East African Journal of Biophysical and Computational Sciences

Journal homepage : https://journals.hu.edu.et/hu-journals/index.php/eajbcs

# Biodiversity conservation and threat reduction in Kibale and Queen Elizabeth conservation areas, Uganda

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**KEYWORDS**:

Biodiversity;

Conservation;

Protected area;

Threats;

Wildlife

## ABSTRACT

This paper examines threats affecting the wildlife conservation areas, threat reduction and adaptive management strategies that enhance biodiversity conservation. The research was conducted through a survey, and data was collected from August 2018 to April 2019 in Kibale and Queen Elizabeth Conservation Areas using literature review, threat reduction assessment technique, Key Informant Interviews and Focused Group Discussions and semi-structured questionnaires. The data was analysed using Geographical Information System software ESRI ArcGIS version 10.31, threat reduction assessment tool, Pearson Chi square test, Spearman's rho correlation coefficient, Paired Samples t-Test, and one-way Analysis of Variables. The study established that staff education level and experience in conservation work influences biodiversity conservation. The conservation areas are threatened by habitat transition/changes, wild fires, human-wildlife conflicts, armed poaching and illegal wildlife trade/trafficking in game meat and game products, increasing human population pressure, and boundary encroachment. Despite these threats, there was a general increase in large mammal population over the past decades, which collaborates well with the threat reduction assessment indices. Both conservation areas had an ecological integrity rating average score of "yellow" indicating significant "concern" and therefore "dissatisfactory". The two conservation areas are majorly threatened by anthropogenic threats, natural threats, and administrative constraints. The wildlife agency should integrate ecosystem health into the conservation agenda. The agency should also strengthen adaptive management, law enforcement, and collaboration with local communities and other stakeholders to reduce on the threats. Finally, further research should focus on ecosystem health, and also the impact of tourism infrastructural development on biodiversity conservation.

## INTRODUCTION

Protected areas harbour a particularly rich and unique biodiversity (Gibson et al.,2011; Tranquilli et al., 2014). However, their existence is challenged by many interrelated anthropogenic activities that have intensified over recent decades (Laurance, 1999; Sodhi et al., 2007; Wittemyer et al., 2008; Tranquilli et al., 2014). Increased human population growth

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has promoted the rapid expansion of threats to wildlife, habitat destruction through agriculture and unsustainable hunting of wildlife. Biodiversity is the wealth of all life forms found on earth and encompasses all species of plants, animals, microorganisms, the ecosystems and ecological processes. Moral justification and value to human existence are two major reasons for conserving biodiversity (Christ et al., 2003). However, renewable natural resources are being utilized by humans at a rate exceeding their natural abilities to renew themselves (Christ et al., 2003). Human encroachment into natural ecosystems is increasing drastically throughout the world. Forests are being exploited and cleared, farmlands have increased in extent, demand for grazing areas is on the rise and unregulated harvesting of the wild resources is becoming uncontrollable. As human activities exert pressure on the global environment, biological diversity declines, habitats are transformed and the population of some species dwindles to the point of extinction (Whitmore and Sayer, 1992). Since man is constantly at variance with nature, the ever increasing human population coupled with technological development place stress on the environment and the world's natural resources hence the unprecedented rate of biodiversity disappearance.

Threats to biodiversity in Africa have led to the creation of numerous protected areas (PAs), which are intended to conserve both fauna and flora, whilst benefitting neighbouring human communities. Nevertheless, human populations throughout Africa have increased the amount of pressure being exerted on PAs. Thus, despite their legal protected status, PAs face significant threats(Tranquilli et al., 2014). The most concerns are overexploitation of natural resources, habitat loss, fragmentation and isolation (Wittemyer, 2008; Laurance, 2012). These factors impact severely on key species and especially taxa with large body sizes, slow reproductive rates, and little behavioural adaptability (DiMarco, 2014).

Protected areas (PAs) are a cornerstone of biodiversity conservation efforts, as they provide various species with safe havens (Radeloff et al., 2010). Protected areas now cover more than 14.7% of the terrestrial land surface (UNEP-WCMC, IUCN, 2016). Recent syntheses suggest that PAs are performing better than the broader landscape (Barnes et al., 2016; Gray et al., 2016), although numerous studies suggest that biodiversity continues to decline within many PAs (Craigie et al., 2010; Laurance et al., 2012; Geldmann et al., 2013). A principal objective of PAs is to conserve nature by eliminating or reducing human pressures and threats operating within their boundaries. In addition to preserving biodiversity, PAs should maintain natural processes and promote survival of species by excluding threats (Margules *&* Pressey, 2000). To achieve these goals, we must understand what the main threats are, where the potential threats occur, and where high-risk areas are distributed. Identifying these threats is therefore crucial for conservation managers to take effective measures to mitigate some of the proximate threats to PAs (Wilson et al., 2005).

Knowledge of the occurrence and severity of threats to PAs has largely been informed by remote sensing data (Geldmann et al., 2014), modeling (Hole et al., 2009), as well as questionnaire surveys with an emphasis on tropical regions (Bruner et al., 2001; Leverington et al., 2010; Laurance et al., 2012). Freely available satellite data offer global and

standardized metrics form measuring those threats to PAs that can be observed remotely, such as deforestation (Joppa and Pfaff, 2011) and fires (Nelson and Chomitz, 2011). However, many other threats, including some of the most frequently reported threats to species, according to the International Union for Conservation of Nature (IUCN) Red List (e.g., overexploitation of species, invasive alien species, pollution, climate change), cannot be measured from space (Joppa et al., 2016) and require field-collected data (Mwangi et al., 2010).

In Uganda, however, little research has been done on the level of threats affecting biodiversity, their consequent impacts in protecting ecological integrity, and therefore, little documentation on the recommendations to mitigate biodiversity threats. Therefore, the main aim of this study was to document the threats affecting the protected areas and propose adaptive management strategies to biodiversity conservation. The specific objectives were to (i) identify threats to biodiversity in the case study conservation areas, (ii) generate the threat reduction assessment (TRA) index for each PA; and (iii) identify management measures employed by the parks that enhance effectiveness and efficiency in addressing threats.

Overall, this study presents tools for PA managers to make effective conservation and restoration decisions and consequently an important influence on global biodiversity conservation.

## MATERIALS AND METHODS

### Selection of the conservation areas for the study

This study was carried out in the national parks and wildlife reserves within Kibale and Queen Elizabeth Conservation Areas because their General Management Plans only highlight the different management challenges that affect the integrity of the protected areas without specifying the threat levels (UWA, 2012, 2015), and also for logistical reasons. Based on knowledge of national parks and wildlife reserves in Uganda, purposive sampling (Babbie and Benaquisto, 2002) was used to select the two conservation areas. Specifically, the national parks and wildlife reserves included in this study were: Kibale National Park (795 $km^2$), Semuliki National Park (220 $km^2$), Toro-Semliki Wildlife Reserve (542 $km^2$) and Katonga Wildlife Reserve (207 $km^2$) in Kibale Conservation Area; and Queen Elizabeth National Park (1978 $km^2$), Rwenzori National Park (995 $km^2$.), Kyambura Wildlife Reserve (157 $km^2$) and Kigezi Wildlife Reserve (330 $km^2$) in Queen Elizabeth Conservation Area (Fig.1)

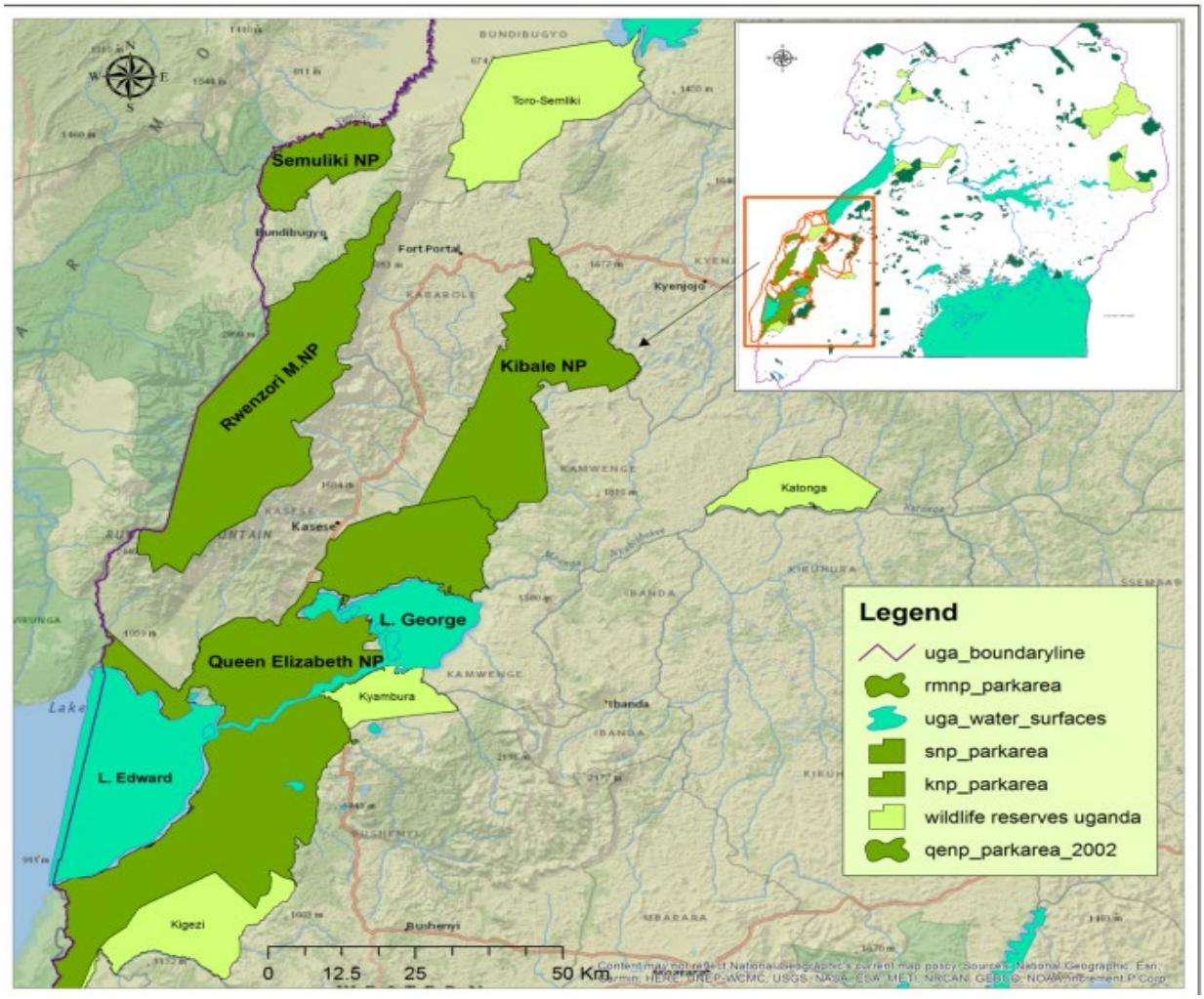


Fig 1: Map showing Kibale and Queen Elizabeth Conservation Areas and location of study sites.

**The sample size and sampling technique**

The sample size of the respondents used during the study was determined using the method adopted from Krejcie and Morgan ( 1970) The study adopted stratified and purposive sampling technique to collect focused information. A total of 287 questionnaires were administered, and these were segregated as 208 individuals from households in the communities adjacent the case study wildlife protected areas, 53 to park staff, 4 to ecological experts, 16 to representatives of local authorities, 2 to Uganda Wildlife Authority headquarters, 2 to Wildlife Conservation Society-Uganda, and 2 to the Ministry of Tourism, Wildlife and Antiquities.

**Data collection**

The data and information used to determine the threats to conservation and how they were being addressed was collected from August 2018 to April 2019. Permission to conduct the study was

obtained from Uganda Wildlife Authority prior to the start of the survey. In-depth interviews with 53 randomly selected resident park staff in the four national parks and four wildlife reserves of Kibale and Queen Elizabeth Conservation Areas was carried out. Eight focused group discussions (FGDs), one per protected area, were made to collect data on the existing threats and identify management options to address them. Each FGD had 5 to 8 park staff. Four ecological experts who had conducted and or supervised various studies in the case study protected areas were interviewed to get expert judgment on the ecological integrity indicators. Key informant interviews (KII) with two representatives (district political head and district environment/natural resources head) from each of the eight selected district local governments neighboring the parks and wildlife reserves; and six national level representatives mainly from Uganda Wildlife Authority, Wildlife Conservation Society-Uganda, and Ministry of Tourism, Wildlife and Antiquities to gather more information. Semi-structured questionnaire were administered to 208 randomly selected community respondents living adjacent the parks and wildlife reserves. In addition, literature review to identify relevant existing information on the national parks and wildlife reserves pertaining wildlife conservation was also done. This data collection was guided by semi structured questionnaire that generated both qualitative and quantitative responses. Both primary and secondary data were collected. Specifically, data were obtained directly from the park staff, and existing literature including park reports, general management plans and annual operation plans, annual reports, field monitoring reports and routine reports. The threats to habitat integrity, quality and ecosystem functioning were identified.

**Data analysis**

Staff at each park and wildlife reserve headquarters were interviewed and GPS points were collected using Garmin eTrex GPS. These collected points in form of latitudes and longitudes were downloaded, entered in Ms-excel, converted to decimal degrees and exported to Geographical Information System (GIS) software ESRI ArcGIS version 10.31 for map production. Responses from the park staff were analyzed using descriptive statistics, and inferential statistics as in the Statistical Package for the Social Sciences (SPSS) Version 22. The statistical tests used in analysis were Pearson Chi square test, Spearman's rho correlation coefficient (r), Paired Samples t Test, Friedman test statistic, and Kruskal-Wallis Analysis of Variance (ANOVA). In addition, the TRA approach by Margoluis and Salafsky (1998) was adopted to assess the main types of threats affecting the PAs, their occurrence, their impact, and their reduction levels. Following Salafsky et al. (2008), threats are defined as any human activity or processes that caused destruction, degradation, and/or impairment of biodiversity targets. This approach based on three key assumptions: a) all biodiversity destructions are human-induced; b) all threats to biodiversity at a given site can be identified and c) changes in all threats can be measured or estimated (Margoluis and Salafsky, 1998). The TRA method identifies threats, ranks them based on the criteria and assesses the progress in reducing them (Rome, 1999). The TRA approach followed the procedural approach developed by IUCN (1998), Margoluis and Salafsky (1999) that involved:

a) Defining the protected area and listing all direct threats present at the site;
b) Ranking each threat based on three criteria: area, intensity and urgency (area refers to the percentage of the habitats in the site; intensity refers to the impact or severity of destruction caused by the threat; and urgency refers to the immediacy of the threat. Out of the total threats, the highest ranked threat for each criterion receives the highest score, and lowest ranked score receives the lowest score;
c) Adding up the scores across all the three criteria for total ranking;
d) Determining the degree to which each threat has been met;
e) Calculating the raw score for each threat and multiplying the total ranking by the percentage calculated to get the raw score for each threat; and
f) Calculating the final threat reduction index score by adding up the raw scores for all threats, dividing by the sum of the total rankings, and multiplying by 100 to get the TRA index as a percentage.

This TRA approach is much simpler and cost effective, as it measures changes in the broader human activities that threaten the integrity of the resource, and then uses that information to draw inferences on the state of the resource itself.

sampling method. By rule of thumb where there is no information for an area it is possible to take 50% of expected prevalence. Using 5% degree of absolute precision, 384 animals need to be sampled but, 400 animals were sampled.

## RESULTS

The study documented the threats to biodiversity in the case study national parks and wildlife reserves. Both primary and secondary threats were identified (Table 2), and their threat reduction percentages and indices calculated (Table 3). The management strategies employed to reduce on the identified threats to enhance wildlife conservation were also documented (Table 4).

### Demographic characteristics of the respondents

*Park staff responses*

The park staff respondents were segregated as 20.8% females and 79.2% males. The Chi square test result was statistically significant ($\chi^2$ (1, $N$ = 53) = 18.132, $p$ =0.000, Cramer's Value=0.445) and the high Cramer's Value indicates a strong effect of gender in conservation. Further analysis using the paired samples $t$ test revealed statistically significant results with t(52) = 8.616, p = 0.000, α = 0.05 (Table 1) indicating that gender plays a vital role in conservation. The staff had varying education levels with majority (43.4%) having a diploma, and 35.8% a college degree in biological science and other related discipline. (Table 1) Analysis by the Pearson Chi-square test revealed statistically significant result that education level had an effect on biodiversity conservation ($\chi^2$ (21, $N$ = 53) = 22.222, $p$ =0.000, Cramer's Value=0.374) and the high Cramer's value indicates a very strong effect. Further analysis using a paired t test revealed statistically significant results t(52) = 5.654, p = 0.000, α = 0.05 (Table 1) indicating that education had a strong correlation with biodiversity conservation. On work experience demographic, 30.2% had between 11 to 15 years, and another 30.2 had over 16 years work experience in wildlife management and

biodiversity conservation (Table 1), and the Pearson Chi-square test revealed statistically significant result that working experience had an effect on biodiversity conservation ($\chi^2$ (196, $N$ = 53) = 214.774, $p$ = 0.000, Cramer's Value = 0.490). The high Cramer's value indicates a very strong effect. Further analysis using the paired samples $t$ test revealed statistically significant results t(52) = 3.817, p = 0.000, α = 0.05. (Table 1) Further analysis on the relationship between length of work experience and level of understanding mandate of PAs using Spearman's rho correlation coefficient (r) revealed statistically significance result (Spearman's rho, r= 0.780, p= 0.000, N=53).

**Table- 1: Socio-demographic characteristics of park staff**

| Variable | | Number (N) | Percentage (%) | Chi-square test ($\chi^2$) | t test statistic |
|---|---|---|---|---|---|
| ***Gender*** | Male | 42 | 79.2 | *$\chi^2$ (1, N = 53) = 18.132, p = 0.000, Cramer's Value= 0.445* | *t(52) = 8.616, p = 0.000, α = 0.05* |
| | Female | 11 | 20.8 | | |
| ***Level of education*** | Secondary | 10 | 18.9 | *$\chi^2$ (21, N = 53) = 22.222, p = 0.000, Cramer's Value= 0.374* | *t(52) = 5.654, p = 0.000, α = 0.05* |
| | Certificate | 1 | 1.9 | | |
| | Diploma | 23 | 43.4 | | |
| | Degree | 19 | 35.8 | | |
| ***Years in service*** | <5 years | 8 | 15.1 | *$\chi^2$ (196, N = 53) = 214.774, p = 0.000, Cramer's Value= 0.490* | *t(52) = 3.817, p = 0.000, α = 0.05* |
| | [5-10) years | 13 | 24.5 | | |
| | [10-15) years | 16 | 30.2 | | |
| | [15-20] years | 10 | 18.9 | | |
| | >20 | 6 | 11.3 | | |

*Community responses*

Responses from the local communities adjacent the wildlife protected areas also revealed that that gender is an important factor in appreciating threats to the wildlife resources and participating in their reduction as revealed by significant $\chi^2$=137.263, d.f=3, p=0.000, N=205, Cramer's Value=0.350 and *t(145) = 0.311, p = 0.265, α = 0.001*. Other demographic factors mainly age [($\chi^2$=137.263, d.f=3, p=0.000, N=205, Cramer's Value=0.350; and *t(145) =0.311, p = 0.265, α = 0.001)]*, education level [$\chi^2$=88.051, d.f=4, p=0.000, N=195, Cramer's Value=0.159 and *t(137) = 1.603, p = 0.001, α = 0.001]*, length of residence [$\chi^2$=174.884, d.f=55, p=0.000, N=190, Cramer's Value=0.617 and *t(139) = 0.545, p = 0.019, α = 0.001*] and land holding [$\chi^2$=79.258, d.f=2, p=0.000, N=194, and *t(139) = 3.940, p = 0.000, α = 0.001]* had an influence on community participation in wildlife conservation aimed to reduce threats to wildlife resources (Table 2).

**Table- 2: Socio-demographic characteristics of community respondents**

| Variable | | Number (N) | Percentage (%) | Chi-square test ($\chi^2$) | t test statistic |
|---|---|---|---|---|---|
| ***Gender*** | Male | 139 | 66.8 | *$\chi^2$=23.558, d.f=1, p=.000, N=208, Cramer's Value=.231* | *t(148) = 2.063, p = 0.000, α = 0.001* |
| | Female | 69 | 33.2 | | |
| ***Age (in years)*** | 18-31 | 56 | 27.3 | *$\chi^2$=137.263, d.f=3, p= 0.000, N=205, Cramer's Value = 0.350* | *t(145) = 0.311, p = 0.265, α = 0.001* |
| | 32-45 | 118 | 57.6 | | |
| | 46-60 | 15 | 7.3 | | |
| | 61+ years | 16 | 7.8 | | |
| ***Level of education*** | Primary | 82 | 42.1 | *$\chi^2$=88.051, d.f=4, p=0.000, N=195, Cramer's Value= 0.159* | *t(137) = 1.603, p = 0.001, α = 0.001* |
| | Secondary | 57 | 29.2 | | |
| | Certificate | 21 | 10.8 | | |
| | Diploma | 20 | 10.3 | | |
| | Degree | 15 | 7.7 | | |
| ***Land holding*** | Owns land | 159 | 82.0 | *$\chi^2$=79.258, d.f=2, p=0.000, N=194* | *t(139) = 3.940, p = 0.000, α = 0.001* |
| | Landless | 35 | 18.0 | | |
| ***Owned Acreage (in hectare)*** | <1 | 7 | 5.3 | *$\chi^2$=162.091, d.f=1, p=0.000, N=132, Cramer's Value=0.249* | *t(93) = 3.060, p = 0.000, α = 0.001* |
| | 1-3 | 84 | 63.6 | | |
| | 3-5 | 13 | 9.8 | | |
| | 5-10 | 21 | 15.9 | | |
| | >10 | 7 | 5.3 | | |
| ***Length of residence*** | 1-3 years | 8 | 4.2 | *$\chi^2$=174.884, d.f=55, p=0.000, N=190, Cramer's Value=0.617* | *t(139) = 0.545, p = 0.019, α = 0.001* |
| | 4-6 years | 13 | 6.8 | | |
| | 7-9 years | 9 | 4.7 | | |
| | ≥10 years | 160 | 84.2 | | |
| ***Occupation of respondents*** | Formal employment | 15 | 10.2 | *$\chi^2$=69.023, d.f=4, p=0.000, N=148, Cramer's Value=0.598* | *t(89) = 1.705, p = 0.092, α =0 .05* |
| | Business | 23 | 15.5 | | |
| | Religious leaders | 2 | 1.4 | | |
| | Peasant farmers | 85 | 57.4 | | |
| | Fisher folk | 23 | 15.5 | | |
| ***Distance of household from the park boundary*** | <5km | 130 | 75.1 | *$\chi^2$=190.465, d.f=2, p=0.029, N=173, Cramer's Value= 0.201* | *t(145) = 3.010, p = 0.003, α = 0.001* |
| | 5-10km | 32 | 18.5 | | |
| | >10km | 11 | 6.4 | | |

## Threats to biodiversity conservation

Across the landscape, the study found that all the case study national parks and wildlife reserves experience nearly similar threats which affect conservation of biological diversity therein. Out of a total of 13 threats identified,

six were primary and common threats to all and these were: i) increasing human population pressure leading to illegal activities/resource off-take, ii) poaching and illegal wildlife trade/trafficking in game meat and of recent in Ivory, iii) habitat transition/changes due to invasive alien species, iv) human-wildlife conflicts arising from wildlife attacks to humans and livestock, and destroying crops, v) wild fires, and vi) boundary encroachment through agricultural development and urbanization (Table 3).

**Table- 3: Prevailing Threats within the Conservation Areas**

| | Threats | Conservation Area | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Kibale | | | Queen Elizabeth | | | | |
| | | Kibale | Semuliki | Toro-Semliki | Katonga | Queen Elizabeth | Rwenzori Mountains | Kyambura | Kigezi |
| **1** | Human population pressure | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **2** | Poaching and illegal wildlife trade | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **3** | Habitat transition/changes | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **4** | Human-wildlife conflicts | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **5** | Wild fires | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **6** | Boundary encroachment | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **7** | Zoonotic and vector-borne diseases | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| **8** | Infrastructure development | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| **9** | Road kills | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| **10** | Trans-boundary issues | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| **11** | Poor waste management | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **12** | Variation in water quality and quantity | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **13** | Negative impacts of climate change | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |

1=present; 0=absent

The rest of the threats were subjected to One-Way ANOVA to compare their means. The results revealed sufficient evidence to conclude that the threats were different as the test statistic was significant for zoonotic diseases and vector-borne diseases ($F_{2,\ 50}$=21.708, $p$=0.001), infrastructural developments ($F_{2,\ 50}$=10.201, $p$=0.001), transboundary issues ($F_{2,\ 50}$=0.677, $p$=0.001), and negative impacts of climate change ($F_{2,\ 50}$=10.362, $p$=0.001) and hence categorized as secondary threats. However, the test statistics results were not significant for road kills ($F_{2,\ 50}$=2.722, $p$>0.001), and poor waste management ($F_{2,\ 50}$=1.802, $p$>0.001) hence do not pose serious threats to wildlife protected areas.

Further, administrative constraints pose a threat to biodiversity conservation. Analysis using the one way ANOVA test revealed that inadequate funding ($F_{7,\ 45}$=5.095, p=0.000), insufficient incentives ($F_{7,\ 45}$=0.35, p=0.000), and inadequate patrol equipment ($F_{7,\ 45}$ =0.328, p=0.001) were statistically significant constraints to biodiversity conservation. Other constraints not statistically significant were poor staff housing ($F_{7,\ 45}$ =0.35, p=0.926), and weak

support from neighboring communities ($F_{7, 45}$ =0.35, p=0.937).

**Threat Reduction Assessment Index and protected areas**

**Threat Reduction**

Threat reduction analysis conducted showed that at all levels of area, intensity and urgency, the national parks and wildlife reserves in Kibale Conservation Area had a higher overall average threat reduction (57.6%) compared to those in Queen Elizabeth Conservation Area (48.25%) (Table 4).

Specifically, habitat change/transition presented the highest threat with a paltry reduction of 1.25% in Queen Elizabeth Conservation Area and 16.25% in Kibale Conservation Area whereas boundary encroachment was the lowest threat with the highest threat reduction in both conservation areas with 86.25% in Kibale Conservation Area and 83.8% in Queen Elizabeth Conservation Area (Table 4).

**Table -4: Threat Reduction in the Conservation Areas**

| Conservation Area | Protected Area | Percentage Threat reduction (%TR) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Habitat changes / transition | Wild fires | Human Wildlife Conflict | Poaching and wildlife trafficking | Population pressure /illegal activities | Boundary encroachment | **Average per PA** |
| **Kibale Conservation Area** | KNP | 50 | 80 | 70 | 77.5 | 70 | 70 | 69.58 |
| | SNP | 5 | 40 | 60 | 50 | 50 | 90 | 49.20 |
| | TSWR | 5 | 50 | 50 | 65 | 80 | 90 | 56.67 |
| | Katonga | 5 | 50 | 60 | 50 | 70 | 95 | 55.00 |
| | *Overall average in KCA* | *16.25* | *55* | *60* | *60.6* | *67.5* | *86.25* | *57.60* |
| **Queen Elizabeth Conservation Area** | QENP | 5 | 60 | 20 | 50 | 80 | 80 | 49.17 |
| | RMNP | 0 | 40 | 80 | 40 | 40 | 80 | 46.67 |
| | Kigezi NP | 0 | 10 | 40 | 30 | 40 | 70 | 31.67 |
| | Kyambura NP | 0 | 90 | 50 | 75 | 80 | 95 | 65.00 |
| | *Overall average in QECA* | *1.25* | *52.5* | *53.8* | *54.7* | *63.8* | *83.8* | *48.25* |

Key: KNP=Kibale National Park ; SNP=Semuliki National Park; TSWR=Toro-Semliki Wildlife Reserve; KCA=Kibale Conservation Area; QENP=Queen Elizabeth National Park; NP=National Park; QECA=Queen Elizabeth Conservation Area

Further, wild fires had reduced by 55% in Kibale Conservation Area compared to 52.5% in Queen Elizabeth Conservation Area. Human wildlife conflict was still a great challenge in all the PAs with a reduction of 60% in Kibale Conservation Area compared to 53.8% in Queen Elizabeth Conservation Area. Human population pressure leading to illegal activities inside the protected areas had reduced by 63.8% in Queen Elizabeth Conservation Area compared to 67.5% in Kibale Conservation Area. Boundary encroachment by adjacent communities had reduced by 86.25% in Kibale Conservation Area compared to 83.8% in Queen

Elizabeth Conservation Area. Armed poaching and illegal wildlife trade in game meat and game products had reduced to 60.6% in Kibale Conservation Area compared to 53.8% in Queen Elizabeth Conservation Area (Table 4).

The national parks and wildlife reserves that lie entirely within Uganda had their threat reduction above 50% compared to those that are shared with Democratic Republic of Congo which had less than 50% (Table 4).

In addition, the focused group discussions revealed that other developments such as road construction, staff accommodation, setting up of tourist lodges and trails inside the national parks and wildlife reserves could have potential impact on the ecosystem. Further, transboundary issues, political interference, poor waste management (including wastes from oil palm processing in Semuliki National Park) and the impacts of climate change could also pose a threat in most protected areas.

**Threat Reduction Assessment Index**

*Effectiveness of PA management in managing threats*

Results of the comparison of staffing (staff per PA) and threat reduction assessment index (per PA) using Paired Samples *t* Test revealed that Staffing and TRA Index scores were moderately and positively correlated ($r = 0.590$, $p = 0.001$) and $t_7 = 1.412$, $p = 0.001$. On average, Staffing scores were 44.2275 points higher than TRA Index scores (95% CI [-29.83, 118.29]). From the box plot, the TRA Index values positively correlated with the staffing level in the PAs. Both variables appear to be symmetrically distributed (Fig 2).

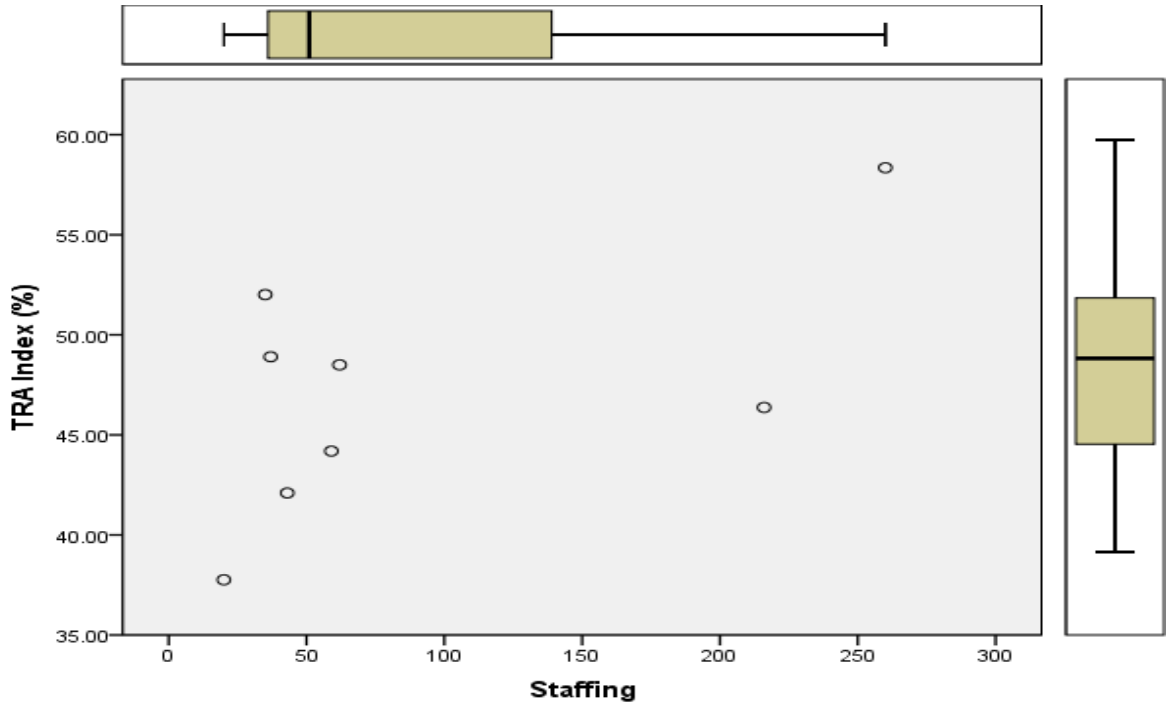


Fig. 2: Relationship between staffing and threat reduction assessment index

*Threat Reduction Assessment Index and PAs*

The threat reduction analysis looked at three criteria: area, intensity and urgency. Kibale Conservation Area had a higher overall average TRA index of 49.46% compared to Queen Elizabeth Conservation Area with 45.1%. At protected area level, Kibale National Park had the highest TRA Index of 58.35% and Kigezi Wildlife Reserve with had the lowest with 37.76%. However, threat reduction assessment indices were independent of the size of the protected areas (Fig. 3).

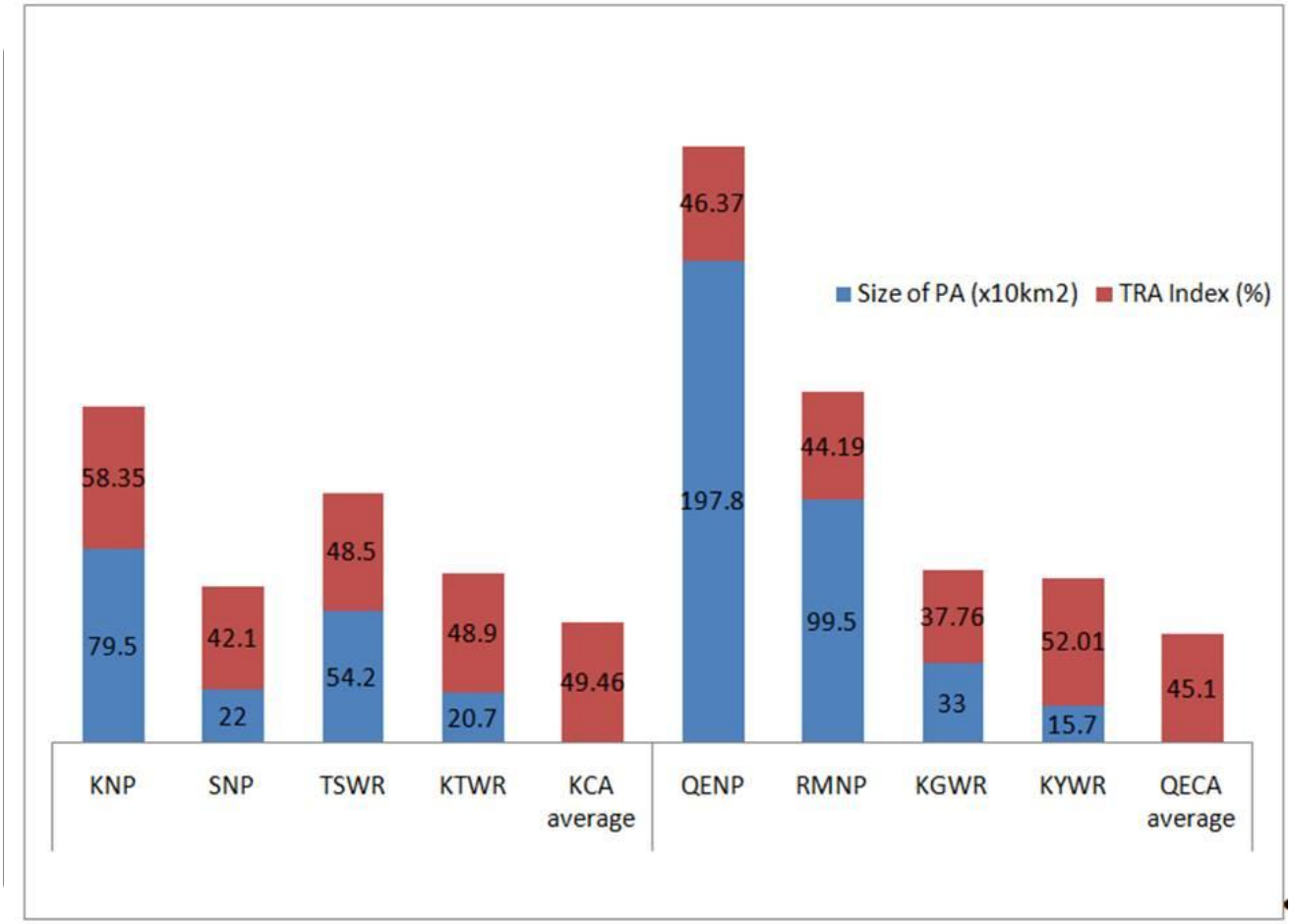


Fig. 3: Threat Reduction Assessment Indices in National Parks and Wildlife Reserves

*Threat reduction and mammal population in Kibale Conservation Area*

Anlysis of data from Kibale Conservation Area shows a general mammal population increase over the past decades. Specifically, in Kibale National Park, the population of the Black and White colobus monkeys increased from 7,346 in 2005 to 10,459 in 2010; the Baboon population increased from 11,603 in 2005 to 12,191 individuals in 2010. However, other primate populations have had a slight increase. The

Chimpanzee population has remained stable over the years (Fig. 4).

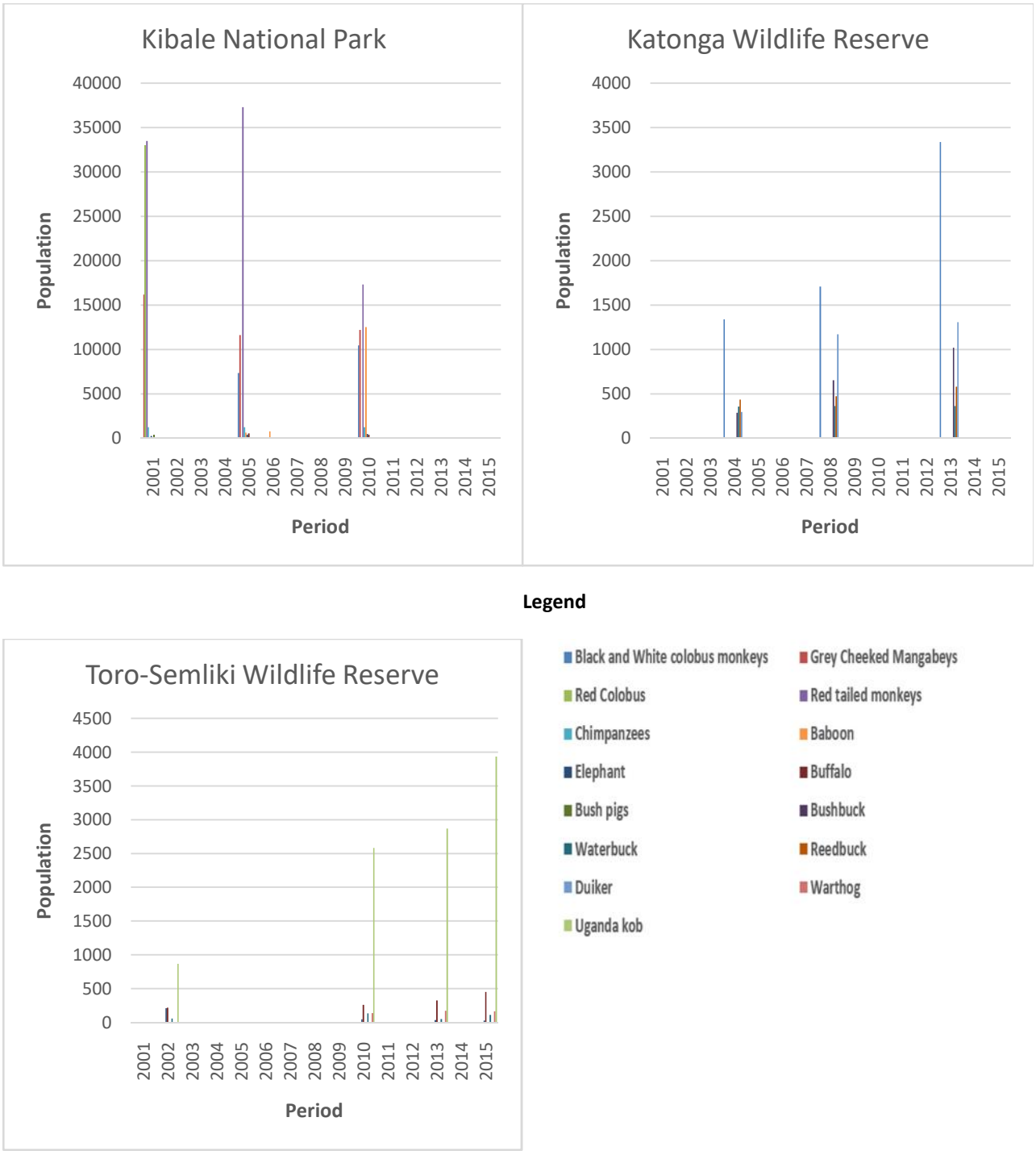


Fig. 4: Population Estimate for Primates and other mammals in Kibale Conservation Area (Raw data adopted from UWA, 2018)

In addition, the Elephant and Buffalo populations have had an exponential increase. The Elephant population has increased from 262 individuals in 2001 to 487 individuals in 2010; the buffalos from 124 individuals in 2001, to 402 individuals in 2010; and the Bush pigs were only estimated at 400 individuals in 2001. (Fig. 4) This general increase collaborates well with highest TRA Index of 58.35% recorded in KNP (Fig. 3).

In Katonga Wildlife Reserve, there was a steady increase in wildlife population from 2004 to 2013 (Fig. 4). The population of the Black and White colobus monkey increased from 1,342 in 2004 to 3,335 in 2013. Duiker population rose from 295 in 2004 to 1,169 in 2008. The Reedbuck and Waterbuck had a more or less stable growth in population over the years.

Similarly, the mammal population in Toro–Semliki Wildlife Reserve had a general increase. Specifically, the Uganda Kob population increased from 3,460 individuals in 1982 to 3,935 by 2015, the waterbuck population increased from 33 individuals in 1982 to through 58 individuals in 2002 to 112 by 2015, and the Buffalo population increased from 219 individuals in 2002 to 449 in 2015. (Fig. 4)

*Threat reduction and mammal population in Queen Elizabeth Conservation Area*

The elephant population in Queen Elizabeth Protected Area (QENP, KyamburaWR and Kigezi WR) reduced from 4,139 in 1969 to about 150 by 1980. It then started recovering until it reached 3018 individuals in 2012. Other wild animal populations have increased in QEPA (Fig. 5).

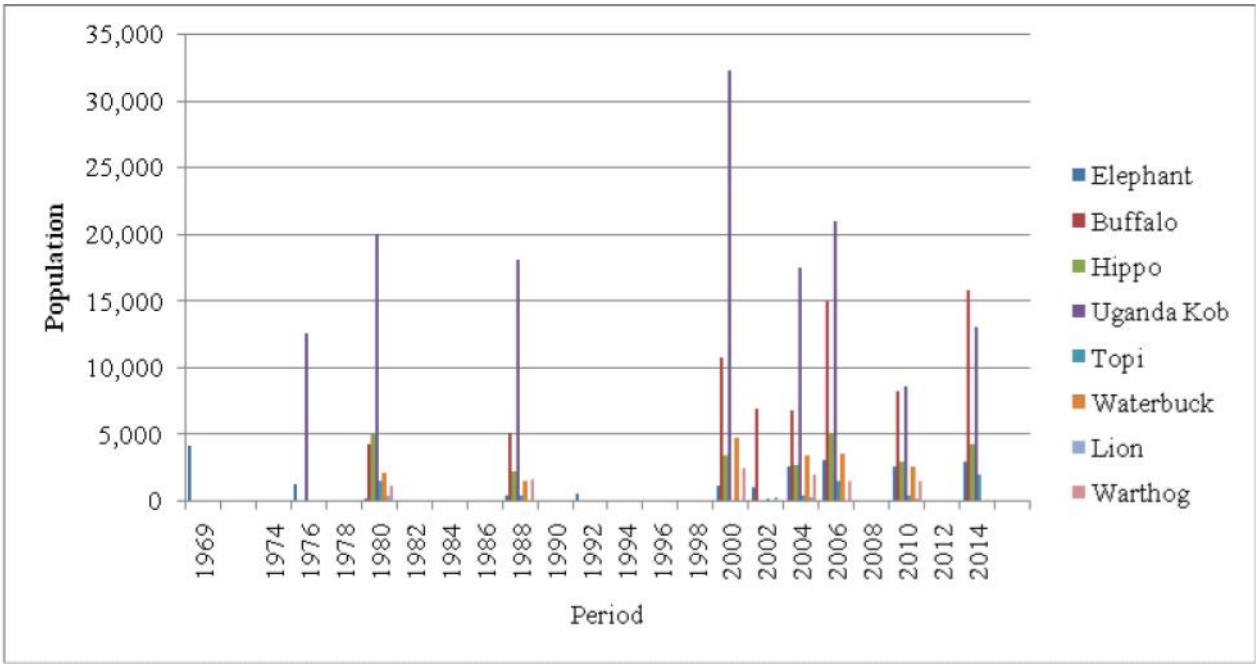


Fig 5: Medium to Large Mammal Population in Queen Elizabeth Protected Area (Raw data adopted from UWA, 2018)

*Threat reduction and ecological integrity rating*

The data indicators were analysed and various scores were assigned basing on the computed TRA Index in Table 4. Each indicator of ecological integrity was assigned a color score: dark green (TRA index 81-100%) for "acceptable" ecological integrity (very satisfactory), light green (TRA index 51-80%) for moderate ecological integrity (satisfactory), yellow (TRA index 21-50%) indicating a "concern," (dissatisfactory) and red (TRA index 0-20%) indicating "impaired" (very dissatisfactory) condition requiring immediate management action. (Table 5) Each national park and wildlife reserve had a score and each threat also had a score to show the level of threat reduction. On the whole, KNP and Kyambura WR had a "light green" score indicating moderate ecological integrity and hence satisfactory, while the rest of the PAs had each an average score of "yellow" indicating significant "concern" and therefore dissatisfactory (Table 5).

In addition, using a scoring of 1 to 4 (where 1- very dissatisfactory, 2- dissatisfactory, 3- satisfactory, and 4- very satisfactory) on the state of conservation of wildlife resources in the national parks and wildlife reserves, the responses from ecological experts, selected district local governments, Uganda Wildlife Authority, Wildlife Conservation Society-Uganda, and Ministry of Tourism, Wildlife and Antiquities indicated the overall performance of the national parks and wildlife reserves as dissatisfactory ($t(25) = 14.148, p = 0.000, \alpha = 0.001$).

**Measures by the parks that enhance effectiveness and efficiency in addressing threats**

In appreciation of the threats affecting wildlife conservation in the Conservation Areas, the study through the FGDs, identified management measures the parks have instituted to enhance effectiveness and efficiency in addressing threats and these include:

a) Undertaking wildlife related disease surveillance in and around the national parks and wildlife reserves and conduct community sensitization programmes on wildlife related diseases
b) Periodically monitoring wildlife and domestic animal movements to and from the national parks and wildlife reserves
c) Carrying out massive conservation sensitization and educational programmes,
d) Strengthening community conservation through the benefit sharing scheme, problem animal management, conservation education and awareness, and community participation in boundary management.
e) Gathering, analysing and acting on intelligence information on illegal activities inside the national parks and wildlife reserves.
f) Conducting cross border and or coordinated monitoring, control and surveillance patrols inside the national parks and wildlife reserves. This also involves cross border joint planning meetings, security operations.
g) Put in place ecological maintenance and restoration programs especially in Kibale National Park and Queen Elizabeth National Park which are intended to counteract threats to ecological integrity. These include eliminating through uprooting hyperabundant species such

as *Dichrostachys cinerea and Lantana camara* that threaten the ecological integrity of the park ecosystems.

**Table- 5: Ecological Integrity Score Card using Data Indicators**

| Protected Area (PA) | Performance of Ecological Integrity using data indicators in the PAs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Large mammal population increase | Frequency of poaching incidences | Human wildlife conflict | Wild fires | Boundary encroachment | Resource harvesting | Zoonotic diseases | Habitat change | Road kills | Average rating per PA |
| *Kibale Conservation Area* | | | | | | | | | | *Y* |
| KNP | Exponential | LG | LG | DG | LG | LG | DG | LG | LG | LG |
| SNP | N/A | LG | LG | *Y* | R | | DG | | | *Y* |
| TSWR | General increase | LG | LG | LG | DG | DG | N/A | R | R | *Y* |
| Katonga WR | Exponential | LG | LG | LG | DG | LG | LG | R | N/A | *Y* |
| *Queen Elizabeth Conservation Area* | | | | | | | | | | *Y* |
| QENP | General increase | LG | DG | LG | DG | DG | DG | R | LG | *Y* |
| RMNP | N/A | *Y* | DG | *Y* | DG | *Y* | N/A | DG | N/A | *Y* |
| Kigezi WR | General increase | *Y* | *Y* | R | LG | *Y* | DG | R | N/A | *Y* |
| Kyambura WR | General increase | LG | LG | DG | DG | DG | N/A | R | N/A | LG |
| Overall rating per indicator | LG | LG | LG | DG | LG | LG | DG | R | LG | *Y* |

LG= light green; R =red; Y =Yellow; DG=Dark green; N/A= not applicable

## DISCUSSION

The Kibale and Queen Elizabeth conservation areas are key wildlife protected areas within the Albertine Graben which house a very rich mammal biodiversity. However, over time, they are faced with key threats that degrade their habitats and conservation in general. The threats identified in this study are similar to those reported by other researchers from a number of countries in Africa (Laurance et al., 2012; DiMarco et al., 2014; Tranquilli et al., 2014; Taylor, 2015; MacKenzie, 2017; Ryan, 2017; Chibueze, 2018; Benı´tez-Lo´pez et al., 2019; Kolinski and Milich, 2021).

Human-wildlife conflicts occur worldwide, and human injuries are the most severe manifestations of these human-wildlife conflicts (Packer et al., 2005; Kabuusu et al., 2018). But the killing of livestock and the crop raiding by wildlife are by far the most widespread source of such conflicts (Allendorf et al., 2012; Andrade and Rhodes, 2012; Kabuusu et al., 2018). For instance, in Canada wolves are reported to have killed close to 3,000 domestic animals in 14 years, whilst elephants in India and China led to a reduction of approximately 14% and 48%, respectively of annual crop production (Madhusudan, 2003; Zang and Wang, 2003). In Tanzania, 86% of the persons living in wildlife buffer zones reported crop damage, while 10% reported the killing of livestock and poultry Kabuusu (2018), and baboons have always caused significant crop destruction in Uganda. The incidence of wildlife-associated human injuries increased in QENP between 2006 and 2010, and was mostly caused by hippos (Kabuusu et al., 2018).

Weather patterns define the corresponding farming activity and the level of threats. The dry season is characterized by limited pastures and water in QENP, consequently wild animals, particularly elephants, move out of the QENP into community areas in search of water and pasture, raiding crops in the process. It was also revealed that the dry season is also the harvest season, and farmers are injured because they stay outside at night for extended periods of time protecting their crops from elephants and thieves. This seasonal change, in both animal and human behavior, mirrors temporal differences in the incidence of wildlife-associated human injuries (Kissui, 2008). This study aimed at determining the threats to conservation and how they were being addressed. Data analysis and interpretation revealed major findings. The study established that socio-demographic factors of park staff mainly gender, age, education level and length of work experience play significant role in addressing threats to wildlife conservation. Equally, the socio-demographic factors of local communities adjacent the national parks and wildlife reserves mainly gender, age, education level and length of residence in the community play significant role in participating in programmes that address threats to wildlife conservation. This agrees with Kabir (2013) that recognition of gender roles in biodiversity management is an important step in the achievement of conservation and sustainable use of biological resources. PA management considers education as a key factor in empowering their staff with knowledge, skills and enhancing capacity and competence to conserve biodiversity. The park employees had the required skills in wildlife management and biodiversity conservation. In addition, length of work experience influences the level of understanding and implementing the mandate of PAs. This implies that the park employees are knowledgeable and could provide the needed information on threats to biodiversity conservation in the Park over the years. The presence of professionals corroborates the suggestion of Green (1999) that some industries required specially trained personnel to actualize set goals, and biodiversity conservation is a peculiar example.

The national parks and wildlife reserves in both KCA and QECA are faced with key primary threats that degrade their habitats and conservation in general. These include: i) habitat transition/changes due to invasive alien species, ii) wild fires, iii) human-wildlife

conflicts arising from wildlife attacks to humans and livestock, and destroying crops, iv) poaching and illegal wildlife trade/trafficking in game meat and of recent in Ivory, v) increasing human population pressure leading to illegal activities/resource off-take, and vi) boundary encroachment through agricultural development and urbanization. Also, secondary threats mainly zoonotic and vector-borne diseases, transboundary issues, negative impacts of climate change, and infrastructure developments within the PAs constrain conservation efforts. These threats could be attributed to anthropogenic factors (including settlement, infrastructural development, agricultural expansion, resource off-take for livelihoods), and natural disturbances such as climate change, biological invasion, etc. These factors affect the aesthetic value, scenery, and also release wastes to the ecosystem. Further, inadequate funding to the sector, insufficient incentives to park staff, and inadequate patrol equipment also constrain conservation efforts.

The national parks and wildlife reserves in Kibale Conservation Area had a higher overall average threat reduction, and overall average TRA index compared to those in Queen Elizabeth Conservation Area. This higher overall average threat reduction compares well with the general increase in mammal population over the years in Kibale Conservation Area. This could be attributed to improved management of the park and law enforcement in particular combating poaching (UWA, 2018).

Despite the prevailing threats, the population of large mammals has generally increased over the past decades. This collaborates well with the TRA indices for each national park and wildlife reserve in each conservation area. The increase in mammal population is probably due to creation of both institutional and legal framework, and strengthened implementation of existing policies, laws and regulations. Specifically, the recovering mammal population in Queen Elizabeth Protected Area could be attributed to better security within Uganda, immigrations and successful breeding. This agrees well with UWA (2018) that improved PA management, increased vigilance through intelligence and patrols, and most importantly the peace, security and stability in the country and the region as a whole, and increased community conservation programs which have contributed to threat reduction. However, the low threat reduction performance of national parks and wildlife reserves shared with Democratic Republic of Congo is probably due to their transboundary nature, which presents with it varied management challenges (GVTC, 2017).

On the whole, the overall ecological integrity of Kibale and Queen Elizabeth Conservation Areas was rated “yellow indicating a “concern” and hence dissatisfactory, a condition that requires immediate management action. Specifically, both KCA and QECA had an average TRA index of less than 50%, an indication that both conservation areas only mitigate less of the PAs threats. This rating of the overall performance of the national parks and wildlife reserves as “dissatisfactory” by the ecological experts, park employees, district local governments, Uganda Wildlife Authority, Wildlife Conservation Society-Uganda, and Ministry of Tourism, Wildlife and Antiquities was a testimony that there was great “concern” to conserve wildlife resources. This level of performance could be attributed to the more emphasis the Wildlife

Agency puts on animal health issues and little on ecosystem health.

## CONCLUSION

The study established that the national parks and wildlife reserves are majorly threatened by habitat transition/changes, wild fires, human-wildlife conflicts, armed poaching and illegal wildlife trade/trafficking, increasing human population pressure, and boundary encroachment through agricultural development and urbanization. Other threats are zoonotic and vector-borne diseases, transboundary issues, negative impacts of climate change, and infrastructure developments within the PAs which constrain conservation efforts.

Creation of both institutional and legal framework, and strengthening implementation of existing policies, laws and regulations is key to biodiversity conservation success. Protection of the integrity of wildlife conservation areas requires an integrative approach of interventions that focus on both animal health, and ecosystem health at national and transboundary level. Reduction in threats affecting wildlife conservation areas calls for a multidisciplinary approach involving local communities, park management, and security agencies. Therefore, improved park management, increased vigilance, and peace, security and stability in a country or region are prerequisites to achieve conservation of wildlife and other biodiversity. Various management approaches to enhance effectiveness and efficiency in addressing threats must include, but not limited to, undertaking wildlife related disease surveillance, periodically monitor wildlife in and outside the national parks and wildlife reserves, conduct conservation awareness and education, strengthen community conservation through the benefit sharing programme, strengthen intelligence information on illegal activities, strengthen adaptive management to address threats to ecological integrity.

Recommendations

The wildlife agency should strengthen adaptive management as a strategy to restore all degraded areas inside the national parks and wildlife reserves and carry out periodical environment audits..

The wildlife agency should strengthen law enforcement and national-level coordination with the community and concerned stakeholders to combat poaching and other illegal activities in the park.

Finally, more research should be conducted to investigate the impact of tourism infrastructure development on ecological integrity of the national parks and wildlife reserves.

**Acknowledgments**

We thank the people adjacent the national parks and wildlife reserves within the Kibale and Queen Elizabeth Conservation Areas for providing information. Thanks also go to Uganda Wildlife Authority for allowing us carry out the study, and their staff for providing us with useful information.

**Declarations of interest**: None

**Authors' contributions**

J.K. initiated and shared the research idea, drafted the concept, coordinated the data collection and analysis and wrote the first draft

of the manuscript. N.M.M and C.K.T assessed the draft concept of the manuscript, made conceptual guidance to collect right data and made critical intellectual adjustments on the first manuscript to make it a clear scientifically and logically drafted manuscript. All authors assessed and approved the final copy of the manuscript for submission.

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