2006). It is not known if this species is consumed specifically within the AR or only in other parts of its range, though it is thought to be the most popular species of amphibian to be eaten in Burkina Faso, Benin and Nigeria (Mohneke *et al.* 2010). Consumption of amphibians for food is regarded as more common in West Africa than in the countries of the AR. The genus *Amietophrynus*, which comprises African Giant Toad (*A. superciliaris*) and another 38 species, was found to rank amongst the top 10 most consumed species groups in Burkina Faso (Frost 2010; Mohneke *et al.* 2010) but no evidence was found to suggest any of these species are important for use in the AR.

One expert suggested that 'ranoid' frog species (including species from the genus: *Afrana*, *Ptychadena*, *Pyxicephalus* and, most importantly, *Hoplobatrachus*) may be more likely to be consumed, while toads and toad-like frogs (such as species from the genus *Bufo, Tomopterna* and *Kassina*) may be more popular in the pet trade. However, as with much of the information on the area's amphibians, this was an 'educated guess' based on research in parts of West and Central Africa and not in the AR. Herrmann *et al.* (2005) also found that, among amphibians, larger ranids are the preferred food species in Cameroon.

One expert consulted in this study stated that frogs are harvested in Burundi for use in local restaurants, though specific species were again unknown. Another expert commented that "there is a trade in local markets of *Xenopus* and the larger species of ranid frogs, for consumption", although he also stated that there were no estimates of the size of the trade at present and did not specify species.

Fraser's Clawed Frog (*Xenopus fraseri*), De Witte's Clawed Frog (*X. wittei*), Kivu Clawed Frog (*X. vestitus*) and Ugandan Clawed Frog (*X. ruwnezoriensis*) are specified on the IUCN Red List as harvested, or likely to be harvested, locally for food, which is regarded as having a possible negative impact on local populations of all species excluding Ugandan Clawed Frog (Tinsley *et al*. 2004a; 2004b; 2004c). According to WCS (2011), De Witte's Clawed Frog, Kivu Clawed Frog and Ugandan Clawed Frog are all endemic to the AR, and all are listed as Least Concern on the IUCN Red List , except Ugandan Clawed Frog which is Data Deficient and has an unknown population trend (Tinsley *et al.* 2004b; 2004c; 2004d). Muller's Platanna (*Xenopus mulleri*) was the only *Xenopus* species in the AR not identified on the IUCN Red List as possibly used for human food. No other published literature was found to confirm that *Xenopus* species are used as human food within the AR. A recent report on the consumption of frogs suggested that in DRC people collect specimens for sale in local restaurants (Altherr *et al*. 2011), although it is not known where in the DRC this was observed or which species were harvested. Overall, the consumption of amphibians as food in Africa has not been focused upon a great deal by researchers (Mohneke *et al*. 2010), and the need for such research has been previously highlighted by Jenkins *et al.* (2009).

Figure 3.3 Distribution of human-utilized amphibians in the AR. Map (a) shows *total numbers* of species known to be of importance for human use. Map (b) shows the *percentage of the total species present* in each region that are of importance for human use.



It is difficult to conclude with certainty whether the scarcity of information is related to no use, inconsequential use or poor data, but the information available suggests that consumption of amphibians as food in the AR does not significantly contribute to subsistence or incomes. However, it is important to bear in mind that amphibians are considered an important source of protein in many other parts of the world (Angulo 2008; Mohneke *et al*. 2009) and as such, should other resources reduce significantly, it is possible that harvest levels may increase and the range of species harvested may broaden.

3.2.2 Harvest for the pet trade

Forty-five amphibian species were specified by experts as important for use in the pet trade, and these were selected for further investigation. Unfortunately no supporting published literature was found on the harvesting of amphibians in the AR for the pet trade, and therefore it is difficult to assess the contribution to local incomes. The majority of experts consulted either did not specify the level of importance to local income or specified it as low, though one expert classed 10 species harvested for the pet trade as of medium importance to local income. These species were primarily from the genus *Hyperolius*. The Two-lined Leaf-gluing Frog (*Afrixalus orophilus*) was the only endemic species which was identified by two experts as harvested for the pet trade.

One consulted expert suggested that the collection of amphibians for the pet trade is increasing in the mountains of Tanzania, and that certain species are requested specifically by traders in Europe. He suggested that species in the genus *Leptopelis* (of which 11 are known to occur in the AR) are particularly popular in the pet trade. In our assessment seven species in this genus were identified as being harvested for the pet trade. Having investigated the availability of *Leptopelis* species for sale briefly online, it appears that the most readily available species are Big-eyed Tree Frog (*Letopelis vermiculatus)* and Uluguru Tree Frog (*Leptopelis uluguruensis*), neither of which are thought to be found within the AR. There is little literature available to determine whether species of *Leptopelis* occurring in the AR are particularly vulnerable to overexploitation for the pet trade, but it does not seem that people are particularly dependant on these species for income. However, more in-depth research specifically targeted at pet suppliers may be required in order to establish the extent of utilization of this genus and others in the area.

African Giant Toad (*Amietophrynus superciliaris*)

This large forest-dwelling species is distributed from the south-eastern tip of Nigeria across to the north-eastern DRC, though it is thought to be uncommon in much of its range (Tandy *et al*. 2009) This colourful toad was previously threatened by overexploitation for the pet trade and accordingly was listed in CITES Appendix I (i.e. international commercial trade prohibited) in 1975. Consultation with experts identified it as being used as medicine in the AR, and in parts of its range it is specifically killed for its bones which are crushed and taken as medicine (WAZA 2012). In western Cameroon the bones are known to be used to treat poisoning and mental disorders (Barej *et al*. 2011).

Although this species was assessed as being sensitive to changes in climate due to its narrow temperature tolerance range, it was not assessed as climate change vulnerable overall as projected climatic changes across its range are comparatively low, and the species is considered to be relatively adaptable.

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3.2.3 Harvest for medicinal purposes

The African Giant Toad was suggested as used for medicinal purposes by one of the experts consulted, and the World Association of Zoos and Aquariums (WAZA) specified that the species is killed and dried so that its bones can be crushed and used in traditional medicine (WAZA 2011). It is not known if the reported medicinal properties of this species may enhance its popularity as a source of food. One of the experts consulted during the study said that he had heard of people of the Bantu ethnic group in Bwindi (Uganda) using certain species of amphibians in 'witchcraft' but was not able specify which species.

3.3 Climate change vulnerability

For the 110 amphibian species assessed, we identified and considered a total of 19 climate change vulnerability traits, of which four related to 'Exposure', 12 to 'Sensitivity' and three to 'Low Adaptability'. These are shown in Tables 3.2, 3.3 and 3.4, respectively.

Through assessing species' Exposure to climatic changes (Table 3.2), we expect 38 species (34.5%) to experience relatively 'high' levels of climatic change throughout their global ranges. A further 30 (27%) are expected to experience 'very high' levels of change. Of these 68 species, 21 are expected to experience notable changes in two of the four climatic variables investigated, 10 across three variables, and one species (*Arthroleptis spinalis*) across all four.

In our assessment of species' Sensitivity to climatic changes (Table 3.2), 85 species (77%) were assessed as possessing traits that make them 'highly' Sensitive to climatic changes, and a further 21 (19%) to be 'very highly' Sensitive to changes. These figures combined suggest that 106 of the 110 species investigated (96%) are, in some way, sensitive to climatic changes. Of these 106 species, 32 possess one single trait, 35 possess two traits, 22 possess three traits, 10 possess four traits, and seven possess five traits.

Within the Sensitivity analysis, the most common trait possessed was a strict seasonal (as opposed to opportunistic) reproductive strategy (trait S11), which was present in a total of 71 species (64.5%). Use of this trait is based on the assumption that reproduction for such species is very likely to be dependent on a particular climatic variable or a seasonal event which, under a changing climate, could either fail or become asynchronous with other important occurrences such as availability of food species. Such risks are less likely to emerge for opportunistic breeders.

Also of high importance was species' reliance on poorly oxygenated swamp habitats (trait S6). Species dependent on such habitats are assumed to exist close to physiological thresholds of low oxygen tolerance. Swamp habitats are believed to be particularly vulnerable to changes in climate themselves, and particularly to changes in precipitation and runoff (Chapman *et al*. 2000); a decrease in precipitation, particularly if coupled with a rise in temperature, could reduce O_2 levels below physiological thresholds, and could ultimately result in the drying up of the habitat altogether. Alternatively, an increase in precipitation could result in an increase of dissolved oxygen, and the subsequent ability for new (typically less specialist species) to move into these areas. Seventy species (64%) were identified as having this trait.

Twenty-five species (23%) were noted as being dependent on a cue of rainfall or increased water availability for their mass (often termed 'explosive') breeding. A change in the timing or severity of these important cues may affect their breeding efforts/successes (Donnelly and Crump 1998). For this trait, we excluded species buffered by occurring in forests, and typically included mud-aestivating grassland species.

Table 3.2 Climate change *Exposure* measures used to assess AR amphibians, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A1).

Trait Group	Trait	Sub-trait	Thresholds	AMPHIBIANS			
				Total species considered = 110			
EXPOSURE				Low	High	Very High	Unknown
Temperature change	Substantial changes in mean temperature occur across the species' range	**E1:** Absolute difference between 1975 and 2050 mean temperatures (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	82	17	11	0
		E2: Absolute difference between 1975 and 2050 values of average absolute deviation in temperature (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	82	17	11	0
Rainfall change	Substantial changes in mean precipitation occur across the species' range	**E3:** Absolute ratio of change in 1975 and 2050 values of mean precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	82	17	11	0
		E4: Absolute ratio of change in 1975 and 2050 values of average absolute deviation in precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	82	17	11	0
			Total	**42**	**38**	**30**	
			Percentage	**38**	**35**	**27**	

Sixteen species (14.5%) were noted as occurring in only one IUCN-defined habitat type. Such species are believed to be specialized in their habitat requirements, suggesting narrow tolerance of conditions and therefore higher sensitivity to changes that may occur as a result of changes in climate.

In our assessment of species' capacity to adapt to climatic changes (Table 3.4), 43 species (39%) were assessed as possessing traits that make them poorly adaptable. Twenty-four species (22%) were found to be unlikely to disperse in response to climate change due to the presence of geographic barriers (trait A1), while 22 species (20%) are known to have relatively low reproductive capacities, making them unlikely to adapt at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ* (trait A3). The species *Afrixalus orophilus*, the Rugege Forest Squeaker Frog

Table 3.3 Climate change *Sensitivity* traits used to assess AR amphibians, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A1).

Trait Group	Trait	Sub-trait	Thresholds	AMPHIBIANS			
				Total species considered = 110			
SENSITIVITY				Low	High	Very High	Unknown
A. Specialized habitat and/or microhabitat requirements	Habitat specialization	**S1:** Number of IUCN habitat types occupied by species	L = >1; H = 1	87	16	n/a	7
		S2: Range of elevations in which species occurs	L = >500m; H = 101-500m; VH = ≤ 100m	82	5	1	22
	Microhabitat specialization	**S3:** Breeding microhabitat specialized? (i.e. other than terrestrial water bodies, or subterranean nests)	L = No; H = Yes	106	4	n/a	0
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of changes to precipitation regimes	**S4:** Average absolute deviation in precipitation across the species' current range	Average absolute deviation in temperature across the species' historical range: L = highest 75%; H = Lowest 25%	82	17	11	0
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of temperature changes	**S5:** Average absolute deviation in temperature across the species' current range	Average absolute deviation in precipitation across the species' historical range: L = highest 75%; H = Lowest 25%	82	17	11	0
	Tolerance of changes in levels of dissolved oxygen (aquatic)	**S6:** Tadpoles reliant upon (poorly oxygenated) swamps?	L = No; H = Yes	40	70	n/a	0
		S7: Tadpoles reliant upon (highly oxygenated) fast flowing streams?	L = No; H = Yes	108	2	n/a	0
	Tolerance of drought/drying	**S8:** Adults or tadpoles depend on permanent water?	L = No; H = Yes	99	11	n/a	0
C. Dependence on a specific environmental trigger that is likely to be disrupted by climate change	Dependence on an environmental trigger	**S9:** Individuals migrate after rainfall events?	L = No; H = Yes	104	6	n/a	0
		S10: Explosive breeder following a climatic event (e.g. rainfall)?	L = No; H = Yes	85	25	n/a	0
		S11: Is reproduction strictly seasonal (vs. opportunistic)?	L = No; H = Yes	39	71	n/a	0
D. Dependence on interspecific interactions which are likely to be disrupted by climate change.	Increasing negative interactions with other species	**S12:** Known to be sensitive to chytrid fungus?	L = No; H = Yes	104	6	n/a	0
			Total	**4**	**85**	**21**	
			Percentage	**4**	**77**	**19**	

Table 3.4 Climate change *Low Adaptability* traits used to assess AR amphibians, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A1).

Trait Group	Trait	Sub-trait	Thresholds	AMPHIBIANS			
				Total species considered = 110			
LOW ADAPTABILITY				Low	High	Very High	Unknown
A. Poor dispersability	Extrinsic barriers to dispersal	**A1:** Dispersal limited by geographic barriers?	L = No; H = Yes	86	24	n/a	0
		A2: Dispersal limited by anthropogenic barriers?	L = No; H = Yes	109	1	n/a	0
B. Poor evolvability	Low reproductive capacity	**A3:** Low annual reproductive output	L <50 and oviparous; H >=50 and/or viviparous	42	22	n/a	46
			Total	**67**	**43**		
			Percentage	**61**	**39**		

(*Arthroleptis adolfifriederici*) and *Hyperolius frontalis* are known to possess both of these traits, and the species *Phrynobatrachus versicolor* was assessed as having limited dispersal ability due to the presence of both geographic and anthropogenic barriers.

Overall, a total of 34 amphibian species (31%) were recognized as being of highest vulnerability to climate change due to being highly sensitive, likely to be highly exposed, and poorly able to adapt (Figure 3.4). Of these 34 species, 20 are endemic to the region. Thirty-two species (29%) are expected to experience high levels of climate change throughout their ranges, are sensitive to climatic change, but are not noted as being poorly able to adapt. Nine species (8%) were assessed as both sensitive and unable to adapt to climate change, but are not expected to experience high levels of change (relative to other amphibians in the region). No species were both highly exposed and unable to adapt, but not actually sensitive to climate change. Under our pessimistic scenario for missing data values (see Methods, Section 2.2.1.3), a total of 51 species (46%) are considered climate change vulnerable.

Table 3.5 shows the families of the 34 species recognized in our assessment as being climate change vulnerable. The most prevalent families among this group are Hyperoliidae, Arthroleptidae, and Phrynobatrachidae, which, as noted previously, are the most commonly found families in the region.

Figure 3.5 shows the distribution of climate change vulnerable amphibians throughout the AR. Interestingly, the vast majority of climate change vulnerable species are found in the north of the region, and densities are particularly high in the area directly north of Rwanda (DRC and Uganda) where up to 12 climate change vulnerable species per grid cell may be found. Other areas containing

Figure 3.4 Numbers of AR amphibians recognized as Exposed, Sensitive and/or unadaptable to climate change, and all combinations of the three.

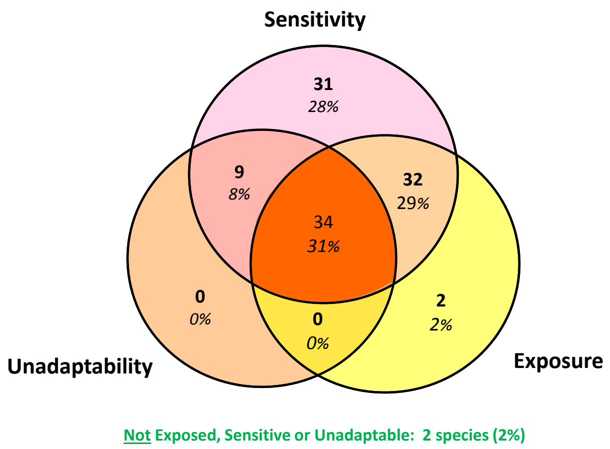

Table 3.5 Families of climate change vulnerable AR amphibians. Numbers in parentheses show percentages of the total species (within each family) considered for this assessment which are climate change vulnerable. Vulnerability figures are based on an optimistic scenario for missing data values.

Family	Number (and percentage) of climate change vulnerable amphibian species
Hyperoliidae	**12** (34%)
Arthroleptidae	**9** (33%)
Phrynobatrachidae	**5** (42%)
Pipidae	**3** (50%)
Bufonidae	**2** (20%)
Pyxicephalidae	**2** (50%)
Caecilidae	**1** (100%)

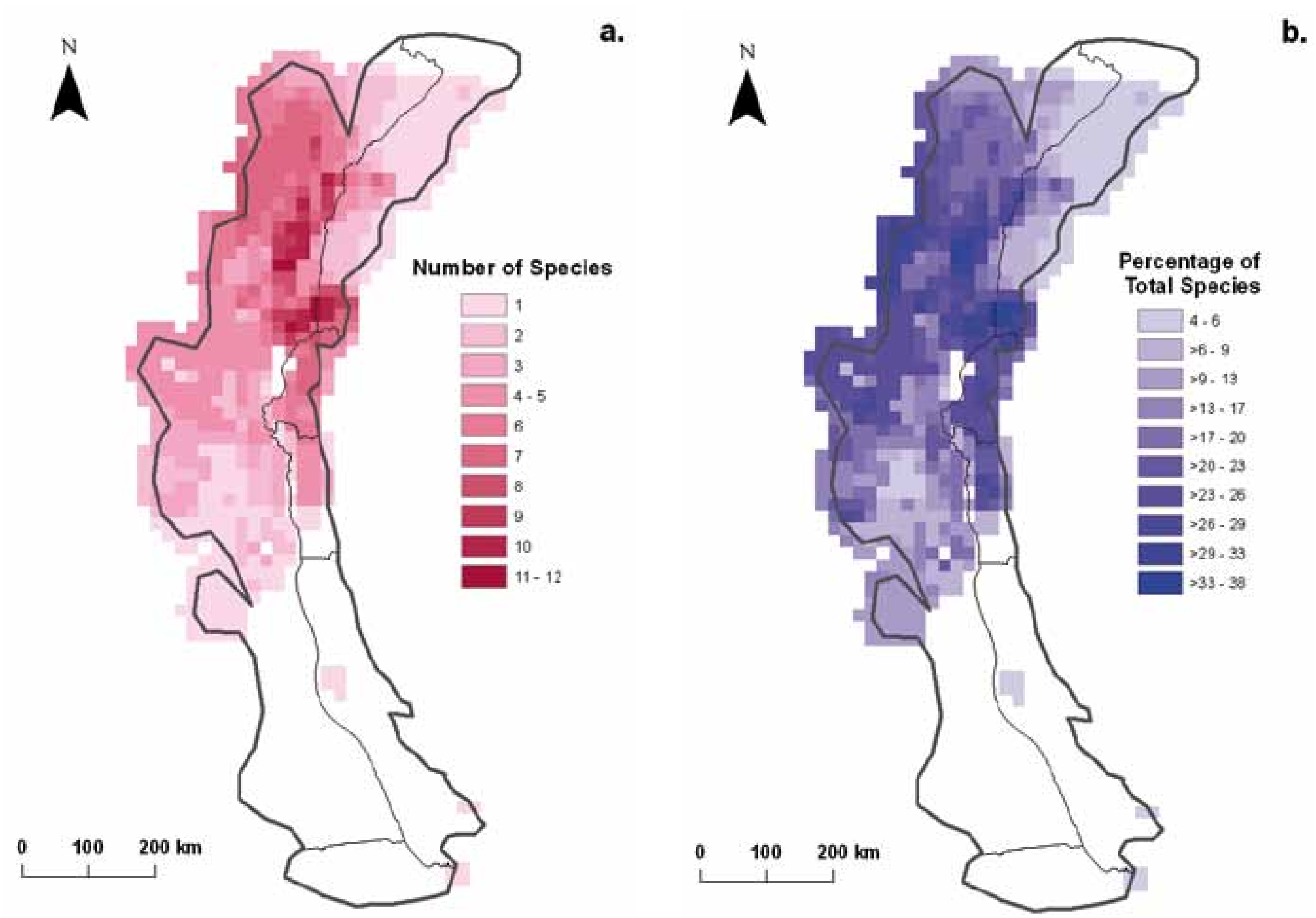

Figure 3.5 Distribution of climate change vulnerable amphibians in the AR. Map a. shows total numbers of species assessed as vulnerable to climate change impacts. Map b. shows the percentage of the total species present in each region that are climate change vulnerable.

high densities of climate change vulnerable amphibians include the northwest of the AR region (DRC) (where species richness is known to be highest (Figure 3.1)), and much of Rwanda and northern Burundi.

While Figure 3.5a, which displays counts of climate change vulnerable amphibians, identifies clear areas of high density in the region, proportions of climate change vulnerable species (Figure 3.5b) appear rather more uniformly distributed. Nevertheless, the same areas given above, in addition to the more southern areas close to Kahuzi-Biega National Park and West of the Itombwe Massif (both DRC), contain relatively high proportions of climate change vulnerable species – typically 20–30%.

3.4 Combined utilization, threat and climate change vulnerability results

The numbers and proportions of amphibian species known to be important for use, climate change vulnerable, globally threatened, and all combinations thereof are shown in Table 3.6.

A total of 14 species were assessed as being both important for use and climate change vulnerable. These species are *Afrixalus fulvovittatus*, *A. leucostictus*, *A. orophilus*, *A. osorioi*, *Hyperolius discodactylus*, *H. frontalis*, *H. langi*, *H. leleupi*, *H. leucotaenius*, *H. xenorhinus*, *Leptopelis modestus*, *X. ruwenzoriensis X. vestitus* and *X. wittei*. Under a pessimistic scenario of climate change vulnerability (see Methods, Section 2.2.1.3), the species *Callixalus pictus*, *Hyperolius diaphanus*, *H. ferrugineus*, *H. kuligae*, *Leptopelis christyi* and *L. oryi* would also be recognized being both important for use and climate change vulnerable, producing a total of 20 species.

Western Rift Puddle Frog (*Phrynobatrachus versicolor*)

This species occurs in the leaf litter of mountain forests in the eastern DRC, western Rwanda, north-western Burundi and south-western Uganda (Drewes and Pickersgill 2004) and is endemic to the AR (WCS 2011). It does not appear to be utilized by humans for any purpose, and its Vulnerable threat status is due to loss of its habitat due to conversion to agricultural land, wood extraction and human settlements.

P. versicolor was assessed as climate change vulnerable due to the comparatively large projected change in precipitation variability throughout its range. The species was assessed as being only able to tolerate a narrow range of precipitation regimes, and as being dependent on poorly oxygenated swamp habitats. Dispersal for this species is restricted by the presence of anthropogenic barriers, particularly agricultural areas and forest clearings, which are now present on a very large scale.

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Table 3.6 Numbers and proportions of AR amphibians known to be globally threatened (IUCN 2011), important for use and climate change vulnerable, and all combinations thereof, including (where applicable) both optimistic and pessimistic assumptions of missing climate change vulnerability data values.

	Amphibians (110 species)			
	Optimistic		Pessimistic	
	Number	%	Number	%
Total threatened*	12	11	12	11
Total used	49	44.5	49	44.5
Total cc vulnerable	34	31	51	31
Used and cc vulnerable	**14**	***13***	**20**	***18***
Used and not cc vulnerable	35	32	29	26
Not used and cc vulnerable	20	18	31	28
Not used and not cc vulnerable	41	37	30	27
Threatened and used	**6**	***5.5***	**6**	***5.5***
Threatened and not used	6	5.5	6	5.5
Not threatened and used	43	39	43	39
Not threatened and not used	55	50	55	50
Threatened and cc vulnerable	**7**	***6.5***	**9**	***8***
Threatened and not cc vulnerable	5	4.5	3	3
Not threatened and cc vulnerable	27	24.5	42	38
Not threatened and not cc vulnerable	71	64.5	56	51
Threatened, used and cc vulnerable	**5**	***4.5***	**6**	***5.5***

* Data Deficient, Near Threatened and unassessed species are grouped with 'not threatened' species.

The densities of AR amphibian species believed to be important for use, climate change vulnerable species (optimistic scenario), and combinations of the two are shown in Figure 3.6a. This image indicates that the Virunga National Park, Bwindi Impenetrable National Park, and areas surrounding the two (particularly northwest of the Virungas) are areas with highest densities of both used and climate change vulnerable species.

A total of six species (*Afrixalus orophilus*, *Callixalus pictus*, *Hyperolius discodactylus*, *H. frontalis*, *H. leleupi* and *H. leucotaenius*) were assessed as being both globally threatened and important for use. Figure 3.6b shows the geographic distributions of these species, and indicates that important locations containing highest densities of both threatened and used species include the area between (and including) the far-eastern limits of Kahuzi-Biega National Park (DRC) to the southern extreme of Virunga National Park, the area directly between Virunga National Park and Tayna Nature Reserve (DRC) and the region at the far north of Virunga National Park.

A total of seven species (*Afrixalus orophilus*, *Hyperolius chrysogaster*, *H. discodactylus*, *H. frontalis*, *H. leleupi*, *H. leucotaenius* and *Phrynobatrachus versicolor*) were assessed as being both globally threatened and vulnerable to climate change impacts. Under our pessimistic scenario of missing climate change vulnerability data the species *Callixalus pictus* and *Leptopelis karissimbensis* would also be recognized under both categories, giving a total of nine species. Figure 3.6c shows the geographic distributions of these species (optimistic scenario for missing data values), and indicates that important locations containing species recognized under both of these variables are very much similar to those containing threatened and used species (Fig. 3.6b), the only notable exception being the southern extreme of Virunga National Park. The similarities between Figures 2b and 2c are likely

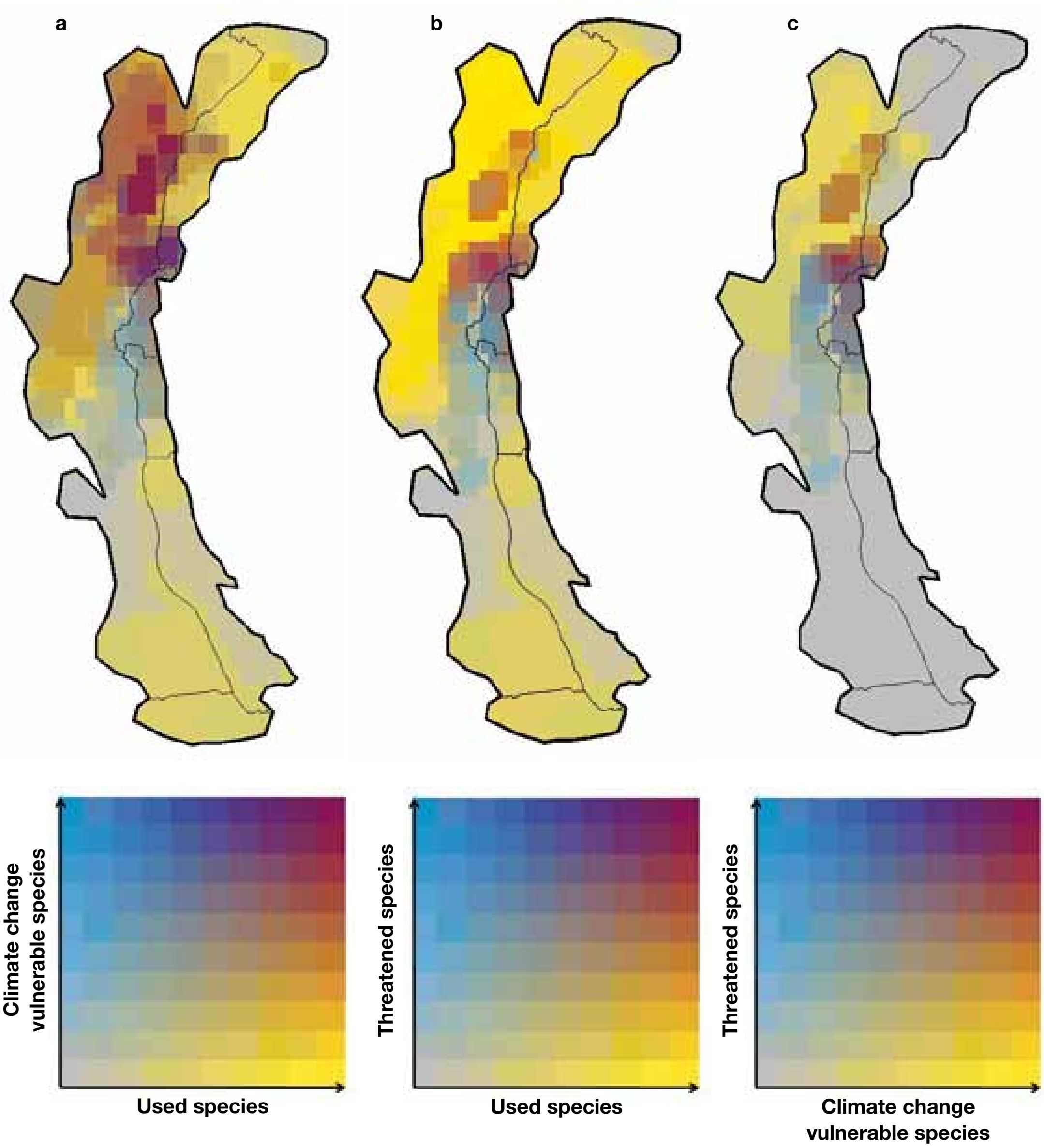


Figure 3.6 Bivariate plots combining results on climate change vulnerability and human use (a), global threat status and human use (b), and global threat status and climate change vulnerability (c) of AR amphibians. Plots use data on total numbers of species per grid cell qualifying under each variable.

the result of the relatively low number of threatened amphibians within our focal area, and the high overlap, within this list, of species that are both utilized and climate change vulnerable.

The five species that are recognized as being important for use, vulnerable to climate change and globally threatened are *Afrixalus orophilus*, *Hyperolius discodactylus*, *H. frontalis*, *H. leleupi* and *H. leucotaenius*. Under our pessimistic climate change scenario this list also includes *Callixalus pictus.*

Twenty-two AR amphibians are listed as Data Deficient on the IUCN Red List. This includes five species that are known to be used: *Hyperolius atrigularis*, *H. diaphanus , H. ferrugineus, H. xenorhinus* and the endemic Uganda Clawed Frog (*Xenopus ruwenzoriensis*). The latter two of these species are also believed to be climate change vulnerable. The following nine species are all also Data Deficient and climate change vulnerable: *Amietia desaegeri*, *A ruwenzorica*, *Arthroleptis spinalis*, *Boulengerula fischeri*, *Laurentophryne parkeri*, *Leptopelis fenestratus*, *Phrynobatrachus asper*, *P. dalcqi* and *P. sulfureogularis*.

Kivu Clawed Frog (*Xenopus vestitus*)

© Paul Freed

The Kivu Clawed Frog is found in south-western Uganda, eastern DRC and western and northern Rwanda (Tinsley *et al.* 2004), and is considered endemic to the AR (WCS 2011). Consultation with experts revealed that, of all species in the genus *Xenopus*, this one is most likely to be consumed by humans for food within the AR. Though currently not threatened, it is thought that local populations may be impacted by harvesting for human consumption (Tinsley *et al.* 2004).

The Kivu Clawed Frog is expected to experience relatively large changes in precipitation means and variability throughout its range. The species was assessed as Sensitive to climate change due to its narrow tolerance range of precipitation regimes, its reliance on swamp habitats and permanent water, its reliance upon rainfall to trigger migratory events, and its probable sensitivity to chytrid fungus (the impacts of which may increase as a result of climate change (Pounds 2001; Pounds *et al.* 2006)). As an inhabitant of the ponds and lakes at the base of the rift, the species is thought to be restricted in its ability to move as a response to climate change due to the presence of the rift walls and associated high mountains in some areas.

3.5 Conclusions and recommendations

Conclusions

- Data on the threat status of the amphibian species of the AR was readily available, due to the completion of the IUCN Global Amphibian Assessment in 2004. However, there was a notable lack of published information on human use of amphibian species, their contribution to AR people's livelihoods, and on aspects of certain species' ecology.
- Although it appears likely that certain amphibian species are eaten by people in the AR, the general consensus from consulted experts was that amphibians are only used at low levels for this purpose so are unlikely to contribute significantly to people's diets or incomes. However, this may change if other food sources become scarce.
- The amphibian pet trade may contribute to local incomes at low levels but it seems unlikely that many people rely heavily on the sale of amphibians to earn money.
- Of the 110 amphibians assessed in this study 31 were found to be climate change vulnerable under an optimistic scenario for values of missing data. This number increases to 51 under a pessimistic scenario, which demonstrates a moderate level of uncertainty (though low compared to other groups, such as fish).
- Important aspects of climate change vulnerability for AR amphibians include sensitivity of reproductive strategies to climatic change, habitat specialization among many species (particularly toward swamp habitats), a restricted dispersal ability due to geographic barriers (particularly swathes of cleared forest and agricultural lands), and a low capacity to adapt genetically at a sufficient rate to mitigate the impacts of climatic changes *in-situ* (due to a relatively low reproductive output). This last trait, however, represents the greatest area of uncertainty.
- The almost ubiquitous assessment of high climate change Sensitivity in AR amphibians is consistent with an emerging global literature describing observed climate change impacts on amphibians worldwide, and suggests that the whole group and particularly for the 43 species that are noted as being both sensitive and poorly able to adapt, should be a monitoring priority.
- Fourteen AR amphibians are currently recognized on the IUCN Red List as being threatened with extinction. This includes six species that are known to be used, and seven species believed to be vulnerable to climate change (of which five are both used and vulnerable to climate change).
- Twenty-two AR amphibians are Data Deficient on the IUCN Red List. This includes five species that are known to be used, and 11 species believed to be vulnerable to climate change (of which two are both used and vulnerable to climate change).
- Several geographic areas contain high numbers of used, climate change vulnerable and/or globally threatened amphibian species. These include Virunga National Park, Bwindi Impenetrable National Park, and the north-western corner of the AR in general.

Recommendations

- Increased research and monitoring of the human use of amphibians would allow the identification of species important for use specifically within the AR, and detect changes in harvest levels.
- Monitoring of the following in relation to climate is desirable: reproductive traits (e.g. timing, frequency, breeding success), species-specific habitat suitability (particularly of swamps and other wetlands) and any species range changes – particularly where a retraction in distribution is not coupled with an expansion elsewhere.
- Climate change adaptation interventions, where deemed necessary and appropriate, may include assisted breeding efforts, site-management or protection (e.g. from increased human water abstraction) or translocation to a more favourable site, among others. Care should be taken to follow the IUCN Guidelines for Reintroductions and Other Conservation Translocations (August 2012), particularly regarding risk assessment of such activities.
- Further research into the reproductive capacity and other aspects of the microevolutionary capacity (e.g. genetic health) of AR amphibians is desirable to determine species' abilities to adapt *in-situ*. Similarly, increased knowledge of species' distributions, particularly elevation limits (a prominent knowledge gap) will be essential if any range changes as a result of climate change are to be recognized.
- Conservation actions for threatened species should be continued or initiated wherever possible. Where not already the case, existing conservation efforts should consider the findings of this study and, wherever appropriate, should involve modifying conservation strategies, actions and research accordingly.
- Where not already occurring, focused research efforts should be undertaken on the 22 Data Deficient amphibian species found in the AR to determine their current threat status. In doing so, researchers should take note of, and expand upon, the information on the use of species and/or their vulnerability to climate change presented in this report.
- The geographic areas described above are of particular interest as they represent regions where conservation research and actions are most urgently required. Conservationists, developers, and all interested parties should be aware of the importance of these areas, but should also acknowledge that species highlighted in this assessment also extend into other areas, where numbers of species are lower overall.

Chapter 4. Birds

4.1 Overview of birds considered in the assessment

Our assessment considered a total of 972 bird species, within 78 families. The largest of the families represented were Muscicapidae (chats and Old World flycatchers; 58 species), Ploceidae (weavers and their allies; 54 species) and Accipitridae (ospreys, kites, hawks & eagles; 48 species). WCS (2011) recognizes a total of 42 bird species as being endemic to the AR. Based on this list, but following the taxonomic standards of BirdLife International (2012a), we recognize a total of 38 endemic birds.

Bird species richness is particularly high (supporting up to 611 species per grid cell) in the areas surrounding Lake Albert and Lake Edward, and the area in-between (Figure 4.1). This area of high richness coincides with Toro-Semliki Wildlife Reserve (Uganda) and much of the northern extent of Virunga National Park (DRC).

Other areas of high richness include much of Queen Elizabeth National Park (Uganda) and the area east of the Burundi border (DRC). Typically, species richness declines as one moves eastward and/or southward, and is lowest in cells representing the centres of the region's lakes (typically containing 14–17 species).

Of the 972 bird species considered, 27 are known to be globally threatened with extinction according to the IUCN Red List (BirdLife International 2012a).

Figure 4.2 shows the distribution of globally threatened birds throughout the AR region. Areas containing the greatest numbers (Figure 4.2a) of threatened species (up to 12 per grid cell) include Virunga National Park (DRC), the eastern portions of Kahuzi-Biega National Park (DRC), the Itombwe Massif (DRC), the area east of Lake Edward (DRC) and Nyungwe National Park (Rwanda). This is largely in agreement with Plumptre *et al*. (2003), who state that the Itombwe Massif contains the greatest number of threatened species of any protected area – 15 throughout its entirety – followed by Virunga National Park and Kahuzi-Biega National Park, which both support 11 threatened bird species.

Figure 4.2b shows the percentages of all species in each grid cell that are globally threatened. In general, such percentages are both relatively low and fairly uniformly spread across the AR region. Such low percentages reflect the high richness of bird species supported in the region, as well as demonstrating a clear correlation between the number of threatened species and number of species in any given grid cell.

4.2 Importance for human use

A total of 83 species were found to be important for use for some purpose[13]. Of these, 71 species (86%) were identified as being important for use as human food, 20 species (24%) as important for use in the pet trade, 10 species (12%) as important for medicinal purposes and four species (5%) as important for wearing apparel or accessories/jewellery. One additional species (*Balaeniceps rex*) was identified as being important for ecotourism. Use of birds for food

White-spotted Flufftail (*Sarothrura pulchra*) is hunted by humans for food and was assessed as vulnerable to climate change. © David Monticelli

[13] The terms 'important' and 'most important' are relative only to other bird species in the AR when discussed in this chapter, meaning that the importance of bird species cannot be compared with species in different taxonomic groups.

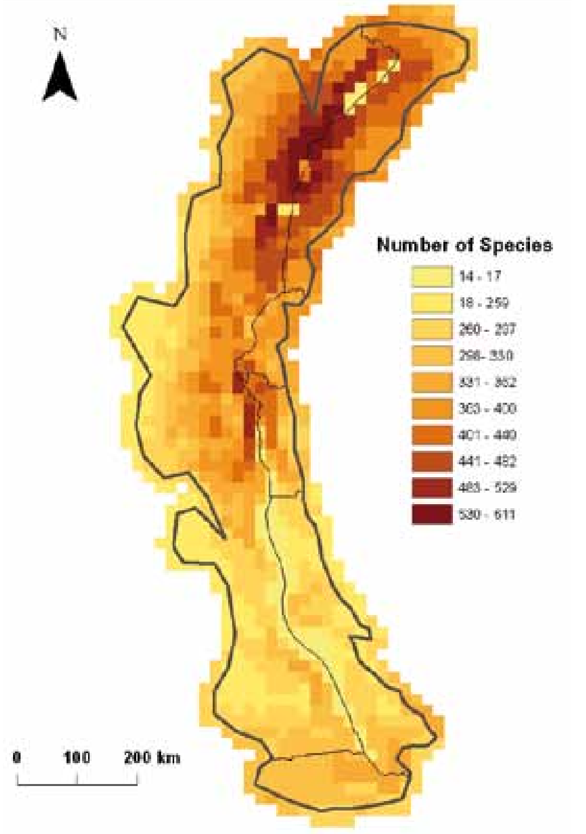


Figure 4.1. Species richness of birds throughout the AR.

The Regal Sunbird (*Nectarinia regia*) is an Albertine Rift endemic that was assessed as vulnerable to climate change under a pessimistic, though not optimistic, assumption of missing data values. © Carlos Pedro

Figure 4.2 Distribution of globally threatened birds (IUCN 2011) in the AR. Map (a) shows *total numbers* of species known to be threatened with extinction. Map (b) shows the *percentage of the total species present* in each region that are threatened.

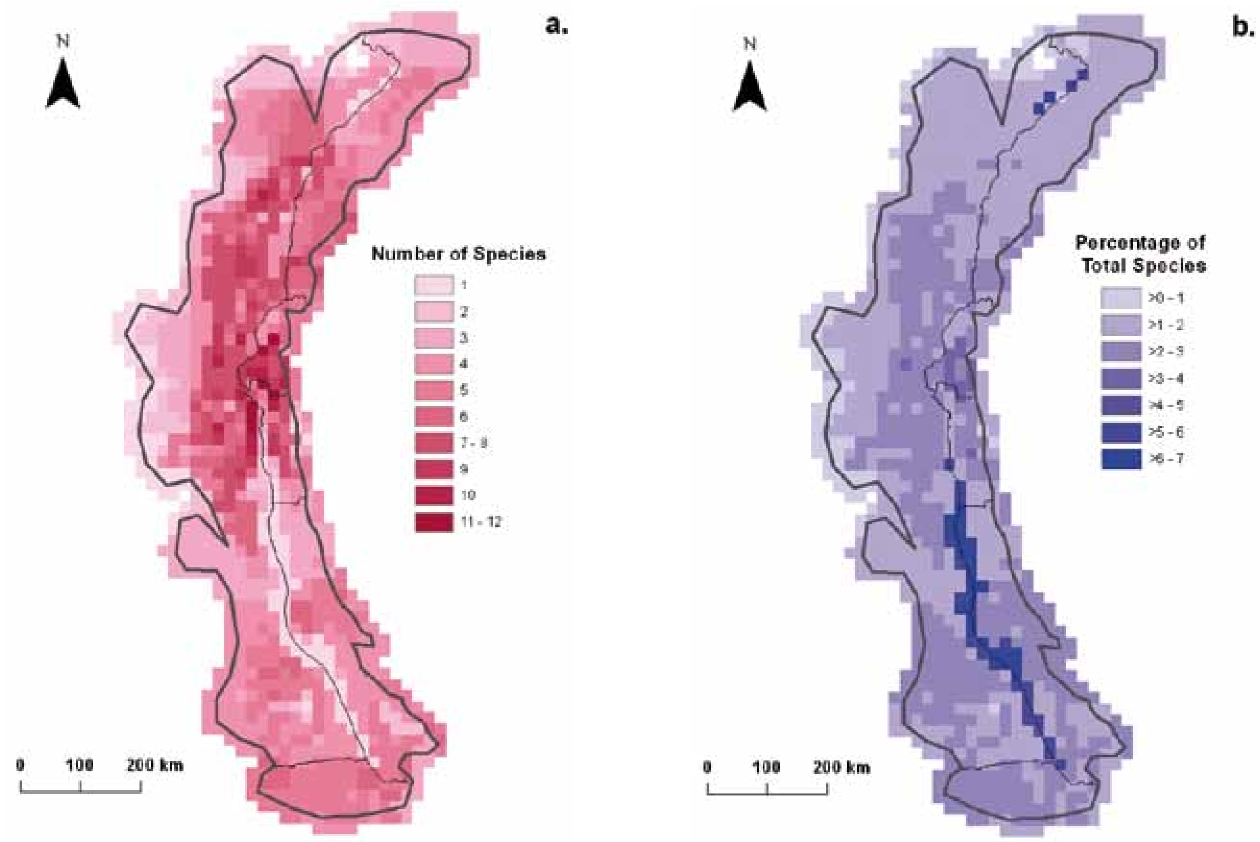


Table 4.1 Most important bird species for subsistence use and/or incomes in the AR.

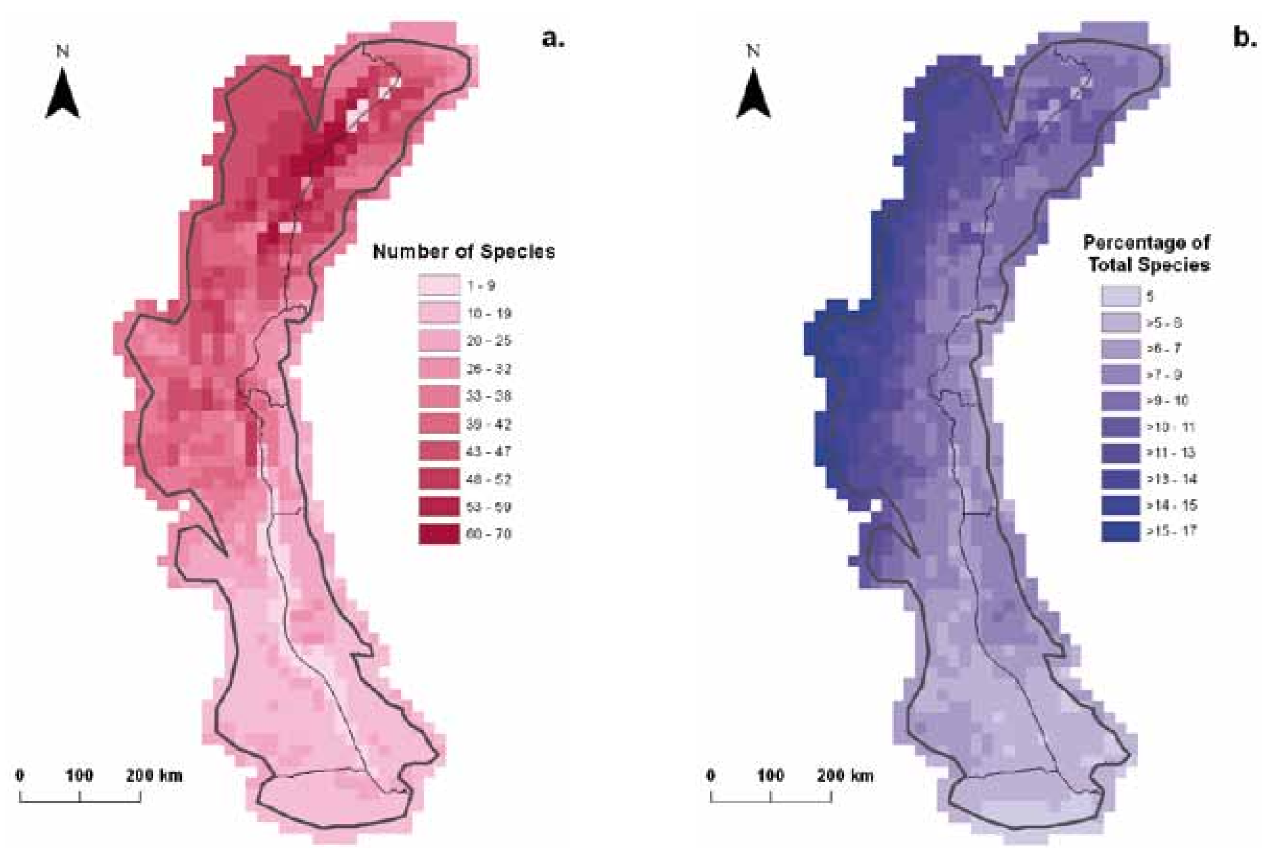
Species	Common Name	Endemic?	International Value?	Uses
Balaeniceps rex	Shoebill			Ecotourism
Balearica regulorum	Crowned Crane		Yes	Human food, medicine, decoration, ritual; pet trade
Colius striatus	Speckled Mousebird			Human food
Corythaeola cristata	Great Blue Turaco			Human food; feathers for rituals
Francolinus nobilis	Handsome Francolin	Yes		Human food; medicine
Guttera plumifera	Plumed Guineafowl			Human food
Numida meleagris	Helmeted Guineafowl		Yes	Human food, medicine, clothing, pet trade
Psittacus erithacus	Grey Parrot		Yes	Pet trade

is less extensive than for fish, mammals or plants for this purpose. It has been suggested that the extent of bird harvest, particularly for consumption as food, may be under-recorded in some surveys (Contesso 2009), so the actual importance of this taxonomic group may be higher than found in this study.

Eight bird species were identified as being most important for use, primarily for their use as food, but also for the income they generate through ecotourism and the pet trade (Table 4.1).

The highest density of bird species found to be important for use was in the west and north-west AR within the DRC, particularly in Nord-Kivu, Sud-Kivu and Maniema districts where densities can reach up to 17 birds per grid cell (Figure 4.3a). Densities are lowest in the southern AR, particularly in northern Zambia. The percentage of the total number of species that are important for use was highest around the DRC/Uganda border, particularly east of Toro-Semliki Wildlife Reserve and the northern part of Virunga National Park, where up to 70% of bird species were found to be important for use (Figure 4.3b).

Figure 4.3 Distribution of human-utilized birds throughout the AR. Map (a) shows *total numbers* of species known to be of importance for human use. Map (b) shows the *percentage of the total species present* in each region that are of importance for human use.



4.2.1 Harvest for human food

Birds seem to be less frequently targeted for meat than mammals, possibly because of their smaller size. Perhaps as a result of this, there have been fewer studies aiming to identify which bird species are utilized by people compared to those focusing on mammals. Seventy-one (85%) of the species identified as important for use were found to be used by people as a source of food, and this varied from species which are actively targeted to those which are caught opportunistically. Generally, the number of species actively targeted appeared to be few; many species were caught opportunistically or as bycatch in mammal nets. A study by Olupot *et al.* (2009a) identified that, of 38 species (across multiple taxonomic groups) being sold for wild meat near hunting sites in Uganda, only seven were birds. In this study, the number of pieces of bird meat recorded for sale was much lower than that for mammals. For example, between one and six pieces of meat/whole birds were recorded compared with 184 pieces of Hippopotamus meat and 171 pieces of Uganda Kob meat. This suggests that birds are not as commonly seen in trade as mammals, which may be due to larger mammals yielding more meat than birds.

Seemingly the most common taxonomic order hunted for wild meat are the Galliformes, whose species are typically large, relatively slow-moving (making them easier to hunt than their faster counterparts) and regarded as palatable (Ssemmanda and Fuller 2005). Within the Galliformes, guineafowl (family: Numididae) appear to be a popular food choice, including Plumed Guineafowl (*Guttera plumifera*), Crested Guineafowl (*G. pucherani*), Helmeted Guineafowl (*Numida meleagris*) and Black Guineafowl (*Agelastes niger*) all of which are categorized as Least Concern on the IUCN Red List as they are generally widespread, with large range sizes (BirdLife International 2009a; 2009b; 2009c; 2012b). The latter two of these species are considered stable while Plumed Guineafowl and Black Guineafowl are thought to be decreasing (BirdLife International 2009a; 2009b). Helmeted Guineafowl was regarded by experts as a key species in terms of fulfilling subsistence needs. A study of wild meat hunting at four field sites in Uganda (all within the AR) ranked guineafowl (species not specified) sixth (out of seven) for overall preference of the species, and this was the only non-mammal included (Olupot *et al*. 2009a). This hides some variation between sites, as guineafowl were identified as one of four species most frequently harvested and eaten by people at Murchison Falls National Park, Uganda. Guineafowl contribute to the income of local hunters, and were found to be sold at an average price of approximately USD1.3 per kg. The average guineafowl weighs 2 kg and has a high meat yield of approximately 80%, meaning that 1.6 kg of meat from a bird would be worth about USD2 (Moreski date unknown). This compares with livestock (beef, goat, mutton, and pork), which sold on average for USD1.7 per kg. Overall, the average price of all wild meat was found to be lower near to hunting sites (USD1.17 per kg) than at sites further away (USD1.75 per kg) (Olupot *et al*. 2009a). Ichikawa (1998) collected data in the Ituri Forest (DRC) and found that, whilst guineafowl may be frequently consumed, catching them was often incidental when hunting for mammal species. However, specific traps were sometimes made for catching guineafowl, mainly constructed by old men no longer capable of participating in the hunting of larger animals.

Other species of Galliformes found to be important for use as food in Uganda were the francolins. Information gathered from experts and published literature suggested that Red-necked Spurfowl (*Francolinus afer*) Forest Francolin (*F. lathami*) (Hart 1979; Ichikawa 1987; 1998), Handsome Francolin (*F. nobilis*) (and AR endemic) and Scaly Francolin (*F. squamatus*) (Ssemmanda and Fuller 2005) are all used as a source of human food. Each of these is listed on the IUCN Red List as Least Concern. It is suspected that other francolin species (of which there are a further 13 in the genus *Francolinus*) in the region are also used as food, but information specific to utilization of these other species was not found. Olupot *et al.* (2009a) found that a francolin species (*Pternistis* spp.) sold at market in Uganda for less than USD1 for the whole specimen, though this was only based on the price of one specimen being sold, and the species was not known. Olupot *et al.* (2009a) also found that francolins are considered crop raiders and, therefore, may be caught primarily as pest control, but eaten once killed.

Many bird species are hunted at low levels, either opportunistically or by children and the elderly. Ichikawa (1998) stated that some of the Mbuti children hunt small birds such as turacos (Musophagidae) with catapults in the Ituri Forest. Ichikawa (1998) identified only five groups of birds that the Mbuti people would not eat; Pied Wagtails (it is taboo to kill them), crows (thought to be ‘polluted’), owls (thought to be a witch’s watchman), nightjars (reason unknown but possibly because they are nocturnal), and swallows and swifts (not eaten but feathers are worn by hunters to increase their speed). Kizungu *et al*. (1998) found that the Tembo people in eastern DRC would eat 87% of the species present, though certain species were only eaten by older people.

In Tanzania, a study conducted just outside of the AR, found that bird hunting was common in the majority of villages, and that the main targets were doves, small game birds, weavers and song birds (Magige *et al*. 2009). Information specific to the AR for Tanzania was not found, but it is likely that if consumption of birds for food is widespread in other parts of Tanzania, it also occurs within the AR region.

It is not always mature birds which are targeted for food; experts identified Grey-headed Gull (*Larus cirrocephalus*) as a species whose eggs are collected for consumption, and Pink-backed Pelican (*Pelecanus rufescens*) whose young are collected. Scaly Francolin and Handsome Francolin eggs are also reportedly eaten during hunting expeditions (Ssemmanda and Fuller 2005). The eggs of Crested Guineafowl are eaten in Bwindi Impenetrable National Park (Uganda), particularly to gain extra protein during hunting excursions (Ssemmanda and Fuller 2005). In Tanzania (location unspecified), guineafowl eggs were sold at market, predominantly by children, for TSH100 (USD0.12)[14] per egg (Ministry of Natural Resources and Tourism 2000).

4.2.2 Harvest for the pet trade

In total, 16 species (19% of all birds identified as important for use) were found to be important for trade as pets, compared with other bird species in the AR, which included members of the Columbidae (four species), Estrildidae (three species), Psittacidae (two species) and Numididae (two species) families. All species are categorized on the IUCN Red List as Least Concern, except Shelley's Crimson-wing (*Cryptospiza shelleyi*) (Vulnerable) and Grey Parrot (*Psittacus erithacus*) (Near Threatened). All 16 species were found to have an international commercial value. Most species considered important for use for sale in the pet trade were identified either through expert consultation or by examining CITES trade data, wherein the assumption was made that if live birds were being traded from AR countries in relatively high numbers, they may have come from the AR on occasion. It is possible that certain species, such as Grey Parrot, may contribute significantly to some people's income. This species was once exported for the international pet trade in very large numbers from the DRC, with a CITES export quota of 10,000 live wild specimens in 1998, though this was lowered to 5,000 specimens in 2007. However, the contribution this species makes to incomes on the whole is unknown, and generally consulted experts thought most bird species in the pet trade only contributed to local income at a low level. Adult and juvenile Grey Crowned-crane are targeted for domestication and export, and the intensification of agriculture has led to an increase in conflicts between people and crop-raiding cranes, which has lead to further capture for domestication (Olupot *et al*. 2009b).

Shelley's Crimsonwing (*Cryptospiza shelleyi*) is a rare bird species found only in the Albertine Rift. It is currently listed as Vulnerable on the IUCN Red List™ and was assessed as vulnerable to climate change. This species is thought to be important for the pet trade and is also utilized for other display purposes.

There was little up-to-date information on the contribution to incomes made through the trading of birds as pets. A study of the commercial export trade in Tanzania described the nature of the trade in the early 1990s (Edwards and Broad, in Thomsen *et al.* 1992) as follows: each dealer sourced birds from an average of 25 traders, who themselves employed 5–10 villagers as trappers. This study found that for Meyer's Parrot (*Poicephalus meyeri*) (CITES Appendix II listed), trappers were paid USD2.21 per bird, whereas traders were paid USD3.10 per bird. Similarly, trappers were paid USD0.18 per bird for finch species (family: Fringillidae), compared with traders who earned USD0.31 per bird. One species of finch, *Serinus mozambicus*, was identified by experts as being used within the AR region for the purpose of the live pet industry. Using the 1990 export figures for finches (185,457 individuals) and Meyer's parrot (1,175 individuals), Edwards and Broad (in Thomsen *et al.* 1992) calculated that, in total, traders earned a minimum of USD35,400 between them, whilst all trappers combined earned a total of USD25,700. However, Tanzania currently has a zero export quota in place

14. Currency conversion carried out using 2000 conversion rates.

for Meyer's Parrot, so the contribution to household incomes from exporting this species is likely to have declined markedly. The same study estimated that between 4,150 and 8,300 people were directly employed in the wild bird trade, benefiting 40,000–80,000 people once family members are included, but cautioned that this is a likely overestimate of the real figure. Though this study illustrates the nature of the trade in the early 1990s, patterns of trade may have changed since.

Roxburgh *et al*. (2006) found that Shoebill (*Balaeniceps rex*) eggs and chicks were being harvested from Bangweulu Swamps, Zambia (outside of the AR) for zoos and collectors. Briggs (2007) suspects that this type of collection could be even greater in Tanzania due to the trade in Shoebills still being legal. This is supported by CITES trade data of the species; the vast majority of reported exports from AR countries for zoos were from Tanzania, and destined for countries in Europe, Asia and the USA. BirdLife International (2010) state that it is now the "most expensive bird in the world", due to the high prices that zoos are willing to pay.

4.2.3 Harvest for medicinal purposes

Ten species (12% of those found to be important for use) are believed to be important for medicinal purposes or in rituals, and two of these are listed as Vulnerable on the IUCN Red List (Albertine Owlet (*Glaucidium albertinum*) and Grey Crowned-crane). The remainder are listed as Least Concern. Half of these species were found to have an international commercial value, however there was little in-depth information on this type of use. Kizungu *et al*. (1998) conducted a study of the Tembo people who live in the east of DRC, and found that 12% of bird species found in the area were used for medicinal purposes. These include Black-casqued Hornbill (*Ceratogymna atrata*), which is used to treat headaches, Blue-headed Coucal (*Centropus monachus*) which is given to new mothers to ensure they produce milk, and the nest of African Pied Wagtail (*Motacilla aguimp*) which is used to treat asthma. None of these species were identified by other experts as being important for medicinal purposes, suggesting these practices may be specific to the Tembo people. In addition, the same study found that 13% of bird species were used for witchcraft and initiation ceremonies, including

Grey Parrot (*Psittacus erithacus*)

This long-lived species is native to all AR countries excluding Zambia. It is renowned for its amazing ability to mimic sounds, including the human voice, which makes it one of the most popular pet birds in Europe, the United States, the Middle East and, increasingly, China (BirdLife International 2012c). Unsustainable harvest for the pet trade has resulted in the species being categorized as Vulnerable on the IUCN Red List and it being listed in CITES Appendix II (i.e. trade strictly regulated) in 1981. Exports to Europe have been greatly reduced following the ban on the import of wild birds in 2007, and there have also been calls to consider a ban on all trade of birds originating in DRC due to a lack of capacity to manage the sustainability of such practices (H. Rainey *in litt.* 2007 in BirdLife International 2012c). Experts identified the Grey Parrot as a species that is harvested in the AR for the pet trade, and as having local, national and international commercial value. Between 2005 and 2010, DRC and Uganda reportedly exported 58,337 and 14 live wild grey parrots, respectively, of which nearly a third were sent to South Africa. No monetary values were available for AR countries, but in Cameroon a local trapper will typically sell a grey parrot for USD10 to a middle man who would sell it again for USD15. Once in the cities, it will be sold once more for USD20–30 (Ngenyi 2003).

Despite the fact that this species is expected to experience large changes in the variability of temperature regimes across its range and is tolerant of only a narrow range of temperatures, this species was not assessed as being poorly able to adapt, meaning that it is not considered to be climate change vulnerable overall.

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Long-crested Eagle (*Lophaetus occipitalis*) which is used by unmarried women to predict when they will marry, and the head of Black-casqued Hornbill which is used as a mask during Tembo initiatory rites in the forest.

Handsome Francolin was found to be used by traditional healers in Bwindi Impenetrable National Park, where this species only occurs at a low density. It is not known what ailment this species is used to treat and therefore how vital it is to fulfilling people's needs (Ssemmanda and Fuller 2005). As mentioned earlier, Grey Crowned-crane, which has been said to be in decline partly as a result of harvesting, is also said to be used for medicinal purposes in Uganda (Olupot *et al*. 2009b).

4.2.4 Harvest for other purposes

Four species were found to be important for use as wearing apparel, jewellery and other accessories; Grey Crowned-crane, Great Blue Turaco (*Corythaeola cristata*), Ross's Turaco (*Musophaga rossae*) and Helmeted Guineafowl. However it was not apparent that birds plays a major role in this type of use, and it is unlikely that these uses are essential to people's subsistence or incomes, or that the birds would be killed purely for this purpose. Ichikawa (1998) found that although the Mbuti people of the Ituri Forest (DRC) would use the feathers of hornbills and turacos for personal beautification, they were only used when found by chance (i.e. the birds were not hunted specifically for their feathers). Kizungu *et al.* (1998) identified several species which were used by Tembo people of eastern DRC to adorn themselves, including the tail feathers of Ross's Turaco, which are used on the hats and bags of traditional chiefs.

The high diversity of birds attracts tourists to the countries in the AR, and it is likely that a number of endemic species are highly sought after for viewing by dedicated bird watchers. Many such 'birding' tours seem to be aimed at wealthy foreigners, with prices of tours being quoted in US Dollars. A fully inclusive 'Pearl of Africa' bird watching tour in Uganda costs up to USD10,385 for 24 days, and states "perhaps Uganda's biggest attraction to birders is the chance to see a large number of Albertine Rift endemics" (lawsons-africa.co.za 2012). Although ecotourism has the potential to generate a large revenue, further work is needed to assess how much of this money reaches local people.

Tourists are also able to pay to hunt certain bird species, for example Tanzania has 14 game birds listed which tourists are able to hunt for a fee of between USD10–15. This fee is much lower than those charged for hunting larger mammals such as elephants (USD4,000), lions (USD2,000) or leopards (USD2,000) (Baldus and Cauldwell 2004) so is unlikely to generate a significant amount of income.

4.3 Climate change vulnerability

This study used bird data gathered for a global assessment of climate change vulnerability carried out by Foden *et al.* (submitted). For the 972 AR bird species assessed, we considered a total of 17 climate change vulnerability traits, of which four related to 'Exposure', eight to 'Sensitivity' and five to 'Low Adaptability'. These are shown in Tables 4.2, 4.3 and 4.4.

Through assessing species' Exposure to climatic changes (Table 4.2), we expect 321 species (33%) to experience relatively 'high' levels of climatic change their global ranges. A further 284 (29%) are expected to experience 'very high' levels of change. Of these 605 species, 184 are expected to be subject to marked changes in two of the four climatic variables investigated, 78 across three variables, and nine species (*Apus batesi*, *Centropus grillii*, *Francolinus albogularis*, *Glaucidium perlatum*, *Ploceus flavipes*, *P. heuglini*, *Prodotiscus regulus*, *Pterocles gutturalis* and *Terpsiphone bedfordi*) across all four.

In our assessment of species' Sensitivity to climatic changes (Table 4.3), 371 species (38%) were considered to possess traits that make them 'highly' Sensitive to climatic changes, and a further 186 (19%) to have 'very high' Sensitivity to changes. Of these 557 species, 367 possess one single trait, 109 possess two traits, 53 possess three traits, 23 possess four traits, four (*Accipiter castanilius*, *A. melanoleucus*, *A. minullus* and *A. nisus*) possess five traits, and one species (*Accipiter badius*) possesses six traits.

Within the Sensitivity analysis, the two most common traits possessed were those relating to narrow temperature and precipitation range tolerances (traits S4 and S5), which were each present in a total

Table 4.2 Climate change *Exposure* measures used to assess AR birds, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A2).

Trait Group	Trait	Sub-trait	Thresholds	BIRDS			
				Total species considered = 972			
EXPOSURE				Low	High	Very High	Unknown
A. Temperature change	Substantial changes in mean temperature occur across the species' range	**E1:** Absolute difference between 1975 and 2050 mean temperatures (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	729	146	97	0
	Substantial changes in temperature variability occur across the species' range	**E2:** Absolute difference between 1975 and 2050 values of average absolute deviation in temperature (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	729	146	97	0
B. Rainfall change	Substantial changes in mean precipitation occur across the species' range	**E3:** Absolute ratio of change in 1975 and 2050 values of mean precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	729	146	97	0
B. Rainfall change	Substantial changes in precipitation variability occur across the species' range	**E4:** Absolute ratio of change in 1975 and 2050 values of average absolute deviation in precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	729	146	97	0
			Total	**367**	**321**	**284**	
			Percentage	**38**	**33**	**29**	

Table 4.3 Climate change *Sensitivity* traits used to assess AR birds, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A2).

Trait Group	Trait	Sub-trait	Thresholds	BIRDS			
				Total species considered = 972			
SENSITIVITY				Low	High	Very High	Unknown
A. Specialized habitat and/or microhabitat requirements	Habitat specialization	**S1:** Number of IUCN habitat types occupied by species	L = >1; H = 1	894	77	n/a	1
	Microhabitat specialization	**S2:** Species has one or more microhabitat dependencies	L = False; H = True	879	92	n/a	1
	Intolerance of disturbance	**S3:** Species is dependent on primary forest and is intolerant of disturbance	L = False; H = True	856	115	n/a	1
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of changes to precipitation regimes	**S4:** Temperature range (max temp -min temp)	Average absolute deviation in temperature across the species' historical range: L = highest 75%; H = Lowest 25%	729	146	97	0
	Tolerance of temperature changes	**S5:** Precipitation range (maximum and minimum annual rainfall used to calculate range tolerated)	Average absolute deviation in precipitation across the species' historical range: L = highest 75%; H = Lowest 25%	729	146	97	0
D. Dependence on interspecific interactions which are likely to be disrupted by climate change.	Declining positive interactions with other species	**S6:** Dependence on one or more interspecific interactions that are likely to be impacted by climate change (e.g. specialized dependency on army ants)	H = Dependence on one or more interspecific interactions that are likely to be impacted by climate change; L = No dependency;	961	10	n/a	1
E. Rarity	Small population size	**S7:** Number of individuals in global population	L = ≥ 10,000; H = < 10,000	216	41	n/a	715
	Small effective population size	**S8:** Low number of reproducing individuals	H = < 20,000 and [(skewed sex ratio) or (polygynous or polyandrous breeding system) or (cooperative breeding system) or (declining or extremely fluctuating population trend)]; L = All other species	216	41	n/a	715
			Total	**415**	**371**	**186**	
			Percentage	**43**	**38**	**19**	

Table 4.4 Climate change *Low Adaptability* traits used to assess AR birds, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A2).

Trait Group	Trait	Sub-trait	Thresholds	BIRDS			
				Total species considered = 972			
LOW ADAPTABILITY				Low	High	Very High	Unknown
A. Poor dispersability	Low intrinsic dispersal capacity	**A1:** Mean maximum intrinsic dispersal distance	L = >1 km/year; H = ≤ 1 km/year	880	91	n/a	1
	Extrinsic barriers to dispersal	**A2:** Extrinsic barriers to dispersal	L = No known barriers; H = Occurs exclusively on mountaintops, small islands and/or polar edges of land masses	956	15	n/a	1
B. Poor evolvability	Low genetic diversity	**A3:** Evidence of low genetic diversity or known genetic bottleneck	L = False; H = True	970	1	n/a	1
	Slow turnover of generations	**A4:** Generation length	L = < 6 years; H = ≥ 6 years	732	240	n/a	0
	Low reproductive capacity	**A5:** Mean clutch size	L = >2; H = ≤ 2	487	271	n/a	214
			Total	**480**	**492**		
			Percentage	**49**	**51**		

of 243 species (146 'High' and 97 'Very High' Sensitivity)[15]. Another common Sensitivity trait, that of a primary forest-dwelling species highly intolerant of disturbance (trait S3), was recorded in 115 species (12%).

Ninety-two bird species were recorded as having microhabitat dependencies (i.e. dependent on bamboo, vines, fallen trees, deadwood, tree hollows, rocky outcrops in forests, caves, streams and/or bromeliads) (trait S2) and 77 species were habitat specialists (trait S1). High levels of specialization in such species suggest a narrow tolerance of conditions and, therefore, higher sensitivity to changes in habitat that may occur as a result of changes in climate.

In our assessment of species' capacity to adapt to climatic changes (Table 4.4), 492 species (51%) were assessed as possessing traits that make them poorly adaptable. Relatively large numbers of species were assessed as having a low likelihood of adapting genetically at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ*, as determined by their long generation lengths (six years or more for 240 species (25%); trait A4) and/or a low reproductive output (two or less offspring per year for 271 species (28%)) (trait A5). Ninety-one species (9%) are known to have relatively short mean maximum dispersal distances (≤1 kilometre per year; trait A1), meaning that they are unlikely to be able to keep track of shifting zones of suitable climate space. Fifteen species (1.5%) are considered unable to disperse in response to climate change due to the presence of geographic barriers (trait A2).

Of the 492 species noted as being poorly able to adapt, 367 possess one single trait, 124 possess two traits, and one species, the Shikra (*Accipiter badius*), possesses three of the four traits.

Overall, a total of 199 bird species (20%) were assessed as being of highest vulnerability to climate change due to being highly sensitive, likely to be highly exposed, and poorly able to adapt. Of these 199 species, 26 (13%) are endemic to the region. 382 species (39%) are expected to experience high levels of climate change across their ranges, are sensitive to climatic change, but are not noted as being poorly able to adapt. 279 species (29%) were assessed as both sensitive and unable to adapt to climate change, but are not expected to experience high levels of change (relative to other birds in the region). 315 species (32%) were assessed as both highly exposed and unable to adapt, but not being sensitive to climate change. Under a pessimistic scenario for missing data (see Methods, Section 2.2.1.3), a total of 441 species (45%) are considered climate change vulnerable.

15. Note that our classification of narrow environmental tolerances is a relative measure based on all species considered. See Section 2.2.2.2 for further details.

Table 4.5 shows the orders of the 199 climate change vulnerable species. The most prevalent orders represented are the Passeriformes (perhaps not surprising, as this group represent 54% of all species assessed), raptors (Falconiformes) and woodpeckers and their relatives (Piciformes).

Figure 4.5 shows the distribution of climate change vulnerable birds in the AR. Figure 4.5a suggests that densities of climate change vulnerable bird species are much higher (typically from 59 to 82 species per grid cell) in the northern half of the AR (approximately from the northern tip of Lake Tanganyika northwards), particularly along the central mountain chain, and either side of the Ugandan, Rwandan and Burundian borders with DRC. Key protected areas with high densities of climate change vulnerable species include the Itombwe Massif, the Réserve naturelle des primates Kisimba Ikobo, Virunga National Park (all DRC), Nyungwe National Park (Rwanda), Rwenzori Mountains National Park and Toro-Semliki Wildlife Reserve (both Uganda), though this list is by no means exhaustive, and densities appear equally high in many places surrounding these protected areas.

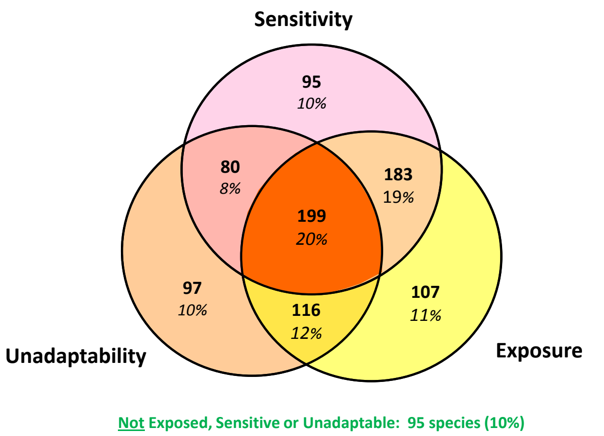

Figure 4.4 Numbers of AR bird species assessed as Exposed, Sensitive or and/or Unadaptable to climate change, and all combinations of the three.

Table 4.5 Climate change vulnerable bird species grouped by taxonomic order. Numbers in parentheses show percentages of the total species (within each order) considered for this assessment which are climate change vulnerable. Vulnerability figures are based on an optimistic scenario for missing data values.

Order	Number (and percentage) of climate change vulnerable bird species
Passeriformes	**85** (*16%*)
Falconiformes	**24** (*39%*)
Piciformes	**17** (*32%*)
Charadriiformes	**15** (*28%*)
Coraciiformes	**10** (*18%*)
Gruiformes	**10** (*38%*)
Apodiformes	**8** (*57%*)
Anseriformes	**7** (*37%*)
Caprimulgiformes	**5** (*36%*)
Columbiformes	**5** (*24%*)
Strigiformes	**4** (*19%*)
Ciconiiformes	**3** (*10%*)
Coliiformes	**2** (*67%*)
Cuculiformes	**2** (*6%*)
Pelecaniformes	**1** (*14%*)
Trogoniformes	**1** (*33%*)

Blue-headed Sunbird (*Nectarinia alinae*)

The Blue-headed Sunbird is an AR endemic, found in all AR countries except Zambia. Despite the fact that this species has a restricted range and a declining global population, it does not meet the thresholds required to designate it as threatened on the Red List. The species is also not believed to be important for use in any way.

The Blue-headed Sunbird was, however, assessed as vulnerable to climate change: climate projections suggest that the species is likely to experience large changes in the variability of precipitation regimes across its current range relative to other AR bird species. It is a habitat specialist, restricted to forests, and is therefore likely to be highly intolerant of change or disturbance. Finally, the species is believed to have a maximum dispersal distance of less than 1 km per year, making it unlikely to be able to track more favourable climates as they arise in new locations.

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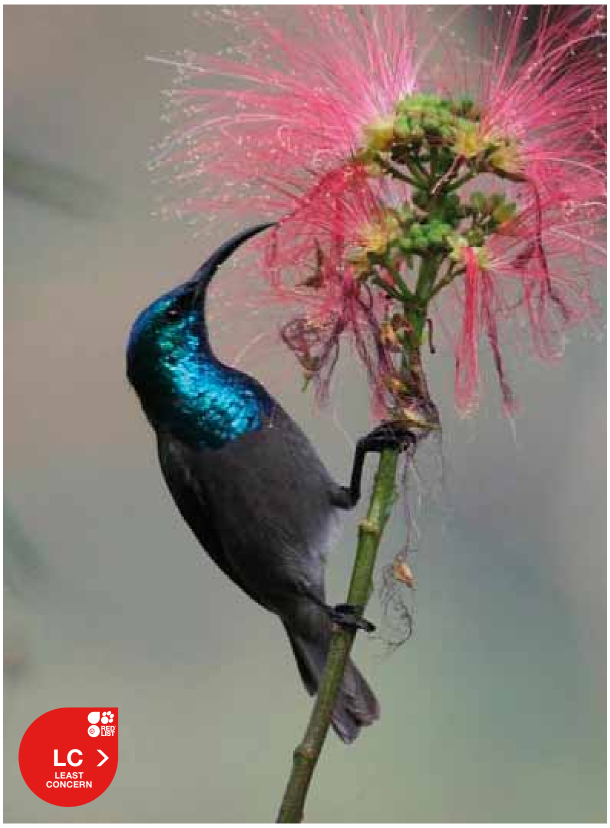

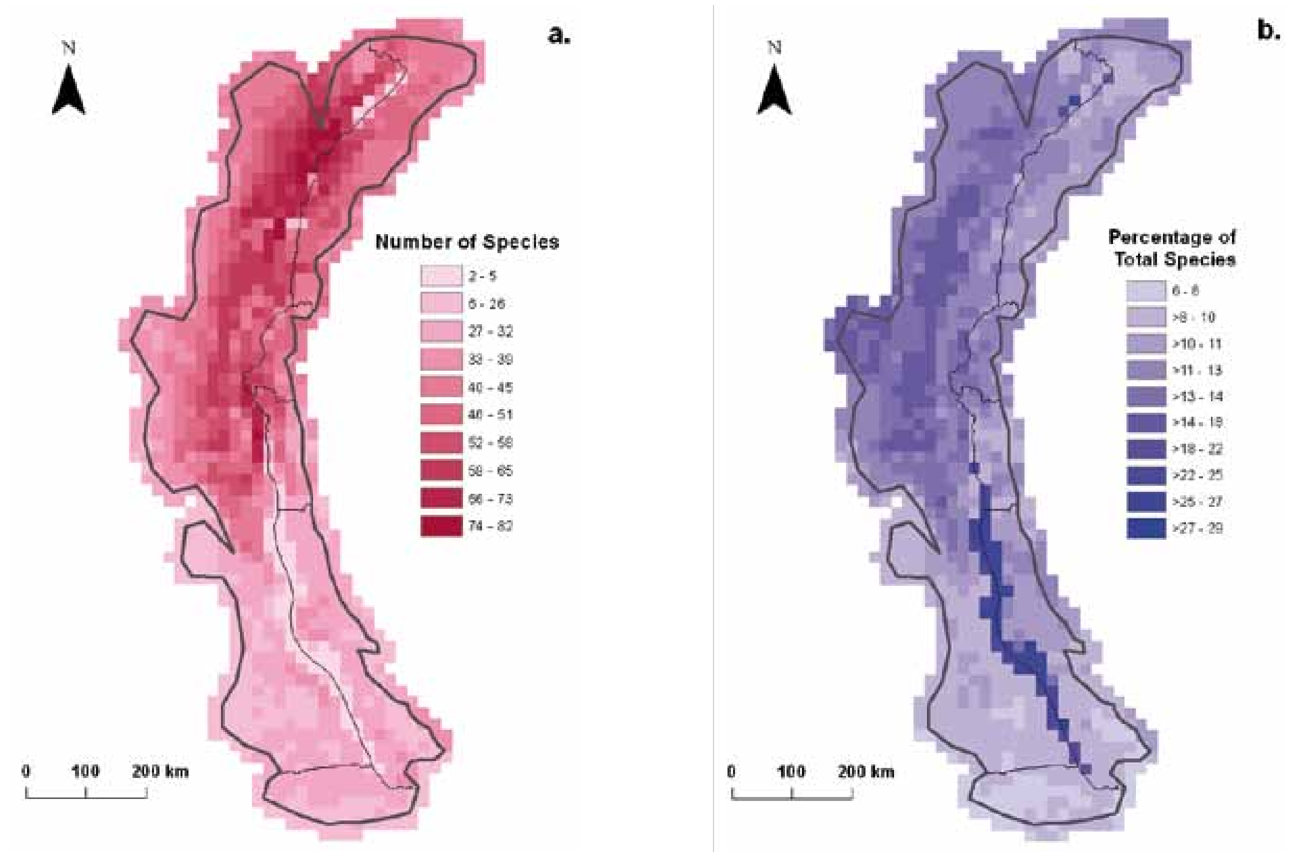

Figure 4.5 Distribution of climate change vulnerable birds throughout the AR. Map (a) shows total numbers of species assessed as vulnerable to climate change impacts. Map (b) shows the percentage of the total species present in each region that are climate change vulnerable.

Map 4.5b shows proportions of the total number of species per grid cell that are climate change vulnerable, and suggests that the northern half of DRC (with the AR boundary) contains some of the highest percentages (typically between 11 and 18 percent). Protected areas with visibly high proportions of climate change vulnerable species include the Réserve Naturelle de Tayna, the Réserve Naturelle des Primates Kisimba Ikobo, Kahuzi-Biega National Park and the Itombwe Massif (all DRC), though once again this list is not exhaustive, and other areas (particularly those in between the areas listed above) also have larger proportions of climate change vulnerable bird species. Lake Tanganyika appears to support the lowest numbers and highest proportions of climate change vulnerable bird species, most likely the result of the low bird species richness in cells located directly within the lake.

4.4 Combined utilization, threat and climate change vulnerability results

The numbers and proportions of bird species known to be important for use, climate change vulnerable, globally threatened, and all combinations thereof are shown in Table 4.6.

We assessed a total of 17 species as both important for use and climate change vulnerable. These species are *Balaeniceps rex*, *Balearica regulorum*, *Buccanodon duchaillui*, *Bycanistes subcylindricus*, *Ceyx lecontei*, *Cryptospiza shelleyi*, *Dendrocygna viduata*, *Gymnobucco bonapartei*, *Malimbus coronatus*, *Nigrita canicapillus*, *Pogoniulus scolopaceus*, *Pseudocalyptomena graueri*, *Sarothrura pulchra*, *Spermophaga poliogenys*, *S. ruficapilla*, *Terpsiphone bedfordi* and *Trachyphonus purpuratus*. Under a pessimistic scenario of climate change vulnerability (see methods, section 2.2.1.3), an additional 20 species would be recognized as being both important for use and climate change vulnerable, giving a total of 37 species.

The densities of AR bird species found to be important for use, climate change vulnerable (optimistic assumption of missing data values), and combinations of these are shown in Figure 4.6a. This image highlights the following areas as those with the highest densities of both used and climate change vulnerable bird species: the region north of Lake Tanganyika and west of the Burundian border (DRC) and the regions surrounding, and inbetween, Lakes Albert and Edward (including Virunga National Park (DRC), Toro-Semliki Wildlife Reserve, Rwenzori National Park and Queen Elizabeth National Park (all Uganda)).

A total of five species (*Balaeniceps rex*, *Balearica regulorum*, *Cryptospiza shelleyi*, *Glaucidium albertinum* and *Pseudocalyptomena graueri*) were assessed as being both globally threatened and important for use. Figure 4.6b shows the geographic distributions of species, and indicates that important locations containing highest densities of both threatened and used species include the northern extent of Virunga National Park, the Réserve Naturelle de Tayna, the Réserve Naturelle des Primates Kisimba Ikobo, and the region north of Lake Tanganyika and west of the Burundi border (all DRC).

A total of 17 species (*Apalis argentea*, *Balaeniceps rex*, *Balearica regulorum*, *Caprimulgus prigoginei*, *Chlorocichla prigoginei*, *Cryptospiza shelleyi*, *Egretta vinaceigula*, *Grus carunculatus*, *Hirundo atrocaerulea*, *Nectarinia rockefelleri*, *Phodilus prigoginei*, *Ploceus flavipes*, *Prionops alberti*, *Pseudocalyptomena graueri*, *Schoutedenapus schoutedeni*, *Torgos tracheliotos* and *Trigonoceps occipitalis*) were assessed as being both globally threatened and vulnerable

Table 4.6 Numbers and proportions of AR birds known to be globally threatened (IUCN, 2012), important for use and climate change vulnerable, and all combinations thereof, including (where applicable) both optimistic and pessimistic assumptions of missing climate change vulnerability data values.

	Birds (972 species)			
	Optimistic		Pessimistic	
	Number	%	Number	%
Total threatened*	27	*2.8*	27	*2.8*
Total used	83	*8.5*	83	*8.5*
Total cc vulnerable	199	*20.5*	441	*45.4*
Threatened and cc vulnerable	**17**	***1.7***	**23**	***2.4***
Threatened and not cc vulnerable	10	*1*	4	*0.4*
Not threatened and cc vulnerable	182	*18.7*	418	*43*
Not threatened and not cc vulnerable	763	*78.5*	527	*54.2*
Threatened and used	**5**	***0.5***	**5**	***0.5***
Threatened and not used	22	*2.3*	22	*2.3*
Not threatened and used	867	*89.2*	867	*89.2*
Not threatened and not used	78	*8*	78	*8*
Used and cc vulnerable	**17**	***1.7***	**37**	***3.8***
Used and not cc vulnerable	66	*6.8*	46	*4.7*
Not used and cc vulnerable	707	*72.7*	404	*41.6*
Not used and not cc vulnerable	182	*18.7*	485	*49.9*
Threatened, used and cc vulnerable	**4**	***0.4***	**4**	***0.4***

* Data Deficient, Near Threatened and unassessed species are grouped with 'not threatened' species

Shoebill (*Balaeniceps rex*)

The Shoebill has a widespread, but patchy distribution from the swamps of South Sudan to Zambia, encompassing parts of all AR countries excluding Burundi (BirdLife International 2012d). Threats to this species include destruction/degradation of its habitat and hunting and capture for the pet trade across its range (BirdLife International 2012d); and these have resulted in the species being categorized as Vulnerable on the IUCN Red List and listed in Appendix II of CITES (i.e. subject to strict trade regulation). During expert consultation, the Shoebill was noted as being important for ecotourism within the AR, as evidenced by the establishment of new tourism and eco-lodge developments in the Budongo Forest (Uganda) which are set up, in part, to cater for birdwatchers (Odull and Byaruhanga 2010). There are numerous websites promoting 'Shoebill tours', particularly in Uganda and northern Zambia. One company offering a 'Shoebill Camp Site' (Pearlsofuganda.org 2012) charges USD10 per night for camping and USD50 per boat for trips to see Shoebills at Murchison Falls National Park (Uganda). The Shoebill has the potential to further develop into an iconic 'must see' species for visitors to the AR, which would mean the possibility of generating income for local people through the provision of guides and necessary amenities for tourists.

The Shoebill is expected to experience changes in mean temperature and precipitation variability across its range. The species is has a low effective population size, making it inherently more vulnerable to extinction, including due to stochastic events (e.g. storms, droughts etc.) which are expected to change in both frequency and severity as a result of climate change. The species has a long generation time (> five years) and a low mean reproductive output (< three eggs per clutch), suggesting a low likelihood of adapting genetically at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ.*

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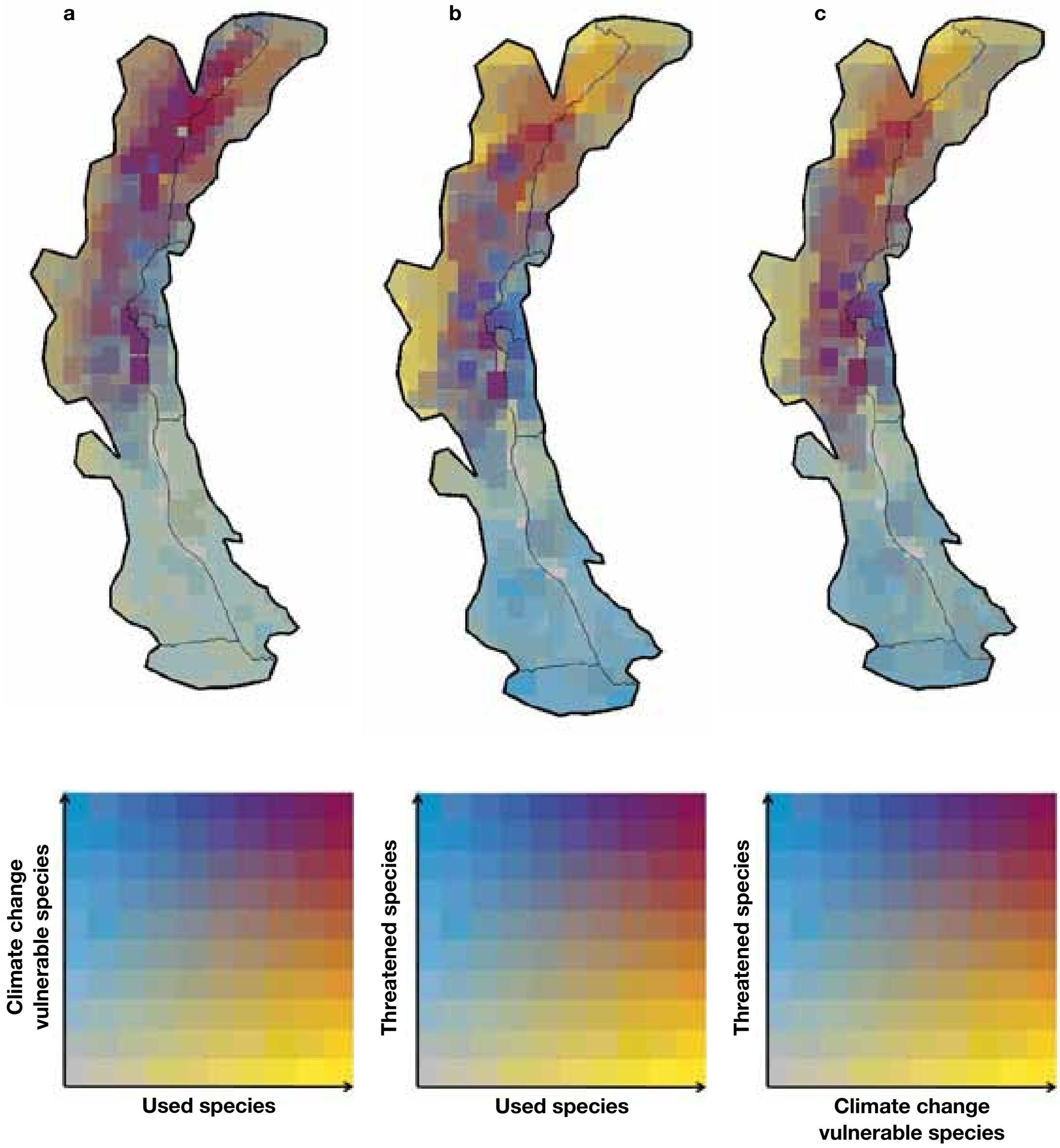
Figure 4.6 Bivariate plots combining results on climate change vulnerability and importance for human use (a), global threat status and importance for human use (b), and global threat status and climate change vulnerability (c) of AR birds. Plots use data on total numbers of species per grid cell qualifying under each variable.



to climate change impacts. Under a pessimistic assumption of missing climate change vulnerability data, the species *Afropavo congensis*, *Ardeola idea*, *Bucorvus cafer*, *Francolinus nahani*, *Necrosyrtes monachus* and *Ploceus aureonucha* would also be recognized under both categories, giving a total of 23 species. Figure 4.6c shows the geographic distributions of these species (under an optimistic assumption of missing climate change data), and indicates that important locations containing species recognized under both of these variables are very similar to those containing threatened and used species (Figure 4.6b). These include the northern extent of Virunga National Park, the Réserve Naturelle de Tayna, the Réserve Naturelle des Primates Kisimba Ikobo, and the region north of Lake Tanganyika and west of the Burundian border, which are all in DRC.

The four species that are recognized as being important for use, vulnerable to climate change and globally threatened are *Balaeniceps rex*, *Balearica regulorum*, *Cryptospiza shelleyi* and *Pseudocalyptomena graueri*. Under a pessimistic climate change scenario this list remains the same.

4.5 Conclusions and recommendations

Conclusions

- Birds are harvested as a source of human food in the AR, though in some cases this hunting is opportunistic and there are examples of birds being specifically targeted only by people who are unable to hunt large mammals (old men/children). However, it is possible that birds are consumed on a larger scale than has been documented, and reports that consumption of birds was increasing in eastern DRC (linked to a rising human population) may reflect similar trends occurring elsewhere in the region – trends which could intensify if mammal and fish stocks decline. Francolin and Guinea Fowl in particular are hunted for their meat, though many other species are hunted opportunistically. A broad range of species are used for sale as pets, and for medicinal purposes and rituals.
- Although involvement in the bird trade, either through collection, or as trading middlemen, is likely to be an important source of income for a select number of people, in general the contribution of the sale of wild birds as pets to local incomes seems fairly negligible, given the low numbers sold and seemingly low prices they fetch. The Dove family (Columbidae) contains the largest number of species that are traded as pets. However, since implementation of the EU wild bird import ban and the US Wild Bird Conservation Act, legal international trade in wild birds is far less profitable than it once was.
- Income can be derived through tourism and related industries that cater for the bird-watching and eco-safari communities. Bird-based ecotourism is beginning to develop within the AR and some successful enterprises are already established.
- Of the 972 birds assessed for this report 199 were found to be climate change vulnerable under our optimistic assumption of missing data values. This number increases to 441 under a pessimistic scenario, which demonstrates a moderately high level of uncertainty (though still lower than some of the other groups assessed for this study).
- Important aspects of climate change vulnerability of AR birds include habitat and microhabitat specialization among many species (including an associated intolerance of disturbance), a heightened sensitivity to stochastic events due low population size, an intrinsically low ability to disperse, and a low capacity for rapid microevolutionary adaptation due to a low reproductive output and/or a slow turnover of generations. Our greatest areas of uncertainty are population sizes and mean clutch sizes.

Grey Crowned-crane (*Balearica regulorum*) is currently listed as Vulnerable on the IUCN Red List™ and was assessed as vulnerable to climate change. The species is thought to be important to humans for several reasons, including as a source of protein, to derive medicines, for the pet trade, and for making feather-based handicrafts and jewellery. © James Gaither

- Twenty-seven AR birds are currently recognized on the IUCN Red List as being threatened with extinction. This includes five species that are known to be used, and 17 species believed to be vulnerable to climate change (of which four are both used and vulnerable to climate change). Three AR birds are currently Data Deficient on the IUCN Red List, including the Eastern Wattled Cuckooshrike (*Campephaga oriolina*) which was assessed as vulnerable to climate change impacts.
- Several geographic areas contain high numbers of used, climate change vulnerable and/or globally threatened bird species. Among others, these include the region of DRC found north of Lake Tanganyika and west of the Burundian border, and large expanses in the north and north-west of the region, including protected areas such as Virunga National Park.

Recommendations

- Research into wild meat consumption in the AR has focused largely on mammals and fish, and further study is needed to reliably determine the contribution of birds to subsistence uses and household incomes. Harvesting of birds may increase if the availability of other meats decreases, so it is important to monitor any changes in consumption patterns once baseline data have been gathered.
- We recommend an investigation of the suitability of the wild farming/domestication or ranching of wild bird species as a means of providing meat to alleviate pressure on wild populations. This may be appropriate in situations where people harvest from the wild because they have a preference (i.e. meat is more palatable) for wild species rather than livestock. However, careful consideration is needed to identify whether these alternatives are suitable for the AR and its people, and if so, which species would be most appropriate. Species of Guineafowl seem well suited due to their palatable meat and eggs, and low maintenance costs. Any harvesting from the wild to supply parent stock or eggs should be sustainably managed to ensure the practice does not negatively impact wild populations.
- We encourage all stakeholders (e.g. residents, government bodies etc.) of the AR region to capitalize further on the high bird diversity and endemism present. We recommend a study of how existing ecotourism benefits local people and generates incomes, and how this can be further developed in a sustainable manner. Important lessons can be learnt from the more established gorilla and chimpanzee ecotourism industry in the AR, which generates large revenue for the countries involved.
- Monitoring of the following areas in relation to climate is desirable: habitat suitability; species range changes, particularly where a retraction in distribution is not coupled with an expansion elsewhere; and population sizes. An increased knowledge of species' population sizes and abundances is essential if we are to track changes. Also, further research into the reproductive outputs of AR birds would give insights into their capacity to adapt to change.
- Climate change adaptation interventions, where deemed necessary and appropriate, may include *ex-situ* assisted breeding efforts, site-management, protection of key habitats and translocation to more favourable or additional sites in order. Care should be taken to follow the IUCN Guidelines for Reintroductions and Other Conservation Translocations (August 2012), particularly regarding risk assessment for such activities.
- Conservation actions for threatened species should continue to be implemented wherever possible. Conservation efforts should take note of the findings on species use and/or climate change vulnerability presented in this work, and conservation strategies, actions and research should be initiated or modified accordingly. Increased research into the threat status and ecology of the three Data Deficient bird species is highly encouraged.
- The highlighted geographic areas listed above are of particular interest as they represent regions where conservation research and actions are of greatest importance. Conservationists, developers, and all interested parties should be aware of the importance of these areas, but should also acknowledge that species highlighted in this assessment may occur in other areas, perhaps where numbers of species are lower overall, or where a lower proportion have been highlighted.

Chapter 5. Freshwater fish

5.1 Overview of freshwater fish considered in the assessment

Our assessment considered a total of 551 freshwater fish taxa, within 24 families. By far the largest of the families represented in our assessment was Cichlidae (cichlids; 234 species). The next largest families were Cyprinidae (carps, true minnows and their relatives; 88 species) and Mochokidae (squeakers and upside-down catfish; 37 taxa). The AR supports approximately 223 endemic freshwater fish taxa (identified through the database Fishbase), and many of these can be found in just one lake or river. Fish were the only taxon for which analyses were occasionally conducted at the sub-species level. This was due to the importance of certain sub-species (e.g. *Protopterus aethiopicus* ssp. *aethiopicus*) for human use, and the availability of experts' taxonomic guidance. Taxon richness of freshwater fish is considerably higher in Lake Tanganyika than anywhere else, where one can typically find 226–253 taxa per grid cell Figure 5.1. In specific areas, such as the far north of the lake (DRC and Burundi) and the region near to Gombe Stream National Park (Tanzania) taxon richness can reach up to 282 taxa per grid cell.

Although all other locations across the AR support much lower numbers of freshwater fish taxa than Lake Tanganyika, areas with relatively high richness include the north-eastern area of the domaine de chasse de la Luama-Kivu, the area due east of the domaine de chasse de la Luama-Katanga (both DRC), and the area west and northwest of Mweru-Wantipa National Park (Zambia), which are all found on the western periphery of the AR and typically support between 86 and 113 freshwater fish taxa.

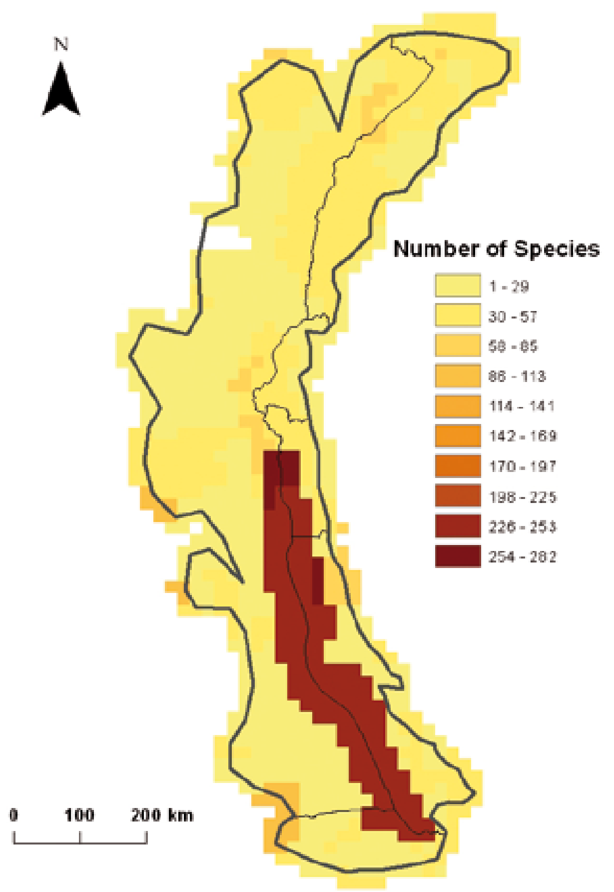
Most other areas within the AR support much fewer taxa – typically between one and 57 taxa.

Of the 551 freshwater fish taxa considered in this study, 42 are known to be globally threatened with extinction according to the IUCN Red List (Darwall *et al*. 2011), and 13 of these are AR endemics. Fifteen taxa considered in our assessment have not yet been evaluated for the Red List, and 41 are considered Data Deficient. The species *Barbus microbarbis* was not included in this assessment as it is regarded by IUCN as having gone extinct (Ntakimazi 2006). For more information on these assessments please see the IUCN Red List of Threatened Species website (http://www.iucnredlist.org/).

Figure 5.2 shows the distribution of globally threatened freshwater fish in the AR region. Areas containing the greatest numbers of threatened taxa (Fig. 5.2a) include Lake Tanganyika (14–16 taxa per grid cell), as well as the areas in and around the region's other lakes: Albert, George, Edward and Kivu. Threatened freshwater fish taxa can also be found at the far northern extent of the AR (in and around Murchison Falls National Park (Uganda)), the south-eastern extent (surrounding Lyango Hill Forest Reserve, Tanzania) and the south-western extent, surrounding the Mweru-Wantipa National Park (Zambia), which is flanked by two large lakes, Lake Mweru and Lake Mweru-Wantipa.

Figure 5.2b shows that the greatest percentages of threatened taxa can all be found in areas on the eastern edge of the Rift, including areas surrounding the Rwanda-Uganda border (including the Ramsar-designated Rugezi-Bulera-Ruhondo Wetlands) and the far eastern area of the Burundian portion of the Rift, where up to 57% (though more typically 15–26%) of freshwater fish taxa are believed to be globally threatened. The south-eastern area surrounding Chala Hills

Figure 5.1 Species richness of freshwater fish in the AR. In contrast to most other maps in this document, this plot uses equal interval breaks.



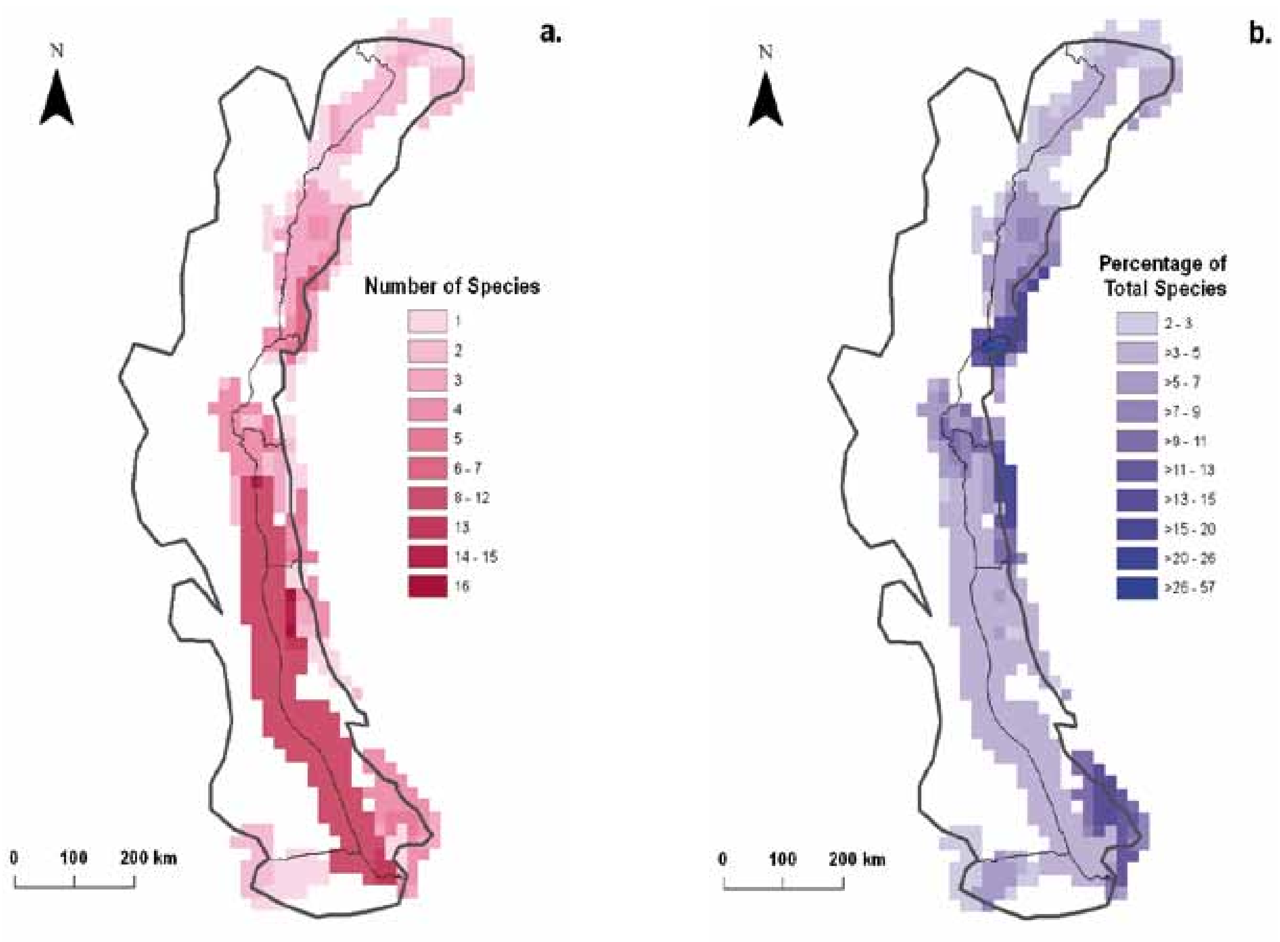


Figure 5.2 Distribution of globally threatened freshwater fish (IUCN 2011) in the AR. Map a shows *total numbers* of taxa known to be threatened with extinction. Map b shows the *percentage of the total taxa present* in each region that are threatened.

Small-scale fisheries are vital for subsistence and support local economies. © Chris Bene, WorldFish

Forest Reserve (Tanzania) also contains high proportions of threatened taxa (up to 15%). By contrast, a relatively low proportion of Lake Tanganyika's fish taxa (typically 3–5%) are threatened with extinction.

5.2 Importance for human use

The AR contains numerous rivers, swamps and freshwater lakes. While production from the largest lakes (i.e. Lakes Albert, George, Edward, Kivu and Tanganyika) is usually relatively well reported, that from smaller water bodies is often overlooked, meaning that there is very little published literature on these. Nevertheless, the contributions that smaller water bodies can make to the nutrition and incomes of the rural poor can be considerable (FAO 2004a). However, due to the known importance of the five large lakes listed above, and the amount of published literature available on these, the focus here is given to them.

Of the 551 fish taxa considered in this assessment, 330 (60%) were found to be important for use[16]. The principal motive for harvesting fish in the AR was found to be for human consumption, and 137 taxa (42% of those used) were found to be important for this use. Since fishing methods are generally unselective, catches are likely to contain a diverse array of taxa. As the vast majority of fish taxa present in the lakes are edible, most taxa are likely to be consumed at some level, if only to fill subsistence needs. Of the 330 taxa found to be important for use, 141 (43%) were identified as being used for subsistence purposes, 219 (66%) were identified as having some sort of local commercial value, 13 (4%) as having some national commercial value (though this was the hardest variable for which to obtain information) and 28 (8%) as having some international commercial value.

In total, 217 taxa (66% of used taxa) were identified as important for use in the aquarium trade, 27 (8%) as important for sport fishing, and a number for other uses at low levels. However, these other low-level use types (including others such as medicines and poisons) appear to be less important for people in the region and much less literature was available on these.

Due to their contribution to subsistence uses and household incomes, 18 taxa were identified as being the most important (Table 5.1). Efforts were made when selecting these most important taxa to

[16] The terms 'important' and 'most important' are relative only to other fish species in the AR when discussed in this chapter, meaning that the importance of fish species cannot be compared with species in different taxonomic groups.

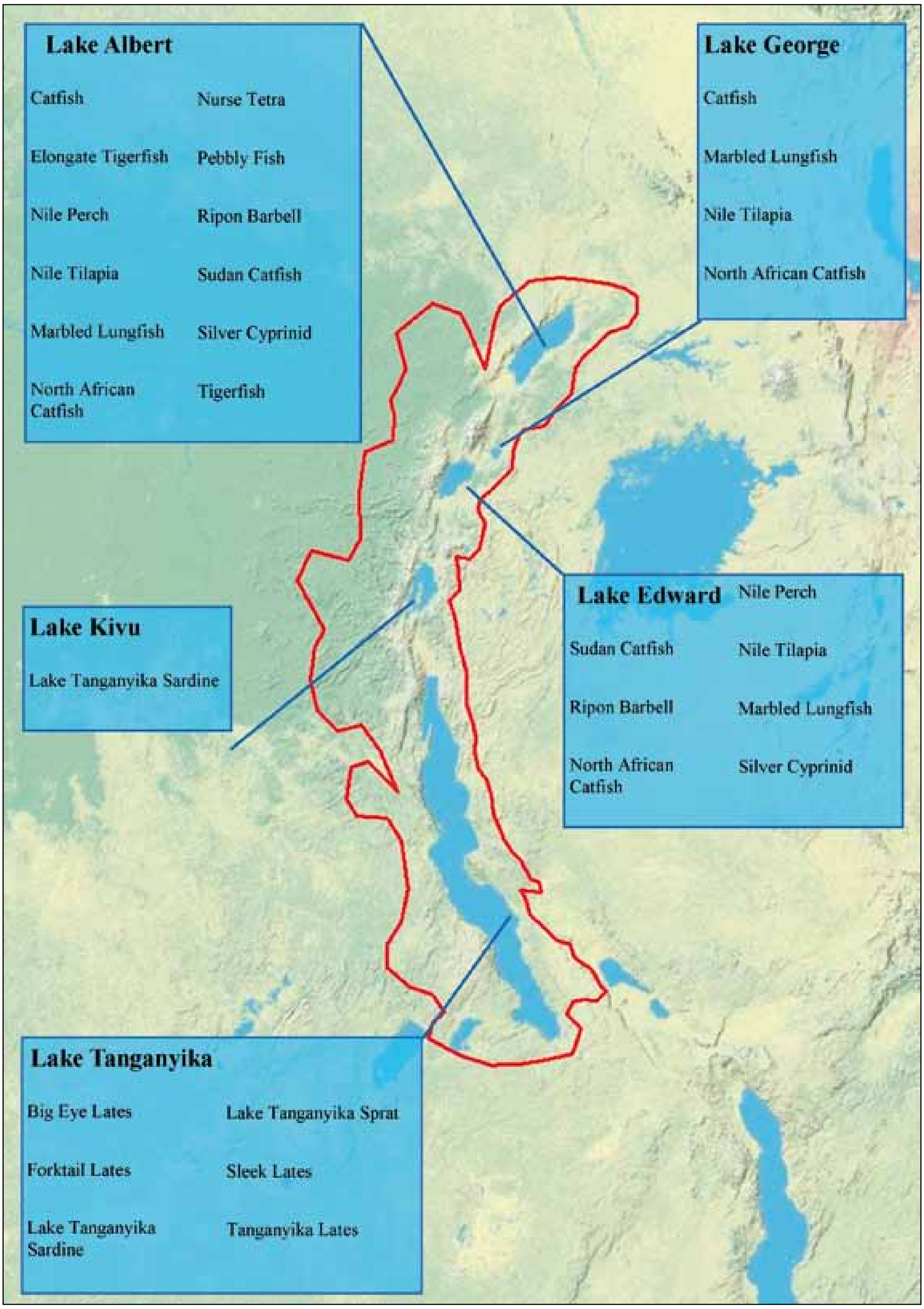
Table 5.1 The most important freshwater fish taxa for subsistence use and/or incomes in the AR.

Taxon	Common Name	Endemic?	International Value?	Uses
Alestes baremoze	Pebbly Fish		Yes	Human food
Bagrus docmak	Sudan Catfish			Human food; medicine; sport fishing
Barbus altianalis	Ripon Barbell			Human food; sport fishing
Brycinus nurse	Nurse Tetra			Human food; pet trade
Clarias camerunensis	Catfish			Human food
Clarias gariepinus	North African Catfish			Human food; medicine; sport fishing
Hydrocynus forskahlii	Elongate Tigerfish			Human food; sport fishing
Hydrocynus vittatus	Tigerfish			Human food; sport fishing
Lates angustifrons	Tanganyika Lates	Yes	Yes	Human food; sport fishing
Lates mariae	Big-eye Lates	Yes	Yes	Human food; sport fishing
Lates microlepis	Forktail Lates	Yes	Yes	Human food; sport fishing
Lates niloticus	Nile perch		Yes	Human food; medicine; sport fishing
Lates stappersii	Sleek Lates	Yes	Yes	Human food
Limnothrissa miodon	Lake Tanganyika Sardine	Yes	Yes	Human food; animal food
Oreochromis niloticus* ssp. *eduardianus	Nile Tilapia			Human food
Protopterus aethiopicus* ssp. *aethiopicus	Marbled Lungfish			Human food; medicine
Rastrineobola argentea	Silver Cyprinid			Human food; animal food
Stolothrissa tanganicae	Lake Tanganyika Sprat	Yes	Yes	Human food

represent those from the region's different lakes, as well as those that appear to be most important for utilization overall. Much of the focus of the remainder of this section will be on the 18 taxa in Table 5.1, in particular those believed to be common in international trade. The main lakes from which these 18 taxa are harvested from are shown in Figure 5.3.

As might be expected, the highest density of freshwater fish taxa identified as important for use can be found in Lake Tanganyika, where densities reach up to 222 taxa per grid cell in Tanzania and Burundi (Figure 5.4a). A similar pattern emerges when considering the percentage of total taxa; in Lake Tanganyika and Lake Kivu between 84–100% of all taxa present were found to be used (Figure 5.4b).

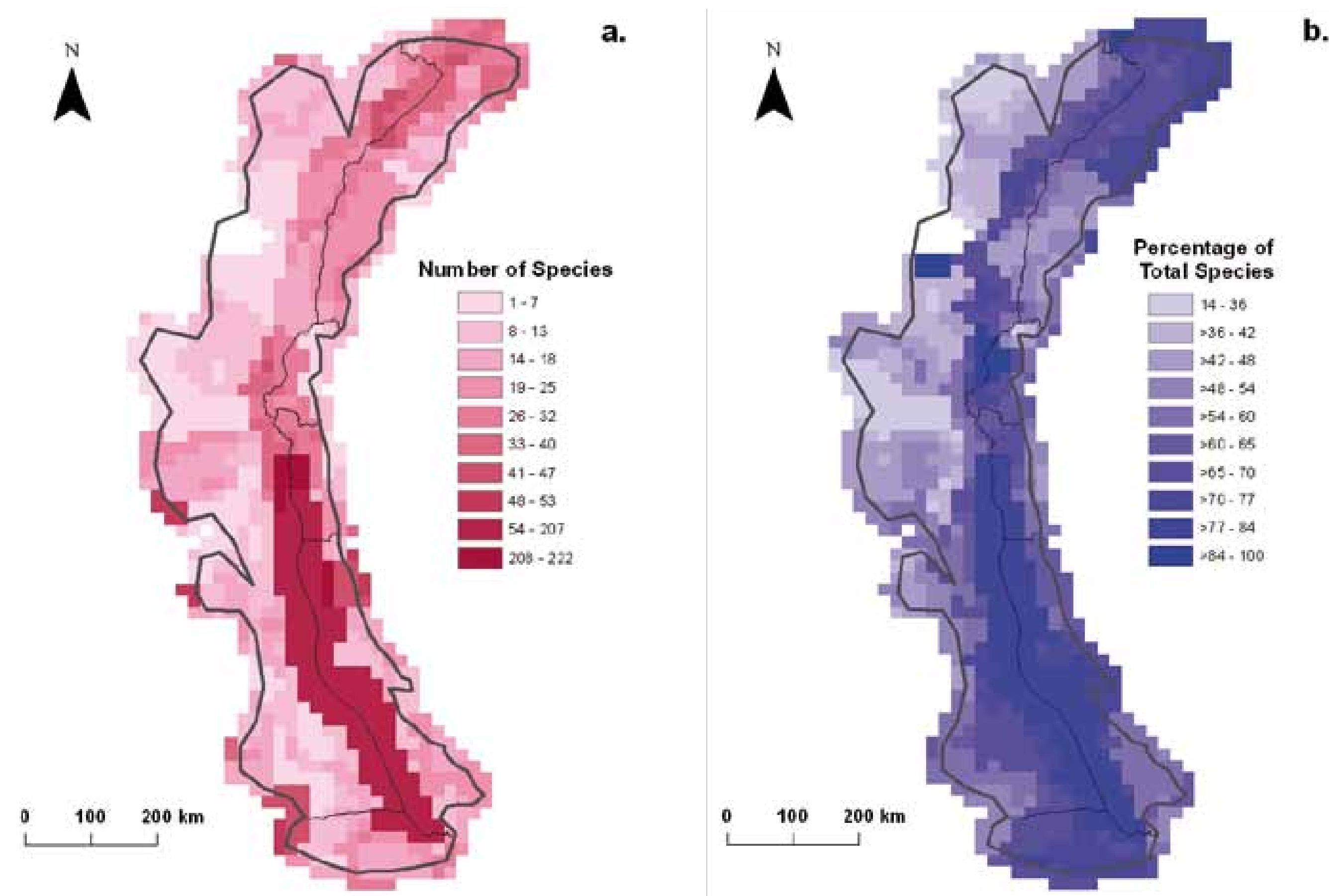
Figure 5.3 Most important freshwater fish taxa caught in the major lakes of the AR.



According to Kent (1986), global fishing methods can vary from traditional and artisanal fisheries to industrial. Traditional fisheries involve households using small fishing craft (or no craft) making short trips close to the shore to catch fish mainly for their own consumption. Artisanal fisheries may operate in a similar manner but utilize low levels of technology and catch fish to be sold as well as for consumption. Both traditional and artisanal fisheries are labour intensive (FAO 2005a). Industrial fisheries generally involve people catching, processing and/or selling fish as an employee of some form of corporation, where the fish are seen as a commodity rather than an item of food. Industrial fishing utilizes technology, is able to generate large sums of revenue and harvest much greater volumes of fish, and is typically aimed at the export market (Kent 1986). The fisherfolk themselves also vary; they may fish as a full- or part-time occupation, and may be engaged in the industry on a permanent or more temporary basis. Catch volumes are given throughout this chapter, but should be treated with caution as statistical data for the fishing industry is weak, often over-estimating legal landings (Kaelin and Cowx 2002) but not including illegal fishing.

Fishing contributes to livelihoods through the provision of food, employment and as a source of income through the sale, processing (e.g. gutting, smoking, drying, frying, salting etc.) and transportation of harvested fish. Fish are sold at the local or national level (e.g. to markets or restaurants, either locally or elsewhere in the country), or traded internationally (including to neighbouring countries and to those on different continents). The long distance and cross-border trade is dominated by men and requires hundreds of dollars of capital (West 2001). Larger operators typically have the capital to buy large quantities of fish at low prices, and transport them to distant locations to be sold for a substantial profit (Reynolds and Molsa 2000). As with direct utilization, levels of reliance on fish and their products for income vary across the region, but in general levels of reliance for income appear to correlate with distance from a major lake. For example, fishing has been found to be a major source of income for those living near water bodies in Uganda and the DRC, particularly for the most destitute of people (ADF 2003). In low-income households around Lake Tanganyika, people sell their labour to generate

Figure 5.4 Distribution of human-utilized freshwater fish taxa throughout the AR. Map (a) shows *total* numbers of taxa known to be of importance for human use. Map (b) shows the *percentage of the total taxa present* in each cell that are of importance for human use.



Sleek Lates (*Lates stappersii*), an Albertine Rift endemic, is traded locally. © John Friel

money, and this includes children who may be involved in the post-harvesting sector (West 2001). Conversely, wealthy households typically diversify away from actual fishing, and move into the trade and transport of fish (West 2001). Average earnings around Lake Tanganyika within the artisanal sector (excluding DRC where no data were available) are typically well above the national average income (Molsa and Reynolds 2000). Those engaged in the traditional sector earn less than those in the artisanal sector, but are still able to command an income on a par with the national average income (Molsa and Reynolds 2000). Brief descriptions of the fisheries of the region's major lakes are outlined in the following paragraphs:

Lake Tanganyika

Three types of fishery have been identified on Lake Tanganyika, including the traditional fishery, the artisanal fishery (which has more technologically advanced devices for fishing than the traditional fishery, such as motor boats) and the semi-industrial fishery (Munyandorero 2002). Munyandorero (2002) claims that artisanal and semi-industrial fisheries target different taxa from traditional fisheries, and that this is largely dictated by the mesh size and type of gear used to catch the fish. While artisanal and semi-industrial fisheries primarily target clupeids (70–80% of catch in weight) and Sleek Lates (*Lates stappersii*) (5–15% of catch in weight), whilst catching other latids, catfishes and lungfishes as by-catch, traditional fisherfolk operate in the reverse of this; targeting these other latid taxa, and catchinig clupeids and Sleek Lates as by-catch (Munyandorero 2002).

Tanganyika Lates (*Lates angustifrons*), Big-eye Lates (*L. mariae*) and Forktail Lates (*L. microlepis)* are recorded as being of commercial importance by FishBase, and have been identified as one of six taxa of major commercial importance in Lake Tanganyika, particularly for traditional fisheries. All six taxa are regarded as susceptible to localized over-harvesting (Reynolds and Molsa 2000).There is no evidence that Nile Perch (*Lates niloticus*) has been introduced to Lake Tanganyika. Nile Tilapia (*Oreochromis niloticus eduardinus*) is native to the Tanganyika basin, though recently, individuals originating from nearby aquaculture practices have been found, which may pose a threat to native populations.

Lake Albert

Lake Albert has higher catch levels and contains more important taxa for subsistence and local income than Lakes Edward and George. The ADF (2003) reported that in 1988, the most heavily fished taxa from Lake Albert were Tigerfish (*Hydrocynus vittatus*) (34% of the total estimated catch of 22,500 tonnes), Nile Tilapia (27%), Nile Perch (23%), Sudan Catfish (*Bagrus docmak*) (7%), *Clarias lazera* (named *Clarias camerunensis* in this study) (5%) and Pebbly Fish (*Alestes baremoze*) (3%). This is in contrast to a more recent study by Witte *et al*. (2009), which reported that key fishery taxa in Lake Albert in 2007 were Nurse Tetra (*Brycinus nurse*) (64% of the total estimated catch of 182,000 tonnes), *Neobola bredoi* (19%), Nile perch (8%), Black Nile Catfish (*Bagrus bajad*) (4%) and Nile Tilapia (2%). Witte *et al.* also comment that not only has there been an increase in landing volumes, but there has also been a shift towards smaller sized taxa. From the literature it is not clear what would have caused such a shift, or indeed whether it is a genuine shift or a difference in methods used between studies.

Lake Edward and Lake George

Of the approximately 80 taxa in these lakes, the majority are from the family Cichlidae (including haplochromines, most of which are endemic (Snoeks 2000)). In Lake Edward, captures in 1992 were estimated at 16,000 tonnes per annum, the main taxa fished being Nile Tilapia (57%), Sudan Catfish (35%), Ripon Barbel (*Barbus altianalis*) (6%) and North African Catfish (*Clarias gariepinus*) (1%) (ADF 2003). Conversely, Kaelin and Cowx (2002) estimated the total fish landings in 1999 for Lake Edward and Lake George combined to be just 5,800 tonnes. However, it is not known if this change in value represents a true decrease in catches, or if the methods used for calculating catch volumes have changed. According to the FAO (2004a) historically important fisheries on Lakes George and Edward have mainly targeted tilapia, catfishes (*Bagrus* spp. and *Clarias* spp.), and lungfish (*Protopterus* spp.), and Witte *et al.* (2009) reported that these were the same taxa being caught in 2006.

Lake Kivu

There are only 26 fish taxa in Lake Kivu (Hanek *et al.* 1991). Among these is the Lake Tanganyika Sardine (*Limnothrissa miodon*), which was first introduced to Lake Kivu from Lake Tanganyika in 1958 (Muderhwa and Matabaro 2010). This taxon now seemingly represents the only one that is harvested for food at any significant level. First attempts to exploit this taxon were made in 1976, though the sardine fishery truly developed after the UNDP/FAO Fishery Development Project began in Rwanda in 1979, introducing new technology with the aim of increasing protein supply, employment and revenue-generating opportunities (Hanek and Baziramwabo 1989). The estimated catch from the lake in 2009 was 3,300 tonnes; 3,000 tonnes of which were Lake Tanganyika Sardine (Sinclair Knight Merz Ltd 2009). Around 1992 it was reported that a total of 2,868 fisherfolk were involved in artisanal fisheries targetting this taxon, and around 3,340 women in the selling of fish at market (Farhani 1991 in Mughanda and Mutamab 1993). At this time the trade was considered to be increasing. Fish consumption in Rwanda, within which roughly half of Lake Kivu is situated, has traditionally not been very common (Hanek and Baziramwabo 1989), despite this project to promote fisheries in the country. Overall, little recent information on current fishing and consumption levels was available.

5.2.1 Harvest for human food

A total of 137 freshwater fish taxa were found to be important for use as human food, compared with other freshwater fish in the AR, though it is likely that almost all taxa of fish would be eaten if caught. Perhaps the main exception to this is the Freshwater Puffer Fish (*Tetraodon lineatus*), which is known to be toxic to humans, and possibly certain other 'taboo taxa'. Consumption of fish in the AR generally appears to be common; however there are distinct differences in both consumption levels and resource availability between its six countries. As might be expected, there is a larger amount of literature available on the region's two largest lakes (Lake Tanganyika and Lake Albert), and in particular on harvest and consumption in Uganda and DRC.

5.2.1.1 Uganda

Uganda contains numerous water bodies and has a strong fish eating culture (Jagger and Pender 2001), though the country's most economically significant water body, Lake Victoria (FAO 2004a), is not within the AR boundary. Nevertheless, Lakes George, Albert and Edward still play important roles in providing subsistence and income for Ugandans. In Uganda in 2008, the per capita consumption of fish was estimated at approximately 8.6 kg per year (FAO 2010 in Gordon and Maurice 2012), which is estimated to represent up to 50% of all protein intake (Maurice 2011). A study of three national parks in the Ugandan AR reported the frequency of fish consumption to be higher than any other meat in local households, despite being less desirable compared to other meat types (Olupot *et al.* 2009). This is likely because it is the cheapest source of animal protein (ADF 2003). Although the vast majority of fish taxa are likely to be edible, some taxa will be avoided by certain groups of people or at certain times of the year. For example, the Buganda people are forbidden from eating fish during wedding preparations and ceremonies, and women avoid *Protopterus* spp. altogether due to its associations with femininity (Kirema-Mukasa and Reynolds 1991a). Interestingly, the same study found that people in the Rwenzori region of Western Uganda considered *Protopterus* spp. to be a prized delicacy.

An uncommonly large Marbled Lungfish (*Protopterus aethiopicus*), caught by local fishermen in the Kazinga Channel, south west Uganda. This species is considered important to humans, both as a source of protein and for medicinal purposes. © Julian Dignall / www.aquaticrepublic.com

In Uganda, fish is the second most important export commodity after coffee, provides the main source of income for approximately 1.2 million people (4% of the population) and reportedly contributes 2.8% to the GDP (Maurice 2011). However, Yaron *et al.* (2004) estimated that once under-reporting, smuggling and other auxiliary services are taken into account, the Ugandan fish industry could be worth up to 5.8% of the GDP. Whilst fishing is likely to be particularly important for people living close to lakes, the majority of fisherfolk were found to have additional income-generating strategies, suggesting that the income derived from fishing alone is not usually sufficient (Kirema-Mukasa and Reynolds 1991a; Marriott *et al.* 2004; Mugabira 2008).

Kirema-Mukasa and Reynolds (1991b) reported that in 1990, 68% of the 1,181 processors around Lake Victoria, Lake George and Lake Albert were male, and in south western Uganda, women only accounted for 32% of the processing workforce (Kirema-Mukasa and Reynolds 1991a). Around Lake George it was found that women specialized in buying and selling by-catch, and may also be engaged in sex-work to earn additional income (Keizire and Muhwezi 2006).

The most frequently harvested species in Uganda as a whole is thought to be the Nile Perch, which has been estimated to account for around 60% of catches, followed by Silver Cyprinid (*Rastrineobola argentea*) and Nile Tilapia (Kaelin and Cowx 2002; ADF 2003). The Nile Perch is a large fish, which is regarded as highly commercial (FishBase 2012) and is generally exported due to the high international market price it can fetch (ADF 2003). According to Nyombi and Bolwig (2004), Nile Perch products alone accounted for over 90% of fish exports from Uganda. It is also regarded as a hugely invasive species in some water bodies and has caused declines in a number of endemic haplochromines following introductions outside of its native range (Witte *et al*. 2009). The most notable introduction of this taxon was in Lake Victoria, which is now the main source of Nile Perch in Uganda. Nile Perch was introduced to Lake Victoria in the 1950s and has created a booming industrial fishery, albeit with now infamous ecological consequences. Nile Perch makes up approximately 8% of all catches in Lake Albert (Witte *et al*. 2009), where it is native, and it is also caught in Lakes George and Edward. Data from Fishstat (2000) (Figure 5.5) suggest that in Uganda catches of Nile Perch and tilapia taxa have declined in recent years, while catches of Dagaa(s) (meaning dried, unspecified, sardine-like fish, though sometimes meaning a specific taxa such as Silver Cyprinid) and characins (small, colourful fish such as tetras) have increased. It is important to note that Silver Cyprinid is in high demand for animal feed, and this might account for much of the volume caught, rather than for human food. *Protopterus aethiopicus* ssp. *aethiopicus* (Marbled Lungfish) was identified by experts as being important for use within the AR, and the species *Protopterus aethiopicus* is believed by some people to have powerful symbolic significance and to be a prized delicacy amongst others (Kirema-Mukasa

Victoria Tilapia (*Oreochromis variabilis*) is Critically Endangered. It is used by humans both for food and in the pet trade. This species was assessed as vulnerable to climate change under a pessimistic scenario for missing data.
© Kevin Bauman

and Reynolds 1991a). Consumption of *Protopterus* is increasing in Uganda, particularly amongst the urban population, as tilapia and Nile Perch catches decline (Kabahenda and Hüsken 2009). In 2009, Ugandan fish and fish product export levels reached 23,931 tonnes, having a total value of over USD114 million (FAO Information and Statistics Service 2012).

In 1989–90, the National Household Budget Survey in Uganda found that local consumers spent an estimated 3% of their total earnings on fish, though urban households spent more, on average, than rural households (Kirema-Mukasa and Reynolds 1991a), most likely because prices are higher and people are wealthier. Similarly, Sender and Uexkull (2009) found that the average expenditure on fish per rural-living adult is about half that of an urban-living adult.

The price of fish varies regionally; tilapia was found to cost USH650 (USD0.37) per kg around Lake Albert, compared with USH550 (USD0.32) per kg around Lakes George and Edward (Marriott *et al*. 2004). Nile Perch is a valuable fish and often commands a high price; in 2002 fresh Nile Perch was found to be sold on average for USH1,730 (USD1kg) per kg compared with USH1,470 (USD0.84) per kg for fresh Nile Tilapia (*Oreochromis niloticus*) (Nyombi and Bolwig, 2004)[17]. Marbled lungfish was reported to be sold in local and regional markets in western and central Uganda, but was considered a low commercial value taxon as it is normally caught as by-catch (Uganda Biotrade Report 2004). A chunk of deep fried *Protopterus* (25g) sells for USH200 (USD0.12)[18] around Lake Victoria, with consumers typically buying a couple of chunks to consume straight away (Kabahenda and Hüsken 2009).

A combination of the rising prices of fish, declining wild fish populations, government intervention and a drive for profit has led to a sharp increase in aquaculture production (FAO 2005b). According to FAO data (FishStat 2000), aquaculture production has increased markedly in Uganda since the mid 1980s (Figure 5.6). In 2010, 63,000 tonnes of North African Catfish (worth USD104,472,000) and 31,500 tonnes of Nile Tilapia (worth USD65,295,000) were produced (FishStat 2000) (Figure 5.6). Although the majority of Ugandan aquaculture (60%) is subsistence based, involving 12,000 farmers in 2005, there is an increasing interest in commercializing it further (FAO 2005b). Those with access to land and water are most likely to engage in profitable small-scale operations, and around 2,000 farmers were thought to be operating in this manner in 2005, including those from the civil service and private business owners. In addition there is an emerging small group (approximately 200 people in 2005) of farmers that engage in industrial aquaculture and operate purely for profit rather than subsistence or local trade (FAO 2005b). Maurice (2011) stated that due to the buyer-driven market for aquaculture products, farmed fish is sold more cheaply than wild-caught.

5.2.1.2 DRC

Fish is a popular food item in DRC; demand is consistently high (FAO 2001) and it has been found to be the cheapest source of animal protein available in the country (ADF 2003). DRC has a very small coastline, but is endowed with vast water bodies (covering approximately 3.3% of the country's total area (ADF 2003)) including some within the AR. UNEP (2011) estimated that fish and fish products

17. Currency conversions carried out using 2003 conversion rates.

18. Currency conversions carried out using 2009 conversion rates.

Figure 5.5 Capture fisheries production of major fisheries in Uganda (FishStat 2000).

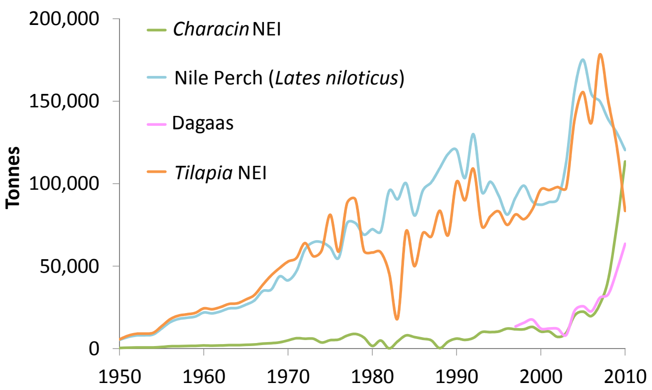
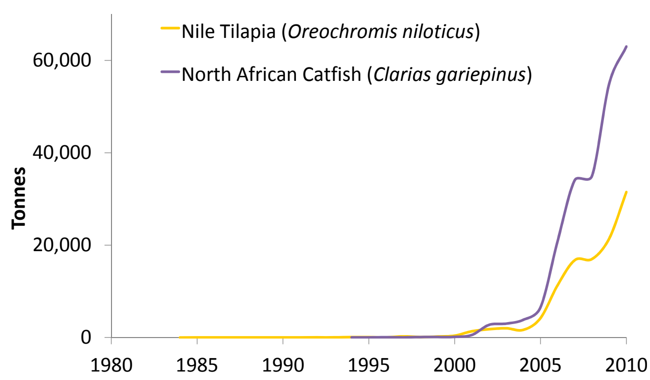


Figure 5.6 Aquaculture production of major fisheries in Uganda (FishStat 2000).



account for 25–50% of the population's protein intake, and annual, per capita consumption was calculated to be 8.5kg (ADF 2003). This is a perhaps somewhat lower than might be expected, considering DRC contains such productive water bodies, and this is likely, in part, attributable to the civil unrest in the country and the collapse of infrastructure making it more difficult to distribute fish products (FAO 2001). A study conducted in Kiliway (north of the AR) found that households are estimated to spend 3.3% of their household budget on fish (de Merode *et al*. 2004), and that consumption of fish increased by 475% during the lean season, when consumption of favoured agricultural produce decreased.

Fisheries and related trade is thought to account for 0.5% of DRC's GDP (ADF 2003), and the production of the capture fishery has shown a gradual increase reaching 230,000 tonnes in 2010 (Figure 5.7). In 2002 national fish production was 162,000 tonnes – lower than the 170,000 tonnes imported from other countries, mainly Tanzania, Uganda and Rwanda (ADF 2003). Annual catches from the lakes were estimated to be 90,000 tonnes from Lake Tanganyika (1995), 7,500 tonnes from Lake Kivu (early 1990s) and 11,400 tonnes from Lake Edward (early 1990s) (FAO 2001). No estimates were available for DRC's portion of Lake Albert. The poor economic environment has meant a shortage of the necessary fuel, spare parts and maintenance required to maintain productive fishing fleets, and the collapse of infrastructure has often restricted marketing opportunities. In combination, these factors are thought to have led to a decrease in previous levels of production (Reynolds and Molsa 2000). In 2009, the fisheries export market was worth just USD595,000, which included marine and freshwater areas outside of the AR (FAO Information and Statistics Service 2012).

Before the economic decline in the 1970s, the fishing industries on Lakes Tanganyika, Edward and Albert were semi-industrial, but now 95% of the catch is taken by artisanal fisherfolk, and the industry operates almost entirely outside of the formal economy (UNEP 2011). Nevertheless, fishing remains the major income generator for the poorest populations living in close proximity to water bodies (ADF 2003). Due to the political instability in the country it is difficult to get recent statistics, but DRC's inland fisheries were estimated to employ the following numbers of people in the early 1990s: Lake Tanganyika: 26,300 people; Lake Kivu: 6,563 people; Lake Edward: 1,041 canoes; and Lake Albert: 3,200 canoes (FAO 2001).

There is some evidence that households dependent on fishing are diversifying their livelihoods away from this practice. For example, populations around Lake Edward have begun cultivating crops such as rice, maize, soya, bananas and manioc to lessen the impact of declining fish stocks on their income (Alinovi *et al.* 2007). However, other households in eastern DRC have swapped from agriculture to fishing, following resource access and entitlement alterations due to the political situation causing a shift the food systems (Vlassenroot *et al.* 2006). The economic decline that occurred after the mining boom in the 1970s caused many people to lose their jobs, and one coping strategy that developed was for women from low income households to work as fish traders (Kalunga Mawazo *et al*. 2009). In parts of DRC both fisherfolk and those in the post-harvest sector often have an additional form of employment, usually related to fishing or agriculture (Reynolds and Molsa 2000).

Figure 5.7 Capture fisheries production of major fisheries in DRC (FishStat 2000).

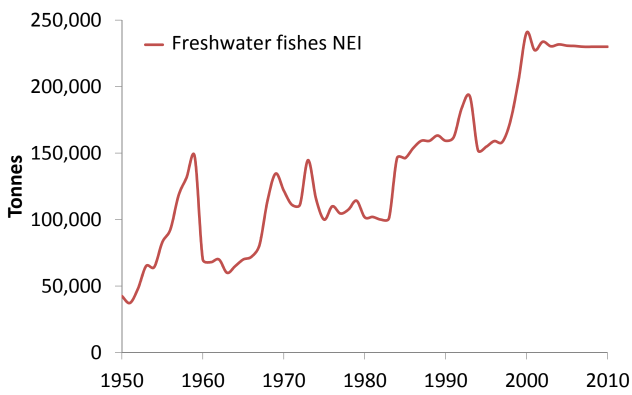
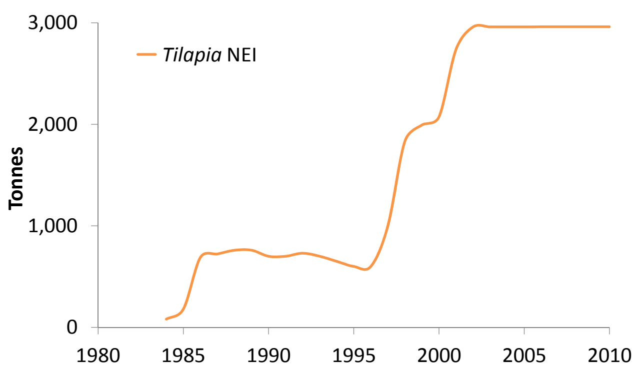


Figure 5.8 Aquaculture production of major fisheries in DRC (FishStat 2000).



Aquaculture is essentially a subsistence activity in DRC. In Nord- and Sud-Kivu provinces dammed ponds are created at springheads and stocked with Red-breasted Tilapia (*Tilapia rendalli*), *Oreochromis nigrus*, Nile Tilapia (*O. niloticus*) and Threespot Tilapia (*O. andersonii*) (FAO 2006a). The national production of fish by aquaculture is dominated by tilapia taxa, of which 2,960 tonnes (worth USD7,400,000) were produced in 2010 (Figure 5.8) (FishStat 2000). The number of aquaculturists in the two main provinces within the AR (Nord-Kivu and Sud-Kivu) were 126 and 1,444, respectively (date unknown) (FAO 2006a).

The cichlid *Aulonocranus dewindti* is endemic to the Albertine Rift and is important to humans both as a source of food and for use in the pet trade. © R. Allgayer and A. Sapoli

5.2.1.3 Tanzania

Despite Tanzania having a large coastal area, freshwater taxa still account for around 80% of the country's fish catches (Kiwale 2003), though this includes numerous water bodies outside of the AR boundary (e.g. Lake Victoria). Overall, per capita supply of fish for consumption was estimated to be 7 kg in 2003, accounting for 27% of the animal protein consumed (FAO 2007). Tanzania benefits from containing large portions of Lake Tanganyika, Lake Victoria and a number of other lakes, in addition to its coastal waters.

Fisheries in Tanzania contribute around 2.9% to the GDP and employ around 150,000 full-time artisanal fisherfolk (FAO 2007). An additional two million people earn a living as processors, traders, net menders and through other related jobs (FAO 2007), though these figures include marine and freshwater sectors both inside and outside of the AR boundary.

Data from Fishstat (2000) indicated that Nile Perch catches have declined since their peak in the early 1990s, but still accounted for 97,177 tonnes in 2010 (Figure 5.9). Similarly, catches of *dagaa* have declined from a peak of 91,327 tonnes in 1977 to 15,191 tonnes in 2010. Catches of freshwater fish not included in other categories (NEI[19]) were at their highest in 2010 when 119,682 tonnes were caught Fishstat (2000) (Figure 5.9). In the Kigoma Region, near Lake Tanganyika, Bosma *et al*. (1997) found that artisanal unit owners earned approximately USD640 per year, which, when compared with the national per capita GDP of USD250 in 1997 (The World Bank 2012) represents a good income. Reynolds also found that artisanal fishery crew members earned around USD340 per year, while traditional fisherfolk earned approximately USD190 per year. In the same region, male processors and traders were estimated to earn USD340 per year, whilst their female equivalents earned approximately USD140 per year (West 2001). Along the northern part of Lake Tanganyika up to 80% of households derive part of their living through fishing or the processing of fish, whereas along the southern coast a greater proportion of people are employed in agriculture (West 2001).

19. Not Elsewhere Included – shows statistics for fish at the higher group level (excludes individual fish that can be reported at the species level).

Figure 5.9 Capture fisheries production of major fisheries in Tanzania (FishStat 2000).

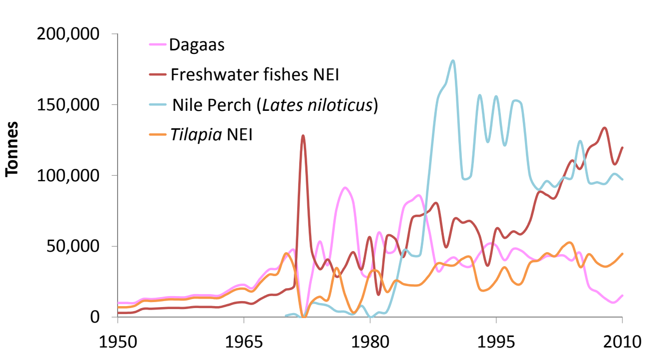
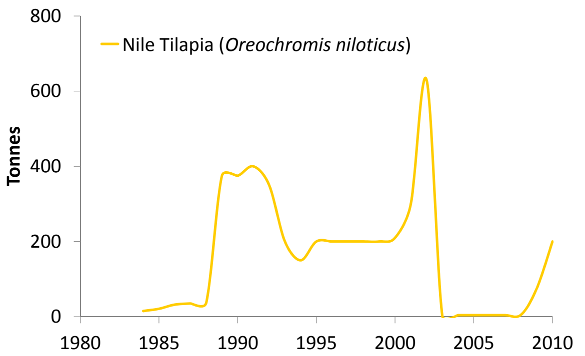


Figure 5.10 Aquaculture production of major fisheries in Tanzania (FishStat 2000).



Freshwater aquaculture employs 14,000 people across Tanzania, and is dominated by subsistence integrated farming, whereby each farmer typically owns one small fish pond. In 2006 the FAO reported that commercial aquaculture was yet to develop in Tanzania (FAO 2006b). Production is primarily of Nile Tilapia (*Oreochromis niloticus*) (Figure 5.10), 200 tonnes of which were produced in 2010, and were valued at USD497,000 (Fishstat 2000). Fish produced in this way are normally consumed locally, and farmers engaged in aquaculture are typically poor, predominantly female and have a low level of education, although younger people are likely to be engaged in the pond construction stage (FAO 2006b).

5.2.1.4 Zambia

Being the cheapest source of animal protein available, fish is eaten by all sectors of society in Zambia, though urban dwellers tend to consume more fish than those in rural areas (FAO 2004b). The annual per capita consumption of fish is estimated as 6.4kg (FAO 2004b), and up to 55% of the average protein intake is estimated to come from fish (FAO 2004b). Although Zambia contains some 15 million hectares of freshwater, only the northern part of Zambia is within the AR boundary, where the southern extent of Lake Tanganyika and Lake Mweru-Wantipa can be found.

In Zambia, the fisheries industry was worth USD109 million in 2007, accounting for 1% of Zambia's GDP (Musumali *et al.* 2009), and the export market was estimated to be worth USD1.2 million in 2009 (FAO Information and Statistics Service 2012). The fisheries industry is estimated to employ up to 300,000 Zambians, and is the third largest employment sector after farming and mining (Reynolds and Molsa 2000). However, to those people living close to water bodies, fishing is the most important, and sometimes only, employment opportunity (Reynolds and Molsa 2000). It is thought that fishing acts as an economic safety net, offering an opportunity to earn money seasonally and during economic downturns. Reynolds and Molsa (2000) found that women are actively engaged in processing and trading activities, comprising the majority of participants in the post-harvest sector surrounding Lake Tanganyika. The same study found that those working in the post-harvest sector were younger and had a lower level of education, particularly if they were women. They also found that both fisherfolk and those working in the post-harvest sector supplemented their main occupation with an additional job, normally within the fishing sector or in agriculture.

The volume of freshwater fish being caught has steadily increased since 1950, and reached 68,575 tonnes in 2010 (Figure 5.11). Catches of *dagaa* are relatively stable, and in 2010 7,821 tonnes were caught.

Fishing boats heading out onto Lake Tanganyika from the Rumonge Port, Burundi. In an attempt to relieve pressures on declining fish populations, night fishing was banned for a period of two months. © R. Allgayer and A. Sapoli

Zambia is one of the major fish farming nations of sub-Saharan Africa, with an industry dominated by tilapia taxa (Figure 5.12). Aquaculture is mainly carried out in areas where there is little livestock or other sources of protein, and fish can be exchanged for farm crops as well as eaten (FAO 2003a). In 2010, production of Nile Tilapia (4,136 tonnes) and Threespot Tilapia (3,715 tonnes) were valued at over USD13 million and USD12 million respectively (FishStat 2000). In total, 6,860 people are estimated to be directly employed in the aquaculture industry, with over 13,000 ponds being owned predominantly by families or partnerships (FAO 2003a). Ponds are typically owned by males (70%) though this proportion is decreasing, and produce is usually consumed at the site of the pond (FAO 2003a).

5.2.1.5 Rwanda

Rwanda does not appear to be heavily reliant on fish for protein, and until the late 1980s there was no tradition of consuming fish or fishery products (Tietze and Merrikin 1989). A number of taboos are known to have existed surrounding the consumption of fish, including a belief that it could endanger the breeding of cows, which are used as a status symbol and for dowries (Hanek and Baziramwabo 1989). The average amount of fish consumed annually per capita was estimated to be 1.5kg – far lower than other countries in sub-Saharan Africa (Rutaisire 2011). However, since the UNDP/FAO Fishery Development Project began in 1979, a commercial fishery of the introduced Lake Tanganyika Sardine has developed. This has increased production greatly and encouraged development of a domestic market for the fish. However, over-fishing and illegal fishing has depleted fish stocks, apparently leading to the government imposing a two month fishing ban beginning in July 2012 to allow stocks to recover (allafrica.com 2012).

The fisheries sector in Rwanda employs approximately 8,700 fisherfolk directly, and contributes up to 0.3% of the GDP (FAO 2004c); a figure which is relatively low compared with other countries in the AR. Fishing is unlikely to be the main occupation of most Rwandans as even households close to Lake Kivu are more likely to derive their living from agriculture than fishing (USAID 2011). The average monthly income for a fisherman in Rwanda is USD25 (USD300 per year) (Sinclair Knight Merz Ltd 2009), which compares with a GDP per capita of USD509 in 2009 (The World Bank 2012). Most of the daily catch is sold at market the same day that it is caught, though losses are high due to lack of preservation capability (Sinclair Knight Merz Ltd 2009).

A study of fish consumption in Rwanda in the early 1990s (Mahy and Farhani 1991) found that the most popular taxa were *Tilapia* spp., Lake Tanganyika Sprat (*Stolothrissa tanganicae*), Lake Tanganyika Sardine, and *Haplochromis* spp., but that meat was still preferred. The same study also found that the middle classes were the greatest consumers of fish. A study by Ngendahimana *et al*. (1993 in FAO 2004c) found that fish was more expensive in Rwanda than any of the other AR countries, which may contribute to the country's relatively low level of consumption. Production has increased slowly since 1950, with freshwater fish exports (excluding Nile Tilapia) reaching 5,100 tonnes in 2010 (Figure 5.13). Catches of introduced Nile Tilapia have also increased since the mid 1990s to 3,950 tonnes in 2010.

Figure 5.11 Capture fisheries production of major fisheries in Zambia (FishStat 2000).

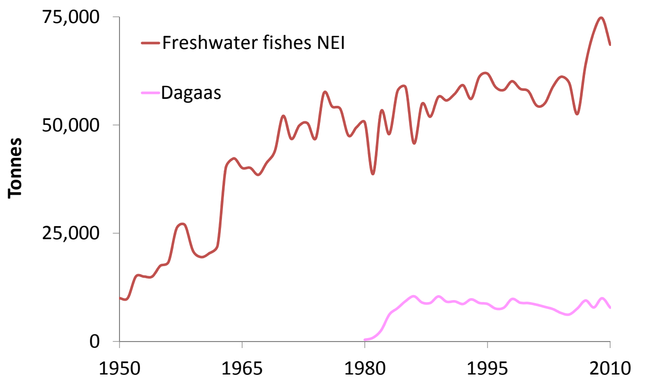
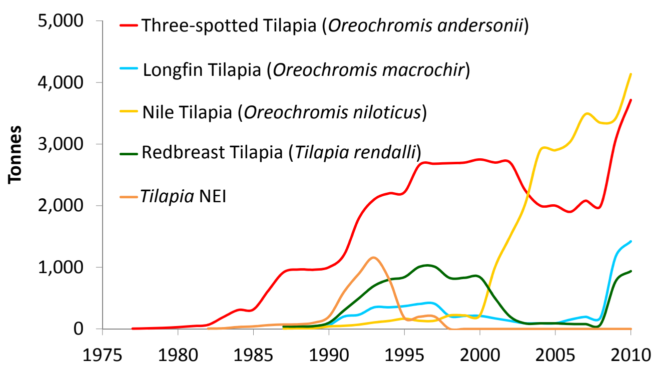


Figure 5.12 Aquaculture production of major fisheries in Zambia (FishStat 2000).



According to Rutaisire (2011), the price of fish increased dramatically between 1991 and 2011, and tilapia now costs RWF2,000 (USD3.2) per kg and fresh African Catfish costs RWF1,500 (USD2.4). Nile Perch and tilapia fillets are the most expensive, costing RWF3,500 (USD5.6) per kg and RWF4,500 per kg respectively (Rutaisire 2011)[20].

As previously mentioned, Rwanda does not historically have a culture of eating fish, and consequently aquaculture remains at a low level. The market that does exist is dominated by Nile Tilapia (Figure 5.14), which earned USD857,000 for the 500 tonnes produced in 2010. The development of aquaculture has been hindered by the physical climate, a lack of land tenure, poor cash flow and negative attitudes towards fish as a food product (Veverica *et al*. 1999).

5.2.1.6 Burundi

Burundi obtains a relatively low level of its annual, per capita food supply from fish and fishery products – around 2kg (Earthtrends 2003). This low figure disguises regional variation, as in major urban areas, including the capital Bujumbura, fish is the single most important source of animal protein (FAO 1999a). In contrast, the interior of the country lacks any regular availability of fish (FAO 1999b). Most fish caught are thought to be sold fresh at the Bujumbura market (Reynolds and Molsa 2000). Fishery resources are thought to be at, or near to, a fully developed state, with few opportunities for much further development (Reynolds and Molsa 2000). Political insecurity has caused the government to introduce a ban on night fishing in recent years, which is thought to have negatively impacted households that rely on fishing for part of their income (West 2001).

Fisheries contribute just 0.5% toward Burundi's GDP, but provide food and employment to a significant proportion of people living close to Lake Tanganyika (Reynolds and Molsa 2000). However, it was found that in rural lake zone areas, only 2% of adults are engaged in fishing as their main economic activity, and the majority work in agriculture (63%) or salaried employment (12%). Of the 2% engaged in fishing, all were reported to be adult males (Adelski *et al.* 1991). A major study of household economies found that 8% of a rural household's weekly food expenditure was on fish, compared with 16% on beans, 11% on meat and 8% on rice (Adelski *et al*. 1991). Urban households also spent approximately 8% of their food budgets on fish, compared with 13% on meat, 10% on beans and 9% on rice. The same study found that in rural areas meat was preferred to fish, but that meat was more expensive and in limited supply, and that fish was normally consumed in the form of ndagala (dried fish) and typically eaten 2–4 times a week.

Dagaa production totalled 13,130 tonnes in 2010, which is lower than its peak in the 1990s, though this value appears to be currently increasing (Figure 5.15). Catches of Freshwater Perch and other freshwater fish remained low in 2010, with catches of 3,160 and 1,280 tonnes, respectively.

Aquaculture remains a minor aspect of fisheries, with 2,000–3,000 small-scale fish farmers operating in the country in the early 1990s (FAO 1999b). Production is mainly centred on Nile Tilapia (Figure 5.16), which accounted for 48 tonnes and had a value of USD72,000 in 2010 (FishStat 2000).

[20] All conversions use 2011 exchange rates.

Figure 5.13 Capture fisheries production of major fisheries in Rwanda (FishStat 2000).

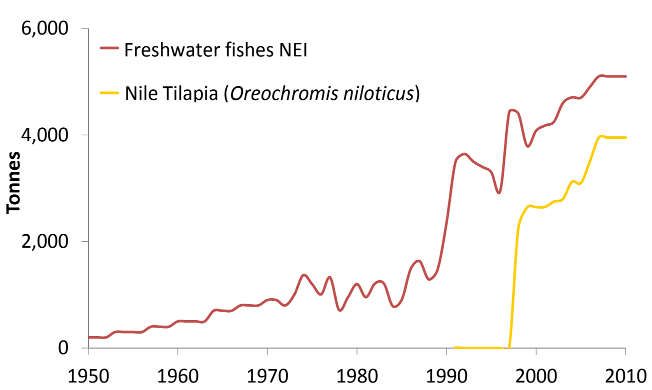
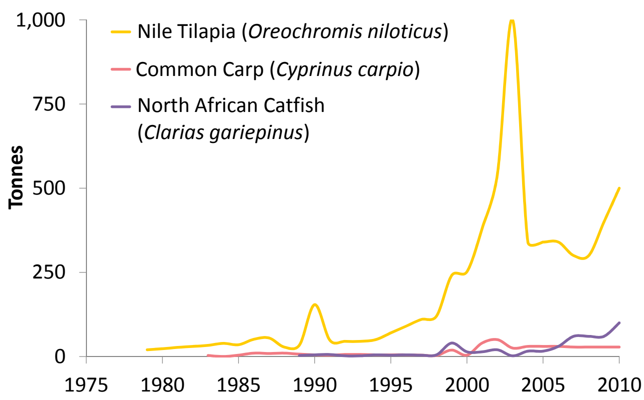


Figure 5.14 Aquaculture production of major fisheries in Rwanda (FishStat 2000).



5.2.2 Harvest for the pet trade

In total, 216 taxa present in the AR were identified as being important for the ornamental fish trade, 17 of which had an international commercial value. However, it is not known whether the individuals in trade came from the AR specifically, as there were very few data on this subject, particularly concerning whether the individuals in trade were wild sourced.

Tanganyika Killifish (*Lamprichthys tanganicanus*) is an Albertine Rift endemic used in the aquarium trade. It is currently listed as Least Concern on IUCN's Red List™. © R. Allgayer and A. Sapoli

Of the 17 taxa in international trade, 15 are cichlids (Cichlidae). The popularity of Lake Tanganyika cichlids (particularly endemics) for the aquarium trade may be resulting in the overharvesting of some taxa. Darwall *et al.* (2008) reports that more than 20% of threatened fish taxa in eastern Africa are (or are expected to be) impacted by the aquarium trade. Despite this figure being for eastern Africa in general, given that the AR contains many of Africa's large water bodies, these threats are likely to remain the same in this region. One of the cichlid taxa in international trade, *Tropheus duboisi,* is listed on the IUCN Red List as Vulnerable due to heavy exploitation for the aquarium trade (Bigirimana 2006a). A second cichlid, *Lepidiolamprologus attenuates*, is listed as Near Threatened due to heavy fishing pressure and sedimentation (Bigirimana 2006b). *Lamprologus kungweensis*, another cichlid listed on the IUCN Red List as Critically Endangered due to its restricted distribution (Bigirimana 2006c), was specified in FishBase as harvested for aquariums at a commercial level. Through a brief internet search, a number of websites were found offering advice on the care of taxa in aquariums, but little information was found about the source of such taxa (i.e. wild or captive-bred). The website www.riftvalleycichlids.com, which imports wild fish to the UK, had a number of the 17 taxa specified as being in international trade available for purchase at the following prices[21]: *Benthochromis tricoti* (USD118); *Cyphotilapia frontosa* (USD102–142); *Julidochromis ornatus* (USD31); *Tropheus brichardi* (USD47) and *Xenotilapia flavipinnis* (USD47). The value of aquarium fish exported from Tanzania between 1993 and 2002 was USD0.5million (Board of External Trade 2003), though this included fish from outside of the AR.

5.2.3 Harvest for animal food

Nine taxa were identified as important for animal feed or fish-bait: Silver Cyprinid in particular is used for this purpose (Reynolds and Ssali 1990). Generally, a low quantity of fish is processed for animal feed (FAO 2004b) though the amount appears to be increasing (FAO 2004a). In 2003, fish produced for animal feed in Tanzania only accounted for 4,680 tonnes, compared with 351,127 tonnes for direct human consumption (FAO 2007). However, as the global demand for animal protein from livestock increases, it is likely that the demand for fish for animal feed will increase also, potentially facilitating conflict between those wanting the fish for human food and those wishing to use it as animal food. In

[21] Prices per fish converted from GBP to USD July 2012.

Figure 5.15 Capture fisheries production of major fisheries in Burundi (FishStat 2000).

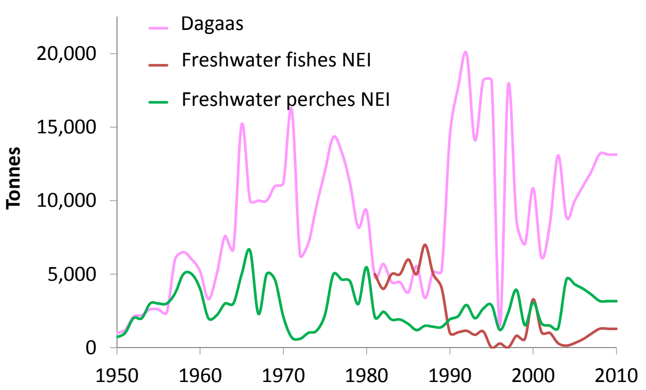
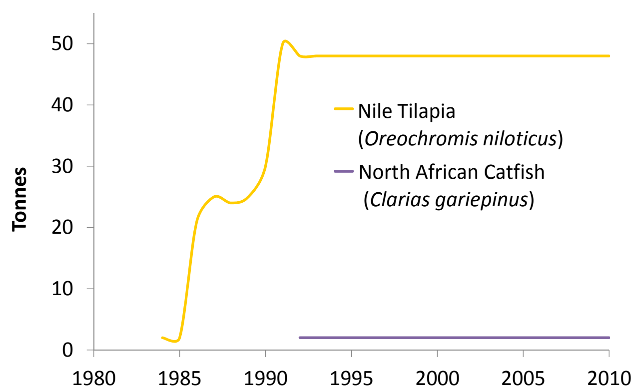


Figure 5.16 Aquaculture production of major fisheries in Burundi (FishStat 2000).



Uganda, certain haplochromines are increasingly being caught for use as live bait for Nile Perch, which has driven up the price, often making it too expensive for local people to afford (Fulgencio 2009). Heck *et al.* (2004) found that on Lake Victoria (outside of the AR), fish from the genera *Clarias* and *Labeo* were being targeted for use as Nile Perch bait.

5.2.4 Harvest for sport fishing

Twenty-seven taxa were identified by Fishbase during the consultation period as being important for sport fishing, but no further information was found on the subject of sport fishing in the AR during the literature review. It is likely that fishing tourism contributes to the economy at a low level, and it was identified in the Uganda Biotrade Report (2004) as an ecotourism activity in which a few private operators and community associations run provisions. An internet search of sport fishing providers found that Nile Perch, *Tilapia* and Tigerfish were the most commonly used to attract sport fishers to the lakes.

5.2.5 Harvest for medicinal purposes

Ten taxa were identified through expert consultation as being important for medicinal purposes, although very little additional information was available, especially specific to the AR. Around Lake Albert, the oil from Nile Perch has been found to be used as a medicine to cure coughing fits (Pringle 2005). Freshwater Puffer Fish is used as a charm for crops, and the dry skin of this species, worn in the fields by Tanzanians, has been found for sale at the market in Kigoma for this purpose (Ankei 1989).

Lungfish (*Protopterus* spp.) were found to have symbolic significance in some parts of Uganda (Kirema-Mukasa and Reynolds 1991a), which may be related to perceived medicinal properties. Around Lake Victoria, Lungfish are reportedly used to combat a wide variety of illnesses including breast cancer, backache, gonorrhoea, childhood malnutrition and to increase appetite and sexual ability (Fulgencio 2009), though it is not clear whether it is used within the AR for these purposes. In Uganda, species of *Haplochromis* are reportedly used in their dry form to cure diphtheria (Reynolds and Greboval 1988).

The Source of the Nile (SoN) fish farm in Uganda promotes tilapia breeding and production in order to reduce the impacts of sport fishing, harvesting for pet trade and human consumption on wild populations. © Jens Peter Tang Dalsgaard, WorldFish

5.3 Climate change vulnerability

For the 551 freshwater fish taxa assessed, we identified and considered a total of 25 climate change vulnerability traits, of which four related to 'Exposure', 18 to 'Sensitivity' and three to 'Low Adaptability'. These are shown in Tables 5.2, 5.3 and 5.4.

Through assessing each taxon's Exposure to climatic changes (Table 5.2), we expect 283 taxa (51%) to experience relatively 'high' levels of climatic change throughout their global ranges, relative to other AR fish taxa. A further 83 taxa (15%) are expected to experience 'very high' levels of change. Of these 366 taxa, 140 are expected to experience changes in one of the four variables considered, 21 across two variables, and 205 across three.

In our assessment of Sensitivity to climatic changes (Table 5.3), 323 taxa (59%) were assessed as possessing traits that make them 'highly' Sensitive to climatic changes, and a further 144 to have 'very high' Sensitivity to change. Of these 467 taxa, 178 possess one single trait, 118 possess two traits, 74 possess three traits, 44 possess four traits, 29 possess five traits, 16 possess six traits, eight species (*Barbus urostigma*, *Lates mariae*, *Lepidiolamprologus kendalli*, *Neolamprologus pleuromaculatus*, *N. tetrocephalus*, *Synodontis angelicus*, *S. decorus* and *S. frontosus*) possess seven traits, and one species (*Cyathopharynx furcifer*) possesses eight traits.

Within the Sensitivity analysis, the most common trait possessed was habitat specialization (i.e. taxa only occurring in one IUCN defined habitat type; trait S1). This trait, which was present in 228 taxa (41%), is expected in infer a tolerance of only a narrow range of conditions and, therefore, higher sensitivity to changes that may occur as a result of changes in climate. Also of high importance were traits relating to a taxon's migratory habits. Eighty-four taxa (15%) are known to migrate upstream to breed (trait S9) which could potentially confer vulnerability due to changes in water levels as a result of climate change. Similarly, 72 taxa (13%) have breeding migrations that are triggered by rainfall (trait S11), a trigger that could be affected should rainfall regimes change. Forty taxa (7%) were identified as having visual intraspecific recognition systems. This is likely to confer sensitivity to the increases in sedimentation and turbidity that may arise as a result of changed precipitation regimes, particularly in combination with other human activities, such as deforestation.

In our assessment of each taxon's capacity to adapt to climatic changes (Table 5.4), 54 taxa (10%) were assessed as possessing traits that make them poorly adaptable. Thirty-seven of these taxa possess one single Low Adaptability trait, and the remaining 17 possess two. Thirty-seven taxa (7%) are considered unable to disperse as a response to climate change due to an affinity to rocky

Table 5.2 Climate change *Exposure* measures used to assess AR freshwater fish, including thresholds used to categorize taxa, and the total numbers of taxa falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the **taxon** summary table at the end of this document (Table A3).

Trait Group	Trait	Sub-trait	Thresholds				
				Total taxa considered = 551			
EXPOSURE				Low	High	Very High	Unknown
Temperature change	Substantial changes in mean temperature occur across the taxon's range	**E1:** Absolute difference between 1975 and 2050 mean temperatures (for all months) across the taxon's current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	343	199	7	2
Temperature change	Substantial changes in temperature variability occur across the taxon's range	**E2:** Absolute difference between 1975 and 2050 values of average absolute deviation in temperature (for all months) across the taxon's current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	338	199	12	2
Rainfall change	Substantial changes in mean precipitation occur across the taxon's range	**E3:** Absolute ratio of change in 1975 and 2050 values of mean precipitation (for all months) across the taxon's current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	414	90	45	2
	Substantial changes in precipitation variability occur across the taxon's range	**E4:** Absolute ratio of change in 1975 and 2050 values of average absolute deviation in precipitation (for all months) across the taxon's current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	304	202	43	2
			Total	**185**	**283**	**83**	
			Percentage	**34**	**51**	**15**	

Table 5.3 Climate change *Sensitivity* traits used to assess AR freshwater fish, including thresholds used to categorize taxa, and the total numbers of taxa falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the **taxon** summary table at the end of this document (Table A3).

Trait Group	Trait	Sub-trait	Thresholds				
				Total taxa considered = 551			
SENSITIVITY				Low	High	Very High	Unknown
A. Specialized habitat and/or microhabitat requirements	Habitat specialization	**S1:** Number of IUCN habitat types occupied by taxon	L = >1; H = 1	301	228	n/a	22
	Microhabitat specialization	**S2:** Taxon is dependent on gravel, pebbles or coarse sand in river stretches for breeding	H = Taxon living only in rapids; L = All other taxa	447	48	n/a	56
		S3: Taxon is dependent on rapids	L = False; H = True	535	13	n/a	3
		S4: Taxon is a mountain rivulet specialist	L = False; H = True	522	29	n/a	0
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of changes to precipitation regimes	**S5:** Average absolute deviation in precipitation across the taxon's current range	Average absolute deviation in precipitation across the taxon's historical range: L = highest 75%; H = Lowest 25%	411	82	56	2
	Tolerance of temperature changes	**S6:** Average absolute deviation in temperature across the taxon's current range	Average absolute deviation in temperature across the taxon's historical range: L = highest 75%; H = Lowest 25%	413	81	55	2
	Tolerance of increases in turbidity and/or sedimentation	**S7:** Taxon possesses recognition system that could be affected by changes in turbidity and/or sedimentation	L = Non-haplochromine mouthbrooding cichlids; H = Haplochromine mouthbrooding cichlids;	511	40	n/a	0
		S8: Taxon has food gathering/ prey selection methods that could be affected by increases in sedimentation and/or turbidity	H = Zooplanktivores (e.g. sardines, some haplochromines); and Visual hunters; L = All other taxa	546	1	n/a	4
	Migration limited by water level changes	**S9:** Taxon migrates upstream to breed and or spawn	L = Taxon does not migrate upstream; H = Taxon migrates upstream	376	84	n/a	91
C. Dependence on a specific environmental trigger that's likely to be disrupted by climate change	Precipitation activated trigger	**S10:** Taxon's eggs develop in dry mud following rains	H = Annual fish that survive one rainy season (e.g. *Nothobranchius*); L = All other taxon	548	3	n/a	0
		S11: Taxon's breeding migration is triggered by rains	L = False; H = True	370	72	n/a	109
		S12: Taxon requires rains to allow resubmergence after cocooning	L = False; H = True	549	2	n/a	0
	Lake level change	**S13:** Juveniles of the taxon migrate back to river or lake as water retreats	L = False; H = True	385	15	n/a	151
D. Dependence on interspecific interactions which are likely to be disrupted by climate change.	Dependence on other fish taxa	**S14:** Taxon relies on another to make food available (e.g. *Tropheus* relies on *Petrochromis* to prepare rocks for grazing)	L = False; H = True	524	18	n/a	9
	Dependence on biocover	**S15:** Taxon is dependent on rocks with biocover	L = False; H = True	482	55	n/a	14
E. Rarity	Taxon abundance	**S16:** Number of mature individuals	Number of mature individuals - VH = <2,500; H = 2,500–10,000; L = >10,000	399	1	1	150
	Range size	**S17:** Extent of occurrence	Extent of occurrence - VH = <5,000 km^2; H = 5,000–20,000 km^2; L = >20,000 km^2	377	59	76	39
		S18: Area of occupancy	Area of occupancy - VH = <500 km^2; H = 500–2,000 km^2; L = >2,000 km^2	414	57	41	39
			Total	**83**	**323**	**144**	
			Percentage	**15**	**59**	**26**	

Table 5.4 Climate change *Low Adaptability* traits used to assess AR freshwater fish, including thresholds used to categorize taxa, and the total numbers of taxa falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the **taxon** summary table at the end of this document (Table A3).

Trait Group	Trait	Sub-trait	Thresholds				
				Total taxa considered = 551			
LOW ADAPTABILITY				Low	High	Very High	Unknown
A. Poor dispersability	Barriers to dispersal	**A1:** Taxon's dispersal is restricted by ecological barriers	VH = Restricted to rapids AND to rivulets H = restricted to rapids OR to rivulets; L= all others	516	5	28	2
	Intrinsic low probability of dispersal	**A2:** Low maximum dispersal distance due to affinity to rocky habitats	H = Rock dwelling cichlids; L = All other taxa	490	37	n/a	24
B. Poor Evolvability	Reproductive capacity/ survivorship	**A3:** Mean annual fecundity	L = >100; H = <50–20; VH = <20	34	0	1	516
			Total	**497**	**25**	**29**	
			Percentage	**90**	**4.5**	**5.5**	

microhabitats (trait A2), which are not contiguous throughout the wider lake habitats and will, therefore, be difficult to move between. Thirty-three taxa (6%) are known to be restricted to rapids and/or mountain rivulets (trait A1), which are, again, not contiguous throughout the AR, making it difficult for them to move between. Due to an extremely low annual fecundity (<20) (trait A3) *Tropheus annectens* was considered unlikely to adapt at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ*. Fecundity information was available for only 35 of the 551 (6%) taxa, making trait A3 the most data deficient of all traits for freshwater fish.

Overall a total of 31 taxa (5.5%) were recognized as being of highest vulnerability to climate change due to being highly sensitive, likely to be highly exposed, and poorly able to adapt. Of these 31 taxa, 18 are endemic to the region. 286 taxa (53%) are expected to experience high levels of climate change throughout their ranges, are sensitive to climatic change, but are not noted as being poorly able to adapt. Twenty-one taxa (34%) were assessed as both sensitive and unable to adapt to climate change, but are not expected to experience high levels of change (relative to other freshwater fish in the region). Only one species (*Zaireichthys brevis*) is likely to be both highly exposed and

Nile Perch (*Lates niloticus*)

© John E. Newby/WWF-Canon

The native range of the large, predatory Nile perch extends through the rivers and lakes of tropical Africa (Azeroual *et al*. 2010), and the species has been introduced to many water bodies in Africa, most notably Lake Victoria. In the AR, the Nile Perch occurs naturally in Lake Albert, though it is uncertain whether it has been introduced to other water bodies in the region. This is a very popular food species with high commercial value, and Nile Perch fisheries generate large amounts of revenue for some AR countries, most notably Uganda (Fishbase 2012). Fillets are exported globally from some AR countries, with prices reaching a peak of nearly USD10 for a large fish on the European market in 2009 (Globefish 2012). Cheaper by-products, such as fish-frames, are also traded locally. Experts identified that Nile perch are also used for medicinal purposes around Lake Albert. The distilled oil extracted from the fish has been found to be used to sooth coughing fits (Pringle 2005). This species is also targeted by sport fisherman. Nile Perch was not found to be particularly vulnerable to climate change impacts.

unable to adapt, but not actually sensitive to climate change. Under our pessimistic scenario for missing data values (see Methods, Section 2.2.1.3) a total of 316 taxa (57%) are considered climate change vulnerable.

Table 5.5 shows the families of the 31 freshwater fish taxa assessed as being climate change vulnerable. The most prevalent families among this group are Cichlidae (perhaps unsurprisingly, as this group represent 42% of all taxa assessed) and the catfish family Mochokidae.

Figure 5.18 shows the distribution of climate change vulnerable freshwater fish throughout the AR. Map 5.18a, which displays the total numbers of climate change vulnerable taxa, shows that the greatest numbers (up to 18 taxa per grid cell) are located in Lake Tanganyika, perhaps unsurprising, given the high taxon richness in this lake. Other locations containing relatively high numbers of climate change vulnerable fish taxa include the north-western extreme of the AR (DRC), including part of Okapi Wildlife Reserve, and a small area which includes the far north-eastern area of Kahuzi-Biega National Park and the west of Lake Kivu. In general, however, most areas supporting climate change vulnerable taxa typically contain low numbers overall.

Blue-faced Duboisi (*Tropheus duboisi*)

© Koen Eeckhoudt

This small cichlid is endemic to Lake Tanganyika (Bigirimana 2006) and was identified by experts as having an international value due to being highly desirable in the pet trade. Despite being described as 'aggressive' and 'quarrelsome', these colourful fish are popular for home aquariums and wild caught Blue-faced Duboisi are advertised for sale on UK websites for USD50 each. Their popularity has led to overexploitation and the species has now been listed as Vulnerable on the IUCN Red List (Bigirimana 2006).

In addition, *T. duboisi* is expected to experience large changes in mean temperature, and in the variability of both temperature and precipitation across its range. The species was assessed as sensitive to climate change for a number of reasons. It is a habitat specialist with highly specialized interspecific dependencies, being dependent upon rocks with biocover and on fish of the genus *Petrochromis* which modify feeding habitats through grazing. The restricted range of this species (its area of occupancy is less than 500 km^2, and its extent of occurrence is less than 5,000 km^2) means that it is vulnerable to extinction, particularly due to stochastic events, which may increase in frequency and severity as a result of climate change. The species' affinity for rocky habitats means that it is unlikely to be able to disperse in response to change. For these reasons, the species was assessed as vulnerable to climate change.

Figure 5.17 Numbers of AR freshwater fish taxa recognized as Exposed, Sensitive or poorly able to adapt to climate change, and all combinations of the three.

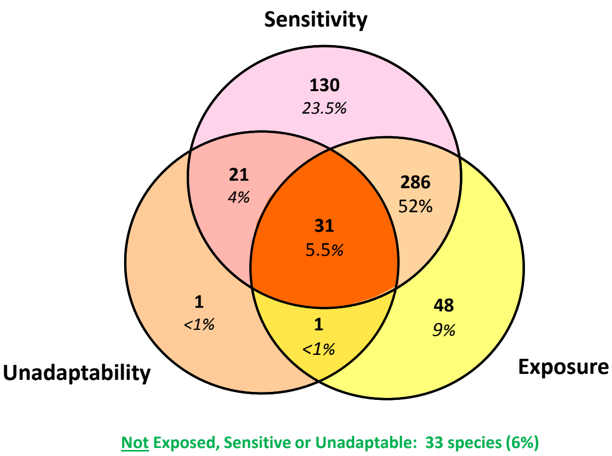


Table 5.5 Climate change vulnerable freshwater fish species grouped by family. Numbers in parentheses show percentages of the total taxa (within each family) considered for this assessment which are climate change vulnerable. Vulnerability figures are based on an optimistic scenario for missing data values.

Family	Number (and percentage) of climate change vulnerable freshwater fish taxa
Cichlidae	**17** (*7%*)
Mochokidae	**6** (*16%*)
Kneriidae	**3** (*50%*)
Cyprinidae	**2** (*2%*)
Nothobranchiidae	**2** (*40%*)
Amphiliidae	**1** (*11%*)

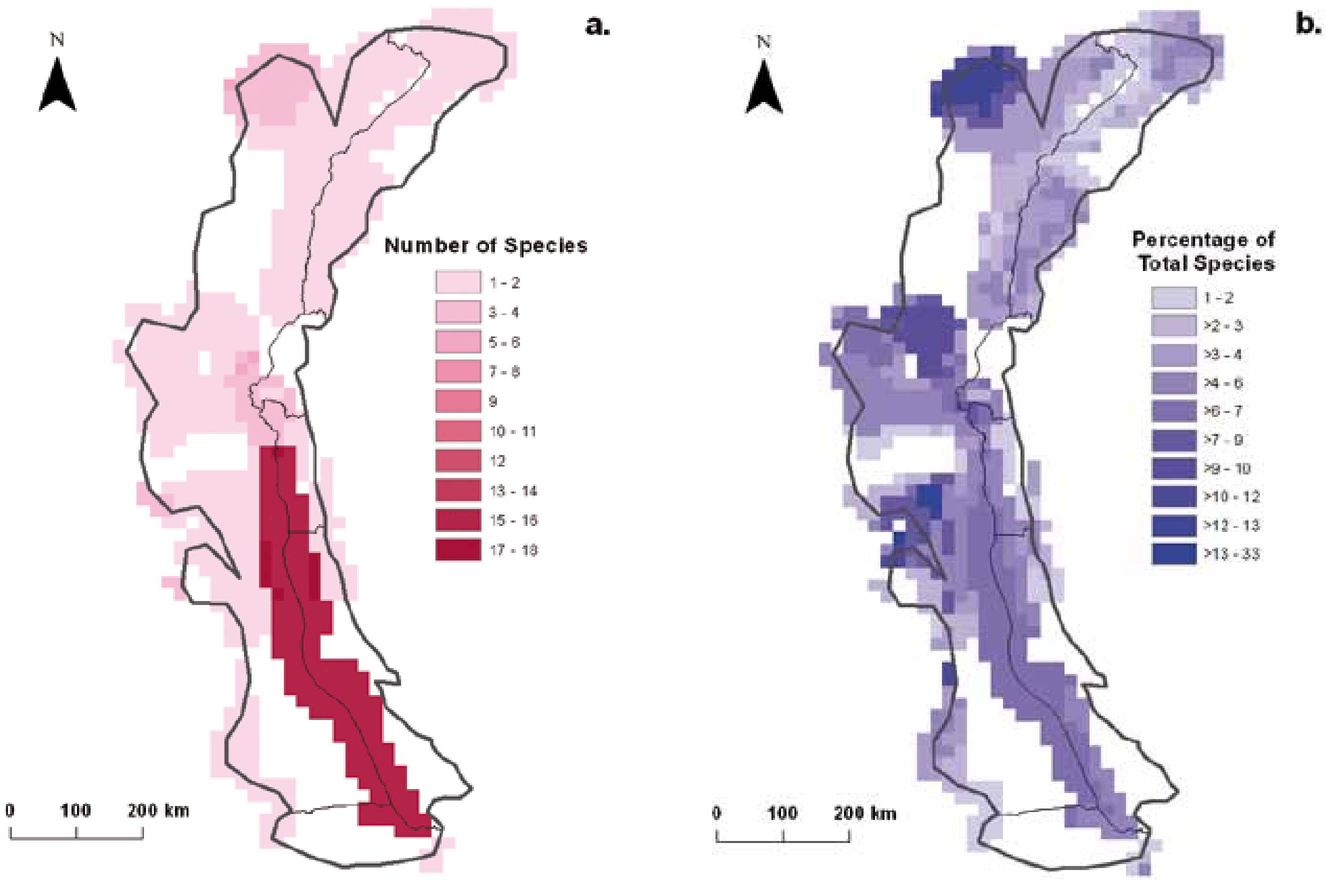


Figure 5.18 Distribution of climate change vulnerable freshwater fish in the AR. Map (a) shows *total numbers* of taxa assessed as vulnerable to climate change impacts. Map (b) shows the *percentage of the total taxa present* in each region that are climate change vulnerable.

In terms of proportions of climate change vulnerable taxa, map 5.18b identifies the areas east of Okapi National Park, northwest of Kahuzi-Biega National Park, and areas in and between the Itombwe Massif and the Domaine de Chasse de Luama-Kivu (all in DRC) as all containing relatively high percentages of climate change vulnerable taxa (up to 33% near to the Itombwe Massif, but typically 10–20%). In most other regions that contain climate change vulnerable taxa (including the region's major lakes), these represent relatively low proportions of the overall fish fauna (typically 2–7%).

5.4 Combined utilization, threat and climate change vulnerability results

The numbers and proportions of freshwater fish taxa known to be important for use, climate change vulnerable, globally threatened, and all possible combinations thereof are shown in Table 5.6.

A total of 19 freshwater fish taxa were assessed as being both important for use and climate change vulnerable. These taxa are *Acapoeta tanganicae*, *Barbus alluaudi*, *Eretmodus cyanostictus*, *Lamprologus ocellatus*, *Neolamprologus brevis*, *N. multifasciatus*, *Nothobranchius taeniopygus*, *Orthochromis luichensis*, *Petrochromis famula*, *Simochromis marginatus*, *Spathodus erythrodon*, *S. marlieri*, *Tanganicodus irsacae*, *Tropheus annectens*, *T. brichardi*, *T. duboisi*, *T. kasabae*, *T. moorii* and *T. polli*. Under a pessimistic assumption of missing climate change vulnerability data values (see Methods, Section 2.2.1.3), an additional 196 taxa would be recognized as being both used and climate change vulnerable, resulting a total of 215 taxa.

The densities of AR freshwater fish taxa known to be important for use, climate change vulnerable (under an optimistic assumption for missing data values), and combinations of the two are shown in Figure 5.19a. As one might expect from Figures 5.4 and 5.18, this image indicates that Lake Tanganyika

A storm near Lake Mutanda. Sediment runoff into freshwater ecosystems is likely to be exacerbated by climate change-driven increases in extreme events, particularly where the surrounding vegetation has been degraded by human activity. © Adam Cohn

Table 5.6 Numbers and proportions of AR freshwater fish known to be globally threatened (IUCN 2011), important for human use and climate change vulnerable, and all combinations thereof, including (where applicable) both optimistic and pessimistic assumptions of missing climate change vulnerability data values.

	Freshwater fish (551 taxa)			
	Optimistic		Pessimistic	
	Number	%	Number	%
Total threatened*	42	*8*	42	*8*
Total used	330	*60*	330	*60*
Total cc vulnerable	31	*6*	316	*57*
Threatened and cc vulnerable	**7**	***1***	**20**	***4***
Threatened and not cc vulnerable	35	*6*	22	*4*
Not threatened and cc vulnerable	24	*4*	296	*54*
Not threatened and not cc vulnerable	485	*88*	213	*39*
Threatened and used	**19**	***3.4***	**19**	***3***
Threatened and not used	23	*4.2*	23	*4*
Not threatened and used	311	*56.4*	311	*56*
Not threatened and not used	198	*35.9*	198	*36*
Used and cc vulnerable	**19**	***3***	**215**	***39***
Used and not cc vulnerable	311	*56*	115	*21*
Not used and cc vulnerable	12	*2*	101	*18*
Not used and not cc vulnerable	209	*38*	120	*22*
Threatened, used and cc vulnerable	**5**	***1***	**12**	***2***

* Data Deficient, Near Threatened and unassessed taxa are grouped with 'not threatened' taxa

supports by far the greatest numbers of both taxa important for use and climate change vulnerable. Further north, and particularly along (and either side of) the DRC border, high numbers of utilized taxa are present, though climate change vulnerable taxa are much fewer in number.

A total of 19 taxa (*Barbus alluaudi*, *Lamprologus kungweensis*, *Lates angustifrons*, *L. macrophthalmus*, *L. mariae*, *L. microlepis*, *Neolamprologus christyi*, *N. schreyeni*, *Oreochromis karomo*, *O. rukwaensis*, *O. variabilis*, *Orthochromis luichensis*, *Poecilothrissa moeruensis*, *Simochromis margaretae*, *S. marginatus*, *Tropheus duboisi*, *T. polli*, *Varicorhinus leleupanus* and *Xenotilapia burtoni*) were assessed as being both globally threatened and important for use. Figure 5.19b shows the geographic distributions of these taxa, and indicates, once again, that Lake Tanganyika contains the greatest densities of both threatened and human used taxa. Also similar to Figure 5.19a, 5.19b shows reasonably consistent high numbers of taxa important for use along and either side of the DRC border, but with fewer threatened taxa in this area and most others. Exceptions to this include the area directly north of Lake Tanganyika (DRC, Burundi and Rwanda) and the area surrounding Queen Elizabeth National Park (Uganda), where some threatened taxa are also present.

A total of seven taxa (*Barbus alluaudi*, *Chiloglanis asymetricaudalis*, *C. ruziziensis*, *Orthochromis luichensis*, *Simochromis marginatus*, *Tropheus duboisi* and *T. polli*) were assessed as being both globally threatened and vulnerable to climate change. Under a pessimistic scenario of climate change vulnerability, the following taxa would also be recognized under both categories: *Barbus alluaudi*, *B. huloti*, *Haplochromis aeneocolor*, *H. petronius*, *Lamprologus kungweensis*, *Neolamprologus christyi*, *N. schreyeni*, *Oreochromis variabilis*, *Simochromis margaretae*, *Synodontis ruandae*, *Varicorhinus leleupanus*, *V. ruwenzori* and *Xenotilapia burtoni*, presenting a total of 20 taxa. Figure 5.19c shows the geographic distributions of these taxa (optimistic assumption of missing data values), and once again highlights Lake Tanganyika as the site supporting the greatest numbers of both climate change vulnerable and threatened taxa. Further north and to the east of the AR, some threatened taxa are apparent, while numbers of climate change vulnerable taxa remains low throughout most other regions.

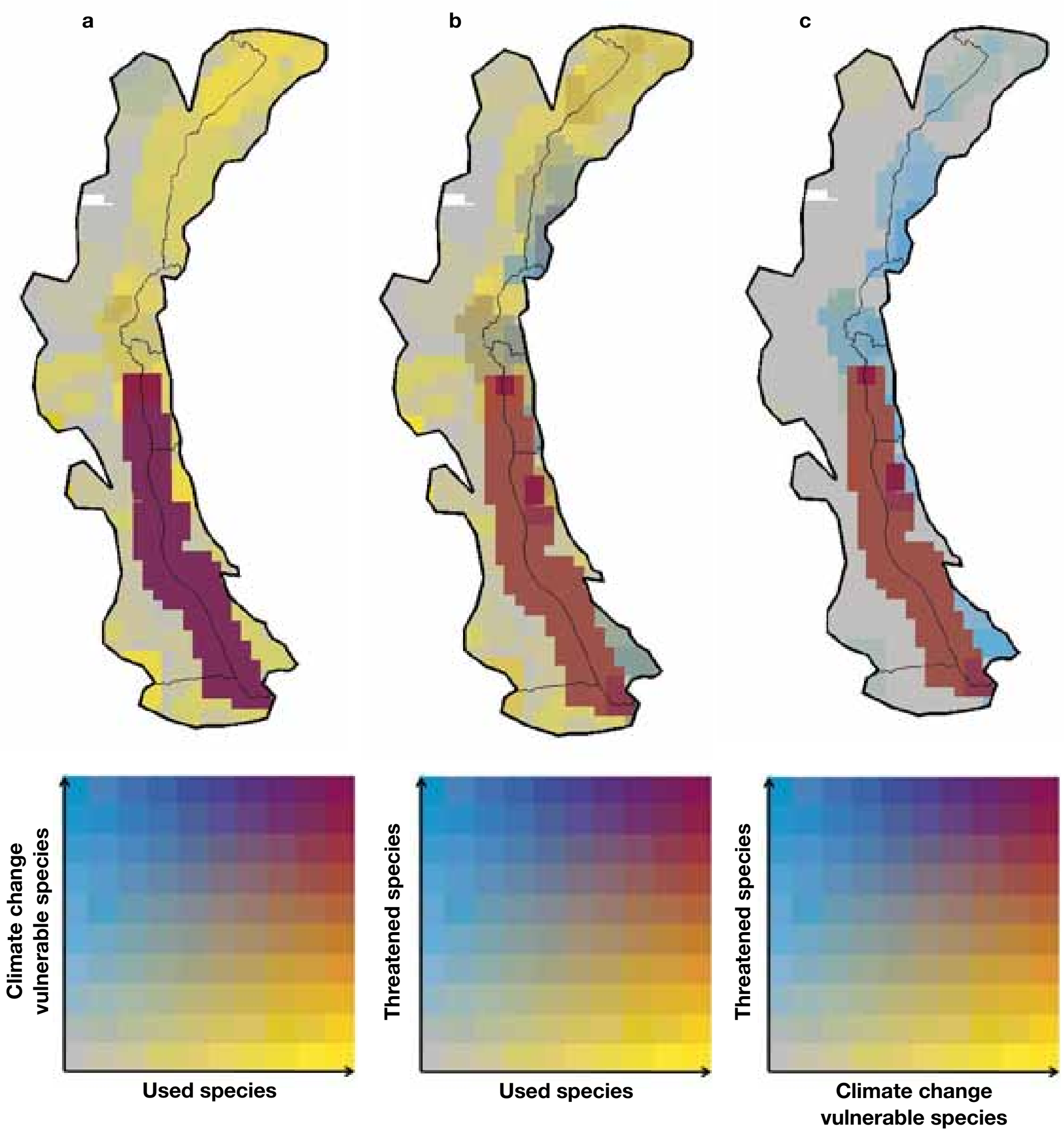


Figure 5.19 Bivariate plots combining data on climate change vulnerability and human utilization (a), global threat status and human utilization (b), and global threat status and climate change vulnerability (c) of AR freshwater fish taxa. Plots use data on total numbers of taxa per grid cell qualifying under each variable.

The five taxa that are recognized as being important for use, vulnerable to climate change and globally threatened are *Barbus alluaudi*, *Orthochromis luichensis*, *Simochromis marginatus*, *Tropheus duboisi* and *T. polli*. Under a pessimistic climate change scenario, the taxa *Lamprologus kungweensis*, *Neolamprologus christyi*, *N. schreyeni*, *Oreochromis variabilis*, *Simochromis margaretae*, *Varicorhinus leleupanus* and *Xenotilapia burtoni*, would also be recognized, giving a total of 12 taxa.

5.5 Conclusions and recommendations

Conclusions

- Fish are an extremely important resource for the people of the AR, providing a source of nutrition and an opportunity to earn a living, as well as contributing significantly to the national economies of several of the countries. The most important use type identified was as food for humans, with some taxa also important in the pet trade, for medicinal purposes and for sport fishing.
- Variations in use of freshwater fish are evident between countries, even when those countries utilize the same water body. Tanzania and Uganda earn the most revenue from exporting fish, and

also consume most per capita. In the future Rwanda's fledgling fishing industry may increase, contributing more to people's diets and incomes. Increased political stability in the region may also increase production and earning potential through improved infrastructure and marketing opportunities, and this could give rise to a more affluent population capable of buying preferred alternatives such as domestic meat. Conversely, a worsening situation is also likely to see more people turn to fishing to earn money due to the low entry requirements. The recent global recession, however, has led to a decline in the volume and value of exports from Tanzania and Uganda, which combined with increased transport costs, shortage of skilled labour, emergence of Nile Perch substitutes and fluctuating exchange rates, is likely to alter the export market (Bagumire 2009).

- Whilst some of the capture fisheries have reached full development (e.g. the pelagic fisheries in Burundian waters of Lake Tanganyika (FAO 1999b) and Ugandan fisheries (FAO 2004a)), others, in particular aquaculture fisheries, have the capability to develop further. Further development of the aquarium trade and sport fishing is also possible.
- Ongoing population growth in the AR, including through growing immigration, is likely to increase the demand for fish. Migration to areas surrounding the region's water bodies may also increase the number of people fishing, and could lead to overfishing and conflict between users of the lakes.
- Of the 551 freshwater fish taxa assessed for this project 31 were found to be climate change vulnerable under an optimistic scenario for values of missing data. This number increases to 316 under a pessimistic scenario for values of missing data, which demonstrates a high level of uncertainty in our assessment. We urge all those interpreting our results to be aware of these unknown data and to remain cautious when acting upon our findings.
- Important aspects of climate change vulnerability of AR fish include (among others) habitat (and/or microhabitat) specialization among many taxa, upstream migrations that could be affected by changes in hydrology, and low maximum dispersal distances (particularly due to an affinity to rocky habitats). By far our greatest area of uncertainty was in the breeding capacity of many taxa, which can provide insights into a taxon's capacity to adapt *in-situ*. Knowledge of migration habits (i.e. whether they occur and what might trigger them) is also lacking for some taxa.
- Forty-two AR freshwater fish taxa are currently recognized on the IUCN Red List as being threatened with extinction. This includes 19 taxa that are known to be used, and seven taxa believed to be vulnerable to climate change (of which five are both used and vulnerable to climate change). Forty-one AR fish taxa are currently Data Deficient on the IUCN Red List, including three climate change vulnerable taxa and 16 taxa believed to be important for use.
- Several geographic areas contain high numbers of used, climate change vulnerable and/or globally threatened freshwater fish taxa. In the case of threatened and climate change vulnerable taxa, densities are much higher in Lake Tanganyika than in all other areas. In terms of taxa that are important for use, Lake Tanganyika once again stands out as containing the highest densities, though other locations, particularly the region's other major lakes, also contain taxa that are important for this reason.

Recommendations

- Further research (e.g. household surveys) to determine levels local reliance on fish as a source of protein and/or income, which taxa are most important, and how these trends vary between locations, is strongly recommended. This is particularly desirable in Burundi and DRC were data are notably lacking. It is also desirable to increase surveys of fish stocks to determine why there has been an observed shift to smaller taxa at some locations.
- We recommend investigation of the potential for increasing aquaculture as a means to reduce pressure on existing fish stocks. Taxa currently used for aquaculture (e.g. tilapia, Nile Perch, catfish) are neither threatened nor thought to be vulnerable to climate change impacts, and so might represent good taxa for this purpose. Wherever possible, however, it would be better to identify native taxa fit for this purpose to avoid the problem of escapees becoming invasive.
- A number of taxa identified as important for use are also believed to be neither climate change vulnerable, nor threatened with extinction, and it is logical that, wherever possible, these taxa are targeted preferentially. However, typical fishing methods currently used in the region are non-discriminatory, making it very difficult to target one taxon over another. We fully advocate research into, and uptake of, more selective fishing approaches wherever possible.
- Monitoring of the following areas in relation to climate is desirable: habitat preferences; success of fish migrations in the light of any changes to the hydrology of aquatic systems, and taxon range

changes (particularly retractions in one area that are not coupled with expansions elsewhere). Research into the reproductive capacity and genetic health of many taxa is a key area for future work that may provide insights into their capacity to adapt to change. An increased knowledge of many taxa's migratory habits is also recommended.

- Climate change adaptation interventions, where deemed necessary and appropriate, may include site-management and protection of key habitats. It may be desirable to give particular attention to the more 'peripheral' habitats of the region's lake ecosystems (which may be particularly susceptible to increased sedimentation), as well as flowing waters (e.g. mountain streams) that are sensitive to changes in the wider hydrological systems (e.g. precipitation and snowmelt regimes). Efforts to preserve the quality of aquatic ecosystems should take account of the roles played by the integrity of surrounding terrestrial ecosystems (e.g. vegetation cover, soil stabilization, water retention), which are also extremely important to protect.
- Conservation actions for threatened taxa should continue to be implemented wherever possible. Existing and planned conservation efforts should take note of the findings on taxon use and/or climate change vulnerability presented in this work, and modify conservation strategies, actions and research accordingly. The protection of spawning grounds of known importance from threats such as disturbance and pollution should be seen as a priority, as should the changes to fishing practices described above. Increased research into the threat status and ecology of the 41 Data Deficient taxa is also recommended.
- The highlighted geographic areas, described above, are of particular interest as they represent regions where conservation research and actions, both present and future, are of greatest importance. Conservationists, developers, and all interested parties should be aware of the value of these areas, but should also acknowledge that taxa highlighted in this assessment may occur in other areas, perhaps where numbers of taxa are lower overall, or where a lower proportion have been highlighted.

Fishing with a monofilament net. This method of fishing does not discriminate between different species. © R. Allgayer and A. Sapoli

Chapter 6. Mammals

6.1 Overview of mammals considered in the assessment

Our assessment considered a total of 353 mammal species, within 45 families. The largest of the families represented include Muridae (68 species), Soricidae (48 species) and Vespertilionidae (34 species). WCS (2011) recognizes a total of 41 mammal species as being endemic to the AR. However, owing to differences in taxonomy (for example, we consider *Tachyoryctes ruandae* to be part of the much more widely distributed *T. splendens* (Schlitter *et al.* 2008)), and that we considered taxonomy down to species level only (for example, WCS consider the subspecies *Cercopithecus mitis kandti* as an endemic) we recognize a total of 30 endemic mammals.

Figure 6.1 shows that mammal richness is highest in the area north of (as well as directly west of) Lake Edward, including protected areas such as Virunga National Park (DRC), the Rwenzori Mountains, Queen Elizabeth National Park and Toro-Semliki Wildlife Reserve (all in Uganda). In such areas mammal richness can reach up to 197 species per grid cell, though more typical densities are between 160 and 176 species per cell.

In general, mammal species richness declines as one moves away from this centre of high richness, and this is particularly true as one moves southward. Notable exceptions to this rule include the far south of the Réserve Naturelle des Primates Kisimba Ikobo, the Réserve de Sud Masisi (west of Lake Kivu), the far south of Kahuzi-Biega National Park (all in DRC) and the area on the Rwanda-Burundian border (including Kbira and Nyungwe National Parks).

Areas with visibly lower mammal richness include the Itombwe Massif (DRC), the southernmost area of DRC within the Rift and the south-easternmost area of Tanzania within the Rift. The lowest mammal richness of all can be found in cells directly over the region's lakes, where densities can be as low as 18 species per grid cell.

Of the 353 mammal species considered, 31 (9%) are known to be globally threatened with extinction according to the IUCN Red List (IUCN 2011) (although seven were not evaluated and 17 were considered Data Deficient).

Eastern Gorilla (*Gorilla beringei*) is endemic to the Albertine Rift. It is listed as Endangered on IUCN's Red List™ and was also assessed as vulnerable to climate change. This species is important to humans due to the ecotourism benefits it generates and, to a lesser extent, as a source of food, for pet/display purposes, and to make handicrafts, jewellery and wearing apparel. © Ron Ritchie

Figure 6.2 shows the distribution of globally threatened mammals throughout the AR, and indicates that areas containing the greatest numbers of threatened species (Figure 6.2a) include the Rwenzori Mountains National Park (Uganda), the northern and southern extents of the Virunga National Park (DRC), Bwindi Impenetrable National Park (Uganda) and the adjacent Domaine de Chasse de Rutshuru (DRC), the far eastern portion of the Kahuzi-Biega National (west of Lake Kivu) (DRC) and Nyungwe National Park (Rwanda). These areas correspond well with areas where high proportions of the total species present are threatened (Figure 6.2b), suggesting that areas with higher species richness are likely to support a disproportionately high number of threatened species.

6.2 Importance for human use

A total of 85 species were selected as being important for use[22]. With the exception of the Black Rhino (*Diceros bicornis*), which was found to only have an economic value, all species were found to have some form of subsistence, according to both the literature search and the expert consultation. In total, 60 species (71% of all used species)

22. The terms 'important' and 'most important' are relative only to other mammal species in the AR when discussed in this chapter, meaning that the importance of mammal species cannot be compared with species in different taxonomic groups.

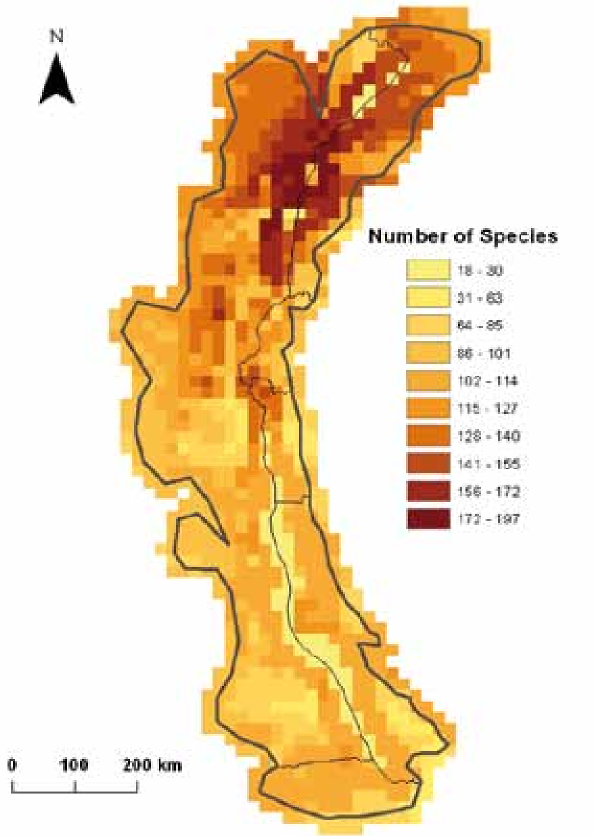
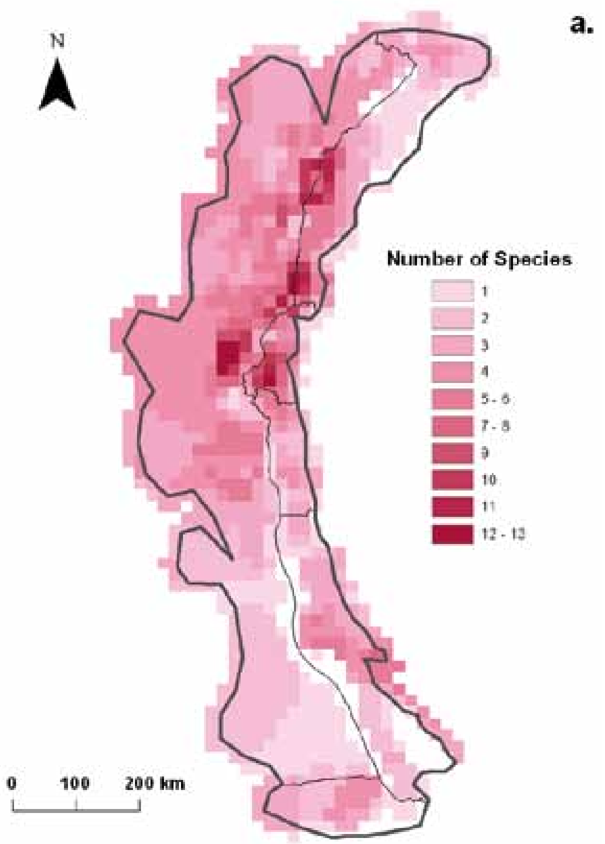
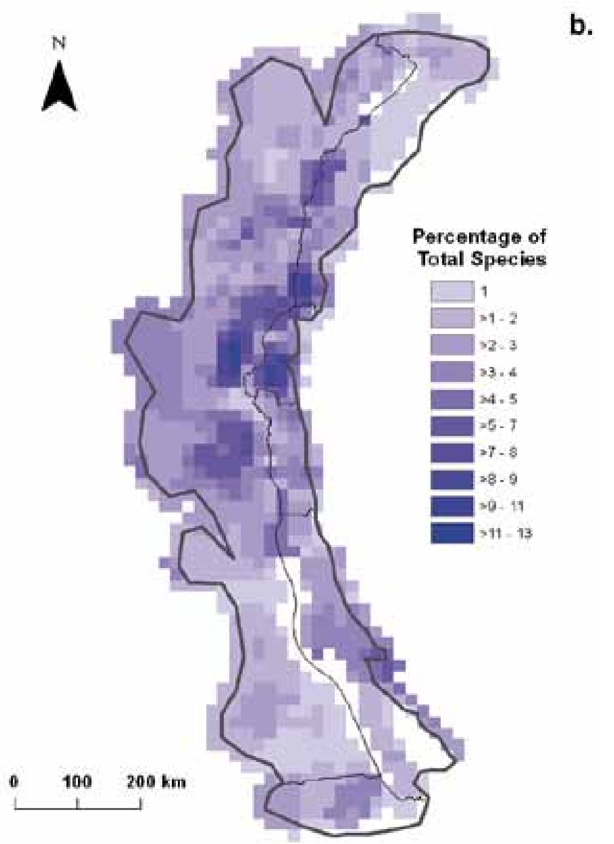


Figure 6.1 Species richness of mammals in the AR.

Figure 6.2 Distribution of globally threatened (IUCN 2011) mammals in the AR. Map (a) shows *total numbers* of species known to be threatened with extinction. Map (b) shows the *percentage of the total species present* in each region that are threatened.





were found to have commercial value at the local level, 14 (16% of all used species) were found to have some sort of national commercial value, and 37 (44% of all used species) some form of international commercial value. Thirty-three species were identified as being most important in terms of their contribution to subsistence and incomes (Table 6.1), and were selected mainly due to their use as a food item, although certain species were selected because of their importance in the pet trade or as a source of medicine.

Mammals are a well studied taxon, and some information was available for all species recognized as important for use, and often this was specific to the AR area. The legality of hunting varies between countries and can be species-specific. For example, in Uganda wild meat hunting of all species is illegal (except licensed sport hunting and some vermin) (Olupot *et al.* 2009), in Zambia some licensed hunting is allowed in Game Management Areas, and in Tanzania hunting it is restricted by season, types of hunting and dependent on licenses, though traditional hunting methods are not allowed (Roe 2008).

Table 6.1 Most important species for subsistence use and/or incomes in the AR.

Species	Common Name	Endemic?	International value?	Uses
Alcelaphus buselaphus	Hartebeest		Yes	Human food; wearing apparel; sport hunting
Atherurus africanus	Brush-tailed Porcupine			Human food; wearing apparel
Cephalophus dorsalis	Bay Duiker		Yes	Human food; wearing apparel
Cephalophus leucogaster	White-bellied Duiker		Yes	Human food; wearing apparel
Cephalophus nigrifrons	Black-fronted Duiker		Yes	Human food; sport hunting
Cercopithecus ascanius	Red-tail Monkey			Human food; wearing apparel; bow covers
Cercopithecus lhoesti	L'hoest's Monkey	Near endemic		Human food; wearing apparel; bow covers
Cercopithecus mitis	Blue Monkey			Human food; wearing apparel; medicine; bow covers; pet trade
Civettictis civetta	African Civet			Human food; wearing apparel; medicine; musk
Colobus guereza	Guereza Colobus		Yes	Human food; wearing apparel; bow covers; pet trade
Cricetomys emini	Emin's Pouched Rat			Human food
Damaliscus lunatus	Topi		Yes	Human food; medicine; sport hunting
Gorilla beringei	Eastern Gorilla	Yes	Yes	Ecotourism; Human food; jewellery; pet trade
Hippopotamus amphibius	Hippopotamus		Yes	Human food; medicine; jewellery; sport hunting
Hyemoschus aquaticus	Water Chevrotain		Yes	Human food; jewellery
Hylochoerus meinertzhageni	Giant Forest Hog			Human food; medicine
Hystrix africaeaustralis	Cape Porcupine			Human food; medicine; wearing apparel
Hystrix cristata	Crested Porcupine			Human food; medicine; wearing apparel
Kobus ellipsiprymnus	Defassa Waterbuck			Human food; medicine; wearing apparel; sport hunting
Kobus kob	Uganda Kob		Yes	Human food; medicine; sport hunting
Orycteropus afer	Aardvark			Human food; medicine; poison; jewellery
Ourebia ourebi	Oribi		Yes	Human food; wearing apparel; sport hunting
Pan troglodytes	Chimpanzee		Yes	Ecotourism; Human food; wearing apparel; medicine; pet trade
Phacochoerus africanus	Warthog		Yes	Human food; sport hunting
Philantomba monticola	Blue Duiker		Yes	Human food
Potamochoerus larvatus	Bushpig		Yes	Human food; animal food; sport hunting
Potamochoerus porcus	Red River Hog			Human food
Redunca redunca	Bohor Reedbuck		Yes	Human food; medicine; sport hunting
Syncerus caffer	African Buffalo		Yes	Human food; sport hunting
Thryonomys swinderianus	Common Cane Rat			Human food; medicine
Tragelaphus eurycerus	Bongo			Human food; medicine; wearing apparel
Tragelaphus scriptus	Bushbuck		Yes	Human food; sport hunting
Tragelaphus spekii	Sitatunga		Yes	Human food; jewellery; wearing apparel

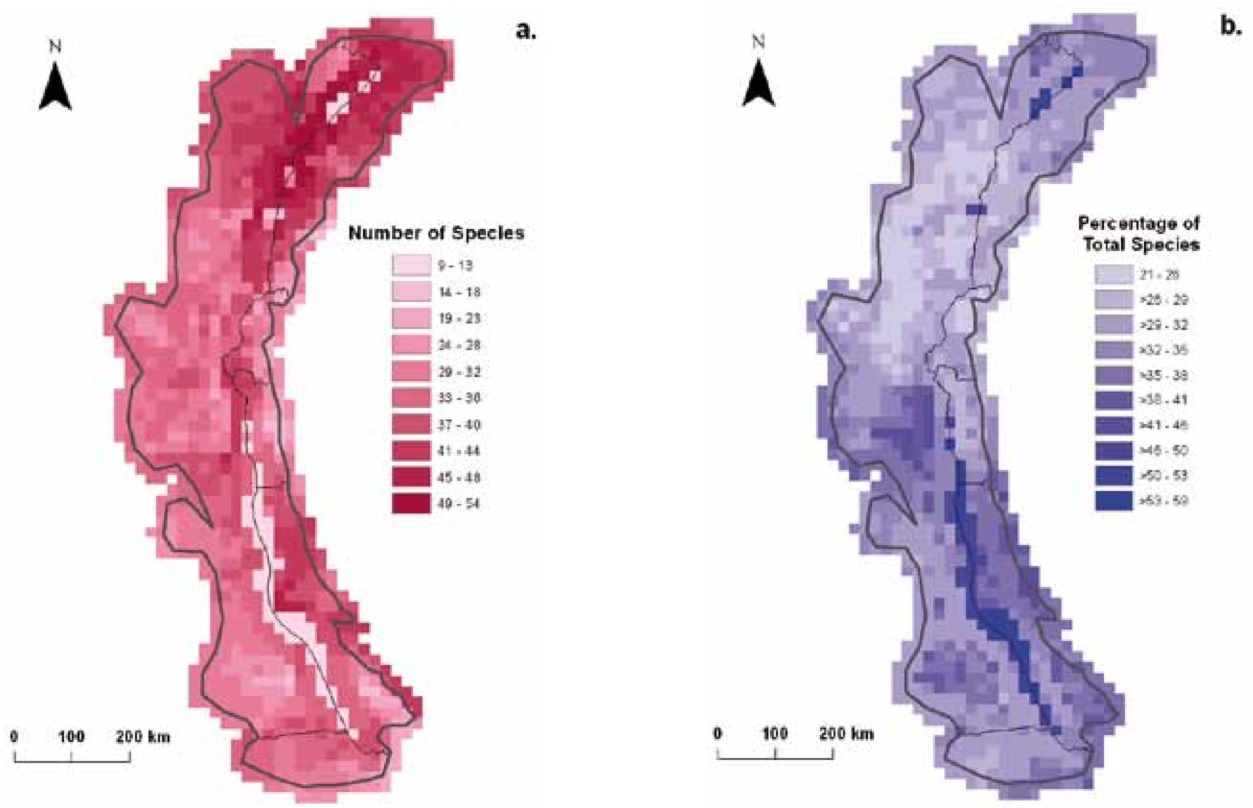
The highest density of mammal species thought to be important for use can be found along the DRC/Uganda border in the north of the AR, where densities can reach up to 54 species per grid cell (Figure 6.3a). High densities can also be found around Mahale National Park in Tanzania. Interestingly, Lake Tanganyika and Lake Edward have the highest proportion of total species found to be important for use (53–59%) (Figure 6.3b), though only low numbers of species important for use (and indeed overall) are located here (9–13 species).

6.2.1 Harvest for human food

Consulted experts identified 81 species that are important, compared with other mammals in the AR, for use as human food. These ranged from very popular food items, such as Bushpig (*Potamochoerus larvatus*) and Giant Forest Hog (*Hylochoerus meinertzhageni*), to those that are primarily hunted due to being a livestock pest, but eaten if killed, such as Leopard (*Panthera pardus*). All 81 species were used for subsistence, 57 also had a local commercial value, 13 a national commercial value, and 35 an international value. However, the commercial value of the species was often a result of another use type, such as being sold in the pet trade, rather than food. Particular species and groups were found to be important or desirable as wild meat in the AR, including duikers and other antelopes, pigs, hippopotamuses, civets and buffalo. Within the literature duikers, primates and rodents were identified as being the most commonly hunted animals in the forests of Africa. Both numerically, and in terms of biomass, duikers are believed to be the most important wild meat group. Fa (2007) suggested that "in most cases, bushmeat markets mainly sell ungulates and rodents, but primates constitute more than 20% of the trade". Fa and Brown (2009) found similar results, stating that "mammals are the prime source of bushmeat, and that ungulates and rodents make up the highest proportion of biomass extracted".

Experts identified 22 species of the family Bovidae that are hunted for their meat, of which five are of the genus *Cephalophus* (duikers), four of the genus *Tragelaphus*, three of the genus *Kobus* and two of the genus *Hippotragus.* There are nine known species and sub-species of duiker in the AR. However, due to a lack of taxonomic clarity, use information derived for some species/sub-species were

Figure 6.3 Distribution of human-utilized mammals in the AR. Map (a) shows *total numbers* of species known to be of important for human use. Map (b) shows the percentage of the *total species present in each region* that are important for human use.



combined, including Weyns' Duiker (*Cephalophus weynsi*) and Peters' Duiker (*C. callipygus*), which were considered as one, and Black-fronted Duiker (*C. nigrifrons*) and Ruwenzori Black-fronted Duiker (*C. nigrifrons rubidus*), also considered as one. Evidence of use was found for all duiker species in the area, except for Harvey's Duiker (*C. harveyi*) whose range is mainly outside of the AR (Antelope Specialist Group 2008). Other species of antelope found to be important as sources of meat in the AR include Waterbuck (*Kobus ellipsiprymnus*), Uganda Kob (*Kobus kob*), Topi (*Damaliscus lunatus*), Hartebeest (*Alcelaphus buselaphus*), Oribi (*Ourebia ourebi*), Bongo (*Tragelaphus eurycerus*), Bushbuck (*T. scriptus*) and Sitatunga (*T. spekii*).

Experts identified 17 species of primate that are used for food; 12 from the family Cercopithecidae (old-world monkeys), two species of Hominidae (great apes), two species of Galagidae (bushbabies) and one species of Lorisidae (lorisids). The two great ape species identified were the Eastern Gorilla (*Gorilla beringei*) and Chimpanzee (*Pan troglodytes*). There are two subspecies of gorilla found in the AR, including the Mountain Gorilla (Gorilla beringei ssp. *beringei*) and the Eastern Lowland Gorilla (Gorilla beringei ssp. *graueri*). Globally, apes have been found to be hunted in 62% of areas in which they are protected (Redmond *et al*. 2006), and both chimpanzees and gorillas have been estimated as having an average annual off-take of 5–7% of the total population, which surpasses the total annual population increase (Bowen-Jones and Pendry 1999). Moreover, surveys across parts of the Congo Basin have indicated that great apes, including gorillas, chimpanzees and bonobos make-up between 0.5 and 2% of the meat found in wild meat markets (Nellemann *et al*. 2010). Off-take levels have been found to be 10 times higher by immigrant commercial hunters compared with local subsistence hunters in the Congo basin (outside of the AR) (Ape Alliance 1998), and given that there is much cross-border movement of people within the AR, particularly between DRC, Rwanda and Uganda, this suggests the potential for an increase in off-take rates in areas with a high rate of immigration.

Four species of the family Suidae and one species of Hippopotamidae were identified by experts as being used for their meat, all of which were used for subsistence and had a local commercial value. Bushpig is a particularly popular source of wild meat, which is readily caught, and consumed or sold within the Ugandan AR, and in other parts of Tanzania and DRC (Carpento and Germi 1989; Caro 1999; Olupot *et al*. 2009; Tumusiime *et al*. 2010).

Okapi (*Okapia johnstoni*) was assessed as vulnerable to climate change. This species is used for food by humans and clothing is made from its unique coat. © Derek Keats

A range of rodents and other small mammals were identified by experts as being used for food, including four species of Manidae (pangolins), four species of Leporidae (rabbits and hares), three species of Hystricidae (porcupines), two species of Mustelidae, two species of Nesomyidae, two species of Procaviidae (hyraxes) and two species of Thryonomyidae (cane rats), among others. Rodents are a popular source of wild meat across most of Africa and many other parts of the world, and in West and Central Africa, they have been estimated to make up almost 40% of hunted species (Fa and Brown 2009). Larger rodents such as species of *Cricetomys* (pouched rats), *Thryonomys* (cane rats) and African Brush-tailed Porcupine (*Atherurus africanus*) have been identified as being more popular than their smaller counterparts (Fa and Brown 2009).

6.2.1.1 Uganda

Fa and Brown (2009) found that Bay Duiker (*Cephalophus dorsalis*) and Blue Duiker (*Philantomba monticola*) were two of the main species hunted in the tropical moist forests of Africa (not specifically the AR). Although popular, duikers, Bushbuck (*Tragelaphus scriptus*) and Ugandan Kob were found to be some of the cheapest wild meats available near hunting sites in the Ugandan AR, which is likely related to their availability (Olupot *et al.* 2009). Olupot *et al*. (2009) found that the average cost of Bushbuck in four of Uganda's National Parks and Conservation Areas was USH1,943 (USD1.14) per kg, whereas Sitatunga was more expensive at UGS2,090 (USD1.23) per kg. Ugandan Kob was found to be one of the most commonly harvested species in Murchison Falls and Queen Elizabeth National Parks, and Oribi was one of the key species harvested in Kafu Basin (partly within the AR). The total number of Oribi recorded as killed over the study period (9–10 months) was 527 in Queen Elizabeth National Park, Murchison Falls National Park and Kafu Basin (the highest of all species recorded), and these sold at an average price of USH1,809 (USD1.09) per kg though Waterbuck sold for a higher price of UGS2,165 (USD1.27)[23] per kg (Olupot *et al*. 2009). In addition, Lwanga (2006) found that duikers were the greatest target for poachers in Kibale Forest, with more than 90% of wire snares the size suitable for catching duikers and other similar sized animals.

Although primates are thought to have a lower meat yield relative to their body size compared with many other mammals (Ape Alliance 1998), many smaller primates are hunted for consumption in parts of the AR. In particular, species of the genus *Cercopithecus* appear to be a popular foodstuff; Red-tailed Monkey (*C. ascanius*) and L'hoest's Monkey (*C. lhoesti*) were found to be popular in parts of Uganda including the Rwenzori Mountains (Olupot *et al*. 2009). Red-tailed Monkeys are also killed due to their crop raiding behaviour (Hill 1997). Blue Monkey (*C. mitis*) was found to be utilized in the wild meat trade and eaten within Uganda (Olupot *et al.* 2009), which may be of concern as this species includes the Critically Endangered subspecies Schouteden's Blue Monkey (*Cercopithecus mitis* ssp. *schoutedeni*). Recent prices for meat within the AR were not available, but meat from *Cercopithecus* species cost on average USD5.92 per carcass (rural areas) and USD11.72 per carcass (urban areas) in Nigeria, and USD7.24 per carcass (rural areas) and USD11.81 per carcass (urban areas) in Cameroon (2002 prices) (Macdonald *et al.* 2011). Olive Baboon (*Papio anubis*) accounted for 16% of all catches in Uganda's Budongo Forest (Tumusiime *et al.* 2010) and was also found to be targeted because of its crop raiding behaviour (Olupot *et al*. 2009; Tumusiime *et al.* 2010).

Tumusiime *et al.* (2010) suggest that Bushpig accounted for 30% of all catches in the Budongo Forest, and poachers ranked the species highly in terms of the amount of income its sale would generate, taste, health benefits, availability and overall preference from a hunter's perspective (Olupot *et al*. 2009), and is also hunted due to its crop raiding behaviour (Olupot *et al*. 2009). Olupot *et al.* (2009) found that people thought that the supply of Bushpig was fairly stable or increasing, suggesting no dramatic population declines, and that the meat was sold for USH2,076 (USD1.22) per kg.

Warthog (*Phacochoerus africanus*), Red River Hog (*Potamochoerus porcus*) and Giant Forest Hog are also seemingly popular species for meat: the former two being cheaper than Bushpig within the AR (Olupot *et al*. 2009). Hippopotamuses (*Hippopotamus amphibius*) are extremely popular for consumption in the AR, and Olupot *et al.* (2009) found that hippo ranked highest in terms of providing income to poachers, taste, health benefits, and availability, though most people, when asked, reported that the supply of hippo meat was decreasing.

African Brush-tailed Porcupine was found to be commonly traded and consumed across Africa, including within the AR, and is regarded as one of the most highly commercialized and commonly exploited wild meat species in Africa, yielding more than 65% of its total body weight in meat (Jori *et al.* 2002; Milner-Gulland *et al.* 2003). The popularity of this species for meat has led to attempts in parts of Africa to breed it (along with Emin's Pouched Rat (*Cricetomys emini*)) in captivity (Jori *et al.* 2002; 2004). Cape Porcupine (*Hystrix africaeaustralis*) and Crested Porcupine (*Hystrix cristata*) are targeted as crop pests and are hunted for their meat. The sale of porcupine meat was found to be fairly common in Kafu Basin and Murchison Falls Conservation Area at an average price of USH2,828 (USD1.66) for a whole specimen (Olupot *et al.* 2009).

Bushmeat hunters in the Albertine Rift (pictured here in the forests of DRC) are often reliant on wild meat as a source of food and/or on the income derived from its trade, and have been known to hunt illegally in protected areas. © Hart Lukuru Foundation

Wild meat provides some people with income and fulfils subsistence needs. It is often preferred in terms of taste, and believed to hold additional health benefits compared with domesticated meat and fish (Olupot *et al.* 2009). Female-headed households have been found to have less daily meat intake than male-headed households (Olupot *et al*. 2009). Olupot *et al.* (2009) did not find a relationship between the

23. Currency conversion carried out using 2007 rates.

daily intake of fish/livestock meat and of wild meat in Uganda, suggesting that if a household increases their intake of fish/livestock meat, it does not mean they will decrease their intake of wild meat. This could mean that people view wild meat as a desirable product, rather than simply a source of protein. Roe (2008) suggested that wild meat is increasing in importance as a traded commodity in Africa, and that income generated from the sale of wild meat varies depending on the species for sale, taste and availability. The location of sale was also found to influence price, Olupot *et al.* (2009) found that around Queen Elizabeth National Park hunter incomes were below the per capita average compared with others in their villages, and that annual wild meat contributed 21% of their income. Conversely, around Murchison Falls National Park sale of wild meat contributed an average of 48% of the annual income, and the average income for poachers in this area was far higher than that of per capita average. From this, Olupot *et al.* conclude that hunters are not necessarily driven by poverty.

6.2.1.2 DRC

Fa *et al.* (2002) estimated that nearly five million tonnes of wild mammal meat was consumed annually within the Congo Basin, which includes the DRC. The annual per capita consumption of wild meat in the DRC was calculated to range from 2.06 kg in 1995 to 1.51 kg in 2005, compared with 3 kg and 2.3 kg of domestic meat during the same years (Ziegler 2010). The same study estimated that wild meat production in the DRC was 88,735 tonnes in 2005, which with a human population of over 58,000,000 would mean annual extraction rates of close to 90,000 tonnes, raising the issue of the future sustainability of harvesting. In a separate study, Fa *et al.* (2003) predicted that protein supplies from wild meat would drop by 81% in all Central African countries in less than 50 years.

Wilkie and Carpenter (1999) determined that over 28 million Bay Duiker and 16 million Blue Duiker are killed in the Congo Basin each year. Wilkie *et al.* (1998) found that duikers and small mammals made up 80% of all meat consumption in Ituri Forest, with over 1,100 tonnes being harvested each year, and this is predicted to rise to over 3,800 tonnes by the year 2034. Similarly, Ichikawa (1987) suggested that duikers and Water Chevrotains made up 80% of the Mbuti people's catch. Interestingly, Ichikawa (1987) also reported that women are prohibited from eating certain parts of duikers and chevrotains, and that in the Tetri region women are entirely prohibited from eating these species. In Kahuzi-Biega National Park, Kasereka *et al.* (2006) interviewed 42 ex-poachers and found that 30% preferred to hunt Bongo, making this the most desired species in the park, whereas only 4.6% preferred Bushbuck.

De Merode *et al.* (2004) found that Chimpanzees are commonly killed by the Azande village community of Kiliwa (outside of the AR), and Rose (2001) suggested that they are killed in timber concessions. Little recent information on the price of primate meat in the AR could be found, but in Nigeria the head, limbs, and internal sex organs were sold for up to USD54 for a male Chimpanzee, compared with nearly USD6 for the head, limbs, internal organs and tail of a male Red Colobus (*Procolobus rufomitratus*) (Eniang et *al.* 2008). In Cameroon, Chimpanzee meat was found to be the most expensive wild meat on offer (Macdonald *et al*. 2011). Red-tailed Monkey and L'hoest's Monkey were identified as being eaten within parts of the DRC, such as Ituri Forest (partly within AR) and Kiliwa (Ichikawa 1987; Carpaneto and Germi 1989; Wilkie *et al*. 1998; de Merode *et al*. 2004) and Olive Baboon is known to be eaten by Mbuti people in the DRC (Ichikawa 1987; Carpaneto and Germi 1989). Carpento and Germi (1989) reported that the Mbuti pygmies ranked Chimpanzee highly for taste.

Ichikawa (1987) found that Giant Forest Hog was highly prized by the Mbuti people of the Ituri Forest. Hippopotamuses are known to be hunted in the DRC (area unknown) and some populations within its range are thought to have declined by more than 95% due to intense hunting pressures (Lewison 2008).

Emin's Pouched Rat is said to be consumed throughout its range, and was found to be commonly exploited in the DRC (Jori *et al*. 2004). In combination with the African Brush-tailed Porcupine these two species accounted for more than 70% of small and medium game captured and consumed in rural areas (Colyn *et al*. 1987 in Jori *et al*. 2004). Much less specific information was found for the Forest Pouched Rat (*Cricetomys gambianus*), suggesting that it is perhaps a less popular species than Emin's Pouched Rat. However, information was found to suggest that this species, along with the Common Cane Rat (*Thryonomys swinderianus*), is eaten by humans in parts of the DRC (Wilkie 1989).

Wild mammals are an important source of food for many people in the AR, especially those that reside close to areas where edible species are readily available. For example, Wilkie *et al.* (1998) found that almost all hunting occurred within 15km of human settlements within the Ituri Forest. It has been suggested that wild meat is often used when the availability of other foods is low, for example in the

Azande village community of Kiliwa, the consumption of wild meat doubled during the lean season when other sources of food (i.e. crops) were scarce (de Merode *et al.* 2003). While wild meat can be extremely important for fulfilling subsistence needs, it is also hugely important for providing an income to many people, including hunters, processors and traders. According to Wilkie *et al.* (1998), wild meat is a major source of income for rural communities in the DRC, and in 1998 over 1.3 million kg of wild meat was being consumed each year by the inhabitants of the 1.39 million hectare Okapi Wildlife Reserve (outside of the AR) (Wilkie *et al*. 1998), much of which will have been caught by hunters and sold. The same study predicted that the human population within this area (28,897 people in 1987) would more than triple to 101,082 people by 2027. Wilkie *et al*. (1998) found that the Ife and Mbuti hunters of DRC obtain more than 60% of their calories by trading field labour and forest goods (often wild meat) for agricultural crops produced by farmers, with whom they often have long-term exchange relationships. Put another way, forest goods can act as a currency for other products.

Gender differences are apparent when considering the hunting of mammals both for subsistence use and to generate income. Men are often the primary hunters in the AR, and particularly for larger mammals: Bailey and Aunger (1989) found that many more physical types of hunting are undertaken by men, but that in the Mbuti tribe women play an important role in net hunting.

6.2.1.3 Tanzania

Hartebeest was identified by Caro (1999) as one of the most hunted species in Katavi National Park, on the outer edge of the AR. Topi were also found to be hunted in the same area, with legal off-take predicted as potentially having an adverse impact on local population sizes within 20km of the road (Caro 1999).

In Tanzania (unspecified area), Bushpig meat was found to be sold predominantly by men at market for TSH400 (USD0.49)[24] per kg (Ministry of Natural Resources and Tourism 2000). Hippopotamuses are hunted in Tanzania for their meat, although it is not known if this occurs specifically within the AR (Jenkins *et al*. 2003).

Muchaal and Ngandjui (1999) suggested that in some areas of sub-Saharan Africa wild meat can be an extremely important component of people's diets, and can contribute as much as 98% of dietary protein to local people. In Tanzania, consumption of wild meat by refugees from neighbouring countries (including Uganda, DRC and Rwanda) has been an important supplement to the typically low-calorie/low-protein diets of many of these people (Jambiya *et al*. 2007). In the Udzungwa Mountains (outside of the AR), wild meat was found to be cheaper than meat from livestock, costing USD0.46 per kg compared with USD1 per kg for beef (Nielsen 2006).

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24. Currency conversion carried out using 2000 exchange rates.

Red Hartebeest (*Alcelaphus buselaphus*) is hunted for its meat, skin (to create clothing or accessories), and for sport-hunting. This species was assessed as vulnerable to climate change.
© Bernard Dupont

Roe (2008) estimated that in Tanzania in 1998 the total amount of game meat that was obtained legally (mainly through trophy hunting, pest animal control and culls) was 1,282 million tonnes and worth in excess of USD1 million. A study in Mpimbwe and Katumba (just outside of the AR) found that 75% and 42% of people from the two areas, respectively, claimed that hunters hunted predominantly to obtain meat to sell rather than to consume it themselves (Martin *et al.* 2012). The same study found that the average price of wild meat was lower than domestic meat in both areas, costing TSH500 (USD0.32) per kg compared with TSH1500 (USD0.95) per kg in Mpimbwe and TSH2000 (USD1.26) per kg compared with TSH3500 (USD2.20) per kg in Katumba[25]. Interestingly this study also found that the frequency of wild meat consumption was higher in Mpimbwe, an area occupied by native Tanzanians, than Katumba, a former forest reserve turned refugee camp for people fleeing Burundi, though this was likely due to a scarcity of mammals close to Katumba and a lack of affordable domestic meat in Mpimbwe, rather than for cultural reasons.

6.2.1.4 Burundi

There was little information in the literature on the consumption of wild meat specific to Burundi, though there has reportedly been widespread poaching of Hippopotamuses for their meat in the country (Lewison 2008). It is not known, however, if this practice occurs within the AR. Primates are not commonly eaten in Burundi, but harvesting may take place in areas close to DRC for the purpose of cross-border trade and eventual consumption (Hobbs and Knausenberger 2003).

6.2.1.5 Rwanda

As with Burundi, there was a scarcity of recently published information regarding the consumption of wild mammal meat in Rwanda. Hill *et al.* (2002) determined that around Volcanoes National Park, the species most often purchased for their meat were Bushbuck and duikers. Apes are highly protected in Rwanda and are not generally targeted, however they can become caught in snares set for other mammals (Sandbrook and Roe 2010). Plumptre and Bizumuremyi (1996) reported that the taste of wild meat plays an important role in creating its demand in Rwanda.

6.2.1.6 Zambia

In northern Zambia (including areas outside of the AR) large mammals such as African Elephant (*Loxodonta africana*), Hippopotamus and African Buffalo (*Syncerus caffer*) are favoured due to their high meat yield, though Roan Antelope (*Hippotragus equinus*), Warthog and duiker species are also hunted and often consumed during the hunting trip (Brown and Marks 2007). The overall production of legal game meat in Zambia in 1998 was approximately 975 million tonnes (worth USD288,000), which, although less than the figure given for Tanzania, given the smaller population size of Zambia, equates to significantly more meat consumed per person (approximately 0.99 kg per person, per year, compared with 0.037 kg per person, per year) (Roe 2008). However, this figure likely represents only a very small proportion of the total amount of game meat (legal and illegal) consumed (Roe 2008). It is speculated that one third of local households derive at least part of their income from the hunting and sale of wild meat in northern Zambia (Brown and Marks 2007). Brown and Marks found that hunters were typically male, that consumption by urban dwellers was driven by preference for taste rather than by a lack of alternatives, and that people were willing to pay a premium for wild meat. A 3–4 kg bundle of dried wild meat typically sold for USD2.45–5.50 between 2002 and 2003, though the species did not appear to influence the price (Brown and Marks 2007). During the same time period, the average income earned by hunters was calculated to be USD490, based on 15 hunting trips per year, and people employed to assist with carrying meat would likely earn at least USD111 annually, based on five trips per year (Brown and Marks 2007). This compares with a per capita GDP of USD346 for the average Zambian in 2002 (UN Data 2012).

6.2.2 Harvest for the pet trade

Six species were identified as being important for use in the pet trade, these included Blue Monkey, Vervet Monkey (*Chlorocebus pygerythrus*), Guereza (*Colobus guereza*), Eastern Gorilla (both subspecies), Chimpanzee and Bosman's Potto (*Perodicticus potto*). All of these species are included in CITES Appendix II, except for the Eastern Gorilla and Chimpanzee which are in Appendix I.

There is an abundance of information available concerning the trade of wild-taken specimens of gorilla and chimpanzee for the pet trade, though often this is not specific to the AR. Bush (2009)

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25. Currency conversion carried out using 2012 exchange rates.

African Elephant (*Loxodonta africana*) has a large but fragmented distribution range across Africa, and is listed as Vulnerable on the IUCN Red List™. This species is used by humans for food, medicine, and to produce handicrafts, jewellery and other household goods. It is often poached illegally.
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reported that adult members of gorilla groups may be killed or wounded by poachers in the effort to obtain infants, and a further report suggested that for each Chimpanzee, gorilla or Bonobo entering the pet trade, between 10 and 50 more will have died in hunting camps or in transit to cities (IFAW and BCTF 2003). It was also reportedly common for baby chimpanzees and gorillas to be opportunistically taken by poachers who were primarily hunting for meat and had killed the infant's mother (Uganda Biotrade Programme 2004). No price information was available for the AR countries, however, four wild infant gorillas exported from Nigeria to a Malaysian zoo in 2002, which had been falsely declared as captive bred, had a reported value of USD1.6 million (Farmer and Courage 2008).

Vervet Monkeys are popular pets, particularly as they are diurnal and reportedly able to 'show emotion'. The reported international trade, however, recorded only four wild individuals exported from Tanzania between 2000 and 2010. Tanzania also reported the export of 143 wild Blue Monkeys between 2000 and 2010, and DRC reported the export of four. It is not known, however, how many (if any) of these individuals came from the AR region. CITES trade data contains no reported exports of wild Bosman's Potto or Guereza from AR countries during that time period.

6.2.3 Harvest for medicinal purposes

Thirty-four species were identified as important for use for some medicinal or health purpose, although data on this topic specific to AR mammals was relatively sparse. These species included three primates (Chimpanzee, Blue Monkey and Vervet Monkey). The bones and incisors of Chimpanzees are said to be used in Central and West Africa, and in DRC their bones were identified as used to treat fractures by the Mbuti people (Carpaneto and Germi 1989). As mentioned earlier in this section, the meat of a number of species, including Chimpanzee and Hippopotamus, is thought to have health benefits (Olupot *et al*. 2009).

In the Ituri Forest of DRC, the scales of Giant Pangolin (*Smutsia gigantea*) are considered highly desirable for use in native medicines and rituals (Ciszek 1999), and their claws are powdered and placed on scars to assist with the normal delivery of a baby (Carpaneto and Germi 1989). The powdered claws of Aardvark (*Orycteropus afer*), Long-tailed Pangolin (*Uromanis tetradactyla)* and Tree Pangolin (*Phataginus tricuspis*) are also used in this way (Carpaneto and Germi 1989). The scales of pangolin species are also prized in China for their perceived medicinal properties, and an international trade between African countries and China is suspected (Challender and Hywood 2012). There is anecdotal evidence that this type of trade may occur within Uganda, and one resident of Kisoro (within the AR) was caught allegedly trying to sell 115kg of scales (bought for USH50,000 (USD20.01)[26] per kg, and claiming that he "had many suppliers and always exported the pangolin scales to China" (www.newvision.co.ug 2012).

The powdered teeth of Aardvark are also used to induce vomiting, and the teeth of Western Tree Hyrax (*Dendrohyrax dorsalis*), believed to have magical powers, are placed on particular items, such as hunting nets and necklaces (Carpaneto and Germi 1989). Black Rhino was also identified as being important for this use type and as having a high international value, which likely relates to the use of its horn in traditional Asian medicine, and to more recent claims of curing cancer and acting as an anti-hangover tonic (Milliken and Shaw 2012).

6.2.4 Harvest for other purposes

A total of 48 mammal species were found to be important for producing handicrafts, jewellery and wearing apparel. These include bracelets, drums, wrist protectors, snuff boxes and a number of other items made from a variety of mammal body parts. In the Ituri Forest (DRC) the skins of old-world monkeys are used as wrist protectors on bows and for bracelets thought to protect the wearer (Carpento and Germi 1989). The skins from a large number of species are used to make various items, though the majority of these are suspected to be by-products from animals harvested for human food.

A major source of income for some AR countries is tourism, including both ecotourism and sport hunting. Twenty-three species were identified as being important for hunting for sport or trophies, the majority of which were larger mammals, including antelopes, hippopotamus, buffalo and big cats. Some smaller mammals including duikers and pigs were also found to be hunted for this purpose. The cost of sport hunting varies depending on the target species, as well as where the hunting is taking place. In Tanzania, trophy hunting fees range from highly sought-after species such as African Elephant (USD4,000) to common, less desirable species such as porcupine (USD70) and species of duiker (USD180–300) (Baldus and Cauldwell 2004). In Uganda it was free to hunt Olive Baboons and Vervet Monkeys, whilst Leopards cost USD7,000 and Sitatunga USD4,000 (Victor Hunting Safaris 2012), however, Uganda apparently banned sport hunting in 2010 due to concerns about declining

[26] Currency conversions carried out using 2012 rates.

Chimpanzee (*Pan troglodytes*)

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Chimpanzees have a widespread but patchy distribution across equatorial Africa. Poaching is among the major threats to this species, including for wild meat, the pet trade and for medicinal purposes (Oates *et al.* 2008). As a consequence, this species is now listed as Endangered on the IUCN Red List and has been listed in CITES Appendix I since 1977. It is also protected by law in most range states (Oates *et al*. 2008). Chimps are considered more 'emotionally robust' than gorillas and survive better in captivity, making them more of a target for the pet trade (Ape Alliance 2006). No monetary values for this species could be found for AR countries, but in Sierra Leone the average price paid for a chimpanzee was USD61 (Kabasawa 2009). Experts also reported that chimpanzees are used for traditional medicine, for example the Mbuti pygmies in Ituri Forest (DRC) use the ground, burnt bones of chimps, combined with salt and stored in the horn of a duiker, to heal bone fractures (Carpaneto and Germi 1989). The meat of chimps is eaten within the AR, with some communities describing it as 'a very good meat' (Carpaneto and Germi 1989). Hicks *et al*. (2010) found that in Aketi, northern DRC (outside of the AR) a large piece of chimp meat cost approximately USD3, making it much cheaper than chicken.

Although this species was assessed as being sensitive to changes in fire and flooding regimes, as well as being tolerant of only a narrow range of temperatures, it not expected to be exposed to significant climatic changes, and is also considered to be capable of adapting to change, if required. Therefore, this species was not assessed as vulnerable to climate change.

wildlife populations (J. Chenga, *in litt*, September 2012). Hunters are primarily from North America and Europe, and have been said to be willing to pay USD14,000–60,000 or more for a 10–21 day hunting safari (Wilkie and Carpenter 1999). However, it appears that there are few hunting concessions within the AR, and it is therefore unlikely that this pursuit provides significant income to the area.

African Lion (*Panthero leo*). Although widespread across much of Africa, the species is listed as Vulnerable on IUCN's Red List™. African Lions are hunted for a broad range of purposes including for medicines, sport and fur (used to make clothing and accessories).
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Ecotourism has the potential to generate significant revenue and can encourage the preservation of natural habitats and species. One of the more well known species bringing revenue to the AR in the form of ecotourism is the Gorilla, which generates significant revenue for Uganda, Rwanda and DRC. In 1998, Rwanda's gorilla tourism industry was estimated to contribute USD3–5million per year to the national economy, and in Uganda 600 tourists were estimated to bring USD1 million to the country in entrance fees alone (Wilkie and Carpenter 1999). In recent years the cost of gorilla permits, which allow tourists to watch the gorillas in the wild for up to one hour (though there is no guarantee of a sighting) has increased; now costing USD750 for a permit for Volcanoes National Park in Rwanda, USD500 for a permit for Bwindi Impenetrable National Park and Mgahinga Gorilla National Park, Uganda, and USD400 for Virunga National Park, DRC (IGCP 2012). A study by Spenceley *et al*. (2010) found that gorilla trekking is the most popular leisure activity for international tourists to partake in when visiting Rwanda, with 86% of the 19,783 visitors to Volcanoes National Park in 2008 choosing to pay to take part. The same study found that gorilla and related tourism employed at least 455 local people on a full time basis and at least 136 on a casual basis, creating an annual wage bill of over USD1 million; with individual's wages varying from USD1.10 per day for cleaners and gardeners in hotels, to porters, many of whom were former poachers, who earned USD8 per trip (Ashley 2008 in Spenceley *et al*. 2010). Benefits to local people also came from donations from tourists to local initiatives (USD300,000 per year), fruit and vegetable purchases (USD110,000–USD266,000 per year), handicrafts (USD91,000 per year), payments for traditional dancing (USD30,000 per year), informal guides and transport (USD26,000 per year) and cultural tours (USD14,000 per year) (Spenceley *et al*. 2010).

Despite the large amounts of money being spent by tourists, there is some criticism of how much ecotourism genuinely benefits local people. A study at Mgahinga Gorilla National Park found that although gorilla tourism generated large amounts of revenue, the amount reaching local communities was not enough to counteract the effects of a loss of farming and grazing land and access to the forest (Adams and Infield 2003). The same study found that local people did not feel as though they benefited from tourism, commenting that tourists ''just drove by and waved''. However, ecotourism remains popular, and as well as gorillas there are opportunities for tourists to take part in 'chimp treks' and other wildlife tours, which appear to be aimed at wealthy tourists. A 'complete primate safari' in Uganda and Rwanda lasting 10 days is priced at USD5,488 and promises luxury accommodation (www.safari365.com 2012). Most advertised tours also include viewing opportunities of other species such as lions, giraffes, elephants and ungulates.

6.3 Climate change vulnerability

For the 353 mammal species assessed, we identified and considered a total of 19 climate change vulnerability traits, of which four related to 'Exposure', nine to 'Sensitivity' and six to 'Low Adaptability'. These are shown in Tables 6.1, 6.2 and 6.3.

Through assessing species' Exposure to climatic changes (Table 6.1), we expect 103 mammal species (29% of those assessed) to experience relatively 'high' levels of climatic change throughout their global ranges. A further 94 (27%) are expected to experience 'very high' levels of change. Of these 197 species, 76 are expected to experience large changes in two of the four climatic variables investigated, 22 across three variables, and 9 species (*Cercopithecus lhoesti*, *Crocidura fumosa*, *C. gracilipes*, *C. montis*, *Gerbilliscus nigricaudus*, *Kerivoula eriophora*, *Lemniscomys macculus*, *Paraxerus alexandri* and *Sylvisorex granti*) across all four.

African Wild Dog (*Lycaon pictus*)

This short, wiry canine has been eradicated from much of its range. Currently only 14 of the 39 range states still host populations, though there is a relatively large population still present in Tanzania (McNutt *et al.* 2008). Despite being legally protected in most range states, African Wild Dogs are threatened by persecution, habitat fragmentation and infectious diseases which are often transmitted from domestic dogs (McNutt *et al.* 2008). No evidence was found for the use of this species by people in the AR.

The African Wild Dog is expected to be exposed to large changes in three of the four climatic variables investigated: mean temperature and precipitation, and temperature variability. As a strict predator (typically of medium-sized antelope) the African Wild Dog was assessed as being sensitive to changes in its prey populations due to climate change. The various metapopulations of this species are known to have poor connectivity, meaning that the likelihood of *in-situ*, microevolutionary adaptation for this species occurring at a rate sufficient to be able to mitigate the impacts of climatic changes is reduced. In combination, these factors mean that the African Wild Dog was assessed as vulnerable to climate change.

In our assessment of species' Sensitivity to climatic changes (Table 6.2), 131 species (37%) were assessed as possessing traits that make them 'highly' Sensitive to climatic changes, and a further 120 (34%) to be 'very highly' Sensitive to changes. Of these 251 species, 142 possess one single trait, 75 possess two traits, 28 possess three traits, 5 species (*Hyemoschus aquaticus*, *Okapia johnstoni*, *Phataginus tricuspis Procolobus rufomitratus* and *Uromanis tetradactyla*) possess four traits, and one species (*Gorilla beringei*) possesses five traits.

Within the Sensitivity analysis, the most common trait possessed was a dependence on a narrow range of food types (trait S7) which was present in 95 species (27%). Species with this trait are likely to be more sensitive to changes in the wider ecosystem, as this could result in a decline in their essential food resources. The next most common traits possessed were a narrow tolerance range to some climatic variable (either temperature and/or precipitation) (traits S4 and S5)[27], which were each present in 86 species (24%). Species with distributions that experience a narrow (relative to other species assessed) range of temperatures and/or precipitation levels are likely to be more sensitive to new climatic conditions, should they arise.

Also an important trait within the Sensitivity analysis was habitat specialization, that is, species only occurring in only one IUCN-defined habitat type (trait S1). This was present in a total of 51 species (14%). Such species are believed to be specialized in their habitat requirements, suggesting narrow tolerance of conditions and therefore higher sensitivity to changes that may occur as a result of changes in climate.

[27] Note that our classification of narrow environmental tolerances is a relative measure based on all species considered. See Methods, Section 2.2.2.2 for details.

Table 6.2 Climate change *Exposure* measures used to assess AR mammals, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A4).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 353			
EXPOSURE				Low	High	Very High	Unknown
Temperature change	Substantial changes in mean temperature occur across the species' range	**E1:** Absolute difference between 1975 and 2050 mean temperatures (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	257	52	34	10
	Substantial changes in temperature variability occur across the species' range	**E2:** Absolute difference between 1975 and 2050 values of average absolute deviation in temperature (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	257	52	34	10
Rainfall change	Substantial changes in mean precipitation occur across the species' range	**E3:** Absolute ratio of change in 1975 and 2050 values of mean precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	257	52	34	10
	Substantial changes in precipitation variability occur across the species' range	**E4:** Absolute ratio of change in 1975 and 2050 values of average absolute deviation in precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	257	51	35	10
			Total	**156**	**103**	**94**	
			Percentage	**44**	**29**	**27**	

In our assessment of species' capacity to adapt to climatic changes (Table 6.4), 244 species (69%) were assessed as possessing traits that make them poorly adaptable, of which 28 (8%) scored 'Very High' in this dimension of the framework. Of these 244 species 174 possess only one trait, 52 possess two traits, and 13 possess three traits. 180 species (51%) are known to have poor connectivity between existing metapopulations (trait A4), suggesting a low probability of genetic transfer, which may be required for adaptive microevolution in the face of climate change. Eighty-eight species (25%) were assessed as being limited in their ability to migrate vertically, due to a lack of available area for them to inhabit at higher altitudes (trait A2).

Overall a total of 107 mammal species (30%) were recognized as being of highest vulnerability to climate change due to being highly sensitive, likely to be highly exposed, and poorly able to adapt. Of these 107 species, 24 are endemic to the region. Thirty-eight species (11%) are expected to experience high levels of climate change throughout their ranges, are sensitive to climatic change, but are not believed to be poorly able to adapt. Sixty-seven species (19%) were assessed as being both sensitive and unable to adapt to climate change, but not expected to experience high levels of change (relative to other mammals in the region). Thirty-four species (10%) are expected to be both highly

Table 6.3. Climate change *Sensitivity* traits used to assess AR mammals, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A4).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 353			
SENSITIVITY				Low	High	Very High	Unknown
A. Specialized habitat and/or microhabitat requirements	Habitat specialization	**S1:** Number of IUCN habitat types occupied by species	L = >1; H = 1	294	51	n/a	8
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of changes to fire regimes	**S2:** Fire frequency tolerance range	L = tolerates annual burns or can tolerate burns every 2–5 years; H = cannot tolerate fire	161	33	n/a	159
	Tolerance of flooding/ waterlogging	**S3:** Flooding frequency tolerance range	L = tolerates annual flooding or can tolerate flooding every 2–5 years; H = cannot tolerate floods	166	27	n/a	160
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of changes to precipitation regimes	**S4:** Average absolute deviation in precipitation across the species' current range	Average absolute deviation in precipitation across the species' historical range: L = highest 75%; H = Lowest 25%	257	52	34	10
	Tolerance of temperature changes	**S5:** Average absolute deviation in temperature across the species' current range)	Average absolute deviation in temperature across the species' historical range: L = highest 75%; H = Lowest 25%	257	52	34	10
D. Dependence on interspecific interactions which are likely to be disrupted by climate change.	Dependence on narrow range of food types	**S6:** Dependence on a particular fire regime to maintain food species	L = Not dependent on species that require fire to be maintained, or <50% of diet; H = Dependence on food species that require fire to be maintained for less than >50% of diet;	175	19	n/a	159
		S7: Number of dietary categories (vertebrate, invertebrate, fruit, flowers/ nectar/pollen, leaves/branches/ bark, seeds, grass and roots/ tubers) eaten by species	L = >2; H = 2 VH = 1	67	26	69	191
E. Rarity	Population size	**S8:** Total number of individuals	L: >2,000; H: 500–2,000; VH: <500	285	3	0	65
	Number of metapopulations	**S9:** Number of metapopulations (number of separate populations)	L = >5 populations; H = 2–5 populations; VH = 1 known population	280	1	0	72
			Total	**102**	**131**	**120**	
			Percentage	**29**	**37**	**34**	

Table 6.4 Climate change *Low Adaptability* traits used to assess AR mammals, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A4).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 353			
LOW ADAPTABILITY				Low	High	Very High	Unknown
A. Poor dispersability	Barriers to dispersal	**A1:** Existence of barriers that are likely to prevent dispersal	L = No known barrier; H = One barrier known to prevent dispersal; VH = >1 barrier known to affect dispersal	263	6	13	71
		A2: Difference between current mean elevation and maximum attainable through vertical migration	Maximum elevation attainable – current mean elevation (Difference between current mean elevation and maximum attainable through vertical migration) L = >500m; H = 250–500m; VH = ≤ 250m	88	80	8	177
B. Poor Evolvability	Known genetic bottleneck	**A3:** Genetic bottleneck	L = Not had a bottleneck; H = Have had a bottleneck and total population > 500 individuals; VH = Have had a botleneck and total population less than 500 individuals	66	1	0	286
	Potential for genetic transfer between metapopulations	**A4:** Connectivity of metapopulations	L = >50% of metapopulations connected; H = <50% of metapopulations connected; VH = No connectivity	109	171	9	64
	Reproductive capacity/ survivorship	**A5:** Reproductive output (mean litter size x mean litters per year)	L = highest 75%; H = Lowest 25%	53	22	n/a	278
		A6: Generation length (Maximum longevity – mean age at maturity)/2	L = highest 75%; H = Lowest 25%	51	17	n/a	285
			Total	**109**	**216**	**28**	
			Percentage	**31**	**61**	**8**	

exposed and unable to adapt, but not actually sensitive to climate change. Under our pessimistic scenario for values of missing data (see Methods, Section 2.2.1.3) a total of 200 species (57%) are considered climate change vulnerable.

Table 6.5 shows the taxonomic families containing two or more species recognized in our assessment as being climate change vulnerable. Interestingly, small mammals such as shrews (Soricidae), mice and their relatives (Muridae) comprise some of the largest groups of climate change vulnerable mammal species. Families of bats (i.e. Vespertilionidae; Rhinolophidae; Hipposideridae Nycteridae and Pteropodidae) are also prevalent on this list.

Figure 6.5 shows the distribution of climate change vulnerable mammals throughout the AR. Map 6.5a highlights total numbers of climate change vulnerable mammal species and suggests that the greatest numbers (40–53 species per grid cell) can be found in and around more northern protected areas such as Virunga National Park (DRC), Toro-Semliki National Park, Rwenzori Mountains National Park, Queen Elizabeth National Park (all Uganda) and Nyungwe\Kibira National Parks (Rwanda and Burundi, respectively). Outside of these areas, numbers of climate change vulnerable species appear reasonably uniform throughout (typically 11–30 species per grid cell), although notable exceptions to this include Lakes Albert, Edward and Tanganyika (where, in places, no climate change vulnerable mammals at all are present), and areas due east, south and west of

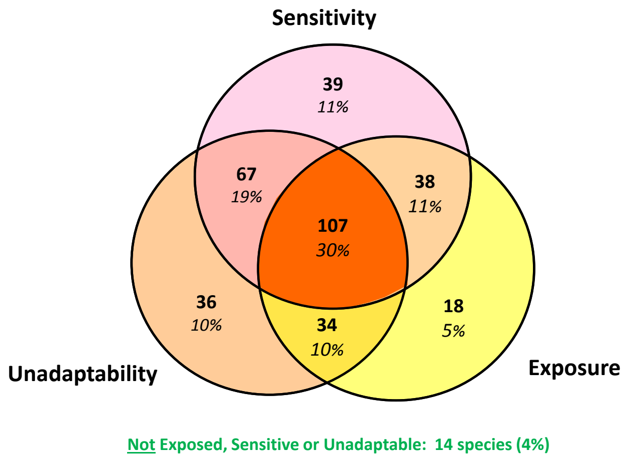


Figure 6.4 Numbers of AR mammal species recognized as Exposed, Sensitive and/or Unadaptable to climate change, and all combinations of the three.

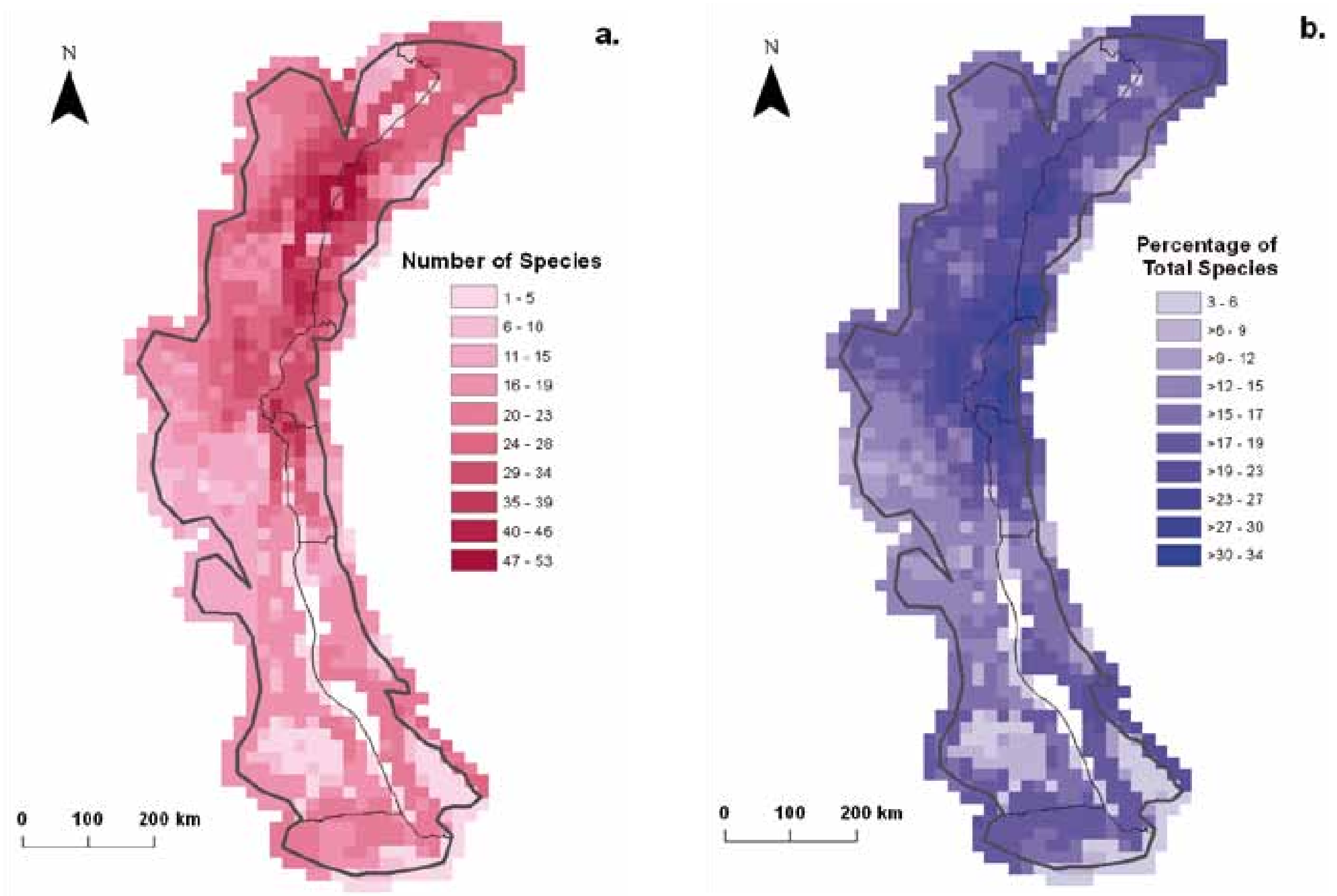


Figure 6.5 Distribution of climate change vulnerable mammals in the AR. Map a shows total numbers of species thought to be vulnerable to climate change impacts. Map b shows the percentage of the total species present in each cell that are climate change vulnerable.

the southern end of Lake Tanganyika (which contain as few as three climate change vulnerable mammal species).

Map 6.5b shows the percentages of all mammal species present in each grid cell that are climate change vulnerable, and highlights similar areas to map 6.5a. This suggests that areas with higher species richness are likely to support a disproportionately high number of climate change vulnerable species.

6.4 Combined utilization, threat and climate change vulnerability results

The numbers and proportions of mammal species known to be important for use, climate change vulnerable, globally threatened, and all combinations thereof are shown in Table 6.6.

A total of 24 species were assessed as being both important for use and climate change vulnerable. These species are *Alcelaphus buselaphus*, *Cephalophus silvicultor*, *Cercopithecus hamlyni*, *C. lhoesti*, *C. mitis*, *C. neglectus*, *Damaliscus lunatus*, *Equus quagga*, *Galago senegalensis*, *Giraffa camelopardalis*, *Gorilla beringei*, *Hippopotamus amphibius*, *Hippotragus equines*, *Kobus ellipsiprymnus*, *K. kob*, *K. vardonii*, *Lepus capensis*, *Okapia johnstoni*, *Ourebia ourebi*, *Papio anubis*, *Phacochoerus africanus*, *Procolobus rufomitratus*, *Redunca redunca* and *Smutsia temminckii*. Under a pessimistic scenario of missing values of climate change vulnerability data (see Methods, Section 2.2.1.3), the following 11 species would also be recognized as both important for use and climate change

Table 6.5 Mammal families with more than one climate change vulnerable species. Numbers in parentheses show percentages of the total species (within each family) considered for this assessment which are climate change vulnerable. Vulnerability figures are based on an optimistic scenario for missing data values.

Family	Number (and percentage) of climate change vulnerable mammal species
Soricidae	**27** (*56%*)
Muridae	**18** (*26%*)
Vespertilionidae	**10** (*29%*)
Bovidae	**9** (*37.5%*)
Cercopithecidae	**7** (*41%*)
Rhinolophidae	**5** (*42%*)
Nesomyidae	**3** (*25%*)
Nycteridae	**3** (*50%*)
Sciuridae	**3** (*27%*)
Galagidae	**2** (*40%*)
Giraffidae	**2** (*100%*)
Hipposideridae	**2** (*40%*)
Pteropodidae	**2** (*14%*)

Table 6.6 Numbers and proportions of AR mammals known to be globally threatened (IUCN, 2012), used climate change (cc) vulnerable, and all combinations thereof, including (where applicable) both optimistic and pessimistic assumptions of missing climate change vulnerability data values.

	Mammals (353 species)			
	Optimistic		Pessimistic	
	Number	%	Number	%
Total threatened*	31	*9*	31	*9*
Total used	85	*24*	85	*24*
Total cc vulnerable	107	*30*	200	*57*
Threatened and cc vulnerable	**21**	***6***	**25**	***7***
Threatened and not cc vulnerable	10	*3*	6	*2*
Not threatened and cc vulnerable	86	*24*	175	*50*
Not threatened and not cc vulnerable	236	*67*	147	*42*
Threatened and used	**8**	***2***	**8**	***2***
Threatened and not used	23	*6.5*	23	*6.5*
Not threatened and used	77	*22*	77	*22*
Not threatened and not used	245	*69*	245	*69*
Used and cc vulnerable	**24**	***7***	**35**	***10***
Used and not cc vulnerable	61	*17*	50	*14*
Not used and cc vulnerable	82	*23*	165	*47*
Not used and not cc vulnerable	186	*53*	103	*29*
Threatened, used and cc vulnerable	**4**	***1***	**4**	***1***

* Data Deficient, Near Threatened and unassessed species are grouped with 'not threatened' species.

vulnerable: *Cephalophus nigrifrons*, *C. weynsi*, *Cercopithecus ascanius*, *C. denti*, *Cricetomys emini*, *Genetta genetta*, *G. victoriae*, *Lepus microtis*, *L. saxatilis*, *Neotragus batesi*, *Poelagus marjorita,* giving a total of 35 species.

The densities of AR mammal species found to be important for use, climate change vulnerable (optimistic scenario), and combinations of the two are shown in Figure 6.6. This image highlights areas in the north, particularly in and around Toro-Semliki National Park, Rwenzori Mountains National Park, Queen Elizabeth National Park (all Uganda), and Virunga National Park (DRC) as having the greatest numbers of both species that are important for use and those that are vulnerable to climate change. In addition, the area surrounding Lake Albert (DRC and Uganda) and just north of Lake Tanganyika (DRC, Burundi and Rwanda) contain relatively large numbers of both human-used and climate change vulnerable species.

The area east and west of Lake Kivu (DRC and Rwanda) also supports both species important for use and vulnerable to climate change, though the latter appears more prominent in this region. The opposite appears true in regions further south (i.e. south DRC, Tanzania and Zambia, where numbers of human-used species appear more prominent than those of climate change vulnerable species.

A total of eight species (*Cercopithecus hamlyni*, *C. lhoesti*, *Diceros bicornis*, *Gorilla beringei*, *Hippopotamus amphibius*, *Loxodonta africana*, *Pan troglodytes* and *Panthera leo*) were assessed as being both globally threatened and important for use. Figure 6.6 shows areas where these two types of species overlap, and highlights the area where Virunga National Park (DRC) meets Rwenzori Mountains National Park (Uganda) as being of particular importance. The area surrounding Lake Kivu (DRC, Rwanda and Uganda to the northeast) is also highlighted as an area of importance, albeit with a higher concentration of threatened species. In all other areas, due the lower numbers of threatened species (see Figure 6.2), human use appears as the more prominent variable.

Hippopotamus (*Hippopotamus amphibius*)

© Scott Kinmartin

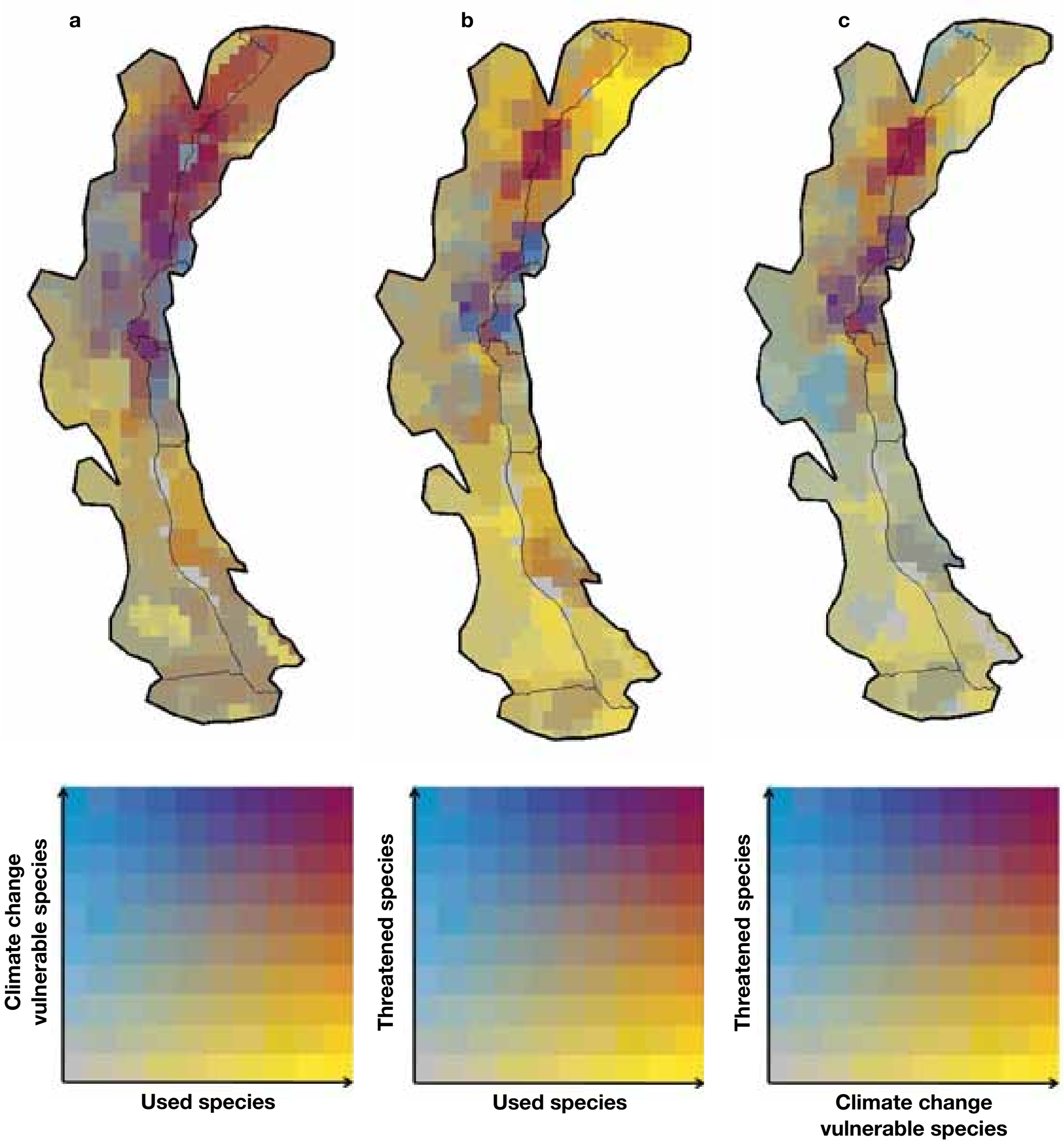
This large semi-aquatic mammal is distributed across much of sub-Saharan Africa, and is present in all six of the AR countries (Lewison and Oliver 2008). It is prized for its meat, and illegal and unregulated hunting for meat and ivory constitute major threats that have resulted in the species being listed as Vulnerable on the IUCN Red List (Lewison and Oliver 2008). According to Olupot *et al.* (2009), Hippopotamus meat sold on average for USD1.35/kg in Murchison Falls and Queen Elizabeth Conservation Areas, Uganda, making it one of the most highly priced meats in the country. In northern Zambia (outside of the AR), Hippopotamus was identified as one of the most popular species to be hunted for its meat, as its large size allows hunters to maximize the amount of meat harvested, whilst minimizing time in the bush and reducing potential the detection by law enforcement groups (Brown and Marks 2007). This species can be legally hunted as a trophy in some countries, and the fee to hunt a Hippopotamus is USD2,000 in Uganda (Victor Hunting Safaris 2012) and USD840 in Tanzania (Baldus and Cauldwell 2004). Furthermore, consulted experts indicated that Hippopotamus meat is often associated with perceived medicinal benefits, and that the ivory from teeth is sometimes used for jewellery.

The Hippopotamus is expected to be exposed to a large change in mean temperatures across its range, relative to other mammals of the region. The specific feeding habits of this species (i.e. the requirement of short 'hippo lawns'), are believed to make it particularly sensitive to changes in the climate, and particularly to associated changes in the natural fire regime. The various metapopulations of this species are known to have low connectivity; a fact which, when combined with the species' low reproductive output, makes adapting to environmental change (i.e. through genetic microevolution) at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ* unlikely. In combination, these factors mean that the hippopotamus was assessed as vulnerable to climate change.

A total of 21 species (*Acinonyx jubatus, Cercopithecus hamlyni, C. lhoesti, Crocidura fumosa, C. kivuana, C. lanosa, C. stenocephala, C. tarella, Dasymys montanus, Delanymys brooksi, Gorilla beringei, Hippopotamus amphibius, Hybomys lunaris, Lophuromys medicaudatus, Lophuromys rahmi, Lycaon pictus, Myosorex blarina, Rhinolophus ruwenzorii, Ruwenzorisorex suncoides, Sylvisorex lunaris and Thamnomys kempi*) were assessed as being both globally threatened and vulnerable to climate change impacts. Under a pessimistic scenario of climate change vulnerability the following four species would also be recognized under both categories: *Dendromus kahuziensis*, *Myotis capaccinii, Praomys degraaffi and Rhinolophus maclaudi*, giving a total of 25 species.

Figure 6.6 shows areas where these two types of species overlap (optimistic assumption of missing data values), and highlights similar areas of importance as Figure 6.6 (i.e. the border of Virunga and Rwenzori Mountains National Parks (DRC and Uganda) and the area surrounding Lake Kivu (DRC, Rwanda and Uganda to the northeast). In other regions, areas of overlap are common, though the patterns evident in Figures 6.2a and 6.5a persist here, particularly the decline in numbers of both types of species in areas other than those listed above, and a general prominence of climate change vulnerability over global threat status.

Figure 6.6 Bivariate plots showing combined results of assessments of climate change vulnerability and human utilization (a), global threat status and human utilization (b), and global threat status and climate change vulnerability (c) of AR mammals. Plots use data on total numbers of species per grid cell qualifying under each variable.



The four species recognized as being important for use, vulnerable to climate change and globally threatened are *Cercopithecus hamlyni*, *C. lhoesti*, *Gorilla beringei* and *Hippopotamus amphibius*. Under a pessimistic assumption of missing climate change data values this list remains the same.

6.5 Conclusions and recommendations

Conclusions

- The AR is home to a large number of mammal species, including several large, charismatic and iconic species, and a wide variety of smaller mammals – many of which are important for use. Mammals play a significant role in the wild meat trade, and provide people with a source of income. It is apparent that wild meat is an important component in the diets of many people in the AR, and during lean times it can be used as an 'emergency resource'. There is also evidence to suggest that in many areas, the consumption of wild mammal meat is related to preference, cultural traditions (and associated beliefs) and its perception as a status symbol.
- Over-exploitation of mammals for human food, alongside habitat loss and other pressures, has, in the past, contributed to an overall decline of many species. There is believed to have been a continent-wide halving in the abundance of large mammals in Africa's protected area network as a whole since the 1970s. This is likely to be the result of a combination of causes, though the overarching threats are thought to be overharvesting and habitat conversion. Changes in the rates of harvest, as well as the species targeted are expected as the region's human population continues to increase (including immigration of individuals with different preferences and cultural backgrounds) and as increased wealth in other countries (e.g. China) leads to an increased demand for AR species, particularly if their more local equivalents have become scarce.
- Many regions of the AR are already benefitting from revenue gained through mammal-based ecotourism, which also provides protection to the species of interest, and its habitat.
- Of the 353 mammals assessed for this project 107 were found to be climate change vulnerable under our optimistic scenario. This number increases to 200 under a pessimistic scenario for values of missing data, which demonstrates a moderately high level of uncertainty (and this is particularly so for some of the smaller mammals).
- Important aspects of climate change vulnerability of AR mammals include (among others) habitat specialization among many species, a low tolerance of extreme events (i.e. fires and/or floods), a lack of available space at higher elevations for species to move into, and a low connectivity of existing metapopulations (suggesting reduced genetic mixing, and a lowered probability of adapting genetically at the rate required to mitigate the impacts of climate change). Our greatest areas of uncertainty include knowledge of species' sensitivity to extreme events (and particularly how fires may impact upon important food species, particularly plants), the dietary requirements of many species, the available opportunities for species to migrate upwards, and many aspects of the genetics and reproduction of mammals that may permit adaptation *in-situ*.
- Thirty-one AR mammals are currently recognized on the IUCN Red List as being threatened with extinction. This includes eight species that are known to be used, and 21 species believed to be vulnerable to climate change (of which four are both used and vulnerable to climate change). Seventeen AR mammals are currently Data Deficient on the IUCN Red List, including seven species believed to be vulnerable to climate change impacts (five shrews and two bats).
- Several geographic areas contain high numbers of used, climate change vulnerable and/ or globally threatened mammal species. Among others, these include Virunga and Rwenzori Mountains National Parks (and particularly the region where the two meet) and the region surrounding Lake Kivu. A large region in the North of the AR, which encompasses Toro-Semliki National Park, Queen Elizabeth National Park, the area surrounding Lake Albert and that just north of Lake Tanganyika, also supports relatively high numbers of human utilized and/or climate change vulnerable species.

Recommendations

- We recommend an increase in efforts to raise awareness of, and enforce laws surrounding, the legality of hunting species. Particular focus should be given to species that are already under threat and/or are vulnerable to climate change, as well as to times of the year when hunting of wild mammal species is known to increase.

- We recommend investigation of the potential for domesticating or wild-farming of mammal species as a means to provide protein and reduce hunting pressures on wild populations. Rodent species such as cane rats (*Tryonomys*) and pouched rats (*Cricetomys*) may be particularly suitable (Hoffman 2008), especially in urban areas where people have little space and may not have easy access to wildlife. However, the choice of species must consider people's willingness to eat that meat, which may vary regionally, and ensure that further pressure is not put on wild populations.
- We encourage all stakeholders in the AR region to capitalize further on the mammal-based tourism opportunities available. We recommend the study of how existing ecotourism benefits local people and generates incomes, and how this can be further developed in a sustainable manner. Revenue generated in this manner could be reinvested into conservation, including for the benefit of species which are less well-known and popular with ecotourists.
- Monitoring of the following areas in relation to climate is desirable: quality (i.e. suitability for species) of key habitats; species' responses (particularly population changes) to extreme events (particularly fire); species range changes, particularly if lower altitudinal range boundaries are contracting, but this is not coupled with an expansion at the upper altitudinal limit, as well as species population changes more generally. An increased knowledge of species' dietary requirements will help us to identify any sensitive dependencies, while research into the reproduction and genetics of species would give insights into their capacity to adapt to change *in-situ*.
- Climate change adaptation interventions, where deemed necessary and appropriate, may include site-management or protection of key habitats, management of fire regimes, alleviation of risks associated with flooding, or efforts to ensure increased genetic mixing (e.g. corridor creation or translocation). Care should be taken to follow the IUCN Guidelines for Reintroductions and Other Conservation Translocations (August 2012), particularly regarding risk assessment around such activities.
- Conservation actions for threatened species, as prescribed on the IUCN Red List, should continue to be implemented wherever possible. Where not already occurring, existing conservation efforts should take note of the findings on species use and/or climate change vulnerability presented in this work, and modify conservation strategies, actions and research accordingly. Increased research into the seven Data Deficient mammal species is also needed.
- The highlighted geographic areas, described above, are of particular interest as they represent regions where conservation research and actions, both present and future, are likely to be of greatest need. Conservationists, developers, and all interested parties should be aware of the importance of these areas, but should also acknowledge that species highlighted in this assessment may occur in other areas, perhaps where numbers of species are lower overall and/or where a lower proportion has been highlighted.

Chapter 7. Plants

7.1 Overview of plants considered in the assessment

Plumptre *et al*. (2007) suggest that a minimum of 5,793 plant species occur throughout the AR, but also warn that this figure is highly tentative. Nevertheless, it is clear that the high plant species diversity within the region makes it of global importance. Through expert consultation, 256 plant and fungi species were identified as being used by humans for some purpose. Of these 256 species, detailed use information was obtained for 153 plants. It is recognized that far more plant species are likely to be used, but detailed information about them could not be gathered within the timeframe of this project. Our assessment of climate change vulnerability considered a subset of 204 plant species from the original 5,793 species, which represented 62 families. The majority of the species belonged to the Fabaceae family (45 species), Euphorbiaceae (13 species) and Meliaceae (11 species). Ninety-three species were considered in both aspects of our assessment, and, unless specified otherwise, it is these species which are discussed in section 7.4.

Plumptre *et al.* (2007) also suggest that the AR supports a minimum of 567 endemic plant species (again highlighting the biological importance of the region) and due to limited data availability we are unable to improve the accuracy of this estimate. The caveats surrounding the selection process of plant species for this assessment, as well as the uncertainties surrounding plant distributions are described in Chapter 2, particularly in Section 2.5.4, and these should be borne in mind when considering our results. As described in Chapter 2, the bias in our selection of plant species for this assessment (which favoured the eastern AR) meant that the resulting density maps (as presented for other taxa) were deemed misleading, and were therefore omitted from this report.

7.2 Importance for human use

Of the 256 plant species considered, 153 were found to be important for use[28], and 149 of these fulfilled some subsistence requirement. In total, 106 species (69% of used species) were identified as being important for medicinal purposes, 63 species (42%) as construction materials, 53 species (35%) as human food, 52 species (34%) as fuels, and a lesser number of species are important for other purposes, including for basket weaving, rope-making, handicrafts, jewellery and wearing apparel. Of the 153 important species, 27 (18%) are of the Fabaceae (legumes) family, 13 (8%) are of the Euphorbiaceae family and 7 (5%) are of the Asteraceae family.

In addition to use at the subsistence level, many species were found to provide some sort of income to harvesters and traders. Seventy-five species were considered to have local commercial value, nine as having national commercial value and 10 as having international commercial value. The majority of species with high commercial value were found to be those traded internationally as timber or for their medicinal properties.

***Aframomum angustifolium* is currently widespread throughout much of Africa, but was found to be climate change vulnerable. It is considered important to humans both for its medicinal properties and as a construction material.** Gerald and Buff Corsi © California Academy of Sciences

Twenty-seven plant species were identified as being the most important for use due to subsistence uses and/or contributions to local income (Table 7.1). Seven of these are from the Fabaceae family, three from the Asteraceae family and three from the Euphorbiaceae family. Twenty-two of these species had more than one type of use associated with them. For example, Wild Date Palm (*Phoenix reclinata*) (used to produce palm wine, which is popular throughout much of Africa and was found to be consumed within the AR, at least in Uganda and the DRC (Lambert 1998; Muhamuza and Byarugaba 2009; Agea *et al.* 2011)) is also used for several other purposes in the AR, including for fuel (Lambert 1998),

28. The terms ‘important’ and ‘most important’ are relative only to other plant species in the AR when discussed in this chapter, meaning that the importance of plant species cannot be compared with species in different taxonomic groups.

Table 7.1 Most important plant species for subsistence use and/or local incomes in the AR.

Species Name	Common Name	International Value?	Uses
Afzelia quanzensis	-		Medicine
Ageratum conyzoides	Goatweed		Medicine; veterinary medicine; during wedding ceremonies
Albizia grandibracteata	-		Construction materials
Albizia gummifera	Peacock Flower		Human food; construction materials fuel; medicine; making bee hives
Bridelia micrantha	Coast Goldleaf		Human food; construction materials; fuel; medicine; veterinary medicine
Cassia occidentalis	Coffee Senna	Yes	Medicine
Combretum collinum	Bush Willow		Medicine; construction materials; fuel
Croton macrostachyus	Broad Leaved Croton		Medicine; construction materials; fuel; protection against witchcraft; bee forage; display purposes
Cynometra alexandri	Uganda Ironwood		Food; construction materials; medicine; fuel; mortars and granaries
Entandrophragma utile	African Cedar	Yes	Construction materials; fuel
Erythrina abyssinica	Flame Tree		Food; medicine; construction materials; veterinary medicine; during ceremonies; retained on farms for support for beans
Ficus sycomorus	Sycamore Fig		Fuel
Kigelia africana	Sausage Tree	Yes	Food; medicine; religious charms; retained on farms for shade and boundary marking
Maesopsis eminii	Umbrella Tree	Yes	Construction materials; fuel; medicine; making bee hives
Maytenus acuminate	-		Construction materials; fuel; medicine; veterinary medicine; to make walking sticks
Microglossa pyrifolia	-		Construction materials; medicine; to make hunting gear
Neoboutonia macrocalyx	Lace-leaf		Construction materials; fuel; medicine; handicrafts; to protect against witchcraft
Newtonia buchananii	Lokundu		Food; construction materials; fuel; medicine; make household items; used during ceremonies
Ocimum gratissimum	African Basil		Food; medicine
Ocotea usambarensis	East African Camphor Wood		Food; fuel; construction materials; medicine
Parinari excels	Sougue		Construction materials; fuel
Phoenix reclinata	Wild Date Palm		Food; construction materials; fuel; handicrafts; medicine; veterinary medicine; ornaments; dance costumes; soil conservation
Prunus africana	Red Stinkwood	Yes	Food; construction materials; fuel; medicine; make household items; mulch; to provide bee forage/nectar/nesting sites
Rauvolfia vomitoria	Swizzle Stick	Yes	Medicine
Trema orientalis	Charcoal Tree		Construction materials; fuel; veterinary medicine; tannins/dyes; bee forage; mulch; ornamental
Vernonia amygdalina	Bitter Leaf		Food; fuel; medicine; veterinary medicine; during cleansing ceremonies
Zanthoxylum gilletii	East African Satinwood		Food; construction; fuel; medicine

for construction of houses and furniture, for poles, posts and fibres (Lambert 1998; Kakudidi 2007; Muhwezi *et al.* 2009) and for medicinal purposes, including to induce labour and for treating sexual impotence and erectile dysfunction (Kamatensi-Mugisha and Oryem-Origa 2005).

7.2.1 Species used for human food

Experts identified 53 plant species as being important for use as human food, compared with the other plant species assessed. Seven (13%) are from the Fabaceae family and four (8%) from the Solanaceae (nightshades) family. Wild plants are consumed in various forms including raw, in sauces, as the main cooked dish and as condiments, spices and pastes (Agea *et al.* 2011), and various parts of plants may be used. Harvesting of specific plant parts, such as fruit, seeds, nuts and leaves is common; and some methods of extraction are lethal to the plant, whereas others are non-lethal. This is in contrast to the harvest of other taxa such as fish and mammals, which are used primarily for their meat and so must be killed. Although plants serve an important function as a food resource, the available literature suggests that when supplies from other food sources are stable, the majority of people will only harvest a relatively small range of wild plant species for food, yet in times of food scarcity or insecurity, the consumption of wild plants as food increases and they can actually play an important role in providing sustenance.

7.2.1.1 Uganda

The evident commonness of species from the Fabaceae family being used as wild food sources found in this study has been previously noted by Cunningham (1996), who stated that beans are one of the most important staple foods around Bwindi Impenetrable National Park (Uganda), though some species are cultivated in addition to being harvested from the wild. *Solanum nigrum* appears to be a popular food plant in the Rukungiri district (within the AR), with over 80% of people having eaten its parts, and 69% of these said to eat it very often (more than eight times per month) (Musinguzi *et al*. 2006). A study by Agea *et al.* (2011) identified species used in Bunyoro-Kitara Kingdom (mainly within the AR) which are the same as those identified by experts in this study. For example, *Vernonia amygdalina* was identified in both cases as used as a side dish after being boiled and pasted with groundnut or sesame. Cunningham (1996) suggested that in Bwindi Impenetrable National Park people tended only to use plants for food as an emergency resource; favoring *Myrianthus holstii* fruits and *Dioscorea* tubers during periods of famine, and selling *M. holstii* and edible fungi species seasonally at local markets to generate an income. Cunningham also found that, with the exception of *Dioscorea* species and during periods of famine, only the poorest people would collect wild plants to eat.

Bitariho and Barigyira (in press) identify *M. holstii* as the most important edible plant in Bwindi Impenetrable and Mgahinga National Parks, though the species is more commonly used during famine periods. Similarly, Banana and Turiho-Hawbe (1997) found that forest foods were particularly important for people during food shortages, and that people in the Masindi and Hoima districts (the greater parts of which are within the AR) were less likely to collect forest foods if they were better educated and/or had formal employment. They also found that those living closer to the forest were more likely to collect forest products than those living further away; 67% of those living within 1 km of the forest collected products whereas only 33% living within 1–5 km away did so. In particular, edible fungi were regarded as a delicacy within all households, whether poor or wealthy, though only 22% of residents actually gathered them (Banana and Turiho-Hawbe 1997). Agea *et al*. (2011) stated that, in the Bunyoro-Kitara Kingdom (mainly within the AR), wild plants are eaten mainly as snacks and side dishes, but due to a recent food crisis caused by recurring droughts, wild plants are now more commonly being consumed as a main meal. The same study noted that there had been a shift from women, children and the elderly being the main consumers of wild plants, to all members of the household consuming them. Again, this is likely due to a lack of other available options as a result of recent droughts.

***Symphonia globulifera* is recognized as important to humans as it provides food, construction materials and fuel, and is also used for horticultural purposes. This species was found to be vulnerable to climate change.** © Cirad/C. Doumenge

Musinguzi *et al.* (2006) found that in the Rukungiri district (within the AR), several plant species used for food would be sold, particularly by poor households, and that even though the income derived was typically very little, it was still important to poorer, rural-living individuals. The same study states that there has been a decline in the use of wild food plants due to encroachment of human development into the forests and swamps, that knowledge about wild food plants and their nutritional content is decreasing, and that there was a general attitude that wild food plants are only suitable for poor people and that exotic species are more nutritious. Agea *et al*. (2011) also found that in the Bunyoro-Kitara Kingdom, younger people had less knowledge of wild plant species, but that, in general, women had a greater knowledge compared with men as they were traditionally the gatherers, along with children of the household. However, Banana and Turiho-Hawbe (1997) found that in the Masindi and Hoima districts the collection of forest foods was not gender-specific. A study in the Ugandan capital Kampala (outside of the AR) calculated that the trade in wild and semi-wild food or medicinal plants provided an average of 36% to the household income of traders (ranging from 2–80% depending on the species sold), the majority of whom were women with a low level of education (Barirega *et al.* 2012).

7.2.1.2 DRC

A study of wild plants available at market in the city of Beni, DRC (within the AR) found *Piper guineensis* fruits for sale, which are usually eaten raw or dried and used as seasoning, *Aframomum* spp. fruits, and the nuts and sap of *Elaeis guineensis,* used to make palm oil and palm wine, respectively (Bauma 1999). Terashima and Ichikawa (2003) found that Mbuti and Efe hunter-gatherers in the Ituri Forest (partially within the AR) eat a wide variety of wild plants including the nuts and bark of *Cola acuminata* which are used to make a bitter drink or chewed as a stimulant, the boiled tuber of *Dioscorea bulbifera*, the fruits, kernels and oil of *Elaeis guineensis*, the leaves of *Momordica foetida* and the fruits of *Myrianthus arboreus*. The leaves of *Microglossa pyrifolia* are also used to increase the strength of beer.

In the AR there is not always a clear distinction between plants that are used for food and those used for medicine, and the same plant is often consumed both for sustenance and for perceived health benefits. For example, fruits from *Piper guineense* are used in the Tshopo district (west of the AR) to season dishes and the stem is used as a tea substitute, but it is also consumed to treat general pain, lumbago, colds and coughs (Termote *et al*. 2010). Similarly, *Alchornea cordifolia* leaves can be used as a substitute for tea, and are also thought to be an effectve treatment for anaemia (Termote *et al*. 2010). De Merode *et al.* (2003) found that households in DRC (including those outside of the AR) consumed, on average, 0.11kg per day of wild plants, compared with 0.04kg per day of wild meat and 0.006kg per day of fish. Only 10% of wild foods collected by a household were consumed, compared with nearly 50% for crops, suggesting that wild foods are typically more important for generating income than for direct consumption. Overall, wild plants in particular appeared to have a low value compared with other wild food products (De Merode *et al.* 2003). The same study found that during the lean season, when agricultural crops are scarce, the price of wild plants can double as agricultural production declines, and also found that the consumption of wild plants decreases as household wealth increases.

7.2.1.3 Tanzania

Many Tanzanians rely on the forests for food to meet their subsistence needs, as well as to generate an income (Kajembe *et al.* 2000). In Tanzania (including areas outside of the AR) one study found that *Afzelia quanzensis, Balanites aegyptiaca, Ficus sycomorus, Kigelia africana* and *Parinari excelsa* were among the most preferred species to eat or make into condiments, and that *Diospyros mespiliformis, Kigelia africana,* and *Parinari excelsa* were commonly made into beverages (*Hines and Eckman* 1993). The Ministry of Natural Resources and Tourism (2000) stated that in Tanzania (including areas outside of the AR), women and younger children are the main collectors of wild vegetables, whilst forest fruits are a popular food to be collected and eaten by children. Hines and Eckman (1993) found that in areas where exotic fruit species (e.g. banana, papaya and mango) are grown, these were usually preferred over native wild species. Wild vegetables may be made into a sauce and eaten with most meals, most commonly maize porridge, and studies outside of the AR have found that wild leafy vegetables contribute significantly to the nutritional intake of many Tanzanians (Kajembe *et al.* 2000). Mushrooms are a delicacy collected by most people in rural areas, and can be important for rural households' food security (Kajembe *et al.* 2000), as well as being sold (mainly by women) at market for TSH100 (USD0.12)[29] for five stems (Ministry of Natural Resources and Tourism 2000). During the rainy season it is thought families eat mushrooms around two to three times per week (Kajembe *et al.* 2000).

Market in DRC's North Kivu Province. The legume family (Fabaceae) is of considerable importance for human use. © Neil Palmer (CIAT)

A study of the economic contributions of different products to household incomes in the Shinyanga Region (east of the AR) from land where 'Ngitili' (an indigenous system of agro-pastoralism (Chamshama and Nduwayezu 2004)) is practiced, found that sale of wild vegetables and mushrooms contributed on average USD3.90 and USD1.70, respectively, to the annual household income, compared with fuelwood, which contributed USD48.91 (Monela *et al.* 2004).

There was no detailed information available regarding the use of wild plants as food within the AR for Burundi, Zambia or Rwanda.

7.2.2 Species used for medicinal purposes

Of the 153 plant species identified as important for use, 106 (69%) are thought to be used in traditional medicines. In the course of the literature review, further species were identified, however these are not discussed in detail as it is thought that those species identified by both experts and in the literature are the key medicinal species. Of the 106 species, 19 (18%) were from the family Fabaceae, 11 (10%) from the family Euphorbiaceae and 7 (7%) from the family Asteraceae. In total, 104 species were used for subsistence and 65 species had a local commercial value. Nine species were identified as having national commercial value and six species as having international value, though these values may have been based on other use types such as timber. The most common conditions treated by medicinal plants appear to relate to childbirth, infertility/erectile dysfunction and diarrhoea/ stomach problems. Some plants, used to treat other dangerous diseases, include *Ageratum conyzoides, Bidens pilosa, Bridelia micrantha, Erythrina abyssinica, Prunus africana* and *Spathodea campanulata,* all of which are used in the treatment of symptoms of HIV and AIDS in parts of the AR (Kamatenesi-Mugisha *et al.* 2008; Lamorde *et al*. 2010). In addition, *Bridelia micrantha*, *Neoboutonia macrocalyx*, *Sesbania sesban*, *Prunus africana* and *Vernonia amygdalina* are used for the treatment of malaria in parts of the AR (Namukobe *et al.* 2011). Medicinal plants were found to be used both for subsistence purposes and to generate income. These can be sold in their raw state or processed into medicinal products (where applicable), and profit can be derived through the administration of such products by traditional practitioners.

7.2.2.1 *Prunus africana*

Prunus africana has been used by the people of East Africa for centuries, particularly for the treatment of genitourinary disorders (El-Kamali 2009), malaria (Maximillian and O'Laughlin 2009), and, in recent times, to alleviate the symptoms of HIV and AIDS (Lamorde *et al.* 2010). There is a high international demand for this species, particularly in Europe and the USA, where the bark is used to treat prostate ailments (Clausen 2001). Although the species is fairly resilient to ring-barking, and re-growth can often occur after bark removal, commercial ring-barkers are known to collect bark from trees when they have only partially re-grown, and this can eventually lead to death of the tree (Cunningham 1996). A study by Bitariho and Barigyira (in press), found that *P. africana* was highly desirable, and that people would prioritize this species when allowed to begin extraction of plants from Bwindi Impenetrable National Park, Uganda. Cunningham (1996), however, found only a low level of trade of this species in the park.

P. africana has been listed in CITES Appendix II since 1995. According to the CITES trade database, the only countries within the AR to have legally exported *P. africana* between 2005 and 2010 were Tanzania, Uganda and DRC, which reported exporting approximately 25 tonnes, 85 tonnes and 1,897 tonnes, respectively. In DRC, *P. africana* bark harvesting was reported to be opportunistic and

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29. Currency conversion carried out using 2000 rates.

unregulated, as civil wars have made controlled harvesting impossible (Betti 2008). However, a CITES trade suspension has been in place since 2009 for both DRC and Tanzania, and Burundi currently has a zero export quota.

A study of the harvesters of *P. africana* in the Udzungwa Mountain Forest Reserves, Tanzania (outside of the AR) found that the average harvester was 57 years old and lived in a household of 10 people, which is twice the national average (Maximillian and O'Laughlin 2009). The authors state that the reason for such large families could be due to harvesters being wealthier than the average Tanzanian, or due to religious reasons. The study also found that harvesters were better educated than the national average standard, most having attained at least primary education. The proportion of male harvesters was slightly higher (57%) than that of female harvesters (43%), and 78% of all harvesters practiced unsustainable harvesting methods (despite nearly half of them owning their own trees). In Tanzania, bark from *P. africana* sells at USD3.51 per kg, generating an annual income of USD74.81 based on making five trips into the forest per year (Maximillian and O'Laughlin 2009). No value data *for Prunus africana* were available specifically for other AR countries, but in Cameroon a tree of the same species, which is repeatedly harvested sustainably (thought to mean up to half the trunk's bark can be harvested every five years (Cunningham *et al*. 2008)), can yield USD10–20 per tree, per harvest, whereas felling and stripping an entire tree at once can generate USD2000 (Futureharvest 2000 in Page 2003) providing a strong incentive to harvest unsustainably. Lambert *et al.* (2005) stated that across *P. africana*'s range states in general (including non AR countries), the collector receives approximately USD0.2 per kg (dry weight). In Cameroon, harvesters were found to receive USD0.38 per kg, and only 6% of the global value of the bark went to harvesters, managers and traders combined (Knox 2001).

7.2.2.2 Uganda

Many plants are used to treat multiple ailments; for example, *Vernonia amygdalina* is used in western Uganda to induce childbirth, in the treatment of gynaecological morbidity, to cleanse people after the birth of twins, to treat malaria, intestinal worms and skin problems, and is also believed to have anti-plasmodial properties (Kakudidi 2004; Kamatenesi-Mugisha and Oryem-Origa 2007; Kamatenesi-Mugisha *et al.* 2007; Namukobe *et al*. 2011). There is increasing interest in the potential use of this species in western medicine to treat cancer, with one study describing it as 'emerging as a very strong candidate for breast cancer treatment' (Gresham *et al.* 2008). This species is described

Forests in Bwindi Impenetrable National Park, Uganda. © Martijn Munneke as one of the most commonly used plants in the northern part of Kibale National Park (within the AR) (Namukobe *et al.* 2011).

In western Uganda, *Cola acuminata* is used to treat multiple illnesses such as bacterial and fungal infections, sexual impotence and erectile dysfunction (Kamatenesi-Mugisha and Oryem-Origa 2005; Kamatenesi-Mugisha *et al.* 2008). This species was found for sale in local markets in Uganda at high prices (Kamatenesi-Mugisha *et al.* 2008) and in Europe the seeds are used as stimulants, to treat migraines, neuralgia, diarrhoea, loss of appetite, depression, melancholy and as a stimulant or cardio tonic (Kamatenesi-Mugisha and Oryem-Origa 2005).

Different parts of the plant species *Zanthoxylum gilletii*, including the bark, roots, leaf components and tubers, were found to be used to make medicines used to induce labour and to treat diarrhoea, gastritis, bacterial and fungal infections, high blood pressure and coughs in both Uganda and DRC (including areas outside of the AR) (Chifundera 2001; Kamatenesi-Mugisha and Oryem-Origa 2007; Kamatenesi-Mugisha *et al.* 2008; Namukobe *et al*. 2011). Cunningham (1996) also found this plant to be administered by herbalists to patients in Bwindi Impenetrable National Park, which is likely to generate income for the herbalist. Bitariho and Barigyira (in press) found that 65% of plant species that local people requested permission to extract from Bwindi Impenetrable National Park were primarily destined for use as medicine, followed by plants used for weaving, wood carving and, lastly, food.

7.2.2.3 DRC

A study by Terashima and Ichikawa (2003) identified a number of plant species used by different pygmy groups in the Ituri Forest, many of which were also selected by experts within this study as being important for use in the AR. These included: *Pseudospondias microcarpa* (to treat stomach disorders), *Ageratum conyzoides* (to treat fever in children), *Albizia gummifera* (to improve strength and 'sexual power'), *Alchornea cordifolia* (to be applied to circumcision wounds), *Bridelia micrantha* (for sore throats and stomach disorders), *Dichrostachys cinerea* (to induce abortions) and *Solanum nigrum* (to treat snake and ant bites) (Terashima and Ichikawa 2003). The species utilized varied between different pygmy groups in the forest, though several species, including *Alstonia boonei*, were used widely, as historically they had been intensively collected and traded with Europeans settlers. *Citropsis articulata* was identified by experts as being used for medicinal purposes in the AR, and Terashima and Ichikawa (2003) found that the Efe group in the Ituri forest used this species to cure a

Red Stinkwood (*Prunus africana*)

© Sandra Mbanefo Obiago/WWF-Canon

Red Stinkwood is a montane tree species that is distributed across tropical Africa and Madagascar (Betti 2008). Experts identified it as a highly valued and commercially important species, particularly due to its medicinal properties. One of the major threats to this species is harvesting of its bark which is exported to Europe to be made into medicine (UNEP-WCMC 1998) for treating prostate gland hypertrophy and benign prostatic hyperplasia (Fashing 2004). As a result of overharvesting for trade, Red Stinkwood has been categorized as Vulnerable on the IUCN Red List (though this categorization is in need of updating as it was carried out in 1998 using old criteria and categories) and was listed in CITES Appendix II in 1995. In some AR communities, the root is used to treat HIV/AIDS, particularly by the rural poor who have little access to modern antiretroviral drugs (Lamorde *et al.* 2008). The fresh bark is used to treat malaria (Namukobe *et al.* 2011), which is prevalent in some areas. Red stinkwood is a hardwood species and its timber is prized in parts of the AR for constructing houses, as the durable wood is able to resist termite attack (Kakudidi 2007). It is also used for fuel, and has been identified as the most common species used in gin distilleries in Kibale National Park, Uganda (Naughton-Treves **et al**. 2007). Other uses of wood from this species include for making furniture, carvings, utensils, flooring and panelling (Lambert 1998).

Red Stinkwood has been assessed as sensitive to climate changes, particularly as a result of its dependency on interspecific interactions that are likely to be impacted by climate change – it was assessed as being reliant upon only a few pollinator species and as having few species that are able to disperse seeds. The species was also assessed as having a low potential to adapt to climatic change – barriers exist that prevent dispersal of this species, and its high longevity makes genetic adaptation at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ* improbable. Nevertheless, this species is not expected to experience particularly large climatic changes across its range (relative to other plant species assessed), and so is not considered climate change vulnerable.

disease contracted by eating catfish, as the plant has sharp spines on the stem which are similar to the spines of the fish. Bauma (1999) found that in DRC it is the healers and traders that harvest and sell the medicinal plants rather than the general population living close to the forest, as this ensures that their knowledge of medicine is not shared, and that their livelihood is protected.

7.2.2.4 Tanzania

A study of commonly used medicinal plants in Tanzania (Rukangira 2004) indicated that several species are important for use within the AR. These include *Securidaca longipenduculata* (the roots of which are used to treat infertility) and *Cassis didymobotria* (the leaves of which are used to treat anaemia and as a laxative). Another study identified *Kigelia africana* as being used in Tanzania during childbirth and to treat splenitis, and *Trichilia emetica* to treat dermatitis, as an anti-inflammatory, and to induce vomiting (El-Kamali 2009). A study in the Shinyanga Region (east of the AR) calculated the annual financial contribution from wild medicinal plants to household incomes to be, on average, USD72 (Monela *et al.* 2004) which, considering the GDP per capita in Tanzania in 2003 was USD278 (OECD 2005), represents a significant contribution. The Ministry of Natural Resources and Tourism (2000) found that the roots of *Securidaca longipedunculata* were sold for TSH200 (USD0.25)[30] per bunch in the Geita District (outside of the AR). In the Bukoba Rural District (close to the AR) it was found that the majority of herbal practitioners were over 50 years old, female, peasant farmers, and not formally educated (Kisangau *et al.* 2007) and, as such, this is likely to provide an important source of income.

7.2.2.5 Zambia

Two plant species, *Kigelia africana* and *Rauvolfia vomitoria*, were identified by experts as being important for medicinal uses in the Zambian AR. Both were found to be sold by traditional medicine sellers in Zambia (Cunningham 1993). *Kigelia africana* is used in western medicines, including hand lotions, although it is not known if the species is specifically collected for export from the AR. Naur (2001) stated that in Zambia 60% of all registered traditional healers were female, and that healers would collect plants themselves (area of Zambia unspecified). A study by UNEP (2006) stated that the annual export value of medicinal plants from Zambia in 2003 was USD4.4 million.

Very little information could be found regarding the use of medicinal plants by people within Burundi and Rwanda.

7.2.3 Species used for construction, fuels and fibres

Sixty-three plant species were identified by experts as being important for use for construction purposes, which varied from timber, used for house building and canoe building, to species used for bean stakes and poles, and grasses used for thatching. The most common family to be used for such purposes was Fabaceae (12 species), followed by Euphorbiaceae (seven species) and Meliaceae (five species). In total, 61 species were used for subsistence, while 32 had a local value, two had a national value and five had an international value.

Fifty-two species were identified by experts as being important for use as a source of fuel, nine of these species (17%) were from the Fabaceae family, four (8%) from the Euphorbiaceae family and four (8%) from the Moraceae family. All species used for fuel had a subsistence value, and 35 had a local value, four had a national value and three an international value. However, these values, as with those given to species used for construction, may have been allocated based on other use types.

7.2.3.1 Uganda

Four hardwood species identified by experts as being used for timber in the AR were also identified in the literature as being valuable in international trade. These were *Entandrophragma utile, E. cylindricum, Khaya anthotheca* and *Maesopsis eminii* (Plumptre 1996; Singer 2002). *Entandrophragma utile*, *E. cylindricum* and *Khaya anthotheca* are all considered Vulnerable on the IUCN Red List as they are exploited heavily throughout their range. Plumptre (1996) noted previous heavy logging of *E. utile* within the AR in Budongo Forest, and it is also known to provide an important source of fuelwood and charcoal in south-western Uganda (Aine-omucunguzi *et al.* 2009). The greatest threat affecting Budongo Forest on the whole is said to be unsustainable selective harvesting of these four species, which produce valuable timber but can take up to 150 years to reach maturity

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30. Currency conversion carried out using 2000 rates.

(Singer 2002). In Uganda, *M. eminii* can be worth up to USH9,000 (USD5.29) per m^3 (compared with up to USH15,000 (USD8.82) per m^3 for *Albizia* species (of which four species were identified as used for construction materials) and up to USH20,000 per m^3 (USD11.76per m^3)[31] for *Chrysophyllum albidum* (Plan Vivo, 2007). There are a multitude of species used for other construction-related purposes. *Cordia millenii* is used for making furniture, carvings and boats (Lambert 1998), and *Erythrina abyssinica* is used for carving musical instruments, including drums and harps (Kakudidi 2004). A number of plants are also thought to be used in the construction of wooden bee hives, including *Albizia gummifera* and *Faurea saligna* (Cunningham 1996).

Fuelwood is an essential component of most people's lives within the AR, and in Bwindi Impenetrable and Mgahinga National Parks, and the adjacent areas, it is known to account for the highest consumption of wood (Cunningham 1996). Many species are used as a source of fuel including *Celtis mildbraedii, Maytenus acuminata, Sesbania sesban* and *Trema orientalis*, which are all used for daily cooking (Naughton-Treves *et al.* 2007; Aine-omucunguzi *et al.* 2009). Many species used for construction purposes were also used to provide fuels, for example *Bridelia micrantha* is preferred for building poles but is also used as fuel for domestic cookers (Cunnigham 1996; Naughton-Treves *et al.* 2007). Around Bwindi Impenetrable National Park, *Parinari excelsa* is used for building and as a major source of wood used by blacksmiths for constructing bellows, which can last for 20–30 years (Cunningham 1996). This species is also used for charcoal production, gin distillation and domestic cookers and, as such, has some local value, although manufacturing charcoal is usually referred to as a 'poor man's work' (Naughton-Treves *et al*. 2007). Prices for a sack of charcoal (weight unknown) vary within the forests of Uganda according to Bush *et al.* (2004), with a sack costing up to USH9,494 (USD5.32)[32] in Rwenzori National Park. It was reported that the Ugandan trade in firewood, charcoal and crop residues for fuel employed 20,000 people and generated USD20 million per year in rural incomes (Ministry of Energy and Mineral Development 2002). Aine-omucunguzi *et al*. (2009) found that in Uganda women were the main harvesters of firewood for household use, while men might harvest wood for sale. Naughton-Treves *et al.* (2007) found a difference between genders in the species relied upon for fuel, with women more typically relying on fast growing species, such as *Vernonia*, for cooking.

A large number of plants are used to provide fibre to make useful products. One such species is *Raphia farinifera*, which was found to be popular for basket weaving (Cunningham 1996; Mwavu and Witkowski 2009) and specifically carrying and tea-picking baskets (Muhwezi *et al*. 2009) in Budongo Forest Reserve, Bwindi Impenetrable National Park, Mgahinga Gorilla National Park and adjacent communities. Bush *et al.* 2004 found that rattan harvesters in the Bugoma area received USH3,500 (USD1.96) for a bundle of rattan (approximately 40 stems around 2–3 metres long), the wholesaler would then sell this for USH8,000 (USD4.48) to a furniture maker, who could then process it to add value. For example a furniture maker in Kasagala (outside of the AR) used 2–3 stems to make a stool costing USH4,500 (USD2.52) (Bush *et al.* 2004). Subsistence farmers across Africa use baskets for the harvesting, drying, winnowing, grinding and storing of agricultural products (Muhwezi *et al*. 2009), and as such, these products are considered important for people's livelihoods.

7.2.3.2 DRC

An estimated 8,000 small-scale loggers across the whole of DRC produce beams and planks for construction, for the domestic market, and for export to neighbouring countries, and these may be either seasonal harvesters or employed permanently (Debroux *et al.* 2007). A high level of this type of 'informal logging' is known to take place in Nord- and Sud-Kivu, which are both partially within the AR (Djiré 2003 in Debroux *et al.* 2007). Hughes (2011) estimated that the value of all domestically-consumed timber was USD18,461,000 in 2007, compared with an estimated USD178,203,000 worth of timber which was exported. Within the Ituri Forest, the Mbuti and Efe groups use a variety of species for constructing buildings. For example, the leaves of *Elaeis guineensis* are used for thatching and the trunk is used for timber. The wood of both *Maesopsis eminii* and *Alchornea cordifolia* is also used for timber (Terashima and Ichikawa 2003). In addition, *Aidia micrantha* was identified as used to make bows and spears, *Alstonia boonei* to make bells to hang around the necks of hunting dogs, honey containers, canoes and drums, *Bidens pilosa* to make paint brushes, and *Celtis mildbraedii* to make axe handles and house frames (Terashima and Ichikawa 2003).

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31. Currency conversion carried out using 2007 rates.
32. Currency conversions carried out using 2004 rates.

The price of a 35 kg sack of charcoal in the city of Bukavu (within the AR) was found to be USD20 – double the price of a sack sold in the villages (Patrick 2011). In the city of Bunia, close to Lake Albert, the price of charcoal has increased rapidly, and now costs USD30–40 for a 10–15 kg sack (Patrick 2011). The increase in the price in recent years has been attributed to declining supplies (IFDC date unknown), and Patrick (2011) highlights that a lack of reforestation and the sale of communal land to mining companies in Ituri District has decreased the availability of wood, whilst in both Nord- and Sud-Kivu, a large increase in the human population following an influx of Rwandan refugees has increased demand, which has served to increase prices further. Charcoal is cheaper in rural areas due to closer proximity to the source trees and a reduction in the need for transporters, which can significantly increase the price. For instance, transporters and sellers in Sud-Kivu buy USD6.30 worth of charcoal 'in the bush' and sell it for USD20 in Bukavu (Patrick 2011). Within the Ituri Forest, the Mbuti and Efe groups make use of plants to fulfil a variety of needs; *Celtis gomphophylla* for firewood, *Cynometra alexandri* for firewood and charcoal production, and the bark from *Ficus sycomorus* to be made into cloth (Terashima and Ichikawa 2003).

Illegal charcoal production in Nyungwe Forest, Rwanda. Charcoal prices are increasing due to declining resources. © John and Melanie Kotopoulos

7.2.3.3 Rwanda

In Rwanda, much wood used for construction is sourced from plantations which predominantly grow exotic *Eucalyptus* and *Pinus* species (Ndayambaje and Mohren 2011). It is estimated that the sawn wood and rough timber industries for the whole of Rwanda are worth USD8,000,000 (0.2% of GDP) and USD32,000,000 (0.7% of GDP), respectively, employing a total of 40,950 people in 2010 (Ministry of Forestry and Mines 2010). The price for wood from plantations in Rwanda was generally found to be USD100–190 per m^3, which was lower than the cost of natural wood imported from DRC and Uganda, which costs USD260–750 per m^3 (Chamshama 2011).

It is reported that 20,000 Rwandans are directly employed in the fuelwood sector (GTZ 2009), though it is not known how many of these live within the AR or what proportion of these source their wood from the wild (the vast majority of fuelwood is thought to come from plantations, typically of *Eucalyptus* species). In southern Rwanda (outside of the AR) in 2009, a 30kg sack of charcoal was sold on average for USD6.87, representing a 15% year-on-year increase in price since 2006 (Mazimpaka 2010). Mazimpaka also reported that a charcoal seller made on average RWF70,000 (USD121)[33] each month, which, when compared with a GDP per capita of USD527 in 2009 (World Statistics Pocketbook 2010), represents a substantial income. The same study found that the majority of wood was collected by women (41%), male children (29.5%) or female children (19%), and that 20kg of wood (the average head load weight) cost RWF500 (USD0.86), giving firewood sellers an average monthly income of RWF20,000–30,000 (USD35–52).

7.2.3.4 Tanzania

Farmers in Tanzania (area not specified) commented that *Dichrostachys cinerea*, *Prunus africana* and *Bridelia micrantha* were highly preferred for use in construction, but that *Prunus africana* and *Ocotea usambarensis*, also used for timber, had disappeared from the forests (Hines and Eckman 1993). In Tanzania in general, the consumer price for natural wood is far higher than for plantation wood; for example, sawn plantation wood was found to cost USD194 per m^3, compared with USD445 per m^3 for the natural forest equivalent (Chamshama 2011).

Fuelwood is believed to account for 88% of Tanzania's total energy consumption, and charcoal for 4% (Malimbwi and Zahabu 2009). A study by the World Bank (2009) found that, in general, the price of charcoal at rural production sites increased from TSH3,000 (USD2.65) per sack in 2004 to TSH8,000 (USD6.33) per sack in 2007[34], though the exact locations were not specified. Women and children are the main collectors of firewood used for subsistence purposes (Malimbwi and Zahabu 2009). *Dichrostachys cinerea* was cited as being frequently used for firewood and charcoal, though the area was not specified (Hines and Eckman 1993). A study of the impact of refugees entering western Tanzania (partially within the AR) from surrounding countries found that prices of many goods

33. Currency conversions carried out using 2009 conversion rates.
34. Currency conversions carried out using conversion rates for the corresponding year.

Hand-sawn timber planks in the DRC. An estimated 8,000 small-scale loggers produce wooden planks and beams from the forests of DRC. © Hart Lukuru Foundation

increased with the influx of refugees, and more so when concurrent with drought or floods in other parts of the country (Whitaker 2002). For example, the minimum price of a bundle of firewood increased from TSH100 to TSH400 (USD0.14 to USD0.60) and a sack of charcoal from TSH300 to TSH1,200 (USD0.45 to USD1.79)[35] (Whitaker 2002). This has potential implications for future large migrations of people into and around the AR region. A study in Dar es Salaam (outside of the AR) found that the poorest people relied on firewood for fuel, lower-middle income households used more charcoal and kerosene, and those on a high income typically used LPG or electricity (Palmula and Beaudin 2007).

7.2.3.5 Burundi

Much natural native forest in Burundi has been lost due to intense human pressures, and harvesting of natural forests is now widely prohibited (Amsallem 2002). Some areas have been replaced with plantations consisting of exotic trees, including species of *Eucalyptus*, *Cupressus*, *Grevillea* and *Pinus* (Schlaifer and Ntahompagaze 2007). Amsallem (2002) identified *Entandrophragma excelsum*, *Prunus africana* and *Symphonia globulifera* as among the most highly demanded and precious wood species in the country. The local price for plantation wood in Burundi as a whole was found to range from USD85 to USD180 per m^3 – far lower than the USD300–450 per m^3 paid for imported natural wood from Tanzania and DRC (Chamshama 2011). Chamshama (2011) also found 108,000 people to be employed in forest plantations, management, and associated processing industries and services across Burundi – higher than in both Rwanda (80,100 people) and Uganda (30,000 people).

Much of Burundi's energy requirements are met by fuelwood (71%) and charcoal (6%) (Hakizimana 2008). In Bujumbura, charcoal prices were found to increase from USD10 to USD16 for a 100 kg sack during 2008 alone (IFDC date unknown).

7.2.3.6 Zambia

Pterocarpus angolensis was identified as being under threat in Zambia (area unspecified) due to a high demand for its timber (FAO 2002). The same study found that *Afzelia quanzensis*, *Diospyros mespiliformis* and *Faurea saligna* are used for timber, and *Faidherbia albida* for poles and fuelwood. Once again, the location(s) from which this information was derived was not specified.

Fuelwood and charcoal provide 43% and 33% of Zambia's energy, respectively, with charcoal production accounting for 2.2% of the country's GDP and a 60 kg sack costing ZMK30,000 (USD6.09) (Müller *et al.* 2011). In Lusaka (outside of the AR) seasonal charcoal workers were found to earn up to ZMK18,000,000 (USD3,655) for six months work (Müller *et al*. 2011), which is more than double the 2011 per capita GDP of USD1,425 (The World Bank 2012)[36].

7.2.4 Other use types

Several other use types for wild plants were identified during this study. For example, a number of species were found to be important for use as medication for livestock. This is essential for people keeping animals who cannot afford to pay for veterinary services or medicines. Chifundera (1998) identified numerous species in the Kivu Provinces of DRC used to treat livestock ailments ranging from infertility, skin and eye problems, bowel problems, parasites, rheumatism, sprains, and even rabies and anthrax. Most parts specified as used were either leaves or the whole plant (Chifundera 1998). The crushed leaves of *Tephrosia vogelii* and *Vernonia amygdalina* are used to treat livestock with ticks and mites, while the stem bark of *Erythrina abyssinica* is mixed with other ingredients to make eyedrops for livestock to treat blindness and conjunctivitis. *Aidia micrantha* was reported to be used to treat dogs with stomach problems in the Ituri Forest (Terashima and Ichikawa 2003).

Two species were also identified by experts as important for use as animal food: Napier Grass (*Pennisetum purpureum*) and *Euphorbia tirucalli*. Napier grass is an important species for fodder, and

35. All currency conversions carried out using 1998 rates.
36. All currency conversions carried out using 2011 rates.

in Uganda it has been attributed with helping smallholder dairy cattle farmers to increase intensification and production (Kabirizi *et al.* 2007). The same study also commented that Napier grass fodder was sold to help pay for household items and school fees (Kabirizi *et al.* 2007), though neither the contribution from wild or cultivated Napier Grass, nor the area of Uganda where this occurs, were known. *Euphorbia tirucalli* was identified as used for animal fodder, and is also highly valued in Tanzania when grown into 'live' fences (they are cheaper than wooden posts and will continue to grow (Hines and Eckman 1993)). It is not known, however, if this practice occurs within the AR specifically.

Seventeen species were identified as important for use for display purposes or horticulture. Several species were identified as important for bee forage or nesting sites, important to aid the production of honey, which is then either consumed directly or sold. Tanzania is among the lead producers of honey in Africa, producing 28,678 tonnes in 2005 (USD0.5 per kg), compared with 327 tonnes from Uganda, 206 tonnes from Burundi, 200 tonnes from Zambia and 42 tonnes from Rwanda (all sold at around USD2 per kg) (van Haaren and Zunderdorp 2008). These totals include production from areas outside of the AR.

Terashima and Ichikawa (2003) highlight an array of additional uses for wild plant species in the AR. For example, the bark or root of *Albizia gummifera*, *Bridelia micrantha* or *Rauvolfia vomitoria* is used to make arrow poison in the Ituri Forest; the leaves of *Vernonia amygdalina* and *Tephrosia vogelii* are used to make fish poison; the wood of *Citropsis articulata* is used to make small charms to wrap around a child's waist to protect against disease; the leaves of *Combretum paniculatum* are used to dye bark cloth and to make body paint; fruits of *Kigelia africana* are placed around fields of crops as they are believed to deter thieves; the foam produced by boiling *Momordica foetida* leaves is used to wash clothes and the fruits to bait birds; and the ash of burned *Myrianthus arboreus* root is rubbed into a hunting dog's nose to increase aggression and courage.

7.3 Climate change vulnerability

For the 204 plant species assessed for climate change vulnerability, we identified and considered a total of 16 climate change vulnerability traits, of which four related to 'Exposure', eight to 'Sensitivity' and four to 'Low Adaptability'. These are shown in Tables 7.2, 7.3 and 7.4.

Through assessing species' Exposure to climatic changes (Table 7.2), we expect 72 species (35% of those assessed) to experience relatively 'high' levels of climatic change throughout their global ranges. A further 61 (30%) are expected to experience 'very high' levels of change. Of these 133

Table 7.2 Climate change *Exposure* measures used to assess AR plants, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A5).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 204			
EXPOSURE				**Low**	**High**	**Very High**	**Unknown**
Temperature change	Substantial changes in mean temperature occur across the species' range	**E1:** Absolute difference between 1975 and 2050 mean temperatures (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	152	31	20	1
	Substantial changes in temperature variability occur across the species' range	**E2:** Absolute difference between 1975 and 2050 values of average absolute deviation in temperature (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	152	30	21	1
Rainfall change	Substantial changes in mean precipitation occur across the species' range	**E3:** Absolute ratio of change in 1975 and 2050 values of mean precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	149	34	20	1
Rainfall change	Substantial changes in precipitation variability occur across the species' range	**E4:** Absolute ratio of change in 1975 and 2050 values of average absolute deviation in precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	150	32	21	1
			Total	**71**	**72**	**61**	
			Percentage	**35**	**35**	**30**	

species, 40 are expected to experience large changes in two of the four climatic variables investigated, 12 across three variables, and four species (*Aloe volkensii*, *Habenaria plectomaniaca*, *Scaphopetalum dewevrei* and *Strophanthus bequaertii*) across all four.

In our assessment of species' Sensitivity to climatic changes (Table 7.3), 111 species (54% of those assessed) were assessed as possessing traits that result in 'high' Sensitivity to climatic changes, and a further 58 (28%) to possess traits resulting in 'very high' Sensitivity to changes. Of these 169 species, 76 possess one single trait, 53 possess two traits, 26 possess three traits, nine species (*Brachystegia manga*, *Chrysophyllum albidum*, *C. perpulchrum*, *Desplatsia dewevrei*, *Diospyros bipindensis*, *Greenwayodendron suaveolens*, *Habenaria bequaertii*, *Julbernardia paniculata* and *Satyrium ecalcaratum*) possess four traits, and 5 species (*Habenaria plectomaniaca*, *Lebrunia bushaie*, *Megaphrynium macrostachyum*, *Pentadesma lebrunii* and *Trachyphrynium braunianum*) possess five traits.

Within the Sensitivity analysis, the most common trait possessed was dependence upon a low number of pollinator species (trait S7), which was present in 72 species (35%). Species with this trait are considered highly sensitive to changes in the ecosystem, which may result in the loss or decline of important interspecific interactions.

The next most common traits possessed were a narrow tolerance to climatic variables (either temperature and/or precipitation) (traits S4 and S5)[37], which were each present in 51 (25%) species. Species with distributions that experience a narrow range of temperature and/or precipitation (relative to other species assessed), are likely to be more sensitive to new climatic conditions, should they arise.

[37] Note that our classification of narrow environmental tolerances is a relative measure based on all species considered. See Section 2.2.2.2 for details.

Table 7.3 Climate change *Sensitivity* traits used to assess AR plants, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A5).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 204			
SENSITIVITY				**Low**	**High**	**Very High**	**Unknown**
A. Specialized habitat and/or microhabitat requirements	Habitat specialization	**S1:** Number of IUCN habitat types occupied by species	L = >1; H = 1	169	33	n/a	2
	Microhabitat specialization	**S2:** Occurs exclusively on rocky outcrops, cliffs, ridges and/or steep slopes	L = No = H = Yes (1 only); VH = Yes (>1)	167	22	14	1
	Elevation range	**S3:** Narrow elevation range	L = lowest 75%; H = top 25-10%; VH = top 10%	132	23	19	30
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of changes to precipitation regimes	**S4:** Average absolute deviation in precipitation across the species' current range	Average absolute deviation in precipitation across the species' historical range: L = highest 75%; H = Lowest 25%	152	31	20	1
	Tolerance of temperature changes	**S5:** Average absolute deviation in temperature across the species' current range	Average absolute deviation in temperature across the species' historical range: L = highest 75%; H = Lowest 25%	152	31	20	1
D. Dependence on interspecific interactions which are likely to be disrupted by climate change.	Dependence on host species	**S6:** Parasitic or saprophytic	L = not; H= is Parasitic or saprophytic	196	7	n/a	1
	Dependence on pollinators	**S7:** Species is dependent on few pollinator species	L = >5 species or wind pollinated; H: 2–5 species ; VH: 1 species AND not wind pollinated	129	61	11	3
	Dependence on seed dispersers	**S8:** Species is dependent on few seed dispersal species	L = >5 species or wind dispersed; H = 2–5 species AND not wind dispersed; VH = 1 species AND not wind dispersed	173	29	0	2
			Total	**35**	**111**	**58**	
			Percentage	**17**	**54.5**	**28.5**	

Table 7.4 Climate change *Low Adaptability* traits used to assess AR plants, including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A5).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 204			
LOW ADAPTABILITY				**Low**	**High**	**Very High**	**Unknown**
A. Poor dispersability	Barriers to dispersal	**A1:** Barriers to dispersal (anthropogenic, top of mountain or water bodies)	L = 0 barriers or known to have established outside its historical range; H = 1 barrier and not known to have established outside its historical range; VH = 2 barriers and not known to have established outside its historical range	174	28	2	0
A. Poor dispersability	Intrinsic low probability of dispersal	**A2:** Limited dispersal probability - invertebrate or ballistic seed dispersal	L = different dispersal mechanism OR known to have established outside its historical range; H = invertebrate or ballistic seed dispersal and not known to have established outside its historical range	173	26	n/a	5
B. Poor Evolvability	Reproductive capacity	**A3:** Approximate number of seeds per year	L = ≥ 100; H = 10-99; VH = <1–10	174	28	1	1
	Generation length	**A4:** Longevity	L = Annual - 100 years; H = >100 years	126	77	n/a	1
			Total	**68**	**133**	**3**	
			Percentage	**33.5**	**65**	**1.5**	

Additional traits found to be important within the Sensitivity analysis were habitat and microhabitat specialization, namely species occurring in only one IUCN defined habitat type (trait S1) and species that occur exclusively on rocky outcrops, cliffs, ridges and/or steep slopes (trait S2). The first of these traits was present in a total of 33 species (16%), and the second in 36 species (18%). Such specialized habitat requirements suggest a narrow tolerance of conditions and, therefore, higher sensitivity to changes that may occur as a result of changes in the climate.

In our assessment of species' capacity to adapt to climatic changes (Table 7.4), 136 species (67% of those assessed) were assessed as possessing traits that make them poorly adaptable, of which three scored 'Very High' in this dimension of the framework. Of these 136 species, 110 possess only one trait and 26 possess two traits.

Seventy-seven species (38%) are known to have average lifespans greater than 100 years (trait A4), which we assume will reduce the likelihood of a species adapting to climatic changes *in-situ* (i.e. through genetic microevolution) at a rate sufficient to mitigate the impacts. Twenty-nine species (14%) produce a low number of seeds (99 or fewer) annually (trait A3), with similar implications as trait A4.

Thirty species (15%) are believed to be unable to disperse as a response to a changing climate due to the presence of physical barriers (trait A1), while 26 species (13%) are considered unlikely to be able to track their preferred climates as a result of their typically short-distance seed dispersal (i.e. they have ballistic or invertebrate-based seed dispersal mechanisms) (trait A2).

Overall, a total of 79 plant species (39%) were recognized as being of highest vulnerability to climate change due to being highly Sensitive, likely to be highly Exposed to change, and poorly able to adapt. Thirty-eight species (19%) are expected to experience high levels of climate change throughout their ranges (relative to other plants assessed), are Sensitive to climatic change, but are not noted as being poorly able to adapt. Thirty-seven species (18%) were assessed as both Sensitive and unable to adapt to climate change, but are not expected to experience high levels of change. Nine species (4%) are expected to be both highly exposed and unable to adapt, but not actually Sensitive to climate change. Under our pessimistic scenario for values

Figure 7.1 Numbers of AR plant species recognized as Exposed, Sensitive and/or Unadaptable to climate change, and all combinations of the three.

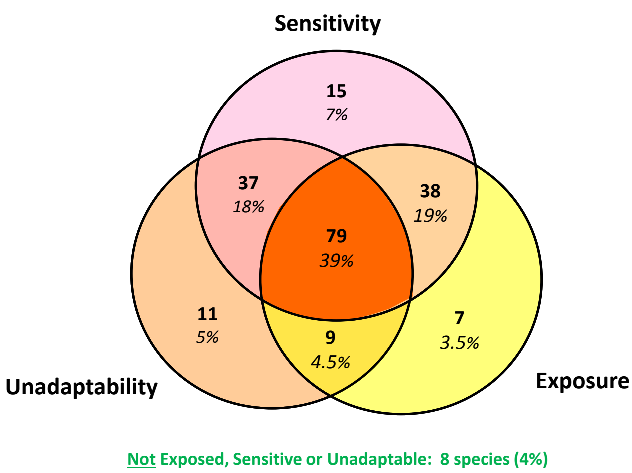

Table 7.5 Plant families with more than one climate change vulnerable species. Numbers in parentheses show percentages of the total species (within each family) considered for this assessment which are climate change vulnerable. Vulnerability figures are based on an optimistic scenario for missing data values.

Family	Number (and percentage) of climate change vulnerable plant species
Fabaceae	**11** (*25%*)
Meliaceae	**6** (*60%*)
Orchidaceae	**6** (*86%*)
Moraceae	**5** (*62.5%*)
Euphorbiaceae	**4** (*33%*)
Annonaceae	**3** (*75%*)
Apocynaceae	**3** (*43%*)
Rutaceae	**3** (*100%*)
Ulmaceae	**3** (*60%*)
Burseraceae	**2** (*100%*)
Urticaceae	**2** (*100%*)
Clusiaceae	**2** (*100%*)
Malvaceae	**2** (*67%*)
Sapotaceae	**2** (*67%*)
Xanthorrhoeaceae	**2** (*67%*)
Zingiberaceae	**2** (*100%*)

of missing data (see Methods, Section 2.2.1.3) a total of 82 species (40%) are considered climate change vulnerable.

Table 7.5 lists the taxonomic families containing two or more species recognized in our assessment as being climate change vulnerable. Species of the family Fabaceae (which comprise 22% of all plant species assessed) are most common on this list, followed by Meliaceae, Orchidaceae and Moraceae (of which totals of ten, seven and eight species were assessed, respectively).

7.4 Combined utilization, threat and climate change vulnerability results

The numbers and proportions of plant species known to be important for use, climate change vulnerable, globally threatened, and all combinations thereof are shown in Table 7.6. **The values presented in this table only represent species that have been fully considered for all parts of the respective assessments given.**

A total of 93 species were found to be important for use and were assessed for climate change vulnerability. Of these 93 species, a total of 33 (34.4%) are believed to be climate change vulnerable. These species are: *Aframomum angustifolium*, *Alstonia boonei*, *Antiaris toxicaria*, *Balanites aegyptiaca*, *Borassus aethiopum*, *Canarium schweinfurtii*, *Cassia occidentalis*, *Celtis adolfi-friderici*, *C. gomphophylla*, *C. mildbraedii*, *Chrysophyllum albidum*, *C. perpulchrum*, *Citropsis articulata*, *Cola acuminata*, *Cynometra alexandri*, *Entandrophragma angolense*, *E. cylindricum, E. excelsum*, *E. utile*, *Ficus mucuso*, *F. sycomorus*, *Funtumia elastica*, *Irvingia gabonensis*, *Julbernardia seretii*, *Maesopsis eminii*, *Myrianthus arboreus*, *M. holstii*, *Piper guineense*, *Pseudolachnostylis maprouneifolia*, *Ricinodendron heudelotii*, *Symphonia globulifera*, *Xymalos monospora* and *Zanthoxylum gilletii.* Under a pessimistic climate change scenario the species *Trichilia emetica* would also be included, giving a total of 34 species.

Sipo Mahogany (*Entandrophragma utile*)

Sipo Mahogany is a tall, hardwood species that is widely distributed across tropical Africa, including within DRC and Uganda. It is categorized as Vulnerable on the IUCN Red List due to heavy exploitation across its range (Hawthorne 1998). The species is considered one of the most valuable timber species in Budongo Forest Reserve, Uganda (Plumptre 1996), and the Mbuti Pygmies of DRC's Ituri forest consider it one of the 'best grade commercial species', though also commented that it is not regularly used by local people (Terashima and Ichikawa 2003). The timber was also found to be harvested in Uganda's Kalinzu Forest Reserve, and made into walking sticks, poles and tool handles, as well as into charcoal (Aine-omucunguzi *et al.* 2009).

This species was assessed as vulnerable to climate change. It is expected to be exposed to large changes in both the mean and variability of precipitation across its range (relative to other plant species assessed). It has a global range which encompasses a narrow range of temperatures (again, relative to other species assessed) suggesting narrow environmental tolerances (and hence sensitivity to change), and has a low number of pollinator species, making it vulnerable to disruption of this interaction by climate change. Finally, the long lifespan of this species means that is unlikely to adapt at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ.*

Of the 204 plant species assessed for climate change vulnerability in this study, 22 have been assessed for the IUCN Red List. Of these 22 species, 8 (36%) were assessed as being both climate change vulnerable and threatened with extinction. These species are: *Afzelia bipindensis*, *Entandrophragma angolense*, *Entandrophragma cylindricum*, *Entandrophragma utile*, *Garcinia kola*, *Guarea cedrata*, *Khaya grandifoliola* and *Ocotea kenyensis*. Under a pessimistic climate change scenario this list remains the same.

Of the 153 plant species identified as being important for use in this study, 13 have been assessed for the IUCN Red List. Of these, six (*Entandrophragma angolense*, *E. cylindricum*, *E. utile*, *Khaya anthothica*, *Prunus africana* and *Vitellaria paradoxa*) are threatened with extinction. The remaining seven species (*Cordia millenii*, *Entandrophragma excelsum*, *Euphorbia tirucalli*, *Irvingia gabonensis*, *Podocarpus latifolius*, *Pouteria altissima* and *Pterocarpus angolensis*) are categorized as either Least Concern or Near Threatened.

Of the 11 species that have been assessed for all three factors considered in this report, four species (*Entandrophragma angolense*, *E. cylindricum*, *E. utile* and *Irvingia gabonensis*) are thought to be important for use, threatened with extinction and climate change vulnerable. This list does not change under a pessimistic assumption of missing data values.

Table 7.6 Numbers and proportions of AR plants known to be globally threatened (IUCN 2012), important for use, climate change vulnerable, and all combinations thereof, including (where applicable) both optimistic and pessimistic assumptions of missing climate change vulnerability data values.

	Plants			
	Optimistic		Pessimistic	
	Number	%	Number	%
Total threatened (of 24 assessed)	12	*50*	11	*50*
Total used (of 256 considered)	153	*60*	93	*46*
Total cc vulnerable (of 204 considered)	79	*39*	82	*40*
Threatened and cc vulnerable*	**8**	***36***	**8**	***36***
Threatened and not cc vulnerable	3	*14*	3	*14*
Not threatened and cc vulnerable	6	*27*	6	*27*
Not threatened and not cc vulnerable	5	*23*	5	*23*
Used and cc vulnerable†	**33**	***35.5***	**34**	***36.5***
Used and not cc vulnerable	60	*64.5*	59	*63.5*
Threatened and used‡	**6**	***46***	**6**	***46***
Not threatened and used	7	*54*	7	*54*
Threatened, used and vulnerable§	**3**	***27***	**3**	***27***

* Of 22 species assessed for both elements (Data Deficient, Near Threatened and unassessed species are grouped with 'not threatened' species); †Of 93 species assessed for both elements; ‡Of 13 species assessed for both elements; §Of 11 species assessed for all three elements.

Fruit of *Chrysophyllum perpulchrum*. This species, which was found to be climate change vulnerable, is considered important to humans due to the construction materials it provides. © N.J. Cordeiro, TanzaniaPlantCollaboration

Sapele (*Entandrophragma cylindricum*) flowers (5–8mm diameter). This species is listed as Vulnerable on IUCN's Red List™, and was also found to be vulnerable to climate change. This species is often used for construction materials. © Xander van der Burgt / Royal Botanic Gardens, Kew

7.5 Conclusions and recommendations

Conclusions

- It is apparent that a wide diversity of wild plant species are used for multiple purposes throughout the AR. Species from the Fabaceae family were most frequently identified as being important for use as food, medicine and for construction materials, though *Prunus africana* (family: Rosaceae) appears to be a key species; valued internationally and locally for its medicinal properties, it is used in the treatment of serious illnesses such as malaria and HIV/AIDS, as well as being used for construction and for fuel.
- The most common use types found for wild plants were for medicine (for humans or livestock) and fuel. It is not surprising that plants were found to be used extensively for medicinal purposes; the FAO (2001) stated that 80% of people in Tanzania, and likely other East African countries, rely on wild plants for medicines. Medicinal plants provide an essential resource, especially to people for whom access to modern medicines is limited, perhaps by proximity, availability and/or price. Fuelwood is the primary energy source across much of Africa, and the AR countries are no exception. In Rwanda fuelwood is thought to fulfil 98% of rural households' energy needs, while in DRC the volume of fuelwood harvested each year for subsistence use is 200 times greater than the volume of harvest for commercial purposes. Wild plant-derived foodstuffs are also important, despite seeming to be more commonly consumed by poorer groups in society, particularly during times of food insecurity.
- Relatively little attention is paid to the flora of the AR in literature, particularly when compared with the region's charismatic large mammals and economically important fisheries. Nevertheless, plants are essential for a variety of commercial and subsistence purposes, including those described above. There is evidence of a shift in consumers of edible wild plants (e.g. more men are consuming wild plants; wild plants are acting as a main food item rather than a side dish), and it seems likely that consumption of wild plants will become even more important, particularly if other food sources (e.g. crops, fish, mammals) become less secure (e.g. through climate change or other threats). Some studies indicate that people prefer to eat exotic species and/or agricultural crops, and there is evidence that knowledge of native wild plants is declining. This has implications for opportunities for cultivating wild crop relatives, for the provision of medical care to local people, as well as for the development of future medicines.
- Of the 204 plant species assessed for this project 79 were found to be climate change vulnerable under an optimistic assumption of missing data values. This number increases only marginally to 83 under a pessimistic scenario, which demonstrates a high level of confidence in our results.
- Important aspects of the climate change vulnerability of AR plants include (among others) dependence upon a low number of pollinator species; habitat (including microhabitat) specialization, a long generation length (suggesting a lowered probability of adapting genetically at the rate required to mitigate the impacts of climate change); and poor dispersal ability due to either the presence of restrictive barriers and/or a dispersal mechanism that does not lend itself to covering a large distance over a short period of time.
- Of the full 264 plant species considered across the various aspects of this assessment, only 24 have been assessed for the IUCN Red List. This includes 22 of the 204 species assessed for climate change vulnerability (of which 11 are threatened, 14 are climate change vulnerable and eight are both) and 13 of the 153 species identified as important for use (of which six are threatened). Three species were identified as threatened, climate change vulnerable and important for use.
- Perhaps the greatest area of uncertainty relating to plants for our assessment was a general lack of knowledge of species' distributions, as well as about how species use differs regionally. Although broad generalizations of species' ranges allowed us to quantify, to some degree, the exposure measures used in our climate change vulnerability assessment, there can be no doubt that these measures are subject to a greater level of uncertainty than for other taxa considered. Similarly, this knowledge gap meant that it was not possible for us to identify geographic areas containing high densities of species highlighted through any aspect of our study.

Recommendations

- Harvesting of plants for fuel is significant within the AR, and increasing human populations and urbanization are likely to elevate demand further, particularly for charcoal. Therefore, we recommend considering the potential of responsibly creating community-based fuel wood plantations of non-climate change vulnerable native and non-invasive exotic plant species as a means to supply fuel wood. It must be stressed that the creation of plantations should be carefully considered and the location, size and choice of species designed in such a way as to avoid negatively impacting biodiversity or people. With this in mind, we suggest that such a programme should be framed within the context of landscape restoration, of which there is a growing body of experience in the AR, notably in Rwanda and Uganda. Landscape restoration will avoid conventional risks associated with plantations such as the creation of single-aged, single species stands. In order to be successful, such programmes would need to be able to offer a practical economic alternative to rural communities, underpinned with clear ownership rights, and be supported by a workable market network to supply urban populations with cultivated wood that is cheaper and more accessible than wild collected wood. We note that the establishment of a viable fuel wood production base that is capable of supplying a significant amount of people with wood requires significant investment and must operate over large time scales (Fenning and Gershenzon 2002), thus would likely need the assistance of governments and up-front public sector finance and/or assistance from the private sector or NGOs in becoming established. In some local situations it may be more appropriate to ensure fuelwood needs are met in other ways, including multi-purpose on farm plantings and the establishment of home and community gardens, establishment of mixed agroforestry systems and enrichment planting. As well as providing a sustainable supply of wood, there may be additional benefits such the provision of non-timber forest products, erosion prevention and slope stabilization, carbon storage, reduced emissions from deforestation and potential habitat creation depending on the mixture of species selected.
- Programmes focusing on reducing overall consumption of fuel should be promoted. This could include introducing more fuel efficient household stoves, introducing more efficient kilns for charcoal producers, and the use of alternative cooking technologies.
- Much of the supporting literature used for this section was not specific to the AR. Therefore, it was difficult to determine the contribution that wild plants make to subsistence uses and incomes within this region specifically. Household ethnobotanical surveys are recommended to collect more precise data for this region, and to monitor changes in consumption patterns.
- Monitoring of the following areas in relation to climate is desirable: pollination success rates in focal species; population trends of important pollinator species/guilds; quality (i.e. suitability for species) of key habitats and microhabitats; reproductive success and recruitment (particularly of long-lived species); and species range changes, particularly if retracting upward/poleward, and not simultaneously expanding at the upper altitudinal/poleward limit).
- Climate change adaptation interventions, **where deemed necessary and appropriate**, may include assisted breeding efforts of key species, increased site-management and/or protection of key habitats, or assisting in species' dispersal efforts (e.g. through corridor creation or translocation, depending on the species and the nature of the restriction). Care should be taken to follow the IUCN Guidelines for Reintroductions and Other Conservation Translocations (August 2012), particularly regarding risk assessment around such activities.
- We recommend a greater focus upon assessing extinction risks of AR plant species (and indeed those of the wider African continent). We recognize that the high diversity of plant species present, coupled with a likely lack of resources, makes this challenging, and we recommend prioritizing families which have been found to be particularly important for use, such as Fabaceae, or species which are important for use types such as fuel or medicine. The findings on use and/or climate change vulnerability presented in this study should be included in such assessments.
- Increased research into the global geographic distributions of AR plant species is highly desirable. This would most likely accompany the assessments of conservation status, suggested above, and would provide essential baseline information that could be used to measure range changes, assess threats (including a more rigorous assessment of climate change vulnerability) and to inform sustainable development and/or adaptation options for local communities.

Chapter 8. Reptiles

8.1 Overview of reptiles considered in the assessment

Our assessment considered a total of 168 reptile species, within 19 families. The largest of the families represented include Colubridae (56 species), Scincidae (skinks; 17 species) and Chamaeleonidae (Chameleons; 14 species). WCS (2011) recognizes a total of 20 reptile species as being endemic to the AR. At the time of our assessment, however, the chameleon species *Kinyongia gyrolepis* was not officially described, so this study considers a total of 19 endemic reptiles.

Figure 8.1 shows the density of the 149 reptile species known to occur in the AR region of Uganda, Rwanda, Burundi and Tanzania. Because reptile ranges in DRC and Zambia were not available, we were unable to consider these areas in the assessment (see section 2.5.3). The figure suggests that richness is particularly high (supporting 35–47 species per grid cell) in Toro-Semliki Wildlife Reserve, Kibale National Park, Rwenzori National Park, Queen Elizabeth National Park and Bwindi Impenetrable National Park (all in Uganda). Other areas with high reptile richness (26–34 species per grid cell) include Virunga National Park, Gishwati Forest Reserve, Mukura Forest Reserve, Nyungwe National Park (all in Rwanda), Kibira National Park (Burundi) and Bugungu Forest Reserve/Murchison Falls National Park (Uganda). Reptile species richness within the AR appears to decline as one moves southward from this centre of high richness and, perhaps unsurprisingly, is visibly lowest over Lake Tanganyika.

A thorough assessment of the extinction risk of the reptiles of this region has not yet been conducted. However as part of other initiatives, a total of 26 reptiles relevant to our assessment have been assessed for the IUCN Red List. Of these, the two species *Leptosiaphos meleagris* and *Osteolaemus tetraspis* are considered Vulnerable, the four species *Atractaspis reticulata*, *Crocodylus cataphractus*, *Kinixys erosa* and *Leptosiaphos rhodurus* are considered Data Deficient and the remaining 20 species are considered Least Concern.

8.2 Importance for human use

Data pertaining to the utilization of reptiles in the AR was not easily obtained and it was apparent that little scientific research has been conducted in recent years on the use of reptiles in the region. Where

Graceful Chameleon (*Chamaeleo gracilis*) is an Albertine Rift endemic found to be vulnerable to climate change, as well as harvested for the pet trade. © Paul Freed

information was available, it was often not specific to the AR, part of a wider study on human consumption or behaviours, and/or out-of-date. Despite this, some information was found and the consulted experts provided valuable information on the use of reptiles and their contribution to household income.

Fifty-seven species were selected by experts as being important for use[38]. The majority of reptiles were found to be either used directly for subsistence in the form of food, or for income generation through harvesting for the pet trade, Of the 57 species, 20 were found to be used for some sort of subsistence use and 56 were considered to have some sort of commercial value either at the local, national or international level. A number of other use types for reptiles were also identified, in particular use of skins and tortoise shells.

Twenty species were identified as being most important for use based on their contribution to subsistence and incomes in the AR (Table 8.1), and were mainly selected due to their use for multiple purposes. Nile crocodile (*Crocodylus niloticus*), for example, has been found to be used by humans for food, as pets, for skins, for decorative apparel, and for sport hunting. None of the 20 species identified are endemic to the region.

38. The terms 'important' and 'most important' are relative only to other reptile species in the AR when discussed in this chapter, meaning that the importance of reptile species cannot be compared with species in different taxonomic groups.

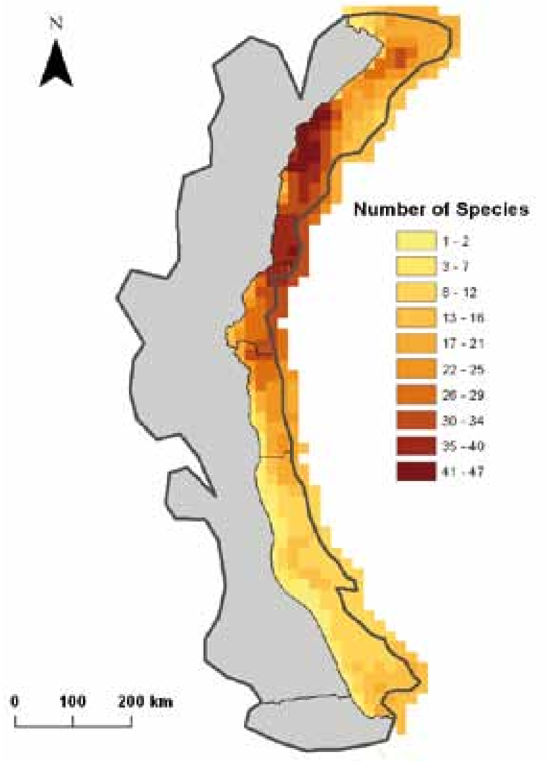

Figure 8.1. Species richness of reptiles in Uganda, Rwanda, Burundi and Tanzania. Reptile range maps were not available for DRC or Zambia, so these regions were not considered in our reptile assessment.

Table 8.1 Most important species for subsistence use and/or local income in the AR.

Species	Common Name	International value?	Uses
Bitis arietans	Puff Adder	Yes	Human food; pet trade; wearing apparel
Bitis gabonica	Gaboon Viper	Yes	Human food; pet trade; wearing apparel
Bitis nasicornis	Rhinoceros Viper	Yes	Human food; pet trade; wearing apparel
Crocodylus cataphractus	Slender-snouted Crocodile	Yes	Human food; pet trade; wearing apparel
Crocodylus niloticus	Nile Crocodile	Yes	Human food; pet trade; wearing apparel; sport hunting
Kinixys belliana	Bell's Hinged Tortoise	Yes	Human food; medicine; jewellery
Kinixys erosa	Serrated Hinged Tortoise	Yes	Human food
Kinixys spekii	Speke's Hinged Tortoise	Yes	Human food
Osteolaemus tetraspis	Dwarf Crocodile	Yes	Pet trade; wearing apparel
Pelomedusa subrufa	African Helmeted Terrapin	Yes	Human food; pet trade; jewellery
Pelusios gabonensis	Forest Hinged Terrapin	Yes	Human food; pet trade; jewellery
Pelusios rhodesianus	Variable Mud Turtle	Yes	Human food; pet trade; jewellery
Pelusios sinuatus	Serrated Hinged Terrapin	Yes	Human food; pet trade; jewellery
Pelusios subniger	East African Black Mud Turtle	Yes	Human food; pet trade; jewellery
Python natalensis	African Rock Python	Yes	Human food; pet trade; wearing apparel
Python sebae	African Rock Python	Yes	Human food; pet trade; medicine; wearing apparel
Trionyx triunguis	Nile Soft-shelled Turtle	Yes	Human food; pet trade
Varanus exanthematicus	Savannah Monitor	Yes	Human food; pet trade
Varanus niloticus	Nile Monitor	Yes	Human food; pet trade; wearing apparel
Varanus ornatus	Ornate Monitor	Yes	Human food; pet trade; wearing apparel

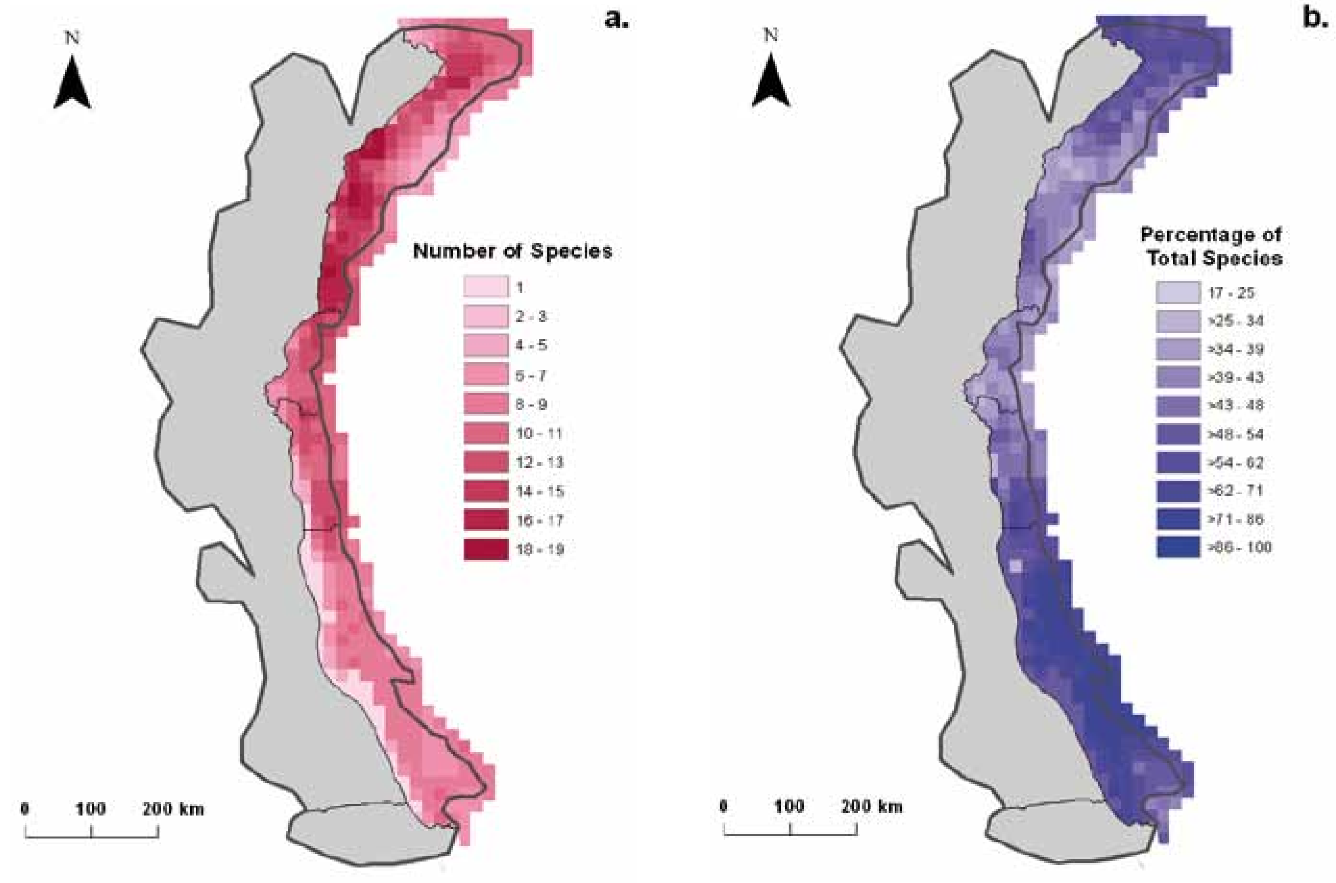

Figure 8.2 Distribution of human-utilized reptiles in AR regions where reliable reptile distribution data were available. Map (a) shows the *total numbers* of species known to be of importance for human use. Map (b) shows the *percentage of the total species present* in each region that are of importance for human use.

Within the countries for which reliable reptile distribution data were available, the density of species recognized as important for use is highest in the southern part of Uganda (within the AR), and along the DRC/Uganda border, particularly around Toro-Semliki Wildlife Reserve (Figure 8.2a). Conversely, the highest proportion of species present that were reported to be important for use was found in the northern part of Uganda and the Tanzanian portion of the AR, where up to 100% of all reptile species present are thought to be important for use of some kind (Figure 8.2b).

8.2.1 Harvest for human food

Twenty-one reptile species were identified as being important for use, compared with other reptile species in the AR, as a human food source (37% of all used species), including six species of the family Pelomedusidae (side-necked turtles), three species of Crocodylidae (crocodiles), three species of Testudinae (tortoises), three species of Varanidae (monitor lizards), three species of Viperidae (viperid snakes), two species of Pythonidae (pythons) and one species of Trionychidae (soft-shelled turtles). Of these 21 species, 20 were found to have a subsistence value, and 20 were traded for commercial gain through the sale of their meat at the local level.

Of the 21 species specified by experts as used for human food, 10 were in the order Testudines. One consulted expert speculated that all tortoise and turtle species would be used for their meat for subsistence and for local trade, including species of the genus *Pelusios* and the African Helmeted Turtle (*Pelomedusa subrufa*), which might be caught as by-catch but would still provide a little in the way of income. He suggested that the only species likely to contribute a significant amount of protein was the Nile Soft-shelled Turtle (*Trionyx triunguis*) as this species can yield approximately 18kg of meat. In support of this, Nile Soft-shelled Turtle was identified by another expert as being of medium importance for income, and by several as a source of human food. Broadley *et al.* (1989) found that species of tortoise in the genus *Kinixys* were eaten by humans throughout most of their range, with the primary driver for their harvest being for meat.

Shirley (2010) found that Slender-snouted Crocodile (*Crocodylus cataphractus*) is often eaten by humans when caught as by-catch in small-scale subsistence fisheries, and suggested that this, combined with the international trade in its skins and disruption of habitat, may be threatening the species. Supporting this, Behar (1987) claimed that Slender-snouted Crocodile might already be extinct in some parts of its range due to hunting pressure. Nile crocodile (*Crocodylus niloticus*) was documented as being caught and eaten by people in parts of Uganda (Olupot *et al.* 2009) and DRC (Ichikawa 1987) but, according to Olupot *et al.* (2009), this species is more typically caught for reasons relating to attacks on humans or livestock. Olupot *et al.* (2009) recorded very few harvested Nile Crocodiles but found that their meat was sold at market for approximately USH1,500 per kg (less than USD1).

Ornate Monitor (*Varanus ornatus*) and two other species of monitor lizard (Varanidae) were identified as being important as a human food source. They are also used to make handicrafts and are traded as pets. This particular species was assessed as vulnerable to climate change. © Brian Rasmussen

On the whole, reptiles do not appear to be popular as food items throughout the AR when compared with other taxonomic groups, particularly fish and mammals. Ichikawa (1987) recorded six reptiles as being eaten in the Ituri Forest, of which three are described to species level (Gaboon Viper (*Bitis gabonica*), Nile Crocodile and Dwarf Crocodile (*Osteolaemus tetraspis*)) and three to genus (*Bitis*, *Python* and *Varanus*) but this is dwarfed by the number of bird species (105 species) and mammal species (57 species) eaten.

8.2.2 Harvest for the pet trade

Fifty-four reptile species were identified through the expert consultation process as important for use in the pet trade; almost all of which (53 species) have a local and/or international value, though in some cases this was attributed to the use of skins, which are traded internationally. The families with the most species identified as harvested for the pet trade were Colubridae (11 species), Chamaeleonidae (nine species), Viperidae (nine species) and Pelomedusidae (six species). Although the reptile pet trade is thought to be a threat to many species throughout Africa, and important for certain people's incomes, there is very little AR-specific information available on which species are most commonly traded, and the contribution that this trade makes to household income.

Popular pets that may originate from this region, include Bell's Hinged Tortoise (*Kinixys belliana*), which is thought to be traded into the EU in large numbers (Engler and Parry-Jones 2007). An examination of the CITES Trade database showed that DRC reported the export of 521 wild-caught Bell's Hinged Tortoises between 2005 and 2010, making it the only AR country to report the export of wild individuals. In addition, Zambia and Tanzania reported exporting 880 and 61 captive-born/bred individuals, respectively.

The Nile Monitor (*Varanus niloticus*) was identified in the CITES Trade database as being important for use in the pet trade, though Tanzania was the only country which reported export of this species from the AR region specifically. Tanzania reported a total export of 3,462 wild live individuals between 2005 and 2010. Nile Monitors were found to be one of the most highly traded species of wild-caught reptiles into the USA between 1998 and 2002 (Schlaepfer *et al*. 2005). Enge *et al.* (2004) commented that most Nile Monitors imported into the USA are wild caught, and this is supported by data from within the CITES Trade database. Hatchlings of this species can cost as little as USD10. Snakes are also popular in the global pet trade; however, species from the AR countries do not appear to play a major role. An analysis of data from the CITES Trade database indicated that imports of live, wild, CITES-listed snake species (including species not found within the AR) into the EU-27 were predominantly from Ghana and Togo, which accounted for 83% of all imports between 2006 and 2010, compared with 0.03% from the AR countries combined.

Species that were identified by experts as being traded from the AR at relatively high levels include six chameleon species of the genus *Chamaeleo*, which are all listed in CITES Appendix II. Tanzania, DRC and Uganda reported a combined export of 32,827 live individuals of these six species between 2005 and 2010, of which 17,820 individuals (54%) were Flap-necked Chameleons (*Chamaeleo dilepis*).

Uganda and DRC reported exports of 271 wild, live individuals from two species of *Kinyongia* over the same time period.

Six of the 19 species considered to be endemic by WCS were identified by experts as likely to be harvested for the pet trade: *Atheris nitschei,* Strange-nosed Chameleon (*Kinyongia xenorhina*), *Kinyongia adolfifriderici,* Ruwenzori Three-horned Chameleon (*Chamaeleo johnstoni*), Rough Chameleon (*C. rudis*), and Nocturnal Forest Gecko (*Cnemaspis quattuorseriata*).

The Uganda Biotrade Programme (2004) estimated the annual export trade in chameleons, tortoises, lizards and snakes from Uganda to be worth USD1,280,000. Only six wildlife-export companies were registered, all of which were engaged in wildlife farming, though it is unknown if this means ranching or captive-breeding operations. The same paper outlines the supply chain of tortoises, whereby collectors, whose sole income comes from collecting wildlife, earn around USH20,000 (USD11.11) per tortoise (species not specified), which later commands up to USH3,600,000 (USD2,020)[39] on the international market. This equates to a requirement of 33 tortoises per collector, per year to ensure an average income of greater than USD1 per day (The Uganda Biotrade Programme 2004).

8.2.3 Harvest for medicine

Bell's Hinged Tortoise (*Kinixys belliana*) and African Rock Python (*Python sebae*) were the only species identified by experts as important for medicinal purposes. Olupot *et al.* (2009) also identified African Rock Python as being used for medicinal purposes through interviews with hunters in Queen Elizabeth and Murchison Falls National Parks in Uganda. African Rock Python has also been found to be used for medicinal purposes in Nigeria (Banjo *et al*. 2006; Ibrahim *et al*. 2010) as has *Kinixys* spp. (Sodeinde and Soewu 1999). Ibrahim *et al*. (2010) found that pythons are harvested for their fat, which can be used to treat backache and burns, and Sodeinde and Soewu (1999) found that the consumption of the head of African Rock Python is believed to protect against witches. In the Geita district, Tanzania (outside of the AR boundary), python droppings are sold for medicinal purposes for TSH20 (USD0.01) per spoonful (Ministry of Natural Resources and Tourism 2000). People in some parts of Nigeria also believe that *Kinixys* species can provide fertility medicines for women (Sodeinde and Soewu 1999).

Alves *et al.* (2008) published a broad overview of the use of reptiles in traditional medicines throughout the world and the implications for conservation. The species listed in this report included five found in the AR: Common Agama (*Agama agama*), Nile Crocodile, Tropical House Gecko (*Hemidactylus mabouia*), Bell's Hinged Tortoise and Nile monitor. Since these species are all also found outside of the AR, it is not possible to verify whether or not they are important for use in this region specifically.

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39. Currency conversions carried out using 2004 conversion rates.

Nile Crocodile (*Crocodylus niloticus*)

This large aquatic predator is widely distributed throughout sub-Saharan Africa, and is present in all six AR countries (Crocodile Specialist Group 1996). Experts identified the Nile Crocodile as being hunted for its skin in the AR, including for the export market. The commercial company Uganda Crocs collects 2,500 eggs annually from Murchison Falls National Park, Uganda and raises the crocodiles at a ranching facility in Buwama (outside the AR). The raw skins are sold for around USD200 each, and are exported to Italy and South Korea to be processed into leather (SPORE 2012). According to CITES trade data, between 2005 and 2010, 281,914 skins were reportedly exported from Zambia (99% of which were declared as wild/ranched), 8,748 skins from Tanzania (>99% declared as wild) and 1,990 skins from Uganda (14% declared as wild). The Nile Crocodile is also used for food, sport hunting and for sale to the pet trade in the AR. Although used by humans throughout its range, and being listed in CITES Appendix I in much of its range (i.e. international trade is illegal) and Appendix II in the remainder (i.e. international trade is regulated), this species is currently categorized as Least Concern on the IUCN Red List.

The Nile Crocodile is expected to experience significant changes in mean temperature across its range, and is also believed to be sensitive to climatic changes – the result of its restriction to specific habitat types and an intolerance to changes to the natural fire regime. However, this species was assessed as likely to be capable of adapting to climatic changes, meaning that it was not assessed as climate change vulnerable overall.

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Overall, it seems likely that some reptile species are used in small numbers by certain groups of people for medicinal purposes, but that reptiles do not play a significant role in treating medical conditions or in providing income for local people through the sale of derived medicinal goods.

8.2.4 Harvest for other purposes

Experts identified 10 species as being important for making into wearing apparel and accessories; predominantly skins of viperid species (three species) and crocodiles (three species). In addition, seven species were identified as being important for use in making handicrafts and jewellery, six of which were side-necked turtles. The use of reptiles for these purposes was mostly thought to be for income, as all but William's Mud Turtle (*Pelusios williamsi*) had both a local and an international value.

Both Slender-snouted Crocodile and Nile Crocodile (*Crocodylus niloticus*) are used extensively for their skins, and Shirley (2010) suggested that harvest of Slender-snouted Crocodile for this purpose, in combination with habitat disruption and by-catch in fisheries, could pose a threat to the species. In contrast, Nile Crocodile populations are thought to be relatively stable (Fergusson 2010). According to CITES trade data; Tanzania, Uganda and Zambia reported exporting a combined number of 241,595 skins between 2005 and 2010, 98% of which were reported to come from ranched crocodiles. No exports of Slender-snouted Crocodile, which is listed in CITES Appendix I, were reported by AR countries during this time period.

Tourists are able to pay to hunt Nile Crocodile in Tanzania for a fee of USD840, and python for USD300 (compared with, for example, USD90 to hunt a baboon or USD4000 to hunt an elephant) (Baldus and Cauldwell 2004). In Uganda, Nile Crocodile can be hunted for a fee of USD2,500, but only where they have been identified as problem animals (Victor Hunting Safaris 2012). Zambia and Tanzania reported the export of 1,473 Nile Crocodile trophies between 2005 and 2010.

8.3 Climate change vulnerability

For the 168 reptile species assessed, we identified and considered a total of 17 climate change vulnerability traits, of which four related to 'Exposure', nine to 'Sensitivity' and four to 'Low Adaptability'. These are shown in Tables 8.2, 8.3 and 8.4.

Through assessing reptile species' Exposure to climatic changes (Table 8.2), we expect 59 species (35%) to experience relatively 'high' levels of climatic change throughout the portions of their range which were investigated (see Methods, Section 2.5.3). A further 37 species (22%) are expected to experience 'very high' levels of change. Of these 96 species, 21 are expected to experience large changes in two of the four climatic variables investigated, seven species (*Adolfus vauereselli*, *Atheris acuminata*, *A. rungweensis*, *Chamaesaura anguina*, *Leptosiaphos kilimensis*, *Pelomedusa subrufa* and *Trionyx triunguis*) across three variables, and six species (*Atheris nitschei*, *Cnemaspis elgonensis*, *Hemidactylus angulatus*, *Loveridgea phylofiniens*, *Polemon gabonensis* and *Varanus niloticus*) across all four.

Table 8.2 Climate change *Exposure* measures used to assess AR reptiles (excluding those of DRC and Zambia), including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A6).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 168			
EXPOSURE				**Low**	**High**	**Very High**	**Unknown**
A. Temperature change	Substantial changes in mean temperature occur across the species' range	**E1:** Absolute difference between 1975 and 2050 mean temperatures (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	112	22	15	19
	Substantial changes in temperature variability occur across the species' range	**E2:** Absolute difference between 1975 and 2050 values of average absolute deviation in temperature (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	112	22	15	19
B. Rainfall change	Substantial changes in mean precipitation occur across the species' range	**E3:** Absolute ratio of change in 1975 and 2050 values of mean precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	112	22	15	19
	Substantial changes in precipitation variability occur across the species' range	**E4:** Absolute ratio of change in 1975 and 2050 values of average absolute deviation in precipitation (for all months) across the species' current range	L = Lowest 75%; H = Highest 25%; VH = Highest 10%	111	23	15	19
			Total	**72**	**59**	**37**	
			Percentage	**43**	**35**	**22**	

Table 8.3 Climate change *Sensitivity* traits used to assess AR reptiles (excluding those of DRC and Zambia), including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A6).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 168			
SENSITIVITY				**Low**	**High**	**Very High**	**Unknown**
A. Specialized habitat and/or microhabitat requirements	Habitat specialization	**S1**: Number of IUCN habitat types occupied by species	L = >1; H = 1	123	39	n/a	6
	Microhabitat specialization	**S2:** Number of microhabitats in which the species occurs	L = >1; H = 1	107	56	n/a	5
	Elevation range	**S3:** Species elevation range	L = >1,000 m; H = <1,000 m or found only above 2,000 m altitude	137	24	n/a	7
	Tolerance of changes to fire regimes	**S4:** Species is tolerant of a wide range of fire frequencies	L = True; H = False	97	43	n/a	28
C. Dependence on a specific environmental trigger that is likely to be disrupted by climate change	Precipitation activated trigger	**S5:** Species requires rainfall to stimulate breeding	L = False; H = True	148	5	n/a	15
		S6: Species requires rainfall to stimulate general activity	L = False; H = True	125	28	n/a	15
D. Dependence on interspecific interactions which are likely to be disrupted by climate change	Dependence on narrow range of food types	**S7:** Species a dietary specialist (i.e. feeds on only one or two taxa)	L = False; H = True	108	53	n/a	7
		S8: Species dependent on a prey item likely to be affected by any of the previously listed factors	L = False; H = True	132	24	n/a	12
E. Rarity	Range Size	**S9:** Does this species have an extent of occurrence (EOO) of less than 5,000 km² (yes = high, low = no)?	Extent of Occurrence (EOO) L = >5,000 km²; H = <5,000 km²	156	8	n/a	4
			Total	**53**	**115**		
			Percentage	**31.5**	**68.5**		

Table 8.4 Climate change *Low Adaptability* traits used to assess AR reptiles (excluding those of DRC and Zambia), including thresholds used to categorize species, and the total numbers of species falling into each category for each of trait. Note that the codes (in red text) given next to each sub-trait may be used to interpret the species summary table at the end of this document (Table A6).

Trait Group	Trait	Sub-trait	Thresholds				
				Total species considered = 168			
LOW ADAPTABILITY				**Low**	**High**	**Very High**	**Unknown**
A. Poor dispersability	Barriers to dispersal	**A1:** Higher (cooler) habitat is available for the species to move to	L =True; H = False	155	8	n/a	5
	Intrinsic low probability of dispersal	**A2:** Species has a maximum reasonable dispersal distance > 5 km	L =True; H = False	13	152	n/a	3
		A3: Species is fossorial	L = False; H = True	140	25	n/a	3
B. Poor Evolvability	Reproductive output	**A4:** Species has a potential annual offspring output of > 20 offspring/year	L =True; H = False	41	93	n/a	34
			Total	**8**	**160**		
			Percentage	**5**	**95**		

In our assessment of species' Sensitivity to climatic changes (Table 8.3), 115 species (68%) were assessed as possessing traits that make them 'highly' sensitive to climatic changes. Of these 115 species, 33 possess one single trait, 26 possess two traits, 39 possess three traits, seven species (*Atheris acuminata*, *Buhoma depressiceps*, *Causus lichtensteinii*, *Chamaeleo ituriensis*, *Leptosiaphos blochmanni*, *L. graueri* and *Osteolaemus tetraspis*) possess four traits, and 10 species (*Boulengerina annulata*, *Dipsadoboa unicolor*, *Grayia smythii*, *G. tholloni*, *Kinyongia carpenter*, *K. xenorhinum*, *Leptosiaphos hackarsi*, *L. meleagris*, *Lycodonomorphus bicolor* and *Natriciteres olivacea*) possess five traits.

Within the Sensitivity analysis, the most common trait possessed was a dependence on a specific microhabitat (trait S2) which was present in 56 species (33%). This trait suggests a narrow tolerance of conditions and, therefore, higher sensitivity to changes that may occur as a result of changes in climate. The next most common Sensitivity trait possessed was 'dietary specialization' (i.e. only able to feed upon a small number of species) (trait S7), which was present in 53 species (31.5%). Such species are likely to be more sensitive to changes in the wider ecosystem, as this could result in a decline in their essential food resources.

Also an important trait within the Sensitivity analysis was an intolerance of a wide range of fire regimes (throughout the species' entire range) (trait S4), which was present in 43 species (26%). Both the frequency and intensity of natural fires is expected to change as a result of climate change (Scholze *et al*. 2006; Fishchlin *et al*. 2007; Moritz *et al*. 2012), and species that are dependent on a specific fire regime are likely to be sensitive to any changes that occur.

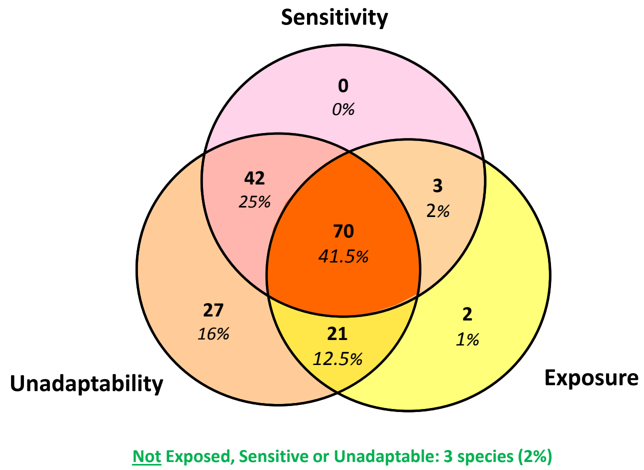

Figure 8.3 Numbers of AR reptiles (excluding those in DRC and Zambia) recognized as Exposed, Sensitive and/or Unadaptable to climate change, and all combinations of the three.

In our assessment of species' capacity to adapt to climatic changes (Table 8.4) 160 species (95%) were assessed as possessing traits that make them poorly adaptable. Of these 160 species 60 possess only one trait, 82 possess two traits, and 18 possess three traits. 152 species (90.5%) are believed to have low intrinsic capabilities for dispersal (estimated as being less than, or equal to, 5 km during the lifetime of one individual) (trait A2), making them unlikely to adapt to climate change through dispersal. This value includes all species with fossorial lifestyle (trait A3). Ninety-three species (55%) have low annual reproductive outputs (less than a maximum of 20 individuals per year; trait A4), suggesting a low likelihood of adapting to climatic changes through *in-situ* genetic microevolution at a rate fast enough to mitigate the impacts.

Overall a total of 70 reptile species (41.5%) were recognized as being of highest vulnerability to climate change due to being highly sensitive, highly exposed, and poorly able to adapt. Of these 70 species, six are endemic to the region. Three species (2%) are expected to experience high levels of climate change throughout their ranges (relative to other reptiles in the region), are sensitive to climatic change, but are not noted as being poorly able to adapt. Forty-two species (25%) were assessed as both sensitive and unable to adapt to climate change, but are not expected to experience high levels of change. Twenty-one species (12.5%) are expected to be both highly exposed and unable to adapt, but not actually sensitive to climate change. Under our pessimistic

Elliot's Chameleon (*Chamaeleo ellioti*), a near endemic to the Albertine Rift, is used in the pet trade and was found to be vulnerable to climate change. © Paul Freed

scenario for values of missing data (see Methods, Section 2.2.1.3) a total of 92 species (55%) are considered climate change vulnerable.

Table 8.5 shows the taxonomic families of the 70 reptile species recognized in our assessment as being climate change vulnerable. The largest group on this list is the Colubridae, with 18 climate change vulnerable species (32% of the 56 considered in our assessment). Other large groups include Chamaeleonidae (eight climate change vulnerable species, or 57% of the 14 assessed) and Scincidae (seven climate change vulnerable species, or 41% of the 17 assessed).

Figure 8.4 shows the distribution of climate change vulnerable reptiles of the AR for which reliable distribution data were available. Map 8.4a shows total numbers of climate change vulnerable species, and suggests that the greatest numbers (13–16 species per grid cell) can be found in and around protected areas such as Toro-Semliki, Semuliki and Rwenzori Mountains National Parks (all Uganda) Mukura hotspot area (Rwanda) and Nyungwe\Kibira National Parks (Rwanda and Burundi, respectively). Other important areas, typically with 9–12 climate change vulnerable species, include Kibale hotspot area, Queen Elizabeth National Park, Bwindi Impenetrable National Park (all Uganda) and Gishwati hotspot area (Rwanda). Excepting the far north, Tanzania typically supports 2–3 climate change vulnerable reptile species in any given grid cell throughout.

Slender-snouted Crocodile (*Crocodylus cataphractus*) was found to be climate change vulnerable. This species is important to humans as a source of food and its skin is used to make clothing and accessories. It is sometimes found in the pet trade. © Brian Rasmussen

Table 8.5 Climate change vulnerable reptile species grouped by family. Numbers in parentheses show percentages of the total species (within each family) considered for this assessment which are climate change vulnerable. Vulnerability figures are based on an optimistic scenario for missing data values.

Family	Number (and percentage) of climate change vulnerable reptile species
Colubridae	**18** (*32%*)
Chamaeleonidae	**8** (*57%*)
Scincidae	**7** (*41%*)
Atractaspididae	**6** (*60%*)
Pelomedusidae	**6** (*86%*)
Elapidae	**4** (*50%*)
Typhlopidae	**4** (*57%*)
Testudinidae	**3** (*100%*)
Agamidae	**2** (*67%*)
Crocodylidae	**2** (*67%*)
Gekkonidae	**2** (*25%*)
Lacertidae	**2** (*33%*)
Viperidae	**2** (*17%*)
Amphisbaenidae	**1** (*100%*)
Gerrhosauridae	**1** (*100%*)
Trionychidae	**1** (*100%*)
Varanidae	**1** (*33%*)

Rwenzori Side-striped Chameleon (*Chamaeleo rudis*)

Found in western Uganda, Rwanda, Burundi and eastern DRC, the Rwenzori Side-striped Chameleon is an Albertine Rift endemic. This species was identified by experts as being collected for the pet trade, and as having both local and international value. The species was listed in CITES Appendix II (i.e. international trade strictly regulated) in 1977, and between 2000–2010 four AR countries reportedly exported the following numbers of Rwenzori Side-striped Chameleons: Tanzania (19,883), Uganda (382), DRC (109) and Rwanda (45). Of these 20,419 individuals, 93% were declared as wild caught. This species has not yet been assessed for the IUCN Red List.

The Rwenzori Side-striped Chameleon is expected to experience large changes in the variability of both temperature and precipitation regimes across its current range (relative to other reptile species assessed). The species is believed to have specific microhabitat requirements, particularly for low bushes and ericaceous shrubs, and is also known to occur only at sites within a narrow range of altitudes (>2,000 metres above sea level only) (Tilbury 2010). These two factors suggest that the species is likely to be particularly sensitive to changes in its environment. Finally, the species is believed to be unable to disperse further than 5 km within one lifetime, and is also known to have a low reproductive output (≤ 20 offspring per year). These two factors make the species' likely rates of adapting to environmental change, either *in-situ* or by relocating to more suitable areas, insufficient to mitigate the impacts of climate change. In combination, these factors resulted in the species being assessed as vulnerable to climate change.

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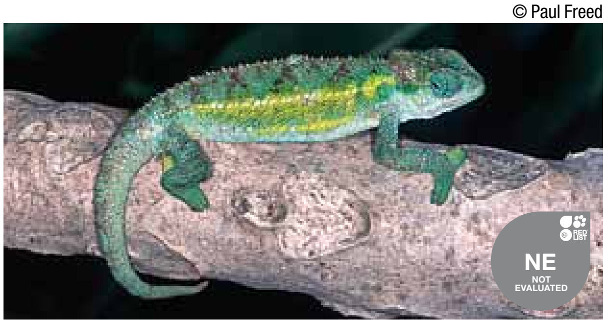

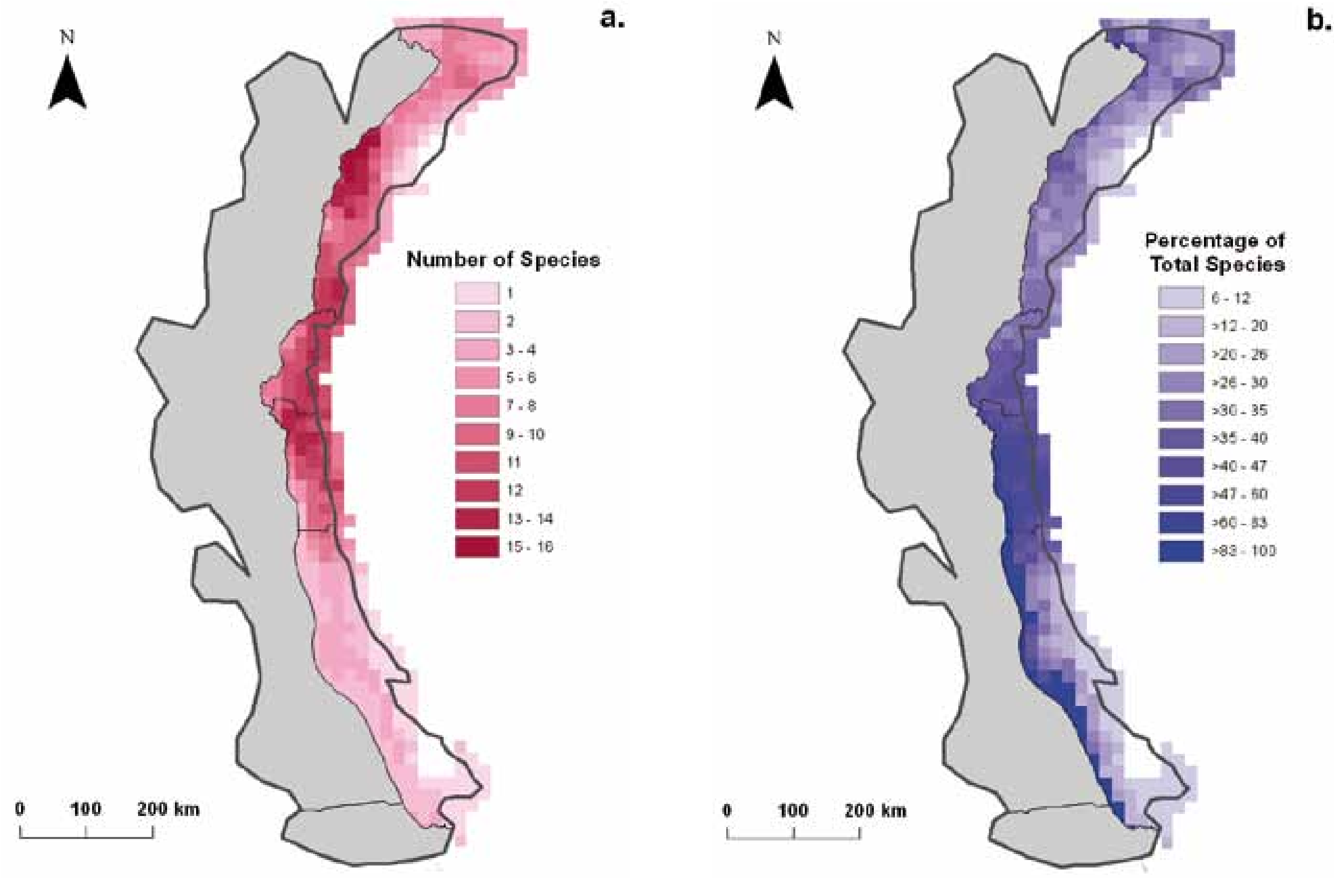

Figure 8.4. Distribution of climate change vulnerable reptiles in the AR (excluding those of DRC and Zambia). Map a shows total numbers of species thought to be vulnerable to climate change impacts. Map b shows the percentage of the total species present in each region that are climate change vulnerable.

Map 8.4b shows the percentages of all reptile species present in each grid cell that are climate change vulnerable, and highlights Lake Tanganyika as having the largest proportion of its reptiles vulnerable to climate change impacts (up to 100% in places), largely due to the low number of reptile species actually recorded in this lake. Much of Burundi also contains a high proportion of climate change vulnerable reptiles (around 50% in most places), and this value typically decreases as one moves northward or southward, though more so towards the south.

8.4 Combined utilization, threat and climate change vulnerability results

The numbers and proportions of reptile species known to be important for use, climate change vulnerable, globally threatened, and all combinations thereof are shown in Table 8.6.

A total of 25 reptile species were assessed as being both important for use and climate change vulnerable. These species are *Acanthocercus atricollis*, *Agama agama*, *Chamaeleo dilepis*, *C. ellioti*, *C. gracilis*, *C. rudis*, *Crocodylus cataphractus*, *Gerrhosaurus major*, *Kinixys belliana*, *K. erosa*, *K. spekii*, *Kinyongia xenorhinum*, *Osteolaemus tetraspis*,

Sudan Plated Lizard (*Gerrhosaurus major*) was found to be vulnerable to climate change, and is thought to be particularly sensitive to changes in fire regimes. This species is recognized as important in the pet trade. © Paul Freed

Table 8.6 Numbers and proportions of AR reptiles known to be globally threatened (IUCN 2012), important for human use and climate change vulnerable, and all combinations thereof, including (where applicable) both optimistic and pessimistic assumptions of missing climate change vulnerability data values.

	Reptiles (168 species)			
	Optimistic		Pessimistic	
	Number	%	Number	%
Total threatened*†	**2**	***8***	**2**	***8***
Total used	57	*34*	57	*34*
Total cc vulnerable	70	*42*	92	*42*
Threatened and cc vulnerable	**2**	***8***	**2**	***8***
Threatened and not cc vulnerable	0	*0*	0	*0*
Not threatened and cc vulnerable	10	*38.5*	15	*57.5*
Not threatened and not cc vulnerable	14	*53.5*	9	*34.5*
Used and vulnerable	**25**	***15***	**29**	***17***
Used and not vulnerable	32	*19*	28	*17*
Not used and vulnerable	45	*27*	63	*37.5*
Not used and not vulnerable	66	*39*	48	*28.5*
Threatened and used	**1**	***4***	**1**	***4***
Threatened and not used	1	*4*	1	*4*
Not threatened and used	9	*34.5*	9	*34.5*
Not threatened and not used	15	*57.5*	15	*57.5*
Threatened, used and vulnerable	**1**	***4***	**1**	***4***

* Data Deficient, Near Threatened and unassessed species are grouped with 'not threatened' species.
† Twenty-six of the 168 AR reptiles have been assessed for the IUCN Red List™.

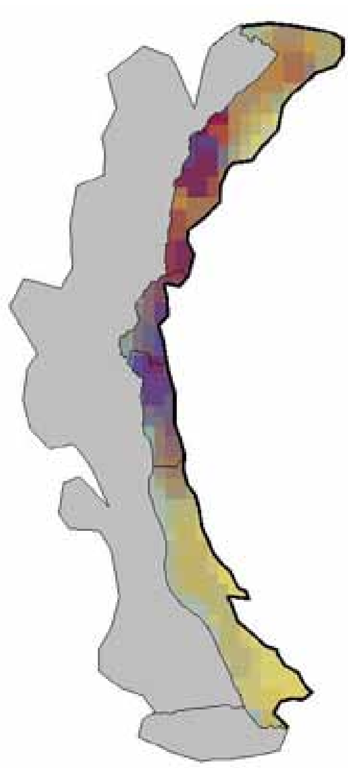

Figure 8.5 Bivariate plot combining results on climate change vulnerability and human utilization of AR reptiles (excluding those of DRC and Zambia). Plot uses data on total numbers of species per grid cell qualifying under each variable.

Pelomedusa subrufa, *Pelusios gabonensis*, *P. rhodesianus*, *P. sinuatus*, *P. subniger*, *P. williamsi*, *Philothamnus carinatus*, *P. heterodermus*, *P. hoplogaster*, *Rhampholeon boulengeri*, *Trionyx triunguis* and *Varanus ornatus.* Under a pessimistic scenario for values of missing climate change vulnerability data (see Methods, Section 2.2.1.3), the following four species would also be recognized as being both used and climate change vulnerable: *Atheris nitschei*, *A. squamiger*, *Bothrophthalmus lineatus* and *Toxicodryas blandingii,* giving a total of 29 species.

The densities of AR reptile species (excluding those of DRC and Zambia) known to be important for use, climate change vulnerable (optimistic scenario), and combinations of the two are shown in Figure 8.5. This image highlights three regions in particular as having high numbers of both types of species: Toro-Semliki, Semuliki and Rwenzori Mountains National Parks (all Uganda) Mukura Hotspot Area (Rwanda) and surrounding cells, and Nyungwe\Kibira National Parks (Rwanda and Burundi, respectively). In most other regions, and particularly to the south, a lower number of climate change vulnerable species, coupled with a relatively consistent number of species known to be important for use, is visible.

Of the 26 AR reptile species that have been assessed for the IUCN Red List, two (*Leptosiaphos meleagris* and *Osteolaemus tetraspis* are believed to be globally threatened with extinction. Both species were assessed as being vulnerable to climate change impacts. *O. tetraspis* is known to be used by humans, while *L. meleagris* is not.

Bell's Hinged Tortoise (*Kinixys belliana*)

Bell's Hinged Tortoise is widely distributed across sub-Saharan Africa, and is actively harvested throughout its range for its meat and traditional medicine (Arkive 2012). Experts reported the same uses in the AR, and added that the species is used for the production of jewellery and handicrafts. The species is listed in CITES Appendix II (i.e. international trade is strictly regulated) and, according to CITES trade data, between 2005 and 2010 1,666 live individuals were exported from three AR countries (DRC, Tanzania and Zambia), mainly to Europe, presumably for the pet trade. However, experts did not identify this as a use type within the AR specifically. This species has yet to be assessed for the IUCN Red List.

Bell's Hinged Tortoise is expected to be exposed to large changes in temperature variability across its range (relative to other reptile species assessed). It is believed to be highly dependent on current rainfall regimes, which are thought to initiate both breeding and activity more generally, making it highly sensitive to changes in its environment. Finally, this species is known to have particularly low reproductive output (< 20 eggs laid per year), meaning that is unlikely to adapt at a sufficient rate to be able to mitigate the impacts of climatic changes *in-situ*. In combination, these factors led to the species being assessed as vulnerable to climate change.

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8.5 Conclusions and recommendations

Conclusions

- Very little relevant information was available on the human use of reptiles in the AR, and it appears that reptiles play a relatively minor role as a food source compared with other taxonomic groups such as fish. However, some groups such as the testudines (turtles, tortoises and terrapins) are exploited for their meat, both for subsistence use and for sale to generate income.
- The capture of reptiles for use in the pet trade appears to be one of the most significant use types, and 95% of the species identified as important for use were selected for this reason. The majority of these species had an international value. It is likely that the collection of reptiles contributes significantly to some people's incomes, and this could increase over time if the popularity of reptiles as pets increases, or if other supply countries deplete their own reptile populations.
- The use of skins from crocodiles, monitor lizards, pythons and vipers to create wearing apparel was also found to be an important use type; indeed the trade in crocodilian skin is likely to contribute more to household incomes than their meat. The Slender-snouted Crocodile, Nile Crocodile and Dwarf Crocodile were all found to have a commercial value based on their skins, and for the Slender-snouted Crocodile and Nile crocodile this was the primary reason for hunting them. The majority of Nile Crocodile skins are, however, from ranched sources, but it is unclear to what extent these operations contribute to local people's incomes.
- Although reptiles in the AR do not currently appear to be heavily used for their medicinal properties, either locally or internationally, this may change in the future as the traditional medicine market in Asia looks further afield for products. This could potentially create new income-generating opportunities for people living in the AR.
- Of the 168 reptile species assessed for this study 70 were found to be climate change vulnerable under our optimistic scenario for values of missing data. This number increases to 92 under a pessimistic scenario, which demonstrates a moderate level of uncertainty in our assessments.
- Important aspects of climate change vulnerability of AR reptiles include, among others, habitat and/or microhabitat specialization, specific requirements in terms of natural fire regimes, a low intrinsic ability to disperse, and a low annual reproductive output (suggesting a low probability of adapting *in-situ* at a rate fast enough to mitigate climate change effects). Two of these traits (tolerance of changes to fire regimes and annual reproductive output) however, are among our greatest areas of uncertainty. Detailed knowledge of the distributions of several AR reptile species (particularly in DRC) is also lacking.
- Only 26 of the 168 AR reptiles have previously been assessed for the IUCN Red List. Of these, two are considered to be globally threatened with extinction (both climate change vulnerable, and one

important for use), 20 are classified as Least Concern, and four are Data Deficient. Many of these assessments are, however, thought to be in need of re-evaluation.

- Several geographic areas contain high numbers of used and/or climate change vulnerable reptile species. These include Toro-Semliki, Semuliki and Rwenzori Mountains National Parks in Uganda) Mukura Hotspot Area and Nyungwe National Park in Rwanda, and Kibira National Park in Burundi. However, as mentioned earlier high uncertainty surrounds some aspects of our knowledge of species' distributions, including several whole species and two whole countries.

Recommendations

- Given the endemism of certain reptile species within the AR, trade should be monitored and managed to ensure that it is not detrimental to their survival.
- We recommend investigating the current levels, and future potential, of ranching reptile species to determine how much this practice contributes to local people's income, and how it may contribute in the future. Any harvesting from the wild should be sustainably managed to ensure the practice does not negatively impact wild populations.
- Monitoring of the following areas in relation to climate is desirable: quality (i.e. suitability for the species) of key habitats and microhabitats important for reptiles, changes to fire regimes (and how this might be impacting reptile species), any species range changes – particularly where a contraction in distribution is not coupled with an expansion elsewhere, as well as general demographic factors including population sizes and trends.
- Climate change adaptation interventions, where deemed necessary and appropriate, may include increased site-protection, site management (particularly in terms of fire regimes) and/or translocation to more favourable sites, among others. Care should be taken to follow the IUCN Guidelines for Reintroductions and Other Conservation Translocations (August 2012), particularly regarding risk assessment around such activities.
- Further research into the distributions of many AR reptiles, particularly those of the DRC and Zambia, is essential if we are to monitor population trends and range sizes with respect to climate change and other threats. Research into the reproductive capacities (and other aspects of the microevolutionary capacity – e.g. genetic health) of AR reptiles is desirable to determine species' capacities to adapt *in-situ*.
- Assessment (or reassessment) of the conservation status of AR reptiles is highly desirable as this would provide essential baseline information (including more accurate distribution data) for the assessment of future trends.
- The highlighted geographic areas, described above, are of particular interest as they represent regions where conservation research and actions, both present and future, may be of increased impact (and, arguably, importance). Conservationists, developers, and all interested parties should be aware of the importance of these areas, but should also acknowledge that species highlighted in this assessment also extend into other areas, where numbers of species are lower overall. Once again we reaffirm the need for increased knowledge of the distributions of the region's reptiles.

Chapter 9. Conclusions and recommendations

Through this study, we aimed to (1) identify species that are of importance for human use in the AR, and to gather available information describing this use; (2) assess the relative climate change vulnerability of AR species; and (3) use these results to identify the use types, livelihoods, species and areas that are most likely to be negatively impacted by climate change, so that these can inform climate change adaptation strategies for both biodiversity conservation and human development.

Chapters 3–8 provide specific information to address these aims for each taxonomic group. In this concluding chapter, we aim to draw together over-arching conclusions based on five key questions:

- How are wild species used by people of the AR?
- How does human use impact species of the AR?
- How might climate change impact species of the AR?
- How might climate change interact with non-climatic threats to species of the AR?
- How might climate change impact species of importance for human use in the AR?

Finally, we compile recommendations for ongoing human development and biodiversity conservation planning in the AR region.

9.1 How are wild species used by people of the AR?

We have described the ranges of uses of wild species from each taxonomic group in each of the results chapters. To conclude, we provide a brief overview of our findings and highlight regions where highest concentrations of species of importance to humans for each taxonomic group overlap with each other, thereby identifying the regions of the AR where interventions focusing on direct use of wild species would be best targeted.

The use of wild species in the AR varies greatly both between and within countries in terms of species used and the levels of reliance upon them. Such differences are influenced by ethnicity, gender and wealth (Hartter 2010). It is not only poorer people who rely on wildlife; people of all levels of wealth are known to collect forest products for subsistence purposes and/or to be sold to generate income (IUCN 2012). Reliance on wildlife may be higher in rural areas due to a lack of alternatives, but urban people are also important consumers and typically have higher disposable incomes to spend on wildlife-derived products than their rural counterparts. Biodiversity-based livelihoods may be especially important where there are no alternative means of obtaining nutrition or generating money, such as for refugees, the landless and women.

Freshwater fish are extremely important to people of the AR both as a source of protein and as a commodity to be sold for income (e.g. as food or, to a lesser extent, for the aquarium trade). This is perhaps unsurprising, given that the region is endowed with such large, species-rich water bodies. In much of the AR (Rwanda being a notable exception) fish are a popular food item, and many people rely on fish for their primary source of animal protein.

***Simochromis diagramma* is endemic to the Albertine Rift and is considered important to humans as a food source and in the pet trade. This species was found to be vulnerable to climate change under a pessimistic assumption of missing data.**
© R. Allgayer and A. Sapoli

Many wild **plant** species are of high importance to the region's human population for a variety of reasons. One of the most common use types is for **medicinal purposes**, and this can range from the treatment of minor ailments to the relief of symptoms of serious diseases such as malaria and HIV/AIDS. Though no figures were available for the AR specifically, it appears that a great many people rely on these 'traditional' medicines for their primary health care.

A great number of the region's people rely on wild plants for **fuel**, both for cooking and heating their homes, and for many people, particularly those in rural areas, there is no alternative fuel source. Some studies have indicated increases in the price of fuel wood, possibly as a result of declining supplies in the face of rising demand. Charcoal, which typically requires 10 tonnes of wood to make one tonne of charcoal, is more popular than wood in urban areas due to its ease of transport and because it produces more heat and less smoke (Mercer *et al.* 2011).

Food and **timber** are also both important products derived from wild plants. Wild plant-based foods can provide vital nutrients and vitamins that are missing from common staple crops such as maize (Frison *et al*. 2006). There is evidence that as more women in Africa undertake paid employment, there is a move away from indigenous foodstuffs towards 'convenience' foods such as easy-to-cook rice (Frison *et al*. 2006). This could mean a decline of knowledge regarding the potential uses of wild plants. This may have serious implications if conventional crop yields decline (e.g. as a result of climate change), and people are forced to seek alternative food sources potentially from the wild.

Mammals are mainly hunted for their meat which provides protein and generates income when sold. Although preferences are highly variable, wild mammal meat is generally preferred to domestic meat or fish, and those that can afford to be selective may opt for wild mammal meat even if it means paying more. If levels of wealth rise for people within the AR, this could have serious implications for mammal species already under heavy hunting pressure. A number of wild mammals were also found to be used for medicinal purposes, and some also contribute to incomes through sale for the pet trade. In addition to the consumptive use of mammals, the region holds some highly charismatic species such as gorillas and chimpanzees that generate large sums of money through ecotourism.

Birds do not appear to be as important for use as fish, plants or mammals, though they are often still hunted for their meat and may be important to people who are unable to hunt mammals. The high number of endemic bird species in the region attracts many birdwatchers, and an ecotourism industry catering for this purpose continues to grow.

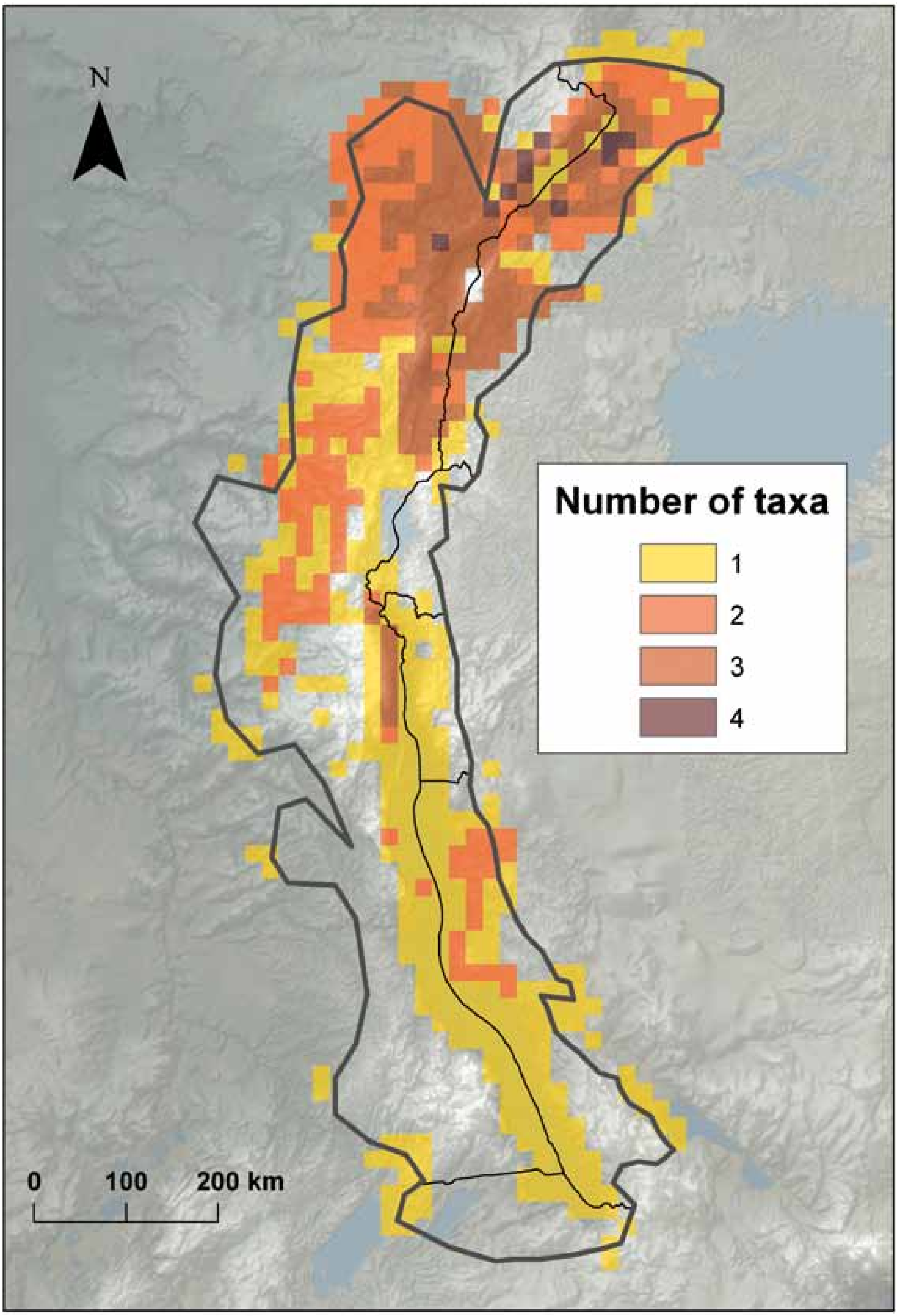
The use of **reptiles** and **amphibians** does not appear to be of great importance when compared with the other taxonomic groups, though some people may rely on the sale of skins or of live specimens for the pet trade to generate income. Sales of reptile skins, as well as certain species of edible fish, and a variety of species (across taxa) to the pet trade are some of the only examples of AR species that have a significant international trade value. There has been little, if any, work carried out to determine the contribution of the sale of wildlife for the pet trade to household incomes in the AR, but it is likely to benefit a select group of people.

Figure 9.1 shows regions where high numbers of wild species from multiple taxonomic groups, occur that are known to be important for use. This map suggests a general increase in the number of taxonomic groups present that contain species important for use as one moves northward through the AR. In the northernmost areas, and particularly in and around areas such as Virunga National Park, Queen Elizabeth National Park and the areas surrounding Lakes Albert, Edward and George, some of the highest of numbers of species from up to four (though more typically three) taxonomic groups are identified as important for use. Regions in the far northeast and far northwest are highlighted as having high numbers of species important for use from two taxa (mainly amphibians and mammals). More centrally in the Rift (i.e. areas west of Rwanda) numbers of species important for use are high for either one or two taxa – where one typically represents areas with a high number of amphibian species, and two representing the addition of high numbers of bird species. Below this, in the southern half of the Rift, most of the highlighted areas (i.e. most of Lake Tanganyika and odd areas on the periphery of the Rift boundary) contain high numbers of important for use species from only one group – fish. Exceptions to this include several small patches within Tanzania and (to a lesser extent) DRC where high numbers of important for use mammal species are present, and a small strip just west of Burundi that also contains high numbers of mammal and bird species that are important for use.

9.2 How does human use impact wild species of the AR?

The central area of the AR (Rwanda, Burundi and their borders with DRC, and the region of southern Uganda within the AR) has a particularly **high human population density** (Figure 1.4). We have previously described the substantial reliance of the region's peoples on wild species, and hence the impacts of use on biodiversity may be particularly marked in these areas. Continued high birth and

Figure 9.1 Overlap between areas of highest concentrations of *species important for human use* for amphibians, birds, freshwater fish and mammals. Colours represent the numbers of taxonomic groups for which the area or cell is identified as a priority. For each taxonomic group, high concentration areas represent cells containing the upper 25% (based on the cumulative distribution frequency) of the total numbers of species important for human use.



Charcoal production produces a valuable source of income for many households. However illegal production continues throughout the Albertine Rift and wider Africa, and many plant species are in decline as a result.
© Toon Defoer

immigration rates mean that in many areas of the AR, population densities look set to increase. This population growth is likely to result in growing demand for wild species. However, despite the importance of biodiversity to the people of the AR, it remains difficult to assess the impact of this reliance upon wild species because it is poorly documented.

Though there is evidence of the impact of human utilization on wild species, the studies that have assessed this have normally been carried out in several well-studied protected areas, meaning the impact across the AR as a whole (or at least the part which overlaps with a species' range), is largely unknown. Examples where direct overharvesting has been shown to negatively impact populations of some individual or groups of species include a reduction in mammal density of 13–42% in areas of Ituri, DRC that were subject to moderate/heavy hunting pressure compared with unhunted areas (Hart 2000 *in* Robinson and Bennett 2000). A survey of Kahuzi-Biéga National Park in 2008 found that hunting caused numbers of Grauer's Gorilla (*Gorilla beringei* ssp. *graueri*) to decline from 258 in the early 1990s to 168 in 2004, and that elephants in the lowland area of the park numbered 3,720 in 1994, but by 2000 they had disappeared (Amsini *et al.* 2008). In parts of Bwindi Impenetrable National Park, Handsome Francolin (*Francolinus nobilis*) have become locally extinct due to intense hunting for food (Ssemmanda and Fuller 2005). One cichlid species popular in international trade, the Blue-faced Duboisi (*Tropheus duboisi*), is listed on the IUCN Red List as Vulnerable due to heavy exploitation for the aquarium trade (Bigirimana 2006). More than 20% of the threatened freshwater fish species in eastern Africa are reported to be (or expected to be) impacted by the aquarium trade (Darwall *et al.* 2008). Although this figure is for eastern Africa in general, the AR is likely to be similarly impacted. In recent years, international demand for live wild bird species has declined due to the banning of trade to Europe and the United States, which were previously key markets for wild birds. This may have alleviated the pressure on wild populations harvested for the pet trade, though this could change as pet keeping becomes more popular in Asia.

As well as declines in species, entire ecosystems are impacted by humans. Forest cover appears to be declining. Rwanda, for example, experienced a 33% decline in natural forest cover between 1958 and 1996, and Parc National des Volcans reduced in size by nearly 50% due to government-approved schemes allowing the settlement of people and the growing of pyrethrum (Plumptre *et al*. 2004), which is sold internationally as an organic pesticide. However, it is difficult to determine how much of forest decline is caused by direct use compared with clearing for agriculture and grazing.

Information on the global status of species occurring in the AR is available from the IUCN Red List. Among all groups investigated for this study, amphibians have the highest proportion of species that are both important for use and considered threatened on the IUCN Red List (12%) (Table 9.1). However, compared with the other taxa, amphibians were not a highly utilized group. The proportion of species threatened and used from the taxa which appear to contribute the most to people's subsistence use and livelihoods (fish, plants and mammals) varied from 4–9%. The true percentage for plants may be much higher as this taxon includes many species assessed as Data Deficient. It is not possible to identify from Red List assessments the relative proportion of total threats to species arising from direct human utilization compared with those arising for other reasons (e.g. pollution, disease, invasive species etc.). Also, as the majority of the species found in the AR are not endemic to the region, global Red List assessments also incorporate threats faced by species at locations outside of the AR.

International trade for some species is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prevents commercial trade in species considered to be threatened with extinction

Table 9.1 Proportion of AR species that are important for use, globally threatened and/or included in the CITES Appendices.

Taxon	% of species important for use that are threatened (CR, EN, VU)	% of species important for use that are listed in the CITES Appendices (I,II,III)*
Amphibians	12	2
Birds	6	11
Fish	6	0
Mammals	9	35
Plant	4	1
Reptiles	2	32

* More species in the AR may be listed in the CITES Appendices but were not considered to be important for human use within this study.

and regulates trade in other species to ensure that trade does not threaten their survival. Not all species in international trade are regulated through CITES and not all listed species are in trade. Thirty-five percent of AR mammals identified as important for use are listed in the CITES Appendices (I, II, or III) (Table 9.1), a significant proportion of which are primates. In addition, nearly a third of all reptile species identified as important for use are listed in the CITES Appendices. However, that species are listed in the CITES Appendices may not be an indication that they are harvested and traded from areas within the AR. Therefore, using Red List assessments and CITES listings alone, it cannot be concluded how much of an impact human use may be having on wild populations in this region specifically.

In short, although information exists on the impacts of direct human use on species at a case study level (typically a protected area or forest) and at a global level, there is a dearth of evidence indicating impacts at the regional level. It would be unwise to extrapolate case study level data to the AR as a whole, or to generalize that threats facing the species at the global level must also be relevant to the AR.

The intensity of harvesting and the potentially negative implications of overharvesting are exacerbated by two key features of the AR, namely high levels of poverty and political instability. **Poverty** can influence the levels of use of wild species, as those with little or no land or money have fewer opportunities to purchase items, cultivate crops or obtain credit, and are therefore more likely to rely on wild resources. Poverty is extreme in parts of the AR; for example, the areas around Bwindi Impenetrable and Mgahinga Gorilla National Parks and Echuya Forest Reserve contain some of the poorest people in Uganda (35% of people around Echuya Forest Reserve live on less than USD1 per

Slums of Bukavu, DRC. Population densities are already extremely high in some areas of the Albertine Rift, and are expected to rise further. © Luis M. Tello

day (Ministry of Finance Report in Nature Uganda 2003). The farming and cattle rearing practices of those living near to Virungas National Park has been disrupted by the civil war, which has further exacerbated the problems of an area already facing a shortage of clean water, high levels of disease, poor education and little investment (Plumptre *et al*. 2004). The high number of refugees in the region may mean additional people relying on wild resources to survive. The more negative implications of site protection (e.g. a reduction in access to resources) are thought to affect the poorest people the most (Plumptre *et al*. 2004).

Both poverty and **political instability** may mean that more people are likely to be attracted to the freely available resources of forests and lakes, the use of which requires relatively little start up investment. There is evidence that some farmers, attracted by increased revenues available from the sale of fish, have migrated to Lake Victoria to begin fishing. This has led to an increase in the use of harmful fishing techniques such as use of monofilament fishing nets which are indiscriminate, non-biodegradable and have a large impact on fish stocks (Fulgencio 2009). The large lakes within the AR are likely to have been affected in a similar way. The region's political instability has consequences for both wild resource consumption and conservation. For example, Hill *et al.* (2002) commented that an observed increase in poaching at Parc National des Volcans in Rwanda after the civil war was most likely due to a combination of the loss of livestock during the war and a reduced ability of park staff to patrol for poachers. Similarly, within Kahuzi-Biéga National Park (DRC), arrests and confiscations of poaching equipment declined sharply from 2000–2002, which coincided with the occupation of two competing groups, the Congolese Rally for Democracy rebel army and the Mai-Mai militia in the upland sector of the park, making it dangerous for patrols to be carried out (Mubalama and Bashigg 2006).

An additional factor which may increase demand for wild-sourced AR species relates to changes in economic prosperity, both within AR countries and in **foreign consumer countries**. As nations become wealthier, more people can afford products derived from wild sources. This demand may be for existing traditional products or for new products, and may in part be driven by declines in wildlife populations in established source countries elsewhere in the world.

9.3 How might climate change impact species of the AR?

In previous chapters, we have identified a range of mechanisms through which climate change is likely to impact upon AR species, as well as a number of geographic areas within the region that contain high numbers and/or proportions of climate change vulnerable species. Although the particularities of these findings differ between taxonomic groups, there are also various similarities, which should be acknowledged.

In terms of Sensitivity to climatic changes, **habitat specialism** is a trait that emerges in many species across all taxa. Although these specialist requirements differ among species, and indeed broader taxonomic groupings, a number of key habitats appear particularly important and warrant specific mention. **Moist montane forest** is important for a number of specialist bird, mammal, reptile and plant species. **Moist lowland forest**, **moist shrubland** and **dry shrubland** were also highlighted as important for a number of specialist plant species. The potential effects of climatic changes on forest and shrubland ecosystems are described in the opening chapter of this document, and include increased mortality or productivity (associated with decreased and increased precipitation, respectively), changes to predator and pathogen communities, and changes in the frequency and/or intensity of naturally occurring fires – all of which could impact upon populations of the species occurring within.

Bushfire in Murchison Falls National Park Uganda. Many species possess traits that could make them sensitive to changes in fire regimes. © flöschen

Wetlands of all kinds, including the region's lakes, rivers, rivulets and ponds, support a variety of specialist species including fish, mammals and reptiles. For amphibians, swamp habitats are of particular importance. All of these habitats are subject to the variations in precipitation and/or snowmelt regimes, which can directly affect their hydrology, particularly flow rates and water levels. Mwingira *et al*.

(2012) have already shown reduced health and increased mortality in several wetland-dependent species, including hippopotamus and crocodiles, during extended periods of drought. In some cases this has also led to species moving closer to human settlements, where they have faced increased persecution. Wetlands may also experience increased **sedimentation**, particularly if extreme events such as storms and floods increase in intensity, and if the surrounding terrestrial environment has already been degraded or transformed. Such changes could be damaging to the biota of these environments, and particularly so to the diversity of fish species present.

African Dwarf Kingfisher (*Ceyx lecontei*) was found to be climate change vulnerable. This species is believed to be eaten by humans in the Albertine Rift.
© Hart Lukuru Foundation

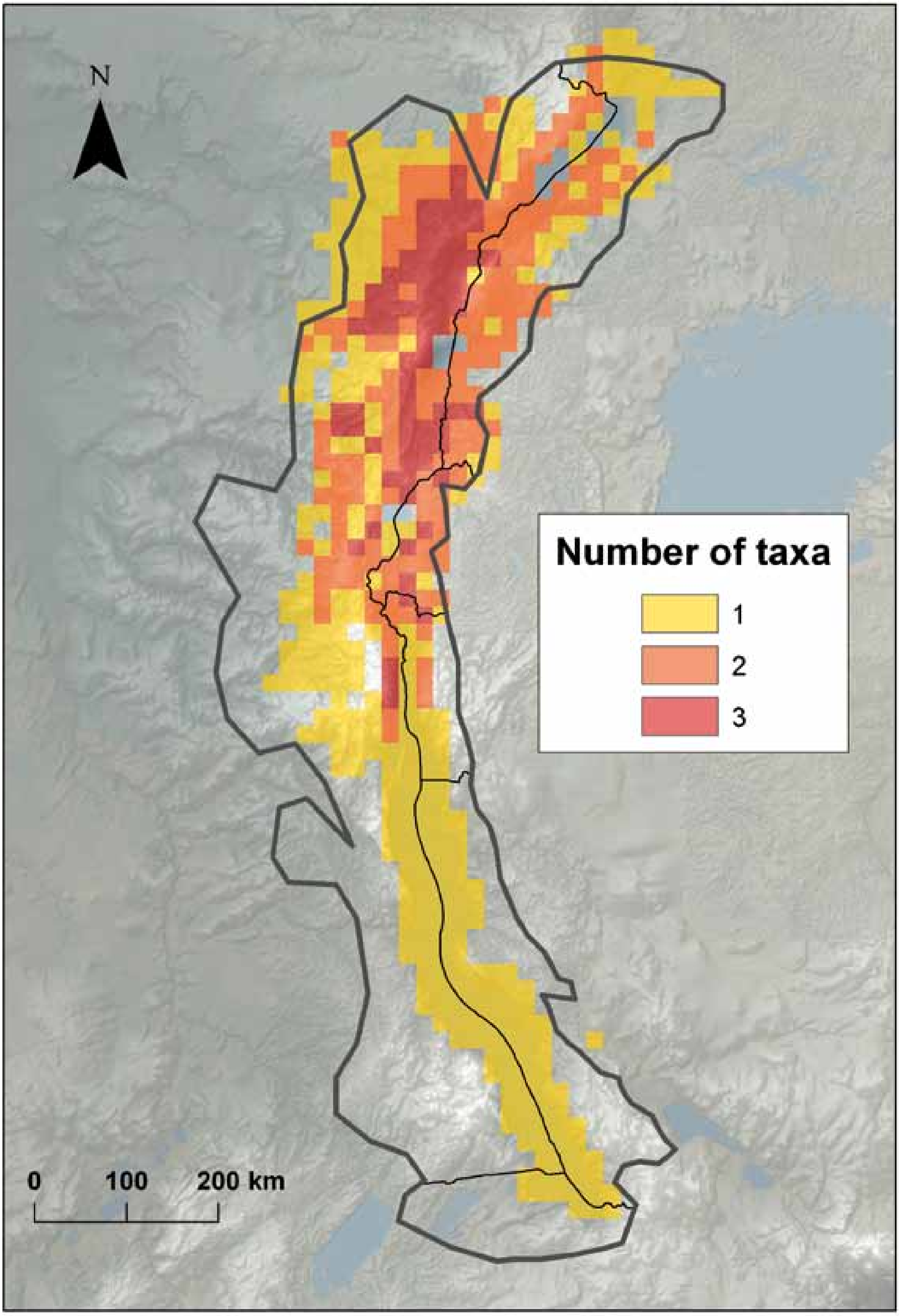
Beyond direct loss or degradation of their habitat, a number of species may experience a range of other climate change impacts. Amphibians and reptiles are anticipated to be particularly sensitive to disruption of climate-related **triggers** or cues for breeding and activity. A number of mammals, birds and, to a lesser extent, reptiles, could be impacted by loss of the small number of food species upon which they are dependent. Similarly, a significant number of the plant species investigated in this assessment are thought to be dependent upon a low number of pollinator species, potentially making them sensitive to changes in the wider environment. A number of bird species were recognized as already having **low population sizes**, putting them at risk from stochastic events which are expected to increase in both frequency and severity across the region. Similarly, changes in the frequency and/or severity of **natural fires** could impact upon a number of mammal and reptile species which are reliant upon specific fire regimes.

Limitations in adaptive capacities were identified for numerous species across all groups investigated. The most common cause was an obstruction to dispersal due to one or more **barriers**. As described earlier in this document, the highly fragmented nature of many of the AR's natural systems due to urbanization and agriculture makes natural species dispersal impossible in many cases. For several amphibian, mammal and plant species in particular, it was noted that little opportunity for upward migration exist as their distributions already occur at the limits of available **altitudinal gradients**. Some species, particularly of birds and plants, were noted for their **low intrinsic dispersal distances**, meaning that even where newly suitable areas become available, they will be unlikely to move fast enough to keep up with the rate of change in their location.

We also identified numerous species, across all taxa, which have one or more life history traits (typically **low reproductive outputs** and/or **long generation times**) that make them unlikely to be capable of accumulating adaptive genetic responses at a sufficient rate to counteract negative climate change impacts. This trait played a role in characterizing several bird, mammal and plant species as being of low adaptability. For many mammals (and likely for species of other groups, although this was not assessed) **poor connectivity of metapopulations** (likely due to the barriers described above) means that genetic exchange between these units (which could facilitate genetic adaptation *in-situ*) is limited.

For five of the six taxa investigated, we have identified locations that contain high numbers of climate change vulnerable species, and Figure 9.2 shows a combination of these data for four taxa (uncertainties in the distributions of many reptile and plant species meant that these two taxa were omitted). In the south of the AR, and in an area covering the majority of Lake Tanganyika (excluding the far north), only one taxon (fish) is highlighted as containing a large number of climate change vulnerable species. Further north, highlighted areas more typically contain high numbers of climate change vulnerable species from two or three taxa. Areas where three taxa are highlighted are predominantly found along the centre of the Rift (close to, or on, the DRC border) and include the area directly east of the Itombwe Massif, the area encompassing the southern extent of the Réserve naturelle des primates Kisimba Ikobo, Nyungwe National Park, the region surrounding Lake Kivu, and much of Virunga National Park.

Figure 9.2 Overlap between areas of highest numbers of *climate change vulnerable species* for amphibians, birds, freshwater fish and mammals. Colours represent the numbers of taxonomic groups for which the area or cell is identified as a priority. For each taxonomic group, high concentration areas represent cells containing the upper 25% (based on the cumulative distribution frequency) of the total numbers of climate change vulnerable species.



Our analysis of species vulnerability has investigated a variety of ways that a species may be directly affected by climate change, but we note that our approach does not explicitly cover the impacts of **human responses to climate change** on species. Such adaptive human responses may include changes in the type of wild resources used and the level of dependence, changes in land use (e.g. altered agricultural practices), migration to new areas and increased extraction of water, among others. Such aspects remain difficult to anticipate, but the information base available on the subject, though relatively new, is developing rapidly. We urge individuals and organizations developing or implementing climate change adaptation plans to consider the latest information on human responses to climate change in conjunction with the climate change vulnerability assessments presented here.

Finally for this section, it is important that we acknowledge the many unknowns within the datasets gathered for these assessments. **Areas of uncertainty** specific to each taxon are given in the preceding chapters, and we refer readers back to these sections for further detail. However, several key areas stand out as data gaps and warrant further mention. In particular, we found a poor knowledge of the general **biology of many of the region's freshwater fish**, and this resulted in a high variation between results based on our optimistic and pessimistic uses of unknown data values. Knowledge of the breeding capacity (related to 'evolvability') was particularly sparse and represents a key area for future research. It is important to be aware that a large number (286) of the region's freshwater fish species were assessed as being likely to be both highly Exposed and Sensitive to climatic changes – meaning that, should our assumptions about species' adaptive capacities prove incorrect, the situation for freshwater fish of the region may actually be worse than anticipated. Two further key areas of uncertainty relate to the **distributions of the region's reptile and plant species**. As discussed, these knowledge gaps have limited our ability to assess climate change exposure and sensitivity in particular and thus represent key areas for future research.

9.4 How might climate change interact with non-climatic threats to species of the AR?

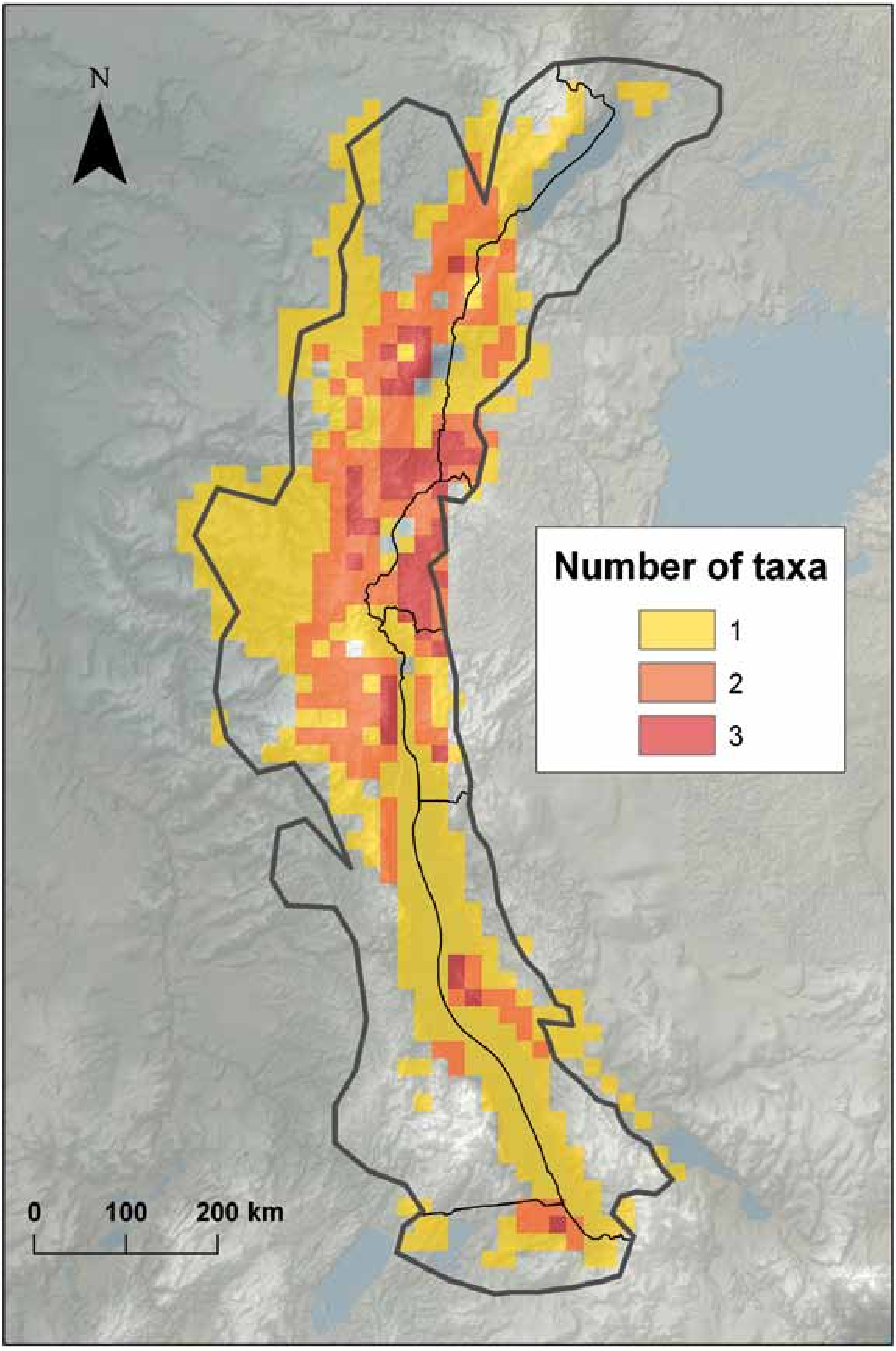
Through various projects, IUCN's Red List Unit and the Species Survival Commission have been able to evaluate the global extinction risk of many of the species found within the AR. For some groups (e.g. amphibians and birds) these assessments have covered all known species present. In other cases, such as for freshwater fish and mammals, the vast majority of AR species have been assessed in this way, although more recent taxonomic changes mean that there are a few 'new' species that are without assessments. For some groups, however, only a few of the total number of species present have been assessed; for example, only 26 (or 16%) of the 168 known reptile species present, and 24 (or 9%) of the 262 plant species considered in this assessment, have been considered in this way. Similarly, even within groups of species that have been assessed there are number which are considered Data Deficient, and the proportions of species that fall into this category can vary between taxa. For example, while only three of the 972 bird species (0.3%) are Data Deficient, this number is 22 (or 20% of 110 species) for amphibians.

Within each group, and of the total species assessed, the numbers and proportions of species considered globally threatened vary. For amphibians, birds, freshwater fish and mammals, 11%, 3%, 8% and 9% of species are considered threatened, respectively. For plants and reptiles, 50% and 8% of the species assessed are threatened, respectively, although these values do not necessarily represent random samples of the full suite of species present, and should not be interpreted in this way.

For four of the six taxa investigated (i.e. excluding plants and reptiles), we have identified locations that contain high numbers of threatened species. Figure 9.3 shows a combination of these data for the four groups. This image shows that, in the southern half of the AR, areas containing high numbers of threatened species are more or less congruous with Lake Tanganyika, and that in most cases this is representative of only one group (freshwater fish). Exceptions to this include a few small clusters of cells where high numbers of threatened birds and/or mammals are present.

In the northern half of the Rift, high numbers of threatened species from an increasing number of taxa appear to be present as one moves inward towards the centre of the Rift and its high mountainous areas. Broadly speaking, areas highlighted as containing high numbers of threatened species from only one taxon typically represent threatened bird species. Areas containing high numbers of

Figure 9.3 Overlap between areas of highest concentrations of *threatened species* (IUCN 2011) for amphibians, birds, freshwater fish and mammals. Colours represent the numbers of taxonomic groups for which the area or cell is identified as a priority. For each taxonomic group, high concentration areas represent cells containing the upper 25% (based on the cumulative distribution frequency) of the total numbers of threatened species.



threatened species from two taxa represent the addition of threatened mammal species, and areas with three groups represent the addition of threatened amphibians (which are highly localized (see Figure 3.2)). The northern half of the Rift contains no areas with particularly high numbers of freshwater fish, as the majority of these are concentrated in Lake Tanganyika.

We combined data on global threat status and climate change vulnerability for all groups considered, although, as mentioned briefly above, data on the threat status of plants and reptiles were incomplete and so should be interpreted with caution. For species recognized as both threatened with extinction and climate change vulnerable it will likely be desirable to give highest priority in terms of conservation attention and action. It is beyond the scope of this document to make prescriptive advice at the species level, particularly as the nature of the threats and the specifics of vulnerability can vary widely between species, even within a lower taxonomic grouping. Nevertheless, we urge all parties interested in the conservation of these species to refer to both the information gathered during the most recent Red List assessment (available at: http://www.iucnredlist.org/), and the specific components of the climate change vulnerability assessments gathered for this project.

Sapele (*Entandrophragma cylindricum*) is listed as Vulnerable on the IUCN Red List™ and was also found to be vulnerable to climate change. This species is used by humans for construction materials. © Xander van der Burgt / Royal Botanic Gardens, Kew

The numbers (and proportions) of species recognized as both globally threatened and climate change vulnerable vary between the taxonomic groups considered, and also between our optimistic/pessimistic assumptions of missing data values (Table 9.2), and range from 1% (freshwater fish, optimistic scenario) to 8% (amphibians, pessimistic scenario).

As well as presenting numbers of species recognized as both threatened with extinction and climate change vulnerable, we also identified, for each taxon, geographic areas containing high numbers of species recognized under either criterion (Figures 3.6c, 4.6c, 5.19c and 6.7c). Patterns differed between groups; for freshwater fish, Lake Tanganyika was identified as the area containing the greatest numbers, with few other regions highlighted. In contrast, all regions containing high numbers of climate change vulnerable and/or globally threatened amphibians, birds and/or mammals were located in the northern half of the Rift, and in particular, at locations close to the DRC border (i.e. along the central mountain chain). In the case of birds, areas identified as containg high numbers of both of these species types spanned broadly across the northern half of the Rift, whereas for

Table 9.2 Summary of numbers of species considered in this assessment, including numbers assessed for the Red List™, globally threatened, climate change vulnerable, and globally threatened *and* climate change vulnerable. For each species count using climate change vulnerability outputs, values are given for both optimistic and pessimistic assumptions of missing data values (see Methods, Section 2.2.1.3). Rows in grey font are groups for which comprehensive Red List™ assessments have not yet been conducted.

Taxon	Number of species considered	Number (%) assessed for the Red List™	Number (%) of threatened species	Number (%) of climate change vulnerable species (optimistic/pessimistic)	Number of climate change vulnerable *and* threatened species (optimistic/pessimistic)
Amphibians	**110**	**110** (100%)	**12** (11%)	**34** (31%) / **51** (46%)	**7** (6%) / **9** (8%)
Birds	**972**	**972** (100%)	**27** (3%)	**199** (20%) / **441** (45%)	**17** (2%) / **23** (2.5%)
Freshwater fish*	**551**	**536** (97%)	**42** (8%)	**31** (6%) / **316** (57%)	**7** (1%) / **20** (3.5%)
Mammals	**353**	**346** (98%)	**31** (9%)	**107** (30%) / **200** (57%)	**21** (6%) / **25** (7%)
Plants	**262**	**24** (9%)	**12** (50%)	**79** (39%) / **82** (40%)	-
Reptiles	**26**	**26** (15%)	**2** (8%)	**70** (42%) / **93** (55%)	-

* Includes both species and subspecies.

amphibians and mammals these where more localized. For amphibians, the highlighted areas included a small region within DRC close to the borders of Uganda and Rwanda, and an area directly above this, close to Lake Edward. For mammals, the highlighted areas included the far northern extent of Virunga National Park, an area spanning DRC and Uganda (and close to the Rwandan border), and the area surrounding Lake Kivu.

9.5 How might climate change impact species of importance for human use in the AR?

Through our assessments of human utilization and climate change vulnerability of AR species, we have been able to identify species important for use which may be at increased risk from this emerging threat. In combination with other information sources, this insight can be used to provide important guidance for those seeking to ensure that provision of the important services wild species provide is maintained. Both human utilization and climate change vulnerability differ between taxa and across the region. However, our understanding of the interactions between climate change's direct impacts and those arising from human responses to it are not well understood. Given this, we urge those using our findings to consider them as generalized guidance, to be interpreted in light of the details and specifics of the area or context that they wish to address.

Results from this study indicate that the taxon with the greatest proportion of species assessed as both important for use and vulnerable to climate change (using an optimistic scenario for missing data values) is reptiles (15%) (Table 9.3). However, generally reptiles were found to be a relatively unimportant taxon when compared with other groups. Between 7–10% of mammals, one of the most important taxa for human use, are climate change vulnerable and important for use. Freshwater fish are also a highly utilized group, which, under a pessimistic scenario of missing data, contains the highest proportion of species both used and climate change vulnerable (39%). The variation of proportions from 3% of freshwater fish under an optimistic scenario to 39% under a pessimistic scenario highlights a general lack of available information for many freshwater fish species. Under both scenarios, more than a third of plant species identified as important for use are also climate change vulnerable. However, this figure should not be directly compared with the other taxa as this only represents a subset of 93 plant species present in the AR that are known to be used.

Throughout this report, individual species that are both important for use and vulnerable to climate change have been identified. However, it is useful to also identify higher taxonomic groupings, which are used for similar purposes by humans and are vulnerable to climate change. For example, all six of the monkeys in the genus *Cercopithecus* present are used by humans in a variety of ways including as food, for wearing apparel and for medicine. Four of these six are also vulnerable to climate change, increasing to all six under a pessimistic scenario. Of the seven species of duiker (genera: *Cephalophus*, *Philantomba* and *Sylvicapra*) present, all are hunted, mainly for their meat but also for sport and for wearing apparel. One of these species was assessed as climate change vulnerable using our optimistic approach, and this rose to three when unknown data values were treated pessimistically. In total, four mammals were identified as being important for use, climate change vulnerable and globally threatened: Owl-faced Monkey (*Cercopithecus hamlyni*), L'hoest's Monkey (*C. lhoesti*), Eastern Gorilla (*Gorilla beringei*) and Hippopotamus (*Hippopotamus amphibious*). All of these species are used by people as food, and Hippopotamus in particular was cited as being highly popular for its meat (Olupot *et al*. 2009a).

Table 9.3 Summary of numbers of species both climate change vulnerable and important for human use. For each species count using climate change vulnerability outputs, values are given for both optimistic and pessimistic assumptions of missing data values (see Methods, Section 2.2.1.3).

Taxon	Number of species considered	Number of climate change vulnerable *and* used species (optimistic)	Number of climate change vulnerable *and* used species (pessimistic)
Amphibians	110	14 (13%)	20 (18%)
Birds	972	17 (2%)	37 (4%)
Freshwater fish*	551	19 (3%)	215 (39%)
Mammals	353	24 (7%)	35 (10%)
Plants°	93	33 (36%)	34 (37%)
Reptiles	168	25 (15%)	29 (17%

* Includes both species and subspecies.
° All 93 species were important for use (see section 7.4).

Of the four species of hardwood tree in the genus *Entandrophragma* (all used for construction materials and fuel, amongst other uses), all are climate change vulnerable under an optimistic scenario. Similarly, all three species of *Celtis*, which are used for fuel, medicine and construction materials, are climate change vulnerable. However, of the four *Albizia* species, all used for construction materials, medicine and other household items, none are climate change vulnerable under either scenario. Twenty-four species that are used for fuel were assessed as not being climate change vulnerable, and depending upon other threats they may be facing, may potentially offer a sustainable supply of fuel. Two plant species were identified as being important for use, climate change vulnerable and globally threatened, however, it must be remembered that only a very small number of plant species have been assessed for IUCN's Red List overall.

Eight species of Francolin and Guineafowl (genera: *Agelastes*, *Francolinus*, *Guttera* and *Numida*) are hunted for their meat, and whilst no species were found to be climate change vulnerable under an optimistic assumption of missing data values, six were vulnerable under a pessimistic scenario. Four bird species, Shoebill (*Balaeniceps rex*), Grey Crowned-crane (*Balearica regulorum*), Shelley's Crimson-wing (*Cryptospiza Shelleyi*) and African Green Broadbill (*Pseudocalyptomena graueri*), were assessed as important for use, vulnerable to climate change and globally threatened. Grey Crowned-crane is used for several purposes: as well as being killed for meat, its eggs are taken to be eaten by humans or to be sold to tourists, its feathers are used as decoration and other parts are used for medicinal purposes (Olupot *et al*, 2009b), whilst Shoebill is internationally valued in the tourism industry and often traded to zoos.

It is difficult to discuss the species of fish that are both important for use and climate change vulnerable, due to the uncertainty surrounding the impacts of climate change on this group. For example, of the 13 species in the genus *Haplochromis* used for human food, none of them were assessed as climate change vulnerable under an optimistic assumption of missing data values, whilst all were assessed as vulnerable under a pessimistic scenario. Similarly, of the 11 species of tilapia (genera: *Oreochromis*, *Sarotherodon* and *Tilapia*) identified as important for use (either as food and/or for sale in the aquarium trade), numbers of climate change vulnerable species ranged from zero to five under our optimistic and pessimistic uses of missing data values, respectively. However, of the species that form the major fisheries of the lakes (Tanganyika Lates (*Lates angustifrons*), Big-eye Lates (*L. mariae*), Forktail Lates (*L. microlepis)* Sleek Lates (*L. stappersii*) Nile Perch (*L. niloticus*) Nile Tilapia (*Oreochromis niloticus* ssp. *eduardianus*) Sudan Catfish (*Bagrus docmak*) and Nurse Tetra (*Brycinus nurse*)), none were assessed as climate change vulnerable under either scenario, except Nurse Tetra which is considered vulnerable under the pessimistic scenario.

A total of five freshwater fish species were assessed as important for use, climate change vulnerable (optimistic scenario) and globally threatened, and this increased to 12 under a pessimistic assumption of missing data values. All 12 of these species are used for food and/or sold for the aquarium trade.

Of the five species of *Xenopus* amphibians present in the AR (which includes some of the few amphibian species identified as used for human food, as well as being used in the pet trade), three are vulnerable to climate change. Twenty species in the genus *Hyperolius* are important for use in the pet trade and, of these, six were assessed as vulnerable to climate change under an optimistic assumption for missing data values and nine are under a pessimistic scenario. Five amphibian species are recognized as being important for use, vulnerable to climate change and globally threatened, rising to six species under a pessimistic assumption of missing data values.

All three species of crocodile within the AR (Slender-snouted Crocodile (*Crocodylus cataphractus*), Nile Crocodile (*Crocodylus niloticus*) and Dwarf Crocodile (*Osteolaemus tetraspis*)) are important both locally and internationally for their skins which are made into wearing apparel, and are also hunted for their meat and occasionally captured for the pet trade. Two of these species are climate change vulnerable under an optimistic assumption of missing data values. Of the six species of chameleons which are traded internationally as pets, four were assessed as climate change vulnerable when considering missing data values optimistically. Only one reptile species was assessed as important for use, climate change vulnerable and globally threatened, though it is important to note that only a small number of reptiles have been assessed for the IUCN Red List.

From the results of this study it has been possible to identify geographic areas that contain high numbers of species that are climate change vulnerable and/or important for use. It is useful to determine if these areas overlap with areas of high human population density, as this could mean that the pressure on biodiversity from human use may be especially great. However, further research is necessary to determine actual levels of reliance in such areas. We have identified Lake Tanganyika as

Johnston's Chameleon (*Chamaeleo johnstoni*) is endemic to the Albertine Rift and is considered to be important in the pet trade. © Paul Freed

containing the greatest numbers of fish species important for use, while simultaneously holding the highest numbers of climate change vulnerable species, making it a hotspot of potential decline in availability of this essential food source. We note too that the region at the northern tip of the lake has a particularly high human population density. Bujumbura alone, for example, was estimated to contain ~455,000 people in 2009 (UN Data 2012). Aquaculture seems to contribute only a minor amount to the Burundi's fisheries at present. A potential future lack of protein is of concern as data from 2008 suggested that 62% of Burundi's population were undernourished, the highest proportion of all the AR countries apart from DRC, where no figures are available (World dataBank 2012). Although relatively few fish species known to be important for food were assessed as being climate change vulnerable under an optimistic scenario, it is important to once again acknowledge the high uncertainty surrounding the species-specific impacts of climate change on fish species.

High densities of **mammal** species that are important for use and/or are climate change vulnerable occur along the DRC-Uganda border, south of Lake Albert. Human population density is not especially high here compared with other parts of the AR, mainly due to the presence of large protected areas, though there are some densely populated areas such as around Fort Portal (Uganda) and in the area between Virunga National Park and Rwenzori Mountains National Park. There is also a high density of used, climate change vulnerable species in the area surrounding the intersection of the Burundi, DRC and Rwandan borders, which does have a high human population density.

There is a large region in the northern and central part of the AR with a high density of **bird** species that were assessed as climate change vulnerable and/or important for use, particularly in the area west of Lake Albert, and to the south of the lake along the DRC-Uganda border. Human density is generally relatively low here, as it is in much of the DRC compared with other AR countries, and there is relatively high mammal species richness in this part of the AR (see Figure 6.1). Our study has found evidence that, in general, most bird species are not actively targeted for hunting, and are more likely to be caught opportunistically, or by older men and children who cannot hunt larger mammals. It is therefore probable that people in this area rely more on meat from mammals and fish from Lake Albert, than on birds. Human population density is high around Bukavu and Walungu (close to the Rwandan and Burundian borders, respectively), an area with a high density of used and/or climate change vulnerable bird species, as well as relatively high mammal species richness.

The presence of high numbers of people in areas with high proportions of climate change vulnerable **plant** species is not discussed here due to a lack of reliable data (see caveats), nor are **amphibians** or **reptiles** which do not appear to be especially important for use for most people when compared with the other taxa.

9.6 Recommendations

People of the AR rely heavily on natural resources, yet we have found that many of the species of importance for human use are also climate change vulnerable and/or threatened with extinction. Since climate change is likely to lead to even greater reliance on wild species of the AR, it is essential that interventions for both human development and biodiversity conservation are promptly prepared and implemented. Below we present a non-exhaustive list of possible approaches that we believe will help to promote sustainable use of wild species, enhance their potential to adapt to climate change impacts and thereby continue to provide essential services for the people of the AR.

1. Maximize the ability of biodiversity to adapt to climate change:

Our study identifies AR species that are highly vulnerable overall, potential adapters, potential persisters and those of high latent risk (Figure 2.3). These categorizations are useful, firstly, for helping to identify the species for which conservation resources should be prioritized, and secondly, for broadly categorizing species according to the types of conservation interventions that are likely to be most effective in helping them to adapt to climate change. We once again reiterate the important caveats to interpreting the results of our climate change vulnerability assessments (Section 2.5), particularly that scores are relative within each group assessed and cannot, therefore, be compared between groups.

We provide below a list of potential adaption strategies that are likely to be useful for assisting species-level climate change adaptation for each climate change vulnerability group. From the assessment lists associated with each results chapter, the vulnerability type of each of the 2,358 species assessed is apparent and can be cross-referenced with these recommendations to identify appropriate conservation approaches. We note however, that these recommendations are broad-scale and that species' particular circumstances and risks must be considered before management plans are implemented. We elaborate on specific approaches to reducing pressures from harvesting by humans in the following 'Enhance sustainability of the use of wild species in the AR' section.

A number of adaptation options may also be effective at ecosystem, national and/or regional scales. In Table 9.5, we present a summary of potential climate change adaptation strategies, as collated by Mawdsley *et al.* (2009). While these measures are valuable for the region as a whole, we particularly urge their application in the regions highlighted in Figures 3.6a, 4.6a, 5.19a and 6.7a, which have been identified as containing highest numbers of climate change vulnerable and threatened species across a range of taxonomic groups. At broadest levels, we recommend

Table 9.4 Categories of climate change vulnerability (see Figure 2.3) and some of the species-specific conservation interventions appropriate for minimizing extinction risk.

1. Highly vulnerable species	• Carry out specific research to confirm assessments and mechanisms of climate change impact • Reduce pressures from other threats • Potentially: – Translocate to newly suitable areas – Establish captive populations or seed banks to supplement wild populations and safeguard genetic resources
2. Potential adapters	• Monitor to ensure that species are adapting as predicted • Ensure that migration corridors and routes remain unobstructed • Reduce pressures from other threats
3. Potential persisters	• Monitor to ensure that species are persisting *in situ* as predicted • Reduce pressures from other threats
4. High latent risk	• Monitor to ensure that assumptions of low climatic change are correct

Table 9.5 Examples of landscape-scale strategies available for adapting to climate change (adapted from Mawdsley *et al.* (2009)).

Climate change adaptation category	Example strategies
Management/ protection of land/water	• Increase extent of protected areas • Improve representation and replication within protected area networks • Manage/restore existing protected areas to facilitate resilience • Design new natural areas and restoration sites to maximize resilience • Protect movement corridors, stepping stones and refugia • Manage and restore ecosystem function rather than focusing on specific components (species or assemblages) • Improve the matrix by increasing landscape permeability to species movement
Monitoring and planning	• Evaluate and enhance monitoring programmes for wildlife and ecosystems • Incorporate predicted climate change impacts into species and land management plans, programmes and activities • Develop dynamic landscape conservation plans • Ensure wildlife and biodiversity needs are considered as part of the broader societal adaptation process
Law and policy	• Review and modify existing laws, regulations, and policies regarding wildlife and natural resource management

adherence, where possible, to the key principles of Climate-Smart conservation (see Box 9.1) , developed by conservation experts from a range of US agencies and non-profit organizations (National Wildlife Federation 2011).

When applying these proposed adaptation strategies, particularly in high human density areas such as parts of the AR, it is essential to consider that humans too will be responding to climate change. Responses such as migration, changes in land and resource use, and infrastructure development (e.g. dams) are likely to play a defining role in whether conservation strategies will be successful. In particular, when considering actions such as expanding protected area networks and protecting species movement corridors, stepping stones and refugia, care should be taken to select areas least impacted by projected *future* as well as current pressures.

Finally, as the field of climate change vulnerability assessment advances, conservation and human development practitioners are likely to be increasingly presented with multiple vulnerability assessments of the same species. We are aware that this is already the case for many of the region's birds and amphibians, which have been assessed using species distribution model approaches by researchers from BirdLife International working with Durham University, and University of Copenhagen respectively. While interpreting multiple predictions (which may present different conclusions) is challenging, it highlights the uncertainty inherent in *all* climate change vulnerability assessment approaches. Approaches to integrate the results of multiple approaches are in development (e.g. Willis *et al.* in prep.), but at present we recommend conservative interpretation of all results and the use of 'no regrets' strategies, which aim to enhance species' capacity to adapt without reducing options for alternative strategies should species respond in unanticipated ways.

The uncertainties discussed throughout this study underline the need for new and continued efforts to monitor species' responses to climate change. **In conjunction with the establishment of baseline datasets with which to compare the coming changes, such monitoring is imperative for understanding mechanisms of climate change impacts, testing and improving vulnerability assessments and, hence, for the development of sound climate change adaptation strategies.**

2. Enhance sustainability of the use of wild species in the AR:

Our results highlight species that are likely to decline in relative abundance and hence in their availability for human use in the future due to climate change. They broadly indicate the geographical regions at greatest risk of losing the important provisioning ecosystem services wild species provide. While more detailed studies of the specific impacts of resource decline on human communities of the AR are needed, our results are valuable for prioritizing areas requiring further study, and can be used to guide those developing strategies to ensure sustainability of human livelihoods under climate change.

Below, we list a range of recommendations for reducing harvesting pressures on climate change vulnerable AR species, whilst accommodating the vital role(s) that their use may play in helping people to adapt to climate change in this region. These recommendations include activities that are directly associated with climate change, as well as more generic approaches to reducing this potential threat:

- Attempting to ascertain the level to which people rely on wild resources for this report was made difficult by the lack of studies that have been carried out in recent years in much of the AR. Therefore, we recommend further research to determine the extent of human utilization of all taxa across the AR, and the resulting impacts upon wild populations.
- We recommend an increase in efforts to raise awareness of, and enforce laws surrounding, the legality of hunting or harvesting wild species.
- Use of climate change vulnerable species should ideally be substituted with more resilient species, where available. We recognize, however, that this is a viable suggestion only for species that are selectively harvested (e.g. medicinal or timber plants) and where alternative species are available and acceptable, and that changing harvester's behaviour requires significant intervention. Great care is also needed in selecting 'substitute' species since it is important that populations can sustain additional levels of use, and that the substitute species does not become threatened by additional use.

Box 9.1 Summary of the key characteristics of Climate-Smart conservation, developed by experts convened by the National Wildlife Federation (2011).

1. **Actions Linked to Climate Impacts**
   Conservation strategies and actions are designed specifically to address the impact of climate change in concert with existing threats; actions are supported by an explicit scientific rationale.

2. **Forward-Looking Goals**
   Conservation goals focus on future, rather than past, climatic and ecological conditions; strategies take a long view (decades to centuries) but account for near-term conservation challenges and needed transition strategies.

3. **Broader Landscape Context**
   On-the-ground actions are designed in the context of broader geographic scales to account for likely shifts in species distributions, to sustain ecological processes, and to promote collaboration.

4. **Robust in an Uncertain Future**
   Strategies and actions provide benefit across a range of possible future conditions to account for uncertainties in future climatic conditions, and in ecological and human responses to climate shifts.

5. **Agile and Informed Management**
   Conservation planning and resource management is capable of continuous learning and dynamic adjustment to accommodate uncertainty, take advantage of new knowledge, and cope with rapid shifts in climatic, ecological, and socio-economic conditions.

6. **Minimizes Carbon Footprint**
   Strategies and projects minimize energy use and greenhouse gas emissions, and sustain the natural ability of ecosystems to cycle and sequester carbon and other greenhouse gases.

7. **Climate Influence on Project Success**
   Considers how foreseeable climate impacts may compromise project success; generally avoids investing in efforts likely to be undermined by climate-related changes unless part of an intentional strategy.

8. **Safeguards People and Wildlife**
   Strategies and actions enhance the capacity of ecosystems to protect human communities from climate change impacts in ways that also sustain and benefit fish, wildlife, and plants.

9. **Avoids Maladaptation**
   Actions taken to address climate change impacts on human communities or natural systems do not exacerbate other climate-related vulnerabilities or undermine conservation goals and broader ecosystem sustainability.

Fishing boats by the shore of Lake Tanganyika, Rimbo, Burundi. © R. Allgayer and A. Sapoli

- Harvesting of plants for fuel is significant within the AR, and increasing human populations and urbanization are likely to elevate demand further, particularly for charcoal. We recommend investigating the potential of responsibly creating community-based fuel wood plantations of non-climate change vulnerable native and non-invasive exotic plant species as a way to supply fuel wood. Creation of plantations must, however, be carefully considered and the location, size and choice of species designed in such a way as to avoid negatively impacting biodiversity or people. In this respect we suggest that such a programme should be framed within the context of landscape restoration, of which there is a growing body of experience in AR, notably in Rwanda and Uganda. Landscape restoration will avoid conventional risks associated with plantations such as the creation of single-aged, single species stands. Successful programmes would need to be able to offer a practical economic alternative to rural communities, underpinned with clear ownership rights, and be supported by a workable market network to supply urban populations with cultivated wood that is cheaper and more accessible than wild collected wood. We note that the establishment of a viable fuel wood production base that is capable of supplying a significant amount of people with wood requires significant investment and must operate over large time scales, and thus would likely need the assistance of governments and up-front public sector finance and/or assistance from the private sector or NGOs in becoming established. In some local situations it may be more appropriate to ensure fuelwood needs are met in other ways, including multi-purpose on farm plantings and the establishment of home and community gardens, establishment of mixed agroforestry systems and enrichment planting. Additional benefits, particularly if the wood fuel plantations are established using a landscape approach, may include additional economically important co-benefits such as non-timber forest products, erosion prevention and slope stabilization, carbon storage, reduced emissions from deforestation and potential habitat creation depending on the mixture of species selected.
- Programmes focusing on reducing overall consumption of fuel should be promoted. This could include introducing more fuel efficient household stoves, introducing more efficient kilns for charcoal producers, and the use of alternative cooking technologies.
- Domestication of threatened and climate change vulnerable medicinal plants should be investigated and carried out where feasible, in order to reduce pressures on wild populations. For example, a recent project in Burundi saw a traditional medicine centre given permission to collect threatened medicinal plants, domesticate them and distribute them to over 1,000 households (IUCN 2012). Red Stinkwood (*Prunus africana*) may be particularly worth exploring, as it was assessed as having low climate change vulnerability, has a high international value, and is used to treat the symptoms of serious diseases such as malaria and HIV/AIDS, along with having many other use types. It has been cultivated in Cameroon with some success (Cunningham *et al.* 2002), though it is only likely to be viable if a farmer deems it to be more profitable to cultivate the tree than to collect it from the wild, both in terms of money and effort, and factoring in the long rotation period for harvesting.
- Crop breeding for improved tolerances to factors such as drought and extreme temperature is increasingly being undertaken (Hajjar and Hodgkin 2007). Crossing of crops with wild relatives that are more resilient to the extreme climatic variations predicted also offers potential advances and it is therefore clearly important that crop wild relatives and traditional varieties of plants are conserved as they are currently under-represented within gene-banks and under-researched for use (Lane and Jarvis 2007).
- In order to ensure a sustainable supply of fish, we suggest increasing efforts to ensure protection of important wetland habitats and the species within them. This would likely entail increased efforts to enforce current fishing regulations, as well as active management of wetland habitats themselves including nearby habitats (e.g. forests) which are known to influence hydrology and other aspects of wetland habitat quality. The identification and protection of nursery grounds from threats including impacts from climate change (e.g. increased sedimentation) could be considered as a means to ensure a future supply of sustainable fish.
- Ideally, more selective species-specific fishing measures would be adopted, which reduce catches of threatened and climate change vulnerable species. However, this is not likely to be practicable. General measures to encourage sustainable fishing practices, such as using larger mesh sizes to reduce the number of juveniles of multiple species being caught, would be easier to implement. Altering fishing practices in the region is, however, a challenging task, requiring much external input (e.g. from central and local governments, NGOs etc.), and potentially involving provision of new fishing equipment and various educational activities. Nevertheless, we regard these as high priorities for the sustainable use and continued persistence of AR fish diversity.

Hyperolius leucotaenius **is an Albertine Rift endemic and is considered important in the pet trade. This species was assessed as vulnerable to climate change, and is currently listed as Endangered on IUCN's Red List™.** © Eli Greenbaum

- If people are consuming wild meat for protein due to a lack of accessible and affordable alternatives, it would seem logical that increasing access to domestically-reared meat (e.g. cattle, poultry etc.) would decrease the demand for wild meat. Indeed, there is some evidence to suggest that people with better access to livestock consume less wild meat (e.g. Olupot et al. 2009a), but conversely, there are also studies to indicate that in areas where there is still relatively abundant wildlife, it is cheaper and requires less effort for people to hunt or buy wild meat (e.g. Ndibalema and Songorwa 2008). Potential disadvantages to introducing livestock include the risk of introducing diseases, degradation of forest through grazing (van Vliet 2011), and low productivity of livestock farming due to diseases such as trypanosomiasis from Tsetse flies, which are present in many parts of the AR, particularly in the DRC (Wint and Rogers 2000). Furthermore, because of the ease with which livestock can be stolen or killed, particularly during times of war and instability, investing in livestock is a high risk strategy (Bennett and Rao 2002). Finally, it is recognized that there are a variety of factors influencing preferences for wild vs. domestic meat; and it is also likely that these factors will vary widely both within and between countries.
- Although not investigated in this study, various invertebrate groups could (and in some cases already) serve as alternative sources of food. We recommend further investigation of this as a possible additional means to provide protein to an ever increasing human population.
- Farming or domestication of native wildlife is another possible means of providing an alternative to harvesting wild individuals, and has been attempted with some success in western and central Africa, particularly with species of cane rats, bush pigs and brush-tailed porcupine (Wilkie and Carpenter 1999; Jori and Chardonnet 2001; Mensah and Okeyo 2005). Bird species such as Guineafowl may be particularly appropriate due to the ease of raising them domestically and the popularity of their meat. This type of production of small vertebrates can be beneficial as species bred are often native to the region (therefore appropriate food is available) and their size makes them suitable for urban households, requires less effort and can be carried out by women (van Vliet 2011). Domesticating species also means productivity can be increased above that of wild populations (Bennett and Rao 2002), though this could take many generations. However, farming of this type does risk the spread of zoonotic diseases, genetic mixing with wild populations, increasing demand for wild-sourced food items and reliance on wild caught individuals for breeding stock (van Vliet 2011). As with livestock farming, wildlife farming is only viable if it requires less effort and is cheaper than hunting or buying wild meat, or if hunting involves significant penalties if caught (Mockrin *et al*. 2005). Increased rearing of livestock should only be considered where sufficient grazing space is available, and we do not advocate further encroachment into natural habitats for this purpose.

3. Review and adapt regulations, laws and agreements:

- As species shift their ranges due to climate change, they may cross borders into new countries, regions and/or protected areas. While such species may previously have been regarded as invasive aliens, in the newly emerging context of climate change, such migrations should be regarded as adaptive responses and potentially welcomed. Laws and policies typically define invasive species as those occurring outside of their historical ranges, so amendments and updates may be needed. These must be must, however, be made in the complicated context that 'truly' invasive species pose a serious threat to biodiversity in the AR, and control of such species should not cease.
- The shifts in migration routes and distances apparent in some species may result in new or altered trans-boundary migration, necessitating new or altered agreements under the Convention on Migratory Species.
- As a community of forest-rich developing countries, the AR region has already been recognized as a hub of excellent potential for receiving payment for Reduced Emissions from Deforestation and

Degradation (REDD+). The Cancun agreement recognizes that implementation of REDD+ must safeguard natural forests and the ecosystem services they deliver and enhance their social and environmental benefits (Appendix 1 Decision1.CP.16). It has therefore been proposed that during the selection of areas for REDD+ implementation, gains in both forest carbon and biodiversity should be optimized (Gardner et al 2011). When assessing biodiversity conservation priorities, we propose that climate change vulnerability should be considered, along with species richness and Red List status.

- For CITES-listed AR species (i.e. those for which international trade is of concern) that have now been identified as climate change vulnerable and hence are known to be facing multiple pressures from harvesting, climate change, and possibly other threats, monitoring of populations should inform the making of non-detriment findings, a process which aims to ensure exports are not detrimental to the survival of the species.

Forests in Bwindi Impenetrable National Park, Uganda. ©Martijn Munneke

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Appendices – Species Summary Tables

The following six tables (A1–A6) provide a breakdown of all species-level data gathered as part of this project, including regional endemism, Red List categories and criteria, climate change vulnerability and human use. They are intended to be used as a reference for those seeking information on one or more individual species. The numeric codes used to indicate the individual climate change vulnerability traits can be found under each of the corresponding taxonomic chapters, as indicated in the legend of each of the following tables. Codes used to describe the various use types can be interpreted as follows: **CM** = Construction structural materials; **E** = Ecotourism; **F** = Fibre; **FA** = Animal food; **FH** = human food; **FU** = Fuels; **HJ** = Handicrafts jewellery etc; **MH** = Medicine (human); **O** = Other; **OC** = Other chemicals; **OH** = Other household goods; **P** = Poison; **PD** = Pets/display/ horticulture; **SH** = Sport hunting/specimen collection; **U** = Unknown; **WA** = Wearing apparel/accessories.

Table A1. All amphibian species considered in this assessment including Red List categories and criteria (IUCN 2011), climate change vulnerability (P = vulnerable under a pessimistic assumption of missing data values) including individual climate change vulnerability traits (please refer to Tables 3.2, 3.3 and 3.4 for trait descriptions; asterisks denote 'Very High' scores for the traits indicated), importance for human use and use types (please see key at the beginning of these appendices).

Species	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Acanthixalus spinosus		LC	YES	3	5,11	3		
Afrixalus fulvovittatus		LC	YES	3	5,10,11	3	YES	PD
Afrixalus laevis		LC			5,10,11	3	YES	PD
Afrixalus leucostictus		LC	YES	1*,2*,3*	2,4,5,10,11	3	YES	PD
Afrixalus orophilus	YES	VU (B1ab(iii))	YES	4	4,10,11	1,3	YES	PD
Afrixalus osorioi		LC	YES	4	10,11	3	YES	PD
Afrixalus wittei		LC			10,11	3	YES	PD
Amietia angolensis		LC			8,12			
Amietia desaegeri	YES	DD	YES	2*,3*	4*,7,8,12	1		
Amietia ruwenzorica		DD	YES	1,2*	4,7,8,12	1		
Amietophrynus camerunensis		LC			5			
Amietophrynus funereus		LC						
Amietophrynus gutturalis		LC		3			YES	PD
Amietophrynus kisoloensis		LC	YES	2*,3*	10	1		
Amietophrynus maculatus		LC						
Amietophrynus regularis		LC		1			YES	PD
Amietophrynus superciliaris		LC			5*		YES	MH;PD
Amietophrynus vittatus		DD	P	2	4*			
Arthroleptis adolfifriederici		LC	YES	4	1,11	1,3		
Arthroleptis hematogaster	YES	DD	P	2,4*	1,11			
Arthroleptis lameerei		LC	YES	1,2	11	3		
Arthroleptis pyrrhoscelis	YES	NT	YES	4	1,2*,11	3		
Arthroleptis schubotzi		LC	YES	4	4,11	3		
Arthroleptis spinalis	YES	DD	YES	1*,2*,3*,4*	1,5*,11	1		
Arthroleptis stenodactylus		LC			11	3		
Arthroleptis sylvaticus		LC	YES	3	1,5,11	3		
Arthroleptis tuberosus		DD	P	3	5,11			
Arthroleptis variabilis		LC			11	3		
Arthroleptis vercammeni	YES	DD	P	1*,2*	1,5*,11			
Arthroleptis xenochirus		LC			11	3		
Arthroleptis xenodactyloides		LC			11	3		
Boulengerula fischeri	YES	DD	YES	4*	1,3,4,5*,11	1		
Callixalus pictus	YES	VU (B1ab(iii))	P	2,4*	1		YES	PD
Cardioglossa cyaneospila	YES	DD	P	4	11			

Table A1. Amphibians, continued.

Species	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Cardioglossa escalerae		LC	YES	1,3	5*,11	3		
Cardioglossa leucomystax		LC			11	3		
Chiromantis rufescens		LC			6		YES	PD
Chrysobatrachus cupreonitens	YES	DD	P	1*,2*	1,11			
Hemisus guineensis		LC			11			
Hemisus marmoratus		LC		1	11		YES	PD
Hemisus olivaceus		LC		1,3*	4,5*,11			
Hoplobatrachus occipitalis		LC		1	8,11		YES	FH
Hylarana albolabris		LC			8,9,11			
Hymenochirus boettgeri		LC			2,5*		YES	PD
Hyperolius atrigularis	YES	DD			10,11	1	YES	PD
Hyperolius castaneus	YES	VU (B1ab(iii))		2,4	10,11			
Hyperolius chrysogaster	YES	VU (B1ab(iii))	YES	3	1,4*,10,11	1		
Hyperolius cinnamomeoventris		LC			10,11		YES	PD
Hyperolius diaphanus	YES	DD	P	2,4*	10,11		YES	PD
Hyperolius discodactylus	YES	VU (B1ab(iii))	YES	2	4*,10,11	1	YES	PD
Hyperolius ferrugineus		DD	P	1*,2*,3*	4*,5*,10,11		YES	PD
Hyperolius frontalis	YES	VU (B1ab(iii))	YES	2*,3	4*,10,11	1,3	YES	PD
Hyperolius kivuensis		LC			10,11			
Hyperolius kuligae		LC	P	1,4*	5,10,11		YES	PD
Hyperolius langi		LC	YES	1,2*,3*	4,10,11	3	YES	PD
Hyperolius lateralis		LC		4*	4,10,11		YES	PD
Hyperolius leleupi	YES	EN (B1ab(iii))	YES	1*,2*	1,2,10,11	1	YES	PD
Hyperolius leucotaenius	YES	EN (B1ab(iii))	YES	4*	1,2,10,11	1	YES	PD
Hyperolius nasutus		LC		3	11		YES	PD
Hyperolius ocellatus		LC			5,11		YES	PD
Hyperolius platyceps		LC			11		YES	PD
Hyperolius pusillus		LC		3	11		YES	PD
Hyperolius quinquevittatus		LC			10,11		YES	PD
Hyperolius sylvaticus		LC			2,5,10,11		YES	PD
Hyperolius tuberculatus		LC			5,10,11		YES	PD
Hyperolius viridiflavus		LC		1	11		YES	PD
Hyperolius xenorhinus	YES	DD	YES	1*,2*,3	4,5*,10,11	1	YES	PD
Kassina maculata		LC			6,8		YES	PD
Kassina senegalensis		LC		1	11		YES	PD
Laurentophryne parkeri	YES	DD	YES	1*,2*	1,11	1		
Leptopelis bocagii		LC			6,11		YES	PD
Leptopelis calcaratus		LC			1,5,6,11		YES	PD
Leptopelis christyi		LC	P	2*,3,4	4,6,11		YES	PD
Leptopelis cynnamomeus		LC			6,11		YES	PD
Leptopelis fenestratus	YES	DD	YES	1*,2*,3*	1,4*,5*,6,11	1		
Leptopelis fiziensis		DD	P	3,4*	6,11			
Leptopelis karissimbensis		EN (B1ab(iii))	P	1,2	4,6,11			
Leptopelis kivuensis		NT	P	4	6,11			
Leptopelis modestus		LC	YES	1,3*	4,6,11	1	YES	PD
Leptopelis oryi		LC	P	1,2*,3	6,11		YES	PD

Table A1. Amphibians, continued.

Species	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Leptopelis viridis		LC		1*	6,11		YES	PD
Nectophryne afra		LC			1,3,5,6,11	3		
Phlyctimantis verrucosus		LC	P	1,3,4	11			
Phrynobatrachus acridoides		LC			6			
Phrynobatrachus acutirostris	YES	VU (B1ab(iii))		4	6			
Phrynobatrachus asper	YES	DD	YES	2,4*	6	1		
Phrynobatrachus auritus		LC			5,6			
Phrynobatrachus bequaerti	YES	VU (B1ab(iii))		4	4,6			
Phrynobatrachus dalcqi	YES	DD	YES	4*	5*,6	1		
Phrynobatrachus dendrobates		LC	YES	1,2*,3*	4*,6	3		
Phrynobatrachus graueri		LC			4*,6			
Phrynobatrachus natalensis		LC			6			
Phrynobatrachus parvulus		LC			6			
Phrynobatrachus sulfureogularis	YES	DD	YES	4	6	1		
Phrynobatrachus versicolor	YES	VU (B1ab(iii))	YES	4	4,6	1,2		
Phrynomantis bifasciatus		LC		3	3,6,11			
Phrynomantis microps		LC		1*	3,6,11			
Ptychadena anchietae		LC			6			
Ptychadena christyi		DD	P	1,2*,3*	4,5,6			
Ptychadena chrysogaster		LC		4	4,6			
Ptychadena mascareniensis		LC			6		YES	PD
Ptychadena oxyrhynchus		LC			6			
Ptychadena perreti		LC			5,6			
Ptychadena porosissima		LC			6			
Tomopterna tuberculosa		LC			11			
Xenopus fraseri		LC			5,6,8,9,		YES	FH;PD
Xenopus muelleri		LC			6,8,9		YES	PD
Xenopus ruwenzoriensis	YES	DD	YES	2*	4*,6,8,9,12	1	YES	FH
Xenopus vestitus	YES	LC	YES	3,4	4*,6,8,9,12	1	YES	FH
Xenopus wittei	YES	LC	YES	4	4,6,8,9,12	1	YES	FH

Table A2. All bird species considered in this assessment including Red List categories and criteria (IUCN 2011), climate change vulnerability (P = vulnerable under a pessimistic assumption of missing data values) including individual climate change vulnerability traits (please refer to Tables 4.2, 4.3 and 4.4 for trait descriptions; asterisks denote 'Very High' scores for the traits indicated), importance for human use and use types (please see key at the beginning of these appendices).

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Accipiter badius		LC				4,5		
Accipiter castanilius		LC	YES	2	1,3,5*	4,5		
Accipiter melanoleucus		LC				4,5		
Accipiter minullus		LC			7	4,5		
Accipiter nisus		LC	YES	1*	4*,7	4,5		
Accipiter ovampensis		LC	YES	1,3	7	4,5		
Accipiter rufiventris		LC	P		1,5	4,5		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Acrocephalus arundinaceus		LC		1				
Acrocephalus gracilirostris		LC		3				
Acrocephalus palustris		LC		1	4*			
Acrocephalus rufescens		LC						
Acrocephalus schoenobaenus		LC		1*	4*			
Actitis hypoleucos		LC	YES	1*	4	4		
Actophilornis africanus		LC						
Aenigmatolimnas marginalis		LC	YES	4	8	4		
Afropavo congensis		VU (C2a(i))	P	3,4*	1,3,4*,5*,8			
Agapornis pullarius		LC		4*	5			
Agapornis swindernianus		LC		2	4,5*			
Agelastes niger		LC	P	4*	1,3,4		YES	FH
Alcedo cristata		LC				5		
Alcedo leucogaster		LC			2,3,5	5		
Alcedo quadribrachys		LC			2,3,5	5		
Alcedo semitorquata		LC				5		
Alethe poliocephala		LC					YES	FH
Alethe poliophrys	YES	LC	YES	2*,3,4*	5	1		
Alopochen aegyptiaca		LC	P	1,3		5		
Amandava subflava		LC				5		
Amaurornis flavirostra		LC				4		
Amblyospiza albifrons		LC	P	4				
Anaplectes rubriceps		LC						
Anas capensis		LC	YES	3*,4	4*	5		
Anas crecca		LC	YES	1*,4	4*	5		
Anas erythrorhyncha		LC				5		
Anas hottentota		LC				5		
Anas penelope		LC	YES	1*	4*	2,5		
Anas querquedula		LC	YES	1*	4	5		
Anas sparsa		LC	P	2		4,5		
Anas undulata		LC				4,5		
Anastomus lamelligerus		LC		1				
Andropadus ansorgei		LC			4,5	1		
Andropadus curvirostris		LC			2,3,5			
Andropadus gracilirostris		LC			2,3,5			
Andropadus gracilis		LC			1,3,4			
Andropadus latirostris		LC		2	2,3,5		YES	FH
Anhinga rufa		LC				4,5	YES	FH
Anomalospiza imberbis		LC				4		
Anthoscopus flavifrons		LC			5*	4		
Anthoscopus parvulus		LC	P	1*,2*,3		4		
Anthreptes anchietae		LC			2,4	4		
Anthreptes aurantium		LC		2	5*			
Anthreptes collaris		LC						
Anthreptes longuemarei		LC						
Anthreptes orientalis		LC			4*			
Anthreptes rectirostris		LC			2,8			

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Anthus brachyurus		LC						
Anthus cervinus		LC	P	1*		2		
Anthus leucophrys		LC						
Anthus lineiventris		LC		3				
Anthus trivialis		LC		1*	4*			
Anthus vaalensis		LC		1,3*	4			
Apalis argentea	YES	EN (B1ab(i,ii,iii,v))	YES	4*	1,3,4,8	1,4		
Apalis binotata		LC	P	2		4		
Apalis goslingi		LC	YES	2	5*	4		
Apalis jacksoni		LC		4*				
Apalis nigriceps		LC			2,3,5,7			
Apalis personata	YES	LC	YES	3,4*	4	4		
Apalis rufogularis		LC	P		1	1,4		
Apaloderma aequatoriale		LC	YES	2*,4*	2,3,5*	1		
Apaloderma narina		LC			5	1		
Apaloderma vittatum		LC			5	1		
Aplopelia larvata		LC	P			4		
Apus affinis		LC	P		4	4,5		
Apus apus		LC	YES	3*	4*	4,5		
Apus batesi		LC	YES	1*,2*,3,4*	5*	4,5		
Apus caffer		LC				4,5		
Apus horus		LC	YES	3*,4	1,4	4,5		
Aquila africanus		LC	P		3,5*,8	4,5		
Aquila nipalensis		LC	YES	1	4,8	4,5		
Aquila rapax		LC		1		4,5		
Aquila verreauxii		LC	YES	3,4	1,3,5	4,5		
Aquila wahlbergi		LC		1		4,5		
Ardea cinerea		LC		1*,4		4,5		
Ardea goliath		LC				4,5		
Ardea melanocephala		LC				4,5		
Ardea purpurea		LC	P	1		4,5	YES	FH
Ardeola idae		EN (C2a(ii))	P		8	4,5		
Ardeola ralloides		LC				4,5		
Ardeola rufiventris		LC				4,5		
Asio abyssinicus		LC	YES	1*,2*,3*	4*,5	1		
Asio capensis		LC						
Aviceda cuculoides		LC	YES	4	8	4,5		
Aythya ferina		LC	YES	1*	4*	4,5		
Baeopogon clamans		LC	YES	4	2,3,5*,6	1		
Baeopogon indicator		LC			5,7		YES	FH
Balaeniceps rex		VU (C2a(ii))	YES	1,4	8	4,5	YES	E
Balearica regulorum		VU (A2cd+4cd)	YES	4	7	4	YES	FH;HJ;MH;PD
Bathmocercus rufus		LC		2*	3,5			
Batis diops	YES	LC	P	2*,3*,4*	5			
Batis ituriensis		LC	P	2*,3*,4*	5			
Batis minor		LC			7			
Batis molitor		LC	P	3,4				

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Bias musicus		LC			3,5		YES	FH
Bleda notatus		LC			5*			
Bleda syndactylus		LC			3,5		YES	FH
Bostrychia hagedash		LC		1				
Bostrychia rara		LC		2	3,5*			
Bradornis pallidus		LC				4		
Bradypterus alfredi		LC		2*,4*				
Bradypterus baboecala		LC		3	2			
Bradypterus carpalis		LC		2,4*	1			
Bradypterus graueri	YES	EN (B2ab(ii,iii,iv,v))		2,4*	1			
Bubo africanus		LC	P	1,3		1		
Bubo lacteus		LC				1		
Bubo leucostictus		LC			3,5*	1		
Bubo poensis		LC	YES	4	3,5	1		
Bubo shelleyi		NT (C1)	YES	3,4	1,3,4*,5,8	1		
Bubulcus ibis		LC			7	4,5	YES	PD
Buccanodon duchaillui		LC	YES	2	3,5*	1,5	YES	FH;MH;PD
Bucorvus abyssinicus		LC	YES	1*,2*	2,3	1,5		
Bucorvus cafer		VU (A4bcd)	P		2,3	1,5		
Buphagus africanus		LC		1,2*,3*				
Buphagus erythrorhynchus		LC	YES	4	4	4		
Burhinus capensis		LC	YES	3*	4	5		
Burhinus oedicnemus		LC	YES	1,4	4	5		
Burhinus senegalensis		LC	P	1*,3		5		
Burhinus vermiculatus		LC				5		
Butastur rufipennis		LC	P	1,2		4,5		
Buteo auguralis		LC	YES	1,2,3	8	4,5		
Buteo oreophilus		LC	YES	4	1,4,5,8	4,5		
Butorides striata		LC				4,5		
Bycanistes albotibialis		LC	YES	2	2,3,5*	4,5		
Bycanistes bucinator		LC			5	5		
Bycanistes fistulator		LC	YES	2	2,3,5*	5		
Bycanistes subcylindricus		LC	YES	1,2*,4	3	5	YES	FH
Calidris ferruginea		LC		1		2,4		
Calidris minuta		LC		1*,2,3*		2,4		
Calidris temminckii		LC	YES	1*	4	2,4		
Calyptocichla serina		LC		4	2,5			
Camaroptera chloronota		LC			2,7	4		
Camaroptera superciliaris		LC			2,4			
Camaroptera undosa		LC		3	2,4			
Campephaga flava		LC				5		
Campephaga oriolina		DD	YES	2*,3,4*	5*	5		
Campephaga petiti		LC	P	3,4		5		
Campephaga phoenicea		LC	P	1,2		5		
Campephaga quiscalina		LC				5		
Campethera abingoni		LC						
Campethera cailliautii		LC	P	1	2,5			

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Campethera caroli		LC	P	2	2,5*		YES	FH
Campethera nivosa		LC			2,5*,6		YES	FH
Campethera nubica		LC	P	1	2,4*			
Campethera punctuligera		LC	P	1,2	5			
Campethera tullbergi		LC			2,5,6			
Canirallus oculeus		LC	YES	4	3,5*	4		
Caprimulgus batesi		LC	YES	2*,4*	5	5		
Caprimulgus clarus		LC	YES	3	4*	5		
Caprimulgus climacurus		LC	P	1		5		
Caprimulgus europaeus		LC			4*	5		
Caprimulgus fossii		LC	P	4		5		
Caprimulgus inornatus		LC	P	1,3		5		
Caprimulgus natalensis		LC				5		
Caprimulgus nigriscapularis		LC	YES	4	5	5		
Caprimulgus pectoralis		LC	P	3		5		
Caprimulgus prigoginei	YES	EN (B1ab(i,ii,iii,v))	YES	4*	1,3,5*,8	5		
Caprimulgus ruwenzorii	YES	LC	YES	4*	4	5		
Caprimulgus tristigma		LC	P	4		5		
Casmerodius albus		LC		1		4,5		
Centropus cupreicaudus		LC	P	2				
Centropus grillii		LC	P	1*,2*,3*,4	4			
Centropus monachus		LC						
Centropus senegalensis		LC	P	1,3*,4			YES	FH;MH
Ceratogymna atrata		LC			2,3,5*	5	YES	FH;MH
Cercococcyx mechowi		LC			2,6			
Cercococcyx montanus		LC						
Cercococcyx olivinus		LC			5			
Cercomela familiaris		LC	P	3*		4		
Ceryle rudis		LC	P	1,3*,4*		5		
Ceuthmochares aereus		LC				5	YES	FH
Ceyx lecontei		LC	YES	2,4*	3,5*	5	YES	FH
Ceyx pictus		LC				5	YES	FH
Charadrius asiaticus		LC	YES	3	4*	4		
Charadrius dubius		LC		1*	4			
Charadrius forbesi		LC		2*	1,4			
Charadrius hiaticula		LC	YES	1*	4	2		
Charadrius marginatus		LC						
Charadrius pecuarius		LC						
Charadrius tricollaris		LC						
Chlidonias hybrida		LC						
Chlidonias leucopterus		LC						
Chlorocichla flavicollis		LC						
Chlorocichla flaviventris		LC						
Chlorocichla laetissima		LC		2*,4*	4			
Chlorocichla prigoginei	YES	EN (B1ab(i,ii,iii,iv,v))	YES	3*	4*,5,8	1		
Chlorocichla simplex		LC		2	3			
Chloropeta gracilirostris		VU (C2a(i))		2*,4*	1,3,4,8			

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Chloropeta natalensis		LC						
Chloropeta similis		LC		2*,3,4	7			
Chrysococcyx caprius		LC	P	3		5		
Chrysococcyx cupreus		LC	P	2		5		
Chrysococcyx flavigularis		LC	YES	2*	1,5*	5		
Chrysococcyx klaas		LC				5		
Cichladusa arquata		LC				4		
Cichladusa guttata		LC	YES	4	4*	4		
Ciconia abdimii		LC		1,3		4		
Ciconia ciconia		LC			4	4		
Ciconia episcopus		LC						
Ciconia nigra		LC	YES	1	4	4		
Cinnyricinclus leucogaster		LC				4		
Cinnyricinclus sharpii		LC		2*,4*	1,5			
Circaetus cinerascens		LC	P	1,3		4,5		
Circaetus cinereus		LC	P	1,3		5		
Circaetus pectoralis		LC				5		
Circus aeruginosus		LC	YES	1*	4	5		
Circus macrourus		NT (A2cde+3cde+4cde)	YES	1*	4*	5		
Circus pygargus		LC			4*	5		
Circus ranivorus		LC	P	4		5		
Cisticola angusticauda		LC			3,5			
Cisticola anonymus		LC		2	5*			
Cisticola ayresii		LC		3*,4	4			
Cisticola brachypterus		LC				4		
Cisticola brunnescens		LC				4		
Cisticola cantans		LC	P	2		4		
Cisticola carruthersi		LC		2*,4*	4*			
Cisticola chiniana		LC						
Cisticola chubbi		LC		2,4*	4			
Cisticola dambo		LC		2*,4	3,5,8			
Cisticola eximius		LC		1*,2*,3*				
Cisticola fulvicapilla		LC		3*				
Cisticola galactotes		LC	P	4		4		
Cisticola juncidis		LC	P		7	4		
Cisticola lateralis		LC	P		5	4		
Cisticola natalensis		LC	P			4		
Cisticola nigriloris		LC	P		7	2,4		
Cisticola njombe		LC	P			4		
Cisticola pipiens		LC	P	2		4		
Cisticola rufilatus		LC	P	3*		4		
Cisticola tinniens		LC	YES	3*	4	4		
Cisticola troglodytes		LC	P	1,2		4		
Cisticola woosnami		LC	P	2,4		4		
Clamator glandarius		LC	P	1		5		
Clamator jacobinus		LC				5		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Clamator levaillantii		LC				5		
Clytospiza monteiri		LC	YES	2	5	5		
Colius striatus		LC	P			4	YES	FH
Columba albinucha		NT (B1ab(i,ii,iii,v);C2a(i))	YES	4*	3,4*	4		
Columba arquatrix		LC	YES	4	4	4		
Columba guinea		LC	P	1,3		4		
Columba iriditorques		LC	P		5*	4		
Columba unicincta		LC	YES	4	5	4		
Coracias abyssinicus		LC	P	1*,2,3				
Coracias caudatus		LC			5			
Coracias garrulus		NT (A2bcd+3bcd+4bcd)	P	1	4*			
Coracias naevia		LC	P	1,3				
Coracias spatulatus		LC			2,3			
Coracina azurea		LC			5*	5		
Coracina caesia		LC				5		
Coracina graueri	YES	NT (B1ab(i,ii,iii,v))	YES	2,3*,4*	1,3,4*,5	1,5		
Coracina pectoralis		LC	P	1,2*,3		5		
Corvinella corvina		LC		1*,2,3				
Corvus albicollis		LC	P		4	1		
Corythaeola cristata		LC		2	5		YES	FH;WA
Corythaixoides personatus		LC		1*,2*				
Cossypha archeri	YES	LC	YES	4*	1	1,4		
Cossypha caffra		LC			4*	4		
Cossypha cyanocampter		LC					YES	FH
Cossypha heuglini		LC						
Cossypha natalensis		LC						
Cossypha niveicapilla		LC		1,2				
Cossypha polioptera		LC		2,4	3,5			
Cossyphicula roberti		LC			5,7	1		
Coturnix coturnix		LC	P	1*	4*		YES	FH
Coturnix delegorguei		LC						
Creatophora cinerea		LC		3*,4	4			
Crecopsis egregia		LC				5		
Crex crex		LC	YES	1*	4*	5		
Crinifer zonurus		LC						
Criniger calurus		LC			5*			
Criniger chloronotus		LC	YES	2,3	3,5*	1		
Criniger ndussumensis		LC	YES	3	1,3,5*	1		
Cryptospiza jacksoni	YES	LC	YES	4*	4	5		
Cryptospiza reichenovii		LC			2	5		
Cryptospiza salvadorii		LC	P	2,3,4*		5		
Cryptospiza shelleyi	YES	VU (C2a(i))	YES	2,4*	1,3,4	5	YES	PD
Cuculus canorus		LC	YES	1*	4*	5		
Cuculus clamosus		LC				5		
Cuculus gularis		LC	P	2		5		
Cuculus poliocephalus		LC	P	1*,4*		5		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Cuculus rochii		LC	P	3*,4		5		
Cuculus solitarius		LC				5		
Cursorius temminckii		LC		1,3		4		
Cypsiurus parvus		LC	P	4		4,5		
Delichon urbicum		LC	YES	1*	4*	4		
Dendrocopos obsoletus		LC	P	1,2				
Dendrocygna bicolor		LC	P	4		4,5		
Dendrocygna viduata		LC	YES	3*	1,3,5	4,5	YES	FH
Dendropicos fuscescens		LC			2,3			
Dendropicos poecilolaemus		LC	P	1,2	3			
Dicrurus atripennis		LC	YES	2	1,3,5*	5		
Dicrurus ludwigii		LC				5	YES	FH
Dioptrornis fischeri		LC		4				
Drymocichla incana		LC	YES	2	5	4		
Dryoscopus angolensis		LC		3,4				
Dryoscopus cubla		LC						
Dryoscopus gambensis		LC		1,2				
Dryoscopus sabini		LC			5			
Dryoscopus senegalensis		LC		2	5*			
Dryotriorchis spectabilis		LC			1,4,8	5		
Egretta ardesiaca		LC				4,5		
Egretta vinaceigula		VU (C2a(ii))	YES	2,3*,4	8	4,5		
Elanus caeruleus		LC				5		
Elminia albicauda		LC		4				
Elminia albiventris		LC						
Elminia albonotata		LC						
Elminia longicauda		LC		2	5			
Elminia nigromitrata		LC			5		YES	FH
Emberiza affinis		LC	P	1,2*		5		
Emberiza cabanisi		LC				5		
Emberiza flaviventris		LC	P	3*		5		
Emberiza tahapisi		LC	P	1,3*		5		
Eminia lepida		LC	YES	2*,4*	4	4		
Ephippiorhynchus senegalensis		LC			8			
Eremomela atricollis		LC		2				
Eremomela badiceps		LC			5*		YES	FH
Eremomela scotops		LC						
Eremopterix leucopareia		LC	YES	2,3*	4	5		
Erythrocercus mccallii		LC			5			
Erythropygia barbata		LC		2				
Erythropygia hartlaubi		LC		2*,4				
Erythropygia leucophrys		LC						
Erythropygia leucosticta		LC		4	5			
Estrilda astrild		LC				5		
Estrilda erythronotos		LC	YES	1,3*,4	4*	5		
Estrilda melpoda		LC	YES	2	2	5		
Estrilda nonnula		LC	P	2		5		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Estrilda perreini		LC				5		
Estrilda rhodopyga		LC	YES	3	4	5		
Estrilda troglodytes		LC	P	1*,2,3*		5		
Euplectes afer		LC	P	1,3*				
Euplectes albonotatus		LC						
Euplectes ardens		LC						
Euplectes axillaris		LC	P	4				
Euplectes capensis		LC						
Euplectes franciscanus		LC	P	1,3,4			YES	PD
Euplectes gierowii		LC	P	4*				
Euplectes hartlaubi		LC						
Euplectes hordeaceus		LC						
Euplectes macroura		LC			7			
Euplectes orix		LC	P	3*,4	4			
Euplectes progne		LC	P	3*	4			
Eupodotis melanogaster		LC	P	4				
Eupodotis senegalensis		LC	P	4	4*			
Eurocephalus rueppelli		LC		3	4*			
Eurystomus glaucurus		LC	P	1	3			
Eurystomus gularis		LC			1,3,5			
Euschistospiza cinereovinacea		LC	P	3,4*		5		
Euschistospiza dybowskii		LC	YES	2	5	5		
Falco alopex		LC	YES	1	8	5		
Falco amurensis		LC	P	1*,4		5		
Falco ardosiaceus		LC	P	1,2		5		
Falco biarmicus		LC	YES	3	1	5		
Falco chicquera		LC	P	1		5		
Falco cuvierii		LC			8	5		
Falco dickinsoni		LC			8	5		
Falco naumanni		LC	YES	1*	4*	5		
Falco peregrinus		LC	YES	1	1	3,5		
Falco subbuteo		LC	YES	1*	4*	5		
Falco tinnunculus		LC	YES	1*	4*	5		
Falco vespertinus		NT (A2bc+3bc+4bc)	YES	1*	4*	5		
Ficedula albicollis		LC		1	4*			
Ficedula hypoleuca		LC		1*	4*			
Ficedula semitorquata		NT (A2bc+3bc+4bc)		2,4	4			
Francolinus afer		LC	P	1,2*,4*			YES	FH;PD
Francolinus albogularis		LC	P	1*,2*,3*,4	3,4			
Francolinus coqui		LC	P	3				
Francolinus hildebrandti		LC	P	1,3				
Francolinus icterorhynchus		LC	P	2	5			
Francolinus lathami		LC			1,3,5*		YES	FH
Francolinus levaillantii		LC	P	4	4			
Francolinus nahani		EN (B1ab(ii,iii,v))	P	1,2*,3*	1,3,4*,5*			
Francolinus nobilis	YES	LC	P	4*	4*,7		YES	FH;MH
Francolinus sephaena		LC			4,7			

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Francolinus shelleyi		LC	P	3				
Francolinus squamatus		LC	P	4*	5		YES	FH
Francolinus streptophorus		NT (A2bcd+3bcd +4bcd;C1)	P	2,4	4,8			
Fraseria cinerascens		LC		2	5*			
Fraseria ocreata		LC			1,5*			
Fulica cristata		LC	YES	3*	4	5		
Galerida modesta		LC	P	1,2*,3		5		
Gallinago media		NT (A2cd+3cd+4cd)	YES	1*	4*	4		
Gallinago nigripennis		LC	YES	3*,4	7	4		
Gallinula angulata		LC				5		
Gallinula chloropus		LC				5		
Glareola nordmanni		NT (A2bc+3bc+4bc)	YES	3*,4	4	4		
Glareola nuchalis		LC			1,3	4		
Glareola pratincola		LC			4	4		
Glaucidium albertinum	YES	VU (C2a(i))		3,4*	1,3		YES	MH
Glaucidium castaneum		LC		2*,4*	4			
Glaucidium perlatum		LC		1*,2*,3*,4*				
Glaucidium tephronotum		LC			5			
Gorsachius leuconotus		LC				4,5		
Graueria vittata	YES	LC	YES	4*	5	1		
Grus carunculatus		VU (A2acde+3cde+ 4acde;C1+2a(ii))	YES	3	8	4		
Guttera plumifera		LC	P	3	1,3,5*		YES	FH
Guttera pucherani		LC	P	4			YES	FH;PD
Gymnobucco bonapartei		LC	YES	2	2,5*	1,5	YES	FH
Gymnobucco sladeni		LC	YES	2,4*	1,3,4,5*	1,5		
Gypohierax angolensis		LC	P	4*		5	YES	FH
Gyps africanus		NT (A2bcd+3bcd+4bcd)	P	1,3		5		
Gyps rueppellii		NT (A2abcd+3bcd+4bcd)	YES	1*,3	4	5		
Halcyon albiventris		LC	P	3		5		
Halcyon badia		LC			2,3,5*,6	5		
Halcyon chelicuti		LC	YES	1,3	3	5		
Halcyon leucocephala		LC				5		
Halcyon malimbica		LC	YES	2	3,5	5		
Halcyon senegalensis		LC			3	5		
Haliaeetus vocifer		LC	P	3		5		
Heliolais erythropterus		LC	P	1,2		4		
Hemitesia neumanni	YES	LC	YES	3,4*	5	1,2,4		
Hieraaetus ayresii		LC	P		7,8	4,5		
Hieraaetus spilogaster		LC				4,5	YES	FH
Himantopus himantopus		LC				4		
Himantornis haematopus		LC			3,5*	5	YES	FH
Hippolais icterina		LC	YES	1*	4	4		
Hippolais olivetorum		LC				4		
Hirundo abyssinica		LC				4		
Hirundo aethiopica		LC	P	1,3		4		
Hirundo albigularis		LC	YES	3*	4	4		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Hirundo angolensis		LC	P	4		4		
Hirundo atrocaerulea		VU (C2a(i))	YES	4	4,8	4		
Hirundo cucullata		LC	YES	3*	4	4		
Hirundo dimidiata		LC	P	3*		4		
Hirundo fuligula		LC	P	3		4		
Hirundo nigrita		LC			5	4		
Hirundo nigrorufa		LC	YES	2,4	5	4		
Hirundo rustica		LC	P	1		4		
Hirundo semirufa		LC	P	3		4		
Hirundo senegalensis		LC				4		
Hirundo smithii		LC	P	1		4		
Hylia prasina		LC			2	4	YES	FH
Hyliota flavigaster		LC				4		
Hyliota violacea		LC	YES	2	4,5	4		
Hypargos niveoguttatus		LC				5		
Illadopsis albipectus		LC	YES	4*	1,3,4,5*	1		
Illadopsis fulvescens		LC			5			
Illadopsis puveli		LC		4	5			
Illadopsis pyrrhoptera		LC	YES	2*,4*	5	1		
Illadopsis rufipennis		LC			5			
Indicator exilis		LC			5			
Indicator indicator		LC		1*,2*,3	5			
Indicator maculatus		LC		2	1,4			
Indicator meliphilus		LC						
Indicator pumilio	YES	NT (B1ab(i,ii,iii))		2*,3*,4*	2,3,4*,5,6			
Indicator variegatus		LC			5			
Indicator willcocksi		LC		2	5*			
Ixobrychus minutus		LC	YES	1	4	4,5		
Ixobrychus sturmii		LC		4		4,5		
Ixonotus guttatus		LC			5*			
Jubula lettii		DD			1,2,3,5*			
Jynx ruficollis		LC	P	3	3			
Jynx torquilla		LC	P	1*	1,4,5			
Kakamega poliothorax		LC	YES	2	5	1		
Kaupifalco monogrammicus		LC	P	1		4,5		
Kupeornis chapini	YES	NT (B1ab(i,ii,iii,v))	YES	2,3*,4*	3,4*	1		
Kupeornis rufocinctus	YES	NT (B1ab(iii,v))	YES	2,4*	5	1		
Lagonosticta nitidula		LC	P	2,3,4		5		
Lagonosticta rara		LC	P	1,2*		5		
Lagonosticta rubricata		LC				5		
Lagonosticta rufopicta		LC	P	1,2*		5		
Lagonosticta senegala		LC	P	1,3		1,5	YES	PD
Lamprotornis acuticaudus		LC		3,4				
Lamprotornis chalcurus		LC		1,2*,3				
Lamprotornis chalybaeus		LC		1,3				
Lamprotornis chloropterus		LC		1,2				
Lamprotornis elisabeth		LC						

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Lamprotornis purpureiceps		LC			1			
Lamprotornis purpureus		LC		1*,2*,3				
Lamprotornis purpuroptera		LC		1,4	4			
Lamprotornis splendidus		LC			5			
Lamprotornis superbus		LC		3	4*			
Laniarius aethiopicus		LC						
Laniarius erythrogaster		LC		1,3				
Laniarius funebris		LC		3	4			
Laniarius leucorhynchus		LC			5*			
Laniarius luehderi		LC			5			
Laniarius mufumbiri		NT (B1ab(iii))		2*,4*	1,4*,5			
Laniarius poensis		LC			2			
Lanius collaris		LC						
Lanius collurio		LC		1*	4*			
Lanius excubitoroides		LC		1,3	4			
Lanius gubernator		LC		3	5			
Lanius isabellinus		LC		1*	4*			
Lanius mackinnoni		LC						
Lanius senator		LC		1,2*				
Lanius souzae		LC		3	2,4			
Larus cirrocephalus		LC					YES	FH
Larus fuscus		LC		1	4			
Larus ridibundus		LC			4*			
Leptoptilos crumeniferus		LC						
Limosa limosa		NT (A2bc+3bc+4bc)	YES	1*	4	4		
Linurgus olivaceus		LC	YES	2,4	2	5		
Locustella fluviatilis		LC		1*	4*			
Lonchura bicolor		LC			5	5		
Lonchura cucullata		LC				5		
Lonchura fringilloides		LC				5	YES	FH
Lonchura nigriceps		LC				5		
Lophaetus occipitalis		LC	P	1,2,3		4,5	YES	FH;MH
Luscinia luscinia		LC		1*	4*			
Luscinia megarhynchos		LC			4			
Lybius bidentatus		LC	P		3	1,5		
Lybius guifsobalito		LC	YES	1*,4	4	1,5		
Lybius leucocephalus		LC	YES	1,2,3	2	1,5		
Lybius minor		LC	P			1,5		
Lybius rubrifacies		NT (C2a(ii))	YES	1*,2*,3*	1,2,4*,5*	1,5		
Lybius torquatus		LC	YES	3	2	1,5		
Lymnocryptes minimus		LC	YES	1*	4*	2		
Macheiramphus alcinus		LC	P		8	4,5		
Macrodipteryx longipennis		LC				5		
Macrodipteryx vexillarius		LC		4				
Macronyx ameliae		LC	P	3,4		4		
Macronyx croceus		LC			7	4		
Macronyx fuellebornii		LC				4		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Macrosphenus concolor		LC			1,5*			
Macrosphenus flavicans		LC			3,5*	1		
Malaconotus blanchoti		LC		1,2				
Malaconotus cruentus		LC			1,3,5			
Malaconotus lagdeni		NT (A2c+3c+4c)			5*			
Malimbus cassini		LC	P	2,3	4,5*			
Malimbus coronatus		LC	YES	3	3,4,5*	1	YES	FH
Malimbus erythrogaster		LC	YES	2	3,4,5*	1		
Malimbus malimbicus		LC			3,4			
Malimbus nitens		LC			5*		YES	FH
Malimbus rubricollis		LC			5			
Mandingoa nitidula		LC				5	YES	FH;PD
Megabyas flammulatus		LC			5*			
Megaceryle maxima		LC	P	1,2		5		
Melaenornis ardesiacus	YES	LC		4*	4			
Melaenornis edolioides		LC		1,2				
Melaenornis pammelaina		LC		3				
Melichneutes robustus		LC		2	2,3,5*,6			
Melierax gabar		LC	P	1,3		4,5		
Melierax metabates		LC		1*,2,3*		4,5		
Melierax poliopterus		LC	YES	3*	4*	4,5		
Melignomon zenkeri		LC		2	3,4,5*			
Melocichla mentalis		LC						
Merops albicollis		LC		1				
Merops apiaster		LC		1*,4	4*			
Merops boehmi		LC						
Merops breweri		LC		2	3,5*			
Merops bullockoides		LC		3				
Merops bulocki		LC		1*,2*,3				
Merops gularis		LC			5*		YES	FH
Merops hirundineus		LC		1,2,3				
Merops nubicoides		LC		1,3				
Merops nubicus		LC		1*,3				
Merops oreobates		LC		4*	4			
Merops persicus		LC		1				
Merops pusillus		LC		1			YES	FH
Merops superciliosus		LC			7			
Merops variegatus		LC		4				
Mesophoyx intermedia		LC				4,5		
Mesopicos elliotii		LC	P	2	2,3,5*			
Mesopicos goertae		LC	P	1*,2,3	1,5			
Mesopicos griseocephalus		LC	P	3,4	2			
Microparra capensis		LC		3*				
Mirafra albicauda		LC	YES	2	4	5		
Mirafra angolensis		LC	P	2,3*,4		5		
Mirafra rufocinnamomea		LC				5		
Monticola angolensis		LC						

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Monticola saxatilis		LC		1	4*,7			
Motacilla aguimp		LC				4		
Motacilla capensis		LC	YES	3*	4	4		
Motacilla cinerea		LC	YES	1*	4	4		
Motacilla clara		LC				4		
Motacilla flava		LC	YES	1*	4	4		
Muscicapa adusta		LC						
Muscicapa aquatica		LC		1,2,3				
Muscicapa boehmi		LC			2			
Muscicapa caerulescens		LC						
Muscicapa cassini		LC			1,3,5			
Muscicapa comitata		LC			5			
Muscicapa epulata		LC			2,4			
Muscicapa infuscata		LC		2	5			
Muscicapa olivascens		LC			2,6	1		
Muscicapa sethsmithi		LC		2,3	2,4			
Muscicapa striata		LC		1*	4*			
Muscicapa tessmanni		DD			5			
Musophaga rossae		LC		4				
Mycteria ibis		LC		1		4		
Myioparus griseigularis		LC			5			
Myioparus plumbeus		LC						
Myrmecocichla albifrons		LC		1,2*,3				
Myrmecocichla arnoti		LC			2			
Myrmecocichla cinnamomeiventris		LC	P	4		4		
Myrmecocichla nigra		LC	P	4		4		
Neafrapus boehmi		LC				4,5		
Neafrapus cassini		LC	P		2,5*	4,5		
Necrosyrtes monachus		EN (A2acd+3cd+4acd)	P	1,3		4,5		
Nectarinia alinae	YES	LC	YES	4*	1,3	1		
Nectarinia amethystina		LC						
Nectarinia batesi		LC		2,4	2,4			
Nectarinia bifasciata		LC						
Nectarinia bouvieri		LC			2,4			
Nectarinia chloropygia		LC			3,5			
Nectarinia cuprea		LC						
Nectarinia cyanolaema		LC			1,5			
Nectarinia erythrocerca		LC	P	4*	4			
Nectarinia famosa		LC	P	3	4*			
Nectarinia johannae		LC			1,5*			
Nectarinia johnstoni		LC	P	2*,3*,4				
Nectarinia kilimensis		LC	P	4	7			
Nectarinia manoensis		LC						
Nectarinia mariquensis		LC	P	3*,4	4*			
Nectarinia minulla		LC			5			
Nectarinia olivacea		LC						

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Nectarinia oustaleti		LC	P	4				
Nectarinia preussi		LC	P	2*,4				
Nectarinia pulchella		LC	P	1*,2*,3				
Nectarinia purpureiventris	YES	LC	P	4*	5			
Nectarinia regia	YES	LC	P	2*,4*	4			
Nectarinia reichenbachii		LC			5*			
Nectarinia reichenowi		LC	P	2*,3*,4*	4			
Nectarinia rockefelleri	YES	VU (D1)	YES	2*,4*	8	2		
Nectarinia rubescens		LC			5			
Nectarinia seimundi		LC			5			
Nectarinia senegalensis		LC						
Nectarinia shelleyi		LC						
Nectarinia superba		LC			5			
Nectarinia venusta		LC						
Nectarinia verticalis		LC	P	2	5			
Neocichla gutturalis		LC		1,2*,4	3,5			
Neocossyphus poensis		LC			5	4		
Neocossyphus rufus		LC	P		1	1,4		
Neolestes torquatus		LC						
Neotis denhami		NT (A2bcd+3bcd+4bcd)	P	1,2,3				
Nesocharis ansorgei		LC	YES	2,3,4*	4*	5		
Nesocharis capistrata		LC	YES	1,2,3	5	5		
Netta erythrophthalma		LC		4		4,5		
Nettapus auritus		LC	P		1	4,5		
Nicator chloris		LC			5		YES	FH
Nicator gularis		LC	YES	3	4	4		
Nicator vireo		LC	YES	2,3	5*	4		
Nigrita bicolor		LC			5	5		
Nigrita canicapillus		LC	YES	2	5	5	YES	FH
Nigrita fusconotus		LC			2,4	5		
Nigrita luteifrons		LC	YES	2	5*	5		
Nilaus afer		LC		1,3				
Numenius arquata		NT (A2bcd+3bcd+4bcd)			4			
Numenius phaeopus		LC	YES	1,4	7	2		
Numida meleagris		LC					YES	FH;MH;PD;WA
Nycticorax nycticorax		LC		1				
Oena capensis		LC	P	1,3		4		
Oenanthe isabellina		LC		1	4*			
Oenanthe oenanthe		LC		1*	4*			
Oenanthe pileata		LC		3				
Oenanthe pleschanka		LC		1	4*			
Onychognathus fulgidus		LC			3,4,7,8			
Onychognathus morio		LC		1				
Onychognathus tenuirostris		LC			5			
Onychognathus walleri		LC		2,4	5			
Oreolais pulchra		LC	YES	2*,3*,4	5,7	1,4		
Oreolais ruwenzorii	YES	LC	YES	3,4*	4	4		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Oriolus auratus		LC						
Oriolus brachyrhynchus		LC			5*		YES	FH
Oriolus larvatus		LC						
Oriolus nigripennis		LC	P	1*,2*,4	7			
Oriolus oriolus		LC	P	1	1			
Oriolus percivali		LC	P	4*	4			
Ortygospiza locustella		LC				5		
Otus icterorhynchus		LC			5*			
Otus leucotis		LC		1,3				
Otus senegalensis		LC		1,3				
Oxyura maccoa		NT (C1)	P		4,8	4,5		
Pachycoccyx audeberti		LC				5		
Pandion haliaetus		LC	P		4	4,5		
Parmoptila jamesoni		LC	YES	3,4*	4*,5	5		
Parus fasciiventer	YES	LC	P	4*	5			
Parus funereus		LC	P	2,4	2,5*			
Parus griseiventris		LC			2			
Passer griseus		LC	P	1				
Pelecanus onocrotalus		LC						
Pelecanus rufescens		LC	P	1,3			YES	FH
Pernis apivorus		LC	YES	4	1,4	5		
Petronia superciliaris		LC	P	3				
Phalacrocorax africanus		LC						
Phalacrocorax carbo		LC	P	1	4			
Phodilus prigoginei	YES	EN (B1ab(i,ii,iii,v))	YES	2*,4*	8	2,4		
Phoeniconaias minor		NT (A3c)	P	3*	4			
Phoenicopterus roseus		LC	P	3,4				
Phoeniculus bollei		LC			2			
Phoeniculus castaneiceps		LC			2			
Phoeniculus purpureus		LC	P	1,2,3	2			
Phoenicurus phoenicurus		LC		1*	4*			
Pholidornis rushiae		LC			5*	4		
Phyllanthus atripennis		LC			5			
Phyllastrephus albigularis		LC			3	4		
Phyllastrephus cerviniventris		LC				4		
Phyllastrephus hypochloris		LC	YES	2*,4*	4*	4		
Phyllastrephus icterinus		LC			5*	4		
Phyllastrephus strepitans		LC	YES	3*	4*	4		
Phyllastrephus terrestris		LC	P	3		4		
Phyllastrephus xavieri		LC	YES	2*,3	3,5*	1,4		
Phyllolais pulchella		LC	YES	4	4,7	4		
Phylloscopus budongoensis		LC	YES	4*	5	1		
Phylloscopus laetus	YES	LC	YES	4*	5	1		
Phylloscopus laurae		LC		2	2			
Phylloscopus ruficapilla		LC			5	1		
Phylloscopus sibilatrix		LC		1*	4			
Phylloscopus trochilus		LC		1*	4*			

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Phylloscopus umbrovirens		LC		3,4	4			
Pinarocorys erythropygia		LC	P	1*,2,3*		5		
Pinarocorys nigricans		LC	P	3*		5		
Pitta angolensis		LC	P	4				
Pitta reichenowi		LC	P	2*,3,4*	4*,5		YES	E
Platalea alba		LC		3				
Platysteira castanea		LC			5		YES	FH
Platysteira concreta		LC			5			
Platysteira cyanea		LC			5			
Platysteira jamesoni		LC	P	2,3,4*	4			
Platysteira peltata		LC						
Platysteira tonsa		LC	YES	2,3	3,5*	1		
Plectropterus gambensis		LC		3		4,5		
Plegadis falcinellus		LC						
Plocepasser mahali		LC	P	1,3*,4	4*			
Plocepasser rufoscapulatus		LC			2			
Plocepasser superciliosus		LC	P	1*,2*,3*				
Ploceus albinucha		LC			1,5			
Ploceus alienus	YES	LC	P	4*	1			
Ploceus aurantius		LC						
Ploceus aureonucha	YES	EN (C2a(ii))	P	1*,2*,3*	1,4*,5*,8			
Ploceus baglafecht		LC	P	4				
Ploceus bertrandi		LC						
Ploceus bicolor		LC						
Ploceus castanops		LC	P	2*,4*	4*,5			
Ploceus cucullatus		LC					YES	FH;PD
Ploceus dorsomaculatus		LC	P	2,3*	5			
Ploceus flavipes	YES	VU (B1ab(i,ii,iii,v);C2a(ii))	YES	1,2*,3*,4	1,3,4*,5*,8	1		
Ploceus heuglini		LC	P	1*,2*,3*,4				
Ploceus insignis		LC	P	4*				
Ploceus intermedius		LC	P	4	4			
Ploceus jacksoni		LC	P	2,4	4			
Ploceus katangae		LC	P	1*,2*				
Ploceus luteolus		LC	P	1*,2,3				
Ploceus melanocephalus		LC	P	1,4				
Ploceus melanogaster		LC	P	4*	2			
Ploceus nigerrimus		LC			5		YES	FH
Ploceus nigricollis		LC						
Ploceus ocularis		LC						
Ploceus pelzelni		LC	P	4				
Ploceus preussi		LC			2,4			
Ploceus reichardi		LC	P	1*,2*				
Ploceus spekeoides		NT (C1+2a(i))	P	1,2*	4,5*			
Ploceus superciliosus		LC	P	4	7			
Ploceus tricolor		LC			5			
Ploceus vitellinus		LC	P	1,2,3		1		
Ploceus weynsi		LC		2*,4*	1,4*,5*			

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Ploceus xanthops		LC		4				
Pluvianus aegyptius		LC				4		
Podica senegalensis		LC				1,4		
Podiceps cristatus		LC		1*	4*			
Poeoptera lugubris		LC			4,5			
Poeoptera stuhlmanni		LC		2*,4*	1,2			
Pogoniulus atroflavus		LC	YES	2	2,5*	1,5		
Pogoniulus chrysoconus		LC	YES	1*,2*,3*	2	1,5		
Pogoniulus coryphaeus		LC				1,4		
Pogoniulus pusillus		LC	YES	1	2,4*	1,4		
Pogoniulus scolopaceus		LC	YES	2	2,3,5*	1,4	YES	FH
Pogoniulus subsulphureus		LC	P		5*	1,4		
Pogonocichla stellata		LC						
Poicephalus gulielmi		LC		2,4	5*		YES	PD
Poicephalus meyeri		LC	P	3		1		
Poicephalus robustus		LC		4				
Polemaetus bellicosus		NT (A2acde)	P	1,3		5		
Polihierax semitorquatus		LC	YES	1	4*	1,5		
Polyboroides typus		LC				5	YES	FH
Porphyrio alleni		LC	P	4		5		
Porphyrio porphyrio		LC				5		
Porzana porzana		LC	YES	1*	4*	5		
Porzana pusilla		LC	P	1*,4		5		
Prinia leucopogon		LC	P		2,5,6,7	4	YES	FH
Prinia subflava		LC				4		
Prionops alberti	YES	VU (C2a(i))	YES	2,3,4*	1,3,4	1		
Prionops plumatus		LC				1		
Prionops retzii		LC	P	3		1		
Prodotiscus insignis		LC			5,8			
Prodotiscus regulus		LC		1,2,3*,4				
Prodotiscus zambesiae		LC						
Psalidoprocne albiceps		LC	YES	2,4	7	4		
Psalidoprocne nitens		LC			5	4		
Pseudhirundo griseopyga		LC						
Pseudoalcippe abyssinica		LC	YES	4	5	1		
Pseudocalyptomena graueri	YES	VU (B1ab(i,ii,iii,v);C2a(i))	YES	2*,4*	1,3,4	2,5	YES	E
Psittacus erithacus		NT (A2bcd+3bcd+4bcd)		2	5*		YES	PD
Psophocichla litsitsirupa		LC	P	3*		4		
Pterocles gutturalis		LC		1,2,3*,4	4			
Pteronetta hartlaubii		LC	YES	2	1,4	4,5		
Ptilopachus petrosus		LC						
Ptilostomus afer		LC	P	1,2*,4*	4*			
Ptyrticus turdinus		LC		1,2*	5			
Pyrenestes ostrinus		LC			5	5		
Pyrrhurus scandens		LC	YES	2	5	4		
Pytilia afra		LC	P	3		5		
Pytilia melba		LC	YES	3*	4	5		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Quelea cardinalis		LC		2*,3	4			
Quelea erythrops		LC						
Quelea quelea		LC		3*				
Rallus caerulescens		LC				5		
Recurvirostra avosetta		LC	YES	1	4*	4		
Rhaphidura sabini		LC	YES	4	2,7	4,5		
Rhinopomastus aterrimus		LC	P	1*,2*	2			
Rhinopomastus cyanomelas		LC	P	3*	2			
Rhinoptilus chalcopterus		LC	YES	1,3	7	4		
Riparia cincta		LC		3				
Riparia paludicola		LC						
Riparia riparia		LC		1	4,7			
Ruwenzorornis johnstoni	YES	LC		3,4*	1,2,3,4*			
Rynchops flavirostris		NT (C1+2a(ii))						
Sagittarius serpentarius		VU (A4acd)				5		
Salpornis spilonotus		LC				4		
Sarkidiornis melanotos		LC		3		4,5		
Sarothrura boehmi		LC	YES	2	8	5		
Sarothrura elegans		LC	P	4		5		
Sarothrura lugens		LC	YES	2	8	5		
Sarothrura pulchra		LC	YES	4*	5	5	YES	FH
Sarothrura rufa		LC	P	4		5		
Sasia africana		LC	P	2,4	1,3,5*			
Saxicola rubetra		LC		1*	4*			
Saxicola torquatus		LC		1*	4*			
Schoenicola brevirostris		LC						
Schoutedenapus myoptilus		LC	YES	4*	1	4,5		
Schoutedenapus schoutedeni	YES	VU (C2a(ii))	YES	2*,3*,4*	1,2,3,4*,5,8	4,5		
Scopus umbretta		LC						
Scotopelia bouvieri		LC		2	5*			
Scotopelia peli		LC						
Serinus burtoni		LC	P	4		5		
Serinus capistratus		LC				4		
Serinus frontalis		LC	YES	2*,4*	4	4		
Serinus koliensis		LC	YES	2*,4*	1,4*,5	4		
Serinus leucopygius		LC	P	1*,2,3*		4		
Serinus melanochrous		NT (B1ab(iii,v))	P	3		2,4		
Serinus mennelli		LC			7	4		
Serinus mozambicus		LC				4	YES	PD
Serinus reichardi		LC				4		
Serinus striolatus		LC	P	3,4		4		
Serinus sulphuratus		LC	P	4		4		
Sheppardia aequatorialis		LC		4*	4*			
Sheppardia cyornithopsis		LC		4	5			
Smithornis capensis		LC				5		
Smithornis rufolateralis		LC	YES	2,3,4	5	5		
Smithornis sharpei		LC	YES	2,3*	3,4	5		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Spermophaga haematina		LC			5	5		
Spermophaga poliogenys		LC	YES	3*,4*	1,4*,5	5	YES	FH
Spermophaga ruficapilla		LC	YES	2,4*	4	5	YES	FH
Sporopipes frontalis		LC	P	1*,2*,3*	4			
Stactolaema anchietae		LC	YES	2*,4	2,5*,7	1,4		
Stactolaema whytii		LC	YES	1,4	2	1,4		
Stephanoaetus coronatus		LC			1,3,4	5		
Sterna caspia		LC						
Sterna nilotica		LC						
Stigmatopelia senegalensis		LC	P	1			YES	FH;PD
Stiphrornis erythrothorax		LC			2,4,7		YES	FH
Stizorhina fraseri		LC			5	4	YES	FH
Streptopelia capicola		LC			4		YES	FH;PD
Streptopelia decipiens		LC	P	1,3	7			
Streptopelia lugens		LC	P	4	4			
Streptopelia semitorquata		LC					YES	FH;PD
Streptopelia vinacea		LC						
Strix woodfordii		LC	P	3*		1		
Sylvia atricapilla		LC		1*	4*			
Sylvia boehmi		LC		3*,4	5			
Sylvia borin		LC		1*	4*			
Sylvia communis		LC		1*	4*			
Sylvia lugens		LC						
Sylvia nisoria		LC		1*	4*			
Sylvietta brachyura		LC		1,2				
Sylvietta denti		LC		4	5			
Sylvietta rufescens		LC		3*,4	2,3			
Sylvietta ruficapilla		LC						
Sylvietta virens		LC			5			
Sylvietta whytii		LC						
Tachybaptus ruficollis		LC		1				
Tachymarptis aequatorialis		LC	YES	3*	1	4,5		
Tachymarptis melba		LC	P		1,2,3,4	4,5		
Tauraco leucolophus		LC		1,2	5			
Tauraco porphyreolophus		LC						
Tauraco schalowi		LC		2*,3*	4			
Tauraco schuetti		LC		2*,4*	3,4,5*			
Tchagra australis		LC		3				
Tchagra minutus		LC		4				
Tchagra senegalus		LC						
Telacanthura ussheri		LC	YES	2	3,4	4,5		
Telophorus bocagei		LC		2*,4*	5*			
Telophorus dohertyi		LC		1*,2*,3*	2,4*			
Telophorus multicolor		LC	P	2	5			
Telophorus sulfureopectus		LC		1,2*				
Terathopius ecaudatus		NT (A2acde)				5	YES	FH
Terpsiphone bedfordi	YES	NT (B1ab(i,ii,iii,iv,v))	YES	1,2*,3*,4	3,4*,5*	1	YES	FH

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Terpsiphone rufocinerea		LC		2*	5*			
Terpsiphone viridis		LC		1,2			YES	FH
Thalassornis leuconotus		LC				4,5		
Thescelocichla leucopleura		LC			5*	4		
Thripias namaquus		LC	P	3	2			
Thripias xantholophus		LC	P	2*	2,3,5*			
Tigriornis leucolopha		LC	P		1,3,4	4,5		
Tockus alboterminatus		LC			5	5		
Tockus camurus		LC			2,3,5*	5		
Tockus erythrorhynchus		LC	YES	1*,2,3*	2	5		
Tockus fasciatus		LC	YES	2	2,3,5,6	5		
Tockus hartlaubi		LC			1,2,3,5*	5		
Tockus nasutus		LC	YES	1,3	2	5		
Tockus pallidirostris		LC			2	5		
Torgos tracheliotos		VU (C2a(ii))	YES	1,3*,4	4,8	5		
Trachyphonus darnaudii		LC	YES	3	4*	1,4		
Trachyphonus purpuratus		LC	YES	2,4	3,4	1,4	YES	FH
Trachyphonus vaillantii		LC	YES	3	2	1,4		
Treron calvus		LC					YES	FH
Treron waalia		LC	P	1,2,3				
Tricholaema frontata		LC	P		2,3	1,4		
Tricholaema hirsuta		LC	P		3,5*	1,4		
Tricholaema lacrymosa		LC	YES	4	5	1,4		
Trigonoceps occipitalis		VU (C2a(ii))	YES	3*,4*	8	5		
Tringa erythropus		LC	YES	1*	4	2		
Tringa nebularia		LC		1*				
Tringa ochropus		LC		1*	4,7			
Tringa stagnatilis		LC						
Tringa totanus		LC		1*	4*			
Trochocercus cyanomelas		LC		3	4			
Trochocercus nitens		LC			3,4			
Tropicranus albocristatus		LC			2,3,5*	5	YES	FH
Turdoides hartlaubii		LC	P	3*,4		1		
Turdoides jardineii		LC				1		
Turdoides plebejus		LC	P	1,2,3		1		
Turdoides sharpei		LC	YES	2*,4*	4	1		
Turdoides tenebrosa		LC	P	1,2*,4*		1		
Turdus libonyanus		LC	P	3		4		
Turdus pelios		LC				4		
Turnix sylvaticus		LC				4		
Turtur abyssinicus		LC	P	1*,2,3*				
Turtur afer		LC	P	4				
Turtur brehmeri		LC	YES	2,4	5*	1		
Turtur chalcospilos		LC	YES	1*,2*,3*	4	1		
Turtur tympanistria		LC			5		YES	FH;PD
Tyto alba		LC				4		
Tyto capensis		LC				4		

Table A2. Birds, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S12)	Low Adaptability (traits A1–A3)	Important for human use?	Uses
Uraeginthus angolensis		LC	P	3*		5		
Uraeginthus bengalus		LC	P	1		5	YES	PD
Urocolius indicus		LC	YES	3*,4	4	4		
Urocolius macrourus		LC	YES	1	4	4		
Urolestes melanoleucus		LC		3*,4	4			
Urotriorchis macrourus		LC	YES	2	1,3,5*	5		
Vanellus albiceps		LC		2	1,3,4			
Vanellus armatus		LC		3*,4	4			
Vanellus coronatus		LC		3*,4	4*			
Vanellus crassirostris		LC		1,3*,4				
Vanellus lugubris		LC						
Vanellus senegallus		LC		1,3				
Vanellus spinosus		LC		1,2				
Vanellus superciliosus		LC		2,4*	1,3,4,8			
Vanellus tectus		LC		1*,2*,3	4			
Vidua chalybeata		LC	P	1		4		
Vidua codringtoni		LC	P	3		4		
Vidua macroura		LC				4		
Vidua obtusa		LC				4		
Vidua purpurascens		LC	P	3*,4		4		
Vidua wilsoni		LC	YES	1,2*	2,3,5,7	4		
Zoothera camaronensis		LC	YES	2*,4*	2,3,8	1,4		
Zoothera crossleyi		NT (B1ab(i,ii,iii))	YES	4	5,7	1,4		
Zoothera gurneyi		LC	P		5,7	1,4		
Zoothera oberlaenderi	YES	NT (B1ab(i,ii,iii,iv,v))	YES	2*,3*,4*	3,4*	1,4		
Zoothera piaggiae		LC	YES	2*,4	5	1,4		
Zoothera princei		LC	P		3,4	1,4		
Zoothera tanganjicae	YES	NT (B1ab(i,ii,iii))	YES	4*	1	1,4		

Table A3. All freshwater fish species considered in this assessment including Red List categories and criteria (IUCN 2011), climate change vulnerability (P = vulnerable under a pessimistic assumption of missing data values) including individual climate change vulnerability traits (please refer to Tables 5.2, 5.3 and 5.4 for trait descriptions; asterisks denote 'Very High' scores for the traits indicated), importance for human use and use types (please see key at the beginning of these appendices).

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Acapoeta tanganicae	LC	YES	2*,4*	2,9,15,18	1	YES	FH	YES
Alestes baremoze	LC	P	3	9,11,13		YES	FH	
Alestes dentex	LC	P	3			YES	FH	
Alestes liebrechtsii	LC			6				
Alestes macrophthalmus	LC			6		YES	U	
Altolamprologus calvus	NT	P	1,2,4	1,18		YES	PD	YES
Altolamprologus compressiceps	LC	P	1,2,4	1,18		YES	PD	YES
Amphilius brevis	LC			2,3,4,6*	1*,2			
Amphilius jacksonii	LC			1,2,3,4	1*,2			
Amphilius uranoscopus	LC			2,3,4	1*,2			
Amphilius zairensis	LC	YES	3*	2,3,4,5,6*	1*,2			

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Aphyosemion christyi	LC	P	3*	5,6*		YES	PD	
Aplocheilichthys bukobanus	LC	P	4*	5*		YES	PD	
Aplocheilichthys centralis	LC			5				
Aplocheilichthys fuelleborni	LC			5,18				
Aplocheilichthys hutereaui	LC					YES	PD	
Aplocheilichthys johnstoni	LC		3*			YES	PD	
Aplocheilichthys pumilus	LC			18	2	YES	PD	
Aplocheilichthys vitschumbaensis	LC	P	3,4*	5*		YES	PD	
Astatoreochromis alluaudi	LC	P	4*	5*,7		YES	PD	
Astatoreochromis straeleni	LC	P	4*	1,5,7		YES	PD	
Astatoreochromis vanderhorsti	LC			1,7		YES	PD	
Astatotilapia burtoni	LC			7		YES	PD	
Astatotilapia paludinosa	LC			6*,7,18				
Astatotilapia stappersii	LC			7				
Auchenoglanis occidentalis	LC		3			YES	FH;PD	
Aulonocranus dewindti	LC		4*			YES	FH;PD	YES
Bagrus bajad	LC		3*			YES	FH;SH	
Bagrus docmak	LC					YES	FH;MH;SH	
Bagrus ubangensis	LC			5,6*				
Baileychromis centropomoides	LC	P	1,2,4	1,17*,18*		YES	PD	YES
Barbus acuticeps	EN (A2bcd)	P	3	2,5*,6*,9,11, 13,17*,18				
Barbus alluaudi	VU (D2)	YES	3*	1,4,5*,17*,18*	1	YES	FH	
Barbus altianalis	LC	P	4	2,5,9,11,13		YES	FH;SH	
Barbus apleurogramma	LC			5		YES	FH	
Barbus brachygramma	DD			6				
Barbus brevidorsalis	LC					YES	PD	
Barbus bynni	LC			5				
Barbus cercops	NE	P	3	5		YES	FH	
Barbus eutaenia	DD	P	3	2,9,11,13		YES	FH;PD	
Barbus huloti	VU (D2)	P	1*,2*,3*	1,5*,6,17,18				
Barbus humeralis	LC			5,6*				
Barbus innocens	LC					YES	PD	
Barbus jacksoni	LC			5,9,11		YES	FH	
Barbus jae	LC	P	3	6,7		YES	PD	
Barbus kerstenii	LC			4	1*	YES	PD	
Barbus lineomaculatus	LC	P	3	9,11,13		YES	FH;PD	
Barbus longifilis	DD	P	3*,4*	5*				
Barbus luapulae	LC			17,18				
Barbus lufukiensis	NT	P	4*	1,17,18				
Barbus luikae	LC			17				
Barbus lukindae	DD			6				
Barbus macroceps	DD	P	3*	5*,6*				
Barbus macrolepis	NT	P	3	9,11				
Barbus mawambi	DD	P	2*,3*	5*,6*				
Barbus mawambiensis	LC			5,6*				

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Barbus miolepis	LC			2,9,11,13		YES	PD	
Barbus mirabilis	DD	P	2*,3*	5*,6*,17				
Barbus neumayeri	LC			5				
Barbus nyanzae	LC	P	3	5*,9,11,13,17				
Barbus oligogrammus	LC							
Barbus olivaceus	LC			1,17				
Barbus paludinosus	LC		3			YES	FH	
Barbus paucisquamatus	DD	P	3*	5				
Barbus pellegrini	LC			1,5				
Barbus perince	LC		3			YES	FH	
Barbus quadralineatus	EN (B1ab(i,ii,iii,iv,v)+2 ab(i,ii,iii,iv,v))			1,6,17*				
Barbus radiatus	LC	P	3			YES	PD	
Barbus ruasae	CR (B1ab(ii,iii)+2ab(ii,iii))			1,2,4,5*,6,17*,18*	1*			
Barbus somereni	LC			1,2,4,5	1*	YES	FH	
Barbus stappersii	LC			2,9,11				
Barbus stigmatopygus	LC	P	3					
Barbus taeniopleura	LC							
Barbus tetrastigma	DD			5,6		YES	FH	
Barbus trachypterus	LC	P	3	17				
Barbus trinotatus	LC	P	3*	5*,17,18				
Barbus tropidolepis	LC			9,11		YES	FH	
Barbus unitaeniatus	LC	P	3*	5		YES	PD	
Barbus urostigma	LC		3,4*					
Bathybagrus sianenna	LC		1,2,4			YES	MH	YES
Bathybagrus tetranema	LC		1,2,4	1				YES
Bathybates fasciatus	LC	P	1,2,4	1		YES	PD	YES
Bathybates ferox	LC	P	1,2,4	1		YES	FH;PD	YES
Bathybates graueri	LC	P	1,2,4	1		YES	FH;PD	YES
Bathybates hornii	LC	P	1,2,4	1		YES	FH;PD	YES
Bathybates leo	LC	P	1,2,4	1		YES	FH;PD	YES
Bathybates minor	LC		1,2,4			YES	FH;PD	YES
Bathybates vittatus	LC	P	1,2,4	1		YES	FH;PD	YES
Benthochromis melanoides	LC	P	1,2,4	1		YES	PD	YES
Benthochromis tricoti	LC	P	1,2,4	1		YES	PD	YES
Boulengerochromis microlepis	LC		1,2,4	1		YES	PD;SH	YES
Brachypetersius cadwaladeri	LC		4*					
Brachypetersius pseudonummifer	LC	P	3*	5,6*				
Brycinus bimaculatus	LC			5,6*				
Brycinus grandisquamis	LC			6				
Brycinus imberi	LC			9,11		YES	FA;PD	
Brycinus jacksonii	EN (A2acde)			5				
Brycinus kingsleyae	LC	P	3	6				
Brycinus lateralis	LC	P	3	9,11		YES	PD	
Brycinus macrolepidotus	LC					YES	U	
Brycinus nurse	LC	P	3			YES	FH;PD	

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Brycinus rhodopleura	LC	P	1,2,4			YES	U	YES
Brycinus sadleri	LC	P	3	5,6		YES	U	
Bryconaethiops boulengeri	LC			6		YES	U	
Bryconaethiops macrops	LC			6		YES	U	
Bryconaethiops microstoma	LC			6				
Callochromis macrops	LC		1,2,4			YES	FH;PD	YES
Callochromis melanostigma	LC	P	1,2,4	1		YES	FH;PD	YES
Callochromis pleurospilus	LC		1,2,4			YES	FH;PD	YES
Callochromis stappersii	DD	P	1,2,4	1		YES	U	YES
Campylomormyrus bredoi	VU (B1ab(v))			1,16,17,18				
Campylomormyrus elephas	LC			6				
Campylomormyrus numenius	LC			5,6*				
Campylomormyrus orycteropus	DD			6				
Cardiopharynx schoutedeni	LC	P	1,2,4	1		YES	FH;PD	YES
Chalinochromis brichardi	LC	P	1,2,4	1,8		YES	PD	YES
Chelaethiops congicus	LC							
Chelaethiops minutus	LC	P	1,2,4	1				YES
Chiloglanis asymetricaudalis	EN (B2ab(ii,iii))	YES	4	1,3,4,5,15,17*,18	1*,2			YES
Chiloglanis batesii	LC			3,4,6,15	1*,2	YES	FH;PD	
Chiloglanis kalambo	VU (D2)			1,3,4,15,17*,18*	1*,2			
Chiloglanis lukugae	LC			3,4,15	1*,2			
Chiloglanis marlieri	DD	YES	3*,4*	3,4,5*,15	1*,2			
Chiloglanis mbozi	VU (D2)			3,16*,17*,18*	1*,2			
Chiloglanis pojeri	LC	YES	3,4*	3,4,6,15	1*,2			
Chiloglanis rukwaensis	VU (D2)			1,3,4,15,17*,18*	1*,2			
Chiloglanis ruziziensis	CR (B1ab(iii)+2ab(iii))	YES	4	1,3,4,5,15,17*,18*	1*,2			YES
Chromidotilapia schoutedeni	LC	P	3*	5,6				
Chrysichthys brachynema	LC		1,2,4			YES	FH	YES
Chrysichthys cranchii	LC			6				
Chrysichthys grandis	LC		1,2,4	1		YES	U	YES
Chrysichthys graueri	LC		1,2,4	1		YES	U	YES
Chrysichthys mabusi	LC					YES	FH	
Chrysichthys platycephalus	LC		1,2,4	1				YES
Chrysichthys sharpii	LC							
Chrysichthys stappersii	LC		1,2,4	1		YES	U	YES
Chrysichthys thonneri	LC			5,6*				
Citharinus citharus ssp. citharus	NE	P	3*	9,11		YES	PD	
Citharinus gibbosus	LC			6*		YES	U	
Citharinus latus	LC	P	3			YES	FH	
Clariallabes laticeps	LC			5,6*				
Clariallabes mutsindoziensis	EN (B1ab(i,ii,iii)+2ab(i,ii,iii))			17*,18*				
Clarias alluaudi	LC			5		YES	FH;MH	
Clarias angolensis	LC			6		YES	PD	
Clarias buthupogon	LC			6				
Clarias camerunensis	LC			6		YES	FH	

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Clarias dhonti	LC		3,4*			YES	MH	
Clarias dumerilii	LC							
Clarias gariepinus	NE		3	9,11,13		YES	FH;MH;SH	
Clarias hilli	LC			5,6				
Clarias liocephalus	LC			4	1	YES	FH;MH	
Clarias ngamensis	LC	P	3	9,11,13		YES	PD;SH	
Clarias stappersii	LC	P	3	9,11,13		YES	U	
Clarias theodorae	LC		3			YES	PD	
Clarias werneri	LC			5		YES	FH;MH	
Clypeobarbus congicus	LC			5,6*,9,11,13		YES	PD	
Clypeobarbus pseudognathodon	NT			9,11,13				
Congochromis squamiceps	LC			5,6*				
Ctenochromis benthicola	LC	P	1,2,4	1,17				YES
Ctenochromis horei	LC	P	4*	7		YES	U	
Ctenopoma multispine	LC	P	3			YES	PD	
Ctenopoma muriei	LC							
Cunningtonia longiventralis	LC	P	1,2,4	1,17		YES	PD	YES
Cyathopharynx furcifer	LC	P	1,2,4	1		YES	PD	YES
Cyphomyrus discorhynchus	LC	P	3	9,11		YES	PD	
Cyphomyrus psittacus	LC					YES	U	
Cyphotilapia frontosa	LC	P	1,2,4	1		YES	FH;PD	YES
Cyprichromis leptosoma	LC	P	1,2,4	1,17		YES	PD	YES
Cyprichromis microlepidotus	DD	P	1,2,4	1		YES	PD	YES
Dinotopterus cunningtoni	NT		1,2,4	1		YES	FH	YES
Distichodus affinis	LC	P	3	5,6*,9,11		YES	PD	
Distichodus antonii	LC			6*,9,11				
Distichodus fasciolatus	LC			6*,9,11		YES	PD	
Distichodus lusosso	LC			6*,9,11		YES	PD	
Distichodus maculatus	LC			9,11		YES	FH	
Distichodus rostratus	LC	P	3*	9,11		YES	U	
Doumea alula	LC			2				
Ectodus descampsi	LC	P	1,2,4	1		YES	FH;PD	YES
Eretmodus cyanostictus	NT	YES	1,2,4	1,15	2	YES	PD	YES
Euchilichthys guentheri	LC	YES	3	5,6*	1			
Euchilichthys royauxi	LC	YES	3	5,6*	1			
Fenerbahce formosus	LC	P	3	5,6*		YES	PD	
Garra dembeensis	LC			2,9,15		YES	U	
Gephyroglanis congicus	LC			5,6*				
Gnathochromis permaxillaris	LC	P	1,2,4	1		YES	PD	YES
Gnathochromis pfefferi	LC		4*			YES	PD	
Gnathonemus longibarbis	LC	P	3	5		YES	FH	
Gnathonemus petersii	LC			6		YES	U	
Grammatotria lemairii	LC	P	1,2,4	1		YES	PD	YES
Greenwoodochromis bellcrossi	LC	P	1,2,4	1,17*		YES	PD	YES
Greenwoodochromis christyi	LC	P	1,2,4	1		YES	PD	YES
Haplochromis aeneocolor	VU (D2)	P	3	5*,7,17*,18*				

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Haplochromis angustifrons	LC	P	1*,2*,3*	5*,6,7,17*				YES
Haplochromis crebidens	LC	P	4*	1,5*,6,7,17*		YES	FH	YES
Haplochromis eduardianus	LC	P	3	5*,7,17*,18				
Haplochromis elegans	LC	P	3	5*,7,17*,18				
Haplochromis erythromaculatus	EN (B1ab(iii)+2ab(iii))			5,6,7,17*,18*				
Haplochromis gracilior	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis graueri	LC	P	4*	5,7,17*,18		YES	FH	YES
Haplochromis insidae	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis kamiranzovu	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis katavi	VU (D2)			7,17*,18*				
Haplochromis labiatus	NT	P	3	5*,7,17*,18				
Haplochromis limax	LC	P	1*,2*,3*	5*,6,7,15,17*,18				YES
Haplochromis loati	DD	P	1*,3*	5*,7				
Haplochromis macropsoides	LC	P	3	1,5*,7,17				
Haplochromis microchrysomelas	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis mylodon	LC	P	3	5*,7,17*,18				
Haplochromis nigripinnis	LC	P	3	5*,7,17*,18				
Haplochromis nigroides	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis occultidens	LC	P	4*	1,5*,6,7,14,17*,18		YES	FH	YES
Haplochromis olivaceus	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis oregosoma	NT	P	3	5*,7,17*,18*				
Haplochromis pappenheimi	LC	P	3	5*,7,17*				
Haplochromis paucidens	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis petronius	VU (D2)	P	1*,2*,3*	1,5*,6*,7,15,17*,18*				YES
Haplochromis rubescens	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis scheffersi	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplochromis schubotzi	LC	P	3	5*,7,17*,18				
Haplochromis schubotziellus	LC	P	3	5*,7,17*,18				
Haplochromis squamipinnis	LC	P	3	5*,7,17*				
Haplochromis stigmatogenys	LC							
Haplochromis taurinus	LC	P	3	5*,7,17*,18				
Haplochromis vittatus	LC	P	4*	1,5*,6,7,17*,18		YES	FH	YES
Haplotaxodon microlepis	LC	P	1,2,4	1		YES	FH;PD	YES
Hemibates stenosoma	LC	P	1,2,4	1		YES	PD	YES
Hemichromis elongatus	LC		3					
Hepsetus odoe	LC			9,11,13		YES	FH;PD;SH	
Heterobranchus longifilis	LC					YES	SH	
Hydrocynus forskahlii	LC			9,11,13		YES	FH;SH	
Hydrocynus vittatus	LC	P	3	9,11,13		YES	FH;SH	
Hypsopanchax modestus	LC	P	3*	5*				
Hypsopanchax platysternus	LC	P	3*	5,6		YES	PD	
Julidochromis dickfeldi	LC	P	1,2,4	1,17*,18*		YES	PD	YES
Julidochromis marlieri	LC	P	1,2,4	1,17*,18		YES	PD	YES
Julidochromis ornatus	LC	P	1,2,4	1,17*		YES	PD	YES
Julidochromis regani	LC	P	1,2,4	1,17		YES	PD	YES

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Julidochromis transcriptus	LC	P	1,2,4	1,17*,18*		YES	PD	YES
Kneria auriculata	LC	YES	3	2,4,9,11	1*			
Kneria paucisquamata	LC			2,4,9,11,17*,18*	1*			
Kneria rukwaensis	LC			1,2,4,9,11	1*			
Kneria wittei	LC			2,4,9,11	1*	YES	U	
Labeo altivelis	LC	P	3	2,9,11,15		YES	SH	
Labeo annectens	LC			2,6,9,11,15				
Labeo congoro	LC	P	3	2,9,11,15		YES	SH	
Labeo coubie	LC	P	3	2,9,11,15		YES	FH;PD	
Labeo cylindricus	LC			2,9,11,15		YES	FH;PD	
Labeo dhonti	LC			2,6,9,11,15				
Labeo forskalii	LC	P	3	2,9,11,15		YES	FH	
Labeo fuelleborni	DD			2,9,11,15		YES	FH	
Labeo greenii	LC			2,6,9,11,15				
Labeo horie	NE	P	3*	2,5,9,11,15		YES	FH	
Labeo longipinnis	LC			2,6,9,11,15		YES	FH	
Labeo lukulae	LC			2,6,9,11,15				
Labeo nasus	LC	P	3	2,5,6*,9,11,15				
Labeo parvus	LC			2,9,11,15		YES	PD	
Labeo polli	DD	P	3	2,9,11,15				
Labeo victorianus	LC	P	3	2,5,9,11,15		YES	FH	
Labeo weeksii	LC			2,6,9,11,15		YES	PD	
Labeobarbus caudovittatus	LC			6,9,11				
Laciris pelagicus	LC	P	1*,2*,3*	1,5*,6,17*				YES
Lacustricola matthesi	LC			1,6				
Lacustricola moeruensis	LC							
Lamprichthys tanganicanus	LC		1,2,4			YES	PD	YES
Lamprologus callipterus	LC		1,2,4			YES	PD	YES
Lamprologus finalimus	DD	P	1,2,4	1		YES	PD	YES
Lamprologus kungweensis	CR (B1ab(iii)+2ab(iii))	P	1,2,4	1,17*,18*		YES	PD	YES
Lamprologus lemairii	LC	P	1,2,4	1		YES	FH	YES
Lamprologus ocellatus	LC	YES	1,2,4	1	2	YES	PD	YES
Lamprologus ornatipinnis	LC	P	1,2,4	1		YES	PD	YES
Lamprologus signatus	LC	P	1,2,4	1,17		YES	PD	YES
Lates angustifrons	EN (A2bcd)		1,2,4	1		YES	FH;SH	YES
Lates macrophthalmus	EN (B1ab(iii))		1*,2*,3*	1,5*,6,17*		YES	SH	YES
Lates mariae	VU (A2bcd)		2*,4*	1		YES	FH;SH	YES
Lates microlepis	EN (A2bcd)		1,2,4	1		YES	FH;SH	YES
Lates niloticus	LC					YES	FH;MH;SH	
Lates stappersii	LC		1,2,4	1		YES	FH	YES
Lepidiolamprologus attenuatus	NT	P	1,2,4	1		YES	FH;PD	YES
Lepidiolamprologus cunningtoni	LC	P	1,2,4	1		YES	FH;PD	YES
Lepidiolamprologus elongatus	LC	P	1,2,4	1		YES	FH;PD	YES
Lepidiolamprologus kendalli	DD	P	1,2,4	1		YES	PD	YES
Lepidiolamprologus nkambae	DD	P	1,2,4	1		YES	PD	YES
Lepidiolamprologus profundicola	LC	P	1,2,4	1		YES	FH;PD	YES

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Leptocypris lujae	LC			5,6*,9				
Lestradea perspicax	LC	P	1,2,4	1,17		YES	FH;PD	YES
Lestradea stappersii	LC	P	1,2,4	1,17		YES	PD	YES
Limnochromis abeelei	LC	P	1,2,4	1		YES	PD	YES
Limnochromis auritus	LC	P	1,2,4	17		YES	FH;PD	YES
Limnochromis staneri	LC	P	1,2,4	1,17		YES	FH;PD	YES
Limnothrissa miodon	LC	P	1,2,4	1		YES	FA;FH	YES
Limnotilapia dardennii	LC	P	1,2,4	15		YES	FH;PD	YES
Lobochilotes labiatus	LC	P	1,2,4	15		YES	FH;PD	YES
Lophiobagrus aquilus	LC	P	1,2,4	1				YES
Lophiobagrus brevispinis	LC	P	1,2,4	1				YES
Lophiobagrus cyclurus	LC	P	1,2,4	1				YES
Malapterurus electricus	LC		3			YES	FH;PD;SH	
Malapterurus melanochir	LC	P	4*	5,6*,18				
Malapterurus tanganyikaensis	NE	P						
Marcusenius monteiri	LC			6		YES	U	
Marcusenius stanleyanus	LC			6		YES	FH	
Mastacembelus albomaculatus	LC	P	1,2,4	1				YES
Mastacembelus congicus	LC			6				
Mastacembelus cunningtoni	LC		1,2,4			YES	PD	YES
Mastacembelus ellipsifer	LC	P	1,2,4	1		YES	PD	YES
Mastacembelus flavidus	LC	P	1,2,4	1		YES	U	YES
Mastacembelus frenatus	LC					YES	PD	
Mastacembelus micropectus	LC	P	1,2,4	1		YES	U	YES
Mastacembelus moeruensis	LC							
Mastacembelus moorii	LC		1,2,4			YES	U	YES
Mastacembelus ophidium	LC	P	1,2,4	1		YES	PD	YES
Mastacembelus plagiostomus	LC	P	1,2,4	1		YES	U	YES
Mastacembelus platysoma	LC	P	1,2,4	1		YES	U	YES
Mastacembelus stappersii	LC							
Mastacembelus tanganicae	LC	P	1,2,4	1		YES	U	YES
Mastacembelus zebratus	LC	P	1,2,4	1		YES	U	YES
Mesobola spinifer	LC					YES	U	
Mesoborus crocodilus	LC			5,6*				
Micralestes acutidens	LC	P	3	2,9,11		YES	FA;PD	
Micralestes humilis	LC			2,6,9,11		YES	PD	
Micralestes sardina	LC			2,9,11				
Micralestes stormsi	LC			6				
Micralestes vittatus	DD			1				
Microctenopoma damasi	LC	P	3*	1,5*				
Microctenopoma intermedium	LC		3			YES	PD	
Microctenopoma nanum	LC			6		YES	PD	
Microctenopoma uelense	LC	P	3	5,6*				
Micropanchax loati	LC			5		YES	PD	
Mormyrops anguilloides	LC					YES	FH	
Mormyrops attenuatus	LC			5,6*				
Mormyrus caballus ssp. asinus	NE			9,11				

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Mormyrus caballus ssp. lualabae	NE	P	3,4*	6,9,11				
Mormyrus caschive	LC	P	3	9,11				
Mormyrus longirostris	LC			9,11		YES	PD;SH	
Mormyrus macrocephalus	LC			5,6,9,11		YES	FH	
Mormyrus niloticus	DD	P	3*	5,9,11				
Myomyrus macrops	LC			5,6*				
Nannocharax luapulae	LC							
Neobola moeruensis	LC			17				
Neolamprologus boulengeri	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus brevis	LC	YES	1,2,4	1,18	2	YES	PD	YES
Neolamprologus brichardi	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus buescheri	DD	P	1,2,4	1		YES	PD	YES
Neolamprologus caudopunctatus	LC	P	1,2,4	1,17*,18*		YES	PD	YES
Neolamprologus christyi	VU (D2)	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus crassus	LC	P	1,2,4	1,17*,18*				YES
Neolamprologus falcicula	LC	P	1,2,4	1				YES
Neolamprologus fasciatus	LC	P	1,2,4	1				YES
Neolamprologus furcifer	LC	P	1,2,4	1		YES	PD	YES
Neolamprologus gracilis	LC	P	1,2,4	1,17*,18*				YES
Neolamprologus hecqui	LC	P	1,2,4	1		YES	PD	YES
Neolamprologus leleupi	LC	P	1,2,4	1,17		YES	PD	YES
Neolamprologus leloupi	LC	P	1,2,4	1		YES	PD	YES
Neolamprologus longior	LC	P	1,2,4	1,17				YES
Neolamprologus meeli	LC	P	1,2,4	1,17*,18*		YES	PD	YES
Neolamprologus modestus	LC	P	1,2,4	1,18		YES	PD	YES
Neolamprologus mondabu	LC	P	1,2,4	1,18		YES	PD	YES
Neolamprologus moorii	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus multifasciatus	LC	YES	1,2,4	1	2	YES	PD	YES
Neolamprologus mustax	LC	P	1,2,4	1,17		YES	PD	YES
Neolamprologus niger	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus obscurus	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus olivaceous	DD	P	1,2,4	1				YES
Neolamprologus petricola	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus pleuromaculatus	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus prochilus	LC	P	1,2,4	1,17*,18*		YES	PD	YES
Neolamprologus pulcher	LC	P	1,2,4	1,17,18		YES	PD	YES
Neolamprologus savoryi	LC	P	1,2,4	1,18		YES	PD	YES
Neolamprologus schreyeni	VU (D2)	P	1,2,4	1,17*,18*		YES	PD	YES
Neolamprologus sexfasciatus	LC	P	1,2,4	1,17		YES	PD	YES
Neolamprologus splendens	LC	P	1,2,4	1,17*,18*				YES
Neolamprologus tetracanthus	LC	P	1,2,4	1		YES	FH;PD	YES
Neolamprologus tetrocephalus	LC	P	1,2,4	17		YES	PD	YES
Neolamprologus toae	LC	P	1,2,4	1,17		YES	PD	YES
Neolamprologus wauthioni	DD	P	1,2,4	1		YES	PD	YES
Neolebias trewavasae	LC	P	3	6*				

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Nothobranchius robustus	DD	YES	4*	5*,10	2			
Nothobranchius taeniopygus	LC	YES	3	5,10	2	YES	PD	
Nothobranchius ugandensis	LC			1,5,10	2			
Ophthalmotilapia boops	LC	P	1,2,4	1,17				YES
Ophthalmotilapia heterodonta	LC	P	1,2,4	1,17		YES	PD	YES
Ophthalmotilapia nasuta	LC	P	1,2,4	1,17		YES	PD	YES
Ophthalmotilapia ventralis	LC	P	1,2,4	1,17		YES	FH;PD	YES
Opsaridium splendens	DD			1,6				
Opsaridium ubangiense	LC		3	6				
Oreochromis karomo	CR (B1ab(iii)+2ab(iii))			6*,17*,18*		YES	FH;PD	
Oreochromis leucostictus	LC	P	4*	5		YES	FH;PD	
Oreochromis mweruensis	LC			17				
Oreochromis niloticus eduardianus	NE	P				YES	FH	
Oreochromis rukwaensis	VU (D2)			17		YES	U	
Oreochromis tanganicae	LC		1,2,4			YES	FH;PD	YES
Oreochromis upembae	LC	P	3,4*	6		YES	FH	
Oreochromis variabilis	CR (B1ab(i,ii,iii,iv,v))	P	3*	5,17*,18*		YES	FH;PD	
Orthochromis kalungwishiensis	LC			4,17*,18*	1*,2			
Orthochromis luichensis	VU (D2)	YES	4*	1,4,6,17*,18*	1*,2	YES	FH	
Orthochromis mosoensis	EN (B1ab(iii)+2ab(iii))			1,4,6,17*,18*	1*			
Orthochromis polyacanthus	LC	YES	3,4*	4,6*	1*			
Orthochromis rugufuensis	VU (D2)			4,6,17*,18*	1*,2			
Orthochromis stormsi	LC	P	3,4*	6				
Orthochromis uvinzae	CR (B1ab(iii)+2ab(iii))			1,4,6,17*,18*	1*			
Paracyprichromis brieni	LC	P	1,2,4	1		YES	PD	YES
Paracyprichromis nigripinnis	LC	P	1,2,4	1		YES	PD	YES
Parakneria cameronensis	LC	YES	3	2,4,5,6*,9,11	1*			
Parakneria kissi	DD	YES	3*	2,4,5*,9,11	1*			
Parauchenoglanis balayi	LC		3	6*				
Parauchenoglanis punctatus	LC			5,6				
Pareutropius debauwi	LC	P	3	6		YES	PD	
Perissodus eccentricus	DD	P	1,2,4	1,14		YES	PD	YES
Perissodus microlepis	LC	P	1,2,4	1,14		YES	PD	YES
Petrocephalus catostoma ssp. catostoma	NE			9,11		YES	FH;PD	
Petrocephalus christyi	LC			6*				
Petrocephalus simus	LC			6,9,11		YES	U	
Petrocephalus squalostoma	DD			17*,18*				
Petrochromis famula	LC	YES	1,2,4	1,14,15,17,18	2	YES	PD	YES
Petrochromis fasciolatus	LC	P	1,2,4	1,14,15		YES	FA;PD	YES
Petrochromis macrognathus	DD	P	1,2,4	1,14,15		YES	FA;PD	YES
Petrochromis orthognathus	LC	P	1,2,4	1,14,15		YES	FA;PD	YES
Petrochromis polyodon	LC	P	1,2,4	1,14,15		YES	PD	YES
Petrochromis trewavasae	LC	P	1,2,4	1,14,15		YES	FA;PD	YES
Phractura lindica	LC	P	3	5,6				
Phractura tenuicauda	LC			5,6*				

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Phyllonemus filinemus	LC	P	1,2,4	1				YES
Phyllonemus typus	LC	P	1,2,4	1				YES
Plecodus elaviae	LC	P	1,2,4	1,17				YES
Plecodus multidentatus	LC	P	1,2,4	1				YES
Plecodus paradoxus	LC		1,2,4			YES	FH	YES
Plecodus straeleni	LC	P	1,2,4	1,14				YES
Poecilothrissa moeruensis	VU (B1ab(v))			1,17		YES	U	
Pollimyrus nigricans	LC			5,9				
Pollimyrus petherici	LC	P	3					
Pollimyrus stappersii ssp. stappersii	NE							
Polypterus ornatipinnis	LC			6		YES	FH;PD	
Polypterus senegalus ssp. senegalus	NE		3			YES	FH	
Potamothrissa obtusirostris	LC	P	3	5,6*		YES	FH	
Protopterus aethiopicus ssp. aethiopicus	NE			5,12		YES	FH;MH	
Protopterus annectens	LC	P	3*	12				
Pseudocrenilabrus philander ssp. dispersus	NE			6				
Pseudocrenilabrus philander ssp. philander	NE	P	3*			YES	U	
Pseudosimochromis curvifrons	LC	P	1,2,4	1,15		YES	PD	YES
Raiamas moorii	LC	P	3,4*	5		YES	FH	
Raiamas salmolucius	LC			6				
Rastrineobola argentea	LC	P	3*	1,5		YES	FA;FH	
Reganochromis calliurus	LC	P	1,2,4	1		YES	PD	YES
Rhabdalestes rhodesiensis	LC			9,11		YES	PD	
Sargochromis mellandi	LC					YES	PD	
Sarotherodon galilaeus ssp. galilaeus	NE	P	3			YES	FH;PD	
Schilbe banguelensis	LC			9,11				
Schilbe grenfelli	LC			6,9,11				
Schilbe intermedius	LC	P	3	9,11		YES	FH	
Schilbe marmoratus	LC			5,6*,9,11		YES	PD	
Schilbe mystus	LC	P	3	9,11		YES	PD;SH	
Schilbe uranoscopus	LC	P	3	9,11				
Serranochromis angusticeps	LC		3*			YES	PD;SH	
Serranochromis janus	DD			6*				
Serranochromis macrocephalus	LC		3*			YES	SH	
Serranochromis stappersi	LC			17				
Serranochromis thumbergi	LC		3			YES	SH	
Simochromis babaulti	LC	P	1,2,4	1,15		YES	FH;PD	YES
Simochromis diagramma	LC	P	1,2,4	15		YES	FH;PD	YES
Simochromis loocki	LC	P	1,2,4	1,15,17				YES
Simochromis margaretae	VU (D2)	P	1,2,4	1,15,17*,18*		YES	FH;PD	YES
Simochromis marginatus	VU (D2)	YES	1,2,4	1,15,17	2	YES	FH;PD	YES
Simochromis pleurospilus	LC	P	1,2,4	1,15,17*,18*		YES	FH;PD	YES
Spathodus erythrodon	LC	YES	1,2,4	1,15	2	YES	PD	YES

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Spathodus marlieri	LC	YES	1,2,4	1,15,17*,18*	2	YES	PD	YES
Stolothrissa tanganicae	LC	P	1,2,4	1		YES	FH	YES
Stomatorhinus patrizii	LC			5,6*				
Synodontis acanthomias	LC	P	3	5,6*				
Synodontis afrofischeri	LC			5				
Synodontis alberti	LC			5,6*		YES	PD	
Synodontis angelicus	LC			5,6*		YES	PD	
Synodontis decorus	LC			5,6*		YES	PD	
Synodontis dhonti	LC	P	1,2,4	1				YES
Synodontis frontosus	LC			5,9,11		YES	FH	
Synodontis fuelleborni	LC							
Synodontis granulosus	LC	P	1,2,4	1,17		YES	PD	YES
Synodontis greshoffi	LC			5,6*				
Synodontis iturii	DD	P	2*,3*	5*,6*				
Synodontis katangae	LC							
Synodontis khartoumensis	DD	P	3*	5		YES	FH	
Synodontis lacustricolus	LC	P	1,2,4	1		YES	U	YES
Synodontis maculipinna	LC	P	3*	1,17				
Synodontis multipunctatus	LC	P	1,2,4	1,14		YES	FH;PD	YES
Synodontis nigrita	LC		3					
Synodontis nigromaculatus	LC					YES	FH;PD;SH	
Synodontis petricola	LC	P	1,2,4	1,14		YES	PD	YES
Synodontis polli	LC	P	1,2,4	1				YES
Synodontis polystigma	LC							
Synodontis ricardoae	LC			17				
Synodontis ruandae	VU (D2)	P	3	1,5*,6*,17,18				
Synodontis schall	LC		3			YES	SH	
Synodontis unicolor	LC			17				
Synodontis victoriae	NT	P	3	5,18				
Tangachromis dhanisi	LC	P	1,2,4	1		YES	PD	YES
Tanganicodus irsacae	LC	YES	1,2,4	1,15	2	YES	PD	YES
Tanganikallabes mortiauxi	LC	P	1,2,4	1		YES	FH	YES
Telmatochromis bifrenatus	LC	P	1,2,4	1,17		YES	FH;PD	YES
Telmatochromis brachygnathus	LC	P	1,2,4	1		YES	FH	YES
Telmatochromis dhonti	LC	P	1,2,4	1		YES	FH;PD	YES
Telmatochromis temporalis	LC	P	1,2,4	1		YES	FH;PD	YES
Telmatochromis vittatus	LC	P	1,2,4	1,17		YES	FH;PD	YES
Tetraodon mbu	LC			5,6*		YES	MH;PD;P	
Tilapia baloni	LC			17*,18*				
Tilapia rendalli	LC		3			YES	FH;PD;SH	
Tilapia ruweti	LC		3*			YES	PD	
Tilapia sparrmanii	LC		3*			YES	SH	
Trematocara caparti	LC	P	1,2,4	1				YES
Trematocara kufferathi	LC	P	1,2,4	1				YES
Trematocara macrostoma	LC	P	1,2,4	1				YES
Trematocara marginatum	LC	P	1,2,4	1				YES
Trematocara nigrifrons	LC	P	1,2,4	1				YES

Table A3. Freshwater fish, continued.

Species Name	Red List Category and Criteria	Climate change Vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S18)	Low Adaptability (traits A1–A3)	Important for human use?	Uses	Albertine Rift endemic?
Trematocara stigmaticum	LC	P	1,2,4	1				YES
Trematocara variabile	LC					YES	PD	
Trematocara zebra	DD	P	1,2,4	1				YES
Triglachromis otostigma	LC	P	1,2,4	1		YES	FH;PD	YES
Tropheus annectens	LC	YES	1,2,4	1,14,15,17*,18*	2,3*	YES	PD	YES
Tropheus brichardi	LC	YES	1,2,4	1,14,15,17,18	2	YES	PD	YES
Tropheus duboisi	VU (D2)	YES	1,2,4	1,14,15,17*,18	2	YES	PD	YES
Tropheus kasabae	LC	YES	1,2,4	1,14,15,17,18	2	YES	PD	YES
Tropheus moorii	LC	YES	1,2,4	1,14,15,17,18	2	YES	PD	YES
Tropheus polli	VU (D2)	YES	1,2,4	1,14,15,17*,18	2	YES	PD	YES
Tylochromis lateralis	LC			6				
Tylochromis mylodon	LC					YES	U	
Tylochromis polylepis	LC		4*			YES	PD	
Tylochromis robertsi	LC			5,6*				
Tylochromis variabilis	LC			6				
Varicorhinus brauni	DD	P	3*,4*	2,5*,9				
Varicorhinus leleupanus	VU (D2)	P	2*,4*	2,9,17		YES	FH	YES
Varicorhinus longidorsalis	DD	P	3*,4*	2,5*,9				
Varicorhinus macrolepidotus	LC			2,6,9				
Varicorhinus pellegrini	DD	P	3*,4*	2,5,9				
Varicorhinus platystoma	CR (B1ab(i,ii,iii)+ 2ab(i,ii,iii))			1,2,5*,6,9,17*,18*				
Varicorhinus ruandae	CR (B1ab(ii,iii)+ 2ab(ii,iii))			1,2,5*,6,9,17*,18*				
Varicorhinus ruwenzori	VU (D2)	P	3*	1,2,5*,9,15,17*,18*				
Xenochromis hecqui	DD	P	1,2,4			YES	PD	YES
Xenotilapia bathyphilus	LC	P	1,2,4	1		YES	PD	YES
Xenotilapia boulengeri	LC	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia burtoni	VU (D2)	P	1,2,4	1,17*,18*		YES	PD	YES
Xenotilapia caudofasciata	LC	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia flavipinnis	LC	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia leptura	LC	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia longispinis	LC	P	1,2,4	1		YES	PD	YES
Xenotilapia melanogenys	DD	P	1,2,4			YES	FH;PD	YES
Xenotilapia nasus	DD	P	1,2,4	1				YES
Xenotilapia nigrolabiata	LC	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia ochrogenys	LC	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia ornatipinnis	LC		1,2,4			YES	FH;PD	YES
Xenotilapia sima	LC	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia spilopterus	DD	P	1,2,4	1		YES	FH;PD	YES
Xenotilapia tenuidentata	LC	P	1,2,4	1		YES	PD	YES
Zaireichthys brevis	LC		3		2			
Zaireichthys rotundiceps	LC				2			

Table A4. All mammal species considered in this assessment including Red List categories and criteria (IUCN 2011), climate change vulnerability (P = vulnerable under a pessimistic assumption of missing data values) including individual climate change vulnerability traits (please refer to Tables 6.2, 6.3 and 6.4 for trait descriptions; asterisks denote 'Very High' scores for the traits indicated), importance for human use and use types (please see key at the beginning of these appendices).

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Acinonyx jubatus		VU (A2acd;C1)	YES	1*,3*,4	4*,6,7*	3,4*,6		
Acomys cineraceus		LC	P	1*,3				
Acomys percivali		LC	P	1*,2*	4*			
Acomys wilsoni		LC	P	3	4*			
Aethomys chrysophilus		LC	P	3				
Aethomys hindei		LC	P	1,2		1*,2		
Aethomys kaiseri		LC	YES	1,2*	5	2		
Alcelaphus buselaphus		LC	YES	1*,2	6,7	2,4,6	YES	FH;SH;WA
Anomalurus beecrofti		LC			5*			
Anomalurus derbianus		LC			7*			
Anomalurus pusillus		LC	P	2,3	1,5			
Aonyx capensis		LC		1			YES	FH;MH;WA
Aonyx congicus		LC			5			
Arvicanthis abyssinicus		LC				2		
Arvicanthis niloticus		LC	P	1*,3		2		
Arvicanthis testicularis		NA	P					
Atelerix albiventris		LC	P	1		4		
Atherurus africanus		LC			5	1*,2,4	YES	FH;WA
Atilax paludinosus		LC				6		
Bdeogale crassicauda		LC			7*			
Bdeogale nigripes		LC			1,5*,8	1*,4		
Beamys hindei		LC	P	3	1			
Canis adustus		LC				4	YES	FH;MH
Caracal aurata		NT			2,5		YES	FH;WA
Cephalophus dorsalis		LC			2,5	6	YES	FH;WA
Cephalophus leucogaster		LC			1,2,5*		YES	FH;WA
Cephalophus nigrifrons		LC	P	2*,4*	2		YES	FH;SH
Cephalophus silvicultor		LC	YES	4*	2	4	YES	FH
Cephalophus weynsi		LC	P	4	2,4,5*		YES	FH
Cercopithecus ascanius		LC	P	4	2,3,5		YES	FH;OH;WA
Cercopithecus denti		NA	P		2,3		YES	FH;WA
Cercopithecus hamlyni		VU (A4cd)	YES	1,2*,3*	2,3,4	4	YES	FH;OH;WA
Cercopithecus lhoesti		VU (A4cd)	YES	1,2*,3*,4	2,3,4	4	YES	FH;OH;WA
Cercopithecus mitis		LC	YES	4	2,3	4	YES	FH;MH;OH; PD;WA
Cercopithecus neglectus		LC	YES	2	2,5	4	YES	FH;OH;WA
Chlorocebus cynosuros		LC			3,7			
Chlorocebus pygerythrus		LC			3,7		YES	FH;MH;PD;WA
Chlorocebus tantalus		LC	P	1*,2,3	3,7			
Chrysochloris stuhlmanni		LC	YES	4	7*	1*,4		
Civettictis civetta		LC					YES	FH;MH;OC;WA
Coleura afra		LC			7*			
Colobus angolensis		LC			2,3,7*	4	YES	FH;OH;WA
Colobus guereza		LC			2,3,7		YES	FH;OH;PD;WA
Colomys goslingi		LC	YES	2,4*	4	4		

Table A4. Mammals, continued.

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Cricetomys emini		LC	P	4			YES	FH
Cricetomys gambianus		LC				2	YES	FH
Crocidura cyanea		LC	P	3*				
Crocidura denti		LC	P			4		
Crocidura dolichura		LC	YES	2	5	4		
Crocidura flavescens		LC	P	3*,4	4*,7*			
Crocidura fumosa		VU (B1ab(iii) +2ab(iii))	YES	1*,2*,3*,4*	1	4		
Crocidura fuscomurina		LC	P	1		4		
Crocidura gracilipes		DD	YES	1*,2*,3*,4*	1	4		
Crocidura hildegardeae		LC	P	4*		4		
Crocidura hirta		LC	P	3		4		
Crocidura jacksoni		LC	YES	2,4	4	4		
Crocidura kivuana	YES	VU (D2)	YES	2*,4	1,4,5*	4		
Crocidura lanosa	YES	EN (B1ab(iii))	YES	2,4	4,5	4		
Crocidura littoralis		LC	YES	4	1,4,5	4		
Crocidura ludia		LC	YES	2	1,4,5*	4		
Crocidura luna		LC			1,7*	4		
Crocidura macarthuri		LC	YES	3*,4*	1,4*	4		
Crocidura maurisca		LC	YES	4	4,5	4		
Crocidura monax		LC	YES	2*,3*,4*	1,4	4		
Crocidura montis		LC	P	1*,2*,3*,4*		4		
Crocidura nanilla		LC	P	3*,4		4		
Crocidura nigrofusca		LC				4		
Crocidura niobe	YES	NT	YES	2,4	1,4	4		
Crocidura olivieri		LC				4		
Crocidura parvipes		LC						
Crocidura pasha		LC	P	1,3	1			
Crocidura planiceps		DD	YES	1*,2*,3*	1	4		
Crocidura poensis		LC	P	1,2		4		
Crocidura roosevelti		LC	P	2	1,5			
Crocidura selina		DD	YES	2*	4*,5*	4		
Crocidura somalica		LC	P	1*	1,4			
Crocidura stenocephala	YES	EN (B1ab(ii,iii))	YES	2*	1,4,5	4		
Crocidura tarella		EN (B1ab(iii))	YES	2*,4	4*	4		
Crocidura turba		LC				4		
Crocidura voi		LC	P	1,2*	1			
Crocuta crocuta		LC			7*		YES	FH;MH;SH
Crossarchus alexandri		LC	P	4	4,5*			
Damaliscus lunatus		LC	YES	1*,2,3*	6,7*	4,6	YES	FH;MH;SH
Dasymys incomtus		LC						
Dasymys montanus	YES	EN (B1ab(iii))	YES	2*	4*	1*,4*		
Delanymys brooksi	YES	VU (B1ab(iii))	YES	2,4	4,5	1*,2,4		
Dendrohyrax arboreus		LC				1,4	YES	FH;WA
Dendrohyrax dorsalis		LC			5,7	1,4	YES	MH;WA
Dendromus insignis		LC	YES	4*	5	2		
Dendromus kahuziensis	YES	CR (B1ab(iii))	P	1*,2*	1,5*			

Table A4. Mammals, continued.

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Dendromus kivu	YES	LC	P	2,4	4*			
Dendromus melanotis		LC	P	3		2		
Dendromus mesomelas		LC				2		
Dendromus messorius		LC	YES	2*,3*	1,4*	2		
Dendromus mystacalis		LC				2		
Deomys ferrugineus		LC	YES	3	5*	2		
Diceros bicornis		CR (A2abcd)			7	4	YES	MH;OH;SH
Dologale dybowskii		NA	P					
Eidolon helvum		NT			7	5		
Elephantulus brachyrhynchus		LC			7*			
Elephantulus fuscipes		DD	P	2*	1			
Epomophorus labiatus		LC	P	1	7			
Epomophorus minimus		LC	YES	2,3*	4	2		
Epomophorus wahlbergi		LC			7	2*		
Epomops dobsonii		LC			1			
Epomops franqueti		LC				2*		
Eptesicus serotinus		LC	P	1	4*,7*			
Equus quagga		LC	YES	1,3	6,7	4	YES	FH;SH
Erythrocebus patas		LC	YES	1*,2,3	3	4		
Felis silvestris		LC		1	2,4,7*		YES	FH
Funisciurus anerythrus		LC			5*,7*	4		
Funisciurus carruthersi	YES	LC	YES	2,3,4	1,4*	4		
Funisciurus pyrropus		LC			5,7*	4		
Galago matschiei		LC	YES	2*,3,4*	2,3,4	4		
Galago senegalensis		LC	YES	1	2,3	4,6	YES	FH;MH;WA
Galagoides demidovii		LC			2,3,5	4		
Galagoides thomasi		LC			2,3	4		
Genetta genetta		LC	P	1,3	4		YES	FH;WA
Genetta maculata		LC						
Genetta piscivora		DD	P	1*,2,3*	4,5*,7*			
Genetta servalina		LC	P	2	5			
Genetta tigrina		LC			4*			
Genetta victoriae		LC	P	3,4	1,4,5		YES	FH;WA
Gerbilliscus boehmi		LC	P	1*,2		2		
Gerbilliscus leucogaster		LC				2		
Gerbilliscus nigricaudus		LC	YES	1*,2*,3,4	4*	2		
Gerbilliscus validus		LC	P	1		2		
Giraffa camelopardalis		LC	YES	1,2,3	4	4*,5	YES	FH;WA
Glauconycteris argentata		LC			5	2,4		
Glauconycteris humeralis		DD	YES	1,3,4	1,4,5*	2,4		
Glauconycteris poensis		LC			5*	2,4		
Glauconycteris variegata		LC	YES	1	7*	2,4		
Gorilla beringei	YES	EN (A4abcd)	YES	2,4*	2,3,4,8,9	1,4*	YES	E;FH;HJ;PD;WA
Grammomys dolichurus		LC				2		
Grammomys dryas	YES	NT	YES	2,4	1,4	2		
Grammomys ibeanus		LC				2		
Grammomys kuru		LC			5	2		

Table A4. Mammals, continued.

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Graphiurus christyi		LC	P	3,4	1,4,5			
Graphiurus murinus		LC	YES	4	4	4		
Heliosciurus gambianus		LC	P	1		4		
Heliosciurus rufobrachium		LC			5,7	4		
Heliosciurus ruwenzorii	YES	LC	YES	3,4*	4	4		
Helogale parvula		LC			1,7*			
Herpestes ichneumon		LC						
Herpestes naso		LC			5,7*,8	1*,4*		
Herpestes sanguineus		LC						
Heterohyrax brucei		LC				1,4	YES	FH;MH
Hippopotamus amphibius		VU (A4cd)	YES	1	6,7	4*,5	YES	FH;HJ;MH;SH
Hipposideros abae		LC	P	1,2		2,4		
Hipposideros caffer		LC	YES	1,3	7*	2,4,5		
Hipposideros commersoni		NT	YES	3*,4*	7*	2,4,5		
Hipposideros cyclops		LC			5	2,4,5		
Hipposideros ruber		LC				2,4		
Hippotragus equinus		LC	YES	1*,2,3	6	4,6	YES	FH;SH
Hippotragus niger		LC			6	4	YES	FH;SH
Hybomys lunaris		VU (D2)	YES	2*	1,4*	1*,2,4		
Hybomys univittatus		LC	P	2,3				
Hyemoschus aquaticus		LC			1,2,5*,7*	5	YES	FH;HJ
Hylochoerus meinertzhageni		LC			7	6	YES	FH;MH
Hylomyscus aeta		LC	P	4		2		
Hylomyscus alleni		LC	P	4*		2		
Hylomyscus denniae		LC			1	4*		
Hylomyscus stella		LC	P	3,4		2		
Hylomyscus vulcanorum		NA	P			1*		
Hypsignathus monstrosus		LC			7*	2*		
Hystrix africaeaustralis		LC		3			YES	FH;MH;WA
Hystrix cristata		LC		2		2	YES	FH;MH;WA
Ichneumia albicauda		LC			7*			
Ictonyx striatus		LC		3				
Idiurus macrotis		LC	YES	3	5,7*	4		
Idiurus zenkeri		LC	P	2,3*				
Kerivoula eriophora		DD	YES	1*,2,3,4*	1,5	4		
Kerivoula smithii		LC			4,5*	4		
Kobus ellipsiprymnus		LC	YES	1	6,7	4,6	YES	FH;MH;SH;WA
Kobus kob		LC	YES	1	6,7*	2,4	YES	FH;MH;SH
Kobus vardonii		NT	YES	1*,2*	6,7	2,4	YES	FH;SH;WA
Lavia frons		LC	YES	1	7*	5		
Lemniscomys barbarus		LC	YES	3*,4*	4*	2		
Lemniscomys macculus		LC	P	1*,2*,3,4		2		
Lemniscomys striatus		LC			5	2		
Leptailurus serval		LC			7*		YES	FH;WA
Lepus capensis		LC	YES	1*,3	4*	4	YES	FH
Lepus microtis		LC	P	1,3			YES	FH;MH;WA

Table A4. Mammals, continued.

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Lepus saxatilis		LC	P	1,3*	4*		YES	FH
Lissonycteris angolensis		LC				2*		
Lophiomys imhausi		LC	P	3*,4	4			
Lophocebus albigena		LC			3,5	4	YES	FH
Lophocebus ugandae		NA	P		2,3	1*,2,4		
Lophuromys cinereus	YES	DD	P	1*,2*,4	5*			
Lophuromys flavopunctatus		LC	P	4				
Lophuromys luteogaster		LC	YES	1*,2*,3*	4*,5	2		
Lophuromys medicaudatus	YES	VU (B1ab(iii))	YES	2,4	1,4	2		
Lophuromys rahmi	YES	EN (B1ab(iii))	YES	2,4	1,4,5	1*,4		
Lophuromys sikapusi		LC			5			
Lophuromys woosnami	YES	LC	P	2*,4	4			
Loxodonta africana		VU (A2a)				4	YES	FH;HJ;MH;OH
Lutra maculicollis		LC			7*			
Lycaon pictus		EN (C2a(i))	YES	1,2,3	7*	4		
Malacomys longipes		LC	P	2,3				
Mastomys coucha		LC	P	1*,3*	4*			
Mastomys natalensis		LC			7			
Megaloglossus woermanni		LC	YES	4	5	2*		
Mellivora capensis		LC		1		4	YES	FH;OH;WA
Micropotamogale ruwenzorii	YES	NT	YES	2*,4*	1,4,7	1,4		
Micropteropus pusillus		LC			7*	2		
Mimetillus moloneyi		LC				2,4		
Miniopterus inflatus		LC	YES	4	5*,7*	2,4		
Miniopterus schreibersii		NT			4*,7*	2,4		
Mungos mungo		LC			1,7*		YES	FH;WA
Mus bufo	YES	LC	YES	2,4	1,4	4		
Mus mahomet		LC						
Mus minutoides		LC				4		
Mus musculoides		LC						
Mus triton		LC				4		
Mylomys dybowskii		LC				4		
Myonycteris torquata		LC			5	2*		
Myosorex babaulti	YES	NT	YES	4*	1	4		
Myosorex blarina	YES	EN (B1ab(iii))	YES	2*	4*	4		
Myosorex schalleri	YES	DD	YES	4*	1	4		
Myotis blythii		LC	YES	1*	4*	6		
Myotis bocagei		NA	P		7*	2,4		
Myotis capaccinii		VU (A4bce)	P	3	4*,7*			
Myotis emarginatus		LC			4*	5,6		
Myotis nattereri		LC			4*,7*	5		
Myotis tricolor		LC	P	1		2,5		
Myotis welwitschii		LC	P	1		2,4		
Nandinia binotata		LC			7	6	YES	FH;WA
Neotragus batesi		LC	P	2,3,4*	2,5*		YES	FH
Nycteris arge		LC			5			
Nycteris grandis		LC			7	1*,2,4		

Table A4. Mammals, continued.

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Nycteris hispida		LC				2,5		
Nycteris macrotis		LC	YES	1	7*	2		
Nycteris nana		LC	YES	4*	4	2,5		
Nycteris thebaica		LC	YES	1	7*	2		
Nycticeinops schlieffeni		LC	YES	1,3	7*	2,4		
Oenomys hypoxanthus		LC			5	4		
Okapia johnstoni		NT	YES	1,2,3*	2,4,5*,7*	5	YES	FH;WA
Oreotragus oreotragus		LC			6	4,6		
Orycteropus afer		LC			6,7*	4,5	YES	FH;HJ;MH;P
Otolemur crassicaudatus		LC			3	4,6	YES	FH;MH;WA
Otomops martiensseni		NT	YES	1	7	5		
Otomys denti		LC	YES	2,4*	4	1*,4		
Otomys irroratus		LC	YES	3*	4*,7	4		
Otomys tropicalis		LC	YES	4*	4	2		
Otomys typus		LC	P	2		4		
Ourebia ourebi		LC	YES	1	6	2,4	YES	FH;SH;WA
Pan troglodytes		EN (A4cd)			2,3,5		YES	E;FH;MH;PD;WA
Panthera leo		VU (A2abcd)			6,7*	4*	YES	MH;SH;U;WA
Panthera pardus		NT			7*	4	YES	FH;MH;O;SH;WA
Papio anubis		LC	YES	1*,2	3	4	YES	FH;MH;OH;SH;WA
Papio cynocephalus		LC			3	4	YES	MH
Paracrocidura graueri	YES	DD	YES	2*,4*	1	4		
Paracrocidura maxima	YES	NT	YES	2*,4*	4	4		
Paracrocidura schoutedeni		LC	P	2,4*	1,5*			
Paraxerus alexandri		LC	YES	1,2,3*,4	4,5	4		
Paraxerus boehmi		LC	P	3,4*		4		
Paraxerus cepapi		LC	P	3*				
Pelomys fallax		LC				4		
Pelomys hopkinsi		DD	P	3,4	1,4,5			
Pelomys isseli		DD	P	2,3*,4*	5*			
Perodicticus potto		LC			3,5	4	YES	FH;MH;OH;PD;WA
Petrodromus tetradactylus		LC						
Phacochoerus africanus		LC	YES	1	6,7*	4	YES	FH;SH
Phataginus tricuspis		NT			2,3,5,7*		YES	FH;MH
Philantomba monticola		LC			2		YES	FH
Phoniscus aerosa		DD	P		1			
Pipistrellus capensis		LC			7*	2,4		
Pipistrellus crassulus		LC			5*	2,4		
Pipistrellus eisentrauti		DD	P	2,3,4*		2,4		
Pipistrellus kuhlii		LC	YES	1*,3	4*	2,4		
Pipistrellus nanulus		LC				2		
Pipistrellus nanus		LC			7*	2,4		
Pipistrellus rendalli		LC	P	1		2		
Pipistrellus rueppellii		LC	YES	1,3	7*	2,4		
Pipistrellus tenuipinnis		LC			5*	2,4		
Poecilogale albinucha		LC			7*			
Poelagus marjorita		LC	P	1,2		4	YES	FH

Table A4. Mammals, continued.

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Poiana richardsonii		LC			5*			
Potamochoerus larvatus		LC			2	4	YES	FA;FH;SH
Potamochoerus porcus		LC			5	6	YES	FH
Potamogale velox		LC			1,7	1,4	YES	FH;WA
Praomys degraaffi		VU (B1ab(iii))	P		1	4		
Praomys jacksoni		LC				4		
Praomys misonnei		LC	YES	1*,2*,3*	4*,5*	4		
Praomys verschureni		DD	P	3,4	4,5			
Procolobus rufomitratus		LC	YES	4	2,3,4,5*	4	YES	FH
Protoxerus stangeri		LC			5,7	4		
Raphicerus sharpei		LC			6	4		
Rattus rattus		LC				4		
Redunca redunca		LC	YES	1*,2	6,7*	4	YES	FH;MH;SH
Rhabdomys pumilio		LC	YES	3*	4	4		
Rhinolophus alcyone		LC			5*	2,4		
Rhinolophus blasii		LC	P	1*	4*,7*			
Rhinolophus clivosus		LC	YES	3,4	4	2,4,5		
Rhinolophus deckenii		NT	P	3*,4*				
Rhinolophus fumigatus		LC	YES	1	7*	2,4,5		
Rhinolophus hildebrandti		LC	YES	1	7*	2,4,5		
Rhinolophus hilli		CR (B1ab(iii,v)+ 2ab(iii,v))			5*			
Rhinolophus landeri		LC	YES	1	7*	2,4		
Rhinolophus maclaudi		EN (B2ab(iii))	P	3*,4*		4		
Rhinolophus ruwenzorii	YES	VU (B1ab(ii,iii,iv,v))	YES	2*,3*	4*	2*,4		
Rhinolophus simulator		LC			7*			
Rhinolophus swinnyi		LC	P	3		4		
Rhynchocyon cirnei		NT			7*			
Rousettus aegyptiacus		LC						
Rousettus lanosus		LC	P	3,4		2*		
Ruwenzorisorex suncoides	YES	VU (B2ab(iii))	YES	4	4	4		
Saccostomus campestris		LC	P	3*				
Scotoecus albofuscus		DD				2,4		
Scotonycteris zenkeri		LC			5			
Scotophilus dinganii		LC			7*	2		
Scotophilus leucogaster		LC	YES	1,2	7*	2,4		
Scotophilus nigrita		LC			7*	2,4		
Scotophilus nux		LC			1,5*	2,4		
Scutisorex somereni		LC	YES	2,3,4	4	4		
Smutsia gigantea		NT			2,5,7*	4	YES	FH;MH;WA
Smutsia temminckii		LC	YES	1,3	2,3,7*	4	YES	FH;MH
Stochomys longicaudatus		LC			5*	4		
Suncus infinitesimus		LC	YES	3	4*,7*	4		
Suncus megalura		LC				4		
Sylvicapra grimmia		LC			6		YES	FH;SH
Sylvisorex granti		LC	YES	1,2*,3,4	1	4		

Table A4. Mammals, continued.

Species Name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptabiliy (traits A1–A6)	Important for human use?	Uses
Sylvisorex johnstoni		LC				4		
Sylvisorex lunaris	YES	VU (B1ab(iii))	YES	4	1,4	4		
Sylvisorex vulcanorum	YES	NT	YES	2,4	4	4		
Syncerus caffer		LC			6,7*	4,5	YES	FH;SH
Tachyoryctes ruddi		NA	P			4		
Tachyoryctes splendens		LC	P	1*,4		4		
Tadarida aloysiisabaudiae		LC	P	4	5*			
Tadarida ansorgei		LC						
Tadarida bemmeleni		LC	P	2,4*				
Tadarida brachyptera		LC			5			
Tadarida condylura		LC			7*			
Tadarida fulminans		LC			7*			
Tadarida nanula		LC			5			
Tadarida pumila		LC						
Tadarida thersites		LC			5			
Tadarida trevori		DD	P	4*				
Taphozous mauritianus		LC			7*	5		
Taterillus emini		LC	P	1*		2		
Thamnomys kempi	YES	VU (B1ab(iii))	YES	4*	1,4,5	4		
Thamnomys venustus	YES	VU (B1ab(iii))			1,4*	4		
Thryonomys gregorianus		LC				4	YES	FH
Thryonomys swinderianus		LC			7	4	YES	FH;MH
Tragelaphus eurycerus		NT			2,5*	6	YES	FH;MH;WA
Tragelaphus oryx		LC		3		4	YES	FH;SH
Tragelaphus scriptus		LC				4	YES	FH;SH
Tragelaphus spekii		LC			7	4*	YES	FH;HJ;WA
Uranomys ruddi		LC	P	1,2				
Uromanis tetradactyla		LC			2,3,5*,7*	4	YES	FH;MH
Xerus erythropus		LC	P	1		4		
Zelotomys hildegardeae		LC				4		

Table A5. All plant species considered in this assessment including Red List categories and criteria (where assessed; IUCN 2011), climate change vulnerability (P = vulnerable under a pessimistic assumption of missing data values) including individual climate change vulnerability traits (please refer to Tables 7.2, 7.3 and 7.4 for trait descriptions; asterisks denote 'Very High' scores for the traits indicated), importance for human use and use types (please see key at the beginning of these appendices).

Species Name	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S8)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Abrus precatorius		Not assessed				YES	MH;OH
Acacia hockii		Not assessed				YES	CM;FU;MH
Acacia sieberiana		Not assessed				YES	CM;MH;O
Achyranthes aspera		Not assessed				YES	MH
Acmella caulirhiza		Not assessed				YES	MH
Aframomum angustifolium		YES	1	2	3,4	YES	FH;MH
Afzelia bipindensis	VU (A1cd)	YES	3	5	4		
Afzelia quanzensis				1	4	YES	CM;FH;MH
Ageratum conyzoides			3	4		YES	MH;O;OH

Table A5. Plants, continued.

Species Name	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S8)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Aidia micrantha				1,8	1	YES	CM;O;OH
Ajuga integrifolia		YES	1*	2	3		
Albizia adianthifolia		Not assessed				YES	MH;O
Albizia coriaria		Not assessed				YES	MH
Albizia glaberrima				1,3,7	2	YES	CM;OH
Albizia grandibracteata			2*,4*	4*,5		YES	CM;OH
Albizia gummifera						YES	CM;FH;FU;MH;OC;PD
Albizia versicolor							
Albizia zygia			1,2*,4*	3,4,5		YES	CM;MH
Alchornea cordifolia			1		2,3	YES	CM;FH;MH;OH
Allium sativum		Not assessed				YES	MH
Aloe dawei			4*	3,4			
Aloe lateritia		YES	3*	4	3		
Aloe volkensii	LC	YES	1*,2*,3*,4*	3,4	3		
Alstonia boonei		YES	1,2*,4	3*,4,5*	4	YES	CM;MH
Amaranthus hybridus		Not assessed				YES	FH;OH
Annona mannii		YES	4	5,7*	1		
Annona senegalensis				7	3	YES	FH
Antiaris toxicaria		YES	4	3	4	YES	CM;OH
Antrocaryon nannanii			3,4*		4		
Artemisia afra			3*	4			
Asystasia gangetica		Not assessed				YES	FH;MH
Asystasia mysorensis		Not assessed				YES	FH
Baikiaea insignis		YES	4*	4,5	4		
Balanites aegyptiaca		YES	3*	4	4	YES	FH;FU;OH
Baphia wollastonii		YES	1*,2*,4	3,4*	2,4		
Basella alba		Not assessed				YES	FH;MH;O;OC
Beilschmiedia ugandensis		Not assessed				YES	CM;FU;PD
Bersama abyssinica		Not assessed				YES	MH
Bidens pilosa			2,3	4		YES	MH
Blighia unijugata		Not assessed				YES	CM;FU;MH
Borassus aethiopum		YES	1*	7	4	YES	FH
Brachystegia boehmii				2	2		
Brachystegia bussei				2*	2		
Brachystegia floribunda				2	2		
Brachystegia longifolia				2	2		
Brachystegia manga				1,2,3,8	2		
Brachystegia spiciformis				2	2		
Brachystegia utilis				1,2*	2		
Bridelia brideliifolia				8		YES	MH
Bridelia micrantha				8		YES	CM;FH;FU;MH;O;OC
Canarium schweinfurtii		YES	1*,2	3	4	YES	FH
Canavalia africana		YES	3	7	3		
Capsicum frutescens		Not assessed				YES	FH;MH;O;OH
Carissa edulis		Not assessed				YES	FH
Cassia didymobotrya						YES	MH
Cassia occidentalis		YES	3*	2*	3	YES	MH

Table A5. Plants, continued.

Species Name	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S8)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Celtis adolfi-friderici		YES	4	3*,8	4	YES	FH
Celtis africana		Not assessed				YES	CM;FU;PD
Celtis gomphophylla		YES	3	8	4	YES	FU;MH;OH
Celtis mildbraedii		YES	3	8	4	YES	CM;FU;OH
Centella asiatica		Not assessed				YES	MH;O
Chrysophyllum albidum		YES	4*	1,4*,5,7	4	YES	CM;FH;FU;OH
Chrysophyllum perpulchrum		YES	2,4*	1,3*,4*,5	4	YES	CM
Citropsis articulata		YES	4	7	3	YES	MH;OH
Clausena anisata		Not assessed				YES	MH;O
Clerodendrum myricoides		Not assessed				YES	MH;O
Coffea conifera		Not assessed				YES	FH
Cola acuminata		YES	3,4	8	3,4	YES	FH;MH
Cola lateritia				3*,5*,8	4		
Combretum collinum				7		YES	CM;FU;MH
Combretum molle		Not assessed				YES	CM;FU
Combretum paniculatum				7		YES	MH;OH
Conyza bonariensis			3	2,4			
Cordia africana		Not assessed				YES	MH
Cordia millenii	LC		4	3		YES	CM;MH;OH;PD
Costus afer		YES	1	2,3	3,4		
Crassocephalum vitellinum		Not assessed				YES	MH;OH
Croton haumannianus		YES	2,4	4*,5*	2,4		
Croton macrostachyus					2,4	YES	CM;FU;MH;OH;PD
Croton megalocarpus		Not assessed				YES	CM;FH;MH
Cryptosepalum exfoliatum				2	2,3		
Cucumeropsis mannii			2*	4*,5*,7			
Cynometra alexandri		YES	4*	1,4	1,4	YES	CM;FH;FU;MH;OH
Cyperus articulatus			1*		3		
Cyperus papyrus	LC		1				
Dacryodes edulis		YES	1*,2	1,8	4		
Dalbergia melanoxylon	NT	YES	1*,3	7	2		
Dalbergia nitidula				1,2,7	2		
Desplatsia dewevrei		YES	2*,3,4	3*,4*,5,8	4		
Dichrostachys cinerea				4	2	YES	CM;FU;MH
Dioscorea bulbifera			2	1,4,5		YES	FH;MH
Dioscorea dumetorum			1,2	4,5			
Dioscorea smilacifolia			2	4*,5*			
Diospyros abyssinica		Not assessed				YES	CM;FU;MH;OH
Diospyros bipindensis		YES	2*,3	1,3*,4*,8	4		
Diospyros mespiliformis				1,8	4	YES	CM;FH
Dolichopenta longiflora				2*,5		YES	MH
Elaeis guineensis				7	4	YES	CM;FH;O
Embelia schimperi				7,8			
Entada abyssinica						YES	FU;O;OH
Entada gigas			2	5			
Entandrophragma angolense	VU (A1cd)	YES	1	3,7	4	YES	CM;MH

Table A5. Plants, continued.

Species Name	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S8)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Entandrophragma candollei	VU (A1cd)			3,5,7	4		
Entandrophragma cylindricum	VU (A1cd)	YES	4	3*,5,7	4	YES	CM
Entandrophragma delevoyi				3*,7	4		
Entandrophragma excelsum	LC	YES	4*	3,5,7	4	YES	CM;FU;MH;OH
Entandrophragma utile	VU (A1cd)	YES	3,4*	5,7	4	YES	CM;FU
Eremospatha haullevilleana			4	5,7			
Erythrina abyssinica				2	2,4	YES	CM;FH;MH;O;OH
Eucalyptus globulus		Not assessed				YES	MH
Eucalyptus grandis		Not assessed				YES	FU;MH
Euphorbia hirta		YES	3*,4	2*	3*		
Euphorbia tirucalli	LC		1*		3	YES	CM;FA;MH;O;OH
Faidherbia albida						YES	CM;FU
Faurea saligna			3*	2*		YES	CM;FU;MH;OH;PD
Ficus brachylepis		Not assessed				YES	FU
Ficus exasperata		Not assessed				YES	CM;FU;O;OH
Ficus ingens		YES	3*	7*	4		
Ficus mucuso		YES	1	7*	4	YES	CM;FU;OH
Ficus ovata				7*	4		
Ficus polita				7*	4		
Ficus sycomorus		YES	3*	7*	4	YES	FH;FU;OH
Flueggea virosa			3*	2			
Funtumia elastica		YES	2,4*	3*,4*,5	1	YES	OH
Garcinia kola	VU (A2cd)	YES	3,4	7,8	4		
Gilbertiodendron dewevrei		YES	3,4	1	1,4		
Gladiolus dalenii subsp dalenii				2*,7	3		
Gouania longispicata		Not assessed				YES	MH;O
Greenwayodendron suaveolens	LC	YES	2*,4*	3*,4*,5*,7*	1,4		
Guarea cedrata	VU (A1c)	YES	1,2	5*,7	4		
Gynandropsis gynandra		Not assessed				YES	MH
Gynura scandens			2,3	4			
Habenaria bequaertii		YES	2*,3*,4	1,3,4*,6	3		
Habenaria plectomaniaca		YES	1,2*,3*,4*	1,3*,4*,5,6	3		
Habenaria sylvatica		YES	2	3,6	3		
Habenaria zambesina				6	3		
Hallea rubrostipulata		Not assessed				YES	MH;OC;PD
Harungana madagascariensis				7,8	1	YES	CM;FH;FU;O;OH;PD
Heisteria parvifolia		YES	2*	4*,5*	4		
Holoptelea grandis		YES	2,4	4*,5*	4		
Hymenocardia acida					2	YES	MH
Imperata cylindrica				2*	1	YES	CM;MH;OH
Ipomoea pileata				7	2		
Irvingia gabonensis	NT	YES	3,4	3*	4	YES	MH
Isoberlinia angolensis		P	2		2		
Jatropha curcas		Not assessed				YES	CM
Julbernardia globiflora				1,2,7*	2		
Julbernardia paniculata		YES	2,3	1,2,3*,7*	2		

Table A5. Plants, continued.

Species Name	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S8)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Julbernardia seretii		YES	2,3	1,7*	1,4	YES	O
Khaya anthotheca	VU (A1cd)			7	4	YES	CM
Khaya grandifoliola	VU (A1cd)	YES	1*,3	3,7	4		
Kigelia africana				2	3	YES	FH;MH;OH;U
Laccosperma opacum			4	1,5,7			
Lagenaria siceraria		YES	4	4,7,8	1,3		
Landolphia owariensis			2		1*		
Lannea edulis		Not assessed				YES	MH
Lantana camara		Not assessed				YES	FH;FU;MH;O;OH
Lebrunia bushaie		YES	2,4*	1,3*,4,5*,7	1		
Loudetia simplex				2*	1	YES	MH;O
Luffa cylindrica		Not assessed				YES	FH;MH;OH
Maesopsis eminii		YES	1,2*,4*	3*,4,5*	4	YES	CM;FU;MH;PD
Markhamia lutea		Not assessed				YES	CM;FH;FU;MH;OH
Maytenus acuminata					1,4	YES	CM;FU;MH;OC;OH
Maytenus senegalensis		YES	1*	4	1,4		
Megaphrynium macrostachyum			2*,4*	2*,3*,4*,5*,7			
Microglossa pyrifolia			3	2,4		YES	CM;FH;MH;O
Milicia excelsa	NT	YES	4	7	4		
Millettia dura		Not assessed				YES	CM;FU;MH
Momordica foetida				7,8	1,3	YES	FH;MH;O;OH
Mondia whiteii		YES	1	7	1		
Mondia whytei		Not assessed				YES	FH;MH;OH
Myrianthus arboreus		YES	3,4	3	3	YES	FH;MH
Myrianthus holstii		YES	1	1	3	YES	FH;MH
Neoboutonia macrocalyx						YES	CM;FU;HJ;MH;OH
Newtonia buchananii						YES	CM;FH;FU;MH;OH
Ocimum gratissimum			3			YES	FH;MH
Ocotea kenyensis	VU (A1cd)	YES	1	3,7	1		
Ocotea usambarensis				7		YES	CM;FH;FU;MH
Oreobambos buchwaldii			1		1		
Oxytenanthera abyssinica					1		
Pancovia harmsiana			3,4	5,7			
Parinari curatellifolia				1		YES	MH
Parinari excelsa				1	1,4	YES	CM;FH;FU
Pennisetum purpureum				2*	1	YES	CM;FA;FH;MH;O;OH
Pentaclethra macrophylla			2,3	2,3,5			
Pentadesma lebrunii		YES	4*	1,3*,4,5*,7	1		
Pericopsis angolensis				1,7			
Phoenix reclinata				4,7		YES	CM;FH;FU;HJ;MH; O;OC;OH;PD;WA
Phragmites mauritianus							
Physalis peruviana				4,7		YES	FH;MH
Phytolacca dodecandra				2,7,8		YES	OCMH;O;OC;OH
Piliostigma thonningii		Not assessed				YES	FU;MH
Piper guineense		YES	1,2,4	5,7,8	1*	YES	FH;MH

Table A5. Plants, continued.

Species Name	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S8)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Piptadeniastrum africanum			2*,4*	4*,5*			
Pleiocarpa pycnantha					4		
Podocarpus latifolius	LC	Not assessed				YES	CM;FH;FU
Polyscias fulva		Not assessed				YES	CM;FU;MH;OC;OH;PD
Pouteria altissima	LC		1*		4	YES	CM;FU
Prunus africana	VU (A1cd)			7,8	1,4	YES	CM;FH;FU;MH;OH;PD
Pseudolachnostylis maprouneifolia		YES	3*	7	2	YES	MH
Pseudospondias microcarpa			1*,2*			YES	FH;FU;MH;PD
Psidium guajava		Not assessed				YES	FH;FU;MH;O
Psophocarpus scandens				1			
Psydrax parviflora					4		
Pteridium aquilinum					4		
Pterocarpus angolensis	NT		3	7		YES	CM;MH
Pterocarpus soyauxii		YES	2,3	5	4		
Pycnanthus angolensis		YES	4	1,3,5*	4		
Raphia farinifera				7		YES	F;FU;OH
Rauvolfia vomitoria			1*,2*,4	3*,4,5*		YES	MH;OC
Renealmia africana		YES	1,2,3	2*,5	3,4		
Rhus vulgaris		Not assessed				YES	FH;MH
Ricinodendron heudelotii		YES	4*	8	1,4	YES	MH
Ricinus communis		Not assessed				YES	MH;O;OH
Rotheca myricoides			3*	7			
Rubus apetalus			1	2*,7,8			
Rytigynia kigeziensis		Not assessed				YES	FH;MH
Sapium ellipticum		Not assessed				YES	CM;FH;FU;OH
Satyrium aethiopicum		YES	1*	4,6	3		
Satyrium ecalcaratum		YES	1*,2*	1,3,5,6	3		
Scaphopetalum dewevrei		YES	1,2,3,4*	5*,8	4		
Sclerosperma mannii			2,3,4	5,7,8			
Searsia pyroides			1,3*	4			
Securidaca longipedunculata			3	7		YES	MH;OC
Sesbania sesban					2,4	YES	FU;MH
Shirakiopsis elliptica					4		
Sinarundinaria alpina		Not assessed				YES	CM;F;FU;OH
Solanum incanum			3*	2,4,7		YES	FH;MH
Solanum nigrum				2,4,7		YES	FH;MH;O
Solenangis clavata		YES	4	5*,6	3		
Spathodea campanulata			1*,2*,4	4,5		YES	CM;FU;MH;OH
Steganotaenia araliacea		Not assessed				YES	MH
Sterculia quinqueloba				8	4		
Strombosia scheffleri		Not assessed				YES	CM;FH;FU;MH;OH;PD
Strophanthus bequaertii			1*,2*,3*,4	3,4*,5			
Strychnos cocculoides			3	7,8			
Strychnos icaja		YES	3	3*	4		
Symphonia globulifera		YES	2	1,7	1	YES	CM;FH;FU;PD
Synarundinalia anceps		P		1	1,4		

Table A5. Plants, continued.

Species Name	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S8)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Syzygium guineense			1		4	YES	CM;FU;PD
Tagetes minuta		Not assessed				YES	MH;O
Tamarindus indica		Not assessed				YES	FH;OH
Tephrosia vogelii					2,4	YES	FH;O;OC
Terminalia mollis			1*,2	1,7			
Terminalia sericea			1,3*	1,7			
Trachyphrynium braunianum			1*,2*,3*	2*,3,4*,5*,7			
Treculia africana					4		
Trema orientalis			1	8		YES	CM;FU;O;OC;PD
Trichilia emetica		P	3*			YES	MH
Trichocladus ellipticus		YES	1	4	2,4		
Triumfetta cordifolia		YES	1,2	2,5*,8	4		
Uapaca kirkiana			1				
Uapaca nitida			4				
Vernonia amygdalina			3			YES	FH;FU;MH;O;OC;OH
Vitellaria paradoxa	VU (A1cd)	Not assessed				YES	FH;MH;OH
Voacanga africana		Not assessed				YES	MH
Warburgia ugandensis		Not assessed				YES	MH
Xylopia aethiopica		YES	1,2	5,7*	1,4		
Xymalos monospora		YES	1,2	5,7	1	YES	CM;FH
Zanthoxylum chalybeum		YES	1,4	4*,7	4		
Zanthoxylum gilletii		YES	1	7	4	YES	CM;FH;FU;MH;OH
Zanthoxylum rubescens		Not assessed				YES	CM;OH

Table A6. All reptile species considered in this assessment including Red List categories and criteria (where assessed; IUCN 2011), climate change vulnerability (P = vulnerable under a pessimistic assumption of missing data values) including individual climate change vulnerability traits (please refer to Tables 8.2, 8.3 and 8.4 for trait descriptions; asterisks denote 'Very High' scores for the traits indicated), importance for human use and use types (please see key at the beginning of these appendices).

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Acanthocercus atricollis		LC	YES	1*	6	2,4	YES	PD
Acanthocercus cyanogaster		LC			6	2,4		
Adolfus africanus						2,4		
Adolfus jacksoni				2		2,4		
Adolfus vauereselli	YES	LC	P	1*,2,3*		2,4		
Agama agama			YES	2*,4*	5,6	2,4	YES	PD
Aparallactus lunulatus					2,7	2,3,4		
Aparallactus modestus			YES	3,4	2,7	2,3,4		
Atheris acuminata			YES	1*,2,3*	1,2,3,9	2		
Atheris hispida						2,4	YES	PD
Atheris nitschei	YES		P	1,2,3,4		2,4	YES	PD
Atheris rungweensis			P	1,3,4		2,4		
Atheris squamiger			P	1,3		2,4	YES	PD
Atractaspis corpulenta			P		7	2,3,4		
Atractaspis irregularis		LC	YES	4	7	2,3,4		
Atractaspis reticulata		DD	P		7	2,3,4		

Table A6. Reptiles, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Bitis arietans				1			YES	FH;PD;WA
Bitis gabonica							YES	FH;PD;WA
Bitis nasicornis				4	1,4		YES	FH;PD;WA
Bothrophthalmus lineatus			P	4		2	YES	PD
Boulengerina annulata			YES	1*,3	1,2,3,4,7	1		
Buhoma depressiceps					1,2,3,4	2,4		
Calabaria reinharti						2,3,4		
Causus lichtensteinii			YES	4	1,6,7,8	2,4		
Causus maculatus					6,7,8	2,4	YES	PD
Causus resimus					6,7,8	2,4	YES	PD
Causus rhombeatus					6,7,8	2,4	YES	PD
Chamaeleo anchietae					2	2,4		
Chamaeleo bitaeniatus					2	2	YES	PD
Chamaeleo dilepis		LC	YES	2	2	2	YES	PD
Chamaeleo ellioti			YES	4*	2	2,4	YES	PD
Chamaeleo gracilis			YES	2*,4	2	2	YES	PD
Chamaeleo ituriensis	YES				1,2,3,4	2		
Chamaeleo johnstoni	YES				2,3	2,4	YES	PD
Chamaeleo laevigatus			YES	1*,3	2	2		
Chamaeleo rudis	YES		YES	2*,4*	2,3	2,4	YES	PD
Chamaeleo schoutedeni	YES		P		2	2		
Chamaelycus christyi			P					
Chamaelycus fasciatus								
Chamaesaura anguina				1*,2*,3		2,4		
Chamaesaura macrolepis						2,4		
Cnemaspis dickersoni					3,4	2,4		
Cnemaspis elgonensis			YES	1,2*,3*,4*	3,4	2,4		
Cnemaspis quattuorseriata	YES				3,4,9	2,4	YES	PD
Crocodylus cataphractus		DD	YES	1	1,4,7	1	YES	FH;PD;WA
Crocodylus niloticus		LR/lc		1	1,4		YES	FH;PD;SH;WA
Crotaphopeltis degeni			YES	2	6,7,8	2,4		
Crotaphopeltis hotamboeia					6,7,8	2,4		
Dasypeltis atra			YES	4	7	2		
Dasypeltis fasciata		LC	YES	3*	7	2,4		
Dasypeltis scabra		LC			7	2	YES	PD
Dendroaspis jamesoni				4	1,2,4			
Dipsadoboa duchesnii			P		1,2,4	2		
Dipsadoboa unicolor					1,2,4,7,8	2		
Dipsadoboa viridis					1,2,4	2		
Dipsadoboa weileri			YES	1,3	1,2,4	2,4		
Dispholidus typus						2	YES	PD
Duberria lutrix		LC	YES	2	6,7,8	2		
Elapsoidea loveridgei			YES	2	6	2,3,4		
Elapsoidea semiannulata			YES	4*	6	2,3,4		
Feylinia currori			YES	1	7	2		
Gerrhosaurus major			YES	2*,4*	5	2,4	YES	PD

Table A6. Reptiles, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Gonionotophis brussauxi			YES	4	4,7,8	2		
Grayia smythii			P		1,2,4,7,8	2		
Grayia tholloni					1,2,4,7,8	2		
Hapsidophrys lineatus					7,8	2,4		
Hapsidophrys smaragdina						2,4		
Heliobolus neumanni			YES	1*,3	4	2,4		
Hemidactylus angulatus				1*,2*,3*,4*		2,4		
Hemidactylus mabouia			P		3	2,4		
Hemidactylus platycephalus			YES	2*	3	2,4		
Holaspis guentheri			YES	2*,4*	1,2,4	2,4		
Hormonotus modestus						2		
Ichnotropis squamulosa				4*		2,4		
Kinixys belliana			YES	2	5,6	4	YES	FH;HJ;MH
Kinixys erosa		DD	YES	3	5,6	4	YES	FH
Kinixys spekii			YES	1,2	5,6	4	YES	FH
Kinyongia adolfifriderici	YES				2,3,4	2,4	YES	PD
Kinyongia carpenteri	YES		YES	3*	1,2,3,4,9	1,2		
Kinyongia xenorhinum			YES	3*	1,2,3,4,9	1,2	YES	PD
Lamprophis fuliginosus						2	YES	PD
Lamprophis olivaceus				3		2		
Leptosiaphos aloysiiabaudiae			YES	1	1,2,4	2		
Leptosiaphos blochmanni	YES		YES	4	1,2,3,4	2		
Leptosiaphos graueri	YES				1,2,3,4	1,2		
Leptosiaphos hackarsi	YES		YES	3	1,2,3,4,9	1,2		
Leptosiaphos kilimensis			YES	2*,3,4*	2	2		
Leptosiaphos luberoensis	YES		P			2		
Leptosiaphos meleagris	YES	VU (B1ab(iii))	YES	3*	1,2,3,4,9	1,2,4		
Leptosiaphos rhodurus	YES	DD	P			2		
Leptotyphlops emini					6,7	2,3,4		
Leptotyphlops latirostris	YES		P		6,7	2,3,4		
Leptotyphlops scutifrons					6,7	2,3,4		
Loveridgea phylofiniens			YES	1*,2,3*,4*	3,9	2,3		
Lycodonomorphus bicolor	YES	LC	YES	1*,3	1,2,3,4,7	1,2,4		
Lycophidion capense						2,3,4	YES	PD
Lycophidion laterale					1	2,3,4		
Lycophidion ornatum		LC		4		2,3,4		
Lygodactylus capensis				2		2,4	YES	PD
Lygodactylus gutturalis						2,4		
Lygosoma fernandii			YES	1,3	1,2,4	2		
Lygosoma sundevalli				2		2,4		
Mehelya capensis		LC			7	2,4		
Mehelya poensis			YES	1,3	1,4	2,4		
Mehelya stenophthalmus			YES	3*	1,4,7	2		
Naja haje				1		2	YES	PD
Naja melanoleuca						2	YES	PD
Naja nigricollis						2		
Natriciteres olivacea		LC			1,2,4,7,8	2,4		

Table A6. Reptiles, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Osteolaemus tetraspis		VU (A2cd)	YES	1	1,2,4,9	4	YES	FH;PD;WA
Panaspis burgeoni			P	1				
Pelomedusa subrufa			YES	1*,2,3*	1,2,4	2	YES	FH;HJ;PD
Pelusios chapini			YES	1*,3*	1,2,4	2,4		
Pelusios gabonensis			YES	1	1,2,4	2,4	YES	FH;HJ;PD
Pelusios rhodesianus		LR/lc	YES	1	1,2,4	2,4	YES	FH;HJ;PD
Pelusios sinuatus			YES	1	1,2,4	2	YES	FH;HJ;PD
Pelusios subniger		LR/lc	YES	1	1,2,4	2,4	YES	FH;HJ;PD
Pelusios williamsi			P		1,2,4	2	YES	FH;HJ;PD
Philothamnus angolensis			YES	2*,4	6,7,8	2,4	YES	PD
Philothamnus bequaerti			YES	1,3	6,7,8	2,4		
Philothamnus carinatus			YES	4	6,7,8	2,4	YES	PD
Philothamnus heterodermus			YES	4*	6,7,8	2,4	YES	PD
Philothamnus heterolepidotus			YES	4	6,7,8	2,4		
Philothamnus hoplogaster			YES	2	6,7,8	2,4	YES	PD
Philothamnus irregularis		LC	P		6,7,8	2,4		
Philothamnus nitidus					6,7,8	2,4	YES	PD
Philothamnus ruandae	YES		P		6,7,8	2,4		
Philothamnus semivariegatus					6,7,8	2,4		
Polemon christyi			YES	4	2,7	2,3		
Polemon collaris			YES	3	2,7	2,3		
Polemon fulvicollis			YES	3*	2,7	2,3		
Polemon gabonensis			YES	1*,2,3,4	2,7	2,3		
Polemon graueri			P		2,7	2,3		
Psammophis phillipsii						2		
Psammophis sibilans						2		
Psammophis subtaeniatus		LC				2,4		
Psammophis sudanensis				2		2,4		
Psammophylax tritaeniatus		LC				2		
Psammophylax variabilis			YES	2*,4*	4	2		
Pseudaspis cana			YES	2	2,7	2,3		
Pseudohaje goldii			YES	3	1	2		
Python natalensis						2	YES	FH;PD;WA
Python sebae						2	YES	FH;MH;PD;WA
Rhamnophis aethiopissa						2,4		
Rhamphiophis acutus						2,3,4		
Rhampholeon boulengeri			YES	4	3	2,4	YES	PD
Rhinotyphlops caecus			P		7,8	2,3,4		
Rhinotyphlops gracilis					7	2,3		
Rhinotyphlops graueri			YES	4	7	2,3		
Telescopus semiannulatus						2		
Thelotornis capensis		LC	P		2	2,4		
Thelotornis kirtlandii			YES	4	2	2,4		
Thrasops jacksonii						2,4		
Toxicodryas blandingii			P	4		4	YES	PD
Toxicodryas pulverulenta						4		
Trachylepis maculilabris				2*		2	YES	PD

Table A6. Reptiles, continued.

Species name	Albertine Rift endemic?	Red List Category and Criteria	Climate change vulnerable?	Exposure (traits E1–E4)	Sensitivity (traits S1–S9)	Low Adaptability (traits A1–A4)	Important for human use?	Uses
Trachylepis megalura				2		2		
Trachylepis quinquetaeniata				2		2		
Trachylepis striata						2	YES	PD
Trachylepis varia						2	YES	PD
Trionyx triunguis			YES	1*,2,3*	1,2,4	2	YES	FH;PD
Typhlops angolensis			YES	4	2,7	2,4		
Typhlops congestus			YES	3	2,3,7	2,4		
Typhlops lineolatus					2,3,7	2,4		
Typhlops punctatus			YES	1	2,3,7	2,4		
Varanus exanthematicus		LC		2*,4*		2	YES	FH;PD
Varanus niloticus				1*,2*,3*,4*		2	YES	FH;PD;WA
Varanus ornatus			YES	2,3	4	2	YES	FH;PD;WA

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