

Do Observations during Patrolling Trips Detect Changes in Wildlife Presence & Diversity in National Parks?

Samir A. Koko¹, Ahmed A. H. Siddig¹ , Emad H. E. Yasin^{1,2*} , Nasradeen A. H. Gadallah^{1,3} ,
Mohamed M. A. Adam¹, Ahmed M. M. Hasoba^{2,4} , Ameer Awad Mohammed⁵

¹Faculty of Forestry, University of Khartoum, Khartoum North, Sudan

²Faculty of Forestry, University of Sopron, Bajcsy-Zsilinszky utca 4, Sopron, Hungary

³African Center of Excellence on Climate Change, Biodiversity and Sustainable Agriculture, University Felix Houphouet-Boigny, Abidjan, Côte d'Ivoire

⁴Faculty of Forest Sciences and Technology, University of Gezira, Wad Madani, Sudan

⁵Wildlife Research Center, Khartoum North, Sudan

Email: *emad.yasin823@gmail.com, *Emad.HassaElawadYasin@phd.uni-sopron.hu

How to cite this paper: Koko, S.A., Siddig, A.A.H., Yasin, E.H.E., Gadallah, N.A.H., Adam, M.M.A., Hasoba, A.M.M. and Mohammed, A.A. (2023) Do Observations during Patrolling Trips Detect Changes in Wildlife Presence & Diversity in National Parks? *Open Journal of Ecology*, 13, 794-805.
<https://doi.org/10.4236/oje.2023.1311049>

Received: October 28, 2023

Accepted: November 21, 2023

Published: November 24, 2023

Copyright © 2023 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Globally, mountains encompass spectacular landscapes and a great diversity of species. However, Savannah's mountains in Sudan have been affected by the loss of diversity due to human activities and climate changes. Therefore, this study aims to assess changes in wildlife diversity in Jebel-Eldair Nation Park (JENP) based on only reports from patrolling activities, especially in the absence of regular wildlife monitoring programs. Reports of monthly wildlife observations during patrolling trips were used for the summer season in 2010 and 2018. Findings showed a moderate to high decline in the most important wildlife species (*i.e.* lion, wild dog, and crest porcupine). Six others are documented as rare species in reserve, including the civet, spotted hyena, striped hyena, jackal, seraval, and Siberian bird. Contrary and despite the diversity reduction, some species witnessed increases in their observation frequency, such as lesser kudu, caracal, monitor, and lunar bird. Moreover, human settlements, agricultural activities, and other anthropogenic factors were found to be the main drivers of biodiversity reduction in JENP. The study recommends adopting this method to detect changes in wildlife communities, especially in a situation of deficiency and lack of funding to conduct regular monitoring programs.

Keywords

Wildlife Monitoring, Biodiversity, Jebel-Eldair Nature Reserve, Patrolling

1. Introduction

Protected areas are foundations for almost all national and international conservation strategies that are essential for preserving natural ecosystem functions and conserving biological diversity in such ecologically rich regions [1]-[10]. The ecosystems of Sudan are richly endowed with diverse resources plants, animals, and microbes reflected in diverse socio-cultural and economic ecosystem services. Despite these great values, unfortunately, Sudan's ecosystems and inhabiting populations are facing many threats including conflicts and wars, habitat destruction and large-scale deforestation, urbanization, agricultural expansion, and climatic hazards just to name some [11] [12] [13] [14].

Perhaps the country is doing its best to deal with these threats but also making an effort to conserve these vital resources. Among the many conservation interventions that the government took was to establish protected areas [15]. Many of these protected areas were gazetted as far back as 1935, while others were recently established such as Jebel-Eldair National Park (JENP) in 2010 and El Gazali in 2016 [13] [16]. These areas have been classified into three types according to the level of protection and restrictions on human (community) activities such as; National Parks (NP), Game Reserves (NR), and Game Sanctuaries (GS) [17] [18] (Table 1).

Generally, apart from human activities, climatic changes have been reported to have a negative impact on wildlife and their habitats in protected areas [15] [19] [20] [21] [22] [23]. In recent decades, drought incidences and short rainy seasons have been frequently observed, especially in protected areas in savannas and semi-arid regions including Jebel El-Dair Natural Reserve. Other threats to PAs of Sudan include tribal conflicts civil wars and political instability [24] [25] [26] [27] [28]. Consequently, there were many tribes displaced from Western Sudan due to the Darfur war and settled in more than 40 villages in and around Dinder National Park in 2003 which led to an increase in poaching and illegal trade in wildlife products [14] [24] [29].

Table 1. Protected areas in Sudan [13] [24].

No.	Ecological Zone	National park
1	Mountain	Jabel Jebel-Eldair
2	Desert	Wadi Hawar
3	Semi-desert	Jebel Hassania, EL gazali
4	Low Rainfall Savannah Woodland	Dinder, Pasonda Glatat
5	High Rainfall Savannah Woodland	Radom
6	Marine Coastal	Sanganeb, Dongonab

Keeping in view, in Sudan the agricultural expansion is considered one of the greatest threats to the biological diversity and ecosystems in the country [24] [30]. Moreover, gold mining, the petroleum industry, conflicts, and low funds allocated for the protected areas conservation were also affecting the development and sustainability of wildlife and biodiversity conservation programs [31]. In this regard, the USAID report of 2012 stated that the protected areas of Sudan are facing considerable pressure from degradation, poaching, and livestock encroachment. Later, the same agency added land-use competition among rural communities as another detrimental factor affecting protected areas [32]. The literature characterized the rural communities' life patterns where they are largely depending on natural resources (e.g., forest products and bush meat). These resources in most time limited to meet the needs of the increasing population rate, which will eventually lead to conflicts and many other negative factors including wildfire, wildlife animal migration, and diversity loss [33].

In the light of best monitoring and biodiversity conservation, the report of the World Conservation Monitoring Center of 1996 revealed that assessing wildlife diversity provides information about threatened species, endemic species, and geographic distribution of rich and rare species and hence will boost the biodiversity conservation and management efforts [34]. These kinds of information are essential to support decision-making and provide comprehensive indications for long-term monitoring and conservation planning [18] [35] [36]. Raising concern about the effectiveness of the protected areas system is emerging from increased interest in the status of many protected areas in the world. Accordingly, the Sudan government calls for frequent assessment and revision of all protected areas to make sure that they are effective in meeting the reservation goal and the other values for which they were established. While we have data deficiency and limited information on the status of protected areas in Sudan, cumulative evidence recommends that many are under pressure or are experiencing degradation and continuous loss of their biodiversity [13].

On the other hand, regular wildlife monitoring programs in protected areas of Sudan are very limited due to the absence of rigorous and prescribed management plans, funding, and trained staff [18]. For instance, standard wildlife monitoring methods such as transect surveys; distance sampling, capture-mark-recapture methods, and camera trapping are all associated with many logistical burdens and thus have not yet been implemented in documenting wildlife populations in these protected areas. However, there were recent attempts to utilize road-encountered wildlife observations during patrolling missions inside the parks as wildlife survey methods. Despite the appeal of this method but has not been utilized in monitoring changes in wildlife populations in protected areas, particularly in JENP. Therefore, this study aims to evaluate changes in wildlife diversity in Jabel-Eldair National Park in Sudan's savanna zone using patrolling observation records to determine changes from 2010 compared to 2018 and discuss the validity of using patrolling visits to assess wildlife change.

2. Materials and Methods

2.1. Study Area

The study was conducted in Jebel El-Dair National Park (JENP), Northern Kordofan State which is considered one of the important mountainous parks in Sudan. It was reserved in 2010 for the conservation of flora and fauna of the area. It covers an area of 314.45 Km² which lays between 12°21'N-12°32'N and 30°35'E-30°35'E (**Figure 1**). Climatologically, JENP is located in the low rainfall woodland savanna on clay soil where the rainfall varies from 300 - 400 mm/year and the average summer temperature reaches 48°C in March and April. Regarding the flora, the area lies in *Acacia mellifera* thorn land, where species composition is dominated by *Acacia mellifera* that stretches across a belt between Kassala and Gadarif westwards to Abu Habil clay basins and northern piedmonts of Nuba Mountains. Shrubs such as *Cadaba glandulosa* and *Cadaba rotundifolia* are common, while *Boscia senegalensis*, *Balanities aegyptiaca*, and *Dichrostachys Cinerea* are less common. The fauna of JENP is characterized by wild animal species that mainly consist of measo and small mammals including lesser kudu (*Tragelaphus imberbis*) which is considered one of the most threatened species around the globe in general and in Sudan in particular.

2.2. Data Collection and Analysis

This study was conducted using two types of data collection methods including:

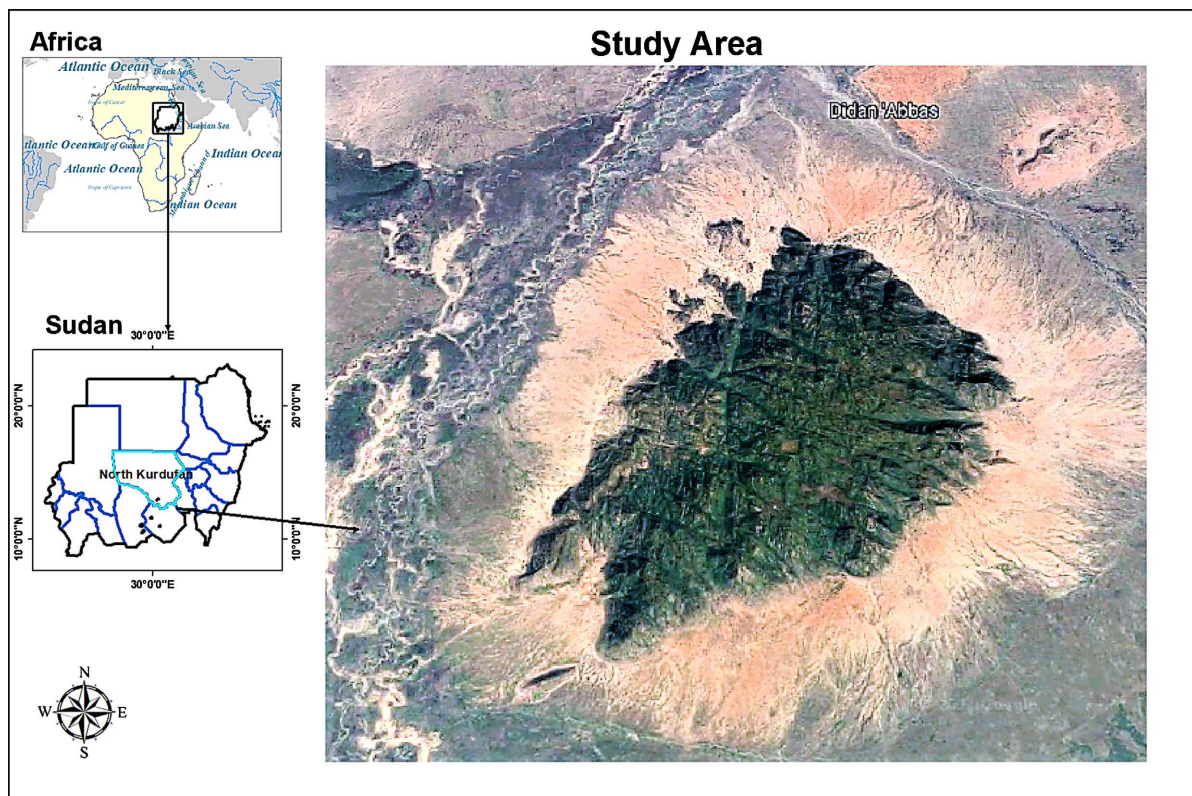


Figure 1. Map of the study area.

1) review and analysis of patrolling reports and 2) interviews with wildlife experts using structured questionnaires. These methods were used to obtain necessary data and information on the status of JENP wildlife diversity and changes along with their drivers. On one hand, the patrolling reports of the park's authority for the dry season (January-June) of the years 2010 and 2018 were identified, and reviewed, and observations (*i.e.* presence and number of individuals) for each species seen along the patrolling route were recorded. Eventually, these abundance data were extracted and analyzed, and changes in species richness, percent change in relative abundance, and abundance trend were derived. On the other hand, the interviews targeted wildlife experts & officers who have recently worked in or visited the park, researchers from the Wildlife Research Center, and wildlife officers from the Wildlife Protection Administrative Headquarters in Khartoum. Subsequently, the interviews with 20 wildlife officers and other researchers were conducted using a structured questionnaire which was developed to validate the patrolling reports regarding the presence and abundance of wildlife species in the park in 2010 and 2018 and to elucidate the threats.

3. Results

3.1. Current Status of Wildlife Groups in JENP

A total of 22 and 19 species have been detected during patrolling trips in the years 2010 and 2018, respectively (**Figure 2**). Mammals are considerably dominant representing 59 percent followed by birds at 27.3 percent then reptiles at 13.7 percent of the species observed.

3.2. Changes in Wildlife Diversity in JENP during 2010-2018

A total number of 100 individual animals were observed in the summer of 2010

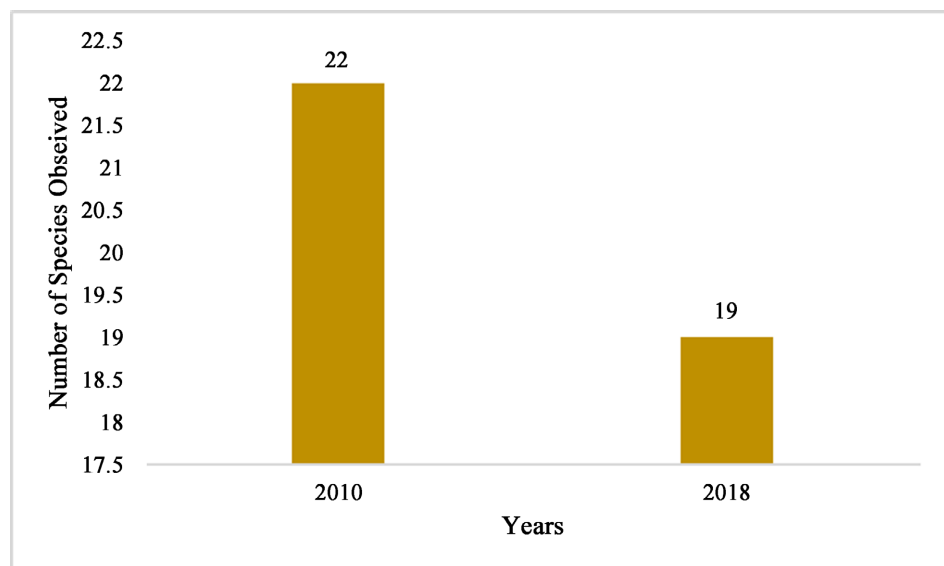


Figure 2. Number of species observed in JENR during patrolling trips in the summer of 2010 & 2018.

and 116 individual animals in 2018 representing three taxonomic groups (*i.e.* mammals, birds, and reptiles). Despite the 16 percent increase in the total number of individual animals detected during the two periods, however, species richness has declined from 22 species in 2010 to 19 species in 2018 (**Figure 2**). As such, three species including lion, wild dog, and crest porcupine disappeared from patrolling routes observations (see **Table 2**). Contrarily and despite the decline in numbers of some species, other species numbers have witnessed an increase such as lesser kudu, caracal, monitor, and lunar bird (**Table 2**). Overall and according to the observations during patrolling routes, the trend of wildlife abundance indicated that 50 percent of the species are increasing, 18 percent stable, and 32 percent declining (**Table 3**).

Table 2. Seasonal presence and change in abundance for different wildlife species in JENP from January to June in the years 2010 and 2018.

No.	Species name	Taxonomic Group	No. of times Observed in summer 2010	No. of times Observed in summer 2018	Abundance Change	Change per cent	Abundance Trend
1	Lion	Mammalia	1	0	-1	-1	Declining
2	Great kudu	Mammalia	4	1	-3	-0.75	Declining
3	Lesser kudu	Mammalia	4	6	2	0.5	Increasing
4	Crest porcupine	Mammalia	10	0	-10	-1	Declining
5	Jackal	Mammalia	3	2	-1	-0.33	Declining
6	Red fox	Mammalia	3	4	1	0.33	Increasing
7	Dassie	Mammalia	10	10	0	0	Stable
8	Caracal	Mammalia	1	10	9	9	Increasing
9	Wild dog	Mammalia	1	0	-1	-1	Declining
10	Striped hyena	Mammalia	1	5	4	4	Increasing
11	Spotted hyena	Mammalia	2	4	2	1	Increasing
12	Baboon	Mammalia	10	10	0	0	Stable
13	Monitor	Reptilia	6	10	4	0.67	Increasing
14	Tortoise	Reptilia	8	1	-7	-0.88	Declining
15	Hoopoe	Birds	10	10	0	0	Stable
16	Lunar bird	Birds	4	10	6	1.5	Increasing
17	Siberian bird	Birds	3	8	5	1.67	Increasing
18	Buffer bird	Birds	3	8	5	1.67	Increasing
19	Wild hen	Birds	10	10	0	0	Stable
20	Pharaonic puma	Birds	1	2	1	1	Increasing
21	Copra	Reptilia	3	4	1	0.33	Increasing
22	Civet	Mammalia	2	1	-1	-0.5	Declining
	Total		100	116			

3.3. Wildlife Threats in JENP

According to respondents' responses in the structured questionnaire, several factors have affected and contributed to the current abundance and trend of wildlife species in Jebel-Eldair National Park (Figure 3). While there are about 40 percent of respondents stated human settlements and the formation of 18 new villages near the park is the most significant factor followed by tree logging (19 percent) and habitat deterioration (19 percent), but soil erosion and fire reported to have a minor and occasional effects (Figure 3).

4. Discussion

4.1. Drivers of Wildlife Changes in JENP during 2010-2018

The study addressed the potential of patrolling observation records in monitoring wildlife diversity in protected areas. Inferring from Table 2, there was a notable decline in species from 2010 to 2018 as about 14 percent of the species were not observed at all in the summer of 2018. Additionally, there were about five mammal species that became rare such as the jackal, spotted hyena, striped hyena, serval, and civet in addition to the Siberian bird. Anthropogenic activities such as agricultural expansion, livestock grazing, and woodcutting have destroyed

Table 3. Abundance trend for different wildlife species in Jebel-Eldair National Park during the period between 2010 and 2018.

Abundance Trend	Sign	No. of species	Per cent
Increasing	+	11	50
Stable	0	4	18
Declining	-	7	32
Total		22	100.00

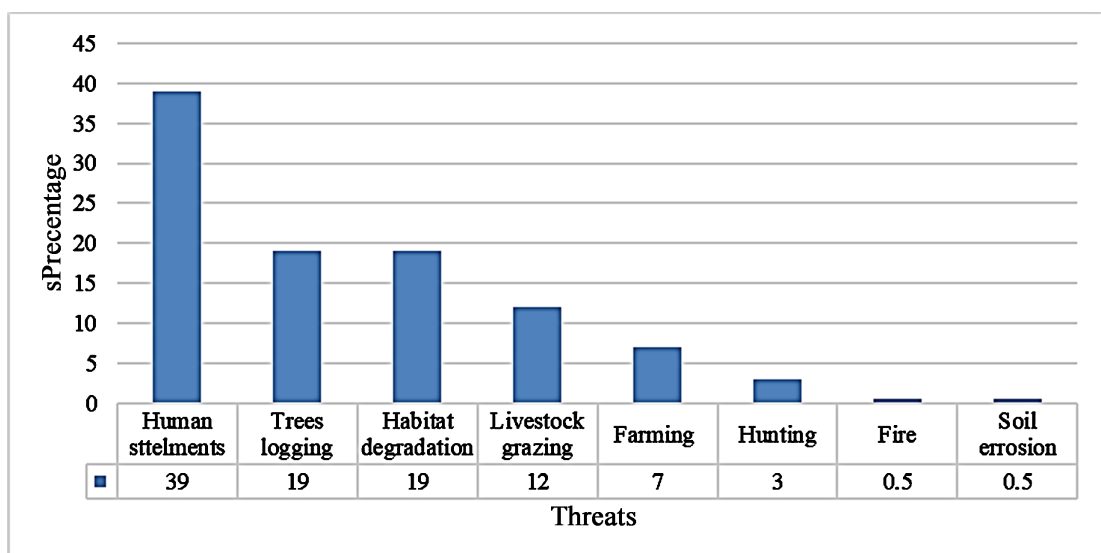


Figure 3. Respondents' views on wildlife threats in JENP National Park.

their habitat and hence it may contribute to these noted changes. In this regard, Ali and Nimir [37] in the study in Dinder National Park have reported that many threats and anthropogenic factors have led to biodiversity decline in which the absence of a proper land use system in the vicinity of the park, increasing the displaced people, trespassing of pastoralists are characterizing the reasons. Although, these activities could have been practiced, in a sustainable and harmonized manner that leads to natural resources benefits sharing and best management practices. The essence of management activities serves to improve the status of the wildlife resources and address the needs of people who utilize this resource to the benefit of all including the management of demographics and economic conditions changes [38]. Therefore, the management of Jebel-Eldair National Park could be directed towards the enhanced balance between man and nature where humans can conserve nature and gain its services such as energy sources, creation of jobs in rural areas, sustainable use of natural resources, improving and modernizing agricultural production [39] [40].

The Plethora of drivers depicted in **Figure 3** has characterized the wildlife diversity decline and loss. The human settlements, habitat destruction by wood-cutting, and farming activities in the surrounding area of Jebel-Eldair have been considered as main drivers. Generally, it could be said that higher population densities inhabit the eastern part of Jebel-Eldair have exert intensive pressure on the natural resources compared to other sides of the park. The topography of the eastern has eased the movement of people and their livestock to invade Jebel-Eldair National Park and consequently become a gate of uncontrolled exploitation of the anthropogenic activities inside Jebel-Eldair account of its natural resources leading to the complete depletion unless the best conservation and coherent management policies being applied.

4.1. Underlying Drivers of Wildlife Diversity

Moreover, the absence of local integrated natural resources management plans was found as another cause of wildlife diversity declining, because the forest authorities permit farming activities around the reserve without consultation with the wildlife administration [41] [42] [43] [44]. These activities are considered as most wildlife habitat destructive factors that reduce forest cover and hinder the migration process in and out of Jebel-Eldair nature reserve. Also, the local forest authorities are allowing tree-felling for charcoal production, because the majority of people depend on firewood as a main energy source for their cooking and lightening where the most preferred trees are *Acacia Seyal*, *Pseudocedreal kotschyii*, *Combretum sp*, and *Anogeissus sp*. This activity also leads to wildlife habitat destruction, which requires strict controlling measures for better conservation [40] [45]. The extensive cutting practice of the above-mentioned species would eventually affect their regeneration compared to the other tree species found within Jebel-Eldair Nature National Park.

Nevertheless, this study has some limitations which are related to data quality

and validity of patrolling observation reports. For instance, the method assumes that animals that were not in the route during patrolling are absent and thus not available. Also, patrolling intensity, timing, and coverage are other determining factors in the observations.

5. Conclusion

The global concern about biological diversity especially in the areas that are in danger of wildlife loss such as the Savanna Mountains of Sudan has driven the initiation of this study to groom some wildlife databases through sound wildlife diversity assessment methods as well as appraising the feasibility of these methods for better and robust monitoring and conservation measures. From the adopted methods of wildlife tracking (season 2010 and season 2018) along with the expert observations, the findings have been drawn. Accordingly, a moderate to high biodiversity decline in the most important wildlife species especially lion, wild dog, and crest porcupine, and six other species were found rare such as civet, spotted hyena, striped hyena, jackal, seraval, and Siberian bird where only 18 (in 2018) out of 22 (in 2010) wildlife species that have been observed. Nevertheless, species like lesser kudu, caracal, monitor, and lunar birds have started to dominate. Many anthropogenic factors have driven wildlife diversity changes including human settlements, and agricultural and livestock grazing activities. The study recommends that there is a need for solid conservation strategies along with wildlife law enforcement by conservation authorities, raising local communities' consciousness and development and adopting modern technologies for wildlife monitoring such as remote sensing, GIS, radio collars, camera traps, and acoustic monitoring to boost the management planning and inform decision-makers. This study presents an innovative, cost-effective method by integrating patrol records with expert interviews to track wildlife population dynamics and anthropogenic impacts in JENP. This approach facilitates strategic conservation planning and offers a model for global biodiversity monitoring, advancing conservation practices; further studies must pay attention to the limitations of the method and develop robust designs for it.

Acknowledgments

The authors would like to thank the contributions of the Wildlife Research Center and wildlife officers from the Wildlife Protection Administrative Headquarters in Khartoum. Many thanks are given to the colleagues who participated directly or indirectly in the data collection and analysis process.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Dudley, N. (2008) Guidelines for Applying Protected Area Management Categories.

- International Union for the Conservation of Nature (IUCN), Gland.
<https://doi.org/10.2305/IUCN.CH.2008.PAPS.2.en>
- [2] Coad, L., Leverington, F., Knights, K., Geldmann, J., Eassom, A., Kapos, V. and Hockings, M. (2015) Measuring Impact of Protected Area Management Interventions: Current and Future Use of the Global Database of Protected Area Management Effectiveness. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **370**, Article ID: 20140281. <https://doi.org/10.1098/rstb.2014.0281>
 - [3] Terraube, J., Helle, P. and Cabeza, M. (2020) Assessing the Effectiveness of a National Protected Area Network for Carnivore Conservation. *Nature Communications*, **11**, Article No. 2957. <https://doi.org/10.1038/s41467-020-16792-7>
 - [4] Hoffmann, S. (2022) Challenges and Opportunities of Area-Based Conservation in Reaching Biodiversity and Sustainability Goals. *Biodiversity and Conservation*, **31**, 325-352. <https://doi.org/10.1007/s10531-021-02340-2>
 - [5] Comer, P.J., Valdez, J., Pereira, H.M., Acosta-Muñoz, C., Campos, F., Bonet García, F.J., Claros, X., Castro, L., Dallmeier, F., Domic Rivadeneira, E.Y. and Gill, M. (2022) Conserving Ecosystem Diversity in the Tropical Andes. *Remote Sensing*, **14**, Article 2847. <https://doi.org/10.3390/rs14122847>
 - [6] Hodge, B.C., Pendleton, D.E., Ganley, L.C., O'Brien, O., Kraus, S.D., Quintana-Rizzo, E. and Redfern, J.V. (2022) Identifying Predictors of Species Diversity to Guide Designation of Marine Protected Areas. *Conservation Science and Practice*, **4**, e12665. <https://doi.org/10.1111/csp2.12665>
 - [7] Brennan, A., Naidoo, R., Greenstreet, L., Mehrabi, Z., Ramankutty, N. and Kremen, C. (2022) Functional Connectivity of the World's Protected Areas. *Science*, **376**, 1101-1104. <https://doi.org/10.1126/science.abl8974>
 - [8] Miah, M.R., Hasan, M.M., Parisha, J.T., Alam, M.S.E., Sayok, A.K., Sarok, A. and Uddin, M.B. (2023) Enhancing National Park Information Knowledge to Improve Biodiversity Conservation in Bangladesh: A Study on Policy Perspectives. *International Journal of Plant Research*, **13**, 1-23.
 - [9] Cheng, Y., Wu, H. and Yang, B. (2023) Conserving Habitat and Ecosystem in Protected Areas Amid Increasing Intensive Human Modification: A Case Study of China's Pan-Pearl River Delta. *Ecological Indicators*, **154**, Article ID: 110799. <https://doi.org/10.1016/j.ecolind.2023.110799>
 - [10] Babu, A. (2023) Review of the Role of the Landscape Approach in Biodiversity Conservation. *Sustainability and Biodiversity Conservation*, **2**, 61-86.
 - [11] USAID (2012) Sudan Environmental Threats and Opportunities Assessment with Special Focus on Biological Diversity and Tropical Forest. Management Systems International.
 - [12] Ali, O.M.M. and Idris, M.F. (2016) The Contribution of Environmental Impact Assessment Studies to the Flora Biodiversity in Sudan. *Journal of Environmental Protection*, **7**, 1707-1718. <https://doi.org/10.4236/jep.2016.712138>
 - [13] Siddig, A.A., Magid, T.D.A., EL-Nasry, H.M., Hano, A.I. and Mohammed, A.A. (2018) Biodiversity in Sudan. In *Global Biodiversity* (pp. 273-294). Apple Academic Press, New York. <https://doi.org/10.1201/9780429469800-10>
 - [14] Ali Osman, M.M. (2020) Sudan: First Stat of Environment and Outlook Report 2020. United Nations Environment Programme.
 - [15] Abdelhameed, S.M. (2016) The Impact of Climate Change on Natural Heritage and Its Management in Sudan. *African World Heritage Seminar "Thinking Ahead"*, Johannesburg, 3-5 May 2016.

- [16] Jeronymo, C.A.L., da Silva, E.R. and Fonseca, K.T. (2021) The Ideal of Environmental Protection as Protected Areas: A Literature Review. *Ciência e Natura*, **43**, e84. <https://doi.org/10.5902/2179460X63107>
- [17] Ferraro, P.J., Hanauer, M.M., Miteva, D.A., Canavire-Bacarreza, G.J., Pattanayak, S.K. and Sims, K.R.E. (2013) More Strictly Protected Areas Are Not Necessarily More Protective: Evidence from Bolivia, Costa Rica, Indonesia, and Thailand. *Environmental Research Letters*, **8**, Article ID: 025011. <https://doi.org/10.1088/1748-9326/8/2/025011>
- [18] Siddig, A.A. (2019) Why Is Biodiversity Data-Deficiency an Ongoing Conservation Dilemma in Africa? *Journal for Nature Conservation*, **50**, Article ID: 125719. <https://doi.org/10.1016/j.jnc.2019.125719>
- [19] Heim, N., Fisher, J.T., Clevenger, A., Paczkowski, J. and Volpe, J. (2017) Cumulative effects of Climate and Landscape Change Drive Spatial Distribution of Rocky Mountain Wolverine (*Gulo gulo* L.). *Ecology and Evolution*, **7**, 8903-8914. <https://doi.org/10.1002/ece3.3337>
- [20] Procko, M., Naidoo, R., LeMay, V. and Burton, A.C. (2022) Human Impacts on Mammals in and around a Protected Area before, during, and after COVID-19 Lockdowns. *Conservation Science and Practice*, **4**, e12743. <https://doi.org/10.1111/csp2.12743>
- [21] Shin, Y.J., Midgley, G.F., Archer, E.R., Arneith, A., Barnes, D.K., Chan, L., Hashimoto, S., Hoegh-Guldberg, O., Insarov, G., Leadley, P. and Levin, L.A. (2022) Actions to Halt Biodiversity Loss Generally Benefit the Climate. *Global Change Biology*, **28**, 2846-2874. <https://doi.org/10.1111/gcb.16109>
- [22] Li, B.V., Jenkins, C.N. and Xu, W. (2022) Strategic Protection of Landslide Vulnerable Mountains for Biodiversity Conservation under Land-Cover and Climate Change Impacts. *Proceedings of the National Academy of Sciences of the United States of America*, **119**, e2113416118. <https://doi.org/10.1073/pnas.2113416118>
- [23] Abrahms, B., Carter, N.H., Clark-Wolf, T.J., Gaynor, K.M., Johansson, E., McInturff, A., Nisi, A.C., Rafiq, K. and West, L. (2023) Climate Change as a Global Amplifier of Human-Wildlife Conflict. *Nature Climate Change*, **13**, 224-234. <https://doi.org/10.1038/s41558-023-01608-5>
- [24] UNEP (2007) UNEP 2007 Annual Report. UNT Digital Library, Denton. <https://digital.library.unt.edu/ark:/67531/metadc25991/>
- [25] Siddig, A.A.H. (2014) Biodiversity of Sudan: Between the Harsh Conditions, Political Instability and Civil Wars. *Biodiversity Journal*, **5**, 545-555.
- [26] El Khidir, S.A. and Ali, O.M. (2018) The Impact of War on Wildlife in Radom National Park, Southern Darfur State-Sudan. *Journal of Biodiversity & Endangered Species*, **6**, Article ID: 1000220.
- [27] Peel, M.J. and Smit, I.P. (2020) Drought Amnesia: Lessons from Protected Areas in the Eastern Lowveld of South Africa. *African Journal of Range & Forage Science*, **37**, 81-92. <https://doi.org/10.2989/10220119.2020.1720292>
- [28] Ahmed, S.M. (2020) Impacts of Drought, Food Security Policy and Climate Change on Performance of Irrigation Schemes in Sub-Saharan Africa: The Case of Sudan. *Agricultural Water Management*, **232**, Article ID: 106064. <https://doi.org/10.1016/j.agwat.2020.106064>
- [29] Abdelhameed, S.M. (2015) Evaluation of Ecosystem Services of Dinder Wetland/Sudan. Nile Ecosystems Valuation for Wise Use (Nile-Eco-VWU) (2015-2016) of Nile Basin, Project Nile Basin Capacity Building Network.
- [30] Van Hoven, W. and Nimir, M.B. (2004) Recovering from Conflict: The Case of Dinder and Other National Parks in Sudan. Protected Areas Programme.

- [31] Desai, B.H. (2020) 14. United Nations Environment Programme (UNEP). *Yearbook of International Environmental Law*, **31**, 319-325. <https://doi.org/10.1093/yiel/yvab060>
- [32] USAID (2018) Sudan Environmental Threats & Opportunities Assessment, 2018 towards Enduring Peace in Sudan (TEPS).
- [33] Beckline, M., Manan, A., Dominic, N., Mukete, N. and Hu, Y. (2022) Patterns and Challenges of Forest Resources Conservation in Cameroon. *Open Access Library Journal*, **9**, 1-13.
- [34] Dorazio, R.M. and Royle, J.A. (2005) Estimating Size and Composition of Biological Communities by Modeling the Occurrence of Species. *Journal of the American Statistical Association*, **100**, 389-398. <https://doi.org/10.1198/016214505000000015>
- [35] Corona, P., Blasi, C., Chirici, G., Facioni, L., Fattorini, L. and Ferrari, B. (2010) Monitoring and Assessing Old-Growth Forest Stands by Plot Sampling. *Plant Biosystems—An International Journal Dealing with all Aspects of Plant Biology*, **144**, 171-179. <https://doi.org/10.1080/11263500903560710>
- [36] Corona, P., Chirici, G., McRoberts, R.E., Winter, S. and Barbati, A. (2011) Contribution of Large-Scale Forest Inventories to Biodiversity Assessment and Monitoring. *Forest Ecology and Management*, **262**, 2061-2069. <https://doi.org/10.1016/j.foreco.2011.08.044>
- [37] Ali, A.M. and Nimir, M.B. (2006) Putting People First. Sustainable Use of Natural Resource in Dinder National Park. Area Guidelines Series No. 21, Gland.
- [38] Akbar, I., Abdreyeva, S., Artemyev, A., Tumazhanova, M. and Orynbasarova, G. (2022) Research on Design and Management of Community-Based Ecotourism Model in Aksu-Zhabagly Nature Reserve of Kazakhstan. *Journal of Geoscience and Environment Protection*, **10**, 33-48. <https://doi.org/10.4236/gep.2022.104003>
- [39] Flandez, M.S. and Ouedraogo, K. (1994) Management of Woodlands Savannah in the Sudano-Sahelian Zone. FAO, Rome, Italy, 33-43. <https://rangelandsgateway.org/dlio/12554>
- [40] Mrosso, H.T., Kicheleri, R.P., Kashaigili, J.J., Munishi, P., Kadigi, R.M.J., Mgeni, C.P. and Kimaro, M.H. (2022) Illegal Wildlife Trade: Trade Flows of Wildlife Products and Facilitation Methods in the Ruaha Landscape, Tanzania. *Open Journal of Ecology*, **12**, 585-603. <https://doi.org/10.4236/oje.2022.129033>
- [41] Nimir, M.B. (1983) Wildlife Values and Management in Northern Sudan. Ph.D. Thesis, Colorado State University, Fort Collins.
- [42] Adewumi, A., Udo, A. and Lameed, G. (2022) Mammal Species Composition in Ini Local Government Area, Akwa Ibom State, Nigeria. *Natural Resources*, **13**, 181-189. <https://doi.org/10.4236/nr.2022.139012>
- [43] Udoma-Michaels, D., Ndukwu, B. and Obafemi, A. (2019) Perception Assessment of the Impact of Human Activities on Stubbs Creek Forest Reserve, Akwa Ibom State, Nigeria. *Natural Resources*, **10**, 139-152. <https://doi.org/10.4236/nr.2019.105010>
- [44] Bassan, K., Kokou, K. and Sills, E. (2020) Constraints to Tropical Forest Conservation and Successful Monitoring and Assessment of Land Uses Cover and Change: Do the Forest Definition and Administration Really Matter? *Natural Resources*, **11**, 1-19. <https://doi.org/10.4236/nr.2020.111001>
- [45] Amare, A. (2015) Wildlife Resources of Ethiopia: Opportunities, Challenges and Future Directions: From Ecotourism Perspective: A Review Paper. *Natural Resources*, **6**, 405-422. <https://doi.org/10.4236/nr.2015.66039>