

Article

Livelihood Security and Perceived Prevalence of Illegal Activities Threatening Mountain Gorilla Conservation in East Africa's Virunga Landscape

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Abstract: Illegal activities pose challenges to the conservation of mountain gorillas (*Gorilla beringei beringei*) across the Virunga Landscape (VL). This paper investigates the relationship between household livelihood security (HLS) and the perceived prevalence of illegal activities across the VL. Results from a survey of 223 residents of areas adjacent to the VL in Uganda and Rwanda reveal varied links between human livelihoods and illegal activities threatening wildlife. For example, while poaching appears to be negatively associated with health and financial security among residents, it is positively associated with education security, indicating that education may be contributing to illegal activities threatening wildlife. Food security constraints were also found to be significantly associated with poaching. Finally, findings suggest that although HLS investments are essential in improving local community livelihoods, only food and financial security are the most effective means of reducing illegal activities in Virunga.

Keywords: protected areas; conservation; livelihoods; illegal activities; parks; transboundary

1. Introduction

Despite threats that they pose to wildlife conservation, illegal livelihood-based activities are prevalent in Africa [1–3]. African conservation efforts have focused on protected areas to guard wildlife and preserve biological diversity [4–7]. For example, despite their protected status, wildlife resources and habitats in the Virunga Landscape (VL) are not sustainably managed due to inadequate government resources, policies, or regulations to restrict illegal activities influencing these protected areas [3,8,9]. Consequently, conservation of protected areas is challenged by human-wildlife conflicts [10–13] and widespread illegal resource harvesting of, for example, bushmeat, bamboo, wood, and medicinal herbs to treat tropical diseases [3,14].

In response to human-wildlife conflicts, conservationists in the early 1990s began exploring new approaches to meet human livelihood and wildlife conservation needs [9,15,16]. This exploration coincided with attempts to include local communities in the planning and management of natural resources [15,17], accessing economic benefits as an incentive for conservation [18,19], and investing in community development initiatives [20,21]. The

rationale for these initiatives was that focusing solely on biodiversity conservation and management is ineffective [16,22], given the frequent and chronic decline of natural resources [4,23,24]. Instead, these initiatives focus on potential ways through which natural resources can contribute to sustainable and improved livelihoods [15,25,26] through economic and other development opportunities to transform residents' negative behaviors into being wildlife stewards [15,27].

Although law enforcement has been somewhat successful in deterring illegal activities in parks [28,29], by integrating conservation and development initiatives, protected-area managers can simultaneously address two development goals: promoting the conservation of mountain gorillas and facilitating the socio-economic development of local communities [26,30]. The premise of community conservation initiatives is to include local people in managing protected areas [17,24] by providing them with opportunities to benefit directly from biodiversity conservation [9,31,32] and mountain gorilla tourism in particular [26]. With this incentive strategy, residents are encouraged to surrender illegal access in exchange for alternative sources of income and livelihood opportunities [33–35].

The incentive strategy, such as the policy on sharing revenues from tourism (5–10%) with adjacent communities through the development of infrastructures like healthcare centers and hospitals, aims to establish coexistence among protected areas and surrounding communities [7,9,36,37] without compromising mountain gorilla conservation [3,18,38]. However, there has been little systematic and empirical study elucidating connections between human livelihoods and perceived illegal activities influencing mountain gorillas in the VL [9,30,39,40]. This paper addresses this knowledge gap by investigating potential associations between livelihood security and the perceived prevalence of illegal activities in VL protected areas.

2. Theoretical Background

2.1. Routine Activities Theory Perspective

Research suggests that the prevalence of illegal activities such as hunting and the harvesting of forest resources that occur in protected areas is mainly because the species targeted for bushmeat are needed as a source of protein by members of the adjacent communities [41,42]. To extend this knowledge, we use the routine activities theory to explain illegal human behaviors in protected areas [43–45]. Walsh and Ellis [46] define routine activities theory as “the day-to-day activities that characterize a particular community”. Routine activities theory is based on three major components: motivated offenders, suitable targets, and the absence of capable guardians [44,46]. Motivated offenders are the individuals (i.e., poachers) who commit the crimes, suitable targets are the items (i.e., illegal activities) or objects that are targeted or taken by individuals illegally, and the absence of capable guardians (i.e., park rangers) means that there is no active law enforcement in place [44,45].

This theory suggests that crime occurs when the three elements converge with motivated offenders taking advantage of the absence of guardians to harvest resources illegally [42,47,48]. Some of these illegal forest resource harvests, such as those in the Virunga, are committed by individuals to feed their households or generate income [44,48]. According to the rational choice model, a backbone of this theory, offenders make rational choices to commit crimes based on the availability of opportunities to engage in illegal activities as well as their evaluation of the benefits, costs, and risks involved [42,47]. Arguably, the most vulnerable individuals who become offenders have limited or no access to livelihood securities needed by their households [3,49,50]. From a developing country's perspective, access to food, education, healthcare, and financial resources are essential indicators of the basic capabilities required to sustain livelihoods [26,34,37]. When such livelihood capabilities are eroded, the most disadvantaged residents fail to maintain their desired livelihoods and, as a result, are highly motivated to engage in illegal activities. In the case of the VL, this entails illegally harvesting park resources despite the consequences [3,30].

2.2. *Illegal Extraction of Protected-Area Resources*

There is a growing interest in exploring how humans influence biodiversity loss [27,51,52]. Some studies have attributed protected areas' resource extraction to poverty in adjacent communities [3,30]. In particular, it has been suggested that in many countries, and in particular, the communities adjacent to the protected areas, such as those in the VL, rely on forest resources to sustain their livelihoods [7,52,53].

Protected areas provide tangible and intangible resources to individuals [24,32,53,54]. Tangible protected area resources include timber products, as well as non-timber forest products such as fruits, medicinal plants, and bushmeat [17,53]. Intangible resources include fresh water, carbon storage, watershed protection, flooding, and erosion control [53,54]. Protected areas act as safety nets for those living adjacent to them during hardship and livelihood crises [53]. Similarly, Wunder and colleagues [55] indicated that the frequency of forest resource extraction increases during livelihood shocks and crises [4,30].

In most countries, extracting protected-area resources, such as firewood, timber for construction, and bushmeat for food, is illegal. In the VL region, all extractive forms of resource use are not permitted. Both MGNP and VNP are national parks and therefore protected by law. The illegal extraction of park resources is typically associated with the desire of the adjacent residents to sustain income and subsistence livelihoods [25,29,30,56]. In these places, such as the VL, population density is high, and farmland is limited, which makes protected areas a targeted source of livelihood for individuals who do not own farmland [10,18,54]. This illegal extraction of protected area resources causes conflicts between protected areas' adjacent communities and the public institutions responsible for conservation [4,29,55]. Therefore, it is not surprising that human-wildlife conflict has become an important conservation issue.

A better understanding of livelihood-based extractive use of protected areas is vital to ensure wildlife sustainability [3,30,39]. There have been attempts to explore the relationship between livelihood constraints and illegal forest use, and findings from these studies demonstrate a high correlation between livelihood needs and illegal forest use [3,24,28]. It is believed that providing alternative means of securing one's livelihood can reduce illegal forest use and the degradation of biodiversity [30,55,57]. Despite the substantial efforts that have been made to explore the link between human livelihoods and the illegal extraction of protected areas' resources, it is unclear how diverse livelihood needs influence the illegal extractive use of protected areas. This paper explores how human livelihood conditions such as food security, health security, education security, and financial security are associated with the extractive use of protected areas.

2.3. *Food Security Constraints and Illegal Forest Use*

Food security is the condition of having sufficient food to sustain an active and healthy life [58]. From the standpoint of household livelihoods, a lack of necessary food and nutrition are significant indicators of food insecurity [59–61]. This insecurity happens when a household's resources are insufficient to enable the members of that household to meet their basic nutritional needs [3,58]. Therefore, food security constraints such as limited food intake, inadequate quality, insufficient quantity, and poor nutrition are potential motivations for illegal forest use [3,30]. A negative relationship between food security and illegal forest use has been shown in the literature [30]. Arnold and colleagues [59] also indicated that forests contribute to food security.

2.4. *Health Security Constraints and Illegal Forest Use*

Health security is necessary for a healthy and long life [62,63]. Health security ensures increased production, income, and poverty reduction among poor households [30,62–64]. In many countries, ill health affects productivity and contributes significantly to poverty [45,61,62] by reducing the income and household capabilities available to create the desired livelihood [49,63,64]. With limited income to afford healthcare services and an inability to buy prescribed medicine, residents cannot pursue regular livelihood means

(e.g., farming) and turn to protected areas to obtain food, medicine, and other resources. They either use these resources themselves or sell them to others to generate income with which they can address their household challenges [3,61,65]. Therefore, according to Munanura et al. [65], the inability to buy prescribed medicine, the inability to access medical services and the lack of access to clean water, or the lack of health insurance are considered indicators of health security constraints that may motivate illegal forest use.

2.5. Education Security Constraints and Illegal Forest Use

Education security is defined by [66] as a household's ability to access educational facilities, pay school fees, and buy school supplies and uniforms for the household's children. Once education is secured, a household's literacy rate and level of education increase. Evidence suggests that access to education guarantees better socioeconomic opportunities to residents, which improves households' chances to better their livelihoods [26,49]. Education security allows household members to acquire training and skills to compete for available job opportunities. Without education, access to employment opportunities is limited. Such limited access increases the social and economic barriers households face and reduces households to poverty [26,65]. Impoverished parents are unable to afford for their children to attend school. Instead, parents prefer to put their children to work on the family farm, which exacerbates their circumstances and compromises their ability to manage livelihood challenges [26,49]. The inability to afford education puts a high burden on households and pushes them further into abject poverty. In turn, residents are left with few means to take care of their families other than engaging in the illegal use of forest resources [26,30]. Therefore, education security constraints such as parents' inability to afford school fees, supplies, and uniforms for their children are likely to increase illegal forest use [49,50,67]. For example, school dropout is likely to increase the number of unemployed young people, typically believed to be potential offenders. Lack of school supplies is likely to motivate households to engage in the illegal harvesting of timber or non-timber forest products to secure income to purchase school materials.

2.6. Financial Security Constraints and Illegal Forest Use

The traditional economic measures of poverty are based on assets such as land, livestock, and income [68]. Economically speaking, when a household's income and stocks of assets are insufficient to meet its basic needs, it is considered financially insecure [69] and is likely to rely on illegally harvesting park resources [61,65]. In many African countries, poverty remains a critical challenge that affects households' ability to improve their livelihoods [29,34]. Poverty from a rural community perspective is characterized by material and financial deprivation, including a lack of income, employment, and land resources, most of which are linked to illegal forest use for livelihood sustenance [70,71].

2.7. Research Hypotheses

The theoretical background provided in the previous section illustrates the potential relationship between livelihood security and illegal activities in protected areas. Building on this literature, in this paper, the following research hypotheses are suggested and empirically tested using data from the GVTL in East Africa:

Hypothesis 1 (H1). *An increase in livelihood security predicts reduced poaching in protected areas. Specifically, an increase in food security (H1a), health security (H1b), education security (H1c), and financial security (H1d) predicts reduced poaching.*

Hypothesis 2 (H2). *An increase in livelihood security predicts reduced wood harvesting in protected areas. Specifically, an increase in food security (H2a), health security (H2b), education security (H2c), and financial security (H2d) predicts reduced wood harvesting.*

Hypothesis 3 (H3). *An increase in livelihood security predicts reduced bamboo harvesting in protected areas. Specifically, an increase in food security (H3a), health security (H3b), education security (H3c), and financial security (H3d) predicts reduced bamboo harvesting.*

Hypothesis 4 (H4). *An increase in livelihood security predicts reduced medicinal plant harvesting in protected areas. Specifically, an increase in food security (H4a), health security (H4b), education security (H4c), and financial security (H4d) predicts reduced medicinal plant harvesting.*

3. Methods

3.1. Description of the Study Area

The Virunga Landscape (VL) is known globally for its high diversity of species, an abundance of large mammals, and high conservation value [72]. The VL stretches across the borders of the Democratic Republic of Congo (DRC), Uganda, and Rwanda [73]. The Greater Virunga Transboundary Landscape's broader landscape (GVTL) comprises eight national parks (Figure 1). These are Virunga National Park in the DRC; Semuliki National Park, Rwenzori National Park, Kibale National Park, Queen Elisabeth National Park, Bwindi Impenetrable National Park, and Mgahinga Gorilla National Park in Uganda; and Volcanoes National Park in Rwanda [3,26]. The GVTL is believed to contain more terrestrial and endemic species than any other eco-region across the African continent and is an essential landscape for global conservation [72,74]. This study focused on two protected areas: Mgahinga Gorilla National Park in Uganda and Volcanoes National Park in Rwanda.

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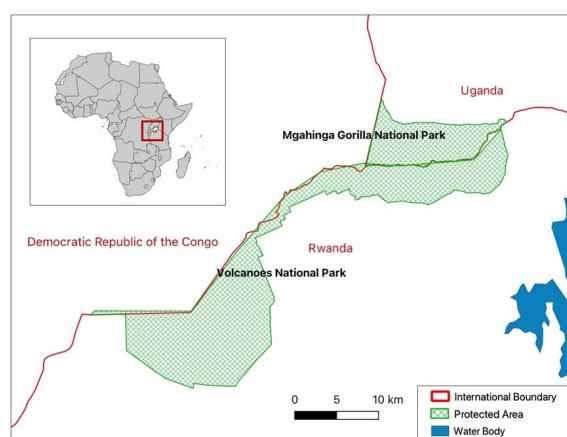


Figure 1. Map of Virunga Landscape (VL). Credit: Katie Bernhard (2022).

3.2. Data Collection

Mgahinga Gorilla National Park (MGNP) is located in the Kisoro District of southwestern Uganda. The park borders Rwanda to the south and the DRC to the west and covers an area of 335 km² [72]. Administratively, MGNP borders the three parishes of Gisozi, Rukongi, and Gitenderi. This method was selected for its straightforwardness and ability to generate a higher response rate [77], given the low literacy levels in the communities around the two parks. Survey instruments included semi-structured interviews lasting 45 min and one hour to reduce the potential for respondent fatigue [80,81,82].

The study surveyed heads of households residing in villages adjacent to either of the study sites. A systematic sampling method was used to select randomly selected households in the northwestern part of Rwanda, bordering Uganda and the DRC. It was created in 1925 [73] to help ensure biodiversity conservation and promote scientific research and mountain gorilla tourism [72,76]. Although the park was legally protected, its parkland was reduced from 328 km² to 160 km² to allow for the growth of cash crops such as pyrethrum and the establishment of communities [72]. The park borders the four administrative districts of Burera, Musanze, Nyabihu, and Rubavu.

3.3. Data Analysis

Household livelihood security was assessed on the four dimensions of food, health, agriculture [72], creating a high demand for park resources.

Measures were adapted from [65]. Like the prevalence of illegal activities, household livelihood security was assessed based on a 5-point Likert scale (Table 1) to allow participants to indicate how they agreed or disagreed with each of the question-item statements. The four measures of illegal activities (poaching, wood cutting, bamboo cutting, and medicinal herbs collection) were selected based on the major illegal activities in the VL and adapted from Munanura et al. [30]. Each of the four identified illegal activities (i.e., poaching, cutting and collecting wood, bamboo, and harvesting of medicinal plants) was represented by four question items that were used to assess the prevalence of illegal activities (Table 2). The prevalence of illegal activities was assessed based on the four dimensions of food, health, agriculture [72], creating a high demand for park resources.

3.2. Data Collection

Face-to-face household survey interviews were conducted in the summer of 2016 as part of a study examining perceptions of illegal activities and livelihood security among individuals living in the villages of Gisozi in Kisoro adjacent to Uganda's MGNP and Kinigi in Musanze adjacent to Rwanda's VNP. This method was selected for its straightforwardness and ability to generate a higher response rate [77], given the low literacy levels in the communities around the two parks. Survey instruments included semi-structured questionnaires containing close-ended questions [78,79]. Each interview was kept between 45 min and one hour to reduce the potential for respondent fatigue [80–82].

The study surveyed heads of households residing in villages adjacent to either of the study sites. A systematic sampling method was utilized to randomly select survey participants. Villages were identified as those adjacent to the park, and resident lists were provided to the researcher by the local sector or parish authorities. Every fourth household on the list was selected to participate in the survey. If a household head refused, was unable, or was found to be ineligible to participate in the survey, the next household on the list was randomly selected. Using this strategy, a sample of 223 respondents living in communities adjacent to the VL was obtained.

3.3. Data Analysis

Household livelihood security was assessed on the four dimensions of food, health, education, and financial [34,83,84]. The household livelihood security measures were adapted from [65]. Like the prevalence of illegal activities, household livelihood security was assessed based on a 5-point Likert scale (Table 1) to allow participants to indicate how they agreed or disagreed with each of the question-item statements. The four measures of illegal activities (poaching, wood cutting, bamboo cutting, and medicinal herbs collection) were selected based on the major illegal activities in the VL and adapted from Munanura et al. [30]. Each of the four identified illegal activities (i.e., poaching, cutting and collecting wood, bamboo, and harvesting of medicinal plants) was represented by four question items that were used to assess the prevalence of illegal activities (Table 2). The prevalence of illegal activities was assessed based on how strongly participants agreed or disagreed with each question-item statement on a 5-point Likert scale.

Table 1. Reliability of Household Livelihood Security Measures.

Measurement Items	M (SD)	λ	AVE	CR	SQRT-AVE
¹ In my household ...					
We eat preferred food regularly.	3.56 (1.32)	0.77	0.47	0.72	0.67
We eat meat regularly.	1.50 (0.86)	0.67			
We own enough land for agriculture.	2.57 (1.26)	0.60			
² In my household ...					
We have health insurance.	4.26 (2.58)	0.77	0.52	0.76	0.72
We have access to well-equipped health centers or hospitals.	4.40 (1.79)	0.52			
We have access to clean water.	3.65 (2.18)	0.83			
³ In my household ...					
We have access to schools.	3.85 (1.33)	0.91	0.64	0.90	0.80
We can afford to pay fees for primary education.	4.86 (1.92)	0.84			
We can afford to pay fees for secondary education	2.28 (1.43)	0.78			
We can afford to buy scholastic materials.	4.11 (1.57)	0.75			
We can afford to buy students uniform.	4.82 (1.70)	0.71			
⁴ In my household ...					
We have access to loan and finance facilities.	2.94 (1.57)	0.77	0.62	0.83	0.79
We have financial savings.	2.87 (1.56)	0.77			
We have finances to deal with hardships.	2.31 (1.31)	0.82			

Note: ¹ Items measuring food security, ² items measuring health security, ³ items measuring education security, ⁴ items measuring financial security. Each item statement was measured on a 5-point scale, where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree. Model fit statistics: $S-B\chi^2 = 312.54$, $df = 71$, $p < 0.001$, CFI = 0.95, RMSEA = 0.07 (95% CI, 0.06–0.08) λ = standardized loading, AVE = average variance extracted, CR = composite reliability, SQRT-AVE = square root of average variance extracted values.

Table 2. Measurement Model Results for Illegal Activities Measures.

Measurement Items	M (SD)	λ	AVE	CR	SQRT-AVE	Fit Indices
¹ Residents of my community similar to myself go to the park to ...						S-B χ^2 = 9.87, df = 2, p < 0.001, CFI = 0.97, SRMR = 0.05, RMSEA = 0.13, 90%CI = [0.05, 0.17]
Hunt because of social pressure	2.01 (1.63)	0.66	0.58	0.80	0.76	
Hunt and exercise of indigenous rights	3.38 (1.95)	0.86				
Hunt for bushmeat to eat	3.48 (2.21)	0.89				
Hunt for bushmeat to sell	2.07 (1.70)	0.61				
² Residents of my community similar to myself go to the park to ...						S-B χ^2 = 2.34, df = 2, p = 0.31, CFI = 1, SRMR = 0.01, RMSEA = 0.02 90%CI = [0.00, 0.14]
Harvest wood for use in fencing households	2.27 (1.78)	0.92	0.76	0.87	0.87	
Harvest wood for use in agriculture farming	2.19 (1.75)	0.94				
Harvest wood for use in making household items	2.24 (1.84)	0.92				
Harvest wood for use in building houses	2.07 (1.49)	0.68				
³ Residents of my community similar to myself go to the park to ...						S-B χ^2 = 19.61, df = 2, p < 0.001, CFI = 0.94, SRMR = 0.07, RMSEA = 0.19, 90%CI = [0.12, 0.28]
Harvest bamboo to make baskets for home use	2.59 (1.86)	0.80	0.65	0.84	0.80	
Harvest bamboo to make baskets for sale	2.33 (1.87)	0.92				
Harvest bamboo to use in house construction	2.31 (1.72)	0.68				
Harvest bamboo to use in agricultural farming	2.65 (2.16)	0.80				
⁴ Residents of my community similar to myself go to the park to ...						S-B χ^2 = 5.6, df = 2, p = 0.07, CFI = 0.97, SRMR = 0.03, RMSEA = 0.06 90%CI = [0.00, 0.18]
Collect plants for household medicine	2.24 (1.69)	0.73	0.50	0.78	0.71	
Collect plants for livestock medicine	2.20 (1.82)	0.65				
Practice rituals for cultural cleansing	2.52 (2.06)	0.72				
Collect seedlings to plant outside the park	2.19 (1.79)	0.72				

Note: ¹ Items measuring illegal hunting or poaching, ² items measuring illegal harvesting of wood, ³ items measuring illegal harvesting of bamboo, ⁴ items measuring medicinal use. Bamboo and wood resources are separated due to their uniqueness in value and use by residents and mountain gorillas (e.g., the loss of bamboo threatens an important source of food and medicine for mountain gorillas). Each item in the table represents statements in the questionnaire measuring the perceived level of use of protected area resources for human livelihoods (e.g., poaching, harvesting wood, harvesting bamboo, and medicinal use). Responses to a question such as “To what extent do you agree or disagree with the following statement ‘Residents of my community similar to myself go the park to hunt bushmeat to eat’” were measured on a 5-point scale, where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree with the statement. M (SD) = Mean (Standard Deviation), λ = standardized loading, AVE = average variance extracted, CR = composite reliability, SQRT-AVE = square root of average variance extracted values.

To ensure data reliability and validity, several steps were taken. In the first step, we examined the demographic variables of respondents, and no differences were found. Our second step consisted of performing an independent samples *t*-test and comparing the mean values of the two populations. In both cases, the results did not differ significantly across the landscapes.

Data analysis was conducted using the EQS software package (version 6.1; Multivariate Software, Inc., Los Angeles, CA, USA). The analysis was a two-step process. The initial step entailed conducting a confirmatory factor analysis (CFA) to confirm the reliability and validity of the measures for the constructs in the research model. According to Kline [85], the best-fitting measurement model must be obtained in CFA before using structural equation modeling (SEM) to test the hypothesized relationships. The best-fitting CFA models are used to examine the psychometric properties of reliability and validity [86]. The evidence of the reliability and validity of this study’s measures is provided in Section 4.2 (i.e., Tables 1–3). The second step involved using SEM following the confirmation of the reliability and validity of the measures in the best-fitting measurement model through CFA. Both steps were carried out in adherence to the guidelines outlined by Byrne [86]. Before model estimation in CFA, missing data were imputed using the expectation-maximization (EM) procedures, argued to be the most appropriate SEM approach for addressing missing data [87]. The initial assessment of the CFA model revealed a high Mardia’s coefficient, which suggests multivariate non-normal data [86]. Following Byrne’s guidelines, citing Satorra and Bentler [88], the model estimation in CFA and SEM was based on robust statistics (i.e., Satorra-Bentler scaled statistics), which adjusts statistical analyses for non-normally distributed data. The results of both the CFA and SEM are presented in Sections 4.2 and 4.3, respectively.

Table 3. Factor Correlations and Testing for Discriminant Validity.

		1	2	3	4
1	Poaching	(0.76)			
2	Wood cutting	0.28	(0.87)		
3	Bamboo cutting	0.53	−0.08	(0.80)	
4	Medicinal	0.47	−0.08	0.38	(0.71)
1	Food security	(0.67)			
2	Health security	0.19	(0.72)		
3	Education security	0.73	0.59	(0.80)	
4	Financial security	0.67	0.53	0.78	(0.79)

Note: Diagonal values in brackets are the square roots of average extracted variance (AVEs).

4. Results

4.1. Description of the Study Population

The study population was comprised of 223 heads of household. In total, 51.3% of participants identified as male, while 48.7% identified as female. Most of the respondents (98.7%) were married and were between 30 and 49 years of age (64.3%). Education levels were very low: 36.2% of the respondents had no education, while 53.1% had only primary education. The majority of the respondents are predominantly agricultural farmers who had an annual income of fewer than 500 USD (83.5%). The average household consisted of two adults and one to two children.

4.2. Measurement Model Results

The CFA model for livelihood security indicated a good model fit [$S-B\chi^2 = 312.54$, $df = 71$, $p < 0.001$, CFI = 0.95, RMSEA = 0.07 (95% CI, 0.06–0.08)]. Table 1 shows evidence of the reliability and validity of the measures of livelihood security. Similarly, Table 2 shows evidence of the goodness of fit for multiple measurement models for the illegal activity variables. Table 2 also provides evidence of the reliability and validity of the measures and the measures' association with the illegal activities constructs. Following [89,90], all constructs in the hypothesized models were reliable and exceeded the 0.40 critical value. Table 1 (i.e., livelihood security) and Table 2 (i.e., illegal activities) show that the composite reliability coefficients were above the 0.7 critical value. As shown in Tables 1 and 2, the Convergent validity of constructs was confirmed by the average variance extracted from each construct exceeding 50% [89]. Discriminant validity of all constructs was confirmed by comparing factor correlations with the square root of average variance extracted (AVE) by each factor [91]. As Table 3 shows, correlations among constructs did not exceed the square root of AVE.

A discriminant validity examination was conducted to determine if the four illegal activities were sufficiently distinct from each other and whether there were any significant overlaps in what each variable measured. The results show that the four illegal activities (i.e., poaching, wood cutting, bamboo cutting, and harvesting medicinal plants) were valid discriminant latent variables [91].

4.3. Structural Model Results

Before testing the hypotheses, all variables for use in the structural model were correlated to preliminarily assess the linear relationships between each pair of variables and determine whether there were any multicollinearity concerns [92,93]. To avoid spurious correlations [94], a common latent factor [90] was included in the model. Table 4 presents the correlations between the variables.

Table 4. Variable Correlations.

S/N		1	2	3	4	5	6	7	8
1	Poaching	1							
2	Wood cutting	0.28	1						
3	Bamboo cutting	0.53	−0.08	1					
4	Medicinal	0.47	−0.08	0.38	1				
5	Food security	0.07	−0.61	0.44	0.50	1			
6	Health security	−0.08	−0.08	0.15	0.60	0.24	1		
7	Education security	0.47	0.02	0.27	0.30	0.01	0.36	1	
8	Financial security	0.61	0.11	0.46	0.37	0.14	0.25	0.58	1

To test the hypotheses in the structural model, CFA was conducted in an SEM using the maximum likelihood and robust estimation methods. A common latent factor was retained in the model to control for common method bias [95] by accounting for commonly shared variance [96]. The structural model for the sample appeared to be adequately specified ($S-B\chi^2 = 314.01$, $df = 146$, $p < 0.001$, CFI = 0.96, SRMR = 0.07, RMSEA = 0.04, 90% CI = [0.040, 0.046]). The following sections present evidence of how residents perceive the aspects of their livelihood security related to illegal activities.

4.3.1. Relationships between Livelihood Security Constraints and Poaching

The analysis confirmed Hypothesis 1, showing that increased access to healthcare services is significantly related to decreased poaching. In contrast, increased access to education and economic opportunities are significantly associated with increased poaching. The four livelihood security variables accounted for 47% of the variance in poaching (see R-square values in Table 5). In summary, the results show no significant effect of food security on poaching; however, it appears that food security likely has a positive relationship with poaching. Similarly, financial security has a positive relationship with poaching. However, the results indicate that health security reduces poaching.

Table 5. Hypothesis Testing Results.

Hypotheses	Relationship	B	SE	β	$t_{(223)}$	p	Conclusion	R ²
H1a	Food security → Poaching	0.09	0.08	0.07	1.19	0.235	Reject	0.47
H1b	Health security → Poaching	−0.43	0.08	−0.33	−5.44	0.000	Accept	
H1c	Education security → Poaching	0.38	0.09	0.29	4.33	0.000	Accept	
H1d	Financial security → Poaching	0.67	0.11	0.51	6.42	0.000	Accept	
H2a	Food security → Wood harvesting	−1.08	0.13	−0.67	−8.14	0.000	Accept	0.43
H2b	Health security → Wood harvesting	0.11	0.08	0.07	1.36	0.175	Reject	
H2c	Education security → Wood harvesting	−0.26	0.11	−0.16	−2.40	0.017	Accept	
H2d	Financial security → Wood harvesting	0.46	0.10	0.28	4.79	0.000	Accept	
H3a	Food security → Bamboo harvesting	0.64	0.09	0.37	7.52	0.000	Accept	0.31
H3b	Health security → Bamboo harvesting	0.16	0.10	0.09	1.50	0.135	Reject	
H3c	Education security → Bamboo harvesting	0.02	0.12	0.01	0.21	0.834	Reject	
H3d	Financial security → Bamboo harvesting	0.52	0.11	0.31	4.99	0.000	Accept	
H4a	Food security → Medicinal plant harvesting	0.38	0.07	0.36	5.43	0.000	Accept	0.53
H4b	Health security → Medicinal plant harvesting	0.48	0.09	0.46	5.24	0.000	Accept	
H4c	Education security → Medicinal plant harvesting	0.03	0.08	0.03	0.36	0.719	Reject	
H4d	Financial security → Medicinal plant harvesting	0.19	0.11	0.19	1.79	0.075	Reject	

Note: H1a = Hypothesis 1a, B = unstandardized regression coefficient, SE = standard error of the unstandardized regression coefficient, β = standardized regression coefficients, $t = t$ -values measuring the precision with which the standardized regression coefficient is measured, $p = p$ -value showing the statistical significance of the hypothesis testing results, R^2 = R-square measuring percentage of variance explained by model predicting a dependent variable (e.g., poaching).

4.3.2. Relationships between Livelihood Security Constraints and Wood Cutting

The analysis also confirmed Hypothesis 2. In particular, the results show that, on the one hand, an increase in access to food and education is significantly related to a decrease in wood cutting; on the other hand, an increase in access to economic opportunities is significantly associated with an increase in wood cutting. The predictors accounted for 43% of the variation in illegal wood cutting (Table 5).

4.3.3. Relationships between Livelihood Security Constraints and Bamboo Cutting

The test of Hypothesis 3 regarding illegal bamboo cutting revealed that an increase in illegal bamboo cutting is significantly related to increased access to food and financial opportunities. However, increased access to healthcare services and educational opportunities was observed to have no significant relationship with illegal bamboo cutting. The four predictors accounted for 31% of the variation in illegal bamboo cutting (Table 5).

4.3.4. Relationships between Livelihood Security Constraints and Harvesting of Medicinal Plants

The analysis showed that increased access to food and health opportunities is significantly related to increased harvesting of medicinal plants. In contrast, access to educational and financial opportunities was found to have no significant relationship with the harvesting of medicinal plants. Combined, the four predictors accounted for 53% of the variance in harvesting medicinal plants (Table 5).

5. Discussion

This study provides empirical evidence of the relationship between household livelihood security and illegal activities across the VL. Results indicate subsistence household livelihood constraints often drive community dependency on park resources. Previous studies examining community dependence on forest resources [30,65,67,97], ranger-based monitoring of illegal activities [48], and community perceptions of household livelihoods security [26] indicate substantial pressure the VL (and in particular) mountain gorilla conservation is experiencing and household livelihood insecurities among local communities.

Specifically, this study's findings suggest that illegal activities (poaching, wood, bamboo cutting, and medicinal herb collection) and household livelihood constraints (food, education, health, and financial) link across the VL. Results indicate a strong inverse relationship between poaching and health security, food security, and wood cutting, as well as between education security and wood cutting. For example, food insecurity will likely increase medicinal herb collection and bamboo cutting. Similarly, financial insecurity is likely to increase bamboo cutting, and health insecurity is expected to increase medicinal herb collection. Results also demonstrate that food security is not likely to impact poaching, and the relationship appears positive. These findings provide a new understanding of ways food, health, financial, and education security constraints relate to illegal activities in communities adjacent to the VL.

For instance, food constraints are likely to increase wood cutting, suggesting that wood cutting for commercial purposes is likely to contribute to an increase in food security. This is because wood resources are scarce and tend to sell quickly, and as a result, communities increase their finances to address household food insecurity. However, as food becomes more secure, bamboo cutting for cooking, house construction, farming, and medicinal herb collection to treat family diseases increases. Moreover, as education becomes more accessible, education costs increase and require families to meet these financial obligations. Confronted with these requirements, family members are likely to participate in poaching as the easiest way to obtain funds needed to pay tuition, buy uniforms and school supplies, and provide meals to keep children in school.

The relationship between medicinal herb collection and financial security indicates that the policy on investing revenue-sharing (5–10% of tourism revenues) meant for developing infrastructures, such as schools, healthcare centers, and hospitals, might not be enough

to reduce community participation in illegal activities. This finding implies that when there is low household financial security, communities might not be able to afford the cost of requirements to keep children in school, obtain prescribed medicines, or visit hospitals, and might resort to illegally harvesting park resources to address their household insecurities. These findings support similar findings by Munanura et al. [98], indicating that indirect tourism benefits in Rwanda's VNP for communities may not be generating tangible conservation benefits. Therefore, policies addressing household livelihood security challenges targeting reduced illegal activity influencing mountain gorilla conservation in the VL should extend beyond infrastructure development and promote investment in projects to improve community financial security.

Findings identifying the relationship between specific household livelihood security (i.e., food, health, education, and financial) and illegal activities (i.e., poaching, wood cutting, bamboo cutting, and harvesting of medicinal herbs) suggest that decreasing the prevalence of illegal activities requires community development initiatives to address food, health, education, and financial challenges. For example, as seen in this study, if one issue in the VL is poaching, then conservation interventions are likely to be effective if they target livelihood security constraints beyond food. These constraints might include directly addressing health security constraints. However, if the issue is bamboo harvesting, an increase in food and financial security is unlikely to be an efficient deterrent. Therefore, to achieve conservation targets of protecting mountain gorillas and their habitats in the VL, community household livelihood security challenges should be considered a priority, and communities should be involved as beneficiaries and major stakeholders.

Although this study contributes to the literature by identifying ways household livelihood security and the perceived prevalence of illegal activities threatening mountain gorilla conservation in the VL, it has several limitations. First and foremost, this study only targeted community members living adjacent to the parks in VL (Uganda and Rwanda). Secondly, the research did not consider beneficiaries of revenue sharing and other projects. It is, therefore, unlikely that results may apply to all community members adjacent to the VL, particularly in the Democratic Republic of Congo (DRC). Therefore, there is a need for more research that incorporates DRC to have a complete representation of the VL. Finally, despite the insightfulness of the results presented for the VL region, there is potential for spatial bias. Illegal resource use and livelihood conditions may be different in Ugandan compared to Rwandan communities. Future studies on this issue in the region ought to control for spatial bias.

6. Conclusions

The increase in illegal activities across the VL has negative implications for mountain gorilla conservation and protection of their habitat; it calls for an understanding of causes linked to community household livelihood constraints. Although community conservation initiatives can improve household livelihoods [95,96], reduce community pressure on park resources, and limit negative impacts on mountain gorilla conservation [28,49,97], there is a need to understand specific areas in which investments that have the potential to influence and reduce illegal activities can be made in the VL. These household livelihood securities that require attention include food and finances. Understanding the relationships between illegal activities and household livelihood security will help inform policy revisions and equip protected area managers with information to help them make informed decisions, revise strategies, and make effective household livelihood investments across the VL. In the long run, these investments will reduce community reliance on park resources and alleviate household livelihood insecurities.

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