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Kafta-Sheraro National Park in Northwest Ethiopia: Exceptional Resource Values, Principal Ecosystem Components and Human-induced Threats

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ABSTRACT

Globally, protected areas such as national parks are mainly established to protect the rapidly declining populations of conservation concern wildlife species, as well as ecologically and economically important areas. In addition, more recently, establishing and maintaining protected areas has become an essential part of the global response of governments to combat climate change and its impacts. However, most of these protected areas are facing an unprecedented rate of biodiversity and ecosystem degradation due to human-induced actions. Mitigation of threats and their impacts on biodiversity in these protected areas is very critical. But limited information, needed to develop strategies for mitigation of the ever-growing threats, is available on the biophysical resources and threats to them. This paper presents for the first time, detailed information on the Exceptional Resource Values (ERVs), Principal Ecosystem Components (PECs; or conservation targets), and human-induced threats in the Kafta-Sheraro National Park (KSNP). Standard ecological and social science methods were used to collect and analyze the data. Overall, 14 key ERVs were identified in the park, including several conservation concerns and/or flagship mammal species (e.g. African Elephant (*Loxodonta africana*)), biome-restricted and migratory bird species (e.g., Demoiselle crane (*Anthropoides virgo*)), three distinct habitat types, and a hydrological system. Six PECs that were assumed to represent the whole ecosystem components of the park were identified in KSNP: the three habitat types, hydrological system, Elephant, and Roan antelope (*Hippotragus equines*). The top human-induced threats to these PECs appeared to be fire, cultivation, grazing, settlement, poaching, and mining. In general, KSNP contains outstanding biodiversity and other natural resources that could play a vital role in the socio-economic development of local and regional communities. To ensure the long-term persistence of the ERVs and PECs and the appropriate functioning of the park ecosystems the development and implementation of threat mitigation strategies are required.

Keywords: African Elephant, Biodiversity, *Boswellia papyrifera*, Conservation, Disturbance, Protected areas.

1. INTRODUCTION

Protected areas are typically established to protect the rapidly declining populations of wildlife species, breathtaking scenery, ecological and geologically important areas, endemic and

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endangered species, and to boost economic gain through tourism (Locke and Dearden, 2005; Gaston et al., 2008; Lakew Berhanu et al., 2011). In addition to conserving such valuable biophysical resources, establishing, and maintaining protected areas has increasingly become an essential part of the global response of governments to climate change, because they help address the cause of climate change by reducing greenhouse gas emissions and help society cope with climate change impacts by maintaining essential ecosystem services upon which people depend (Dudley et al., 2010; Lakew Berhanu et al., 2011). Despite the heavy reliance posed on protected areas globally as a principal strategy for biodiversity conservation and for climate change mitigation and adaptation, many of such protected areas are in danger of not achieving the specific conservation goals for which they were originally set aside or proclaimed as a result of increased anthropogenic threats, poor management systems, and limited finances (van Schaik et al., 1997; Struhsaker et al., 2005). This is particularly the case in developing tropical countries like Ethiopia, where the livelihoods of their citizens are directly or indirectly linked to the environmental goods and services provided by biodiversity (Bruner et al., 2001; Struhsaker, 2001; Millennium Ecosystem Assessment, 2007). Unless effective conservation measures are in place, the future existence of biodiversity in such protected areas is therefore under question. An important step to mitigate the deleterious impacts of human-induced threats to biodiversity and to enhance the effectiveness of biodiversity conservation in protected areas is for conservation managers and policymakers to have, at least, basic information on the biophysical components of the areas, because such information is a significant input for developing and implementing effective management plans (Bruner et al., 2001; Thomas and Middleton, 2003). Of critically needed basic information for developing an effective conservation management plan for a protected area includes, *inter alia*, why the protected area was established (i.e., to conserve what?), exceptional resource values (ERVs) and conservation targets (principal ecosystem components = PECs) of the protected area, and the major threats to the ERVs or PECs (Thomas and Middleton, 2003; for definitions of ERVs, PECs, and Threats, see sections 2.2.2 and 2.2.3 in the 'Methods' section). Identification of ERVs and threats to them for a protected area particularly provides a foundation for developing the purpose and management objectives of that protected area (Thomas and Middleton, 2003; Kinahan and Laurenson, 2013). However, most protected areas, especially in tropical developing countries like Ethiopia, lack such basic

information and clearly defined conservation objectives, resulting in ineffective conservation management (Struhsaker et al., 2005).

Ethiopia is one of the world's biodiversity hotspots and centers of endemism, which is thought to be attributed to the wide range of altitude (116 m b.s.l.- 4506 m a.s.l.) and topographic features that have resulted in the occurrence of wide variations in rainfall, humidity, and temperature, which in turn has resulted in the occurrence of several ecosystems with high diversity and endemic species of flora and fauna (Mckee, 2005; BIDNTF, 2010). A considerable proportion of the biodiversity of the country is being protected within a network of protected areas (20 national parks, 3 sanctuaries, 7 wildlife reserves, and 26 controlled hunting areas) (EWCA, 2016). However, most of these protected areas are under severe threat, which is underpinned by high human population pressure (Mckee, 2005; BIDNTF, 2010). In addition to the transformation of natural habitats into agricultural land and the degradation of land by overgrazing, humans have hunted and killed birds and mammals, reducing their populations to a fraction of what they were 250 years ago. For example, the Gravy's zebra (*Equus gravii*) population in Ethiopia had declined by 93% over a 23 year period (from 1,600 individuals in 1980 to 110 individuals in 2003; Williams et al., 2003), and the African Elephant (*Loxodonta africana*) populations in Ethiopia have declined by some 90% since the 1980s, with extirpation from at least 6 of the 16 areas in which elephants were found in the early 1990s (EWCA, 2015). Currently, an estimated 1,850 elephants are occurring in the country in up to 10 populations, of which 5 are partially transboundary (EWCA, 2015). In addition, settlement encroachment, extraction of timber and non-timber forest products, and forest fire are among the extensively practiced conservation incompatible actions affecting biodiversity in Ethiopian protected areas (Mckee, 2005).

Kafta-Sheraro National Park (KSNP), formerly known as "Shire Wildlife Reserve", is one of the 20 national parks of Ethiopia. In 2007, it was mainly proposed to conserve the northernmost population of African Elephant found in the area and officially gazetted in 2014 by Regulation No. 335/2014 (FDRE, 2014). One of the important wildlife areas of the park is the Tekeze River which is used by wildlife as a permanent source of water during dry season (Mekbeb Eshetu et al., 2002). Historically, the present KSNP area had been inhabited by the Kunama people who used to rely for livelihood mainly on livestock husbandry supplemented by wild flora and fauna. Following the downfall of the dergue regime in 1993, however, the area has

been rapidly populated because of resettlement programmes launched in the region (Mekbeb Eshetu et al., 2002; KSNP, 2016). Currently, the number of settlements and human and livestock populations have been increasing rapidly, leading to ever-escalating pressure on the natural resources of the park. Ultimately, unregulated livestock grazing, cultivation land expansion, and traditional gold extraction activities have resulted in substantial alteration of natural habitats. Furthermore, the park was severely affected by the outbreak of the Ethiopian–Eritrean war, which resulted in a considerable decline in wildlife populations (Mekbeb Eshetu et al., 2002). This is particularly the case of elephants, where they were indiscriminately hunted at the border of the two countries whenever the animals moved between the two countries (Yirmed Demeke, 2008). Thus, there is an urgent need to devise and implement management intervention strategies that would result in the mitigation of the ever-increasing threats to the park. Developing such management strategies requires the availability of information on the natural resources of the park and the nature and extent of threats to them. However, existing data in these aspects is very limited, leaving decision-makers with little knowledge about the conservation significance of the park. Some field assessments have been made in the area, both before and after the establishment of the park, but many of these reports remain unpublished or are found only in the internal reports and are thus relatively inaccessible. This lack of readily available published information has likely contributed to the low level of stakeholder recognition posed by the overall importance of the park, leading to mismanagement and increased vulnerability of many of the important ecosystem components of the park (KSNP, 2016).

In this paper, we attempted to present a synthesis of currently available published and unpublished data on the biophysical resources of KSNP and major threats to these resources. Our intention is to provide important baseline information that would help facilitate a better understanding of the importance and status of the park, which in turn would help promote better park management and further scientific research in the future. The specific objectives of this paper were therefore to describe the exceptional resource values (ERVs) and Principal Ecosystem Components (PECs; or conservation targets) of KSNP and to examine the nature and extent of human-induced threats to these ERVs/PECs.

2. MATERIALS AND METHODS

2.1. Study Area

The Kafta-Sheraro area was formerly set aside in 1968 as a wildlife reserve known as "Shire Wildlife Reserve". The reserve had an area of 5000 km^2 until 1974, but was expanded to cover an area of 750 km^2 in 1996 (KSNP, 2016). The present Kafta-Sheraro National Park (KSNP) was initially proposed in 2007 mainly to conserve one of the relict populations of the African Elephant found in the area and other co-occurring biodiversity and ecosystems (KSNP, 2016). The park had been managed under the auspices of the Tigrai Regional Bureau of Agriculture and Rural Development until 2009, after which the responsibility of its management was handed over to the Ethiopian Wildlife Conservation Authority, a federal level organization responsible for managing globally important protected areas of the country (EWCA, 2016; KSNP, 2016) and ultimately offered legal status in 2014 (FDRE, 2014).

KSNP is situated in the north-western part of Ethiopia in the Tigrai National Regional State, between 14°03'17'' and 14°27'52'' north and 36°41'43'' and 37°40'31'' east (Fig 1). The current spatial extent of the park is ~2176 km^2, and the altitude of the park ranges from 568 m a.s.l to 1,163 m a.s.l. (KSNP, 2016). Administratively, the park lies between North-Western and Western Tigrai Zones and between the three woredas (=Districts): Kafta-Humera, Welkait, and Tahtay-Adyabo (Fig 1).

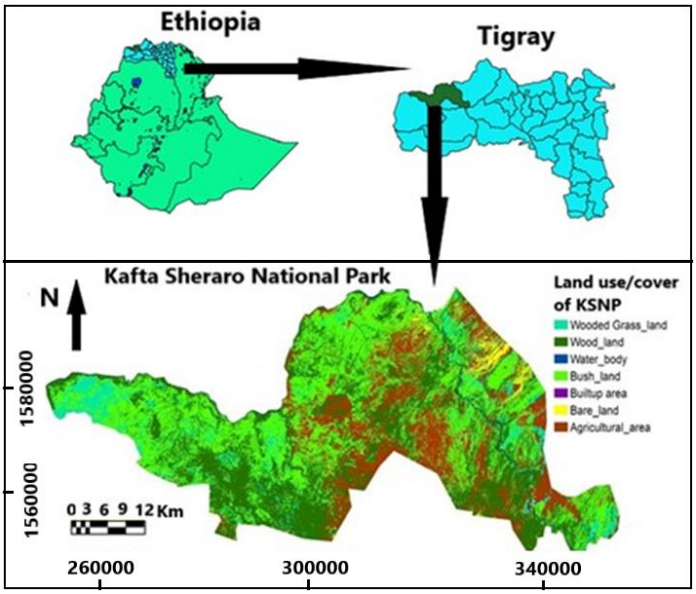

Figure 1. Geographical location of Kafta-Sheraro National Park with major land use/land cover types.

The Kafta-Sheraro area is characterized by a mono-modal type of rainfall regime, occurring between May and early September, although small rains occasionally occur from late September through November. With an annual average precipitation of about 600 mm, the area receives low rainfall amounts compared to the surrounding highlands (Mekbeb Eshetu et al., 2002). The temperature in the area shows variability between dry and wet seasons, with the warmest period being from April through May and the coldest from July through August. Overall, the average monthly temperature in the area varies between 18.2^0C to 37.5^0C (Mekbeb Eshetu et al., 2002).

KSNP is one of the most important conservation areas in Ethiopia (EWNHS, 2001; Mekbeb Eshetu et al., 2002). It hosts several conservation concerns and economically important faunal and floral species, including the African Elephant, Roan Antelope (*Hippotragus equines*), and Red-fronted Gazelle (*Eudorcas rufifrons*), as well as many conservations significant bird species (for details on the biodiversity of the park, see the "Results and Discussion" section).

2.2. Data Collection

In June 2016, 11 multidisciplinary experts (hereafter referred to as "planning experts") were sent to the KSNP with the aim of developing a 10-year (2017-2027) General Management Plan for the park. These planning experts were elected based on their professional experiences in wildlife conservation and/or their better knowledge about the KSNP and were drawn from the Ethiopian Wildlife Conservation Authority and Tigrai National Regional State Wildlife and Tourism Bureau. Part of the planning process involved undertaking a rapid assessment of biodiversity and other physical ecosystem resources of the KSNP, as well as threats associated with these resources. It is therefore primary data collected during this planning stage that was used as the main information source for this paper.

Primary data on the biophysical resources of the park were gathered in June and July 2016 following the Rapid Biodiversity Assessment method (Newton, 2007). This data collection was undertaken along available road networks inside and outside (border) of the park using four-wheel vehicles while slowly moving with an average speed of ~20 km/hr and transect walking on foot where roads were unsuitable for driving. Key data gathered include outstanding natural, scenic, geological, ecological, floral, faunal (mainly mammals and birds) and recreational/scenic resources; vegetation types and landforms; areas essential for protecting the ecological integrity of the park; areas and resources that are vital and provide essential services to local people;

nature and extent of human disturbances; and major historical and cultural sites. Geographical coordinates of locations where observations of such interesting resources were recorded were captured and saved into a Garmin Global Positioning System (GPS) device and used for spatial mapping. Overall, this field assessment covered a total distance of ~3,500 km (on average ~233 km/day) for 15 days. Attempts were made to cover major parts and different habitat types of the park, and stopovers were made, whenever necessary, to observe distant places from vantage points using binoculars.

To supplement these field data, 18 different focus group discussions (FGDs) were conducted with local communities living in and around the park (12 FGDs at the kebele/village level) and with government authorities ranging from district (2 FGDs) to regional levels (1 FGD with each of the two zones and Regional Bureaus of Agriculture and Tourism). Each FGD consisted of 10–20 participants, and discussions lasted between 2-4 hours. Open-ended, semi-structured questions were prepared in English for the discussion and discussions were made in local languages (Tigrigna and Amharic), led by an expert who speaks both languages. The questions were simple and forward and included whether the discussants know the presence of the park and its boundaries; why the park was established; their knowledge about the resources of the park and what actual and potential benefits these resources have for the local and global people; their socio-economic activities and past and present type and level of their dependence on park resources; their knowledge of threats to the park; their attitude towards the park; and their suggestion for future improvement in management of the park. Finally, information gleaned from published and unpublished research papers and technical reports was used to augment the data obtained from the field assessment and FGDs.

It should be noted that we relied on data available and collected until 2016. However, the situation in the park has changed following the Tigray war (between November 2020 and November 2022) causing a significant loss of human life, biodiversity, and humanitarian crisis (Mebrahtu et al., 2023). As revealed by many studies reporting the significant impacts of armed conflicts on large mammal populations in Africa (Conflict and Environmental Observatory, 2021), informal reports (Tatek Shawol, 2023, Pers. Comm.) indicate that a significant number of wild animals were subjected to flee the KSNP area, accidentally injured and killed and deliberately hunted for meat during the warfare during the Tigray war. In addition, park infrastructure and facilities, such as offices and ranger outposts, were misused as military bases

and destroyed. As quantitative data on the impacts of the war on KSNP and its resources have not been available, we were unable to accommodate this factor. Although this lack of recent data may not affect our key findings and alter our general conclusions, we advise readers to keep in mind this limitation while reading the article.

2.3. Data Analysis

2.3.1. Summarizing and Synthesizing Data

A thematic content analysis method (Corbin and Strauss, 2008) was used to summarize and synthesize secondary data collated from published and unpublished literature and reports, and primary data on biodiversity, resources, values and threats of the park collected through rapid biodiversity assessment and data collected through focus group discussions. This analysis method involves a line-by-line open coding of field notes, followed by selective coding, and then inductively grouping together of similar concepts into a unique biodiversity, use, or threat code category (for detail on thematic content analysis and its application, see Corbin and Strauss, 2008; Addisu Asefa, 2021). The three datasets (biodiversity, values and threats; socioeconomic data; and literature review data) were analyzed separately but results were then combined and used as inputs for subsequent analyses to achieve the research objectives.

2.3.2. Identification of Exceptional Resource Values (ERVs)

We used IUCN's definition and criteria for identification of protected areas' Exceptional Resource Values (ERVs) to identify and describe the ERVs of the KSNP. IUCN defines ERVs of a given protected area as: "the biophysical features of an area that are considered to be particularly important in maintaining the unique ecological character, integrity, and functions of an area and that provide outstanding benefits (social, economic, and aesthetic) to local, national, and international stakeholders" (Thomas and Middleton, 2003). Given this definition and following OBARD (2007), seven key criteria were used to identify ERVs of KSNP: outstanding examples of natural, scenic, geological, scientific, ecological, floral, faunal, and recreational values; unique biological attributes, vegetation types, and landforms; areas essential for protecting the ecological integrity of the protected area as a whole; areas and resources that are vital and provide essential services to people in and outside the park; rare and endemic plant and animal species; species or habitats sensitive to natural and human disturbances, threatened or endangered; and major archaeological, historical, or cultural sites.

Accordingly, after completion of the field assessment and FGDs, data obtained from these methods and from the literature were compiled, and a provisional list of ERVs in the park was developed based on the aforementioned criteria. Then, a 1-day workshop was held at Humera town, West Tigray Zone, in July 2016, which was attended by the planning experts under the first author's (AA) facilitation, to refine and finalize the ERVs of KSNP. During the workshop, we initially developed a provisional list of ERVs in the park that was first presented, and then the participants were asked to modify. The list was modified and completed following discussions with the workshop participants, and it was this final list that was agreed upon by the workshop participants that was presented and discussed herein.

2.3.3. Identification of Principal Ecosystem Components (PECs) and Threats

The Nature Conservancy's (TNC) definitions and concepts of PECs and threats to PECs were used for the identification of KSNP PECs and threats to them. TNC (2007) defines PECs (also termed as "conservation targets") of a particular protected area as "Ecosystem components of a protected area that together represent the whole ecosystem and its functions of that area, i.e., together these PECs represent the unique biodiversity and ecological processes of that area" (Kinahan and Laurenson, 2013). The key assumption here is that the PECs are truly representatives of the protected area's biophysical components; hence, concentrating on their management will ensure that all ecosystem components within that park are conserved and, thus, an overall healthy ecosystem will be maintained. The PECs can cover various spatial scales and levels of biological organizations, from processes operating at the landscape and ecosystem level to components representing the community level and species level. In the present paper, species were considered to be PECs if management actions implemented at the habitat level were inadequate to secure their long-term perpetuity (e.g., wildlife disease, poaching, etc.), following the suggestions of Kinahan and Laurenson (2013). Similarly, TNC (2007) defines a "threat" as "any factor, resulting either directly or indirectly from human activities (legal or illegal), that actually or has the potential to destroy, degrade, or impair a PEC at present or within a limited time period". Following Kinahan and Laurenson (2013), in this paper we considered threats that actually and potentially negatively impact KSNP PECs in the next 10 years.

Given these definitions, to identify PECs and threats of KSNP, we followed procedures that have been applied to identify PECs and threats of several protected areas across Africa, including Ethiopia's Bale Mountains National Park (OBARD, 2007) and Senkelle Swayne's

Hartebeest Sanctuary (Kinahan, 2014). Accordingly, a second 1-day workshop was held at Shire town, Tigrai Region, in August 2016, which was again attended by the planning experts under the first author's (AA) facilitation. In the first part of the workshop, a provisional list of PECs of the park was presented, and then the participants were asked to modify and complete the list. Once the checklist of PECs was completed and agreed upon by the participants, a presentation of a provisional list of threats to PECs in the park was made in the second part of the workshop, and then participants were asked to modify and finalize the list. Once the list of threats to PECs in the park was finalized, threat level assessment was carried out based on the following four criteria: severity (the level of damage), permanence (potential for permanent damage/loss), scope (geographic extent of occurrence), and status (increasing/decreasing) (Kinahan and Laurenson, 2013). Accordingly, for each threat occurring within each PEC, the workshop participants were asked to give threat level scores for each of these four criteria. Threat level scores were made on 1 to 4 ordinal scales (for the first three criteria) and on 1 to -1 scales (for the latter criterion) (Table 1). These scores were summed for each threat in each PEC and used to rank the threats according to their relative overall severity, both within and across PECs.

Table 1. KSNP PECs threat level assessment criteria and scoring scales (from Kinahan and Laurenson, 2013).

Threat level	***Threat level score***			
	Severe = 4	***High = 3***	***Moderate = 2***	***Low = 1***
a. Severity	Destroying or eliminating the PEC/irreversible	Seriously degrading the PEC	Moderately degrading the PEC	Slightly impairing the PEC
b. permanence	Impossible to restore	Very difficult to restore	Moderately difficult to restore	Slightly difficult to restore
c. Scope	Very widespread	Widespread	Localized	Very localized
d. Status	1 = increasing	0 = stable	-1 = decreasing	

Finally, we used satellite imagery, and spatial data (e.g., GPS locations) collected during the fieldwork to map and determine the distribution and extent of habitat types and major threats to the park. Habitat classification and mapping were undertaken using ERDAS IMAGINE® 9.1 (Leica Geosystems Geospatial Imaging, LLC, Norcross, Georgia, USA) and ArcGIS® (9.3 ESRI, DC, USA) applications.

3. RESULTS AND DISCUSSION

3.1. Exceptional Resource Values of KSNP

Based on the current available knowledge, 14 ERVs were identified in the KSNP. These were grouped into four main categories; natural, scenic, socio-economic, and historical/cultural values (Table 2) and are briefly described below.

Table 2. Exceptional Resource Values of KSNP.

Category	***Exceptional Resource Values***
Natural	Conservation concern and/or flagship mammal species: e.g. African Elephant, Roan Antelope, Red-fronted Gazelle and Striped Hyena.
	Globally threatened, biome-restricted and/or migratory bird species.
	Acacia-Commiphora Woodland habitat.
	Combretum-Terminalia Woodland habitat.
	Riverine forest habitat.
	Hydrological systems of Rivers.
	Plant species with important genetic stocks: e.g. *Hyphaena thebaica, Diospyros mespiliformis, Boswellia papyrifera,* etc.
Scenic	Mountain Peaks (e.g. Mt. Hilegin, Mt.Tsirga girmay, Tahitay and Laelay Siye, Tebeko Inda zibie), Valleys, Manta-Dubui Islands and Tekeze river course.
Social-economic	River/Water catchment/ such as Tekeze and Dugagum.
	Mineral deposits (e.g. Gold and Marble).
	Environmental/ecosystem services: e.g. climate regulation, soil stabilization, and NTFPs including gum and honey harvesting.
Historical/Cultural	Natural underground meeting Halls of TPLF during 1980's.
	Kunama tribe's spiritual/burial sites found at Manta Dubuei and Tekleamba localities.
	Kunama tribe Indigenous ecological Knowledge.

3.1.1. Natural Values

3.1.1.1. Conservation Concern and Flagship Mammal Species

Historically, the Tekeze Valley has been known to be rich in wildlife (Mekbeb Eshetu et al., 2002; Berihun Gebremedhin et al., 2011). However, several species have been either declining dramatically or locally extinct over the past years due to civil unrest, illegal hunting, and habitat loss in the area. For example, globally threatened mammal species such as Lion (*Panthera leo*), African Hunting Dog (*Lycaon pictus*), and Gravey's Zebra (*Equus gravyi*), as well as other common species like Eland (*Tragelaphus oryx*), Giraffe (*Giraffa camelopardalis*), and African

buffalo (*Syncerus caffer*), that had been thriving in the area in the past, are thought to be absent in the park at present (Yilma Delelegne and Kahsay Gebretensae, 1997; Teklay Girmay et al., 2020). Nonetheless, currently available limited data show that 43 species of mammals are known to be found in the park (KSNP, 2016). This number should be seen cautiously, as information on smaller mammals (e.g., rats, shrews, bats, etc.) is virtually absent (KSNP, 2016). This list includes several conservation concern mammal species, such as African Elephant and Red-fronted Gazelle (both with global conservation status of "vulnerable") and Striped Hyena (*Hyaena hyaena*) (globally considered "near threatened") (IUCN, 2013). The park also hosts considerable populations of other large carnivores like Spotted hyena (*Crocuta crocuta*), Aardwolf (*Proteles cristata*) and Leopard (*Panthera pardus*) as well as herbivores like the Greater Kudu (*Tragelaphus strepsiceros*) and Defassa Waterbuck (*Kobus elypsiprimnus*).

The Elephant population in the KSNP represents one of the nine isolated populations of the species currently occurring in Ethiopia and is the northernmost population of the species on the continent (Yirmed Demeke, 1997). It has been estimated that ~300 individuals of elephants are currently found in the park, accounting for ~15-20% of the total Ethiopian population (Endawek Wendim et al., 2014; KSNP, 2016). Given that elephants are keystone species across their ranges (Shoshani, 1993), protecting them and the large home range they need to survive mean that the conservation area is large enough for the protection of the entire ecosystem covered by the KSNP.

The KSNP is also the only protected area in the country, hosting considerable populations of two conservation-important antelopes; the Red-fronted Gazelle (a globally threatened species) and the Roan antelope [a species legally protected by Ethiopian Wildlife Laws (FDRE, 2009)]. In the present study, the Roan antelope was considered as one of the ERVs of KSNP, although its current global conservation status is under the 'Least Concern' category (IUCN, 2013), because (i) it exists across its ranges in fragmented populations, (ii) the population in Kafta is one of the only two known populations in the country, and (iii) it has been legally protected by Ethiopian Wildlife Laws (FDRE, 2009).

3.1.1.2. Globally Threatened, Biome-restricted and/or Migratory birds

The present KSNP entire boundary falls in the "Shire Lowland Important Bird Area" of Ethiopia (registered as Ethiopian IBA code: ET001; EWNHS, 2001), but the national park can be considered as an IBA right on its own based on the presence of Globally Threatened Species

(IBA criteria 1A), Biome-restricted Assemblages (Criteria A3 & A4), and Congregatory Species (Criteria A5) (for details on these criteria and species that fulfill them, see EWNHS, 2001). Although the bird checklist for the park is incomplete by far, ~204 species belonging to 58 avian families have been known to occur in the park, of which 33 (16%) are migratory species that visit the area annually only for a certain period (Addisu Asefa, 2016 unpubl. data).

The bird list for KSNP consists of several conservation concern species, and the park represents the only confirmed record area in Ethiopia for three bird species, namely: Sennar Penduline-tit (*Anthoscopus punctifrons*) and Demoiselle Crane (*Anthropoides virgo*) (Berihun Gebremedhin et al., 2011; Pohlstrand, H. 2016 unpubl. Data). Conservation concern bird species recorded from KSNP includes: (i) five vulture species, four of which are critically endangered [Egyptian vulture (*Neophron percnopterus*), white-headed vulture (*Trigonoceps occipitalis*), hooded vulture (*Necrosyrtes monachus*) and White-backed vulture (*Gypus africanus*)] and one endangered species [Rüppell's Vulture (*Gypus rueppellii*)], (ii) 6 species of Sudan-Guinea biome assemblage (38% of the 16 species of this biome known to occur in Ethiopia) ; and (iii) four species belonging to the Somali-Masai biome assemblage (Teklay Girmay et al., 2020). Further, ~21,500 individuals of Demoiselle crane (*Anthropoides virgo*) were recorded in KSNP in March 2009 (Berihun Gebremedhin et al., 2011), implying that, with a globally total population of ~240,000 individuals (BirdLife International, 2016), the species' population annually visiting KSNP represents ~9% of its total global population. According to the Rasmar Convention, a wetland could be considered internationally significant if it regularly supports 20,000 or more water birds (Berihun Gebremedhin et al., 2011). Thus, the implication of the occurrence of the Cranes in such a large population in the KSNP is that the area can qualify the criterion for designating the Tekeze valley as a Ramsar site.

3.1.1.3. Distinct Vegetation Types

Studies on the vegetation of the park, like on the animals, have been very scanty, and only a checklist of 53 common tree and shrub species is available (Endawek Wendim et al., 2014; KSNP, 2016). In general, the vegetation of the KSNP can be classified into three broad vegetation types: *Acacia-Commiphora* woodland, *Combretum-Terminalia* woodland, and Riparian woodland (Fig 1). *Acacia-Commiphora* Woodland covers the vast area of the park and contains species with significant economic and ecological values. It is mainly characterized by species such as *Boswellia papyrifera, Acacia millifera*, and *Balanites aegyptiaca*. *Combretum-*

Terminalia Woodland, on the other hand, mostly occurs in areas where the substratum is rocky, sandy soil that has been exposed to recurrent fire burnings. This vegetation type is characterized by dominant species such as *Combretum molle, Terminalia brownii, Anogeissus leiocarpa, Boswellia papyrifera, Zizyphus* spp., *Sterculia africana, Balanites aegyptica, Grewia bicolor*, and *Lannea* spp. (Mekbeb Eshetu et al., 2002). Riparian/Riverine woodland vegetation occurs along river and stream courses, containing characteristic species such as *Tamarindus indica, Borassus aethiopum, Ficus* spp., *Diospyros mespiliformis, Combretum molle, Hyphaene thebica,* and *Mimuspos kummel* (Mekbeb Eshetu et al., 2002; Endawek Wendim et al., 2014).

3.1.1.4. Hydrological System

The hydrological system of the area comprises the Tekeze River and its tributaries that emerge from inside the park. Tekeze River flows inside the park in the eastern section and becomes the park boundary in the north-western boundary of the park. At least five major tributaries of the Tekeze River originate in or around KSNP, namely: Zerbabit, Geytse, Agaf-Urgo, Degagum, and Idris (KSNP, 2016; Fig 2). Tekeze River and most of these tributaries are perennials, although water quantity and quality are very low during the dry season, providing year-round water supply to the surrounding people and their livestock and to wildlife in the park.

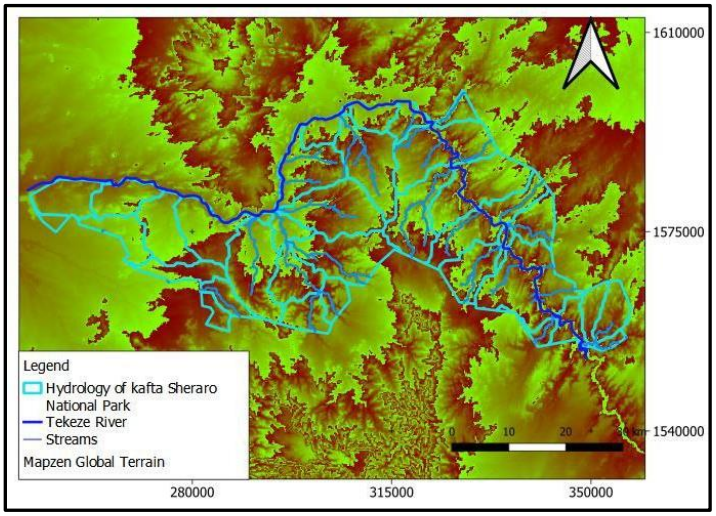

Figure 2. The hydrological system of the Kafta-Sheraro National Park (river features are shown only for areas falling within the boundary of the park; see also Figure 1).

3.1.1.5. Plants with Important Genetic Stocks

The most important plants known to have valuable genetic stocks that are valuable economic sources for the local community are *Boswellia papyrifera* and *Hyphaena thebaica* (for details see below in the subsection on 'Socio-economic Values'). These species are currently considered

nationally/regionally threatened due to overharvesting and land use changes (Wubalem Tadesse et al., 2007).

3.1.2. Scenic Values

The distinctive geomorphic structure of the KSNP area incorporates a deeply dissected valley along the Tekeze riverbed, flat plains slightly undulating to the extreme west, and becoming more and more undulating with scattered hills and chains of small mountains to the east. These land features together form breathtaking scenic views. Some of these specific localities that are outstandingly attractive to tourists and/or could serve as viewpoints include Mt. Hilegin, Mt.Tsirga Girmay, Mt. Emba-durkuta, Keyih Gobo, Kalema, Ziban Wediembi, Tahitay, Laelay Siye, and Tebeko Inda zibie. The Tekeze River alone has several attractions and scenic features. For example, the sandy beaches along the riverbank are ideal recreational sites for visitors interested in picnicking and wetland bird watching, and currently available is boating over the 160 km length of the river along the section that bounds Ethiopia with Sudan and/or Eritrea.

3.1.3. Socio-economic Values

The exceptional resources of KSNP provide ecosystem services that are vital to the sustainable development of the socio-economic system and the wellbeing of people at local, national, and international levels. First, as discussed above, the Tekeze River and its tributaries are the only reliable perennial water sources for hundreds and thousands of people locally and far beyond, as well as for their livestock and wildlife. These hydrological systems are also serving as modern or traditional irrigation schemes. Thus, the future well-being of people whose livelihoods are dependent on the ecosystem services provided by this hydrological system of the area largely relies on the proper functioning of these systems, which in turn relies on the appropriate conservation and management of ecosystems in the KSNP (Mekbeb Eshetu et al., 2002). Second, the presence of unique populations of wildlife species and beautiful landscapes and tourism routes (mainly between Aksum and Gondar) across the region means that KSNP has high potential for eco-tourism development, which could make a significant contribution to the economic development of the country and surrounding local communities. Third, there are several economically important precious mineral deposits within the park boundary, including gold, marble, and iron. If used in a regulated and sustainable way, these resources are in fact among the most income-generating economic activities, both for the government and the local communities. Finally, the area provides several other ecosystem goods and services (see below).

People belonging to the Ethiopian Kunama tribe are the indigenous people who have been living in the Kafta-Sheraro area for several hundred years. The livelihood of these people has been directly linked to environmental goods and services provided by wild plants and animals found in the area. For example, they use the Palm tree (*Hyphenea thebica*) for making different types of foodstuffs, such as local beverages (*Tela*), sauces (*Wot*), porridge (Genfo), and handicrafts including feeding plates and ornamental and jewelry materials. The Kunama people have been using and still use the Baobao tree (*Adonesia digitata*) for carrying materials like baggage and for making mattresses. However, these people have already abandoned their transhumance (pastoralist) mode of life and are made to live outside the park, where they are permanently settled, with the intention of getting the access to basic public services such as education, health, electricity, etc. Despite this, most of these Kunama people still practice their traditional way of life (i.e., depending, to a certain extent, on wild plants as a source of raw material for food). Consequently, even if they are not allowed to harvest raw materials for such traditional use from the park, most people are getting access to use such resources through illegal harvesting or buying from illegal harvesters.

In addition to *H. thebica* and *A. digitat*, KSNP also harbors a number of other tree species that contain economically important genetic stocks, *inter alia*, *Boswellia papyrifera* (a source of frankincense gum), *Diospyros mespiliformis* (seeds used in industries), and *Dalbergia melonocxylon* (important crafting tree for making artifacts). Although the uses are unregulated and their impacts on the species and ecosystem remain unknown, such things as gum and resin collection, cutting grasses for house thatching, and wild honey gathering are among the non-timber forest products (NTFPs) that the local people are accessing from the park. Furthermore, the KSNP ecosystem also provides intangible services that are vital to ensuring the socio-economic development and welfare of the local community because of the crucial role that the ecosystem of the area plays in climate regulation, climate change mitigation *via* CO_2 sequestration, soil formation and stabilization, and prevention of soil erosion and flooding (Millennium Ecosystem Assessment, 2007).

3.1.4. Historical/Cultural Values

So far, at least four sites are known to have historical (one site) and cultural (three sites) significance in KSNP. The natural rock caves found at Aditsetser are considered as a historical site and were used earlier as shelters, and as meeting/ assembly halls by TPLF during its fighting. The sites identified as having cultural values are those that have been used by the indigenous Kunama people for several years, since their ancient ancestral time to the present time, as

tomb/grave and spiritual sites. These sites are found around Menta-Dibue, Tekileemba and Ayifora/Doni. Key informants from members of the Kunama tribe explained the nature and purpose of the sites as follows: "A big hole is dug, leaving a small gate at the top, where dead bodies of people are placed; females are placed on the left side and males on the right side. Members of the community visit these sites every year for memorial service and to pray for their dead ancestors." Although these sites are not used as burial places at present, people still visit them once annually to present their prayers.

3.2. Principal Ecosystem Components

Six PECs were identified in the KSNP: *Acacia-Commiphora* Woodland, *Combretum-Terminalia* woodland, Riverine Woodland, Hydrological System, African Elephant, and Roan Antelope (Table 3). These PECs cover three levels of ecological organizations: the first three PECs cover the landscape level, hydrology covers the ecosystem level, and the last two PECs cover the species level of ecological organizations.

Table 3. PECs of KSNP and their major threats. Given values are sums of each threat level score for each PEC and threat rank within each PEC (i.e. those values given in brackets each cell entry) and across PECs (last column).

Threat	***PECs***						***Sum of scores***	***Threat Rank (across PECs***
	Acacia-Comiphora woodland	***Comretum-Terminalia Woodland***	***Hydrological System***	***Riverine Woodland***	***Elephant***	***Roan Antelope***		
Uncontrolled fire	11 (2)	11 (1)	8 (3)		11 (2)	11 (2)	63	1
Crop cultivation	12 (1)		9 (2)		12 (1)	12 (1)	53	2
Irrigation			12 (1)	11 (1)	11 (2)		34	4
Gold Mining	11 (2)				11 (2)	11 (2)	33	5
Domestic dogs predation						11 (2)	11	11
Settlement			7 (5)	11 (1)	9 (6)		27	6
Livestock overgrazing	9 (4)	9 (2)	8 (3)	9 (3)		9 (6)	53	2
Wildlife poaching					11 (2)	10 (5)	20	7
Tree cutting for construction	7 (5)	5 (5)			8 (7)		19	8
Invasive species	6 (6)	7 (3)		5 (4)			18	10
Charcoal production	3 (8)				8 (7)		11	11
Overharvesting of NTFPs	6 (6)	7 (3)					19	8

The identification of these PECs is of great conservation implications for the KSNP because they are assumed to represent all of the KSNP's biophysical components; hence, concentrating on their management will ensure that all ecosystem components within the park are conserved and, thus, an overall healthy ecosystem will be maintained (TNC, 2007; Kinahan and Laurenson, 2013). In the present study, Elephant and Roan antelope were identified as PECs because both species are currently experiencing population decline due to ever-increasing poaching in the KSNP (Endawek Wendim et al., 2014; KSNP, 2016). Therefore, it is thought that conservation management actions taken at the habitat/landscape level may not adequately address specific issues (e.g., poaching) associated with these species, and specific actions are needed to safeguard the species from local extinction (OBARD, 2007; Kinahan and Laurenson, 2013).

3.3. Threats to Principal Ecosystem Components

Threats identified during the study period were summarized and grouped into 12 types (Table 3). From the threat ranking exercise, it was understood that most of the threats were found to be affecting more than one PEC; thus, a threat matrix was developed to show which threats were cross-cutting and to depict their overall rank across PECs. Accordingly, uncontrolled fire, crop cultivation/irrigation, gold mining, livestock overstocking, and settlement were ranked as high- to very-high-level threats that are affecting several PECs, while others were ranked as moderate- to low-severity (Table 3).

3.3.1. Crop Cultivation

Socio-economic development activities began in the KSNP area in the 1990s after the downfall of the dergue regime in 1993, when people from the surrounding highlands began moving to the area to practice small-scale cultivation and livestock grazing. The opening of new economic activities in the area during that time was welcomed by the present government because it was seen to serve as an evidence of peace and stability, and also one of the preconditions needed to attract investors to the area in the region. Following this, the government has undertaken two (re)settlement programs; the first was undertaken in the 1990s to bring people who fled to Sudan during the civil war back to the country, and the second was undertaken between 2011 to 2013 to bring people from drought-affected areas of the region. Although the resettlement program was executed under clearly stated provisions, a lack of monitoring of their effectiveness and of illegal flow of people to the area has led the park to be considered a free-access resource (KSNP, 2016).

Consequently, ~415 km^2 (~400 sesame and sorghum cultivated and 15 km^2 irrigation lands) of the park area is under crop cultivation (Fig 2), suggesting that ~19% of the natural vegetation of the KSNP has been converted to cultivation land. Rain-fed Sesame and Sorghum cultivations are practiced in the heart of the park, while irrigation-based banana plantations are undertaken along the Tekeze River (Fig 2). Currently, ~3742 households are officially known to hold Sesame and sorghum cultivation land, and ~286 households have irrigation cultivation land inside the KSNP boundary (Tigray Region Bureau of Agriculture and Rural Development, 2011 unpubl. data). Some of these landholders were legally allocated ~2 ha of cultivation land by local government authorities before the establishment of the park, but the rest are illegal landholders that came to the area recently from different areas of the region. In response to such uncontrolled human pressure on the natural resources of the park, the Tigrai National Regional State Government enacted the 2014 Rural Land Administration Proclamation (Proclamation No.239/2013) and its accompanying Regulation (No. 85/2014). These laws put a high emphasis on the need to relocate people who are living and/or cultivating inside the KSNP by providing them with substitute land outside the park. In doing so, although it was often difficult to take out all the people, over 474 households were made to abandon the park and ~20 km^2 of park area became free from cultivation.

The conversion of natural habitats to cultivation land in the KSNP has caused a severe threat to the biodiversity and ecosystem of the park. In addition to causing wildlife habitat loss, it has led to habitat fragmentation and the blockage of wildlife corridors. This, in turn, affects the reproduction and survival of several plant and animal species, the proper functioning of ecosystem processes, and provisioning of ecosystem services (Endawek Wendim et al., 2014). Furthermore, cultivation encroachment in the park has also led to the frequent occurrence of human-wildlife conflicts. For instance, Elephant crop-raiding has been repeatedly reported by the local community as one of the main impacts of wildlife on the socio-economic activities of the local people. Only in 2015/16 has an incidence of crop-raiding by elephants been reported to occur in more than 540 (260 inside and 280 outside the park) householders' cultivation fields (KSNP, 2016). Consequently, people use poisoning techniques to poach Elephants in revenge for the crop damage (KSNP, 2016). Unless urgent mitigation measures are taken, continued cultivation encroachment in the area will have disastrous consequences for the biodiversity and ecosystem of the park.

3.3.2. Fire

Fire in KSNP is set by the surrounding local community either unintentionally during honey harvesting or deliberately to stimulate the growth of new grass for their livestock. It is reported that fire occurs throughout the park every year, often in October, burning over 60% of the park area each year (KSNP, 2016). Although the nature and extent of the impacts on biodiversity and ecosystems have not been examined, this uncontrolled fire is now thought to represent one of the most serious threats to KSNP's PECs.

In Savanna ecosystems like the KSNP, under controlled conditions, fire is an important habitat management tool to improve wildlife range conditions, as it leads to increased plant species diversity, control of undesirable species (e.g., exotic/invasive species) and improved palatability of wildlife forage plants, especially for grazers and browsers that rely on short to medium-height grasses (Dyer, 2002; Abiot Hailu et al., 2015). However, depending on the seasonality, intensity, and frequency of its occurrence, unregulated fire burning also has disastrous consequences both for wildlife and their habitat because: (i) it destroys animals themselves, including bird nests and infant mammals;(ii) it reduce available habitat due to vast area burning; and (iii) it results in a change in vegetation species turnover, likely replacing desirable species with undesirable ones; and (iv) it changes the physical and chemical properties of the soil (Dyer, 2002). Therefore, actions that would ensure the management and control of the extent, frequency and intensity of fire in KSNP need to be developed, whilst acknowledging the role that fire has in ecosystem functioning.

3.3.3. Livestock Grazing

Overgrazing by the livestock is a serious problem during the rainy season when the lands outside the park are covered by crops. It is estimated that about 520,000-530,000 heads of livestock from the surrounding areas and other parts of Tigray, as well as from Eritrea, use the park for grazing during the wet season (KSNP, 2016).

Such unregulated livestock grazing/browsing activities have several undesirable ecosystem consequences. In addition to their impact on wildlife via food competition and destruction of eggs/nests of ground nesting birds, such activities also directly affect wild fauna and flora, as well as the ecosystem as a whole, via reducing vegetation cover, changing vegetation species composition, impairing the regeneration status of trees, and indirectly via soil compaction that leads to a reduction of water infiltration and increased soil erosion (Jensen,

1985; Getachew Tesfaye et al., 2002; Kimball and Schiffman, 2003; Tallowin et al., 2005). Further, herders in the KSNP area also topple branchlets or completely cut down stems of *Boswellia paypifera* trees with axes to provide supplementary feed to their livestock (Endawek Wendim et al., 2014). Therefore, such free-access grazing activities in the park should be regulated or avoided to minimize their impacts.

3.3.4. Mining

The KSNP area contains economically important precious mineral deposits, including gold and marble (KSNP, 2016). Although a traditional mode of gold mining in KSNP has started recently, six years ago, a survey conducted in 2012 revealed that more than 10,000 youth (both males and females) from local people and far beyond were engaged in illegal gold mining in the park (KSNP, 2016). Endawek Wendim et al. (2014), who traversed a 179 km long transect, reported c. 10,000 (i.e., 56 pits per km) gold mining pits that have 20-35m depth at c. 300 quarrying sites. This mining activity in KSNP is undertaken illegally despite the Ethiopian Wildlife Law which strictly prohibits such activities in wildlife protected areas (FDRE, 2009). Apart from modifying the ecosystem through ecological successions, such activities pose a significant threat to wildlife because such pits can act as a trap even for larger animals like Elephants (Endawek Wendim et al., 2014). To develop mitigation measures that can reverse the situation, an assessment of its spatial distribution, and socio-economic and ecological impacts is required.

3.3.5. Settlement Expansion

As discussed above, settlement in and around the KSNP has a recent history. However, the high intrinsic population growth rate and immigration to the area have resulted in a rapid increase in the human population size in the Kafta-Sheraro area. There are 14 (12 outside and 2 inside) villages currently found in/around the park, with ~64,000 estimated people (KSNP, 2016). A major concern, however, is due to the two big settlements, situated west and east of the Tekeze River, that are located inside the KSNP boundary. These settlements were initially established by people who came to the area to work as daily laborers for investors engaged in irrigation-based agricultural activities along the Tekeze River. In addition to causing habitat loss and fragmentation, settlement expansion in the park has caused blockage of the main elephants' movement corridor (Shoshani and Yirmed Demeke, 2006). Developing management actions that would help to control the growth of the villages and/or relocating the villages to outside the park should, therefore, be seen as a matter of urgency.

3.3.6. Wildlife Poaching

Local people poach wildlife in KSNP for different purposes, including ivory (Elephants), bushmeat (e.g., Roan Antelope, Red-fronted Gazelle, and Greater Kudu), and skins (Leopards). Instead of using rifle bullets, poachers use poisoning techniques to kill Elephants which could be a strategy to minimize the risk of being caught by game rangers. They place poison-baited cucumbers/pumpkins on *H. thebica* trees, both of which are Elephants' favorite feeding resources, to get animals that feed on the poison-baited items to die. Overall, the reports indicate that four elephants were killed just between August and November 2006 (Shoshani and Yirmed Demeke, 2006), and tusks of four elephants, skins of five Leopard, five Greater kudu, and two Red-fronted Gazelle skins were confiscated in 2015 from poachers living around the park (KSNP, 2016). There are several possible factors that might have contributed to the high level of Elephant poaching in the KSNP area. First, the KSNP'S Elephant population shows seasonal movement between the KSNP and the adjacent Eritrea's Gash-Barka Wildlife Reserve (Shoshani et al., 2004). This transboundary movement, coupled with the lack of collaboration between the two countries in halting illegal poaching, might have exposed the Elephants to uncontrolled poaching activities in both countries. And, secondly, the location of the KSNP being on the borders of Sudan and Eritrea, which makes it easy transaction to transact ivory across borders, could also have led to increased demand for Elephant ivories (Shoshani et al., 2004; Yirmed Demeke, 2008). In general, Elephant poaching in Ethiopia has remained the biggest threat to their long-term survival; it has led to a decline in its populations by 90% since the 1980s and extirpation from at least six of the 16 areas in which elephants were found in the early 1990s (EEAP, 2015). To halt the incidence of elephant poaching in the park, a combination of activities is needed such as awareness creation, strengthening of law-enforcement, collaborations with Eritrean wildlife conservation authorities, involving Ethiopian defense force operating in the area, and the local community.

3.3.7. Unregulated Harvesting of NTFPs

Commonly reported uses of NTFPs include the collection of gum resin and fuelwood and charcoal making. *B. papyrifera* is the main resin producing tree species in the area. As is the case in Ethiopia, at present, frankincense production, and even the existence of the species in the Tigray region are seriously threatened due to human actions, because the species is very sensitive to natural or human interference and could be damaged easily (Wubalem Tadesse et al., 2007).

Although the population of this tree species exits both inside and outside the park, the population outside the park has been highly threatened, partly due to over-exploitation and unsustainable methods of exploitation that led to the death of parent trees and partly due to lack of regeneration as seedlings are being browsed by the livestock. This led to an increased pressure on the population in the park. Therefore, a system that ensures the sustainable use of these trees both in and out of the park area should be developed.

Although the incidence of fuelwood collection and charcoal production, the latter being practiced only seasonally, is relatively lower in the park, the ever-increasing human population around the park and subsequent increasing demand for park resources can be considered as growing potential threats to the park in future. Such resource exploitation may result in deforestation and habitat loss for wildlife. Although domestic use of fuel wood could be tolerable (FDRE, 2009) but the fuelwood for commercial and charcoal production purposes is considered as prohibited activities. Hence, the domestic consumption should be regulated while looking for alternative energy options and ban use of fuelwood for commercial purposes and charcoal.

3.3.8. Selective Cutting of Tree/Shrub

People living in and around the KSNP largely depend on park resources for house construction (e.g., timber, pole, etc.), fencing, and housewares. Such selective tree removal leads to changes in the regeneration and population structure of some important tree species (Getachew Tesfaye and Demel Teketay, 2005). Thus, it should be halted and alternative options need to be devised.

3.3.9. Domestic Dog Depredation of Ungulates

Furthermore, the population demography of most ungulates shows that calves are under-represented, which may suggest that juvenile predation by carnivores is the most likely cause. Although it is unclear whether wild and/or domestic carnivores, mainly dogs, are responsible for such ungulate juvenile predation, the presence of many free-roaming dogs in the park may suggest that domestic dogs pose an important threat to ungulates in the KSNP. Direct predation and attacks by dogs pose a threat to a number of wildlife populations in the park, including rodents, Greater Kudu, Red-fronted Gazelle, and other antelope species (especially young calves). They can also pose threats to wild carnivores through the completion and transmission of infectious diseases (e.g., rabies and canine distemper; Laurenson et al., 1998). At present, limited information is available on this issue, partly because the park has started recently with not well-placed management, and the data are not systematically collected. Nonetheless,

abnormal age ratios (a lower proportion of juveniles compared to adults) in populations of some ungulates, such as Kudu, Roan Antelope, and others, and the presence of a large number of free-roaming dogs in the park may suggest that domestic dogs could potentially pose serious threats to ungulates in the KSNP. This supposition can be supported by the fact that dogs have been repeatedly reported as key threats to wildlife globally as well as nationally (see Addisu Asefa, 2008), suggesting that there is a high probability that dogs in/around the KSNP cause similar problems to ungulates. Thus, a preliminary assessment is suggested through social survey/key informants to get an insight into the level of threats and need for management intervention.

3.3.10. Expansion of Invasive Plant Species

Invasive plant species, be they alien or indigenous, can seriously degrade communities and ecosystems as they can outcompete native species and permanently alter community composition and structure. Some invasive plant species (e.g., a herb species locally named "*Apaoke Harmesz*") are known to occur in KSNP at localities degraded by livestock grazing and housing actions (Teklay Girmay et al., 2020). This may imply that livestock are the main cause of invasive species expansion in the KSNP. Livestock grazing activity favours the expansion of invasive species in the park in two main ways. First, they act as seed dispersal agents by carrying indigestible seeds that pass with dung, eaten outside the park into the park, or seeds that are stuck to their furs and carried into the park. Secondly, they can play a facilitation role (by modifying soil microenvironments in such a way that is favorable) for the seed germination and growth of invasive plant species. Although little is known about these cause-effect relationships and the distribution and impact of the presumed invasive species, the degree of threat they pose on the ecosystem is typically perceived to be high. Identification and quantification of invasive plant species in the park should be taken as a first step towards the management and control of their expansion to minimize their negative impacts.

4. CONCLUSION

In summary, despite the limitation of our reliance on available data before the recent Tigrai war (between 2020 and 2022) – whose impacts on wildlife and other resources of the park have not been assessed yet –, this study does not only shed light on the importance and status of the globally important KSNP but also provides valuable information that would be directly used as an input for management planning. For example, identifying KSNP's ERVs provides a

foundation for (i) developing the park's purpose, (ii) identifying the park's conservation targets (PECs), (iii) identifying and prioritizing management issues and opportunities, and (iv) formulating management objectives and actions. Furthermore, identification of the park's PECs (conservation targets) is particularly of great conservation importance as it enables managers of the park to practice targeted conservation activities and make use of the limited conservation resources efficiently and effectively. This is because the key assumption of identifying these PECs is that the PECs are truly representatives of KSNP's biophysical components; hence, concentrating on their management will ensure that all ecosystem components within the park are conserved and, thus, an overall healthy ecosystem will be maintained. Finally, in addition to its significant contribution to Ethiopia's biodiversity conservation goal, another reason why KSNP deserves special attention is that there is a possibility to develop a tri-country transboundary wildlife conservation area (i.e., by encompassing the Gash Barka area inside Eritrea, the KSNP from the Ethiopian side, and the adjacent area in Sudan to the east), with elephants being the center or "flagship" species in the great Tekeze Valley and its tributaries. Further research is needed to further understand the values of and threats to the park and practice effective conservation and management of the area. More importantly, the impacts of the Tigray war on wildlife species populations and infrastructure and facilities of the park should be assessed and rehabilitation made as urgently as possible.

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6. CONFLICT OF INTRERESTS

There is no conflict of interest.

7. REFERENCE

Abiot Hailu, Abdella Gure, Girma Mengesha, Yosef Mamo & Addisu Asefa 2015. Response of Swayne's Hartebeest to fire-induced habitat change in Senkelle Sanctuary, Ethiopia. *Science, Technology and Arts Research Journal*, **4(2)**: 112-121.

Addisu Asefa 2008. Mountain nyala *Tragelaphus buxtoni* and Ethiopian wolf *Canis simensis* mortalities in the Northern side of Bale Mountains National Park, Ethiopia. *Ethiopian Journal of Biological Sciences*, **7(2)**: 179-184.

Addisu Asefa 2021. Exploration of human-bird relationships: Oromo proverbs associated with the Northern Ground-hornbill in Ethiopia. *Social Sciences & Humanities Open,* **4(2021)**: 100162. https://doi.org/10.1016/j.ssaho.2021.100162.

Berihun Gebremedhin, Birhane Meressa & Yirmed Demeke 2011. Discovery of wintering site of Demoissel Crane in Kafta-Sheraro National Park, Ethiopia. *Bulletin of the African Bird Club*, **18(2)**: 199-202.

BIDNTF (Biodiversity Indicators Development National Task Force) 2010. Ethiopia: overview of selected bioindicators. EWCA, Addis Ababa, 48p.

Bird Life International 2016. Species factsheets. (Available online: http://www.birdlife.org/datazone/info/spchabalt; accessed 20 June 2016).

Bruner, A.G., Gullison, R.E., Rice, R.E & da Fonseca, G.A.B. 2001. Effectiveness of parks in protecting tropical biodiversity. *Science*, **291**: 125-127.

Conflict and Environmental Observatory. 2021. How Animals Are Harmed by Armed Conflicts and Military Activities. Available at: https://ceobs.org/how-animals-are-harmed-by-armed-conflicts-and-military-activities/ (Accessed 13 February 2024).

Corbin, J & Strauss, A. 2008. Basics of qualitative research. Sage Publications, USA.

Dudley, N., Stolton, S., Belokurov, A., Krueger, L., Lopoukhine, N., MacKinnon, K., Sandwith, T & Sekhran, N. (editors) 2010. Natural Solutions: Protected areas helping people cope with climate change, IUCN WCPA, TNC, UNDP, WCS, The World Bank and WWF, Gland, Switzerland, and Washington DC and New York, USA.

Dyer, A.R. 2002. Burning and grazing management in California grassland: effect on bunchgrass seed viability. *Restoration Ecology*, **10 (1)**: 107-111.

Endawek Wendim, Gebremeskel Gizaw & Zenebe Arefine 2014. Wildlife conservation assessment study on Kafta Shiraro National Park. EWCA, Addis Ababa, 52p.

EWCA (Ethiopian Wildlife Conservation Authority) 2015. Ethiopian Elephant Action Plan (2015-2025). EWCA, Addis Ababa, 79p.

EWCA (Ethiopian Wildlife Conservation Authority) 2016. Protected areas of Ethiopia. Available at: http\\www.ewca.gov (accessed on 21 October 2016).

EWNHS (Ethiopian Wildlife and Natural History Society) 2001. Ethiopia. In: Fishpool, L.D.C. & Evans, M.I. (eds.), Important Bird Areas in Africa and Associated Islands: Priority Sites for Biodiversity Conservation, BirdLife International, Cambridge, pp. 291-336.

FDRE (Federal Democratic Republic of Ethiopia) 2009. Ethiopian Wildlife Development, Conservation and Utilization Council of Ministers Regulation No. 163/2009. *Federal Negarit Gazeta*, **26**: 4567-4600.

FDRE (Federal Democratic Republic of Ethiopia) 2014. Establishment of KSNP Council of Ministers Regulation No. 163/2009. *Federal Negarit Gazeta*, **26**: 4567-4600.

Gaston, K.J., Jackson, S.F., Cantu-Salazar, L & Cruz-Pinon, G. 2008. The ecological performance of protected areas. *Annual Review of Ecology Evolution and Systematics*, **39**: 93-113.

Getachew Tesfaye, Demel Teketay & Masresha Fetene 2002. Regeneration of fourteen tree species in Harenna forest, Southeast Ethiopia. *Flora*, **197**: 461-474.

Getachew Tesfaye & Demel Teketay 2005. The influence of logging on natural regeneration of woody species in Harenna montane forest, Ethiopia. *Ethiopian Journal of Biological Sciences*, **4(1)**: 59-73.

International Union for Conservation of Nature and Natural resources (IUCN) (2013). IUCN red list of threatened species, version 2013. [Available online: http://www.iucnredlist.org. accessed on 06 June/2016].

Jensen, A. 1985. The effect of cattle and sheep grazing on salt marsh vegetation at Skallingen, Denmark. *Vegetation*, **60**: 37-48.

Kimball, S & Schiffman, P. M. 2003. Differing effects of cattle grazing on native and alien plants. *Conservation Biology*, **17**: 1681-1693.

Kinahan, A. A. 2014. Ecological and Threat Monitoring Priorities for Senkelle Hartebeest Sanctuary, Ethiopia. Ethiopian Wildlife Conservation Authority, Addis Ababa, Ethiopia, 47p.

Kinahan, A.A. & Laurenson, K. 2013. Guidelines for developing an ecological and threat monitoring programme. Frankfurt Zoological Society, Serengeti, Tanzania, 66p.

KSNP (Kafta-Sheraro National Park) 2016. Biodiversity of and threats to KSNP. KSNP, Humera, Ethiopia, 26p.

Lakew Berhanu, Kumara Wakjira, Rezenom Almaw & Kinahan, A. 2011. Sectoral program of plan on adaptation to climate change: Ethiopian Wildlife Conservation Authority (EWCA). EWCA, Addis Ababa, 109p.

Laurenson, M. K., Sillero-Zubiri, C., Thompson, H., Fekadu Shiferaw, Thirgood, S & Malcolm, J. R. 1998. Disease threats to endangered species: Ethiopian wolves, domestic dogs, and canine pathogens. *Animal Conservation*, **1**: 273-280.

Locke, H & Dearden, P. 2005. Rethinking protected area categories and the new paradigm. *Environmental Conservation*, **32**: 1-10.

Mebrahtu G. Tedla, Kibrom F. Berhe & Kibrom M. Grmayz. 2023. The impact of armed conflict on animal well-being and welfare and analyzing damage assessment on the veterinary sector: The case of Ethiopia's Tigray region. *Heliyon* **9(2023)**: e22681. https://doi.org/10.1016/j.heliyon.2023.e22681.

Mckee, J. 2005. Ethiopia: country environmental profile. The European Union, Addis Ababa, Ethiopia, 64p.

Mekbeb Eshetu, Kumara Wakjira & Minassie Gashaw. 2002. Management Plan of Kafta-Sheraro Wildlife Reserve. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia, 59p.

Millennium Ecosystem Assessment. 2007. A toolkit for understanding and action. Island Press, Washington, DC, 28p.

Newton, A.C. 2007. Forest ecology and conservation: A handbook of techniques in ecology and conservation series. Oxford University Press, Oxford, UK, 454p.

OBARD 2007. Bale Mountains National Park General Management Plan (BMNP GMP). Oomia Bureau of Agriculture and Rural Development (OBARD), Finfinne, Ethiopia, 239p.

Shoshani, J. 1993. Elephants: the super keystone species. *Swara*, **16(2)**: 25-29.

Shoshani, J., Hagos, Y., Yacob, Y., Ghebrehiwet, M & Kebrom, E. 2004. The elephants (*Loxodonta africana*) of Zoba Gash Barka, Eritrea: Part 2. Numbers and distribution, ecology and behaviour, and fauna and flora in their ecosystem. *Pachyderm*, **36**: 52-68.

Shoshani, J & Yirmed Demeke 2006. Report on a reconnaissance trip to the remnant elephant population at the Kafta-Sheraro Wildlife Reserve, Tigray Region, Ethiopia, 16p.

Struhsaker, T. T., Struhsaker, P. J & Siex, K. S. 2005. Conserving Africa's rain forests: problems in protected areas and possible solutions. *Biological Conservation*, **123**: 45-54.

Tallowin, J., Rook, A. J & Rutter, S. M. 2005. Impact of grazing management on biodiversity of grasslands. *Animal Science*, **81**:193-198.

Teklay Girmay, Zeyede Teshome & Tesfay Tesfamichael. 2020. Bird Diversity and Community Composition in Kafta Sheraro National Park, Tigray, Northern Ethiopia. *Hindawi International Journal of Zoology*, **Volume 2020**: Article ID 5016804, 10 pages. https://doi.org/10.1155/2020/5016804.

Thomas, L & Middleton, J. 2003. Guidelines for management planning of protected areas. Best practice protected area guidelines series no. 10, IUCN Gland, Cambridge, 79p.

TNC (The Nature Conservancy) 2007. Conservation action planning handbook: Developing strategies, taking actions and measuring success at any scale. The Nature Conservancy, Arlington, Virginia, USA.

van Schaik C.P., Terborgh, J & Dugelby, D. 1997. The Silent Crisis: The State of The Rainforest Nature Reserves. In: R. Kramer, C. P. van Schaik and J. Johnson (eds.). The Last Stand: Protected Areas and the Defense of Tropical Biodiversity. Oxford University Press, pp64-89.

Williams, S. D., Nelson, A. P. W & Fanuel Kebede 2003. Grevy's zebra survey: Ethiopia 2003. Wildlife Conservation Research Unit, University of Oxford, Oxford, UK, pp. 22.

Wubalem Tadesse, Getachew Desalegn & Alia, R. 2007. Natural gum and resin bearing species of Ethiopia and their potential applications. *Investigación Agraria: Sistemasy Recursos Forestales*, **16(3)**: 211-221.

Yirmed Demeke. 1997. The status of the African Elephant *(Loxodonta africana)* in Ethiopia. *Walia*, **18**: 15-27.

Yirmed Demeke. 2008. Conservation and management of the relic Elephant population in Kafta-Sheraro National Park, north Ethiopia. The U.S. Fish and Wildlife Service, USA, 6p.