

Factors Contributing to the Protection of Mountain Gorillas to Promote One Health and Sustainable Tourism among Populations Interacting with Volcanoes National Park, Rwanda

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Abstract

Mountain gorillas are central to biodiversity conservation and high-value nature-based tourism in Rwanda, but repeated human-gorilla interaction creates public health and conservation risks that require integrated prevention. This study assessed socioeconomic, community participation, socio-cultural, and health education factors contributing to mountain gorilla protection among populations interacting with Volcanoes National Park. A cross-sectional mixed-methods approach was used. Quantitative data were collected from 406 respondents, comprising 261 residents/workers and 145 visitors, using a semi-structured questionnaire, while qualitative data were obtained through key informant interviews and focus group discussions. Descriptive statistics were used for quantitative analysis, and qualitative data were analyzed thematically and integrated with the survey findings. Among residents/workers, 148 (56.7%) had earned income from park or gorilla tourism in the previous 12 months, yet 39 (14.9%) reported entering the park or buffer areas for livelihood purposes. Community participation structures were present, with 142 (54.4%) belonging to conservation-related groups, but only 42 (16.1%) had personally reported illegal or risky behaviour. Positive attitudes were common, with 138 (52.9%) viewing gorillas as national heritage that should be protected. Health education reached 150 (57.5%) residents/workers and 108 (74.5%) visitors, while 349 (86.0%) respondents correctly indicated that persons with flu-like symptoms should avoid gorilla activities and report or reschedule. The findings show that protection is strengthened by visible livelihood benefits, trusted participation structures, supportive social norms, and practical preventive health communication. Coordinated action across conservation, tourism, community, and health systems is therefore important for reducing risks at the human-gorilla interface and sustaining tourism benefits.

Keywords: Community Participation, Gorilla Protection, Health Education, One Health, Sustainable Tourism, Volcanoes National Park

1. INTRODUCTION

Mountain gorillas (*Gorilla beringei beringei*) are among Africa's most intensively protected wildlife species and a major component of nature-based tourism in the Virunga-Bwindi landscape [1]. Their

conservation extends beyond biodiversity because gorilla health is closely linked to the health and behaviour of people who live, work, or travel within the same landscape [2]. Repeated contact through tourism, conservation work, and park-edge livelihood activities creates opportunities for disturbance and for the transmission of infectious agents between humans and great apes. This makes the human-gorilla interface an important One Health setting in which human health, animal health, and environmental integrity must be considered together [3], [4], [5], [6], [7].

The One Health approach is particularly relevant to great ape tourism because mountain gorillas are susceptible to several human respiratory pathogens [8]. Close physical proximity, coughing, sneezing, poor adherence to illness restrictions, and inadequate hygiene can increase preventable exposure. Great ape tourism guidance therefore emphasizes minimum viewing distance, exclusion or rescheduling of visits when a person is ill, hygiene precautions, controlled group size, limited viewing time, and consistent enforcement by guides and park staff [9], [10]. These measures are not only wildlife conservation rules; they function as public health controls intended to reduce risks to gorillas, visitors, tourism workers, and surrounding communities.

Rwanda has developed a high-value, low-volume model of mountain gorilla tourism in Volcanoes National Park (VNP), combining strict visitor management with conservation financing and community-oriented benefit mechanisms [11]. Tourism contributes through direct employment, guiding and porter services, hospitality, sale of agricultural products and handicrafts, cultural activities, and community development projects supported by tourism revenues [1], [12], [13]. These benefits can increase the perceived value of conservation and strengthen local willingness to support park protection. However, the protective effect of tourism is not automatic. Where benefits are perceived as uneven, where crop damage or other conservation costs remain unresolved, or where households continue to depend on protected-area resources, support for rules and conservation institutions may weaken [14], [15], [16], [17].

1.1. Socioeconomic Factors and Gorilla Protection

Socioeconomic conditions influence the choices available to households living around protected areas and therefore shape the feasibility of conservation-supportive behaviour. Employment, tourism-linked income, access to markets, education, household livelihood strategies, and the distribution of conservation benefits can either reduce or intensify pressure on park resources. Studies from Rwanda and other mountain gorilla tourism settings show that jobs, enterprise opportunities, community investments, and other visible benefits can strengthen stewardship, while poverty, livelihood insecurity, crop losses, and perceived inequity can reduce cooperation with conservation measures [13], [18]. Around VNP, tourism-linked benefits coexist with continued dependence on agriculture and other natural-resource-based livelihoods. This creates a practical tension: the park generates income and development opportunities, yet some households may still experience opportunity costs or wildlife-related losses [14]. Understanding the extent to which residents and workers benefit from tourism, the channels through which those benefits are received, and the extent to which people still enter VNP or its buffer areas for livelihood purposes is therefore essential for interpreting conservation behaviour. Socioeconomic factors were consequently treated in this study as determinants that may influence both support for gorilla protection and adherence to measures intended to reduce risks at the human-gorilla interface.

1.2. Synergistic Community Participation and Gorilla Protection

Sustained protection of mountain gorillas also depends on the extent to which local communities participate in conservation structures rather than remaining passive recipients of rules. Community participation may involve membership in conservation groups, attendance at meetings, participation in

anti-poaching or sensitization activities, engagement in tourism-related cooperatives, reporting of illegal or risky behaviour, and involvement in benefit-sharing or local decision-making processes [1], [15]. Such participation can strengthen trust, improve information flow, and create shared responsibility for the protection of gorillas and the surrounding ecosystem [14]. Participation is most effective when institutional mechanisms are visible, responsive, and trusted by the communities they are intended to serve. Simply being aware of a reporting channel does not always lead to actual reporting, particularly when community members fear conflict, expect little or no feedback, or lack confidence that authorities will respond. In the same way, belonging to a conservation-related group does not automatically translate into active participation, as meaningful engagement depends on trust, regular involvement, clear roles, and visible follow-up on community concerns [15], [19]. This study examined both the presence of participation structures and the extent to which residents/workers and visitors reported using or supporting them. This allowed community participation to be assessed not only as institutional availability but also as practical involvement in protection.

1.3. Socio-cultural Factors and Protection Behaviour

Socio-cultural factors shape how communities interpret wildlife, conservation rules, and institutional authority. Cultural values, social norms, beliefs, trust in institutions, and perceptions of the costs and benefits of conservation shape attitudes toward gorillas. Positive identification of gorillas with national heritage, tourism, and local development can strengthen support for protection, at the same time, persistent losses, perceived inequity, or beliefs that normalize prohibited practices may weaken cooperation and compliance [16], [20], [21], [22]. These influences are reinforced through families, community networks, local leaders, religious institutions, and interactions with conservation authorities. Evidence from the Volcanoes National Park context indicates that culture and limited conservation awareness can constrain participation, particularly when formal conservation expectations do not align with local experiences of benefits, crop losses, or other conservation-related costs [15]. Trust and perceived fairness are therefore important because communities are more likely to support conservation measures when institutions are viewed as legitimate and responsive [14], [23]. The socio-cultural component of this study consequently assessed attitudes toward gorillas, taboos and cultural rules related to forests and wildlife, beliefs that may discourage or encourage harmful practices, and visitor attitudes toward protection measures. Particular attention was given to the difference between supporting a rule and understanding its health rationale, since visitors may comply with distancing or other instructions without fully understanding the risk of disease transmission at the human–gorilla interface. This distinction is important for strengthening both conservation behaviour and preventive health practices.

1.4. Health Education and One Health Awareness

Health education is central to translating gorilla protection rules into everyday behaviour because it influences knowledge, risk perception, and the ability to comply with preventive measures. In great ape tourism settings, education is delivered through visitor briefings, guide and ranger instructions, signage, workplace training, and community sensitization, with emphasis on minimum viewing distance, hygiene, illness exclusion, symptom reporting, and other measures that reduce disease transmission risks [19], [24]. The way these messages are communicated is also important, as clear and appropriately framed guidance can strengthen compliance during wildlife tourism encounters [19], [25]. Knowledge of One Health further supports understanding that human, animal, and environmental health are interconnected, although conceptual knowledge may not always correspond directly with practical behaviour. Individuals may correctly follow instructions on illness exclusion or distancing without being able to define One Health,

while others may understand the concept but not consistently comply with protective measures. The study therefore assessed both exposure to health education and practical knowledge, including whether respondents had received briefings or training, the appropriate action when experiencing flu-like symptoms, knowledge of the One Health concept, and understanding of measures that reduce infection risk to gorillas. This distinction is important because preventive communication and illness exclusion remain essential for reducing infectious disease risks at the human–gorilla interface [4], [9].

1.5. Study Rationale and Objective

Although Rwanda has achieved notable progress in mountain gorilla conservation, there remains limited integrated evidence on how socioeconomic conditions, community participation, socio-cultural influences, and health education operate together among populations interacting with VNP across Burera, Musanze, Nyabihu, and Rubavu districts. Existing studies often address individual dimensions such as tourism benefits, community attitudes, or visitor compliance separately. This study therefore assessed factors contributing to the protection of mountain gorillas to promote One Health and sustainable tourism among populations interacting with Volcanoes National Park, Rwanda. Specifically, it examined socioeconomic factors, evaluated the level of synergistic community participation, assessed socio-cultural factors, and determined the level of health education and One Health awareness related to gorilla protection.

2. MATERIALS AND METHODS

2.1. Study Design

A mixed-methods approach was employed to generate both measurable patterns and contextual explanations of factors influencing mountain gorilla protection. The quantitative component used a cross-sectional design, which enabled assessment of the relationship between selected independent variables and reported protection practices at a single point in time. The qualitative component used an exploratory design through Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) to provide deeper explanations, institutional practices, community experiences, and communication processes that could not be captured adequately through structured survey items alone.

The independent variables were organized into four domains: socioeconomic factors, synergistic community participation, socio-cultural factors, and health education/One Health awareness. The principal outcome was mountain gorilla protection practice, operationalized through reported adherence to protection measures and other behaviours supportive of risk reduction at the human-gorilla interface. The mixed-methods structure allowed quantitative findings to be triangulated with qualitative evidence and supported interpretation of why particular patterns were observed.

2.2. Study Area

The study was conducted within the Volcanoes National Park interface landscape and surrounding administrative sectors in Burera, Musanze, Nyabihu, and Rubavu districts of Rwanda. Data collection focused on VNP-adjacent sectors and authorized tourism operational points where interaction with the park occurs through tourism activities, conservation work, or park-edge livelihoods. The twelve adjacent sectors considered in the study included Cyanika, Gahunga, and Rugarama in Burera; Gataraga, Shingiro, Kinigi, and Nyange in Musanze; Bigogwe, Jenda, Kabatwa, and Mukamira in Nyabihu; and Bugeshi of Rubavu. The combined population of the selected VNP-adjacent sectors was approximately 379,991, within four districts whose total population exceeds 1.7 million according to the Fifth Rwanda Population and Housing Census [26]. Agriculture remains an important livelihood in much of the landscape,

particularly in Burera and Nyabihu, while Musanze and Rubavu have comparatively stronger tourism, trade, and service-sector activity [27]. This mixture of agricultural dependence, tourism employment, dense settlement, and repeated human-wildlife interaction makes the area suitable for assessing the social and health-related determinants of gorilla protection.

2.3. Target Population

The target population comprised adults who visit, work in, or otherwise interact with the VNP tourism and conservation system. Quantitative participants included residents and workers from communities surrounding the park, tourism and conservation personnel, and domestic and international visitors. Interface personnel included guides, trackers, porters, conservation workers, and health or veterinary personnel where accessible. These categories were selected because they either interact directly with gorilla tourism operations or influence the conditions under which protection measures are implemented. For the qualitative component, key informants were selected from individuals with operational or community knowledge relevant to mountain gorilla protection, One Health risk management, tourism compliance, livelihood issues, and community participation. Focus group participants were drawn from community settings in VNP-adjacent areas to capture shared experiences concerning tourism benefits, conservation costs, local norms, participation mechanisms, and health education.

2.4. Sampling Techniques and Sample Size

2.4.1. Sample Size Determination

The quantitative sample size was determined using Fisher's formula for a cross-sectional survey. Because the expected prevalence of the key outcome is unknown, the initial sample size was computed using Fisher's formula for large populations [28].

$$n = \frac{Z^2 * p * q}{d^2}$$

Where:

n = required minimum sample size

Z = standard normal deviate at 95% confidence level (1.96)

p = estimated proportion of the attribute present in the population (0.5, when unknown)

q = 1 – p = (0.5)

d = margin of error (0.05)

Substituting the parameters:

$$n = \frac{1.96^2 * 0.5 * (1 - 0.5)}{0.05^2}$$
$$n = 384$$

During the planned data collection period, the accessible population of eligible visitors interacting with Volcanoes National Park is expected to be less than 10,000. Therefore, a finite population correction (FPC) was applied to obtain an adjusted sample size.

$$nf = \frac{n}{\left(1 + \frac{n}{N}\right)}$$

Where:

nf is the finite-population adjusted sample size,

N is the estimated population size during the study period. Using an estimated visitor population of N = 9,000 [26]

$$nf = \frac{384}{1 + \frac{384}{9000}}$$

$$nf = 368.29 \approx 369$$

To account for potential non-response, a 10% allowance was added to the corrected sample size:

$$nf_{final} = nf + (0.10 * nf)$$

$$nf = 369 + 36.9 = 405.9 \approx 406$$

Accordingly, the final target sample size for the quantitative survey was 406 respondents.

2.4.2. Sampling Techniques

For the quantitative component, systematic random sampling was applied at authorized gorilla tourism operational points and other approved interface locations. During each data collection session, eligible participants were selected using a fixed sampling interval after a randomly determined starting point. Eligibility required that the respondent was an adult, was present in relation to VNP tourism or conservation activities, and provided informed consent. This approach introduced a probability element into recruitment and reduced the risk of selecting only the most readily available participants. For the qualitative component, purposive sampling was used because detailed information was required from individuals with direct knowledge of the study domains. Key informants were selected according to their responsibilities and experience in conservation, tourism, community engagement, health, or risk management. Focus group participants were selected from communities adjacent to VNP to reflect variation in livelihood experience and interaction with conservation activities. Qualitative recruitment emphasized information richness and diversity of perspectives rather than statistical representativeness.

2.5. Research Instruments

Three complementary instruments were used. First, a semi-structured questionnaire was administered to quantitative participants. It contained predominantly closed-ended items for statistical analysis, with a limited number of open-ended questions to clarify reasons for particular responses. The questionnaire was organized into sections covering respondent characteristics and interface profile; socioeconomic factors and tourism-related benefits; community participation and benefit-sharing; socio-cultural attitudes, norms, and beliefs; health education and One Health awareness; and reported mountain gorilla protection practices. Second, a semi-structured KII guide was used with selected institutional and community informants. The guide explored implementation of gorilla protection rules, operational challenges, tourism benefits and costs, participation and reporting systems, socio-cultural influences on adherence, health communication, and recommendations for improving protection. Third, an FGD guide was used to obtain group-level perspectives on livelihood conditions, participation, cultural beliefs, fairness of benefits, health messages, and locally proposed strategies for improving adherence and conservation support. The questionnaire and qualitative guides were prepared in English and translated into Kinyarwanda for community-facing data collection. Standardized wording and prompts were used to improve consistency while allowing qualitative participants sufficient flexibility to describe experiences in their own terms.

2.6. Piloting of Research Instruments

Before the main data collection, the questionnaire and qualitative interview guides were piloted in a comparable setting outside the selected study sites. The pilot assessed clarity of wording, cultural appropriateness, logical sequencing, completeness of response options, administration time, and the

accuracy of translated terminology. Particular attention was given to concepts that could be interpreted differently by respondents, including One Health, tourism benefits, gorilla health protection measures, and participation in conservation activities. Feedback from the pilot was used to revise ambiguous questions, improve the order of items, refine response categories, and strengthen probes for KIIs and FGDs. This process improved the practical usability of the instruments and reduced the likelihood of measurement error during the main study.

2.7. Validity, Reliability, and Trustworthiness

Content validity was strengthened through review of the questionnaire and qualitative guides by the research supervisor and individuals with relevant expertise in public health, One Health, conservation, and tourism systems. Review focused on whether the items adequately represented the study objectives and key constructs, whether the wording was appropriate for the VNP context, and whether there were gaps or unnecessary overlaps. For quantitative measures composed of multiple items, internal consistency was assessed using Cronbach's alpha where applicable. Standardized interviewer procedures and data collector orientation were also used to minimize variation in administration. For the qualitative component, trustworthiness was supported through use of consistent semi-structured guides, documentation of field decisions, review of notes or transcripts for completeness, maintenance of an audit trail during coding and theme development, and comparison of qualitative themes with quantitative findings.

2.8. Data Collection Procedures

Quantitative data were collected through face-to-face administration of the semi-structured questionnaire at authorized VNP operational points and other approved locations. Data collectors first confirmed eligibility and obtained informed consent, after which questionnaire sections were administered in a standardized sequence. Residents/workers and visitors answered items appropriate to their role and type of interaction with VNP. KIIs were scheduled at times and locations convenient to informants and designed to minimize disruption to professional duties. FGDs were conducted in selected community settings using agreed ground rules on confidentiality and respectful participation. Where consent was provided, interviews or discussions were recorded to improve accuracy; otherwise, detailed notes were taken. Qualitative discussions were structured around the four study objectives but allowed probing to clarify experiences, motivations, and examples.

2.9. Data Analysis and Presentation

Quantitative data were coded, cleaned, and analyzed using SPSS version 19 and Microsoft Excel. Frequencies, percentages, means, and other descriptive statistics were used to summarize respondent characteristics and key study variables. Bivariate associations between selected independent variables and reported protection practices were assessed using chi-square tests. Multivariable logistic regression was used to identify independent predictors of reported adherence to gorilla health protection measures while controlling for potential confounders. Statistical significance was set at $p < 0.05$. Qualitative data from KIIs and FGDs were transcribed or organized from detailed notes and analyzed thematically. Codes were grouped under the study domains, and recurring themes were identified concerning tourism benefits and livelihood pressure, participation and reporting, socio-cultural influences, and health education. Qualitative findings were integrated with quantitative results during interpretation to explain observed patterns and provide contextual depth. Results were presented using narrative summaries supported by selected quotations, tables, and figures.

2.10. Ethical Considerations

Ethical approval was obtained from Mount Kigali University and the Rwanda National Ethics Committee, and authorization for VNP-related activities was obtained from the Rwanda Development Board and park management. Participants received information on the study purpose, procedures, expected time commitment, voluntary nature of participation, and their right to decline or withdraw without penalty. Written or otherwise approved informed consent procedures were completed before data collection. Confidentiality was protected by avoiding unnecessary personal identifiers, assigning codes to study data, conducting interviews and discussions in appropriate settings, and limiting access to raw data to the research team. Electronic data were stored in password-protected files and physical materials were kept securely. Fieldwork was organized to respect park operations, community norms, and participant dignity. The study also adhered to academic integrity requirements and relevant national data-protection obligations.

3. RESULTS

3.1. Respondent Characteristics

A total of 406 respondents participated. Residents/workers accounted for 261 (64.3%) and visitors for 145 (35.7%). Among residents/workers, 164 (62.8%) were community residents, 71 (27.2%) were tourism workers, and 26 (10.0%) were conservation or health workers. Among visitors, 105 (72.4%) were international and 40 (27.6%) were domestic. Overall, 209 (51.5%) respondents were female, 193 (47.5%) were male, and 4 (1.0%) preferred not to state their sex. Age ranged from 18 to 72 years, with a mean of 42.0 years. Table 1 describes the selected characteristics of the study respondents

Table 1: Selected Characteristics of Study Respondents

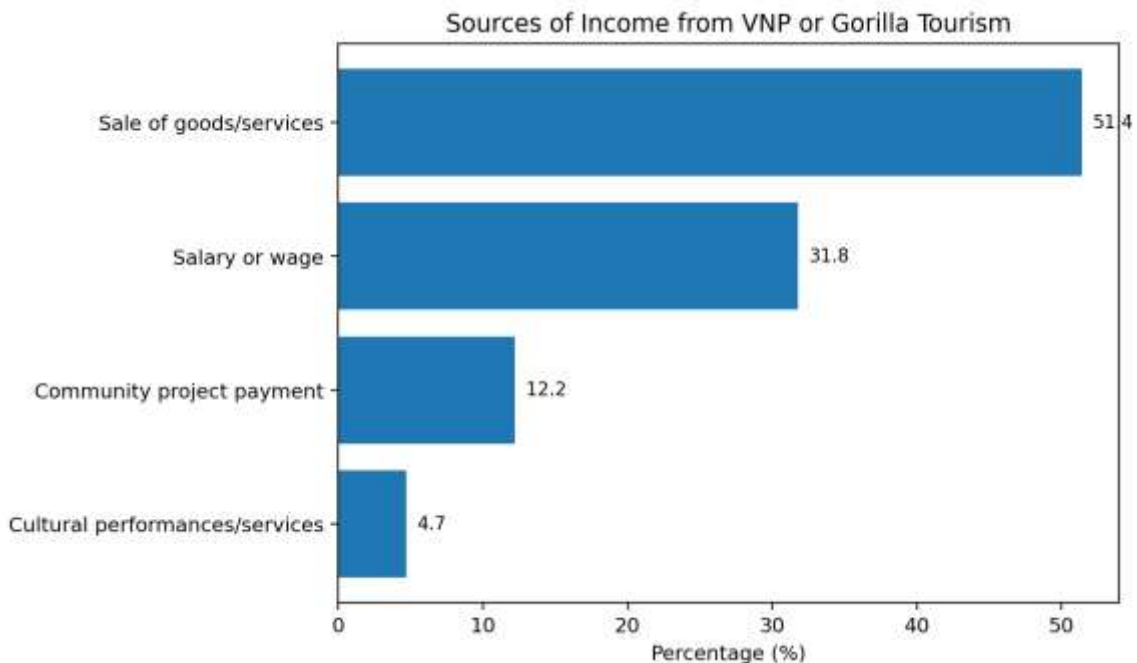
Characteristic	Category	Frequency (n)	Percentage (%)
Respondent group	Residents/workers	261	64.3
	Visitors	145	35.7
Sex	Male	193	47.5
	Female	209	51.5
	Prefer not to say	4	1.0
Resident/worker category	Resident/community member	164	62.8
	Tourism worker	71	27.2
	Conservation/health worker	26	10.0
Visitor category	International visitor	105	72.4
	Domestic visitor	40	27.6

3.2. Socioeconomic Factors Contributing to Gorilla Protection

Tourism-related income was an important livelihood link for residents/workers, as shown in Figure 1. A total of 148 (56.7%) reported personally earning income from VNP or gorilla tourism during the previous 12 months. Among those earning tourism income, 76 (51.4%) reported selling goods or services to tourists, 47 (31.8%) received a salary or wage from tourism or park-related work, 18 (12.2%) received community project payments, and 7 (4.7%) earned income from cultural performances or services. At the same time,

39 (14.9%) residents/workers reported entering VNP or buffer areas for livelihood reasons, compared with 222 (85.1%) who did not. Among those who entered, the most common reason was collection of firewood or forest products (48.7%), followed by water access (17.9%), hunting or trapping (15.4%), grazing (10.3%), and farming or land access (7.7%). Only 100 (38.3%) residents/workers reported benefiting from a tourism revenue-sharing project, while 103 (39.5%) reported no benefit and 58 (22.2%) were unsure. Qualitative evidence reinforced the importance of visible local benefits; one key informant explained that jobs, markets, infrastructure, and revenue-sharing projects can increase willingness to support gorilla protection.

Figure 1: Sources of Income from VNP or Gorilla Tourism among Residents and Workers



3.3. Synergistic Community Participation

Table 2 provides details on community participation and reporting indicators. More than half of residents/workers, 142 (54.4%), belonged to a community group or structure involved in conservation or VNP-related activities, while 116 (44.4%) had participated in conservation or VNP-related activities during the previous 12 months. Awareness of formal channels for reporting illegal or risky behaviour was higher, at 159 (60.9%), but only 42 (16.1%) had personally reported such behaviour in the previous year. This difference between awareness and action was also reflected in qualitative data, where trust, responsiveness, and feedback were repeatedly described as conditions for effective participation. A ranger summarized this as: “They work best when information flows both ways.” Visitor participation was also evident. Of the 145 visitors, 103 (71.0%) reported that they had been informed how visitors could support gorilla protection, and 109 (75.2%) stated that they would report unsafe behaviour to a guide or park staff member if they observed it.

Table 2: Community Participation and Reporting Indicators

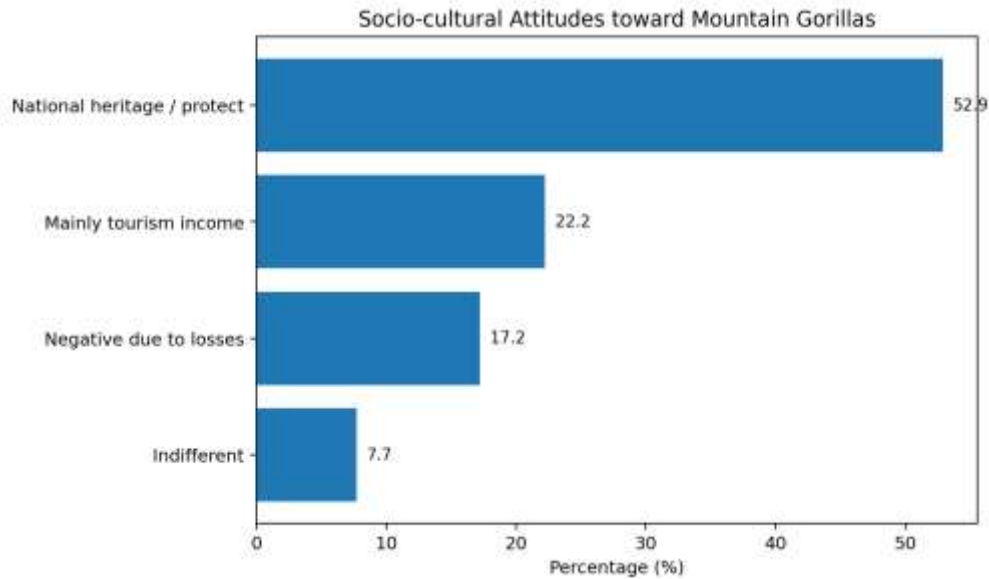
Indicator	Category	n	Percentage (%)
	Yes	142	54.4

Member of conservation/VNP-related group	No	119	45.6
Participated in conservation/VNP activity in past 12 months	Yes	116	44.4
	No	145	55.6
Aware of formal reporting channels	Yes	159	60.9
	Not sure	69	26.4
	No	33	12.6
Personally reported illegal/risky behaviour	Yes	42	16.1
	No	197	75.5
	Prefer not to say	22	8.4
Visitors informed how to support protection	Yes	103	71.0
	No	42	29.0
Visitors would report unsafe behaviour	Yes	109	75.2
	No	36	24.8

3.4. Socio-cultural Factors

Positive attitudes toward gorillas were common among residents/workers. A total of 138 (52.9%) viewed gorillas as national heritage that should be protected, 58 (22.2%) mainly valued them for tourism income, 45 (17.2%) viewed them negatively because of losses, and 20 (7.7%) were indifferent. Taboos, customs, or cultural rules related to forests, wildlife, or gorillas were reported by 112 (42.9%), and 126 (48.3%) stated that taboos or customs discourage actions that may harm gorillas. However, 75 (28.7%) reported beliefs that may encourage prohibited activities, showing that socio-cultural influences can support or weaken protection depending on their content and social context. Among visitors, 75 (51.7%) recognized that disease transmission between humans and gorillas is possible in both directions. A larger proportion, 106 (73.1%), stated that gorilla protection rules should always be followed even if compliance reduced photo opportunities. Figure 2 depicts the socio-cultural Attitudes toward Mountain Gorillas among residents and workers. Qualitative findings indicated that schools, local leaders, faith institutions, and community networks can reinforce conservation norms over time.

Figure 2: Socio-cultural Attitudes toward Mountain Gorillas among Residents and Workers



3.5. Health Education and One Health Awareness

Figure 3 describes exposure to Gorilla Health protection briefing or education. Among residents/workers, 150 (57.5%) reported receiving a formal briefing or health education on gorilla health protection measures in the previous 12 months. Among visitors, 108 (74.5%) reported receiving a park or tour briefing before the activity, while 15 (10.3%) had not and 22 (15.2%) considered the question not applicable. Knowledge of the appropriate response to flu-like symptoms was high: 349 (86.0%) respondents overall indicated that a person with such symptoms should avoid participation and report or reschedule. Knowledge of the One Health concept was present in most respondents but was not universal. Among residents/workers, 165 (63.2%) correctly recognized the interconnection between human, animal, and environmental health, compared with 100 (69.0%) visitors as depicted in Figure 4. Qualitative participants emphasized practical messages on illness, hygiene, distance, and guide instructions. A community health worker summarized the central message as: “If you are sick, do not go near gorillas.”

Figure 3: Exposure to Gorilla Health Protection Briefing or Education

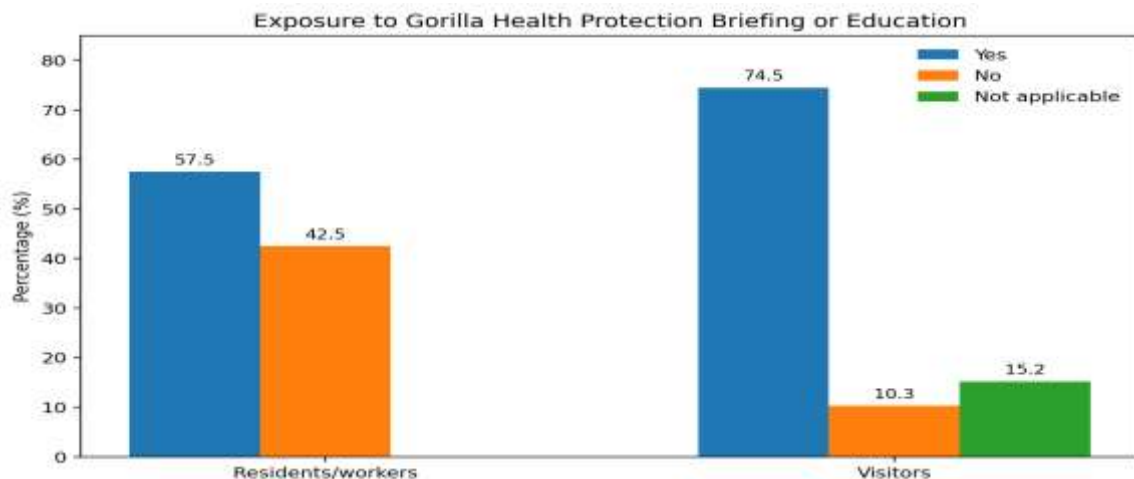
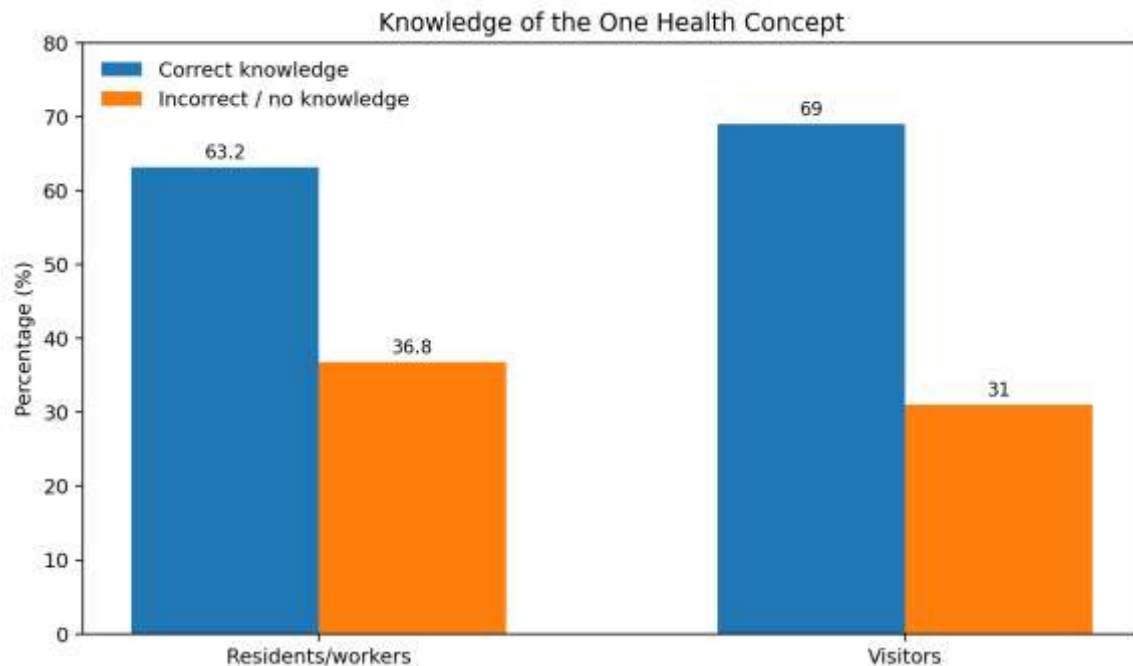


Figure 4: Knowledge of the One Health Concept among Residents/Workers and Visitors



4. DISCUSSION

4.1. Socioeconomic Factors

The finding that more than half of residents/workers had earned income from VNP or gorilla tourism confirms that tourism is an important livelihood pathway around the park. The pattern is consistent with evidence from Rwanda showing that gorilla tourism can generate employment, local enterprise, sales of goods and services, and community development benefits [14], [13], [14], [29]. Such benefits can strengthen the local legitimacy of conservation when households can identify a direct relationship between gorilla protection and economic opportunity. However, continued entry into the park or buffer area for firewood, water, grazing, hunting, or land access shows that livelihood pressure has not been eliminated. This finding is consistent with studies showing that poverty, crop losses, and unequal exposure to conservation costs can weaken support even where tourism generates wider benefits [30], [15], [17], [31]. The mixed experience of revenue-sharing in the present study further suggests that the existence of a benefit-sharing mechanism is not sufficient on its own; benefits must be visible, accessible, and perceived as fair by communities bearing the costs of living near protected areas.

4.2. Community Participation

Community participation structures were relatively visible, but the gap between awareness of reporting channels and actual reporting is important. More than half of residents/workers belonged to conservation-related groups and 60.9% knew formal reporting channels, yet only 16.1% had personally reported risky or illegal behaviour. This indicates that knowledge of a reporting pathway does not automatically produce action. Qualitative evidence pointed to trust, timely feedback, and confidence in institutional response as practical conditions for participation. Similar observations have been reported around VNP, where community engagement is strengthened by tangible benefits and meaningful inclusion but weakened by information gaps and unresolved livelihood pressures [1]. Visitors also emerged as potential participants in protection, with most indicating that they would report unsafe behaviour. This supports the view that tourism governance can treat visitors not only as rule recipients but also as contributors to a culture of safe

practice. The finding is consistent with research showing that the framing and communication of wildlife tourism rules can influence visitor compliance and willingness to act [15], [19].

4.3. Socio-cultural Factors

The predominance of heritage-oriented attitudes toward gorillas is a positive social foundation for conservation. Previous work around VNP has similarly reported generally supportive community attitudes where gorillas are linked to national identity, tourism, and development opportunities [32]. At the same time, the presence of negative attitudes associated with losses and beliefs that may encourage prohibited activities shows that conservation norms are not uniform. Socio-cultural influences can function as protective resources when they discourage harm, but they can also normalize risky behaviour where certain practices are viewed as acceptable or justified [18], [33]. The visitor results reveal a notable distinction between rule support and disease-risk understanding. Nearly three-quarters supported following rules even when this reduced photo opportunities, but only 51.7% clearly recognized bidirectional disease transmission. This suggests that behavioural acceptance may exceed conceptual understanding. Great ape health guidance emphasizes that preventive rules are more sustainable when visitors understand the disease rationale behind them rather than following them only as instructions [6], [34].

4.4. Health Education and One Health Awareness

Health education reached a substantial proportion of both residents/workers and visitors, and knowledge of the appropriate response to flu-like symptoms was high. This is important because respiratory infections remain a major concern in great ape conservation, and illness exclusion, distance, hygiene, and rapid reporting are central preventive measures [5], [7]. The result supports the continued use of practical briefings and repeated messages at tourism and community contact points. Knowledge of the broader One Health concept was lower than knowledge of specific preventive actions. This pattern suggests that concrete behavioural messages may be easier to retain than an abstract systems concept. Nevertheless, understanding the connection between human, animal, and environmental health can strengthen the rationale for compliance and encourage shared responsibility across conservation, tourism, veterinary, public health, and community actors [1], [12]. Communication strategies should therefore combine simple operational instructions with clear explanations of why the measures matter.

4.5. Strengths and Limitations

A key strength of the study was the integration of quantitative and qualitative evidence across four complementary domains, allowing numerical patterns to be interpreted alongside community and institutional perspectives. The inclusion of residents/workers and visitors also captured different dimensions of the human-gorilla interface. However, the cross-sectional design does not establish causality or temporal sequence. Several measures were self-reported and may therefore be affected by recall or social desirability bias. The study did not directly measure pathogen transmission, biological outcomes, or objectively observed tourist-gorilla distance. Findings are most applicable to populations interacting with VNP and should be generalized cautiously to other protected areas.

5. CONCLUSION

Mountain gorilla protection around Volcanoes National Park is shaped by the interaction between livelihoods, community participation, socio-cultural influences, and health education. Tourism provides meaningful economic opportunities and can reinforce conservation support, but this effect is reduced where benefits are uneven or livelihood pressures continue to drive dependence on protected resources.

Participation structures are present, yet the low level of actual reporting compared with awareness shows that effective participation also requires trust, responsiveness, and feedback. Positive social attitudes toward gorillas are common, although some beliefs and experiences can still weaken compliance. Health education is a particularly important enabling factor because practical messages on illness, hygiene, distance, and guide instructions directly support safer behaviour at the human-gorilla interface. Protection therefore cannot rely on tourism regulations and park rules alone. It should be reinforced through equitable and visible benefit-sharing, livelihood and conflict-mitigation support, stronger community reporting and feedback systems, socially grounded conservation messaging, and repeated preventive health education for residents, workers, and visitors. Closer coordination among park management, tourism operators, health actors, local leaders, schools, faith-based institutions, and community groups can strengthen both gorilla conservation and the sustainability of Rwanda's nature-based tourism model.

6. ACKNOWLEDGMENTS

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7. CONFLICTS OF INTEREST

The authors declare no conflict of interest.

8. REFERENCES

1. IGCP, "INTERNATIONAL GORILLA CONSERVATION PROGRAMME Over 30 Years of Impact Report," 2024.
2. M. Maekawa, A. Lanjouw, E. Rutagarama, and D. Sharp, "Mountain gorilla tourism generating wealth and peace in post-conflict Rwanda," *Nat. Resour. Forum*, vol. 37, no. 2, pp. 127–137, 2013, doi: 10.1111/1477-8947.12020.
3. WHO, "One Health," Geneva, 2023. Accessed: Jan. 14, 2026. [Online]. Available: <https://www.who.int/news-room/fact-sheets/detail/one-health>
4. C. A. Devaux, O. Mediannikov, H. Medkour, and D. Raoult, "Infectious Disease Risk Across the Growing Human-Non Human Primate Interface: A Review of the Evidence," *Front. Public Heal.*, vol. 7, no. November, pp. 1–22, 2019, doi: 10.3389/fpubh.2019.00305.
5. D. S. Azevedo *et al.*, "One health perspectives on new emerging viral diseases in african wild great apes," *Pathogens*, vol. 10, no. 10, Oct. 2021, doi: 10.3390/PATHOGENS10101283.
6. K. Gilardi *et al.*, "Endangered mountain gorillas and COVID-19: One health lessons for prevention and preparedness during a global pandemic," *Am J Primatol*, 2021, doi: 10.1002/ajp.23291.
7. R. F. P. Costa, V. Romano, A. S. Pereira, J. D. A. Hart, A. MacIntosh, and M. Hayashi, "Mountain gorillas benefit from social distancing too: Close proximity from tourists affects gorillas' sociality," *Conserv. Sci. Pract.*, vol. 5, no. 1, p. e12859, Jan. 2023, doi: 10.1111/CSP2.12859;ISSUE:ISSUE:DOI.
8. K. Cooksey *et al.*, "Socioecological Factors Influencing Intergroup Encounters in Western Lowland Gorillas (*Gorilla gorilla gorilla*)," *Int. J. Primatol.*, vol. 41, no. 2, pp. 181–202, Apr. 2020, doi: 10.1007/S10764-020-00147-6.
9. K. V. Gilardi *et al.*, "An update on great ape population health, disease control and outbreak response

- Supplement to the best practice guidelines for health monitoring and disease control in great ape populations,” 2025. Accessed: Jan. 05, 2026. [Online]. Available: <https://x.com/IUCN>
10. IUCN, “International Union of Conservation of Nature - Annual Report 2022,” 2023. Accessed: Jan. 14, 2026. [Online]. Available: www.blueverdestudio.com
 11. H. Faustin and X. Fuhua, “STUDY ON TOURISM MANAGEMENT AND PROTECTION OF VOLCANOES NATIONAL PARK LANDSCAPE IN RWANDA,” *Int. J. Mod. Hosp. Tour.*, vol. 2, no. 1, pp. 1–12, Oct. 2021, doi: 10.47604/IJMHT.1393.
 12. T. Nyatanyi *et al.*, “Implementing One Health as an integrated approach to health in Rwanda,” *BMJ Glob Heal.*, vol. 2, no. 1, p. e000121, 2017, doi: 10.1136/bmjgh-2016-000121.
 13. A. Spenceley, S. Habyalimana, R. Tusabe, and D. Mariza, “Benefits to the poor from gorilla tourism in Rwanda,” *Dev. South. Afr.*, vol. 27, no. 5, pp. 647–662, 2010, doi: 10.1080/0376835X.2010.522828.
 14. G. Ntabakirabose *et al.*, “An Economic Analysis of the Effect of Volcano National Park Tourism Demand on Human Livelihood in Rwanda: A Case Study of Burera and Musanze Districts,” *Int. J. Hosp. Tour. Manag.*, vol. 5, no. 2, p. 45, 2021, doi: 10.11648/J.IJHTM.20210502.13.
 15. G. Umuziranenge, J. B. Nshimiyimana, and M. Pelagie, “Local Communities’ Perceptions of Their Participation in Mountain Gorilla Conservation Around Volcanoes National Park in Rwanda: Case of Kinigi Sector,” *ASC-TUFS Work. Pap.*, vol. 4, pp. 151–170, Mar. 2024, doi: 10.51062/ASCWP.4.0_151.
 16. K. Ronald, T. Emmy, and N. Emmanuel, “Local Community Attitude and Perceptions towards Tourism Conservation Policies in Rwanda Case of Volcanoes National Park,” *Adv. Econ. Bus.*, vol. 4, no. 12, pp. 631–640, 2016, doi: 10.13189/aeb.2016.041201.
 17. G. Muresherwa, I. Amony, C. G. Iwu, and C. N. Dube, “The impact of mountain gorilla tourism: A residents’ perspective,” *African J. Hosp. Tour. Leis.*, vol. 9, no. 2, pp. 1–18, 2020.
 18. WEF, “How conservation is protecting mountain gorillas in Rwanda | World Economic Forum.” Accessed: Jan. 13, 2026. [Online]. Available: <https://www.weforum.org/stories/2024/10/sustainable-tourism-mountain-gorillas-rwanda/>
 19. S. J. Gessa and J. M. Rothman, “The importance of message framing in rule compliance by visitors during wildlife tourism,” *Conserv. Sci. Pract.*, vol. 3, no. 10, p. e515, Oct. 2021, doi: 10.1111/CSP2.515;WGROU:STRING:PUBLICATION.
 20. K. E. Khumalo and L. A. Yung, “Women, human-wildlife conflict, and CBNRM: Hidden impacts and vulnerabilities in Kwandu Conservancy, Namibia,” *Conserv. Soc.*, vol. 13, no. 3, pp. 232–243, Jul. 2015, doi: 10.4103/0972-4923.170395.
 21. M. L. Rurangwa and R. J. Whittaker, “Making space for birds: Sourcing solutions from the mountain gorilla conservation model in Rwanda,” *J. Nat. Conserv.*, vol. 54, p. 125797, Apr. 2020, doi: 10.1016/J.JNC.2020.125797.
 22. T. Telbisz, Z. Imecs, A. Máthé, and L. Mari, “Empirical Investigation of the Motivation and Perception of Tourists Visiting the Apuseni Nature Park (Romania) and the Relationship of Tourism and Natural Resources,” *Sustain.* 2023, Vol. 15, Page 4181, vol. 15, no. 5, p. 4181, Feb. 2023, doi: 10.3390/SU15054181.
 23. W. Eckardt, T. S. Stoinski, S. Rosenbaum, and R. Santymire, “Social and ecological factors alter stress physiology of Virunga mountain gorillas (*Gorilla beringei beringei*),” *Ecol. Evol.*, vol. 9, no. 9, pp. 5248–5259, May 2019, doi: 10.1002/ECE3.5115.
 24. E. A. Williamson and E. J. Macfie, “Guidelines for best practice in great ape tourism,” *Primate Tour.*,

- pp. 292–310, Sep. 2014, doi: 10.1017/CBO9781139087407.022.
25. J. Nziza, “Gorilla Doctors work in Africa: One health approach in Conservation,” University of Glasgow, Glasgow, 2023. Accessed: Jan. 14, 2026. [Online]. Available: https://www.aawconference.org/2023/presentations/Day_Three/Gorilla_Doctors_Work_in_AfricaOne_Health_Approach_in_Conservation.pdf
26. NISR, “Fifth Rwanda Population and Housing Census, 2022 Main Indicators Report,” 2023. Accessed: Apr. 20, 2023. [Online]. Available: https://www.statistics.gov.rw/publication/main_indicators_2022
27. NISR, “Fifth Population and Housing Census, Rwanda, 2022 District Profile Bugesera,” 2023. Accessed: Jul. 27, 2025. [Online]. Available: <http://www.statistics.gov.rw>.
28. L. D. Fisher, “Self-designing clinical trials,” *Stat Med*, vol. 17, no. 14, Jul. 1998, Accessed: Jan. 15, 2026. [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/9699229/>
29. M. Maekawa, A. Lanjouw, E. Rutagarama, and D. Sharp, “Mountain gorilla tourism generating wealth and peace in post-conflict Rwanda,” *Nat. Resour. Forum*, vol. 37, no. 2, pp. 127–137, 2013, doi: 10.1111/1477-8947.12020.
30. RDB, “ANNUAL REPORT 2024 SUSTAINING GROWTH, TOWARDS TRANSFORMATION,” 2024. Accessed: Jan. 13, 2026. [Online]. Available: <https://rdw.rw/rwanda-development-board-annual-report-highlights-strong-economic-performance-and-strategic-progress-in-2024/>
31. G. Muresherwa, W. Makuzva, C. N. Dube, and I. Amony, “The management of mountain gorilla tourism in Uganda: Are the socio-economic benefits realised?,” *J. Transdiscipl. Res. South. Africa*, vol. 18, no. 1, pp. 1–9, Apr. 2022, doi: 10.4102/TD.V18I1.1136.
32. K. Cecilly, K. Sonia, L. Chakanet, C. Sylvia, and U. Simonia, “Exploring the Gorilla Trekking Safari and the Tourism Industry in Rwanda,” *J. Tour. Hosp. Sport.*, vol. 62, no. 2000, pp. 30–39, 2022, doi: 10.7176/jths/62-04.
33. A. H. Wade, N. Malone, M.-O. Forest, M. Wink, and J. E. Lambert, “Ecological, Historical, Economic, and Political Factors Shaping the Human–Gorilla Interface in the Mone-Oku Forest, Cameroon,” *Divers. 2021, Vol. 13, Page 175*, vol. 13, no. 4, p. 175, Apr. 2021, doi: 10.3390/D13040175.
34. E. A. Williamson and E. J. Macfie, “Best Practice Guidelines for Great Ape Tourism,” *Primate Tour.*, 2014, Accessed: Jan. 14, 2026. [Online]. Available: www.iucn.org/themes/ssc