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The Influence of Long-Term Wildlife Monitoring on Policy Development to Conserve Biodiversity in Uganda

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Abstract
The influence of Long-term Wildlife Monitoring on policy to conserve biodiversity in Uganda was explored. The study particularly sought to evaluate the indicators monitored, policies formulated, new conservation initiatives developed, and also suggest innovative conservation policy areas with guidance of the long-term wildlife monitoring program. The study was conducted through a survey from May to October 2019 using document review, Key Informant Interviews, semi-structured questionnaires, and Geographical Information System/remote sensing. The study established that Long-term Wildlife Monitoring contributes to development of conservation policies. The policies developed include the merger of Uganda National Parks and the Game Department, integration of interests of local communities in the wildlife legislation, shift from protectionism to conservation, and elevation of conservation status of protected areas. The program guides adoption of conservation initiatives mainly adaptive management, park boundary demarcation and management, restocking of wildlife protected areas, and landscape approach to management of wildlife resources. The study identified innovative conservation policy areas namely ecosystem health, community involvement in wildlife monitoring, management of wildlife outside protected areas, management of wildlife corridors, and Payment for Ecosystem Services that should be integrated into the wildlife policy and legal framework. The study concludes that wildlife monitoring program guides development of conservation policies, conservation initiatives, and innovative conservation policy areas to conserve biodiversity. Further research should investigate ecosystem health to assess the condition of the wildlife protected areas.
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1. Introduction

Ecological monitoring is integral to environmental management and biological conservation (Cord et al., 2017; Hays et al., 2019). Ecological monitoring is the process of purposefully collecting information to track and understand changes in ecosystem structure, ecological processes, and the ecological services that ecosystems provide (Lindenmayer & Likens, 2018). As the need for monitoring species, habitats, and ecosystems increases, so too do the ways in which scientists and managers involve personnel and technology to collect, process, and analyze both samples and data (Allan et al., 2018; Hill et al., 2018). Managing wildlife (i.e. the processes of dealing with or controlling wildlife for different purposes) in a sustainable way is a key challenge around the globe. To balance societal needs and ecological functions, the complex interactions between humans, wildlife, and habitats must be fully understood (Apollonio et al., 2017).

Data from monitoring have substantial value for detecting relationships between management actions and animal populations (Pollock et al., 2002) and should provide direction regarding future management decisions (Nichols & Williams, 2006; Kendall & Moore, 2012). In addition, monitoring that is not otherwise driven by a specific hypothesis can help researchers understand impacts of unplanned events such as weather (short term) and climatic patterns (long term) on wildlife populations (Beever & Woodward, 2011; Fancy & Bennetts, 2012; Johnson, 2012). Proper planning and implementing of a monitoring program includes identifying an appropriate species or taxa (Carignan & Villand, 2002), selecting metrics that are sensitive to changing conditions (Williams et al., 2002), selecting sampling methods that best maximize efficiency (Garton et al., 2005), using an experimental design to isolate the hypothesis of interest (e.g., change detection) with the most efficient probabilistic sampling (Garton et al., 2005; Morrison et al., 2008), and employing sufficient effort (sample size) to achieve the desired level of power for detecting biologically meaningful changes (Williams et al., 2002; Field et al., 2007). Failure to give these decisions proper attention often leads to misallocated resources, resulting in suboptimal information for decisions and planning objectives (Legg & Nagy, 2006). Therefore, the ability to contextualize scientific information for park decision-makers by scaling up among multiple parks and with surrounding landscapes is a particularly important aspect of long-term monitoring and research in protected-area networks (Rodhouse, 2016). Studies by Lindenmayer et al. (2015) revealed that there is a particular need for

monitoring designs that anticipate future needs (and social conflicts), and quantify current ecological changes in a manner which enables the forecasting of ecosystem change to improve risk management and sustainable economic and social development.

In Uganda, Uganda Wildlife Authority (UWA) that promotes the generation and use of scientific researched information in wildlife management in the country. UWA's aims in this is provide broad-based, scientific information to guide decision making as provided for under both the Uganda Wildlife Act (2019) and the Wildlife Research and Ecological Monitoring Policy (1999). UWA had not carried out over 47.6% of the surveys that should have been conducted in the period from 2008 to 2011 for both forested and Savannah parks and in the absence of frequent surveys, and therefore, lacks sufficient data to adequately monitor the status of wildlife and other resources and develop plans that will adequately ensure sustainable wildlife management (OAG, 2011). UWA's Research and Monitoring Unit is not carrying out surveys consistently for biodiversity management; as a result, the promotion, collection and provision of relevant, accurate and timely information for conservation and good management of Uganda's wildlife resources and its biodiversity is not being fully achieved (OAG, 2011). None of the past studies provide an assessment of the contribution of wildlife monitoring initiatives in influencing policy, decision making and implementation of conservation interventions, which is one of the key outputs of conservation efforts. Hence, inadequate information existed on whether the long-term wildlife monitoring program influences formulation of policies to conserve biodiversity. In this study, therefore, we hypothesized, first, that wildlife monitoring guides formulation of policies to conserve biodiversity; second, that wildlife monitoring guides formulation of new conservation initiatives; and three, that wildlife monitoring guides formulation of innovative conservation policy areas for consideration into future policies and identification of strategies to conserve biodiversity. The objectives were: (i) to identify priority indicators used in long-term wildlife monitoring, (ii) to evaluate conservation-related policies formulated with guidance from the long-term wildlife monitoring information to conserve biodiversity, (iii) to identify new biodiversity conservation initiatives developed as a result of long-term wildlife monitoring program, and (iv) to suggest innovative conservation policy areas with guidance of the monitoring program for consideration into future policies and strategies to conserve biodiversity.

2. Materials and Methods

2.1 Research Design

Our study employed a survey research design, and both qualitative and quantitative research methods were used. Primary data was collected using interviews with park staff. Key questions employed in this study were: "What key indicators do you monitor in the wildlife protected area", "How does your institution use the results of monitoring efforts in protected areas?", "Do findings from monitoring wildlife guide formulation of policies to conserve biodiversity?, explain", "What innovative conservation policy areas do the findings from wildlife monitoring generate to enhance biodiversity conservation?", "What initiatives to conserve biodiversity are generated from the findings of wildlife monitoring?", "What innovative conservation policy areas do you recommend for consideration into future policies and strategies to further enhance biodiversity conservation?", and "Suggest how the wildlife monitoring information could be improved". Secondary data was obtained from existing park documents mainly wildlife monitoring reports, state of the park reports, and general management plans.

2.2 Study Area

Our study covered an area bounded by altitudes 0° 34' South and 1° 09' North and longitudes 29° 28' West and 30° 56' East in the Albertine Graben, Uganda. The wildlife protected areas studied 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 Mountains 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). The landscape experiences a bimodal rainfall pattern occurring during March-May, and August- November. Annual rainfall ranges from 800 mm to 1600 mm, and is greatly influenced by altitude. The landscape lies astride the equator. It experiences small annual variation in air temperature; and the climate is generally hot and humid, with an average monthly temperatures varying between 27°C and 31°C, with maximums consistently above 30°C and sometimes reaching 38°C Average minimum temperatures are relatively consistent and vary between 16°C and 18°C. The average monthly humidity is between 60 and 80%. The high air temperatures result in high evaporation rates causing some parts to have a negative hydrological balance. The drainage consists of three main lakes; Lake Albert, Lake Edward, and Lake George and there are a number of rivers and streams. A wide variety of vegetation ecosystems and species are known to exist in this landscape; on the mountain and escarpment slopes and in the valleys and flats. The main vegetation ecosystems include montane forests, tropical forests (including riverine and swamp forests), savannah woodlands and grassland mosaics, papyrus and grassland swamps. (NEMA, 2009)

2.3 Sampling

The sample size of the respondents was determined basing on guidelines for sample sizes for studies that measure the proportion or percentage of people who have some characteristic, and from a known population (Conroy, 2018). A total of 81 park staff (disaggregated as 15 staff in each of the 4 parks, 5 staff in each of the 4 wildlife reserve, and one staff from UWA headquarters, Kampala) were sampled for this study.

2.4 Data Collection

Data were collected with permission from Uganda Wildlife Authority. The study was an exploratory research conducted through a survey from May to October 2019 using document review, semi-structured questionnaires, Key Informant Interviews (KIIs), and Geographical Information System/remote sensing. The documents reviewed were wildlife monitoring reports, state of the park reports, and general management plans. Respondents were purposefully selected from park staff including those involved in ecological monitoring and research. Semi-structured questionnaires were administered to 81 park staff to generate both qualitative and quantitative responses. Hence both primary and secondary data were collected. A consent was obtained from the respondents before start of the interviews.

2.5 Data Analysis

Data were analysed using descriptive and inferential statistics as in the Statistical Package for the Social Sciences (SPSS) Version 22; and presented in tables. To determine the scale's internal consistency, the scales were tested for reliability using the Cronbach's alpha coefficient (α) and the scale's internal consistency and the scales' reliability ranged from 0.263 to 0.80 in all the wildlife protected areas. These reliability results were all acceptable as the reliability statistic Cronbach's Alpha (α) value was 0.538 for all the measures indicating a high level of internal consistence for the scale of the sample. Also, the Analysis of Covariance (ANCOVA) test revealed $F_{(1)} = 1.591$ at significance level of 0.00163 which was less than 5% hence generally accepted. This meant that there were only 1.591 possibilities out of 100 that the results were due to chance when the confounding variable (gender of respondent) is controlled.

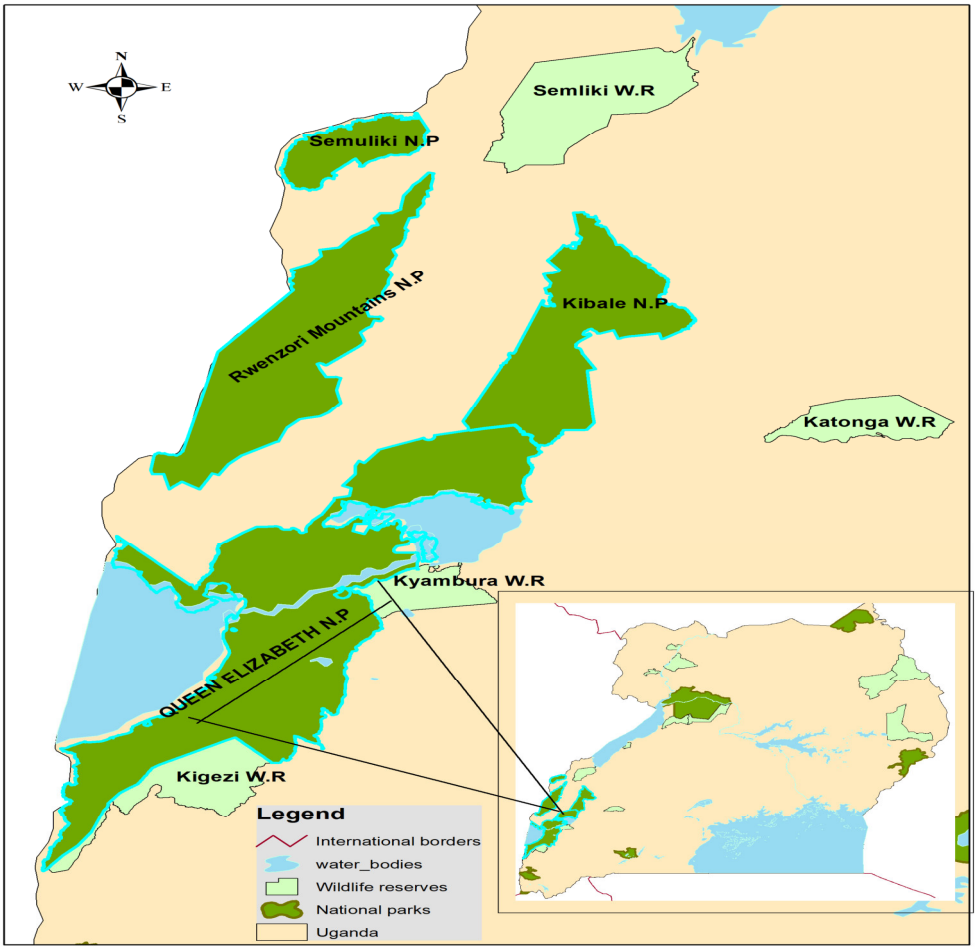

Fig 1: Location of the Study Area (N.P-National Park, W.R-Wildlife Reserve)

3. Results

3.1 Preliminary Information

Socio-demographic characteristics of park staff—The influence of long-term wildlife monitoring on policy to conserve biodiversity in Uganda was explored using staff managing the wildlife protected areas. The staff had varied qualifications in wildlife conservation or related qualification in natural resources management; and varied length in service (Table 1).

Table 1: Socio-demographic Characteristics of Park Staff

Variable	Category	Frequency	Percent (%)
Gender	Male	65	80.2
	Female	16	19.8
Education	Certificate	1	1.2
	Secondary	15	18.5
	Diploma	36	44.5
	Degree	29	35.8
Length in service in managing wildlife protected areas	1-5 years	12	14.8
	6-10 years	20	24.7
	11-15 years	25	30.9
	16-20 years	15	18.5
	21+ years	9	11.1

Wildlife monitoring indicators—The study revealed that each wildlife protected area had developed an ecological monitoring and research program basing on its conservation values, management purpose, management zone and management programs. In all the case study PAs, wildlife monitoring was carried out primarily in-house within the protected area (Fig. 2), rarely through co-operation with other agencies and universities, and without involvement of local communities.

Fig. 2: A Team of Park Staff Monitoring Wildlife inside the Park (Field photo)

The KIIs revealed that Long-term Wildlife Monitoring is constrained by inadequate gadgets for monitoring, inadequate financial resources, inadequate staffing, inadequate skills in GIS/remote sensing, and the challenging weather, remoteness and large geographic areas of the wildlife PAs. The key indicators that were considered focused on animal species (their health, population density and distribution, and behavior), invasive alien species (identification and minimally pilot restoration in degraded areas), poaching, and illegal activities (resource off-take, grazing, and fishing). (Table 2)

Table 2: Ecological Monitoring Indicators and Standards used to Evaluate Ecological Monitoring in all the Wildlife Protected Areas

Threat	Monitoring parameter(s)	Indicator(s)	Method(s)	Frequency
Poaching	Frequency of poaching incidences; large mammal population size; extent of poaching; origin of poachers	Number of poachers arrested; number of prosecutions; population sizes of key species; density of key species; number of snares and carcasses per km; number of armed exchanges with poachers; number of reports of poaching activities; mammal density	Ground truth monitoring; remote sensing monitoring	Periodically
Fires	Incidences of fire; extent of fire; vegetation change; vegetation regeneration	Number of fires; area burnt and its location; habitat area on satellite/aerial images increased; number per unit area of trees, poles, saplings	Ground truth monitoring; remote sensing monitoring	Periodically
Human Wildlife conflict	Community attitudes and behavior towards the PA and control measures; sites where raiding/ injuries occur	Number of animals or people injured or killed; number of animals or people injured or killed; number of park - related projects that people have volunteered to participate in	Ground truth monitoring	Periodically
Resource harvesting	Quantities harvested; incidences of illegal activity in multiple use zone	Number of bundles per harvest day per licensed person; number of illegal activities encountered per km walked	Ground truth monitoring; remote sensing monitoring	Periodically
Road kills	Incidences of road kills; incidences of illegal fishing	Number of animals killed; number of people arrested	Ground truth monitoring	Periodically
Climate change	Impacts of climate change; vegetation changes; weather data; glacier and snow recession; water quality and quantity of rivers	Habitat size, density, distribution & diversity including gap distribution, tree density, species diversity, gap size; area in Kms	Ground truth monitoring; remote sensing monitoring	Periodically

(Adopted from UWA, 1999)

Further, from the park documents reviewed, the ecological monitoring indicators did not include baseline information on natural ecosystem processes (such as hydrology), abiotic components (non-living chemical and physical factors in the environment, geology, and soils), other biotic components such as vegetation change, birds, etc, (UWA, 1999) that pose a threat to biodiversity conservation. No socio economic data was captured. The human category indicators of landscape spatial organization (infrastructure density, fragmentation and periphery land use), park boundary status, and infrastructure (paths) were sparingly captured (UWA, 1999). Other indicators not given particular attention were non-indigenous plant propagation, environmental disturbance, and restoration of degraded sites. In addition, water quality parameters including benthic faunal quality, bacterial and physical-chemical stream water quality, acidity level and trophic level were not considered. 、

3.2 Long-Term Wildlife Monitoring and Conservation Policy Development

3.2.1 Responses to policy aspects of wildlife monitoring

Responses on the mode of wildlife monitoring were statistically significant χ^2 (1, N=81) =15.523, p=0.000, Cramer's Value=.526. The Long Term Wildlife monitoring program had an influence on conservation-related policy development to conserve biodiversity, as revealed by the responses of park staff on the question "Do findings of the Long-term Wildlife Monitoring Program influence formulation of policies to conserve biodiversity of the protected areas? The responses revealed statistically significant Pearson Chi-square result, χ^2 (1, N=81) =297.1, p=0.000, Cramer's Value=.342 (Table 3) and the high Cramer's Value indicates a strong influence that the long-term wildlife monitoring program has on formulation of policies to conserve biodiversity. Specifically, the respondents (N=81) indicated the program improves planning, management decision making and improvement in conservation of biodiversity (57%); mainstreaming wildlife PA operations and provision of intelligence information to the national agency (29%); informs the conservation agency of its appropriateness/relevance and need to adapt wildlife management approaches (12%); and streamlining revenue

mobilization to finance management of wildlife (2%). The findings also indicated local communities do not participate in monitoring wildlife (Table 3)

Table 3: Pearson Chi-Square Test results on Policy Aspects of Wildlife Monitoring (N=81, α =0.05)

Variable	Variable question	χ^2 Value	d.f	p value	Cramer's Value
Participation in monitoring	Do you participate in wildlife monitoring? State the mode of monitoring	15.523	1	.000	0.526
Policy formulation	Do findings from monitoring wildlife guide formulation of policies to conserve biodiversity? If yes list them	297.1	1	.000	0.342
Conservation initiatives	Over the last decade, have you participated in developing and implementing new conservation initiatives? If yes list them	7.247	1	.000	0.370
Conservation policy areas	Are there any innovative conservation policy areas recommended as guided by the findings from wildlife monitoring that could enhance conservation? If yes list them	9.351	1	.001	0.416
Tourism infrastructure development	Is increase in development of tourism infrastructure inside wildlife PAs in conflict with conservation of biodiversity?	35.314	1	.000	0.858
Community participation	Do you (park staff) involve local communities in monitoring wildlife?	16.750	1	.071	0.562

3.2.2 Key conservation policies developed

The study findings through KIIs and documents reviewed revealed the following conservation policies formulated with input of findings and recommendations from the long-term wildlife monitoring program.

The merger of Uganda National Parks and the Game Department into Uganda Wildlife Authority—The merger took place in 1996 by an Act of Parliament, because there was an observed duplication of roles by both government agencies in the management of wildlife, and also the Game Department had failed to manage wildlife outside national parks. This was informed, in addition, by reports of wildlife monitoring generated by Uganda National Parks. The merger was done to not only ensure sustainable management of wildlife; coordinate, monitor and supervise activities related to wildlife management; and provide guidance for the management of Community Wildlife Areas and Wildlife Sanctuaries; but also brought in and recognized management of wildlife outside the protected areas and participation of park adjacent communities in conservation activities.

Shift in the national institutional arrangements to integrate local interests in the wildlife legislation—The Uganda Wildlife Authority (UWA) is charged with the responsibility of, inter alia, ensuring the sustainable management of wildlife. Significantly, the Wildlife Policy, 2014 laid the basis for the wildlife law in Uganda with a mission to "conserve in perpetuity the resources within the National Parks and other wildlife areas to enable the people and the global community to derive ecological, economic, and aesthetic and education benefits from wildlife". The Uganda Wildlife Act, 2019 provides for integrating local interests in the implementation of the wildlife legislation where local authorities are empowered to form wildlife committees to advise on wildlife management and utilization within the local jurisdiction.

The shift from protectionism to conservation as enshrined in the Wildlife Policy—Policy change involved a shift from the traditional state-centric approach of wildlife management to a modern approach involving the people living with wildlife or affected by wildlife legislation. This policy change resulted into stakeholder involvement in the conservation of biodiversity through the community based conservation approach which provides adjacent communities with access and rights over use of selected in-park resources. While people had been illegally exploiting the wildlife resources in the past, the policy gave an opportunity to park adjacent communities to access in-park resources including medicinal plants, firewood, mushrooms building poles, walking stakes and also participate in wildlife conservation programmes. The policy also enhances benefit sharing through wildlife use rights and promoting public participation in wildlife management. It vests the ownership of wildlife in the government *in trust* for the people and allows the use of wildlife for cultural purposes by any community. The policy contributes towards promoting the conservation and sustainable utilization of wildlife for the benefit of the people of Uganda; enhancing benefit sharing through wildlife use rights and promoting public participation in wildlife management.

Revenue Sharing Policy and Guidelines—The Uganda Wildlife Policy, 2014, provides for revenue sharing where 20% of the park entry fees collected from a wildlife PAs is given to the local government(s) of the areas surrounding such PAs. This act was formulated with input from the long-term wildlife monitoring program. The goal of revenue sharing is to ensure strong partnership between protected areas management, local communities and local governments leading to sustainable management of resources in and around wildlife protected areas by enabling people living adjacent to wildlife protected areas obtain financial benefits derived from the existence of these areas that contribute to improvements in their welfare and help gain their support and acceptance for protected areas conservation. The shared revenue is managed by the respective District Local Governments and is used to fund conservation, livelihood and public goods projects decided upon by the beneficiary park adjacent communities.

Community Conservation Policy—Originally, the agency responsible for wildlife management used to protect wildlife in isolation of other parties. With the birth of this policy on Community Conservation in 2004 whose goal is to strengthen conservation of wildlife resources through sustainable and equitable distribution of conservation benefits and/or costs among all stakeholders, there was a paradigm shift in conservation. This policy provides for collaborative management arrangements and partnerships, benefit sharing and community-based tourism management with local communities, local governments, private sector and others for wildlife resource sustainable management. In addition, collaboration with other agencies including the security agencies (army and tourism police) in the conservation of the biodiversity has supported the law enforcement department to combat armed poaching in wildlife protected areas. This policy, whose formulation was guided by the periodic wildlife monitoring reports, has strengthened collaboration of park management with other players including local communities.

Research and Ecological Monitoring Policy—Formulation of the Research and Ecological Monitoring Policy (1999), a new policy reform, mandates UWA to carry out ecological monitoring and research in the PAs. This policy emphasizes research and ecological monitoring as a key strategic program to support decision making, and was formulated with input from the periodic wildlife monitoring reports to strengthen ecological monitoring in the protected areas.

Elevation of conservation status of protected areas—Elevation of protected areas to higher status of conservation, were guided by the periodic wildlife monitoring reports. During this study it was revealed by park staff that processes were underway to elevate Toro-Semliki Wildlife Reserve to a National Park status as guided by the periodical wildlife monitoring reports, among others.

Review of the Wildlife Act cap 200 of 2000—Review of the wildlife monitoring reports revealed that the reduction in elephant population, the increase in cases of armed poachers, among other factors, caused revision of provisions in the Wildlife Act to include formulation of stringent and deterrent measures to control illegalities, hence influencing policy. In addition, introduction of a section into the wildlife law on compensation was another development. The section on compensation was premised, among others, on the emerging issues including human wildlife conflict, the loss occasioned by wild animals escaping from wildlife protected areas, and revelations by the wildlife monitoring reports. Specifically, the compensation issue was critically examined with a view i) to provide for compensation of the loss occasioned by wild animals escaping from wildlife protected areas and this would be premised on mitigation for loss of property to wildlife, ii) to provide for clarification of the extent of liability of UWA in regard to wildlife induced damage and conservation area land ownership, and iii) to strengthen an effective mechanism for management of wildlife outside protected areas by providing for broader structures particularly community structures for management of wildlife outside PAs.

3.3 Long-Term Wildlife Monitoring and New Conservation Initiatives

Over the past two decades, conservation of wildlife resources in Uganda had seen a number of new conservation initiatives. This was revealed by statistically significant results (Table 3) of the responses of park staff on the question "Over the last one or two decades, have you participated in developing and implementing any new conservation initiative(s) to conserve biodiversity in Uganda?" The identified initiatives developed include:

Adaptive management—On what measures park management employs to conserve biodiversity, the park staff indicated i) adoption of sympathetic/modified management practices around/adjacent to protected areas to reduce/mitigate external stresses (74%); and ii) use of monitoring and adaptive management in the wildlife protected areas (26%). The habitats under adaptive management through restoration activities were recorded in Kibale National Park and Queen Elizabeth Protected Area. The restoration initiatives include tree growing with indigenous trees namely *Spathodea campanulata, Erythrina abyssinica, Bridelia micrantha* which was evident inside Kibale National Park and along the boundaries of Rwenzori Mountains National Park; and eliminating through uprooting of hyper-abundant species such as *Dichrostachys cinerea,* and *Lantana camara* that threaten biodiversity conservation, and ecological integrity of the park ecosystems.

Adoption of Spatial Monitoring and Reporting Tool (SMART) in conservation—The use of SMART approach started in 2014 in the PAs and covers three areas: software, capacity building and site-based protection

standards. This tool uses icons to represent animals and threats in a SMART configured data model. SMART is a site-based approach to monitor, evaluate and improve the effectiveness of conservation management through monitoring wildlife, mapping poaching and trafficking hotspots and other threats, and helping in reporting by ranger teams. The adoption and use of *SMART* in data collection in the wildlife PAs guides identification of areas for adaptive management, wildlife distribution, documenting trends of illegal activities and prosecuting of offenders in Courts of Law (as the tool provides evidence of where the wildlife offence was committed), and park management planning and decision-making.

Opening and demarcation of park boundaries—Park management engages in securing park boundaries and plant concrete pillars and live marks. In 2002, park management jointly with the local communities opened boundaries of PAs, and in 2005 concrete pillars were planted—an effort to address the park boundary conflict—and this development was informed by the periodic monitoring of wildlife and park boundaries.

Restocking wildlife protected areas—Restocking wildlife protected areas is done through translocation of wild fauna from one wildlife protected area to another as guided by the periodical wildlife monitoring reports and animal census. For instance, in 2013, a total of 90 Impalas and 6 zebras were successfully translocated to Katonga Wildlife Reserve (UWA, 2013). Such decisions on translocation of animals help to control numbers where populations are high and to boost numbers where they are low, and also improve tourism.

Mitigate wildlife crime and trafficking—New units that address wildlife crime and trafficking have been established. The use of the canine unit (one of the new units) was introduced in Uganda in 2016 to mitigate wildlife crime and trafficking. The canine unit uses sniffer dogs as a tool to sniff out wildlife contraband and provide evidence that the product is an actual specimen wildlife contraband (some of which include ivory, pangolin scales, hippo teeth and rhino horns), and such evidence is used to facilitate effective prosecution of wildlife cases. Other new technologies for curbing illegal activities and managing park resources are use of drones, forest alerts; and employing e-governance- use of emails, telephones, twitter, skype, etc.

3.4 Innovative Conservation Policy Areas for Consideration into Future Policies and Strategies to further Enhance Biodiversity Conservation

The existing legal and policy regimes do not adequately capture various areas that would enhance biodiversity conservation, (χ^2 (1, N=81)= 9.351, p=0.001, Cramer's Value=.416. These innovative conservation policy areas include ecosystem health, community involvement in wildlife monitoring, management of wildlife outside protected areas, management of biological corridors, Payment for Ecosystem Services (PES)—which should be considered key policy areas/issues for inclusion in the legal and policy frameworks to further enhance biodiversity conservation—, and regulating development of tourism infrastructure inside the PAs. Specifically, on the question of whether "increasing development of tourism infrastructure inside wildlife PAs conflict with conservation of biodiversity", the results revealed statistically significant responses from park staff, (χ^2 (1, N=81)=35.314, p=0.000, Cramer's Value=.858, (Table 3), and the high Cramer's Value indicates a very strong effect. For instance, trails constructed in the parks interrupt the wildness and pristineness of the wildlife protected areas (Fig. 3)

Fig. 3: Bukurungu Trail Infrastructure in Rwenzori Mountains National Park (Field photo)

4. Discussion

Long-term wildlife monitoring influences policy development to conserve biodiversity. Long-term wildlife monitoring is done basing on monitoring indicators grouped into two broad categories: 1) the ecosystem category indicators which measure changes occurring directly within the habitats; and 2) the human category indicators which measure changes directly linked to human presence in the ecosystem. Specifically, long-term monitoring focused on selected indicators—animal species, invasive alien species, poaching, and illegal activities. UWA has been carrying out periodical surveys of medium - large mammals using both aerial and ground count methods to establish species' population trends and distribution patterns in the country (UWA, 2018), which information guides decision making. Indicators on natural ecosystem processes, abiotic components, biotic components such as vegetation, birds, etc, and socio economic data were not captured. The indicators for wildlife monitoring identified in this study are similar to those monitored by other researchers in some parts of the World (Sadaula et. al., 2019; Fancy et. al., 2009). In Nepal, population monitoring is being done for few wildlife species only although monitoring of other species is also important for making proper conservation plan and such studies provide strong recommendations to community persons, leaders, conservation NGO/INGO, and government bodies to prepare the future action plan strategies about the conservation and monitoring of flagship endangered wild animal species at protected areas (Sadaula et. al., 2019). In the United States, the National Park Service indicated that a long-term ecological monitoring program provides information on the status and trends of selected park resources as a basis for making decisions and working with other agencies and the public for the long-term protection of park ecosystems (Fancy et. al., 2009).

The long-term wildlife monitoring information influences development of conservation policies as outlined in Section 3.2. These findings support our first hypothesis that wildlife monitoring guides formulation of conservation-related policies to conserve biodiversity. This agrees with MTWA (2014) that policies result into a positive impact on conservation and environmental management—specifically, these changes have strengthened benefit sharing and promoting local participation in wildlife management, have also provided guidance for the creation and management of Community Wildlife Areas, have contributed towards livelihood and public goods projects decided upon by the park adjacent communities through implementing the revenue sharing scheme, and reduction in overall illegal activities.

Further, long-term wildlife monitoring information guides identification of new conservation initiatives mainly: adaptive management, adoption of Spatial Monitoring and Reporting Tool (SMART) in conservation, opening and demarcation of park boundaries, restocking wildlife protected areas, mitigating wildlife crime and trafficking, adoption of landscape approach to management of wildlife including transboundary management of wildlife resources, community involvement and stakeholder participation in conservation work, and developing monitoring and evaluation and standard report writing tools, which are all integral to biodiversity conservation. These findings support our second hypothesis that long-term wildlife monitoring guides formulation of new initiatives to conserve biodiversity. These findings are similar to those reported by other researchers (Roux & Foxcroft, 2011; Schoenefeld & Jordan, 2017). The wildlife monitoring provides a *basis for adaptive management by* helping to identify sites within the park and along the park boundary that need restoration. Roux and Foxcroft (2011) asserted that monitoring aims at generating scientific and management oriented information and is the basis for adaptive management and better management, and UWA (2013) adds that monitoring information is necessary to be able to adapt to the changes and modify conservation strategies. Schoenefeld and Jordan (2017) also report that monitoring results used to inform decisions about environmental management in order to fulfil the adaptive management cycle. Further, wildlife monitoring yields into *adoption of Spatial Monitoring and Reporting Tool (SMART) in conservation*—a tool which plays a major role in adaptive management including; and data collection by rangers, data entry, analysis and report, debriefing and strategic planning. Rangers use this tool to capture data on threats in close to real time and transmit the information to the head office. This allows the head office to deploy rangers in response hence mitigating the threat. The tool strengthens planning, management decision making and operations, and also ensures clear flow of information to the wildlife agency which all contribute to improved biodiversity conservation. This tool helps ascertain the state of wildlife resources in the wildlife protected areas, provide scientific and management oriented information for planning, better understanding of the ecological and social economic dynamics, and also enable development of management strategies for sustainable wildlife management. SMART has been widely adopted to monitor law enforcement efforts and allow adaptive management in the conservation of wildlife resources (Kuiper et al., 2020; Lynam et al., 2016). While data from SMART informs law enforcement locally, it has also been relevant to the global conservation of several endangered species (Gray et al., 2018; Hoette et al., 2016). Wildlife monitoring guides generation of more *initiatives* that strengthen efforts to conserve biodiversity mainly adoption of the wildlife protected area system, opening of park boundaries, restocking of the wildlife protected areas, accountability for wildlife resources and benefits accruing to the communities, and mitigation of wildlife crime and trafficking.

More so, long-term wildlife monitoring information identifies innovative conservation policy areas: a)

Involvement of local communities in wildlife monitoring—a policy area that would present an opportunity for indigenous knowledge which would not only create attitudinal change of communities towards the PAs but also contribute to sustainable management and conservation of wildlife. According to Springer (2005), participation in wildlife monitoring provides concrete opportunities for indigenous people to be heard by the park authorities and for the authorities to benefit from indigenous knowledge, and the indigenous community members report immediately and directly to the protected area head and rangers on matters such as violations of resource use regulations by outsiders. b) *Management of wildlife outside protected areas*—a policy area that would enable the country protect wildlife resources outside PAs. It is estimated that over 50% of Uganda's wildlife resources still remain outside designated protected areas, mostly on privately owned land; and is of most urgent concern for protection and development (UWA, 2014). These resources are at the mercy of individual land owners since the existing land tenure systems (freehold, customary and lease) do not provide for maintenance of habitats and conservation of biodiversity and this leaves them vulnerable to various threats including hunting and other unsustainable harvesting methods and practices (UWA, 2014). c) *Establishment and management of biological corridors*—a policy area that would enable establishment and management of biological corridors to create connectivity between protected areas for effective protected area system as well as facilitate animal migrations across the landscape. d) *Regulating increase in development of tourism infrastructure*—a policy area that would not interfere with the pristineness and naturalness of park environment, and interrupt animal movements. Wildlife tourism can cause significant disturbances to animals in their natural habitats through a boom in infrastructure and construction projects, scare away animals, disrupt their breeding and feeding patterns, or acclimate them to the presence of people, disrupt parent-offspring bonds and increase vulnerability to predators and competitors (Korir et al., 2013). e) *Payment for Ecosystem Services*—a policy area that would provide a strategic initiative to finance conservation. The PES scheme in the short term, would not only strengthen capacity of local communities to engage in park management through the taungya system, setting up apiaries along the park boundaries to reduce on human wildlife conflicts, but also through sustainable land management interventions enhance crop yield and fertility creating income generating opportunities and benefits for the local communities, reducing soil erosion (which improves the water quality within the ecosystem- an ecosystem service). In the long term, the scheme would contribute towards increasing vegetation cover; water quality, quantity and reliability; and the increasing fauna population. f) *Integrating ecosystem health into wildlife monitoring*—a policy area that would capture information on natural ecosystem processes, abiotic components, climate change aspects, human component indicators of landscape spatial organization, and socio economic data. Here, the study findings indicate that the current wildlife monitoring program only considered ecosystem drivers (for instance human pressures such as poaching, disturbances such as fires), threats (for instance illegal resource harvesting), animal populations (trends, distribution and health), and miniature on extent of spread of exotic and invasive species, presence/absence of zoonotic diseases. Yet the monitoring program should consider ecosystem or landscape-scale paradigms which emphasize ecological processes (e.g. nutrient cycling) and habitats rather than individual species (Franklin, 1993), using rationale that biological diversity is best preserved by maintaining healthy ecosystems. (Bourgeron & Jensen, 1993) Studying ecosystem health will contribute to scientific knowledge and make significant progress towards the preservation of existing biodiversity. This would assess the condition of the protected area (condition monitoring), and the success of ecosystem maintenance and restoration initiatives (effectiveness monitoring). This agrees with Noss (1990) that wildlife monitoring should look at detecting ecosystem health in terms of trends in the components, processes or functions and to provide early warning of situations that require interventions. Davis (2005) adds that long-term wildlife monitoring program is used to track the overall condition or "health" of park natural resources. These findings support our third hypothesis that wildlife monitoring guides formulation of innovative conservation policy areas for consideration into future policies and strategies to conserve biodiversity.

5. Conclusion and Recommendations

5.1 Conclusion

The study investigated the effectiveness of the Long-term Wildlife Monitoring Program in influencing policy to conserve biodiversity, using a case study of 8 wildlife protected areas in Uganda. The study explored the indicators for wildlife monitoring, influence of wildlife monitoring in formulation of conservation policies, development of conservation-related initiatives, and innovative conservation policy areas proposed for consideration into future conservation. The Long-term Wildlife Monitoring is based on ecosystem category, and human category indicators which measure changes occurring directly within the habitats, and changes directly linked to human presence in the ecosystem respectively. Long-term Wildlife Monitoring emphasizes mammal population monitoring, through appropriate protocols, such as point-counts or line transect surveys, and little on habitat monitoring where key attributes of habitat, such as vernal pools are less emphasized. Further, this current monitoring does not comprehensively capture issues of condition and effectiveness of the wildlife protected areas which constitute ecosystem health. Long-term Wildlife Monitoring guides government to formulate

policies that promote conservation of biodiversity in the country. Long-term Wildlife Monitoring program guides the agency to develop and adopt new conservation initiatives namely adaptive management, adoption of SMART tool in conservation, park boundary opening and demarcation, restocking wildlife protected areas, creation of new units to mitigate wildlife crime and trafficking, adoption of landscape approach to management of wildlife resources, and monitoring, evaluation and reporting tool which have guided the wildlife agency to move with the current trends in the global conservation. Long-term Wildlife Monitoring guides identification of innovative conservation policy areas such as community involvement in wildlife monitoring, management of wildlife outside protected areas, management of biological corridors, and Payment for Ecosystem Services which should be incorporated in future policies and strategies to further enhance biodiversity conservation of wildlife protected areas. In view of these findings, the study concludes that Long-term Wildlife Monitoring influences formulation of conservation policies, development and adoption of new conservation initiatives, and recommend innovative conservation policy areas to enhance biodiversity conservation. In addition, it contributes to biodiversity conservation through improved planning and management decision making; mainstreaming wildlife PA operations and provision of intelligence information to the national agency, informing the conservation agency of its appropriateness/relevance and need to adapt wildlife management approaches; and streamlining revenue mobilization to finance management and conservation of wildlife.

5.2 Recommendations

Basing on the findings, the study recommends that the wildlife agency should include, in the wildlife monitoring program, indicators on ecosystem drivers (for instance climate, human pressures), ecosystem integrity (e.g., biogeochemical indicators), and ecosystem processes or functions (such as fire and hydrology) to be able to detect ecosystem health and provide early warning of situations that require interventions. The agency should fortify adaptive management as a strategy to restore degraded areas inside the wildlife PAs. The agency should carry out animal census in Rwenzori Mountains National Park and Semuliki National Park that had never been surveyed to have a complete state of wildlife resources in Uganda. The agency should ensure infrastructural developments inside the wildlife PAs are minimized, and where inevitable, conduct Environmental Social Impact Assessment, and periodic Environment Audits for compliance. Further studies should investigate ecosystem health aspects to assess the condition and effectiveness of the wildlife protected areas; as well as the status of biodiversity outside the PAs.

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Competing Interests

We declare that there were no financial or personal relationship(s) that have inappropriately influenced the writing of this article.

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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