Secretariat of the Convention on Biological Diversity

CBD Technical Series No. 54

54

Interdependence of Biodiversity and Development Under Global Change

UNEP

2010 International Year of Biodiversity

CBD

Université de Montréal

HNE Eberswalde
Hochschule für nachhaltige Entwicklung (FH)

CBD Technical Series No. 54

Interdependence of Biodiversity and Development Under Global Change

Published by the Secretariat of the Convention on Biological Diversity ISBN: 92-9225-296-8

Citation
Ibisch, P.L. & A. Vega E., T.M. Herrmann (eds.) 2010. *Interdependence of biodiversity and development under global change*. Technical Series No. 54. Secretariat of the Convention on Biological Diversity, Montreal (second corrected edition).

Federal Ministry for Economic Cooperation and Development

Financial support has been provided by the German Federal Ministry for Economic Cooperation and Development

For further information, please contact:
Secretariat of the Convention on Biological Diversity
World Trade Centre
413 St. Jacques Street, Suite 800
Montreal, Quebec, Canada H2Y 1N9
Phone: +1 514 288 2220
Fax: +1 514 288 6588
Email: secretariat@cbd.int
Website: www.cbd.int

Typesetting: Em Dash Design

Cover photos (top to bottom): Agro-ecosystem used for thousands of years in the vicinities of the Mycenae palace (located about 90 km south-west of Athens, in the north-eastern Peloponnese, Greece). In the second millennium BC Mycenae was one of the major centres of Greek civilization (photo P. Ibisch).

Modern anthropogenic urban ecosystem dominated by concrete, glass and steel materials (London City Hall, Great Britain) (photo P. Ibisch).

Undernourished child in deforested and desertified inter-Andean dry valley ecosystem (between La Viña and Toro Toro, northern Potosí, Bolivia) (photo P. Ibisch).

CONTENTS

B.1.2. INTERLINKAGES BETWEEN HUMAN DEVELOPMENT AND BIODIVERSITY: CASE STUDIES

The following two case studies shall provide some background to the conception of the Radical Ecosystem Approach from a practical perspective. It was our hypothesis that so-called undeveloped or developing regions like Madagascar or the Ukrainian Carpathians can still be described as more or less closed socio-ecological systems with mainly local utilisation and circulation of ecosystem goods and services and rather insignificant exchange with external systems. It was also intended to better understand concrete interlinkages between human development and biodiversity in regions where a more intensive interdependence was assumed.

We based our analysis on the following eight guiding questions, which were later translated into chapters (humans & biodiversity, vulnerability against global change, conservation approaches, future developments).

1. In what way is biodiversity reflected by cultural and land use diversity?
2. How and how much do the various 'socioeconomic strata' depend on biodiversity, especially referring to ecosystem goods and services?
3. To which extent does economic growth and human wellbeing depend upon the trade of ecosystem services, especially the import of ecosystem goods and services or the export of environmental costs?
4. In what way is the status of biodiversity and ecosystem services impacting the socio-economic/socio-political stability?
5. How is the status of biodiversity influencing the vulnerability against global change?
6. How significant and effective are current biodiversity conservation efforts for human development (and vice versa)?
7. Which current approaches and instruments attempt the conciliation of development and biodiversity conservation?
8. What could the interdependence of biodiversity and development look like in future, taking environmental and socio-economic changes into account?

Answers for each of those guiding questions were elaborated from a combination of sources. Most input came from local experts and those having worked and conducted research in the focal regions for a long time. Further information was derived from the analysis of research results of completed and ongoing projects including numerous interviews with the local population, local and regional authorities, protected area management staff and other experts. Additionally, literature was searched to support and complement the findings. Especially grey literature and reports of NGOs, ministries and other relevant institutions and projects proved most informative.

B.1.2.a DEVELOPMENT, BIODIVERSITY CONSERVATION AND GLOBAL CHANGE IN MADAGASCAR

Iris Kiefer, Pascal Lopez, Claudine Ramiarison, Wilhelm Barthlott & Pierre L. Ibisch[11]

ABSTRACT

Madagascar's outstanding biodiversity, with exceptionally high species richness and a remarkable rate of endemism, is largely threatened by anthropogenic pressure driven by population growth and non-sustainable use of its natural resources. Its mainly rural and poor population shows a high dependence on natural resources and a strong relation to nature and environment, which is reflected in the Malagasy culture and traditions. Urban populations and (semi-)external stakeholders also depend on Madagascar's ecosystem goods and services, but generally have more choices and access to alternatives. As a tropical island state, Madagascar's economy depends to a great extent on exported ecosystem goods such as seafood and spices, and increasingly on minerals derived by extractive industries. Human well-being could be enhanced by generating income from the sustainable use of its biodiversity and related ecosystem services. The condition and availability of biodiversity and ecosystem services seems to be interlinked with political stability. Unsustainable use of its biodiversity, probably coupled with foreign investments related to land and natural resource use imply the risk of social inequality and unrest. Global environmental and socio-economic changes, such as climate change or high population growth rates, increasingly have an influence on human wellbeing, which makes the access to, and availability of, ecosystem services a major concern. The integrity of biodiversity, hence, contributes to the extent of vulnerability of Madagascar's population and the reduction of dependences and poverty. Various approaches are undertaken to conserve Madagascar's unique biodiversity, but they still need to be amplified and to be conciliated with development (aid and cooperation). In three scenarios we suggest possible futures for Madagascar, depending on internal and external factors such as political and economic performance, demographic changes and global warming. The worst-case scenario of failing governance and collapsing ecosystem services has to be avoided by all means.

INTRODUCTION

Madagascar is one of the most critically threatened global centers of biodiversity. Its remarkable flora and fauna, exceptional species richness and high percentages in endemism are highly endangered by the ongoing destruction of natural habitats (Myers *et al*. 2000, Ganzhorn et al. 2001).

With a length of 1,600 km and a surface of 587,000 km^2 Madagascar is the Earth's fourth largest island and stretches from the Tropics to the southern Subtropics (Figure 1). Separated by the Mozambique Channel it is located 400 km off the southeastern coast of the African continent from which it is disconnected some 160 million years ago. The central high plateau divides the island into a dry western part and a moist eastern part. The trade winds in the austral winter (from May to September) and the tropical storms, driven by monsoon in the southern summer (from December to April), can bring more than 3,000 mm annual rainfall to the eastern humid rainforests, but only little arrives in the western dry and southern spiny forests, in some areas less than 400 mm per year.

Biodiversity: The high geodiversity of the island contributed to the evolution of diverse ecosystems. They are home to Madagascar's outstanding biodiversity (Lourenço & Goodman 2000, Barthlott *et al.* 2005). The Masoala Peninsula in the Northeast harbors the highest proportion of undisturbed lowland humid evergreen forest while the eastern and southeastern rainforest patches are smaller, more degraded and often disconnected. Since the 1970s, 33.4% of Madagascar's humid forest has been lost (Moat & Smith 2007). The last remaining patches of littoral forest are restricted to the southeastern parts of the island. The natural vegetation of the central highlands is evergreen sclerophyllous *tapia* (*Uapaca bojeri*, Phyllanthaceae)

11 I.K. and P.L. implemented the study and collected data; P.L.I. guided and supervised the research; C.R. and W.B. contributed data and ideas; I.K., P.L., C.R. and P.L.I. wrote the paper.

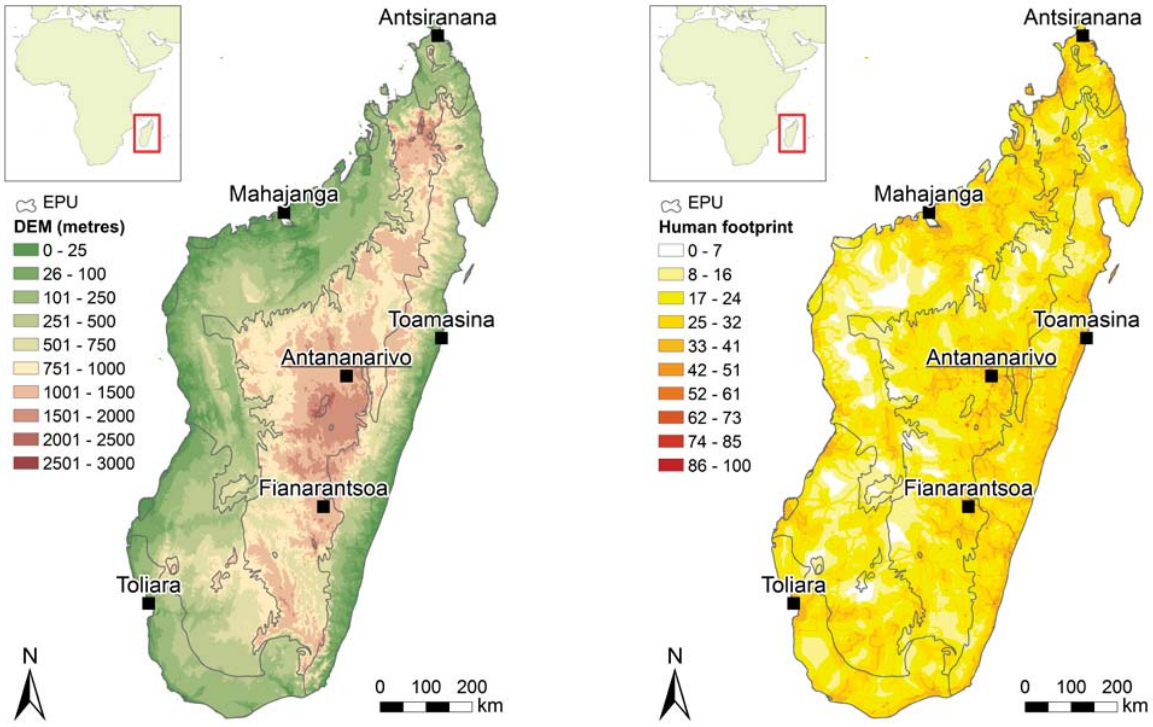


FIGURE 1: Maps of Madagascar showing topography (based on a Digital Elevation Model (DEM), left) and the "Human Footprint" (after WCS & CIESIN 2005, right). Ecopolitical Units (EPU) indicate the major terrestrial ecoregions of Madagascar. Lighter shades in the map on the right side indicate lower direct human impact on the land's surface from e.g., human land uses, human access from roads, railways, major rivers, or electrical infrastructure. Protected areas and remaining forest patches, but also hardly accessible or mountainous regions in the lowlands show low human footprint, while urban agglomerations appear in darker colors. Generally, human footprint, as defined by WCS & CIESIN 2005, is rather low in Madagascar.

woodland and montane scrubland, but these formations are severely reduced and replaced by vast areas of species-poor grass savannahs and partly by pine and eucalyptus plantations. In the dry western regions of the island deciduous formations are naturally dominating such as the seasonally dry western forest and the coastal forests. The natural vegetation of the semi-arid Southwest is a dense and low spiny forest-thicket and coastal bushland, today mainly replaced by grass savannahs and patches of prickly pear (*Opuntia* spp., Cactaceae). The bushland was already reduced by 38% since the 1970s (Du Puy & Moat 1996, Moat & Smith 2007). Small patches of mangroves remain on the western coastline. Four major terrestrial ecoregions, one marine and one freshwater ecoregion are listed as priority for conservation in the "Global 200" reaching from tropical moist broadleaf forest in the East to the spiny forests in the Southwest. Five of these six ecoregions are classified as critically endangered (Olson & Dinerstein 2002).

More than 13,000 vascular plants, over 360 reptile species and more than 370 species of amphibians, almost 290 bird species and 155 mammal species, including nearly 70 species of lemurs, are part of Madagascar's extraordinary biodiversity (Phillipson *et al.* 2006, Glaw & Vences 2007, Vieites *et al.* 2009). The uniqueness of Madagascar's biodiversity has been caused by its early split-off from the ancient super-continent Gondwana and its long isolated history. It has some exceptional features related to its endemism richness, especially in vascular plants, reptiles and mammals (Kier *et al.* 2009). Estimates reveal that 92% of the vascular plant species are endemic (excluding ferns), and 99–100% endemism exists in native amphibians, non-volant mammals and some plant families (Goodman & Benstead 2005). Six of the world's eight species of Baobab only exist in Madagascar, world's unique lemurs are restricted to this island and the neighboring Comoro islands and the giant elephant bird *Aepyornis*, pygmy hippos and some of the larger lemur species became extinct only a millennium upon the arrival of humans (Burney *et al.* 2004). Additionally, Madagascar shares some biogeographical features with South America like

the boas and iguanas, which are absent in Africa. Furthermore, the absence of large native herbivores like zebras, giraffes, elephants, or larger carnivores, which developed in continental Africa, is remarkable (Glaw & Vences 2007). The largest predator is the cat-like *fosa* (*Cryptoprocta ferox*).

People: Madagascar has a rather young history of human colonization. The first settlers arrived in Madagascar some 2,000 years ago and were of Indo-Malaysian and East-African origin, making Madagascar the last great landmass to be colonized (Dewar & Wright 1993). Madagascar became a melting pot of south-east Asian and African traditions and languages and had also some Arabian influence. The Malagasy language evolved from the different influences and is today spoken in dialects by the 18 main ethnic groups. It is an Austronesian language and shows a very high similarity with a native language spoken in southern Borneo and also contains vocabulary from Bantu languages of East Africa (Hurles *et al.* 2005).

The ethnical diversity follows geographical patterns of its early settlers. Their descendants still occupy biogeographic zones of the island that are similar to their places of origin and practice similar land use techniques as their ancestors, such as extensive cattle breeding, slash-and-burn agriculture or rice cultivation. Cattle play a very important role in the Malagasy culture (Hurles *et al*. 2005), especially in the western and southern parts of the country. Rice cultivation in terraces was brought from the Asian regions and is mainly found in the central high plateau. At the coastal areas (total coastline of Madagascar: > 4,800 km) the local population depends mainly on fishing and, additionally, on the cultivation of, e.g., manioc, corn, and millet. Since the first colonization of Madagascar, the settlers transformed the ecosystems, mainly forests, into arable land, and almost all larger animals were driven to extinction.

Today, Madagascar is home to 21.3 million people[12] with an estimated total population growth rate of 2.7% for 2005-2010. In cities the growth is significantly higher. About 71% of the population is living in rural areas, and less than one third is living in urban areas (UN 2006). Madagascar is classified as a country with a medium human development level. It has a Human Development Index value of 0.543, which ranks it at the 145th place out of 182 countries (HDR 2009). According to the World Bank (2007), 61% of the population lives on less than 1 US$ per day, 85% on less than 2 US$/day; most of them are highly dependant directly on natural resources for their livelihood. The access to "modern" media is rather restricted for the rural population, since electricity supply in rural areas is very limited; the TV and telephone grid are not well developed and many regions remain difficult to access (Figure 1).

Political history: Madagascar had a partly turbulent history since its first colonization 2,000 years ago. Several parallel kingdoms were widely united from the end of the 18th century onwards. In 1896 Madagascar was conquered by the French and became a colony. Since it achieved independence from France in 1960 Madagascar adopted several forms of governance and—similar to the French system—"republics". Its first republic, which was still characterized by a post-colonial era, was replaced in 1972 by a socialist regime. Nationalization and centralization marked the era of this 2nd republic. It was destabilized several times by lack of a firm foundation within the Malagasy society and a difficult economic development. Political fragility (recently in 1991, 2001/2002 and since 2009) has repeatedly destabilized the country, negatively affecting its population and its natural resources, including biodiversity (USAID 2010).

The present ongoing political crisis started late 2008 and had a peak, when Marc Ravalomanana stepped down in March 2009 after months of protests and Andry Rajoelina became president of a transitory government. However, the takeover of power by Andry Rajoelina was widely considered as unconstitutional and thus many bi- and multilateral partners suspended their cooperation with Madagascar or its membership from international bodies, such as the African Union and the South African Development Community (SADC) (Ploch 2009).

Threats to biodiversity and conservation: Madagascar's outstanding native biodiversity evolved without human impact until the first settlers arrived. As its terrestrial biodiversity is mainly harbored in forest ecosystems, which was the prevailing vegetation type, any decrease of forest area can be considered as a vital

12 1950: 4.2 million, 1980: 9.1 million, estimated for 2050: 44.4 million people (UN 2006)

threat to its biodiversity. The conversion of natural sites into arable land by the first settlers led to extensive habitat destruction. Particularly, the burning of grassland and savannahs for the provision of grazing areas, the conversion of forests into agricultural sites and the overexploitation of forests for timber and fuel wood have led to a decrease of forest cover to less than one fifth of its original size. Almost 40% of the forest cover was lostbetween 1950 and 2000 (Harper *et al.* 2007). Today, most of Madagascar's territory is covered with species-poor grass savannahs, which have little water retention capacity, resulting in large-scale erosion phenomena (local name for the deep clefts caused by erosion: *lavaka*). Ongoing deforestation is exacerbating soil erosion and sediment run-off (UNEP 2004). The intensive soil erosion gave Madagascar the name "red island" since it looks like it would be bleeding, when the washing-out of red lateritic soils colors the rivers. Additionally, introduced invasive plants threaten the native vegetation, e.g., prickly pear (*Opuntia* spp., Cactaceae) or sisal (*Agave sisalana*, Asparagaceae) in the dry regions of Madagscar (Binggeli 2003). The prickly pear was introduced to Madagascar by the French to defend their forts and is still used as a "living fence" for cattle or crop fields by the Malagasy. The green leaf-like cladodes are used as fodder and the fruits are often the basic food resource for the local population in times of food scarcity. The French also introduced sisal and established a prosperous sisal business in southern Madagascar. Today, sisal plants are also used as "living fence". Both are widespread along roads and even in protected areas.

The unchecked growth of the population and their growing demand for agricultural land and ecosystem services in combination with unsustainable land use management practices is severely threatening Madagascar's biodiversity as more and more forest areas are exploited or converted. Plans for the implementation of industrial agriculture investments for the production of palm oil, bio-fuels or animal fodder have been made (Üllenberg 2009). Expanding industrial agriculture is considered to be a main threat driving deforestation, habitat loss and general degradation of the environment. Large-sized mining projects are also going up in numbers, due to new exploration and extraction technologies as well as increasing global prices for minerals. More than half of Madagascar's territory is covered with exploration concessions; in many protected areas minerals, such as ore and sapphire, oil, and uranium are confirmed or expected. The conciliation of mining and biodiversity conservation is becoming a challenge (Cardiff & Andriamanalina 2007). Another threat to Madagascar's biodiversity, which is still difficult to assess since reliable data is scarce, is climate change. It is especially related to extreme weather events such as droughts, floods, and cyclones with potentially devastating direct and indirect impacts on ecosystems and their flora and fauna.

Currently, Madagascar's biodiversity conservation is severely weakened by the ongoing political crisis. National parks and other valuable forest areas are plundered for precious wood and poaching and the illegal export of its unique fauna and flora are said to have risen dramatically (USAID 2010). Consequently, CITES has imposed a six month moratorium for export of crocodile products (CITES 2010) and UNESCO has included Madagascar's World Heritage Site, the Eastern rainforest (Rainforest of the Atsinanana), on its *List of World Heritage in Danger* due to extensive logging activities (UNESCO 2010).

The aim of this paper is to provide an overview of the interdependencies of biodiversity and human development in Madagascar, regarding economic development, social and cultural aspects, and the integrity of biodiversity and its conservation status, by pointing out and analyzing the influencing factors. The three scenarios apply the various drivers and show possible future trends for biodiversity and development with special focus on global change impacts.

MATERIAL AND METHODS

The represented findings and analyses are based on many years of research and experience[13] living in Madagascar and working in the Malagasy environmental sector, derived from numerous interviews with experts and local stakeholders. Apart from personal assessments and consultations of experts in biodiversity and sustainable development, an intensive literature review was made to support the findings, including grey literature and reports of NGOs, ministries and other relevant institutions.

HUMANS & BIODIVERSITY

Cultural diversity, biodiversity and natural resource use

Madagascar's cultural diversity, contemporarily expressed by its 18 main ethnic groups, is still linked to the origins of its early settlers and is also the result of its ecosystem diversity and the corresponding variety of natural resources. The late colonization of Madagascar brought people from the Indonesian archipelago, East Africa and the Arabic region. The common cultural base is expressed particularly by the Malagasies relation to nature and their environment. The Antandroy ("*people of the thorns*") and the Mahafaly ("*those who make taboos*"), in the southern and western lowlands are predominantly cattle breeders with ancestors probably mainly coming from East Africa, while the highland Merina ("*people of the highlands*") and Betsileo ("*the many invincible ones*") are traditionally rice cultivators and primarily of Asian origin. The Vezo population living mainly at the southwestern coastal zone traditionally depends mainly on marine resources, particularly derived from traditional fishing. Cattle-rice cultivators are found amongst the Antankarana, Bara, Bezanozano, Sakalava, Sihanaka, and Tsimihety. Tanala and Betsimisaraka are called the forest peoples (Minten & Barrett 2008).

Culture plays an important role in perceiving, preserving, and using nature and biodiversity for the Malagasy population. The meaning of "*land*" can be translated into "*land of the ancestors*" or "*tanindranzana*" which is related with the respect of traditions. Land is a sacred place and a kind of mediator between the living people and their ancestors. That is also true for many continental African countries. Religion is important for rural as well as for urban populations and Christianity and ancestral worship are harmoniously co-existing. The land and its resources provide food, but also ecosystem services and, hence, it is necessary to preserve its capacities and cultural values by applying spatial organization and social regulations, which are decreed by traditional and local laws, called "*dina*". *Dina* govern the use of water resources, plants, animals and the use of land, e.g., in the form of local use rights for yield and hunting transferred to people living close to forests. Those traditional laws are based on rights, obligation, and taboos, locally called "*fady*". The *fady* may concern a plant or an animal, a forest site or even a certain behavior and may be specific for a family, a village or in a certain territory (Lingard *et al.* 2003, Jones *et al.* 2008). The applications of those regulations are supervised by the elder or "*tangalamena*". The *dina* are even recognized by the modern Malagasy law and are still applied in rural areas. Sacred places are an important part of the culture and local traditional rights. For example, in Ranomafana national park in southeast Madagascar or in the Sakoantovo forest on the Mahafaly plateau, certain

13 *Iris Kiefer* started research in biodiversity conservation in Madagascar in 2005 with a major focus on anthropogenic impacts on biodiversity. In several visits, at least every two years, she spent in total more than 12 months in the country. During this time she was living in urban agglomerations as well as rural communities and worked with local and national authorities, the national parks administration (Madagascar National Parks, MNP), NGOs and research institutions. *Dr. Pascal Lopez* conducted research in Madagascar from 1998 to 2000 and was then frequently working as a consultant in the environmental sector. Since early 2008 he has worked permanently in the country and is today head of the German-Malagasy Environmental Program (PGM-E) implemented by the German technical cooperation (GTZ). Both have been working in the context of community-based management of natural resources and conservation, with a main focus on developing solutions for integrative conservation approaches and sustainable natural resource management. *Dr. Claudine Ramiarison* is an expert on biodiversity issues and held the position as the Malagasy CBD focal point from 2002 to 2008. From 2005 to 2007 she was a member of the SBSTTA bureau. As executive secretary of SAGE, a para-statal agency for environmental management, she worked intensively in the field of Access and Benefit-sharing (ABS) but also local natural resources management. Currently, she is a temporary member of the advisory board of the Ministry for Environment and Forests and works as a consultant on protected areas, governance, and ABS.

sacred places exist which are used as graveyards by the local populations. Those sites are often the best preserved forest areas outside protected areas (Tengö *et al.* 2007).

Moreover, single biodiversity or landscape features such as trees or lakes can be sacred. Their access and use is regulated by local laws and can be a place of worship, which is respected by (local) peoples. In some parts of Madagascar, certain trees, e.g., *mendoravy* (various species, often *Mendoravia dumaziana*, *Albizia greveana* or *Albizia tulearensis*, all Fabaceae) or *ramiavona* (various species, often genus *Xylopia*, Annonanceae) are even exclusively used either for coffins or as totem and may not be felled except for these purposes. Another biocultural aspect is traditional knowledge of the use of medicinal plants by healers, by rural populations and also by inhabitants of urban areas. There is a set of rites for their collection and use, which are in relation with the origin of the land they are found on and certainly vary depending on the species and local culture.

Biocultural considerations continue to have influence on the local management of biodiversity in the rural areas. With the development of modern sustainable management concepts, like protected areas, and the arrival of new migrants with different cultural values and concepts, these local traditions are altered; also due to the trade of ecosystem services, the development of bioprospecting and other processes that bring in new concepts, ideas and values to rural areas and its populations.

Traditional land use techniques like slash-and-burn agriculture (locally called *tavy*) may increase soil fertility in a short-term view. Agricultural fields are usually abandoned after two to four years (Erdmann 2003). Applied in a small scale and with time intervals of 10 to 15 years, soil fertility may be restored and the natural vegetation has often the potential to regenerate. Thus, under certain conditions slash-and-burn agriculture is not necessarily unsustainable. However, in Madagascar population growth and the increasing demand for land and food made the agricultural systems often ecological instable and unsustainable. Additionally, agricultural production might be only slowly developing in some areas since cultural constraints demand to keep traditional but low productive land use techniques.

In the southern regions of Madagascar, cattle are bred as a status symbol and money storage with numerous heads per herd. However, with the purpose to keep open extensive grazing land, it is a major cause for deforestation and spacious anthropogenic bush fires (Kull 2002). Ongoing population growth may continuously favor the increase of cattle herds in these regions. Especially, in the Antandroy and Mahafaly regions cattle herds can reach up to 300 heads and more. However, they do not produce regular economic income since they are usually only sold in "emergency" situations.

In general, all forest areas outside protected areas are already affected by *tavy*, artificial fires, and forest clearings for the purpose of opening of new arable and pasture land. The high demand for ecosystem services by urban agglomerations, especially provisioning services like food, timber and fuel wood, are satisfied by the vast exploitation of the natural resources in rural areas. Frequently, the corresponding logging and hunting activities are conducted by non-residents or migrants causing social conflicts and overexploitation of local resources. Thus, the degradation of natural resources may lead to migration and to further social conflicts if local *fady* are not respected in the recipient region, which may then experience "cultural homelessness" and a loss of traditions. Conversely, the loss of biodiversity may exacerbate the loss of culture, e.g., in the case of medicinal plants and related indigenous knowledge. In urban agglomerations the connection to traditions might be rather decoupled, since sacred places might be far away. However, ancestors and taboos still play an important role in the daily life of urban population.

Dependency of socioeconomic strata on biodiversity

Being an island state the size of a micro continent, Madagascar has experienced a dependency on its own biodiversity and ecosystem services. Corresponding to its size and its location, Madagascar has good capacity for cultivation of a great variety of fruits and crops. Furthermore, being a country where more than 70% of the population lives in rural areas (UN 2006), where poverty is prevailing, leading to

TABLE 1: Dependency on ecosystem services among socio-economic strata (ecosystem services according to the Millennium Ecosystem Assessment; red = high, green = low)*.

		Rural Population	Urban Population	(Semi-)External Stakeholders
Provisioning S.	Food			
	Fresh water			
	Fuel wood			
	Fiber			
	Biochemicals			
	Genetic resources			
Regulating S.	Climate regulation			
	Disease regulation			
	Water regulation			
	Water purification			
	Pollination			
Cultural Services	Spiritual & religious			
	Recreation & ecotourism			
	Aesthetic			
	Inspirational			
	Educational			
	Sense of place			
	Cultural heritage			

* The dependency on supporting services like soil formation, nutrient cycling, and primary production is rather indirect and therefore not listed in this table, however, it is of high importance for each stratum.

an overall low purchasing power and little access to imported industrial or natural goods, the majority of the population depends directly on local ecosystem services for their livelihoods. Traditional agricultural and pastoralist systems as well as traditional fishery are prevailing in rural areas.

Different socio-economic strata have varying dependencies on local or national biodiversity and ecosystem services due to their respective possibilities of choice. In this study, the following main socio-economic strata were identified for Madagascar: rural populations, urban populations, and (semi-)external stakeholder, i.e., people related to inter- and transnational institutions, or to global commerce including also tourists. Table 1 categorizes the dependency on biodiversity and ecosystems services among these strata.

Local and rural populations: Madagascar's rural population lives largely under subsistence conditions. For these people, ecosystems and ecosystem services play a vital role in their livelihood strategies as sources for food, freshwater, timber and remedy and by providing services such as erosion control and agricultural land resources. The (relative) dependence on ecosystem services is determined by several economic, ecological, and cultural factors: purchasing power is so low that the substitution of services from ecosystems is out of the reach. Ecosystem services are rarely traded, and (urban) markets are hardly accessible due to distances.

Since access to major markets is limited, the rural population highly depends on subsistence farming for the supply of basic agricultural products. Small scale fields are located in the surroundings of the villages, mainly used for the cultivation of manioc, corn, rice or potatoes, depending on soil and climate conditions. Fruits are only seasonably available. The most important fruits are plantains, mangos, litchis, bananas, pineapple, and apples. Dairy products play a minor role in rural areas since cattle are mainly

bred for status purposes or for trade. Zebu cattle are most dominant, while dairy cows are rather rare and mainly to be found in the highlands. The farming of goats and sheep is widespread only in Southern and Western parts. They are often herded together for different families by young children. Most families have poultry, and some chicken, ducks, and turkeys. Small mammals, including lemurs, birds and even Nile crocodiles and caimans may complement the diet, depending on the region.

Rural people, in particular, depend on a considerable diversity of medicinal plants, which are used for self-treatment. The access to modern medicine is difficult since pharmacies or shops selling pharmaceutical products generally only exist in larger villages. Dependency is also accentuated by limited access to forest areas, which provide a variety of important services, particularly when forests are designated as (potential) protected areas with limited access rights.

Urban populations: Accordingly, almost 30% of the Malagasy population lives in urban agglomerations (UN 2006). For them, ecosystem services play an important role as a source of food (cereals, fruits, meat) and for the provision of drinking water. However, this stratum is less dependant on direct and local ecosystem services, as access to traded goods is better since shops and markets provide a big variety of international goods. Forest products play an important role as energy sources and as construction wood for housing and artisanal furniture building for the urban population. Both modes of utilization account for a wood consumption of approximately 9.7 million m^3 per year in urban areas (GISC 2009). While more than 90% of the households use charcoal as the primary energy source, construction wood is used in practically every house building. According to the ecoregion, the dependency on wood products differs considerably. In the central highlands and towards the eastern slopes of Madagascar climatic conditions with a minimum of 1,500 mm of annual precipitation have encouraged people from colonial times onwards to establish timber plantations. Nowadays, the major cities in the central highlands like Antananarivo, Antsirabe, or Fianarantsoa, obtain their fuel wood in form of charcoal exclusively from introduced species of the genera *Eucalyptus* (Myrtaceae) and *Pinus* (Pinaceae) (Bertrand *et al.* 2010). A considerable part of the consumed construction wood in these cities comes also from pine and *Eucalyptus* plantations. In contrast to this situation, the regional capitals in the dry western and southern parts of the island depend to a large part on charcoal that has been produced from natural forests; only small amounts originate from manmade plantations. Investments in plantations are limited due to major climate constraints[14] that put economic and silvicultural sustainability at at risk. In default of sustainable alternatives, natural forest formations harboring the lion's share of Madagascar's biodiversity are the main sources for charcoal. Consumers indeed prefer this charcoal because of the mix of many hardwood species including even precious wood species, such as ebony (*Diospyros* spp., Ebenaceae) rosewood or *palissandre* (both *Dalbergia* spp., Fabaceae).

(Semi-)External stakeholders or people related to inter- and transnational institutions and globally connected companies perceive biodiversity and ecosystem services from Madagascar's forests mainly in two ways:

1. Forest landscapes as natural heritage often managed as protected areas and visited by international tourists for recreational purposes. According to Madagascar National Parks, the state protected area authority, about 130,000 persons visited sites within their protected area network in 2008. Although relatively low in figures, the tourism sector is one of Madagascar's major foreign exchange earners. According to Ballet & Rahaga (2009) the monetary value of this subsector amounted to an added value of more than 165 million US$ in 2008. Madagascar is classified as a biodiversity hotspot (Myers *et al.* 2000) and up to now several hundreds of millions US$ have been invested in the Environmental Program (1990–2010), with the purpose of preserving its unique biodiversity.

2. Timber derived from species-rich forests that is commercialized and transformed outside the country. Madagascar's precious timber species are highly coveted for high quality furniture, marquetry, and

14 Annual rainfall varies between <400 and 1,500 mm per year, depending on region.

music instruments (guitars, woodwinds). The specific features and rarity of the precious hardwood, mainly ebony, rosewood, and *palissandre*, is reflected by their commercial value: high quality rosewood is traded at 5 US$ per kg (GW & EIA 2009). The illegal exploitation and exportation of those timber species has increased significantly during the 2009/2010 political crisis and severely impacted several national parks and protected areas (Schuurman & Lowry 2009, Wilmé *et al.* 2009).

Importance of trade of ecosystem services for economy and human wellbeing

Self-sufficiency

Madagascar, in terms of ecosystem services, is a rather self-sufficient country. Favored by its low economic performance and, hence, little international trade, its insular setting, and a high percentage of rural people that live largely under subsistence conditions, the import of ecosystem services from other countries is limited. In terms of ecosystem services, one of the main goods being imported is rice at a value of 74 million US$, which is less than two percent of total national imports in 2008 (ITC 2010). The amount being imported depends highly on yearly national yields, but has dramatically changed within the last decades: "*Madagascar has gone from being one of the world's top rice producers in the 1960s to being a net importer of rice today*" (BS 2010). However, the diverse natural environment of Madagascar provides a wide range of ecosystem services that both still serve national and international markets. In terms of electricity consumption, Madagascar's situation is quite remarkable: more than two thirds of its national electric consumption of nearly 486,000 MWh is provided by hydropower (ADER 2008), which is highly depending on ecosystem functioning, such as water regulation by forests.

Economic development

In the context of the economics of ecosystems and biodiversity, Madagascar faces two major obstacles that are common to many countries: there is a "*systematic under-valuation of ecosystem services*" and many ecosystem services are not captured in national accounting systems (TEEB 2009). For Madagascar this is particularly true because of the informal character of most markets. In Madagascar, ecosystem services derived from forests, such as timber, fuel wood, ornamental plants and animals are in general under the authority of the state forest administration. A body of (forest and environmental) law, governing all steps from management and exploitation to trade exists. However, the governance within the forest sector is weak due to the lack of manpower, infrastructure, communication, and transportation facilities at all levels. Law enforcement has also to be seen in the context of poverty: any attempt to formalize access and markets for natural resources would limit the access and lead to higher retail prices through taxing and reduction of offer. These are impacts that would hit the poorest both at the production and consumption side severely. Corresponding measures by the Atsimo-Andrefana regional administration in 2007 to formalize charcoal production led to local riots and the measures were immediately withdrawn (Bertrand *et al.* 2010). Hence, "*access to forest and biodiversity resources is in essence open*" (World Bank 2003). This favors informal markets that are not accounted in national statistics. The case of charcoal shows that for some cities like Toliara or Morandava in the Southwest 100% of the charcoal is from natural forests (Bertrand *et al.* 2010), thus illegally harvested and informally traded, as no harvesting permits are issued. As for construction wood, estimations from 2004 indicate that only 5% of the consumed wood is legally produced, i.e., on the base of harvesting/exploitation permits (GISC 2009). For other products, like orchids (as ornamental plants) no information on harvested or traded quantities at national level is available at all. To sum up, the contribution of the forest sector, despite its potential, remains rather limited. The most important exported ecosystem goods, in terms of monetary value, are sea food (crustaceans) and spices (particularly vanilla and cloves); these three products had a share of 12% of total exports and a monetary value of nearly 200 million US$ in 2008 (ITC 2010). Wood products, as defined by WTO, amount to only about 16 million US$ in 2008 or 0.95% of the total national export value in 2008 (ITC 2010). The economic potential derived from activities such as wood

production, bio-prospecting (Acces and Benefit-Sharing, ABS), controlled trade with CITES species and from environmental fiscal reform, are still to be developed or at their beginning.

Human wellbeing

Particularly in rural areas, ecosystem services are almost entirely derived from or provided by locally available natural resources, whether it is goods (agricultural products, fodder, fuel wood, construction wood, food, medicinal plants, and water) or services (such as water purification or soil protection). Beyond direct use, several ecosystem services play an important role in some areas in enhancing human wellbeing through the generation of income. That is the case when markets for ecosystem services exist, which is particularly true for wood energy. Fuel wood and charcoal represent more than 90% of domestic energy sources in Madagascar (Bertrand *et al*. 2010). The entire offer is provided by forests (natural and artificial) located in rural areas. Charcoal makers, transporters, and lumbers all receive their monetary share in the value chain at the local level. Other direct sources of income from ecosystem services are related to protected area management. Madagascar maintains a network of more than 70 protected areas that currently totals 4.8 million hectare (MEFT & UNDP 2009). The engagement of riparian local populations in their management is often foreseen and is part of the governance scheme, e.g., as local guides, rangers, temporary workers or others. Moreover, the concept of sharing visitors' entry fees with local communities and the commitment of many conservation agencies to enhance local social development contribute to human wellbeing through nature conservation. Christie & Crompton (2003) state that 55% of the international tourist arrivals (ITA) visit Madagascar for ecotourism, which can be linked to "visiting" Madagascar's biodiversity, and actually 68% of the international tourists visited at least one protected area (ATW Consultants 2009). Nevertheless, benefitting local populations with the earnings from tourism remains a challenge for national politics, development agencies, and certain tourism operators.

The role of biodiversity for socio-economic and -political stability

Since gaining its independence in 1960, Madagascar has been shaken by recurrent political crises (Maunganidze 2009). Madagascar's political stability, as highlighted during the 2009/2010 political crisis, can be described as rather fragile. Independent rating agencies consider the current situation of Madagascar between "critical" and "warning" (The Fund for Peace 2010). Among others, this becomes manifest in the form of security problems, "absence of adequate legal guarantees, weak political institutions, and capricious policymaking" (Control-Risks 2009).

Madagascar's political crisis that started early 2009 has revealed that political stability can also be linked with increasing scarcity of ecosystem services and the availability of land they are produced on. According to Üllenberg (2009), the issue of foreign direct investment in land (for agricultural purposes) can be seen as one of the underlying causes for the former head of state Marc Ravalomanana to resign and the subsequent mounting political crisis. A case which caused international attention was the so called *DAEWOO deal*. A foreign investor from South Korea was about to sign a 1.3 million ha land lease deal with the Malagasy government. It was the intention to produce, among other products, corn and palm oil for the South Korean domestic markets. The size of the project and its non-transparent handling was perceived skeptically by the Malagasy and was used as an argument for the opposition to question the former president (Maunganidze 2009). In the follow-up of the crisis, when many bi- and multilateral partners of the environmental and forest sector suspended their aid and cooperation with the government, the state sector was close to paralyzed as activities could not be further executed as necessary and planned.

The dependency of the Malagasy Ministry of Environment and Forests on international collaboration is illustrated by its annual budget: 81% of the projected income of the fiscal year 2008[15] was planned to be

15 The last "regular" year before the crisis started was 2008 and is therefore chosen as a reference.

provided as external contributions (by donors, technical partners, and non-governmental organizations, both international and national) (Andrianorosoa 2010). Thus, the suspension of (financial and technical) cooperation had direct and harsh impacts on the implementation of the ministry's programs, its activities on the ground and the fulfillment of sovereign tasks such as planning and controlling. The destabilization of the environmental sector, best expressed by the alarming increase of illegal logging of precious woods particularly from national parks in 2009 and 2010, was evident (Schuurmann & Lowry 2009, GW & EIA 2009).

Negative effects on socio-economic stability through the loss of biodiversity and ecosystem services are generalized in Madagascar. The main drivers of biodiversity loss are deforestation and degradation of forests, the loss of fertile soils, large scale erosion, in combination with an ever growing population and its growing demand for natural resources, which leads to less access to ecosystem services in terms of quality and quantity. Further degradation of resources and internal migration movements are part of this vicious circle (WWF 1999). Large parts of Madagascar have become rather uninhabitable, as they are providing less and less ecosystem services due to repetitive clearings and burnings, leaving unproductive grasslands and degraded soils behind. The fact that urban centers of Madagascar have a significantly higher population growth (approx. 5 vs. 3%) reflects this rural exodus and the socio-economic fragility in parts of the rural zones. With unorganized city development and considerable numbers of people living under precarious conditions, the rapid growth of urban centers also has the potential of contributing to political destabilization. Migration also happens towards still relatively resource-rich areas, which then in turn are exploited by migrants (WWF 2002).

BIODIVERSITY INTEGRITY AND VULNERABILITY AGAINST GLOBAL CHANGE

Compared to the world's average per-capita CO_2 emissions of 3.22 (1960) and 4.27 (2005), respectively, Madagascar's emissions are very low: 0.07 (1960) and 0.15 (2005) (WRI 2009). Irrespective of its low contribution to climate change, the country is among the territories that may be significantly hit by its impacts, especially related to extreme weather events such as abnormal precipitation, floods, storms, droughts and heatwaves. As shown above, the tropical island state of Madagascar is strongly dependant on national ecosystem services. Therefore, losses of biodiversity and ecosystem services may weaken the island's autarky and may increase the vulnerability of its population against global change. This is particularly true for provisioning and regulative services in terms of global environmental change and the loss of food and timber resources.

The high deforestation rate and ongoing degradation of forest areas lead to desertification and critical changes of local climates and microclimates and may, additionally, drive the change of local precipitation regimes. Severe droughts are frequently reported in the southern parts of the island causing famines and migration. The majority of the larger rivers running southwestwards carries water only a few days or weeks per year. Decreasing precipitation and water regulating services (due to loss of forest cover) might consequently diminish the amount of water reaching the riparian fertile soils in the lowland, thus making flood irrigation agriculture increasingly unfeasible. High sedimentation due to erosion may, additionally, threaten the reefs and the fragile equilibrium of the mangrove forests.

Access to water might be of even larger concern in the future if droughts become even more severe and, hence, migration may become more common and intense. This might increasingly cause social conflicts in population-receiving areas. So far, only minor migration events may be ascribed to climate change driven events, such as the emigration of coastal inhabitants towards the central regions in search of more fertile soils.

In the southern and southwestern regions of the island, food sources are already dramatically scarce during the winter months (May-September) and famines affecting thousands of people are frequent (WFP 2010). Cattle die and animal husbandry becomes unfeasible. Adapted crops are rare and the

local population mainly depends on manioc (*Manihot esculenta*, Euphorbiaceae), yams (*Dioscorea* spp., Dioscoreaceae), and introduced invasive plants like the prickly pear (*Opuntia* spp., Cactaceae) that is widely spread in the dry regions often covering vast areas. Former crops such as millet, which are better adapted to the dry weather conditions, were replaced by corn in some regions when foreign investors promised higher revenues. However, corn was not well adapted to the dry conditions and some investors cut back their local business.

Since water sources are often very limited (and in the southern and western dry regions only seasonally available), the applicability of sustainable utilization techniques is already limited. If temporary water basins appear they are extensively used for drinking and washing purposes and to gain water for cooking, watering cattle and bathing of humans and animals, but not usually for watering the cultivable acreage. In some regions temporary water is stored in Baobab trees (*Adansonia* spp., Malvaceae) for drinking purposes (WWF 2009). Alternative and more efficient water storages to cleanly collect and store rain water are in great need in the semi-arid regions.

Tropical cyclones hit Madagascar regularly in the austral summer; they are most numerous and severe from January to May. In 2007, Madagascar was impacted by six cyclones killing at least 150 people and affecting hundreds of thousands of people which lost their houses and goods. In February 2008, cyclone Ivan was one of the most severe cyclones recorded in Madagascar and destroyed 90% of the infrastructure of Sainte Marie Island a few kilometers off the east coast of Madagascar (DPA 2008, JDLNA 2008, Reuters 2008). Furthermore, such extreme events harm the agricultural sector through direct losses of crops and cattle and, indirectly, through the loss of supporting services like the erosion-driven loss of arable land and fertile soil cover. There is evidence that the frequency and intensity of these extreme events is increasing due to climate change and, particularly, the warming of the Indian Ocean's water temperature (Emanuel 2005).

Global socio-economic changes like the investment of foreign enterprises in agricultural resources, or the development of the telecommunication sector by foreign investors, may lead to complex international dependencies. The loss of medicinal plants and traditional knowledge by overexploitation and the replacement by "modern" medicine may weaken rural populations in terms of self-supply. The dissolution of social structures and the destruction of traditional biodiversity-based livelihoods are likely to cause the loss of safety-nets that do not have an alternative.

CURRENT APPROACHES AND INSTRUMENTS FOR THE CONCILIATION OF BIODIVERSITY AND HUMAN DEVELOPMENT

Policies and legal aspects

As early as 1989, the Malagasy government's commitment to environmental protection already resulted in the elaboration of a *National Environmental Action Plan* (NEAP). At that time it was the first of its kind in Africa. Its overall objective was to protect and improve the environment while working for sustainable development and economic growth. The NEAP received legal status in 1990 by the adoption of the *National Environmental Charter* and the *National Environment Policy* (law 90-033) The NEAP was put into operation in 1991; it was established as a 15-year plan, divided into three 5-year phases, which was subsequently extended until 2009. The engagement of the government was also reflected by its readiness to work with the international conservation and development aid community, and its ratification of all the major regional and international conventions related to the environment and sustainable development (CBD, UNFCC, UNCCD, etc.).

Another major orientation for biodiversity conservation and local development was set in 1996/97, when the government adopted its new forestry policy (law 97-017) allowing the management of renewable natural resources to be handed over to local communities (known as the GELOSE law; *Gestion*

Locale Sécurisée: secured local management) either for conservation and/or sustainable utilization. Later, the GCF decree was adopted (*Gestion Contractualisée des Forêts*: contractualised forest management), which partly responded to the complexity of GELOSE by providing a more adapted and simplified mechanism for the unique transfer of forest resources.

A new dynamic was created in 2003, when Madagascar's Head of State Marc Ravalomanana announced at the World Parks Congress in Durban, South-Africa, the so-called "*Durban Vision*": An undertaking to extend the size of Madagascar's protected areas by 2012 from 1.7 million to 6 million hectares, meeting the IUCN objective to protect at least 10% of the national territory, while aiming mutually at conserving biological diversity and promoting sustainable development (Norris 2006).

The second generation of Madagascar's *Poverty Reduction Strategy Paper* (PRSP), called *Madagascar Action Plan* (MAP) was released in 2007. One of the eight top priorities for development was the seventh engagement, called "*Cherish the Environment*". By this step, the government acknowledged the importance of Madagascar's natural resources for economic development and, thus, poverty reduction. It formed the basis for the Ministry's program of work from 2008 onwards. Up to now, the MAP has not been replaced by another PRSP. Early in 2010, the transitional government adopted a new *National Environmental Policy,* which follows the previous policy. It recognizes the challenges that biodiversity conservation and poverty reduction are facing, including climate change. Furthermore, it points out the importance of the environment for human and economic development in Madagascar.

Widely supported by bi- and multilateral cooperation, Madagascar has adopted a wide range of legal instruments for managing and conserving its biodiversity. Among others are: a law that decrees environmental impact assessments for different forms of investments that may harm the environment (mining, infrastructure, but also protected areas); a protected areas code that governs all type of protected area categories (including the formal participation of "new" stakeholders like private sector actors or the recognition of local communities as managers of protected areas); and several regulation for CITES species (e.g., crocodiles, lemurs, chameleons, and orchids). The use of traditional medicine is recognized by modern law (decree 62-072 from 1962) and at present, Madagascar actively participates in the actions for establishment of a protocol on *Access and Benefit-Sharing of genetic resources* (ABS) within the *Convention on Biological Diversity*.

Traditional rights and culture are considered in modern Malagasy law:

- The legalization of usufruct rights in the new forestry law (1997), along with the maintenance of rights to practice the collection and hunting of (unprotected) plant and animal species for local use on their territory.
- The obligation not to resettle local populations in new protected areas, as is the case for the Mikea forest in the Southwest, where some groups of indigenous populations are living who are very much tied to their land.

The *Malagasy Protected Area Code* (Code des Aires Protégées, COAP) foresees that the national protected area authority redistributes 50% of the entrance fees to concerned municipalities for social investments; new categories of protected areas have been legally adopted by the government and allow for management of protected areas by local communities, private operators and foresee sustainable valorization activities of the natural resources. The *GELOSE* law on management transfers of natural resources to local communities recognizes explicitly the local *dina* and gives them legal status as part of the transfer contract between the administration and the local population.

In addition, Madagascar has developed new strategies for the integration of environmental aspects into other sectors as well as promoted an intersectoral approach that aims at better coordination of programs and actions (for instance in the context of oil exploration and exploitation, mining, and fishery). Intersectoral synergies are also pursued within the ratified international environmental conventions and their national

action plans, for example the *National Action Plan for Adaptation* (to climate change) and the undertaking to fight desertification, derived from the *United Nations Convention to Combat Desertification*.

Institutional aspects

The institutional landscape of the environmental sector was developed significantly during the first phase of the NEAP (1990–1995). Besides the existing sector ministry, currently in charge of the environment and forests, several institutions in charge of managing, financing, and monitoring environmental aspects were created and still exist in order to implement the national policy. Some of the most important institutions include: *Madagascar National Parks* (MNP), formerly known as *Association Nationale pour la Gestion des Aires Protégées* (ANGAP), in charge of managing a network of almost fifty major protected areas; l'*Office National pour l'Environnement* (ONE), which is mainly responsible for environmental protection and coordination of those activities; the *Observatoire National du Secteur de l'Environnement et des Forêts* (ONESF); as well as SAGE (*Service d'Appui à la Gestion de l'Environnement*), which in particular supports management transfers of natural resources to local communities and also hosts the ABS focal point. At the operational level, the ministry has two general directorates (environment and forests) and several directorates that are in charge of the overall strategy and current programs: protected areas, the valorization of natural resources, planning and monitoring, control and integrity, environmental awareness and communication. Regional directorates are located in all of Madagascar's 22 regions.

Conscious of the challenge of sustainably financing biodiversity conservation and sustainable natural resources management, Madagascar set up two foundations: *Tany Meva* for financial assistance to local initiatives and activities as well as the *Madagascar Foundation for Protected Areas and Biodiversity* (FAPBM), which finances protected area management and is mainly fueled by official development aid and private funding.

It has to be pointed out that the state forest sector never received the same attention and support as the conservation sector. Management transfers of forests were indeed supported by donor agencies and non-governmental organizations, but usually for the purpose of creating community-based types of "protected areas" and rarely with the intention of producing any products for markets in order to improve livelihoods. However, any form of institutional support was—compared to biodiversity engagements—rather limited. The forest administration is lacking capacities and institutional reform has been on the agenda for many years.

As mentioned above, a large part of conservation activities is financed and also implemented through international development cooperation, but also through a multitude of international and national environmental non-governmental organizations, and local consultancy companies. Substantial aid comes from the World Bank and the United Nations and their institutions, the European Union, France, Germany, USA, Japan, and Switzerland as well as from environmental organizations such as WWF, Conservation International, the Wildlife Conservation Society, and the Durrell Wildlife Conservation Trust. An evolving actor is a recently created platform of civil society organizations, called "*Alliance Voahary Gasy*" assembling national and regional environmental non-governmental organizations and lobbying particularly at the national level for environmental consciousness and action.

Local populations and associations play an important role in formal or contracted natural resource management; they are one of the key actors in biodiversity conservation. The government (by its policy and legal framework) as well as international and national organizations from science to development aid, have acknowledged this fact. They support local populations to be formalized and recognized as a legal entity by the state, and they develop their capacities and assist technically and financially in the implementation of activities related to natural resources. However, a major challenge is to render community-based associations effective and sustainable. Within the given context of limited market access, a high illiteracy rate, and the remoteness of their territories, new approaches need to be developed.

A new concept for coordinating the numerous partners and aid (technical and financial) of the environmental sector was about to be established in 2008, which involved the government, with the support of the major international and national stakeholders. However, this effort was suspended at the beginning of the 2009 political crisis when many donors halted their official aid to the government.

Practical/technical aspects

The above described rural exodus and the intra-national migration show the importance of stable ecosystems for stable human systems, particularly, at the local level: ecosystem services are directly used for livelihoods by more than 70% of the Malagasy population and are stabilizing or improving their socio-economic situation. Wherever income is generated from ecosystem services, the contribution to stability can be considered even more important. Monetary income can be used for investments in agricultural productivity, education, and health and is thus stabilizing. For this reason the promotion of local economic development is pursued by developing agencies and the government (e.g., PSDR: *Programme de Soutien pour le Développement Rural*), and increasingly technical cooperation agencies involved in natural resource management are supporting local initiatives to set up sustainable value chains and get market access at the local, national, or international level. The diversity of promoted ecosystem services, not exclusively concerning native species, is considerable and ranges from the production of certified Bourbon vanilla (*Vanilla planifolia*, Orchidaceae), essential oils (*Ravensara aromatica,* Lauraceae), charcoal (*Eucalyptus camaldulensis*, Myrtaceae) to ecotourism. Stabilizing effects from formal valorization of natural resources also take place at the municipal level, as the municipality receives local taxes that contribute to their communal budget. However, stabilization effects for the state are rather a potential than a reality and are highly underdeveloped. Not only is value-added processing of natural resource into higher value products generally low, but the state receives little taxes and fees, due to the dominance of informal markets and the current fiscal legislation for natural resources (which was under revision as of 2009). Important financial resources required for a stable sector development are thus missing. The above mentioned dependency on external resources for financing sector activities, such as protected area management mirrors the weak internal resource mobilization. Indeed, a particular case is that of protected areas in Madagascar. While they are set up for conservation aspects they can, however, have negative affects on the socio-economic stability of the "affected" population. This is the case, if access to ecosystem services, such as timber, fruits, and watering places is limited or even cut due to the management regime put in place. The World Bank, which supported the establishment and management of protected areas within the Environmental Program, requires for each new creation or extension of a protected area, an environment and social safeguard plan following its safeguard policies for project implementation, in order to prevent unfavorable impacts on affected populations inside and outside of a protected area.

The first efforts to protect Madagascar's outstanding biodiversity date back to 1927, when the first protected areas were established as *nature reserves* representing the main ecosystems. Since that day, a comprehensive network of protected areas was established progressively in order to cover the main ecosystems and their biodiversity. Following Madagascar's independence (1960), new categories were introduced in order to have adapted forms of governance and objectives: national parks, special reserves, classified forests, hunting reserves, and reforestation and restoration zones. The conservation strategies have evolved ever since. In the 1980s the concept of *Integrated Conservation and Development Projects* (ICDP) was introduced to Madagascar, applying a zoning concept with a central protected core zone and adjacent peripheral zones with regulated access and sustainable use by local populations. The promotion of sustainable land and resource management techniques as well as income generating activities were the key supports to local populations that were deprived from part of their traditional rights. It was not before 2000 that the governance and management of protected areas became more open and more adapted to the prevailing socio-economic conditions. They favored the sustainable management and use of ecosystems and integrated new stakeholders such as private operators for tourism development and local communities.

In the beginning of 2010, Madagascar was holding 76 protected areas within the network, including additional ecosystems such as marine protected areas, and using the six IUCN categories. Currently, almost five million hectares are under protection, some of them still temporary. As a result of these biodiversity conservation efforts the annual loss of forest (cover) has been reduced (MEFT *et al.* 2009a).

Another major pillar of biodiversity conservation is the management transfers of natural resources to local communities or associations. Stipulated in the new forestry law of 1997, this tool recognizes the importance of the local population in managing and preserving ecosystems. The main features of this concept are the elaboration of a management plan for the resources or ecosystem, the creation of a local association to whom the management of the resources is transferred, and the contract between the administration and the association. While in the first years many transfers were concluded, several obstacles were realized: the social, institutional, and technical weakness of local associations, the reduced capacity of the administration to monitor and support the transfers, the elevated costs for technical support (e.g., inventories, elaboration of management plans), the reduced possibilities to serve markets with local products, and gaps in the legislation. Today, the support for management transfers is aiming at rendering the local population capable of managing their sites and setting up economic incentives through the commercialization of ecosystem services by sustainable use and the valorization of forest products.

A major potential threat to all biodiversity conservation efforts are resource or area consuming economic activities, such as infrastructure projects and, in particular, mining activities (Cardiff & Andriamanalina 2007). For the majority of Madagascar's terrestrial territory, mining exploration concessions have been issued, including within protected areas and sites where management transfers exist. In order to solve those potential conflicts a commission composed of the ministry in charge of environment and forests and the ministry in charge of mining has been created. Furthermore, the handling of the permits is rather transparent, as a land registry exists that facilitates access to information. In addition, the two ministries have issued a guide to address the problem (*Manuel de procédures de traitement des problématiques de superposition des Nouvelles Aires Protégées avec les carrés miniers*) (MEFT *et al.* 2009b), and the subject is treated in several legal texts. However, large mining projects develop a certain dynamic due to their size and economic volume and it is, finally, a political decision if and how area and biodiversity consuming investments are prioritized and implemented.

FUTURE DEVELOPMENTS

It is not time to sing the requiem for Madagascar's biodiversity; there remain options for a more sustainable development that embraces an effective conservation of biodiversity. Many forests and presumably large parts of unknown biodiversity have been lost in the past; however, the island still harbors a unique treasure of ecosystems and biodiversity that can be preserved for the wellbeing of future generations. In the previous sections of this study, the drivers of biodiversity loss in Madagascar have been identified and stakeholder-influencing conditions have been described.

In Madagascar's history, political changes were often followed by times of uncertainty. Biodiversity conservation was a major issue for most of the former governments, regardless of their political direction. However, biodiversity governance is not becoming easier as it is facing strong and increasing challenges. Some of them, such as demographic change or poverty, are not new but gain ever more importance. Additionally, the development of Madagascar is more than ever under the influence of international relations, dependencies of global markets, and other often unpredictable drivers of global change, such as global climate change. Rising sea-level, extreme weather events, and subsequent food scarcity may harm Madagascar's efforts towards better biodiversity conservation and hamper its endeavors for sustainable development and poverty reduction.

In the following paragraphs three possible future developments, simply called 'scenarios', are succinctly outlined, taking into account past developments, current settings, and possible future directions. They are influenced by various internal and external (international) interacting drivers and are equally conceivable depending on the commitment, performance and power of various stakeholders as well as the impacts of global change. In the first possible future, major obstacles and challenges, as described above, are overcome and lead Madagascar into a sustainable, 'green' future. In contrast to that, the second scenario leaves Madagascar with the same or even growing obstacles and biodiversity loss worsens. The third scenario presents an intermediary future development, and takes up elements from both the first and second scenario.

Alternative future 1: **"Madagascar's green future"—conciliating biodiversity conservation and development**

For achieving biodiversity conservation and sustainable development simultaneously, both internal and external factors of the environmental sector have to be favorable. If biodiversity conservation, sustainable management of natural resources and the contribution of both to socio-economic development shall be achieved, important sector external processes and drivers have to be adjusted towards this "green future". A sustainable "green" development of the Malagasy environmental sector depends particularly on the achievement of the following goals:

- Population growth is curbed, particularly in urban areas where ecosystem services are intensively consumed;
- Poverty reduction strategies are successfully implemented;
- Global environmental and socio-economic change are considered in all sectors;
- Good governance at all levels and intersectorial coordination are efficient;
- Economic development contributes ecologically and sustainably to Malagasy people's wellbeing—without a strong integration into global markets;
- Mining and other large scale infrastructure projects are implemented following socially and ecologically sound standards;
- The agricultural sector enhances its performance sustainably and provides enough food for the population, from local to national level, without major further extension of areas under cultivation;
- National policies favor sustainable development, with a major component being environmental fiscal reform.

Concerning the environmental sector, major goals to be achieved are:

- Stakeholders negotiate climate change issues at the international level and develop and implement (adaptation) strategies and solutions at the national level;
- Biodiversity conservation and climate change management are harmonized;
- Competences and capacities of relevant stakeholders, particularly the ministerial authorities, civil society, private sector, and local populations in charge of environmental management are strengthened;
- Decentralization and support by local actors is favored;
- Sustainable financing of relevant institutions and activities;
- Development and implementation of a policy that ensures sustainable provisioning of ecosystem services;
- Development and formalization of markets for ecosystem services and value-adding for natural resources;
- Development aid within the sector is harmonized, coordinated, and follows national policies and priorities.

Effects on biodiversity and development

If above mentioned conditions are realized, Madagascar's biodiversity has a great chance of being conserved in the long term. This would mean that the country would be developed on the basis of its natural richness, without selling it cheaply to industrialized economies. The remaining extent of natural habitats (particularly forests and protected areas that harbor forests) will be preserved and its biodiversity maintained as conversion of forests into agricultural land will be halted. This will require the improvement of traditional land use techniques, and the effective adaptation of the agricultural sector to climate change. Limited population growth will lead to less (growing) demand for food and other ecosystem services. The network of protected areas will grow in size and number, both improving connectivity and taking into account local community needs. Revenues from entry fees are fairly distributed within the communities and are also reinvested in the protected areas. Ecosystems that provide marketable services (water purification, energy and construction wood, medicinal plants, etc.) will contribute to local and national development by providing jobs, income, and taxes for the state, which will be in turn further invested into the sector. Alternative income activities will be generated, especially for the rural population, by protection and sustainable use of forest products and services. This will reduce the pressure on natural resources from charcoal production, timber and firewood exploitation; therefore, wood is also grown in sustainable timber plantations to cover national and international demand. Mining and oil industrial projects will minimize environmental harm to an acceptable extent; benefits derived from these operations shall contribute to the compensation and mitigation of negative impacts. Authorities are competent and have good presence at the local level to adapt policies to new developments and challenges, and to implement existing policies and supervise action on the ground. The vulnerability of both biodiversity and local populations to global change and, particularly, climate change is diminished by implementation of strategies and solutions that include consideration of global and climate change in land use and urban planning and are supported by competent authorities, NGOs, and other stakeholders. Alternative and sustainable sources of funding of forests and protected areas are functional with large participation at local level (REDD, Payment for Ecosystem Services, etc.) and support conservation efforts. Resilience will be increased and biodiversity becomes a main source of sustainable development.

Alternative future 2: ***Driving beyond tipping points***

Efforts to enhance biodiversity conservation may be undermined by various factors including low and unsustainable development. The framework conditions which anticipate the development towards a sustainable future are:

- Population continues to grow at rates between three (rural) and five (urban areas) percent each year and will double by 2025 in major cities;
- Poverty reduction strategies are weak and social inequalities increase;
- Global change is not considered in national policies and, therefore, the development and implementation of adaptation strategies is low;
- Harmonization and profiting from synergies is not achieved between different but adjacent sectors, particularly with regard to land use planning;
- The performance of the national economy is too weak to have favorable impacts on the development;
- Important foreign exchange earners, such as mining projects or bioenergetic enterprises extract and export natural resources, harm the environment, neglect environmental and social requirements and negatively affect local populations; profits received are not invested in development;
- Subsistence farming dominates and barely feeds the rural population, major imports of rice and other agricultural products are necessary to satisfy the growing national demand;
- Sustainable development is not promoted as a guiding principle for national policies.

Concerning the environmental sector, driving factors are:

- Ministerial authorities are weakened and—together with other relevant stakeholders—neither able to manage the natural resources sustainably nor to implement international mechanisms such as REDD or ABS on a broad scale;
- The efforts to strengthen competences and capacities are weak and interventions by state authorities, development aid agencies, and non-governmental organizations achieve only localized and temporary effects, since coordination is not enhanced;
- Biodiversity conservation and climate change adaptation management are not harmonized but rather inconsistent;
- Many decisions are taken on a central level without comprehensive participation of different stakeholders on other relevant levels;
- The concepts and principles of sustainable development and biodiversity conservation are not integrated into national policies;
- Modes of sustainable financing of the environmental sector are not implemented, leading to a constant lack of money to support institutions and activities, even though several structures or institutions have been set up formally;
- Most markets for environmental services remain informal and the state authorities and communities hardly benefit.

Effects on biodiversity and development

Forest and biodiversity loss will continue because the principle drivers are not adequately addressed (e.g., growing population, subsistence farming with little output, demand for ecosystem services such as wood for energy and construction). The access to natural resources remains mainly unregulated; biodiversity and ecosystems services are undervalued and prone to be overexploited. Vulnerability to climate change is high, and the adaptive capacities of both human populations and biodiversity are low. Ecosystem services are lost in some regions since the resilience of ecosystems is weakened. Mitigation projects are few in number and weak. Adaptation strategies exist, but are only slowly implemented. The agricultural sector shows insufficient adaptation to climate change and rural populations lack the skills and resources to implement more productive techniques. Unsustainable land-use techniques dominate and the amount of arable land decreases while food scarcity is amplified by growing demand and stagnating (or even decreasing) productivity. Climate change reduces the quantity and increases the variability of agricultural production. The purchase of land remains difficult and land property is increasingly in the hands of few. The (rural) populations' self-sufficiency is endangered and internal migration becomes a major problem. Sustainable management of forests, including plantation forestry, is not sufficiently implemented leading to degradation and deforestation. As natural resources are disappearing, the pressure on biodiversity-rich areas is growing, impacting especially vulnerable and unique areas. Local efforts of sustainable management of resources continue, but fail to achieve a critical mass required for effectiveness. Large-scale investments harm the environment and even protected areas are threatened both by mining activities and exploitation of resources. Protected areas do not benefit the neighboring population and become less relevant destinations for visitors because access and lodging infrastructure are insufficient. Community-based organizations are weakened by a lack of enforcement, and a lack of income generating alternatives may lead to a violation of traditional and modern rights due to ongoing exploitation of their managed natural resources. Illegal trade of biodiversity (faunal and floral species, precious wood) and habitat destruction increasingly threaten already endangered species. In the energy sector, sustainable alternatives and renewable energies are still lacking, and charcoal as well as firewood from natural forests remains the main source for energy supply in many regions. The existing sustainable plantations for timber and fuel wood are insufficient to satisfy the increasing demand and are depleted.

Alternative future 3: ***Avoiding the worst and maintaining the hope***

This "scenario" is marked by two antagonist developments, where the sector performance is enhanced while the parameters outside the environmental sector are rather unfavorable. The improved performance of the environmental sector is not embedded in a similar national and cross-sectoral policy and is, thus, lacking effectiveness.

The main parameters outside the environmental sector hampering sustainability are:

- Constant population growth between three and five percent per year;
- Poverty reduction strategies that are successfully developed, but whose implementation remains difficult;
- The inconsistent consideration of global change issues without adequate mainstreaming;
- Large-scale projects increasingly follow environmental and social requirements but control mechanisms stay weak;
- Stagnation of the agricultural sector performance, which continues to be based on subsistence farming, increasing conversion of forests into agricultural land and increasing dependency on imports;
- Environmental sustainability is seen only sectorally, without being acknowledged as a cross-sectoral issue of strategic and systemic importance;
- A (weak) economic performance that does not set off significant development.

Concerning the environmental sector, this development would be somewhat (but in the mid-term insufficiently) counter-balanced by the following tendencies:

- Significant strengthening of competencies and capacities of all stakeholders taking part in environmentally relevant decisions;
- Encouragement and harmonization of environmental institutions; the administration of their programs leads to an efficient use of natural resources;
- Enhancement of decentralization and development of local structures;
- The environmental sector generates income that allows sustainable financing;
- Continued implementation of an emerging forestry reform and good governance;
- Development and strengthening of environmental policies.

Effects on biodiversity and development

The high population growth rate in both rural and urban areas will lead to a continuously growing demand for natural resources and an overexploitation of agricultural land and forest areas. The implementation of poverty reduction strategies hardly makes progress, and the direct dependence on diminishing natural resources is high, especially amongst the rural population. The agricultural sector has a low performance; in some regions techniques will be unsustainably improved, but in most regions subsistence farming and traditional land use techniques are predominant and are not adapted to cover the rising demand for food. More arable land is needed leading to advancing degradation of valuable ecosystems. The environmental sector faces many challenges that may reduce effectiveness of conservation, but develops sustainably, including various stakeholders. Biodiversity governance and conservation are enhanced by good management inside and in the vicinities of protected areas. Sustainable forest management, including the establishment of additional sustainable timber and fuel wood plantations, mitigates the pressure on natural resources. The illegal traffic of flora and fauna diminishes slowly, but progressively. Communities are increasingly involved in biodiversity conservation and generate corresponding basic income. However, the intellectual and financial external input required for these achievements stays high since framework conditions (derived from other sectors) are not favorable. Since the good approaches of the environmental sector

are difficult to be harmonized with other sectors such as mining, fishery, agriculture, or energy, conflicts may rise and long-term conservation of biodiversity remains a major challenge. Global change and, particularly, climate change are considered in decisions concerning the environmental sector, but vulnerability of the local population is still high, especially in poor regions with multiple stressors. Adaptation strategies and approaches are not mainstreamed and are mainly applied in priority ecosystem and conservation zones. Priority setting, taking into account existing human and financial circumstances, and sustainable approaches, enhance both sustainable development and biodiversity conservation.

CONCLUSION

The three scenarios drafted above show three possible futures for Madagascar. The influencing drivers show that political will and good governance are of major concern for Madagascar's future development. Global change processes enhance the existing problems and new ones; they will require ever improving environmental governance. A strong focus on the conciliation of biodiversity conservation and development could probably avoid the worst-case scenario of failing governance and collapsing ecosystem services. There is still a potential for achieving higher social equality, fair access to ecosystem services, higher benefits from the economic potential, and more effective conservation of biodiversity.

Today's environmental management is still dominated by a rather centralized and sectoral approach, and the development towards an integrative and participatory management involving all actors has to be reinforced and mainstreamed. On the international level, Madagascar's participation in treaties and conventions is an important component of successful biodiversity conservation, including the negotiation and development of adaptation strategies. The bi- and multilateral development cooperation activities should support Madagascar in pursuing the objectives established by signing and ratifying international conventions such as the CBD. Approaches must especially contribute to a national climate change management strategy which comprises all feasible adaptation and mitigation options.

ACKNOWLEDGEMENTS

We would like to thank Alberto Vega, his colleagues from the CBD secretariat, Dilys Roe (IIED), Monica Hernandez Morcillo and Jessica Jones (UNEP-WCMC) for their review efforts to improve this paper and most valuable comments on earlier drafts of this study. Special thanks also to Martin Schluck for the preparation of the maps and to Chris Hogan for his linguistic revision. We are grateful to the Faculty of Forest and Environment, Eberswalde University of Sustainable Development (University of Applied Sciences) and the Nees Institute for Biodiversity of Plants of the University of Bonn for valuable support and fruitful discussions. Our work was supported by the Heinrich Boell Foundation and the Academy of Sciences and Literature Mainz ("Biodiversity in Change" program).

REFERENCES

ADER (Agence de Développement de L'Electrification Rurale). 2008. Statistique officiel 2008. Unreleased, internal report.

Andrianorosoa, O. 2010. Analyse du budget du ministère de l'environnement et forêt (MEF). Internal Report for GTZ—Public Finances.

ATW Consultants. 2009. Enquête visiteurs pour la filière tourisme à Madagascar. Rapport final. Unpublished report of the World Bank project "Pôles Integrés de Croissance PIC"

Ballet, J. and N. Rahaga. 2009. Impact Économique des Arrêtés autorisant les Exportations de Bois Précieux à Madagascar. Unpublished report to PGM-E/GTZ.

Barthlott, W., J. Mutke, M. D. Rafiqpoor, G. Kier and H. Kreft. 2005. Global centres of vascular plant diversity. Nova Acta Leopoldina **92**:61–83.

Bertrand, A., B. Ramamonjisoa and P. Montagne. 2010. Les filières péri-urbaines d'approvisionnement en bois énergie des grandes villes de Madagascar. Pages 23–36 in P. Montagne, S. Razafimahatratra,

A. Rasamindisa and R. Crehay, editors. ARINA, le charbon de bois à Madagascar: entre demande urbaine et gestion durable. CITE, Antananarivo.

Binggeli, P. 2003. Introduced and invasive plants. Pages 257-268 in S. M. Goodman and J. P. Benstead, editors. The Natural History of Madagascar. The University of Chicago Press, Chicago, London.

Burney, D. A., L. Pigott Burney, L. R. Godfrey, W. L. Jungers, S. M. Goodman, H. T. Wright and A. J. T. Jull. 2004. A chronology for late prehistoric Madagascar. Journal of Human Evolution **47**:25–63.

BS (Bertelsmann Stiftung). 2009. BTI 2010—Madagascar Country Report. Bertelsmann Stiftung, Gütersloh.

Cardiff, S. G. and A. Andriamanalina. 2007. Contested Spatial Coincidence of Conservation and Mining Efforts in Madagascar. Madagascar Conservation & Development **2**:28-34.

Christie, I. T. and E. D. Crompton. 2003. Republic of Madagascar: Tourism Sector Study. Africa Region Working Paper Series No. 63. Worldbank.

CITES (Convention on the International Trade with Endangered Species). 2010. Madagascar. Recommendation to suspend trade. Notification to the parties, no. 2010/015. http://www.cites.org/eng/notif/2010/E015.pdf

Control-Risks. 2009. A world of seismic change. Press release. Available from http://www.control-risks.com/pdf/riskmap_2009_press_release.pdf.

Dewar, R. E. and H. T. Wright. 1993. The Culture History of Madagascar. Journal of World Prehistory **7**:417–466.

DPA (Deutsche Presse-Agentur). 2008. Cyclone Ivan kills 11 in Madagascar, headed for Mozambique. Available from http://www.reliefweb.int.

Du Puy, D. J. and J. Moat. 1996. A refined classification of the primary vegetation of Madagascar based on the underlying geology: using GIS to map its distribution and to assess its conservation status. Pages 205–218 in W. R. Lourenço, editor. Biogéographie de Madagascar. Proceedings of the International Symposium on the Biogeography of Madagascar, Paris.

Emanuel, K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. Nature **436**:686-688.

Erdmann, T. K. 2003. The dilemma of reducing shifting cultivation. Pages 134–139 in S. M. Goodman and J. P. Benstead, editors. The Natural History of Madagascar. The University of Chicago Press, Chicago, London.

Ganzhorn, J. U., P. P. Lowry II, G. E. Schatz and S. Sommer. 2001. The biodiversity of Madagascar: one of the world's hottest hotspots on its way out. Oryx **35**:346–348.

GISC (Global Innovation and Strategy Center). 2009. Etude sur la production et la consommation en produits forestier ligneux à Madagascar. Report submitted to IRG/USAID.

Glaw, F. and M. Vences. 2007. A fieldguide to the amphibians and reptiles of Madagascar. 3rd edition. Vences & Glaw, Köln.

Goodman, S. M. and J. P. Benstead. 2005. Updated estimates of biotic diversity and endemism for Madagascar. Oryx **39**:73–77.

GW and EIA (Global Witness and Environmental Investigation Agency). 2009. Investigation into the illegal felling, transport and export of precious wood in SAVA Region Madagascar. Unpublished report to the Government of Madagascar. Available from http://www.illegal-logging.info/uploads/madagascarreportrevisedfinalen.pdf.

Harper, G. J., M. C. Steininger, C. J. Tucker, D. Juhn and F. Hawkins. 2007. Fifty years of deforestation and forest fragmentation in Madagascar. Environmental Conservation **34**:325–333.

HDR (Human Development Report). 2009. Overcoming barriers: Human mobility and development. Report published for the United Nations Development Program (UNDP). Palgrave Macmillan, New Hampshire, New York.

Hurles, M. E., B. C. Sykes, M. A. Jobling and P. Forster. 2005. The dual origin of the Malagasy in Island Southeast Asia and East Africa: evidence from maternal and paternal lineages. American Journal of Human Genetics **76**:894–901.

ITC (International Trade Center). 2010. Trade performance HS: imports of Madagascar. Available from http://www.intracen.org.

JDLNA (Joint Damage, Losses and Needs Assessment). 2008. Damage, Loss, and Needs Assessment for Disaster Recovery and Reconstruction after the 2008 Cyclone Season in Madagascar. Cyclone Fame, Ivan and Jokwe in Madagascar. A Report prepared by the Government of Madagascar with the support of the United Nations and The World Bank. Available from http://www.pdf.ph/downloads/PDNA/Library/Madagascar_JDLNA_Report_Final.pdf.

Jones, J. P. G., M. M. Andriamarovololona and N. Hockley. 2008. The importance of taboos and social norms to conservation in Madagascar. Conservation Biology **22**:976–986.

Kier, G., H. Kreft, T. M. Leeb, W. Jetz, P. I. Ibisch, C. Nowicki, J. Mutke and W. Barthlott. 2009. A global assessment of endemism and species richness across island and mainland regions. Proceedings of the National Academy of Science of the United States of America **106**:9322–9327.

Kull, C. A. 2002. Madagascar aflame: landscape burning as peasant protest, resistance, or a resource management tool? Political Geography **21**:927–953.

Lingard, M., N. Raharison, E. Rabakonandrianina, J.-A. Rakotoarisoa and T. Elmqvist. 2003. The role of local taboos in conservation and management of species: the radiated tortoise in Southern Madagascar. Conservation and Society **1**:223–246.

Lourenço, W. R., and S. M. Goodman, editors. 2000. Diversité et Endemisme à Madagascar. Mémoires de la Société de Biogéographie, Paris.

Maunganizde, O. 2009. Madagascar: anatomy of a recurrent crisis. Institute for Security Studies. Pretoria, South Africa.

MEFT (Ministère de l'Environnement, des Forêts et du Tourisme) and United Nations Development Programme. 2009. Quatrième rapport national de la convention de la biodiversité biologique.

MEFT (Ministère de l'Environnement, des Forêts et du Tourisme), United States Agency for International Development and Conservation International. 2009a. Evolution de la couverture de forêts naturelles à Madagascar, 1990-2000-2005.

MEFT (Ministère de l'Environnement, des Forêts et du Tourisme), Ministère de l'Energie et des mines and United States Agency for International Development. 2009b. Manuel de procédures de traitement des problématiques de superposition des Nouvelles Aires Protégées avec les carrés miniers. Minten, B. and C. B. Barrett. 2008. Agricultural technology, productivity, and poverty in Madagascar. World Development **36**:797–822.

Moat, J. and P. Smith, editors. 2007. Atlas of the vegetation of Madagascar. Kew Publishing, Royal Botanic Gardens, Kew, Richmond.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca and J. Kent. 2000. Biodiversity Hotspots for Conservation Priorities. Nature **403**:853–858.

Norris, S. 2006. Madagascar Defiant. BioScience 56 (12): 960–965.

Olson, D. M. and E. Dinerstein. 2002. The Global 200: priority ecoregions for global conservation. Annals of the Missouri Botanical Garden **89**:199–224.

Phillipson, P. B., G. E. Schatz, P. P. Lowry II and J.-N Labat. 2006. A catalogue of the vascular plants of Madagascar. Pages 613-627 in S. A. Ghazanfar and H. J. Beentje, editors. Taxonomy and Ecology of African Plants: Their Conservation and Sustainable Use. Proceedings XVIIth AETFAT Congress. Royal Botanic Gardens, Kew.

Ploch, L. 2009. Madagascar's 2009 Political Crisis. CRS Report for Congress, R40448. Available from http://www.opencrs.com/document/R40448/2009-10-07/download/1005/.

Reuters. 2008. Cyclone hits Madagascar, threatens Mozambique. Available from http://www.alertnet.org/thenews/newsdesk/L1829902.htm.Schuurman, D. and P. P. Lowry II. 2009. The Madagascar rosewood massacre. Madagascar Conservation & Development **4**:98-102.

TEEB. 2009. The Economics of Ecosystems and Biodiversity for National and International Policy Makers. Summary: Responding to the Value of Nature. Available from http://www.teebweb.org.

Tengö, M., K. Johansson, F. Rakotondrasoa, J. Lundberg, J.-A. Andriamaherilala, J.-A. Rakotoarisoa and T. Elmqvist. 2007. Taboos and Forest Governance: Informal Protection of Hot Spot Dry Forest in Southern Madagascar. Ambio **36**:683-691.

The Fund for Peace 2010. 2010. Failed State Index. Available from http://www.fundforpeace.org.

Üllenberg, A. 2009. Foreign Direct Investment (FDI) in Land in Madagascar. GTZ, Eschborn.

UN (United Nations). 2006. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2007 Revision. Available from http://esa.un.org/unup.

UNEP (United Nations Environment Programme). 2004. Payet, R. A., N. Soogun, E. Ranaivoson, R. J. Payet and F. Ali Abdallah. Indian Ocean Islands. Global International Waters Assessment, Regional Assessment 45b. University of Kalmar, Kalmar, Sweden. Available from http://www.unep.org/pdf/sids/giwa_regional_assessment_45b.pdf.

UNESCO (United Nations Educational, Scientific and Cultural Organization) 2010. World Heritage Committee inscribes Rainforests of Atsinanana (Madagascar) on List of World Heritage in Danger. Available from http://whc.unesco.org/en/news/639.

USAID (United States Agency for International Development). 2010. Paradise Lost? Lessons from 25 years of USAID environment programs in Madagascar. Final report. Available from http://www.rmportal.net/library/paradise-lost-madagascar/view.

Vieites, D. R., K. C. Wollenberg, F. Andreone, J. Kohler, F. Glaw and M. Vences. 2009. Vast underestimation of Madagascar‘s biodiversity evidenced by an integrative amphibian inventory. Proceedings of the National Academy of Sciences of the United States of America **106:**8267–8272.

WCS and CIESIN (Wildlife Conservation and Center for International Earth Science Information Network). 2005. Last of the Wild Data Version 2: Global Human Footprint data set (HF). Available from http://sedac.ciesin.columbia.edu/wildareas/.

WFP (World Food Programme). 2010. Countries: Madagascar. Available from http://www.wfp.org/countries/madagascar

Wilmé, L., D. Schuurman, P. P. Lowry II and P. H. Raven. 2009. Precious trees pay off—but who pays? Poster for the World Forestry Congress in Buenos Aires, Argentina, October 18-23, 2009.

World Bank. 2003. Madagascar Rural and Environment Sector Review; Report No. 26106-MG; Volume I: Main Report.

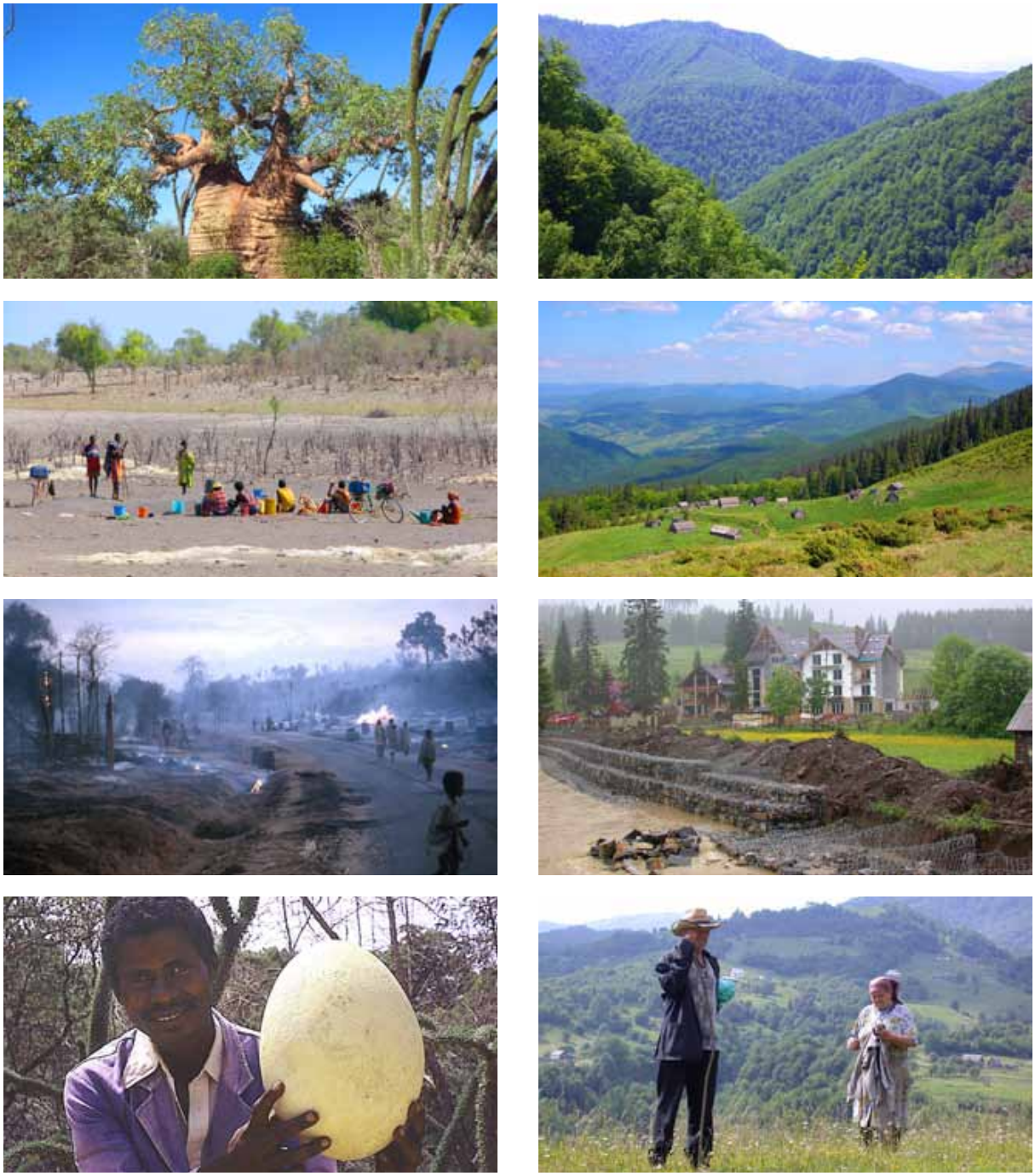
World Bank, Development Data Group. 2007. 2007 World Development Indicators Online. The World Bank, Washington, DC. Available from http://data.worldbank.org/data-catalog/world-development-indicators/wdi-2007.

WRI (World Resource Institute). 2009. Climate Analysis Indicators Tool (CAIT). Version 6.0. Washington, DC. Available from http://cait.wri.org.

WWF (World Wide Fund for Nature). 1999. Les tendances actuelles de la migration des peoples et son impact dans la région écologique des forets épineuses à Madagascar.

WWF (World Wide Fund for Nature), Conservation Strategies Unit. 2002. Mapping the Connections: Population-Environment Lessons from Madagascar. WWF, Washington, DC.

WWF (World Wide Fund for Nature). 2009. Nos baobabs lancent un sos. WWF Madagascar & Western Indian Ocean Programme Office, Antananarivo.



The case study regions Madagascar (left column) and the Ukrainian Carpathians (right column).
LEFT COLUMN FROM TOP TO BOTTOM: Adansonia rubrostipa (Malvaceae), one of 6 native baobab species; rural population waiting for a well to refill in South Madagascar (photos by I. Kiefer); burning dry forest close to Sakaraha (photo by W. Barthlott), Southwest-Madagascar; egg shell of the extinct elephant bird Aepyornis (photo by W. Barthlott).
RIGHT COLUMN FROM TOP TO BOTTOM: managed deciduous mountain forest in East Transcarpathia; traditional high alpine cattle farm (polonyna); accelerating (tourism) development and resulting erosion problems near Bukovel, Hutsul couple tending cattle on a mountain meadow (photos by P.L. Ibisch).

Authors and Affiliations

Prof. Dr. **Wilhelm Barthlott**, University of Bonn, Nees Institute for Biodiversity of Plants, Meckenheimer Allee 170, 53115 Bonn, Germany, barthlott@uni-bonn.de, (Chapter B1.1.—B.1.2a)

Dr **Grazia Borrini-Feyerabend**, International Union for Conservation of Nature (IUCN), Commission on Environmental, Economic and Social Policy (CEESP) Vice-Chair for Europe, and ICCA Consortium, Coordinator, Ancienne Ecole, Rue de Bugnaux 18, Bugnaux CH 1180, Switzerland, www.iccaforum.org(Chapter B.1.3.)

Prof. Dr. **Wolfgang Cramer**, Potsdam Institute for Climate Impact Research (PIK), Telegraphenberg A 31, 14473 Potsdam, and University of Potsdam, Germany, wcramer@uni-potsdam.de (Chapter B.1.1.)

Prof. Dr. **Graham Dutfield**, School of Law, University of Leeds, Professor of International Governance, LeedsLS2 9JT, United Kingdom, g.m.dutfield@leeds.ac.uk(Chapter B.1.3.)

Lisa Freudenberger, Eberswalde University for Sustainable Development (University of Applied Sciences), Faculty of Forest and Environment, Alfred-Moeller-Str. 1, 16225 Eberswalde, Germany, lfreudenberger@hnee.de (Chapter B.1.1.)

Juliane Geyer, Eberswalde University for Sustainable Development (University of AppliedSciences), Faculty of Forest and Environment, Alfred-Moeller-Str. 1, 16225 Eberswalde, Germany, juliane.geyer@hnee.de (Chapter B.1.2b.)

Victoria Gubko, Carpathian Biosphere Reserve, Department for Recreation, Public Relations and International Cooperation, 77, Krasne Pleso Street, 90600 Rakhiv, Ukraine, victoria_gubko@gala.net (Chapter B.1.2b.)

Dr.**Terence Hay-Edie**, GEF Small Grants Programme, UNDP, Programme Specialist, 304 East 45th Street, Room FF-906, New York, N.Y.10017, USA, terence.hay-edie@undp.org(Chapter B.1.3.)

Prof. Dr. **Thora Martina Herrmann**, Université de Montréal, Director of the Canada Research Chair in Ethnoecology and Biodiversity Conservation, CP6128 Succursale Centre-Ville, Montréal, Québec, H3C 3J7, Canada, thora.martina.herrmann@umontreal.ca (Chapter A.1., B.1.3.)

Dr. **Peter Hobson**, Writtle College, University of Essex, Senior Lecturer in Conservation Management, Chelmsford, Essex CM1 3RR, UK, Peter.Hobson@writtle.ac.uk(ChaptersA.1.-B.1.1., B.2.1.-B.2.3.)

Prof. Dr. **Pierre L. Ibisch**, Eberswalde University for Sustainable Development (University of AppliedSciences), Faculty of Forest and Environment, Research professorship for "Biodiversity and natural resource management under global change", Alfred-Moeller-Str. 1, 16225 Eberswalde, Germany, pierre.ibisch@hnee.de (Chapters A.1.-A2., B.1.1.-B.1.2., B.2.1.-B.2.3.)

Iris Kiefer, EberswaldeUniversity for Sustainable Development (University of AppliedSciences), Faculty of Forest and Environment, Alfred-Moeller-Str. 1, 16225 Eberswalde, Germany, iris.kiefer@hnee.de, and University of Bonn, Nees Institute for Biodiversity of Plants, Meckenheimer Allee 170, 53115 Bonn, Germany (Chapter B.1.2.a.)

Dr. **Ivan Kruglov**, Associate Professor, Ivano Franko University Lviv, Faculty of Geography, Doroshenko str. 41, 79000 Lviv, Ukraine, ikruhlov@gmail.com (Chapter B.1.2b.)

Dr. **Pascal Lopez**, Head of the German-Malagasy Environmental Program (PGM-E/GTZ), Deutsche Gesellschaft für technische Zusammenarbeit, BP 869, Antananarivo 101, Madagascar, pascal.lopez@gtz.de (Chapter B.1.2a.)

Dr. **Gary J. Martin**, Director of the Global Diversity Foundation, Dar Ylane, BP 1337, Marrakech Hay Mohammadi, Morocco 40007, gary@globaldivesity.org.uk; Senior Fellow at the Rachel Carson Center, Leopoldstraße 11a, 80802 München, Germany, gary.martin@carsoncenter.lmu.de; Lecturer in the Centre for Biocultural Diversity, School of Anthropology and Conservation, Marlowe Building, University of Kent, Canterbury CT2 7NS, United Kingdom (Chapter B.1.3.)

Dr. **Paul Oldham**, ESRC Centre for Economic and Social Aspects of Genomics (Cesagen), Institute for Advanced Studies, Lancaster University, Lancaster LA1 4YD, United Kingdom, p.oldham@lancaster.ac.uk (Chapter B.1.3.)

Dr. **Laxmi Prasad Pant**, School of Environmental Design and Rural Development, University of Guelph, Guelph, Ontario, N1G 2W1, Canada, lpant@uoguelph.ca (Chapter B.1.3.)

Dr. **Claudine Ramiarison**, Temporary member of the advisory board of the Ministry of Environment and Forest and consultant on biodiversity management, Lot IIL 83, Ankadivato, 101 Antananarivo, Madagascar, ramiaris@moov.mg (Chapter B.1.2a.)

Pier Carlo Sandei,Associate Programme Officer, United Nations Environment Programme, Regional Office for Europe—Vienna Office, PO Box 500—A-1400 Vienna—Austria, piercarlo.sandei@unvienna.org (Chapter B.1.2b.)

Martin Schluck, Eberswalde University for Sustainable Development (University of Applied Sciences), Faculty of Forest and Environment, Alfred-Moeller-Str. 1, 16225 Eberswalde, Germany, mschluck@hnee.de (Chapters A.1., B.1.1.)

Lars Schmidt, Freelance consultant, Schillerstr. 2, 16225 Eberswalde, Germany, lars.schmidt@gmx.org (Chapter B.1.2b.)

Dr. **Henning Sommer**, University of Bonn, Center for Development Research (ZEF), Department of Ecology and Resource Management, Walter-Flex-Str. 3, 53113 Bonn, Germany, hsommer@uni-bonn.de (Chapter B.1.1.)

Alberto Vega E. Senior Programme Officer, Biodiversity for Development Initiative, Secretariat of the Convention on Biological Diversity, 413, Saint Jacques Street, suite 800 Montreal QC H2Y 1N9, Canada, alberto.vega@cbd.int and alberto.vega@gtz.de (Chapters A.1.–A.2.)