GESA
GLOCAL ENVIRONMENT & SOCIAL ASSOCIATION

International Journal of Biological Innovations
http://ijbi.org.in | http://www.gesa.org.in/journals.php
https://doi.org/10.46505/IJBI.2026.8115
IJBI 8(1): 137-146 **(2026)**
E-ISSN: 2582-1032

CONCEPTUALIZATION OF LOCAL COMMUNITY IN THE CONSERVATION OF THE VULNERABLE OWL-FACED MONKEY, *CERCOPITHECUS HAMLYNI*: NYUNGWE NATIONAL PARK, RWANDA

Methode Majyambere[1,3]*, Felix Niyonzima[2], Theogene Nsengiyumva[3], Laurent Twizeyimana[4] and Fidele Tugendahayo[5]

[1]Department of Biology, School of Science, University of Rwanda, Kigali, Rwanda
[2]ASTRIK International Ltd. Kigali, Rwanda
[3]Center of Excellence in Biodiversity and Natural Resource Management, Butare, Rwanda
[4]Fauna Trekking and Educational Tours Ltd, Kigali, Rwanda
[5]LIKANO Project Development GmbH, Nyarugenge, Rwanda

**Corresponding author*: m.majyambere@ur.ac.rw

Article Info:
Research Article
Received
08.12.2025
Reviewed
19.02.2026
Accepted
31.03.2026

Abstract: The owl-faced monkey, *Cercopithecus hamlyni*, is an understudied primate that exhibits elusive behaviour and is found in only two countries: the Democratic Republic of the Congo and Rwanda. With the help of certain projects, authors investigated the conservation status of this species, the factors driving local people to threaten its bamboo habitat in Nyungwe National Park (NNP) and opportunities to abandon illegal collection. A park-driven incentive program and bamboo plantations in community fields could not alleviate such threats. Potential solutions, including supporting bamboo users in cooperatives to optimise the dependency on bamboo from the community fields, were analysed. The authors suggest a bamboo value chain as a practical and flexible way forward—one that can serve as a reliable solution in the face of future contingencies. More research is urgently needed to reassess the community dimension of *Cercopithecus hamlyni* conservation and to more extensively investigate its population ecology in NNP. The study highlights the urgent need to conserve the owl-faced monkey and emphasises the importance of taking timely and effective measures. It not only enhances our understanding of this unique species but also underscores the need for collective conservation efforts. Additionally, it points toward practical strategies to safeguard its habitat from growing threats that could otherwise lead to its local extinction.

Keywords: Bamboo habitat, Conservation, Local community, Owl-faced monkey, Rwanda, Threats.

Cite this article as: Majyambere M., Niyonzima F., Nsengiyumva T., Twizeyimana L. and Tugendahayo F. (2026). Conceptualisation of local community in the conservation of the vulnerable owl-faced monkey, *Cercopithecus hamlyni*: Nyungwe National Park, Rwanda. *International Journal of Biological Innovations*. 8(1): 137-146. https://doi.org/10.46505/IJBI.2026.8115

INTRODUCTION

The owl-faced monkey, also known as Hamlyn's monkey or owl-faced guenon, was first described in 1907; therefore, the species is named *Cercopithecus hamlyni* Pocock, 1907. Currently, *Cercopithecus hamlyni* is found in the Democratic Republic of the Congo (DRC) and Rwanda only (Hart *et al*., 2012). Subspecies have been described, including *C. hamlyni hamlyni* and *C. hamlyni kahuziensis*, with the former being the subspecies located in Nyungwe Forest (Colyn and Rahm, 1987), currently known as Nyungwe National Park (NNP), located in south-

western Rwanda. Together with the recently described species *Cercopithecus lomamiensis,* the two species make the *hamlyni* lineage, a threatened sister group mainly affected by anthropogenic factors, rather than genetic ones, with geographically separated populations (Hart *et al.*, 2012; Jensen *et al.*, 2025).

In Ituri Forest in the DRC, the results of earlier surveys on the abundance and densities of anthropoid primates described the species as exceedingly rare, with only one individual detected during the survey (Thomas, 1991). However, at Kahuzi-Biega, the owl-faced monkey seemed to be an overspread and common species; they were also relatively common among the primates that fed on the fruits of tree *Myrianthus holstii* and exhibited diurnal behavior (Hall *et al.*, 2003). More recent data indicate that the species is still much common among other mammals in camera traps in the Nkuba Conservation Area in the DRC, not far from Kahuzi-Biega (Van der Hoek *et al.*, 2023).

The main habitat of the owl-faced monkey in Rwanda is the bamboo (Easton *et al.*, 2011). Such a bamboo forest was also the main habitat in Kahuzi-Biega from the DRC (Colyn and Rahm, 1987). The alpine bamboo *Oldeania alpina*, formerly known by the names *Arundinaria alpina*, *Sinarundinaria alpina*, or *Yushania alpina*, is widely distributed across central Africa (POWO, 2025). In Rwanda, the park leadership has taken measures to protect the bamboo habitat of NNP from illegal harvesting after realising that bamboo was the main diet and habitat shelter of the owl-faced monkey (Chao *et al.*, 2011; Pascual *et al.*, 2014).

Globally, bamboo is a forest product of significant economic importance with versatile functions in human life and in industrial processes (Bull and Nilsson, 2004; Kigomo, 2007; Brias and Hunde, 2009). Due to its high biomass and high regeneration capacity in favourable conditions, it is a resource mostly used by rural poor communities (Mathewos, 2017). Bamboo from protected areas, such as those in Uganda, has been facing many anthropogenic threats, especially illegal harvesting, which has implications for the survival of primates that depend on it (Twinomugisha and Chapman, 2007; Tumusiime *et al.*, 2011). Especially, people were sometimes reluctant to plant bamboo in their farmlands, and the bamboo from the park was almost the sole source of income for some local people (Tumusiime *et al.*, 2011). The identification of threats in protected areas within the Greater Virunga Landscape, ranging between Rwanda, DRC, and Uganda, revealed that illegal bamboo collection was one of the major threats identified by ranger patrols and surveys (Plumptre *et al.*, 2014).

In NNP, illegal bamboo collection was reported. In 2001, bamboo was identified as one of the forest products sold on local markets, despite being illegally collected (Masozera and Alavalapati, 2004). Between 2008 and 2009, illegal bamboo collection remained the primary threat to the habitat of the vulnerable owl-faced monkey, and the problem was exacerbated by inefficient transboundary control and difficult collaborative mechanisms between Burundi and Rwanda (Easton *et al.*, 2011). Illegal bamboo collection occurred mainly for the purpose of construction, basket weaving, mats, and roofing (Easton *et al.*, 2011; Gross-Camp *et al.*, 2012). In the south-eastern section of NNP, the various uses of bamboo include construction (poles for walls, roofs, and fences), agriculture (poles for climbers and bananas, as well as channeling water), and handicrafts and domestic materials (chairs, baskets, and beds) (Majyambere, 2018). Crawford (2012) noted that poverty and unemployment are significant factors in resource access conflicts around NNP.

The regeneration capacity of the highland bamboo, *Oldeania alpina* has been greatly reduced due to indiscriminate and destructive harvesting methods, and its uncontrolled extraction has reduced productivity and habitat quality in the natural habitats (Brias and Hunde, 2009). Conservation managers seek ways to improve livelihoods and opportunities for the most vulnerable communities, while still conserving a protected area and its biodiversity. Adequate information about bamboo technology and policy, research development (such as training and laboratory facilities), as well as effective collaboration with stakeholders, are the key strategies adopted by institutions to promote bamboo (Bonsi, 2009). Due to the increasing demand for bamboo and the lack of alternative resources, it is imperative to improve collaboration between various stakeholders and rural communities to understand and effectively monitor the bamboo value chain (Phimmachanh *et al.*, 2015).

The research is focused on the primate species *Cercopithecus hamlyni* and the bamboo found in NNP, which is the natural habitat of a vulnerable monkey species. This contribution was necessary because the monkey species occurs in a small, restricted area of bamboo and bamboo-forest mix (32 km^2) in the zone of connection between the Nyungwe (Rwanda) and Kibira(Burundi) National Parks (Easton *et al.*, 2011). Authors showed a long-standing interest in studying the primates of NNP before that project was demonstrated by an academic research project on chimpanzees (Majyambere, 2009) and proactive involvement in 2013 in two projects, one focused on primates as seed dispersers (Martino, 2015) and chimpanzee habitat use (Kaplin, 2014). As a result, authors procured more knowledge about the species in NNP, which was not covered by any particular study, except Easton *et al.* (2011).

A project related to the same site targeting and same species allowed the authors to document and to consult directly with the author (Tumwesigye, 2014). Baseline information was acquired through consultation with the park staff and the research unit. During the preparation of the 2017-2018 conservation action project, it was revealed that local communities near the bamboo area of the Nyungwe forest, especially in adjacent sectors (Nyabimata, Ruheru, Busanze) of Nyaruguru District, were still frequently using bamboo from the park for construction, basket weaving, and roofing. The incentive program of tourism revenue sharing with the communities around protected areas of Rwanda, noted by some authors such as Sabuhoro *et al.* (2017) and Akayezu *et al.* (2022), and other conservation incentives, such as support for bamboo planting, have been applied without yielding pragmatic results in that community. The authors aimed to contribute to assessing the measures that would contribute to future conservation efforts for the owl-faced monkey for its long-term conservation.

The owl-faced monkey, *Cercopithecus hamlyni* was lastly assessed in 2018 (Hart and Maisels, 2020). Its first assessment in 1986 resulted in its categorization as 'Insufficiently Known', and subsequent assessments defined it as 'Vulnerable' (VU), except in the period of 1996-2007, where it was considered as Near Threatened (NT) (Hart and Maisels, 2020). In general, insufficient knowledge is available about the species. The fact that this species remains unstudied is not unique to this study; this was also highlighted by Hart *et al.* (2012) and Jensen *et al.* (2025) as well. The main objectives of this study were to investigate the knowledge about *Cercopithecus hamlyni* through field surveys and from the local communities, and the potential measures that can help to reduce illegal bamboo collection threatening its restricted habitat and the long-term survival of its population. Through this research, contributions were also made to conceptualise community-based initiatives that can foster alternative means and skills for communities, aiming to prevent further threats to the bamboo cover in NNP, which is the key habitat of the vulnerable species.

MATERIALS AND METHODS

Study area description and the study species

The study was conducted in Nyungwe National Park (NNP) and two administrative sectors of Nyaruguru District located adjacent to the NNP's south-eastern zone, namely the Ruheru and Busanze sectors (Fig. 1). The targeted conservation focus for this research was the bamboo habitat in NNP, which hosts the vulnerable owl-faced monkey, *Cercopithecus hamlyni*, among other wildlife components of the tropical mountain rainforest, such as the data-deficient (DD) Itombwe owl, *Phodilus prigoginei* and the Kungwe apalis, *Apalis argentea* then endangered (EN) but currently least-concern (LC) (Tumwesigye, 2014). The owl-faced monkeys inhabit a restricted range of bamboo in the south-eastern part of the park, near the borders of NNP with Kibira National Park of Burundi (Easton *et al.*, 2011). They depend mostly on the bamboo habitat in NNP, and during earlier surveys of these elusive animals, one group has been observed (Chao *et al.*, 2011).

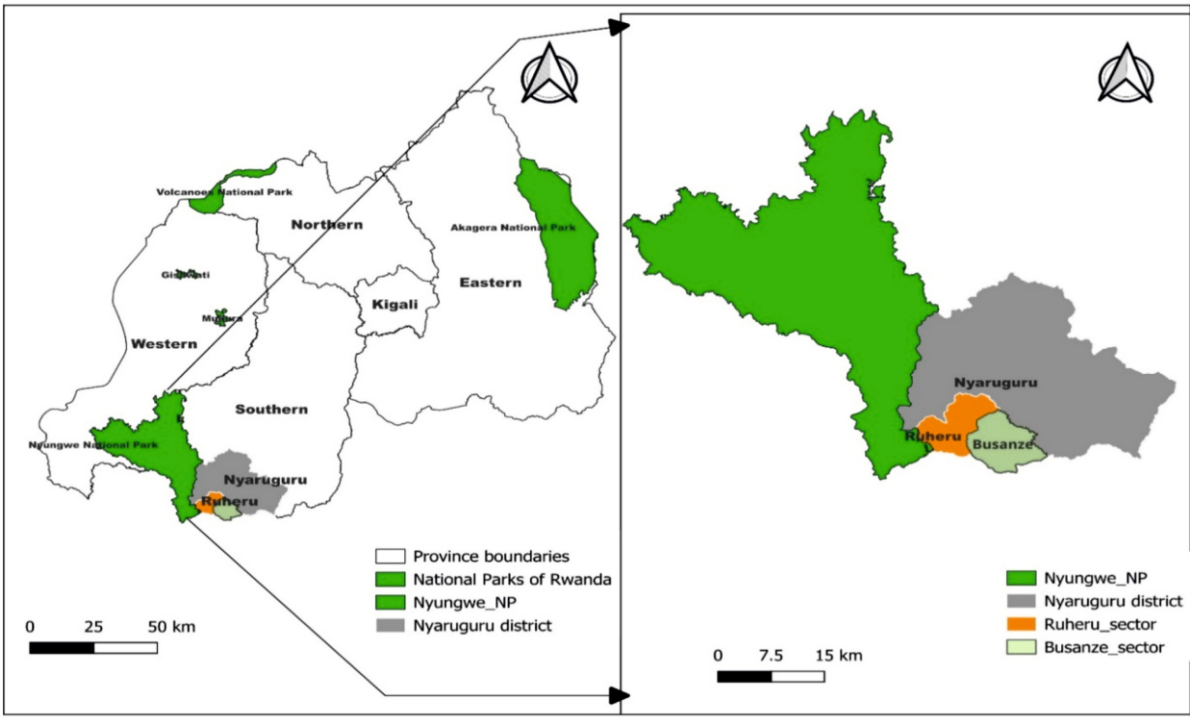

Fig. 1: Location of the study area, indicating Nyungwe National Park and two sectors where local communities are involved in bamboo conservation issues.

Sampling design and data collection

The fieldwork carried out in 2017, focused on understanding the threats present in the forest and surveying owl-faced monkeys in their natural habitat. Study locations were carefully chosen based on ease of access, safety, and closeness to forest edges, especially in bamboo-rich areas that are under increasing pressure. Observations and data were gathered along forest trails, extending 5-10 meters on either side, as well as within 20 × 20 m plots established in the field. Along reconnaissance paths and known poaching routes, different types of threats were also noted. Furthermore, in August, 2017, a field visit organised by the park authorities took place, involving local stakeholders and security personnel.

In 2017, the surveys in the communities considered the two sectors, where local people have been more actively involved in conflicts with the park. Cells with heavy bamboo exploitation were chosen, especially where local people were familiar with past conservation efforts such as incentive schemes, revenue-sharing programs, and bamboo propagation activities. Five cells were selected from the two sectors, including three cells from the Ruheru Sector and two cells from the Busanze Sector. Systematic random sampling was used to select respondents. One way to apply it is to have a list of population elements and randomly identify a starting point, after which elements are selected using a sampling interval (Dattalo, 2008). Accordingly, a total of 159 household members were selected for participating in interview sessions, comprising 89 individuals from the Ruheru sector and 70 individuals from the Busanze Sector. The respondents were selected from the list of inhabitants (reduced to households as the focus units) kept in the offices of the respective cells. Structured questionnaires were administered to the heads of families. In addition, focus group discussions (FGDs) were used to collect information that could not be completely or accurately accessed through individual interviews.

A survey was conducted in August and September months of 2018, focusing on individual interviews with representatives of household members. In total, 181 household members participated in the interview, comprising 104 individuals from Ruheru Sector and 77 individuals from Busanze Sector. The survey took approximately three weeks to complete. Another survey was conducted in May 2019, which consisted of a FGD in the Ruheru Sector and another in the Busanze Sector. Up to 8 people, including local leaders at the sector, cell, or village level, cooperative leaders, park informers, and community members actively participated in FDGs. Collaborative strategies were also explored to identify sustainable ways of addressing the problem. In February 2022, a final survey was carried out, involving interviews with 79 household members to better understand their knowledge, skill and awareness of biodiversity conservation.

To explore existing knowledge about the owl-faced monkey, we comprehensively reviewed the literature on the species, focusing on peer-reviewed articles and scientifically reliable online sources such as the IUCN and the Mammal Diversity Database. Such literature could help examine the extent to which this species has been covered in research, fieldwork, conservation efforts, and journal articles. Therefore, efforts were made to review all existing literature on the species, providing species information covered in the introduction and additional details in the discussion section.

Data analysis

Data analysis was conducted using both qualitative and quantitative approaches, as applicable to the various types of results. The data were first treated in Excel for arrangement, sorting, and cleaning. Quantitative analysis of data was conducted using both RStudio and Microsoft Excel analysis tools to produce charts or tables. In RStudio, ggplot2 and various interactive packages such as tidyverse, dplyr, and ggpubr were used. Bar charts and tables were generated using the Pivot Table tools, primarily with frequencies expressed as percentages of respondents for each question. Several types of data, such as FGD outputs, workshop and surveys were analysed qualitatively by compiling and summarising them in a convenient format according to how they align with the objectives. A bamboo value chain framework based on reflections on its likely format was proposed, considering the overall situation at hand and the outcomes of the workshop. The maps included in this article were produced through mapping tools from the QGIS Software.

RESULTS AND DISCUSSION

Knowledge of the threats to the owl-faced monkey and its habitat

Illegal activities occurring around the bamboo habitat of NNP are generally dominated by bamboo cutting, as indicated by both field observations and community data (Fig. 2). While the frequencies of responses from the people differ slightly based on their knowledge of threats, various types of threats were recognized by the people, where illegal bamboo collection (22.07%) was only slightly higher than the other illegal activities (Fig. 3). The experiences and understanding of the local people on the threats were especially influenced by their perceptions of deprivation, since they consider that poverty is the main driver of illegal activities (97.99% of responses), while bamboo

illegally collected from the park is much more affordable by the communities. Considering the results from the field survey, there is a significant difference in illegal bamboo cutting compared to other threats, as observed in the field (Fig. 3). Some observations from the communities were not documented in the field, as the field work focused on the bamboo habitat only.

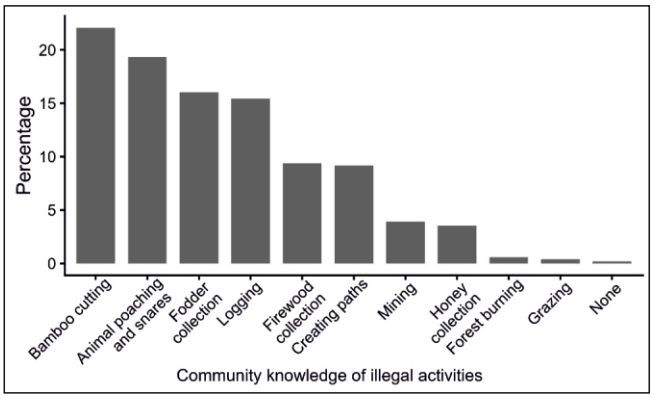

Fig. 2: Summary of the knowledge of illegal activities around the bamboo habitat from interviews conducted in the communities around, as per 2017-2018 surveys.

Most of the threats observed were recent, through estimation with guidance from park rangers, that those spanning only six months could be relatively recent, while those extending beyond that period could be older. The owl-faced monkeys indirectly by sound (twice) or movement (four times) were recorded during the study period. Preliminary observations indicated that *C. hamlyni* could be detected in areas with fewer threats and avoided areas with more threats. In the field excursion event, many parts of bamboo were cut but remain inside the forests in large piles (Fig. 4).

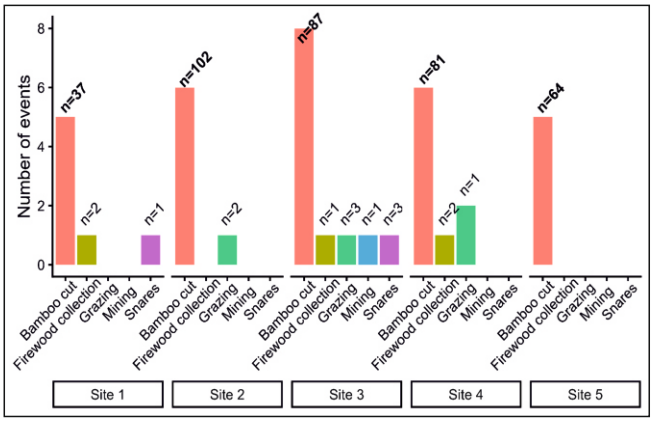

Fig. 3: The prevalence of threats as documented in five selected sites in the bamboo habitat of Nyungwe National Park in the 2017-2018 field study (The number of events encountered are on the y-axis, while the counts of individual observations are in the figure; for the bamboo, the numbers refer to individual bamboo cuts that were counted).

Fig. 4: A sample of threatened bamboo habitat, where piles of bamboo cuts can be found in the forest (A), and some thriving bamboos are cut selectively (B).

Conservation and management dimension

The local communities feel that several combined measures need to be applied to protect the bamboo habitat and, consequently, the owl-faced monkey, including, among the main ones, strict measures against wildlife encroachment, increased efforts in conservation education, and park employment opportunities for local communities. From the Rufford-funded project validation, the transboundary issue was a key concern. Regarding the transboundary issue, which is still pending in diplomatic and cooperative arrangements, several approaches have been proposed (Table 1). The major ones emphasise a collaborative framework.

Status of bamboo propagation as an intermediate solution

Several inventive strategies have been applied in the two sectors of the study; however, one of the main strategies was bamboo propagation in people's fields to increase yield and reduce the tendency to resort to bamboo from the park. The survey of all existing bamboo plots or clumps selected three cells as samples due to their relatively higher bamboo density. Field surveys revealed the presence of 146 bamboo patches (Fig. 5), with the first two largest measuring 1,880.45 m^2 and 722.56 m^2. The total surface covered by bamboo was 9,922.5 m^2; 1024 were counted as mature bamboo culms that can be harvested.

Bamboo value chain framework

The key informants and local communities highlighted that the priority measure for sustainably conserving the bamboo habitat in Nyungwe is based on a strategy to reduce bamboo needs while promoting the value of bamboo products. This should ensure that the use of bamboo is minimal and profitable, while other uses of bamboo should be progressively restricted. The most common off-farm support opportunities mentioned by the local community are

based on financial assistance to the communities through an efficient and transparent scheme. Therefore, if local communities need support from the park, this support will be channeled through community cooperatives and implemented under sustainable business models. Handicrafts made from bamboo are a key profitable business once cooperatives are linked with remote markets through a bamboo value chain framework. Through the integration of expert and local knowledge, we identified key components of the bamboo value chain as desirable.

Table 1: Collaborative mechanisms on the Rwanda-Burundi border of NNP.

S. No.	Measure to be taken	Number of responses	Percentage
1.	Collaborative judicial framework	111	28.91%
2.	Collaborative Park authorities	97	25.26%
3.	Efficient collaborative work of park rangers	88	22.92%
4.	Efficient security work on the country's borders	47	12.24%
5.	Promotion of information-sharing networks	37	9.64%
6.	Collaborative local governance units	4	1.04%

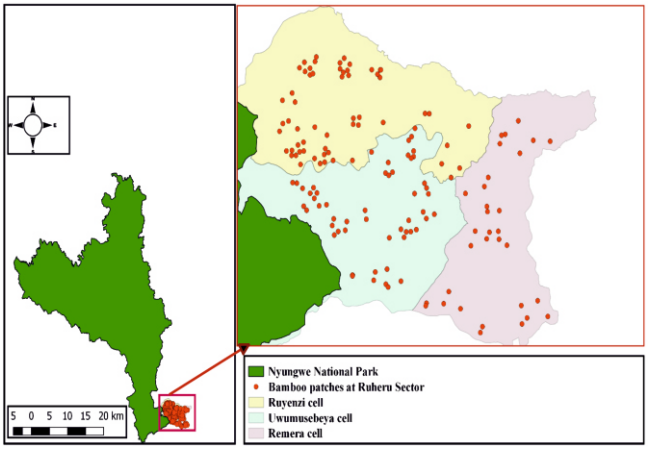

Fig. 5: Map of the visited patches of bamboo in three cells of the Ruheru Sector.

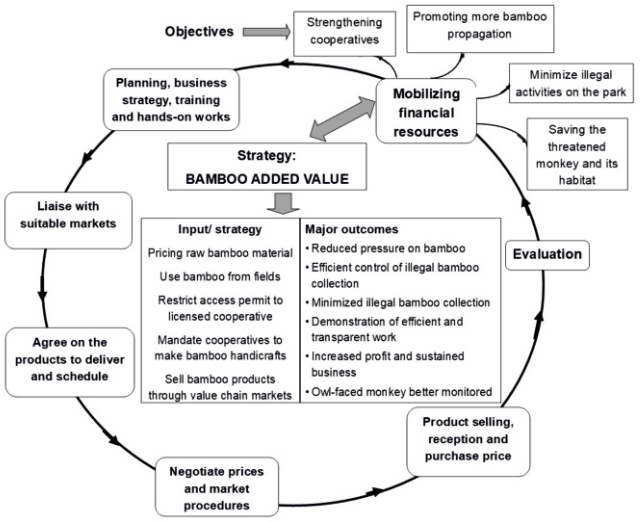

Fig. 6: Initial conceptualisation of bamboo value chain development as a key step towards addressing the problem of illegal bamboo collection in Busanze and Ruheru Sectors.

The initial framework under which future research using economic analysis, relevant socio-economic metrics, and market analysis could be used as a basis to initiate a strong business model. This will be promoted nicely by the park, and they will integrate equal contributions of ecologists, park managers, and socio-economic analysts, and involve different categories of users (consumers, buyers, and producers). Different operators should play specific roles and obtain interests in all stages of the bamboo value chain, from raw material sourcing to the commercialisation of final products (Fig. 6). Specific management measures and options can be analysed at each step of the chain.

Observations of the owl-faced monkey in the field have been scarce to the extent that only a few photographic records of this species exist outside zoos. The primate could not be sighted in its habitat for six days during the survey. Studying the ecology of owl-faced monkeys is currently a challenging research task, as sightings are becoming increasingly difficult, mainly due to growing habitat disturbance. The limited number of park rangers constantly monitoring threats to the bamboo habitat prevents them from focusing on the ecological study of the species. Probably, the increasing threats that persisted in their habitats caused the monkeys to shift their ranges or exhibit other behavioural changes, making them more elusive. Field research and phylogenetic studies have established that this species, together with its sister species *C. lomamiensis*, is terrestrial in habit, unlike other arboreal cercopithecine species (Hart *et al.*, 2012; Fournier *et al.*, 2023; Jensen *et al.*, 2025). However, this terrestrial behavior has not yet been documented in NNP; adding to the information from the park rangers who sporadically spotted the species, it was found that they move in the heights of the bamboo trees. Adding to the several other speculative

accounts of the owl-faced monkey, its highly elusive behaviour makes it poorly understood.

In Rwanda, bamboo is a versatile plant resource cultivated by local communities mainly in humid zones and valleys, particularly near rivers. It is also a natural resource found in protected areas, especially Rwandan tropical forests, including Volcanoes National Park, Nyungwe National Park, and Gishwati Forest. The bamboo preference of *C. hamlyni* is not known only in Nyungwe, but was also noticed in the DRC, where the new subspecies was documented (Colyn and Rahm, 1987). The global distribution of the species is limited. Some sources have noted the uncertain presence of *C. hamlyni* in Burundi (De Jong and Butynski, 2012). This should still be possible, given that the bamboo forest is located at the boundary with Kibira National Park, and this park still has a small stretch of bamboo; however, no formal document exists regarding its range in Burundi. The density of the owl-faced monkey, estimated using line transect surveys in Kahuzi-Biega National Park, was very low compared to other monkey species, underscoring its elusive behavior (Plumptre *et al.*, 2022).

Poverty is cited as a factor contributing to the continued use of bamboo in crafts among the people living in the vicinity of the bamboo habitat, as they feel deprived of their livelihood opportunities (Pascual *et al.*, 2014). One of the primary actions to address local community needs involved establishing bamboo plantations in community fields. A revenue-sharing program aimed to integrate local communities in sustainable conservation efforts and emphasise their active role in addressing livelihood-related issues. However, these measures did not prevent people from illegally harvesting bamboo from the park, as observed over the last few years (Majyambere, 2018). Intense pressure on the natural bamboo has led to noticeable negative effects, including subsequent poor yields and permanent canopy cover gaps (Twinomugisha and Chapman, 2007). Bamboo was widely used in construction, but this has shifted to a greater emphasis on handicraft items. Sustainable measures that strategically lead to reduced bamboo use are more promising. If bamboo continues to be used for several purposes, pressure on the park will increase accordingly.

Law enforcement alone cannot provide a sustainable solution to illegal activities surrounding Rwandan parks such as the Volcanoes National Park; instead, park managers should exert positive efforts to include the local community as essential stakeholders in all decision-making processes (Munanura et *al.*, 2018). In future conservation efforts, communities should be involved in park management. The transboundary dimension of the issue is critical in the area of study (WCS, 2009; Easton *et al.*, 2011; Majyambere, 2018). The two forest ecosystems (Nyungwe and Kibira) are continuous and constitute the Nyungwe-Kibira complex. Over the last decade, suspicions had arisen about security issues within and around the bamboo habitat zone, with significant consequences for research and monitoring efforts, affecting much of the park rangers' work at the site (Majyambere, 2018). This ultimately made the monitoring of the ongoing bamboo cutting issue more challenging.

The long-term strategy in Nyungwe should carefully consider species that are vulnerable to habitat loss and habitat selectivity, which face silent but intense threats such as those faced by the owl-faced monkey. In fact, a study called for considering many mammals that are vulnerable to hunting, rather than focusing on a single charismatic species, which helps conserve an entire range and reduces biases in ecological observations (Inogwabini *et al.*, 2000). The global situation of the owl-faced monkeys, which appears stable, should be an artefact created by the presence of large stretches of forests in the DRC. Hunting has always been reported for the owl-faced monkeys and other mammals in the DRC. Hunting and habitat destruction have long been recognised as major threats; however, the persistence of human conflicts around these habitats further hinders conservation efforts and exacerbates existing threats (Hart and Maisels, 2020). Thus, attention needs to be directed to the restricted habitat in Rwanda, as well as to reassessing this species.

The transboundary issue has been identified as an impediment to realizing a sustainable solution for bamboo at the research sites, noted by Easton *et al.* (2011) and Crawford (2012). The latter indicated that weak management strategies were particularly noticeable on the side of Burundi, jeopardising the situation of bamboo on both sides. If the collaboration is not promptly effective, while other strategies are being explored, alternative measures or approaches can still be mobilised. One such approach is to invest more in regular awareness campaigns about the species and reinforce the ranger-based patrols in the area of the vulnerable species. Regular monitoring of the species should be planned with the same efforts as the ones invested in chimpanzees and colobus monkeys, which are main primate attractions for tourism. Even if habituation of the owl-faced monkey is not an endeavor that can bear promising results in

the near future, research projects will be triggered with many funding and fundraising options arising. Since community involvement in the conservation of the species is imperative, education programs should be regularly supported or implemented by the park. In the meantime, we call for a long-term plan that can lead to addressing the root cause of the threats, thus a bamboo value chain framework.

Specifically, Mekonnen *et al.* (2014) recommended measures to reinforce community cooperatives in their use of bamboo, in promoting value chains, and building strong entrepreneurship, which aligns with our proposed approach. That study provides a broader framework that can be useful once bamboo production is increased, extending business models beyond handicrafts. A more recent study of Lee *et al.* (2021) found that the local people's use of bamboo chains as the primary product in the market increased benefits by nearly four times compared to trading raw bamboo to end markets. In our case, there will be no intermediate traders to acquire raw bamboo.

In the present investigation, an initial concept for its future development has been provided. The cooperatives would purchase raw bamboo directly from communities and be trained to produce final products for sale in markets. As conceptualised, once they have achieved some benefits, they can shift away from dependence on external funding by utilising the funds they have acquired throughout the project cycle and improve their business.

The development of the bamboo value chain will be a promising solution to the significant challenge. Possibly be a source of funding be a source of funding or a complementary strategy for long-term capacity building for the communities. This requires licensing the certified community cooperative, which will help efficiently monitor all illegal users.

Bamboo handicrafts should be a sustainable tourism business, and the products are in high demand among many museums across the Rwanda, especially the ethnographic museum, where they can be purchased at reasonable prices, ultimately benefiting high-end businesses. Many other markets and tourism destinations in Rwanda can partner with these cooperatives to establish sustainable value chains. With this strategy, bamboo products from community fields alone can provide a sustainable income for the people who use them, thereby stimulating efforts to propagate bamboo without relying on resources from the park. Such measures should directly contribute to safeguarding the vulnerable species.

CONCLUSIONS

Present study clearly highlighted that the existing information on the distribution, ecology, behavior, and conservation of the owl-faced monkey remains limited. The local people in the two sectors adjacent to the bamboo habitat of NNP in Rwanda, the only other habitat of the species outside the DRC, still illegally harvest bamboo; however, the rate at which this occurs is not currently well documented. The community education, collaborative conservation work, and restrictive measures on bamboo use are key strategies, alongside pragmatic interventions for the livelihoods of the local communities. While short-term interventions are possible, a long-term strategy should help both restrict the bamboo use while generating tangible benefits to licensed bamboo users. Creating a sustainable business through a bamboo value chain framework can help licensed bamboo users benefit from their operations while relying solely on bamboo sourced outside the park. Implementing a value chain framework and monitoring the outcomes to inform improvements in the practice will be a long-term strategy. Furthermore, conservation strategies need to be leveraged, and the park's priorities adjusted to keep under control the factors that could jeopardise the long-term survival of the owl-faced monkey in NNP.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

ACKNOWLEDGEMENTS

The authors are grateful to the Rufford Foundation for the funding (RSG-21933-1), the Rwanda Development Board for the research permits, the Wildlife Conservation Society for technical and scientific support, Nyaruguru District office for permitting access to the communities and socio-economic data, the Protestant Institute of Arts and Social Sciences for workshop hosting facilities and other people for their valuable contribution in this research.

REFERENCES

1. **Akayezu P., Ndagijimana I., Dushimumukiza M.C., Bernhard K.P. and Groen T.A.** (2022). Community livelihoods and forest dependency: Tourism contribution in Nyungwe National Park, Rwanda. *Frontiers in Conservation Science*. 3: 1034144. https://doi.org/10.3389/fcosc.2022.1034144
2. **Bonsi R.** (2009). Adoption of bamboo in Ghana's forest products industry: An investigation of the principal exporters and institutions. Virginia Polytechnic Institute and State University, Blacksburg, 240 pp. http://hdl.handle.net/10919/27851

3. **Brias V. and Hunde Tesfaye** (2009). Bamboo cultivation manual: Guidelines for cultivating Ethiopian highland bamboo. United Nations Industrial Development Organization (UNIDO), Vienna, 58 pp.
4. **Bull G.Q. and Nilsson S.** (2004). An assessment of China's forest resources. *International Forestry Review*. 6(3-4): 210-220. https://doi.org/10.1505/ifor.6.3.210.59979
5. **Chao N., Mulindahabi F., Easton J., Plumptre A.J., Seimon A., Martin A. and Fimbel R.** (2011). Long-term changes in a montane forest in a region of high human population density, pp. 147-174. In: Long-term changes in Africa's Rift Valley: Impacts on biodiversity and ecosystems. Nova Science Publishers, US. http://ir.must.ac.ug/handle/123456789/777
6. **Colyn M. and Rahm U.** (1987). *Cercopithecus hamlyni kahuziensis* (Primates, Cercopithecidae): Une nouvelle sous-espèce de la forêt de bambous du Parc National 'Kahuzi-Biega' (Zaïre). *Folia Primatologica*. 49(3-4): 203-208. https://doi.org/10.1159/000156324
7. **Crawford A.** (2012). Conflict-sensitive conservation in Nyungwe National Park: Conflict analysis. International Institute for Sustainable Development, Manitoba, 19 pp.
8. **Dattalo P.** (2008). Determining sample size: Balancing power, precision, and practicability, Oxford University Press, New York, 167 pp. 10.1093/acprof:oso/9780195315493.001.0001
9. **De Jong Y.A. and Butynski T.M.** (2012). The primates of East Africa: Country lists and conservation priorities. *African Primates*. 7(2): 135-155.
10. **Easton J., Chao N., Mulindahabi F., Ntare N., Rugyerinyange L. and Ndikubwimana I.** (2011). Status and conservation of the only population of the Vulnerable owl-faced monkey Cercopithecus hamlyni in Rwanda. *Oryx*. 45(3):435-438. https://doi.org/10.1017/S0030605310001468
11. **Fournier C.S., Mc Phee S., Amboko J.D. and Detwiler K.M.** (2023). Camera traps uncover the behavioral ecology of an endemic, cryptic monkey species in the Congo Basin. *Animals*. 13(11): 1819. https://doi.org/10.3390/ani13111819
12. **Gross-Camp N.D., Martin A., McGuire S., Kebede B. and Munyarukaza J.** (2012). Payments for ecosystem services in an African protected area: exploring issues of legitimacy, fairness, equity and effectiveness. *Oryx*. 46(1): 24-33. https://doi.org/10.1017/S0030605311001372
13. **Hall J.S., White L., Williamson E.A., Inogwabini B.I. and Ilambu O.** (2003). Distribution, abundance, and biomass estimates for primates within Kahuzi-Biega lowlands and adjacent forest in eastern DRC. *African Primates*. 6(1&2): 35-42.
14. **Hart J.A., Detwiler K.M., Gilbert C.C., Burrell A.S., Fuller J.L., Emetshu M. *et al.*** (2012). Lesula: A new species of *Cercopithecus* monkey endemic to the Democratic Republic of Congo and implications for conservation of Congo's central basin. *PLoS ONE*. 7(9): e44271. https://doi.org/10.1371/journal.pone.0044271
15. **Hart J. and Maisels F.** (2020). *Cercopithecus hamlyni* (amended version of 2019 assessment). The IUCN Red List of Threatened Species. e.T4219A166615690.
16. **Inogwabini B.I., Hall J.S., Vedder A., Curran B., Yamagiwa J. and Basabose K.** (2000). Status of large mammals in the mountain sector of Kahuzi-Biega National Park, Democratic Republic of Congo, in 1996. *African Journal of Ecology*. 38(4): 269-276. https://doi.org/10.1046/j.1365-2028.2000.00223.x
17. **Jensen A., Horton E.R., Bisimwa K., Detwiler K.M. and Guschanski K.** (2025). Holotype genome of the lesula provides insights into demography and evolution of a threatened primate lineage. *BioRXIV*. 1-37. https://doi.org/10.1101/2025.06.05.657981
18. **Kaplin B.A.** (2014). Chimpanzee conservation in Nyungwe National Park, Rwanda: The impacts of buffer zone type and land use change. Final report to the U.S. Fish and Wildlife Service (Grant F12AP00411).
19. **Kigomo B.N.** (2007). An overview of bamboo and rattan sector in Kenya. Kenya Forestry Research Institute (KEFRl), Nairobi, 7 pp.
20. **Lee B., Rhee H., Kim S., Lee J., Koo S., Lee S., Alounsavath P. and Kim Y.** (2021). Assessing sustainable bamboo-based income generation using a value chain approach: case study of Nongboua village in Lao PDR. *Forests*. 12(2): 153. https://doi.org/10.3390/f12020153
21. **Majyambere M.** (2009). Diet, activity budget and home range of chimpanzees *Pan troglodytes schweinfurthii* in Cyamudongo Forest. Memoir dissertation, National University of Rwanda, Butare, 42 pp. https://doi.org/10.6084/m9.figshare.31727680
22. **Majyambere M.** (2018). Assessing conservation efforts, incentives, and current status of threats on the Hamlyn's monkey and its bamboo habitat in

Nyungwe National Park.The Rufford Foundation, London, 50 pp.
https://doi.org/10.6084/m9.figshare.31729222

23. **Martino R.M.** (2015). Matrix and edge effects on the maintenance of ecological function in an Afromontane protected area. Doctoral dissertation, Antioch Uni., New England, 125 pp.
https://aura.antioch.edu/etds/206

24. **Masozera M.K. and Alavalapati J.R.R.** (2004). Forest dependency and its implications for protected areas management: A case study from the Nyungwe Forest Reserve, Rwanda. *Scandinavian Journal of Forest Research*. 19(S4): 85-92.
https://doi.org/10.1080/14004080410034164

25. **Mathewos M.** (2017). Multiple uses of bamboo species and its contribution to forest resource management in Ethiopia. *Journal of Resources Development and Management*. 32: 123-130.

26. **Mekonnen Z., Worku A., Yohannes T., Alebachew M., Teketay D. and Kassa H.** (2014). Bamboo resources in Ethiopia: Their value chain and contribution to livelihoods. *Ethnobotany Research and Applications*. 12: 511-524.

27. **Munanura I.E., Backman K.F., Sabuhoro E., Powell R.B. and Hallo J.C.** (2018). The perceived forms and drivers of forest dependence at Volcanoes National Park, Rwanda. *Environmental Sociology*. 4(3): 343-357.
https://doi.org/10.1080/23251042.2017.1414661

28. **Pascual U., Phelps J., GarmendiaE., Brown K., Corbera E., Martin A., Gomez-Baggethun E. and Muradian R.** (2014). Social equity matters in payments for ecosystem services. *BioScience*. 64(11): 1027-1036.
https://doi.org/10.1093/biosci/biu146

29. **Phimmachanh S., Ying Z. and Beckline M.** (2015). Bamboo resources utilization: A potential source of income to support rural livelihoods. *Applied Ecology and Environmental Sciences*. 3(6): 176-183.
https://pubs.sciepub.com/aees/3/6/3

30. **Plumptre A.J., Fuller R.A., Rwetsiba A., Wanyama F., Kujirakwinja D. *et al.*** (2014). Efficiently targeting resources to deter illegal activities in protected areas. *Journal of Applied Ecology*. 51: 714-725.
https://doi.org/10.1111/1365-2664.12227

31. **Plumptre A.J., Kirkby A., Spira C., Kivono J., Mitamba G., Ngoy E., Nishuli R., Strindberg S. *et al.*** (2022). Changes in Grauer's gorilla (*Gorilla beringei graueri*) and other primate populations in the Kahuzi-Biega National Park and Oku Community Reserve, the heart of Grauer's gorilla global range. *American Journal of Primatology*. 83(7), e23288.
https://doi.org/10.1002/ajp.23288

32. **Pocock R.I.** (1907). On a new species of guenon of the genus *Cercopithecus* from the Ituri Forest. *Proceedings of the Zoological Society of London*. 677-681.

33. **POWO** (2025). Plants of the World Online.The Royal Botanic Gardens, Kew. https://powo.science.kew.org/. Accessed on 15 September 2025.

34. **Sabuhoro E., Wright B., Munanura I.E., Nyakabwa I.N. and Nibigira C.** (2017). The potential of ecotourism opportunities to generate support for mountain gorilla conservation among local communities neighboring Volcanoes National Park in Rwanda. *Journal of Ecotourism*. 20(1): 1-17.
https://doi.org/10.1080/14724049.2017.1280043

35. **Thomas S.C.** (1991). Population densities and patterns of habitat use among anthropoid primates of the Ituri Forest, Zaire. *Biotropica*. 23(1): 68-83.
https://doi.org/10.2307/2388690

36. **Tumusiime D.M., Vedeld P. and Gombya-Ssembajjwe W.** (2011). Breaking the law? Illegal livelihoods from a protected area in Uganda. *Forest Policy and Economics Journal*. 13: 273-283.
https://doi.org/10.1016/j.forpol.2011.02.001

37. **Tumwesigye W.** (2014). Transboundary conservation of *Cercopithecus hamlyni*, *Apalis argentea*, *Phodilus prigoginei*, and their habitat, RSG-13518-1. The Rufford Foundation, London, 16 pp.

38. **Twinomugisha D. and Chapman C.A.** (2007). Golden monkey ranging in relation to spatial and temporal variation in food availability. *African Journal of Ecology*. 46(4): 585-593.
https://doi.org/10.1111/j.1365-2028.2007.00905.x

39. **Van der HoekY., Binyinyi E., Ngobobo U., Stoinski T.S. and Caillaud D.** (2023). Diversity and diel activity patterns of terrestrial mammals in the Nkuba Conservation Area, Democratic Republic of the Congo. *Oryx*. 57(1): 107-117.
https://doi.org/10.1017/S003060532100106X

40. **WCS** (2009). Ten year transboundary strategic plan (2009-2018), Nyungwe-Kibira Landscape. Wildlife Conservation Society, Kigali, 67 pp.