

Contribution Of Community Knowledge To Wildlife Protection In Volcanoes National Park, Rwanda

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Abstract: Wildlife conservation remains a critical environmental priority in Rwanda, particularly in and around Volcanoes National Park, where biodiversity is increasingly threatened by poaching, illegal resource extraction, and human-wildlife conflicts. Despite the implementation of various conservation initiatives between 2020 and 2024, these challenges persist, highlighting the need to understand the role of local communities in supporting wildlife protection. Community-based conservation emphasizes the importance of equipping local people with conservation knowledge to enhance their participation in protecting wildlife and natural resources. Therefore; this study investigated the contribution of community knowledge to wildlife protection in Volcanoes National Park. Specifically; the study assessed the forms of conservation knowledge among surrounding communities, examined the effectiveness of wildlife protection measures, and analyzed the relationship between community knowledge and wildlife protection outcomes. The study adopted a descriptive research design using a mixed-methods approach. Quantitative data were collected through structured questionnaires administered to a stratified sample of 400 households located around volcanoes national park from Kinigi, Nyange, Shingiro, and Gataraga sectors in Musanze District; Kabatwa, Bigogwe, Jenda, and Mukamira sectors in Nyabihu District; Gahunga, Cyanika, and Rugarama sectors in Burera District. Qualitative data were obtained through purposive interviews with eleven local leaders (4 leaders from Musanze District, 3 leaders from Burera District, and 4 leaders from Nyabihu District), one community conservation warden, and one chief park warden. Data were analyzed using descriptive statistics and Pearson correlation analysis in SPSS, while qualitative data were examined through thematic analysis. Significant biodiversity awareness (Mean = 4.41-4.67), indigenous knowledge (Mean = 4.53), and training programs (Mean = 4.53) were observed. Wild life conservation was quite effective in terms of reducing poaching (Mean = 4.54-4.58), human-wild life conflicts (Mean = 4.55-4.58), and illegal resource harvesting (Mean = 4.51-4.55). There was a strong correlation between community knowledge and wild life conservation ($r = 0.824$, $p = 0.000$).

Keywords: Community-based conservation; Community knowledge; Human-wildlife conflict; Indigenous knowledge; Volcanoes National Park; Wildlife protection

1. INTRODUCTION

Wildlife conservation in protected areas has shifted from conservation strategies that view local communities as an alien threat to those that incorporate local ecological knowledge and participation as key elements of sustainable wildlife conservation [1]. The previous fortress approach of conservation has been criticized for sidelining people residing near conservation areas and generating social conflict that may be detrimental to the legitimacy of conservation efforts [2]. Therefore, community-based conservation not only incorporates ecological considerations but also involves local participation, learning and livelihood benefits

[3]. There is also evidence from African conservation landscapes of how community-based conservation strategies can promote wildlife survival when aligned with local institutions and incentives [4].

Environmental education, community engagement, and tourism benefit-sharing are becoming key components of conservation policies and practices in relation to protected areas in Rwanda [5]. In particular, community involvement in Rwanda has been associated with local support for the conservation of mountain gorillas in relation to VNP. However, the level of involvement, access to benefits and the role played in conservation vary among communities [6]. Poachers and other community members have also played a role in wildlife protection programs [7].

The VNP is one of the most significant sites of biodiversity and tourism in Rwanda. It serves as a protection area of high-altitude volcanic ecosystems and home for the mountain gorillas and other species [8]. The importance of the ecosystem in both ecological and economic aspects highlights the significance of the interactions between conservation agencies and local communities [9]. However, at the same time, those communities located nearby the VNP suffer from the presence of human-wildlife encounters, limitations in resources and economic activities.

Even though there exist numerous community-based conservation programs, there are several questions which have to be answered: what types of conservation knowledge exist in communities around the VNP, how successful the wildlife protection actions are seen by locals, and how the knowledge of community members affects the results of wildlife protection actions. These questions should be answered since awareness itself does not lead to conservation actions. Hence, this paper was conducted with an aim of evaluating the role of community knowledge in wildlife conservation within VNP. The specific objectives include: (1) evaluating types of community knowledge within communities adjacent to VNP; (2) evaluating the efficacy of the wildlife conservation practices; and (3) examining the connection between community knowledge and wildlife conservation.

2. MATERIALS AND METHODS

2.1 Study Area

The Volcanoes National Park is located in the Northern Province of Rwanda and makes up part of the trans-boundary Virunga ecosystem. The park spans an area that includes Musanze, Burera, and Nyabihu districts, occupying about 160km². The park's volcanic environment, bamboo and montane forests, and high altitudes provide homes for mountain gorillas, golden monkeys, buffalo, and many other wildlife [10]. This study targeted communities from the sectors neighboring the park or in close proximity to it. These sectors include Kinigi, Nyange, Shingiro and Gataraga in Musanze District, Kabatwa, Bigogwe, Jenda and Mukamira in Nyabihu District, and Gahunga, Cyanika and Rugarama in Burera District.

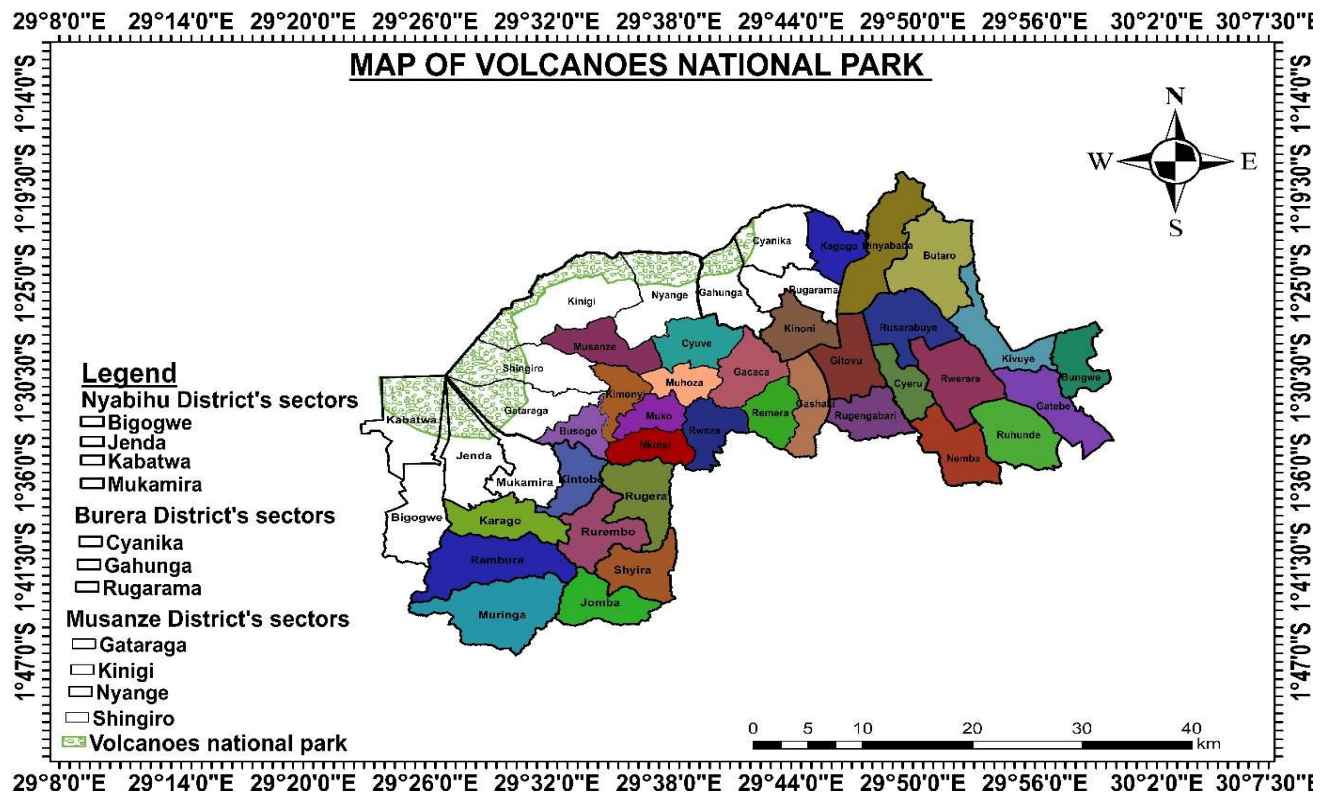


Figure 1. Study area and selected sectors around Volcanoes National Park. Source:

2.2 Research Design, Population and Sampling

The design used for this study was descriptive mixed-methods in order to integrate quantitative data from the households with qualitative explanation from the conservation stakeholders. The target population was households in the eleven sectors that were selected [11]. The thesis shows an estimated household population of 346,099 and a sample size of 400 respondents, which was calculated based on the Yamane formula at 5% level of error. Sampling techniques followed the standard procedures for survey research [12].

The households were sampled through stratified sampling, whereas key informants were sampled through purposive sampling, owing to their familiarity with the conservation and park management issues [13]. The sample included eleven local leaders, four from Musanze, four from Nyabihu, and three from Burera, as well as two park managers, namely the Community Conservation Warden and the Chief Park Warden.

2.3 Data Collection and Measurement

Data on attitudes, knowledge, and practices were collected using a structured questionnaire [14], which is the right tool for the systematic measurement of these factors in large samples. The questionnaire included questions on local biodiversity awareness, traditional conservation, training and workshops in the community, poaching, human-wildlife conflicts, and illegal extraction of resources. The answers to these questions were marked using five-point Likert-type scales. Semi-structured interviews were conducted with local leaders and members of park management. Interviews were conducted in order to get context-related explanations of indigenous knowledge, participation of the community, poaching trends, conflict management techniques and pressures on resources [15]. Academic sources on literature and conservation practices were used to place our findings into the broader framework of conservation research.

2.4 Data Processing and Analysis

Coding, cleaning and analysis of questionnaire data were done using SPSS software. The descriptive statistics consisted of frequencies, mean and standard deviation of items. Data was prepared using the usual rules of ensuring consistency and converting data into meaningful variable for analysis [16]. Pearson correlation was employed to measure the relationship between community-knowledge construct and wildlife-protection construct. One-tailed significance testing is reported in this thesis. Interview data collected through qualitative method was analyzed thematically and used to interpret the results of the quantitative data. The analysis is an observation study; hence the relationship is interpreted to be an association and not causation. The latter is significant in understanding that apart from community-knowledge, there are several other issues that could affect conservation efforts including enforcement, livelihood, benefits sharing among others.

3. RESULTS AND DISCUSSION

3.1 Community Knowledge Around Volcanoes National Park

The knowledge of the community was found to be very high across all three dimensions tested. Biodiversity awareness had mean values of 4.41-4.67, where the highest agreement was observed regarding awareness of the impacts of biodiversity loss on wildlife and the surrounding community. The knowledge of conservation policies and practices was high with mean 4.64, while the knowledge of the endangered and threatened species was high at 4.49. All the above indicate an existing pool of common knowledge of conservation.

The traditional ecological knowledge was still considered valuable but was inconsistent [17]. It was found that the respondents agreed strongly that traditional knowledge plays a role in conserving the wildlife (mean 4.53), while knowledge on the preservation and integration of the traditional conservation practices was low at mean 3.98-3.99. Such results suggest that the knowledge itself is still valuable even if some traditional practices are being lost or altered. It is consistent with the existing literature which emphasizes the role of traditional ecological knowledge in biodiversity conservation [18].

Community training and workshops were also found to be positive [19]. Community training was thought to foster positive attitudes about wildlife conservation and to increase awareness of conservation issues (means 4.53), and its role in helping reduce practices such as poaching and illegal use of resources was found to have a mean of 4.52 [20]. Awareness of conservation laws through workshops was rated somewhat lower, but still positive (mean 3.99) [21]. This overall trend is consistent with research supporting the influence of environmental education and ecological learning on pro-environmental knowledge and actions [22].

Table 1. Summary of community-knowledge indicators (N = 400).

Domain	Indicator	Mean	SD	Interpretive note
Biodiversity awareness	Role of biodiversity in tourism/livelihoods	4.41	0.628	High awareness
Biodiversity awareness	Knowledge of conservation rules/practices	4.64	0.541	Very high
Biodiversity awareness	Awareness of biodiversity-loss impacts	4.67	0.621	Highest awareness item
Biodiversity awareness	Knowledge of threatened species	4.49	0.532	High
Traditional knowledge	Intergenerational indigenous knowledge	4.53	0.572	Strongly valued
Traditional knowledge	Traditional practices promote protection	3.99	0.204	Positive but lower
Traditional knowledge	Traditional practices still respected/applied	3.98	0.249	Positive but lower
Traditional knowledge	Integration with modern management	3.98	0.317	Positive but lower
Training/workshops	Workshops raise awareness of laws	3.99	0.203	Positive

Training/workshops	Training encourages positive attitudes	4.53	0.577	Very high
Training/workshops	Training reduces harmful activities	4.52	0.624	Very high
Training/workshops	Training improves conservation understanding	4.53	0.590	Very high

3.2 Perceived Effectiveness of Wildlife-Protection Measures

The measures used to combat poaching were also perceived as highly effective with item means ranging from 4.54 to 4.58. Cooperation between the local communities and park management was rated highly (4.58) followed closely by awareness raising initiatives and deterrents by means of punishment (both 4.57). Livelihood alternatives were seen as highly effective too (4.54) [23]. The findings are in line with the claim that anti-poaching initiatives work effectively when enforced not just as policing but also involving community cooperation and alternative livelihoods [24].

Measures for minimizing the human-wildlife conflict were also seen as very effective with item means from 4.55 to 4.58. Participation of communities in handling conflict cases was given the highest rating (4.58). It was also found that respondents rated positively the measures for compensations/supports (4.56) and also believed that the conflicts had reduced over the past couple of years (4.57). The findings are supported by other studies which show how participation, support measures and trust may help in co-existence and reduce antagonism towards wildlife [25]. Illegal resource exploitation measures were also highly ranked (means 4.51-4.55). The focus was on enforcement, provision of livelihood alternatives, cooperation with conservation agencies, and the reporting of illegal activities [26]. The highest mean score (4.55) was for willingness to report illegal resource exploitation, which suggests that community involvement and cooperation could be important signs of legitimacy in conservation efforts [27]. Other related studies have found the importance of collective action, livelihood alternatives, and governance in addressing resource exploitation [28].

Table 2. Summary of wildlife-protection indicators (N = 400).

Domain	Indicator	Mean	SD	Key implication
Poaching	Awareness campaigns reduce poaching	4.57	0.696	Education matters
Poaching	Community cooperation with authorities	4.58	0.649	Highest anti-poaching item
Poaching	Alternative livelihoods reduce reliance	4.54	0.673	Livelihood support matters
Poaching	Legal penalties deter poaching	4.57	0.685	Enforcement matters
Human-wildlife conflict	Conservation measures reduce conflict	4.55	0.514	High perceived effectiveness
Human-wildlife conflict	Community manages/reports cases	4.58	0.649	Highest conflict item
Human-wildlife conflict	Compensation/support improves attitudes	4.56	0.698	Institutional support matters
Human-wildlife conflict	Conflict incidents decreased	4.57	0.650	Perceived improvement
Illegal extraction	Environmental-law enforcement	4.53	0.572	Deterrence

Illegal extraction	Alternative livelihoods	4.52	0.574	Reduces resource dependence
Illegal extraction	Community-authority collaboration	4.51	0.649	Shared management
Illegal extraction	Willingness to report offenses	4.55	0.513	Strong community engagement

3.3 Relationship Between Community Knowledge and Wildlife Protection

The most significant quantifiable finding is the correlation between the combined indicators of community knowledge and wildlife protection. The correlation coefficient using Pearson's method was $r = 0.824$ ($p < 0.001$; one-tailed test; $N = 400$), which denotes a very high positive correlation. Those people who scored better on community-knowledge indicators were likely to report more effective wildlife protection results.

Such a correlation is significant in terms of its impact, but it cannot be regarded as a single causal link. Community knowledge may work alongside enforcement, benefit sharing, livelihood options, participation, and institutional trust. Community-based natural resource management literature demonstrates that conservation achievements become the most sustainable when community knowledge and participation go along with institutions and incentives [29].

Table 3. Pearson correlation between community knowledge and wildlife protection.

Variable / statistic	Community knowledge	Wildlife protection	Interpretation
Pearson correlation	1.000	0.824	Strong positive association
Sig. (1-tailed)	-	<0.001	Statistically significant
N	400	400	Survey sample

3.4 Qualitative Evidence from Community Leaders and Park Management

Interview data helped to contextualize the statistical findings. The local leaders and park managers revealed that the indigenous knowledge about animal behavior, migration patterns, key habitat sites, and restrictions is a valuable asset to conservation efforts. The interviewees explained that there had been erosion of certain traditions and taboos as a result of modernization; however, they viewed such practices positively when applied alongside conservation methods. Moreover, it was mentioned in interviews that the training sessions and education raised awareness about the goals of conservation programs and promoted the reporting of illegal actions. It was explained that there had been a decrease in poaching during the period from 2020 to 2024 due to community-based patrols, increased awareness, enforcement, and alternative livelihoods. Human-wildlife conflicts were said to be resolved by means of community reporting, buffer zone actions, compensation for crop damage, or alternative livelihoods such as beekeeping and craft work. When put together, both the qualitative and quantitative results suggest that community knowledge works best if it is linked to the means for implementing actions. The absence of such implementation of knowledge might lead to ineffectiveness, and the absence of community support for enforcement might generate resistance. Therefore, the VNP experience suggests adopting an integrated approach towards conservation.

Table 4. Main themes from key-informant interviews.

Theme	Evidence reported by interviewees	Conservation implication
Indigenous ecological knowledge	Knowledge of animal behavior, seasonal movement, habitats, taboos and customary restrictions.	Integrate useful local knowledge into formal management and education.
Training and awareness	Improved understanding of conservation objectives and greater reporting of illegal activities.	Maintain repeated, locally relevant learning programs.
Anti-poaching cooperation	Community patrols, awareness, enforcement and alternative livelihoods were linked to declining poaching.	Use combined social, economic and enforcement approaches.
Human-wildlife conflict	Reporting systems, buffer measures, compensation/support and livelihood diversification were viewed positively.	Strengthen rapid response and fair support mechanisms.
Illegal resource extraction	Reduced firewood collection and grazing where alternatives and engagement improved.	Pair enforcement with feasible livelihood substitutes.

3.5 Implications for Community-Based Conservation

The implications from this study include the following four. First, conservation education must be approached as an ongoing management process, and not a one-time awareness-raising exercise. Second, indigenous knowledge needs to be documented and appropriately incorporated into the conservation planning process wherever it makes ecological sense, and it is legal under wildlife laws. Third, the highest rating scores were for cooperation and reporting; thus, authorities need to preserve and enhance the channels that community members can use for reporting and participating in decision-making [30]. Finally, evaluation of the livelihood alternatives should include the extent to which they alleviate dependency on the illegal or conflict-generating resource use. These implications are consistent with the findings in Rwandan research literature showing a close relationship between the outcome of conservation in protected areas and community participation in the process and perceptions about conservation benefits distribution.

3.6 Study Limitations

4. Several caveats must be considered when interpreting these findings. The survey is cross-sectional and highly dependent on self-reported perceptions; hence the findings indicate perceptions of conservation effectiveness as opposed to objectively determined trends in wildlife numbers, poaching incidences or conflict. The high correlation coefficient could have been influenced by common method variance since the two variables under investigation were measured from the same participants. Furthermore, purposive interviews are an important source of insight but not statistically representative.

4. CONCLUSIONS

This This research focused on the relationship between community knowledge and wildlife protection in Volcanoes National Park, Rwanda. The findings reveal a high level of biodiversity awareness and indigenous conservation knowledge, as well as good evaluations of the training programs. Moreover, it has been found that measures aimed at combating poaching, wildlife-human conflict and illegal extraction of resources work effectively. Community cooperation, involvement in reporting, and livelihood support were found to be the important components of wildlife protection.

There is a high correlation ($r = 0.824$, $p < 0.001$) between the level of community knowledge and wildlife protection. It means that people who possess more conservation knowledge reported better results concerning the protection measures. However, being an observational study, the research cannot confirm causality. Nevertheless, the qualitative findings indicate that there is a sound explanation of this finding – community knowledge becomes important when people can cooperate with the park authorities, engage in other forms of livelihoods, get help in case of conflicts, and conservation measures are consistently implemented. The recommendations for policies and management that stem from this study are: continuous environmental education in the communities neighboring VNP; means of integrating the indigenous knowledge system into conservation efforts and monitoring; improved community reporting and response systems; clear compensation arrangements; and livelihoods strategies that are based on reduced reliance on resources from the park. Further research should examine the nature of the relationship between these variables using longitudinal and geographical data and determine if changes in knowledge come before changes in poaching, conflicts, and wildlife populations.

5. SUPPLEMENTARY INFORMATION

Author Contributions: Conceptualization, methodology, investigation, data collection, formal analysis, writing - original draft, and visualization: R.E. Supervision and methodology: P.N. Review and editing: P.N. Both authors must approve author contributions prior to submission.

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