Biodiversity of Sudan: between the harsh conditions, political instability and civil wars

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ABSTRACT   More than 90% of the area of Sudan is classified as desert and semi-desert ecosystems, and desertification is spreading with global climatic changes. Also the country is suffering from 60 years of chronic civil wars and instability. Consequently these situations have severely affected the status and trend of biological diversity of the country to critical thresholds (i.e. extinction) as many reports show. Improved knowledge of the current status of biodiversity in response to such conservation challenges is critically important. In this review, my aim is to highlight the recent conservation challenges of Sudan as they relate to desertification and civil wars, and to look at the big picture of the impacts of these challenges to biodiversity conservation in Africa. I then present examples of urgent management interventions and research needs for better biodiversity conservation. The primary message of this paper is to confirm the possibility of making conservation actions in these vulnerable areas. It is never too late as long as there is peace and willingness. This framework could be a model to tackle and analyses biodiversity conservation issues in similar cases in the region.

INTRODUCTION

The news coming from Sudan is always about civil war, political conflicts, awful statistics about the refugees and displaced people and rarely optimistic. In addition to the political instability, environmentally the country is one of the most fragile, dry and desertified areas in Sub-Saharan Africa, which leads to high vulnerability to global climatic changes and extreme events such as drought and flooding (I.P.C.C., 2013). The United Nations Convention on Combating Desertification (U.N.C.C.D.) defined dry lands (arid, semi-arid and dry sub-humid zones) as areas other than polar and sub-polar regions in which the aridity index (i.e. the ratio of annual precipitation to potential evapo-transpiration) falls within the range of 0.05-0.65 (U.N.C.C.D., 1994). According to this definition, about 93% of the area of the country is classified as dryland (Table 1), which extends from hyper arid and arid zones in the north to the semi-deserts in the middle to low rainfall woodlands savanna in the deep south and south east (Goda, 2007; Mustafa, 2007).

In addition to the dominant harsh conditions there are some areas with unique ecological conditions such as mountains, the Nile strip and wetlands depressions. These areas support vegetation communities and natural habitats that are critical to maintaining biological diversity, particularly wildlife and forest resources (Mukhtar & El

Wakeel, 2002). The forest resources in Sudan were estimated by F.A.O. in 1990 to be about 19% of the total area of the northern part of the country, but the current report of U.S.A.I.D. in 2012 showed the total forested areas of the country have been reduced substantially to about 11.6 % (Fig.1).

Despite the habitat loss and degradation, these forests are still playing vital environmental roles in biodiversity conservation and combating desertification as well as supporting the livelihood of local communities. For instance the forest products consumption survey conducted by the Forest National

Aridity Zone	Ecosystem type	Area (Square Km)	% (Area of the Sudan)	Annual Rainfall (mm)	Aridity Index (R=P/PET)
Hyper-arid	Desert	776000	41	< 20	< 0.05
Arid	Semi-desert	630000	33	20 - 100	0.05 – 0.20
Semi-arid	Grassland Savanna	340000	18	100 – 300	0.21 – 0.50
Dry sub-humid	Low rainfall woodland Savanna	65000	3	300 – 500	0.51 – 0.65
Sub-tropic	High rainfall woodland Savanna	70000	4	500 – 800	> 0.65
Total		1881000	100		

Table 1. Classification and extent of dry lands in Sudan adapted from Ayoub (1998), Mustafa (2007) and Badri (2012).
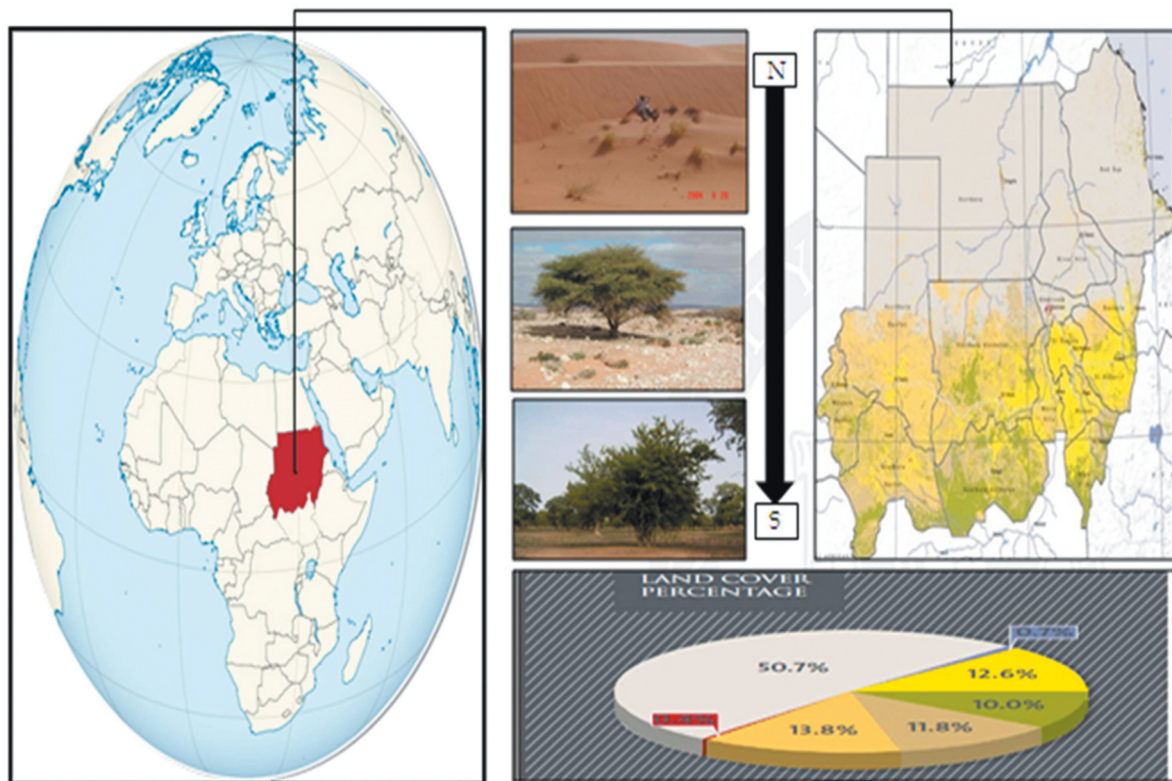

Figure 1. The location of Sudan in Africa (left). The map of land cover showing the ecological gradients from the desert in the north to rainy savannah in the deep south (right). The area of the country divided between 50.7% as desert, 13 % agricultural lands, 12.6 % grass lands, 10% forests cover,1 % Water resources. ~ 1% others (i.e. urban areas). Adapted from F.A.O. (2012).

Corporation (F.N.C.) in 1995 showed that forests are the main sources of sawn timber, round poles, building materials and 87.5% of energy (fuel wood) to the country. Also about 100 indigenous trees species provide direct food, oil, honey, fruit, fodder, gum, fiber, medicine, and tannin agents to the people (Badi, 2004). Takona (1999) and Siddig & Abdellhameed (2013) emphasized the great socioeconomic, cultural and heritage values of biodiversity of Sudan, and the value of local markets based on wildlife products, forest products and fibers crafting materials as an employment opportunity for many people, especially in rural areas.

Although there are a few efforts by local governmental agencies and NGOs, there are many critical challenges facing biodiversity of Sudan. First, political instability and civil wars led the country to lose about 70% of its biodiversity that was concentrated in the southern part, as it became independent state in 2011 as republic of South Sudan. Severe wars continue in about 50% of the rest of the country (8 states out of 15). Second, the combination of socio-economic (e.g. food insecurity and refugees) and global environmental factors (e.g. climate change, drought and desertification) plus the lack of integrated plans exacerbate the decline of biological diversity of the country to critical thresholds (i.e. extinction). The need to know the current status of biodiversity in response to such complex political and environmental challenges is critically important. Nimir, (1995), Takona, (1999), Funk et al. (2011) and Badri (2012) pose many logical questions on this topic. I suggest that the most important questions include: What is the current state of biodiversity of the country in the light of these wars and harsh conditions? What and where are the hot spots of conservation? What are the subsequent challenges facing biodiversity? And most importantly, how can these challenges will be solved?

This review comes to bring attention to the impacts of wars combined with harsh conditions on biodiversity as regional theme with a particular case of Sudan after July 2011 based on recent governmental and international agencies reports working in Sudan as well as the domestic literature. The specific aims of this paper are two-fold. First, I display and diagnose the most serious challenges of biodiversity conservation in the country based on my point of view. Second, I present a vision of solutions as a suggested framework for biodiversity conser-

vation, including a top ten management strategies and urgent research needs.

CONSERVATION CHALLENGES

The critical challenges facing biodiversity in Sudan are similar to elsewhere in the continent, and have been listed in Takona (1999), Goda (2000), Abdelhameed & Nimir (2007), Nur (2007), U.N.E.P. (2007), and Badri (2012). Although I generally agree with these previous studies about these problems, I argue that political conflicts and civil wars is a challenge that substantially affects everything in the country including biodiversity. In the following points I show how continuous conflicts and unrest directly impact biodiversity conservation:

Species loss and mass extinctions

Almost 60 years of violence led the country to lose its southern part, and continues in more than 50% of the rest of the rest of the country (9 states out of 17). In addition, there are intermittent military tensions in the border between Sudan and South Sudan from time to time. Consequently, hundreds of individuals of many taxa have been killed as a direct effect of shootings and fire set by fighters. Also, several species (e.g. Gazelles and Ostrich) have declined due to overhunting by the militants who use them as a primary food source in the woods. Recent IUCN (2013, e.g. Tables 5) Tables of endangered species indicate the absence of information for about 114 animals' species (i.e. data deficit) and 127 species reported as threatened, including 19 plants and 108 animals (16 mammals, 18 birds, 3 reptiles, 21 fishes and 50 invertebrates). Many ecologically important species went extinct since 1980s or are thought to be extirpated from their natural territories in Blue Nile, South Darfur and the Nuba mountains regions. Species endangered because of these conflicts and other stressors (e.g. drought) include top predators: cheetah, *Acinonyx jubatus* Schreber, 1775; African lion, *Panthera leo* Linnaeus, 1758; greater spotted eagle, *Aquila clanga* Pallas, 1811; imperial eagle, *Aquila heliaca* Savigny, 1809; houbara bustard, *Chlamydotis undulata* (Jacquin, 1784); and lesser kestrel, *Falco naumanni* J.G. Fleischer, 1818. Herbivorous on the endangered list are *Hippopotamus, Hip-*

popotamus amphibius Linnaeus, 1758; Barbary sheep, *Ammotragus lervia* Pallas, 1777; Dorcas gazelle, *Gazella dorcas* Linnaeus, 1758; red-fronted gazelle, *Gazella rufifrons* Gray, 1846; Soemmerring's gazelle, *Gazella soemmerringei* Cretzschmar, 1826; African elephant, *Loxodonta africana* Blumenbach, 1797; and African spurred tortoise, *Geochelone sulcata* (Miller, 1779), as well as several bats like Trevor's free-tailed bat, *Mops trevori* (Allen, 1917); horn-skinned bat, *Eptesicus floweri (de Winton, 1901)*; and lappet-faced vulture, *Torgos tracheliotos* (Forster, 1791) (Badri, 2012).

Habitat loss and fragmentation

Habitat loss and fragmentation due to excessive deforestation and agricultural expansion in forest lands. The Sudanese Forest National Corporation (F.N.C.) estimated that vast forested areas of the sub-humid zones in southern Darfur and Kordofan have been cleared by refugees and displaced people for use as fuel wood and building poles. Approximately 1 million hectares was cut down during 2005-2010 in both Sudan and South Sudan (F.A.O., 2005; Gaafar, 2011). Also according to the U.N. mission in Sudan, millions of people from both Sudans have become internally displaced and refugees as a direct impact war, surviving hard conditions and depending largely on the already poor forests for shelter and livelihood.

Insufficient governmental support

For decades, the government's major concern always is to deal with wars. There is not enough government effort or budget allocated to develop conservation programs. It is no secret in Sudan that for decades, the budget of the ministries of defense and interior is about 50-60% of the total, with the rest divided among more than 25 ministries. Furthermore, the latest trends in international arms transfers showed that Sudan is classified among the top three African countries in weapons imports, after Algeria and Morocco, receiving 9% of the total continent's imports (Wezeman & Wezeman, 2014). These numbers show the priorities of the government, and why ministries like environment and physical development, higher education, and science and technology receive less than 1% of the total budget annually.

Redundant and weak institutions

Redundant and weak institutions are responsible for managing natural resources and enforcing conservation policies. It is surprising that many ministries are formed to accommodate opposition and former militia leaders who agree to participate in the government and not because of the technical need for these ministries. Thus the issues of biodiversity are divided among at least 5 ministries and unfortunately none of them is fully functional. For example it is primarily follow to Ministry of the Environment and Physical Development, but it has redundancies with the Ministry of Agriculture (especially at the state level), Forest National Corporation, the Higher Council of the Environment and Natural Resource and Wildlife Protection Administration in the Ministry of Interior.

Data deficits

A general problem in Sudan is information gaps in almost all sectors, particularly the current biodiversity status and geographical distribution (What is where? What are the trends?). For example, there are no current detailed studies about the state of biodiversity of some important ecosystems such as Blue Nile state (e.g. Al-Angesena area) and South and West Darfur states (e.g. Radom National park). Because of the unsecure conditions, it is not surprising that the data collection (e.g. species diversity) for conservation (e.g. habitat restoration) is extremely rare and sometimes impossible. This shortage of information makes conservation planning haphazard and interventions cannot even begin.

Accelerating natural disturbances

Desertification is a familiar scenario in almost 70% of the country and one of the biggest challenges not only because of its fast annual creeping rate but also because it is encroaching on vast habitat areas (Table 1). The high rate of deforestation, soil erosion, forest fires and few reforestation efforts are primary drivers of this phenomenon. In addition, the I.P.C.C. 5th report classified Sudan as one of the most vulnerable spots to climatic changes since the country is at the defense line of the sub-

Saharan region and has high deforestation rates. Consequently extreme events such as drought, flooding and fire are likely to increase severely (Badri, 2012). Conflicts result in more stochastic deforestations and unplanned use of natural resources which ultimately increase the risk of erosion and desertification.

Absence of local communities in establishing

Absence of local communities in establishingand adopting participatory conservation projects. Community involvement varies from place to another, but for the time being the general public, is concerned more about safety, peace, poverty alleviation, and food security rather than conserving biodiversity.

Political restrictions

Political restrictions from the government over the NGOs working in environmental fields. Due to these tensions some NGOs are having difficulties implementing their conservation projects because the government wants them to do it according to its agenda which is not necessarily the same as the NGO's plans.

THE BIG PICTURE OF BIODIVERSITY CHALLENGES IN AFRICA

The truth is that the circumstances (i.e. civil wars and instability) threatening the biodiversity of Sudan occur elsewhere, not only in neighboring countries (e.g. South Sudan, Libya and Central Republic of Africa) but also in the majority of the African countries (e.g. Mali and Somalia). Unfortunately, political instability, spreading wars and chronic conflicts, millions of refugees and displaced people, severe levels of poverty and low education are the largest common denominator among most countries of the region (Swatuk, 2007; Nur, 2007). Furthermore, these countries have weak conservation institutions with no clear plans aggravated by budget issues. Because conservation in general needs committed governments, people living in a safe and healthy environment, and available resources, it is not surprising that issues of biodiversity conservation are a low priority in Africa.

The other dimension of this dilemma is that we do not know when these decades of unrest and conflicts are going to stop (though the reasons behind them are well known) so that development can begin. Meanwhile, the consequences of such deterioration of biodiversity in African countries on the global environment and biodiversity become more severe and uncertain. For instance, U.N.E.P. (2013) reported that the globally important and richest tropical areas in Africa such as Lake Victoria, Congo basin and the Nile fall in regions where conflicts have raged for decades and consequently no detailed biodiversity updates or related environmental data are available. The ecological significance of this area is not limited to global water budget and winter habitat for several western migratory birds. The region is also considered an important sink for carbon dioxide, thus significant to the global carbon budget and all global climate change (U.N.E.P., 2006).

While the governments and the oppositions in countries like Mali, Libya, Egypt, Somalia and Sudan are so busy in fighting each other and allocating most resources and efforts to this, apparently they have forgotten to be united against drought and desertification as the biggest enemy these countries and their people have ever faced. The region has the most severe deforestation worldwide, since vast areas being cleared by millions from local communities who were forced by wars, poverty and lack of development to use forests as their only source for shelter, livelihood, energy, and building materials. There is much to lose: more than 70% of the African tropical forests are located in Democratic Republic of Congo, Rwanda, Burundi, Central African Republic, Sudan and South Sudan, where deforestation related to conflicts is happening every day (Montagnini & Jordan, 2005).

It is important to mention the influences of this continental unrest on the ability of international partners (e.g. U.N.E.P., U.N.D.P., W.W.F., World Bank, U.S.A.I.D., Conservation International, and WCS) to continue funding biodiversity and environmental conservation projects in Africa. Not only is there the direct risks of performing field work or wasting money, but part of this discouragement is because it is very unlikely that conservation plans will achieve the goals of the projects in a sustainable manner.

Despite this dark picture of biodiversity in Africa, there are a couple of bright spots. There is tremendous progress in some countries such as South Africa, Kenya and Tanzania whom just passed through a long history of similar political tragedies but ended up as successful stories. South Africa, after years and years of violence, is a good example of how stability can make development possible. Among several paths of reforms, biodiversity conservation was launched following simple principles based on strong governmental authority and involvement of universities and research centers, local communities and NGOs in planning and management of natural resources. By 2012, official South African reports stated that 9.3 million people come to the country from all over the world for wildlife and ecotourism, which is a great achievement in biodiversity conservation.

My second example is Kenya that came a long way from crises to become the largest center of international and regional environmental organizations in the continent. 'Those trees make Kenya, Kenya!' is a familiar slogan to Kenyans and people who visit Kenya. It represents the vision of the country regarding the environment and indicates awareness and adoption by local communities. Establishing community based-ecotourism organizations is an impressive and creative example that shows what can be done when a committed government works together with responsible NGOs and engaged citizens.

Let me conclude by mentioning the interesting lesson of Tanzania in biodiversity conservation and its significance in stabilizing the economy of the country. There is no doubt that Tanzanian government, with local and international partners, has worked very hard to develop the current working plan for managing protected areas and positioning them as a primary source of income to the country. This wonderful model of managing natural resources is not only a plan for biodiversity conservation, but also made Serengeti, Arusha and other 12 national parks among top tourism areas in the world. The Tanzanian government announced in 2013 that the country has joined the club of 1-million wildlife tourists per year, which is a big achievement. There are also other encouraging attempts by few countries including Zimbabwe, Botswana, Namibia, and Zambia who are relatively stable with well-developed biodiversity plans.

TOP TEN PROPOSALS FOR BETTER BIODIVERSITY CONSERVATION

The big message I want to convey by this paper is that conservation action is still possible. It is never too late as long as there are peace, stability, willingness, and overall the governmental commitments and engaged citizens and NGOs, no matter how few the resources. Countries can maximize the use of land resources for the benefit of people at the same time as aiming towards sustainable biodiversity conservation. Consistent with this belief and drawing from success stories mentioned above and call by recent reports e.g. U.N.E.P. & I.E.S. (2007) and Badri (2012), I suggest some strategies (Fig. 2) to improve the existed efforts. These would be a great start towards better biodiversity conservation in Sudan as well as elsewhere in the region where conflicts and unrest continue.

Management strategies

1. Governance and Government commitment towards natural resources conservation by supporting annual budgets and strengthening the institutions that formulate and implement the conservation plans with systematic monitoring and evaluation protocols.

2. Improving environmental educational programs especially at secondary and higher education levels by addressing the recent globally important issues (e.g. climate change, endangered species) as annual updates in the curriculum. More broadly, major needs of the education system of Sudan are strengthened polices, curriculum reforms to match international trends (e. g. millennium goals), training of faculty (teachers) and assistant staff, and improved government commitment and funding. I urge adoption of some international (similar educational models) standards such as quality assurance systems that include strict monitoring and evaluation system of the educational process.

3. Adoption of research and scientific methods to identify conservation priority areas (e.g. ecosystem level vs. population level) but also select among many adaptation strategies (e.g. water harvesting vs. enclosures for habitat restoration).
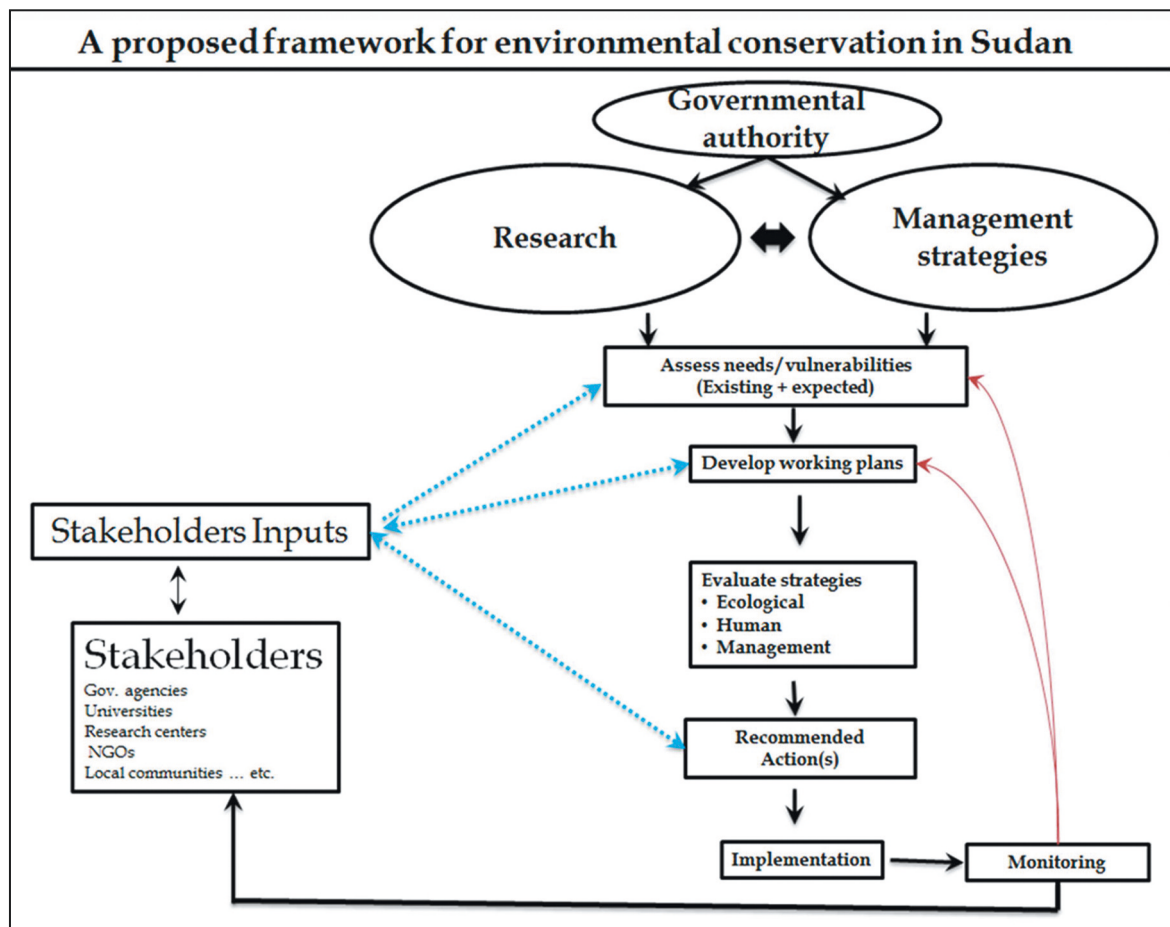
Figure 2. A proposed framework for environmental conservation in Sudan based on the role of the government in initiating research and management plans with consideration of environmental stakeholders.

4. Use of technology in management planning such as remote sensing, GIS, radio collars, camera traps, and acoustic monitoring to improve management and inform decision makers.

5. Adoption of long-term monitoring programs by focusing on specific focal ecosystem indicators (e.g. abundances, composition and richness) and key climatic variables (e.g. amount and length of rainy season) at permanent plots across the country. These monitoring data will be good indications not only for detecting current conditions and trends, but also could alert managers to early warning signals of ecosystem change.

6. Involvement of indigenous communities and nongovernmental stakeholders in conservation planning and implementation. This community involvement could be achieved by using a citizen science approach that can play two roles at once. While involvements of local communities will likely increase the awareness about certain environmental issues (e.g. risk of deforestation) it could be a cost-effective way to collect biodiversity data such as species occupancy information.

7. Capacity building, especially for natural resources mangers, focuses on improving awareness for the reasons to protect biodiversity, identifying hot spots, and building monitoring skills and a documentation system for conservation projects.

8. Enforcing and updating legislation so that conservation efforts are based on the power of law. One sad example though is that National park like Radom is the biggest protected area in the country

but most of its area is dominated by drug cartels farming activates; furthermore there is no government authority inside the park to take actions.

9. Strengthen networking and international partnerships with powerful agencies such as Wildlife Conservation Society (W.C.S.), World Wildlife Fund (W.W.F.), and Nature Conservancy and others to take advantage of their experience in conservation elsewhere.

10. Activating the commitments of Sudan in international environmental conventions (e.g. United Nations Convention on Environment and Development, U.N.C.E.D., United Nations Framework Convention on Climate Change, U.N.F.C.C.C., Convention of Biological Diversity, C.B.D., Convention on international Trade in Endangered Species of Wild Fauna and Flora (C.I.T.E.S.) and protocols (e.g. Kyoto and Ramsar) and following national action guidelines.

Urgent research needs

My suggestions for management interventions emphasize the adoption of research and scientific approaches. I believe that research must play a key role in the next era of conservation biology in Sudan. Research would diagnose major causes of the deterioration of biodiversity and reveals the hot spots of decline during the past. In addition, research will establish baseline information, identify priorities, and inform future management and investment of resources.

Although the importance of research and science-based decisions has been urged by many authors and reports previously (e.g. Abdelhameed, 2007; Zakialdeen, 2009; Funk et al., 2011), like all things in Sudan, research has encountered many obstacles ranging from funding, to weak institutions and facilities, to absence of master plans, to research capacity (e.g. training). Identifying the most pressing research questions will help to focus limited resources. Based on the work of Sutherland et al. (2009) regarding the top hundred most important questions to conservation of global biodiversity, I scaled down to Sudan and adapted a list of top ten research questions about biodiversity of the country.

The questions are:

1. Desertification and drought

Studies on the causes of desertification are relatively better and more focused than studies of strategies of control. Despite these efforts there are many research gaps at the country level such as: Where do the greatest effects of desertification occur? What is the encroachment rate of the desert and where does mostly occur (i.e. how many km/yr.)? Also, important related questions remain unanswered, for example: What is the frequency and duration of drought periods? Are there socioeconomic impacts of desertification and drought? What are these impacts and where?

2. Climate change

The concern with climate change in dry lands is how to adapt to it in the context of the myriad problems already facing these areas. For instance, how to allocate limited resources among many urgent needs - for example, choosing between water harvesting techniques or establishing refugia in protected areas - needs to be studied and choices based on objective (i.e. quantitative) criteria. To design effective studies, it is important that to determine the methods of evaluating the vulnerabilities and effectiveness of adaptations and mitigation measures at any ecosystem.

3. Biodiversity, population dynamics and conservation hot spots

There is an absence of biodiversity information in Sudan; the I.U.C.N. (2013) reported zeros for many taxa to indicate a data deficit. Therefore, to assess the conservation status of species and to make a baseline for any further questions, we need to know who is where and how many of them are there, particularly at the protected areas. For endangered species, we need to assess the status and likelihood of extinction by conducting a population viability analysis (PVA), a widely adopted technique in conservation biology (Lindenmayer et al., 1993; Vie et al., 2009). Additional key studies that relate conservation and populations dynamics include studies of population characteristics other than abundance. For example, fecundity, age classes and sex ratio data, especially for threatened species, are keys to understanding the population dynamics.

Understanding how human activities (e.g. deforestation by refugees), environmental (e.g., fire) and biological (e.g., disease) disturbances impact populations, communities and metapopulation process are also important.

4. Forest ecology, wetlands and habitat assessment

Issues like seed germination and natural regeneration of some threatened trees species such as a desert date (*Balanites aegyptiaca* Del.) and *Boswellia papyrifera* Del. are of great concern and should be a priority area of research. Also there is an absence of studies in important areas like the temporary wetlands and flood plains of the Nile. These are thought to be rich ecosystems supporting several fauna and flora species as well as an essential source of livelihood to millions of people living at the Nile strip and tributaries.

5. Ecological modeling and forecasting

Modeling, simulations and other statistical techniques can be employed to craft very sophisticated ecological questions (e.g. what if) and to improve our understanding about possible future scenarios. Modeling techniques can also integrate data and predictions over large spatial scales (i.e. landscape level).

6. Environmental education

I believe that education is the right way to start making real changes in biodiversity conservation in the country. However, the current education system is broken and needs to be reformed on scientific basis starting by asking questions like: Does our education meet standards at the levels of international criteria (e.g. international education polices of the U.N.E.S.C.O.)? How could we develop a quality assurance system for higher education institutions generally in Sudan in a cost-effective way? I think by answering these questions we can make sure our environmental education meets the international quality standards in higher education with a monitoring and evaluation system.

7. Environmental risk assessments

Despite the political instability and unrest, Sudan has witnessed some developmental projects such new dams, highways and establishment of urban centers. The call here is that biodiversity and risk assessments studies should be considered whenever similar projects are being planned (El-Meghraby, 2009). As violence and conflicts continue in many parts of the country, there is a need to know what exactly the effect of these wars is on biodiversity. I suggest that knowing the effect of a particular civil war that has a certain number of refuges on the surrounding forest cover would be useful to predict the future dynamics of the habitat affected by war.

CONCLUSIONS

Biodiversity is of critical importance to the livelihood of people and is also of high ecological value. Despite its importance, biodiversity in Sudan, as many other resources, has been a victim of political instability and continuous civil wars since the 1950s. Absence of strong governance and polices, and socioeconomic factors have contributed to this substantial deterioration. In addition, the harsh setting, drought, desertification, flooding, fire, habitat destruction and recent climate change have played a great role in reducing habitats and populations.

Despite these stressors on biodiversity and the lack of current information about the ecosystems, communities and populations, conservation efforts must proceed with effective management actions. Urgent management actions at this point should include governance and governmental commitment (e.g. funding, facilities, policies), adoption of research and improving environmental education, adoption of technology and long-term monitoring programs, and involving local communities and NGOs in planning and enforcement of legislations. The government must also stay committed to international environmental conventions and protocols (i.e. U.N.C.E.D., U.N.F.C.C.C., C.B.D., C.I.T.E.S.), Finally, I recommend capacity building and training of conservation practitioners. This would have great value especially if it is conducted in the context of international partnerships with other prominent conservation agencies (e.g. U.S.A.I.D., W.C.S., W.W.F., and The Nature Conservancy).

The research need at this point is to create the bench marks to build upon. Not only questions concerning species richness and abundance are

important. It is also critical to know the effects of different disturbance factors (e.g. desertification and human aspects) on the ecosystems, habitats and populations. Studies investigating the role of biodiversity in the livelihood of local communities as well as the role of communities in conservation should be a priority. The Nile needs more in-depth investigations about its faunal and floral diversity, biogeochemistry, water chemistry and the effects of heavy agricultural and urbanization activities on the environment of the both banks of the Nile. Also areas affected by the conflicts, especially where the effects of refugees and internally displaced people could affect the resources must be a priority of research.

In conclusion, I believe that all researchers and conservation biologists in Sudan share with me the same positive feelings and responsibility about the country's biodiversity and resources. I hope this work to lead to new initiatives from both the government agencies and   conservation biologists. I truly want this report to motivate in-depth work and collaborative efforts that will substantially improve the status of biodiversity in Sudan as well as be a model for conservation in the region.

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