**Socio-Ecological Study around Kahuzi-Biega National Park: Survey on Local Perceptions of Forest Ecosystem Services, willingness to pay, and Commitment in Forest Conservation**

*Research project*

**Abstract:** Although the impact of deforestation has been profound around the Kahuzi-Biega National Park (KBNP) in South Kivu, Democratic Republic of Congo, local communities continue to depend heavily on forest ecosystem services. This study focuses on the local perceptions of these services and their engagement in conservation efforts across six villages: Caminunu, Cifunzi, Cibinda, Fendula, Mule, and Rambo, located within the Kalonge groupement. Utilizing a socio-ecological approach, the survey revealed that provisioning services are deemed most crucial, recognized by 64.7% to 82.4% of respondents. Support services are acknowledged by 11.8% to 29.4% of participants, while regulation services are less frequently mentioned, with only 5.9% citing their importance. Additionally, the willingness to pay for conservation initiatives was assessed, with a higher frequency of respondents (particularly in Cibinda, Cifunzi, Mule, and Rambo) showing a preference for contributing at the 0.50 level. In contrast, the lowest willingness to pay (0.00) was observed less frequently across all villages. These findings highlight the critical need for tailored conservation strategies that consider both the economic capabilities and ecological priorities of local communities. Future studies could explore long-term trends in willingness to pay and investigate the effectiveness of various conservation interventions, providing a deeper understanding of how to sustain both biodiversity and livelihoods in the face of ongoing environmental challenges.

**Keywords:** Deforestation, Forest Ecosystem Services, Kahuzi-Biega National Park, Community Engagement, Socio-Ecological Approach, Willingness to Pay, Conservation Strategies, Biodiversity, Sustainable Livelihoods.

1. **Introduction**

The Kahuzi-Biega National Park (KBNP), situated in the eastern Democratic Republic of the Congo (DRC), is a UNESCO World Heritage site renowned for its exceptional biodiversity. The park is particularly famous for being home to the critically endangered Eastern Lowland Gorilla (Gorilla beringei graueri), which continues to draw global attention (UNESCO, 2023). KBNP spans an impressive area of over 6,000 square kilometers, encompassing both lowland and montane forests. This vast expanse plays a vital role in the conservation of numerous species, many of which are endemic or endangered, and serves as a critical source of ecosystem services that sustain the livelihoods of the surrounding communities (Imani, 2017).

However, the park faces mounting challenges that threaten its ecological integrity and the well-being of local populations. Deforestation, poaching, and human encroachment are persistent issues exacerbated by socio-economic pressures and political instability in the region (Balezi, 2023). These threats not only jeopardize the rich biodiversity within the park but also compromise the ability of the forests to provide essential ecosystem services, such as carbon sequestration, water regulation, and soil fertility (Ferguson, 2022). The degradation of these services has direct and often severe consequences for the local communities who depend on them for their daily needs.

Given these challenges, there is a pressing need to understand local perceptions of forest ecosystem services and the extent to which communities are willing to engage in conservation activities. Such understanding is crucial for developing effective conservation strategies that are both ecologically sound and socially acceptable. Ecosystem services, as defined by the Millennium Ecosystem Assessment (2005), are the benefits that humans derive from ecosystems. These include provisioning services like food and water, regulating services such as climate regulation and disease control, supporting services like nutrient cycling, and cultural services that provide recreational, spiritual, and aesthetic benefits. In the context of KBNP, the surrounding communities rely heavily on these services, particularly through agriculture, the collection of non-timber forest products (NTFPs), and water supply (Balezi, 2023).

The importance of ecosystem services to local communities cannot be overstated. Recent studies have highlighted the critical role that local knowledge and perceptions play in shaping conservation outcomes. Incorporating local perspectives into conservation planning not only enhances the ecological effectiveness of conservation strategies but also ensures that they are more likely to be accepted and supported by the communities involved (Jean de Dieu et al., 2015; Balezi et al., 2023). Local communities often possess a deep understanding of the ecological processes and cultural significance of their landscapes, which can be leveraged to promote sustainable forest management and conservation initiatives (Mukumba et al., 2022).

Despite this, there remains a significant gap in our understanding of how these communities perceive the value of forest ecosystem services and their willingness to support conservation efforts. Perceptions of ecosystem services can vary widely among different stakeholders, influenced by factors such as socio-economic status, education, and proximity to the forest (Elisabeth et al., 2024). For instance, communities that are heavily dependent on forest resources for their livelihoods may place a higher value on provisioning services, while those further away may appreciate the cultural or regulating services provided by the forest (Berihu et al., 2024). Understanding these diverse perceptions is crucial for designing conservation interventions that are aligned with local priorities and capacities.

One approach to assessing the value that individuals place on ecosystem services is through the concept of willingness to pay (WTP). WTP studies are commonly used in environmental economics to estimate the economic value of conservation initiatives and to gauge public support for environmental policies (Qi, 2024). In the context of KBNP, assessing the WTP among local communities can provide valuable insights into the feasibility of implementing payment for ecosystem services (PES) schemes or other market-based conservation approaches (Murhula, 2024). Such approaches could potentially provide a sustainable funding mechanism for conservation activities while also offering direct benefits to the communities involved.

The commitment of local communities to forest conservation is influenced by a complex interplay of social, economic, and cultural factors. Research has shown that communities are more likely to engage in conservation activities when they perceive tangible benefits, such as improved livelihoods or enhanced ecosystem services (Miriam et al., 2022). Conversely, conservation efforts that are perceived as restrictive or that fail to address local needs can lead to resistance and conflict (Peng et al., 2024). Engaging local communities in conservation requires not only addressing their immediate needs but also fostering a sense of stewardship and ownership over conservation initiatives (Azlan, 2024). This can be achieved through participatory approaches that involve communities in decision-making processes, provide them with clear benefits, and build their capacity for sustainable resource management (Peng et al., 2024).

In the case of KBNP, integrating local knowledge, providing alternative livelihoods, and strengthening local institutions have been identified as key factors for successful conservation outcomes (Miriam et al., 2022). By involving communities in conservation efforts and ensuring that they receive tangible benefits, it is possible to build a more sustainable and resilient approach to forest management. This study aims to explore the socio-ecological dynamics around KBNP by examining local perceptions of forest ecosystem services, their willingness to pay for conservation efforts, and their commitment to forest conservation. Through this exploration, the study seeks to contribute to the development of more effective and inclusive conservation strategies that align with the needs and aspirations of local communities.

Understanding the socio-ecological context in which conservation efforts take place is essential for ensuring that these efforts are not only successful in the short term but also sustainable in the long term. By addressing the socio-economic drivers of deforestation and forest degradation and by fostering a sense of ownership and stewardship among local communities, it is possible to create conservation strategies that benefit both biodiversity and human well-being.

1. **Study Area and Methodology**

*2.1. Study area*

This study was conducted in the mountainous eastern part of the DRC, in the South Kivu province, Kalehe territory, in the municipality of Kalonge, around the Kahuzi-Biega National Park (PNKB).

**MAP OF THE STUDY AREAS**

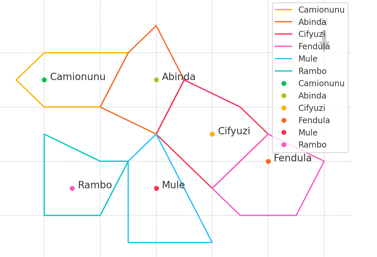


Figure 1 Map of the study area (github repository: [Kaloge-map-with-python](https://github.com/marcelinmurhula) ).

The Kalonge grouping spans an area of 750 km², bordered to the north by the Buholo community and the municipality of Kalima, to the south by the Kabare territory, to the west by the Kahumba and Biapoka rivers, as well as the Nyamusenge massif, separating it from the Shabunda area, and to the east by the Kahuzi-Biega National Park (PNKB) (Murhula, 2024). This territory is influenced by a mountainous climate, situated along the Tumba mountain range. Annual precipitation ranges between 1300 and 1680 mm, with an average annual temperature of 17.5ºC. Absolute maximum temperatures vary from 25.5ºC to 28ºC. Seasons are mainly divided into a rainy period, spanning approximately 9 months from September to May, and a dry season, lasting about 3 months from June to August (Mugisho et al., 2022).

# **2.2. Methodology of the study**

# *2.2.1. Local Perceptions of forest ecosystem services and engagement in conservation*

# This section focuses on local perceptions of ecosystem services provided by forests and evaluates the level of community engagement in conservation. This information was gathered through a survey in Kalonge. Then, This phase involved surveying local opinions on ecosystem services and forest ecosystem conservation in Kalonge. Through a two-day questionnaire, data were collected to achieve the aforementioned objective of the study.

# *2.2.2. Determination of sample size*

# A sample of 123 individuals was targeted for the survey in the Kalonge grouping. The formula used to determine the sample size (n), based on the population size of Kalonge (N) estimated at 189,900 individuals (SANRU, 2019), with a precision (e) of 0.9 (Lunjwire, 2022), was applied:

**n =**

However, only 103 individuals could be reached, representing 16.26% of the initial sample of 123 individuals. This reduction could be explained by the absence of some individuals during the survey or a shortage of participants engaged in the targeted activities for this study. Selection criteria for respondents included aspects such as residence in the study area and availability during the survey period, age (20 and above), and specific occupations related to the study (agriculture, forestry exploitation, and local forest management).

*2.2.3. Survey implementation*

Fendula, Cifunzi, Rambo, Mule, Caminunu, and Cibinda was the six villages targeted. In total, 103 people were able to participate in the survey. Several activities were identified in these villages, including agriculture, charcoal production, timber trading, non-timber forest product (NTFP) sales, and forest management. For agricultural activity, 30 people were surveyed, with 5 people per village. Similarly, 30 people were surveyed in the charcoal production sector, also considering 5 people per village. Regarding timber trading, 18 people were surveyed, with 3 people per village. Likewise, 18 people participated in the survey regarding NTFP sales; that is, 3 people per village. Regarding forest management, the participation of 6 people was obtained, with one person per village. The choice of the number of people per village was based on field observations, where the diversity of economic activities was evident. By prioritizing predominant activities such as agriculture and charcoal production and integrating less dominant sectors such as local forest management, timber trading, and NTFP sales, the selection reflected the diversity of local practices.

# *2.2.4. Analyzed parameters*

# The conducted analyses examined several variables in the context of different villages. These variables include local perceptions of ecosystem services, forest status (initial and current), and engagement in conservation. Each variable was broken down into different modalities. For example, perceptions of ecosystem services were divided into cultural, provisioning, regulating, and supporting services.

# *2.2.8. Data analysis*

# The survey questionnaire was entered into the Kobocollect application, and the database was subsequently extracted for analysis in Python data processing software.

1. **Results** 
   1. *Socio-economic characteristics of the people surveyed*

Tableau 1 Socio-economic characteristics of the people surveyed

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristic | Categories | Frequency (%) |  |
| Villages | Caminunu, Cibinda, Cifunzi, Fendula, Mule, Rambo | 17.5%, 15.5%, 13.6%, 11.7%, 10.7%, 31.1% |  |
| Gender | Female, Male | 66.0%, 34.0% |  |
| Age | 20-40, 41-60, 61-80, 81+ | 11.7%, 71.8%, 16.5%, 0.0% |  |
| Education | Primary, Secondary, Tertiary | 55.3%, 27.2%, 17.5% |  |
| Activity | Agriculture, Charcoal Selling, Commerce, Handicraft, Other | 29.1%, 24.3%, 19.4%, 9.7%, 17.5% |  |

The population is predominantly female, aged 41-60, with most having primary education. Rambo is the largest village, and agriculture is the primary activity, followed by charcoal selling and commerce. (**Table 1**.)

*3.2. Local perception of ecosystem services*

*Table 2: Perception of ecosystem services by village*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Village/ES | Caminunu | Cibinda | Cifunzi | Fendula | Mule | Rambo |
| Provisioning | 82.4% | 64.7% | 72.2% | 76.5% | 76.5% | 76.5% |
| Regulation | 5.9% | 5.9% | 0.0% | 5.9% | 5.9% | 5.9% |
| Support | 11.8% | 29.4% | 27.8% | 17.6% | 17.6% | 17.6% |
| Cultural | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 5.9% |

The results show that in most villages, provisioning services were widely considered the most crucial, representing between 64.7% and 82.4% of opinions. Support services are also mentioned in several villages, ranging from 11.8% to 29.4%. In contrast, recognition of regulation services is less frequent, often cited at 5.9%. These data reveal a dominant trend towards the importance attributed to provisioning services in all villages, highlighting its predominance in the local perception of ecosystem services. (**Table 2.**)

*3.3. Local engagement in forest conservation*

Tableau 3 Level of engagement by village

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Engagement/village | Caminunu | Cibinda | Cifunzi | Fendula | Mule | Rambo |
| Less engaged | 11.8% | 0.0 | 5.6 | 17.6 | 17.6 | 11.8 |
| Very engaged | 52.9 | 41.2 | 33.3% | 23.5% | 23.5% | 23.5% |
| ± Engaged | 35.3% | 58.8% | 61.1% | 76.5% | 58.8% | 64.7% |

The engagement levels of respondents across villages vary significantly. In Caminunu, Cibinda, and Rambo, a notable portion are less engaged (ranging from 0% to 17.6%), whereas in Fendula and Mule, this category constitutes 17.6%. Conversely, a substantial proportion of all villages are very engaged (ranging from 23.5% to 52.9%). The remaining respondents fall within the ± engaged category, with percentages varying between villages (ranging from 35.3% to 76.5%). These findings suggest differing community involvement and interest in forest.

*3.4. Willingess to pay by village (Cost-based approch)*

Tableau 4 Willingness to pay

|  |  |  |  |
| --- | --- | --- | --- |
| 0.00 (Freq, %) | 0.25 (Freq, %) | 0.50 (Freq, %) | 0.70 (Freq, %) |
| 2, 11.8% | 7, 41.2% | 6, 35.3% | 2, 11.8% |
| 1, 5.9% | 4, 23.5% | 11, 64.7% | 1, 5.9% |
| 2, 11.1% | 4, 22.2% | 9, 50.0% | 3, 16.7% |
| 2, 11.8% | 6, 35.3% | 7, 41.2% | 2, 11.8% |
| 1, 5.9% | 7, 41.2% | 8, 47.1% | |  | | --- | | 1, 5.9% | |
| 3, 17.6% | 2, 11.8% | 11, 64.7% | 1, 5.9% |

The table shows that the majority of respondents in most villages are willing to pay at the 0.50 and 0.25 levels, with 64.7% and 41.2% frequencies, respectively. Villages show varying levels of willingness, with lower frequencies at the 0.00 and 0.70 levels. (**Table 4**.)

**4. Discussion**

The observations from Table 2 reveal a strong emphasis on provisioning and support services in villages, relegating regulation and cultural services to a less central position. This trend reflects a general preference for addressing immediate needs such as wood and other forest products, at the expense of more indirect aspects such as climate regulation or cultural benefits. Research by Diaz et al. (2018) corroborates this predominance of provisioning services, suggesting a convergence in the overall perception of ecosystem services. Turner et al. (2019) have highlighted the crucial importance of provisioning services while also highlighting the interconnection between ecosystem services for human well-being. Constanza et al. (2020) reinforce this idea by highlighting the integrated value of all ecosystem services, including regulation and cultural services, to improve community quality of life. Fisher et al. (2018) and Daily et al. (2019) have emphasized the underestimation of regulation services and their potentially detrimental impact on ecological stability and resilience to environmental changes. Villages like Cibinda, Caminunu, and Rambo demonstrated high levels of involvement, reaching 41.2%, 52.9%, and 64.7%, respectively. These figures can be explained by dynamic local initiatives and active participation in these communities. In contrast, Fendula showed lower engagement compared to other villages, with 76.5% displaying moderate or low levels, likely due to limited resources and less developed infrastructure (Hassen, 2023).

Cifunzi and Mule showed more balanced distributions, suggesting diverse social dynamics. Previous research, such as that of Lo and Zhu (2022) in China and Hassen (2023) in Ethiopia, underscores the association between the increasing involvement of local communities in forest conservation, their access to forest resources, and their participation in decision-making. These studies highlight the crucial importance of awareness and community engagement to motivate forest preservation by local populations. The result corroborates the findings of Wang et al. (2019), which showed that participatory conservation programs stimulate the engagement of local communities in forest management. This convergence is explained by strengthening trust, cooperation, and empowerment of local actors, as well as improving their access to forest benefits. In contrast, the conclusions of Wang et al. (2019), highlighting the influence of factors such as education level, income, household size, and perception of ecosystem services in China, differ from the context of local communities in the Democratic Republic of the Congo. These divergences question the model proposed by Wang et al. (2020), which primarily establishes a link between economic incentives and the engagement of local populations in forest conservation.

The villages exhibited different levels of willingness to pay for the preservation of ecosystems (Tab. 4). The main distribution was 50% for Cibinda, Fendula, and Mule, and 25% for Caminunu, Cifunzi, and Rambo. Rambo showed a more polarized distribution (64.7% at 50%), while Fendula had a more balanced distribution (25% to 50%). Very few participants opted for no financial contribution (0%). These differences likely reflect the economic capacities, local priorities, and levels of engagement in forest conservation aimed at ensuring a sustainable supply of ecosystem services (Garcia Matos, 2023). Smith et al. (2020) highlight that variations in communities' financial contributions to forest conservation initiatives can be attributed to economic differences and local perceptions of the value of forest resources. Similarly, Nyangoko et al. (2022) show that local priorities and engagement vary according to socio-economic conditions, which in turn influence the willingness to contribute financially. These similarities underscore the importance of understanding local factors in designing forest conservation strategies that consider economic contexts and specific community concerns (Diaz et al., 2018).

**5. Conclusion**

This study aimed to analyze the evolution of forests around the Kahuzi-Biega National Park (KBNP) grouping, local perceptions of forest ecosystem services, willingness to pay, and community engagement in conservation through a survey. The results highlighted the predominance of provisioning service, with villages like Cibinda and Caminunu standing out for their strong engagement in conservation. A majority of the population reported a widespread decrease in forest density. Thus, it becomes essential to strengthen forest conservation policies in the villages surrounding the KBNP, regulate activities, and promote sustainable agricultural practices. Targeted awareness programs focusing on ecosystem services should be directed towards less-involved villages like Fendula and Rambo. Actively encouraging participation from engaged villages, such as Cibinda and Caminunu, through sustainable incentives and initiatives, is crucial. The conservation of forest ecosystems, particularly in biodiversity hotspots like Kahuzi-Biega National Park, is critical for maintaining global ecological balance and supporting the livelihoods of local communities. However, achieving effective conservation requires a deep understanding of the socio-ecological context in which these ecosystems exist. By examining local perceptions of forest ecosystem services, willingness to pay for conservation, and commitment to conservation, this study aimed to contribute to the development of conservation strategies that are both ecologically sound and socially equitable.

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