

**DIVERSITY AND CONSERVATION OF WILD EDIBLE MUSHROOMS IN MODO
MISSA GAME RESERVE, DEMOCRATIC REPUBLIC OF CONGO**

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ABSTRACT: This study explored the diversity and conservation of wild edible mushrooms in the Modo Missa Game Reserve, bordering Garamba National Park in the Democratic Republic of Congo. The reserve faces pressure from human activities, such as poaching, timber harvesting, mining, and agricultural expansion, all of which threaten biodiversity. Local communities depend on mushrooms as a seasonal food source, but cultivation remains limited due to climate constraints, lack of knowledge, and insufficient institutional support. Mushrooms are often overlooked in conservation planning despite their ecological and nutritional significance. Data were collected from 76 households across four localities using random sampling and field surveys. Diversity analysis revealed nine species, with a Shannon–Wiener index of 2.13 (moderate diversity), Simpson’s index of 0.875 (high diversity and low dominance), and an evenness value of 0.915 (balanced distribution). *Schizophyllum commune* was the most prevalent species (13%), thriving in forest habitats, while *Termitomyces* spp. were more common in savanna areas. Fisher’s Exact indicated no significant association between species occurrence and habitat type, implying that microhabitat and seasonal factors influence the distribution. Respondents highlighted key

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challenges, including pollution, climate change, habitat destruction, limited awareness, and insufficient cultivation skills. Recommended conservation strategies encompassed habitat protection, controlled harvesting, species documentation, and promotion of mushroom farming. The study emphasized that awareness campaigns, training, and further ecological research are vital, and that integrating community initiatives with formal conservation efforts is crucial to protect mushroom biodiversity, enhance food security, and bolster ecosystem resilience.

Keywords: Biodiversity, conservation, Shannon–Wiener index, Simpson’s index,

INTRODUCTION

Globally, an estimated 14,000–22,000 mushroom species are recognized, though only a fraction are cultivated or industrially utilized, mainly *Agaricus bisporus*, *Pleurotus* spp., and *Lentinula edodes* (Sileshi et al., 2023), with about 10,000 formally classified and described (Qwarse et al., 2024; Siteo and Pinto, 2024). However, scientists believe the true number is much higher, as many species remain undocumented, particularly in tropical regions (Kała et al., 2024; Tarafder et al., 2024; Thunberg, 2024). The global mushroom market was valued at over USD 51 billion in 2024 and is projected to exceed USD 156 billion by 2033, with Asia, especially China, dominating production and consumption (Batubenga et al., 2021; Fernandes et al., 2021). In Africa, Nigeria, South Africa, and Zambia are among the African countries where mushroom cultivation and consumption are most widespread, with Nigeria leading in production and utilization for both food security and income generation (Angom et al., 2021; Fernandes et al., 2021; Gorenflo and Romaine, 2021).

The Democratic Republic of Congo (DRC) is renowned for its rich biodiversity, with vast forested areas supporting various plant and animal species, including these wild edible mushrooms (Boa, 2007). These mushrooms, lacking chlorophyll, cannot produce their own food

through photosynthesis. However, they play a vital role in ecosystem functioning by recycling organic matter into the soil, promoting tree growth, and providing a substrate for mushroom cultivation through the reuse of farm waste (Kamalebo et al., 2018). Cultivating edible mushrooms for commercial purposes facilitates the recycling of agricultural waste into a unique and highly nutritious food source with a minimal ecological footprint (Wembodinga et al., 2024), offering significant benefits to smallholder farmers. Mushrooms have long been integral to traditional diets and cultural practices, with local communities passing down traditional knowledge and harvesting techniques through generations (Sileshi et al., 2023). Additionally, they hold cultural significance in ceremonies, rituals, and traditional medicine (Mjaika, 2022). Wild edible mushrooms play an important role not only in food security but also in traditional medicine across many cultures worldwide. Ethnomycological studies have documented their use in folk medicine to treat infections, enhance immune function, reduce inflammation, and support general health (Boa, 2004; Munyaneza, 2018). These medicinal properties are largely attributed to bioactive compounds such as polysaccharides, particularly β -glucans, phenolic compounds, terpenoids, and immunomodulatory proteins, which have been shown to stimulate immune responses, exhibit antimicrobial activity, and regulate oxidative stress (Sande et al., 2019; Qwarse et al., 2024).

Mushrooms contain moisture (85-95%), carbohydrates (35-70%), protein (15-34.7%), fat (10%), minerals (6-10.9%), and nucleic acids (3-8%). They also contain substantial amounts of vitamins such as thiamine 1.4-2.2 mg (%), riboflavin 6.7-9.0 mg (%), niacin 60.6-73.3 mg (%), biotin, ascorbic acid 92-144 mg (%), pantothenic acid 21.1-33.3 mg (%), and folic acid 1.2-1.4 mg/100 g in dry weight basis. Recent studies further highlight that edible and medicinal wild

mushrooms contribute to the prevention and management of chronic diseases through their antioxidant, anti-inflammatory, and immunoregulatory effects, providing scientific support for their long-standing use in folk medicine (Nevins and Heale, 2018; Mjaika, 2021; Qwarse et al., 2021; Habineza Mpunga et al., 2025).

In African and tropical regions, traditional knowledge related to wild edible mushrooms represents an important part of cultural heritage and community health systems, reinforcing the need to conserve mushroom diversity alongside forest ecosystems (Singer, 1962; Smith, 2018; Shalimov et al., 2019; Siteo and Pinto, 2024). Wild mushrooms contribute to local economic development by serving as a food source during times of scarcity, supporting hunger and poverty alleviation through well-developed farming strategies. However, their sustainability is threatened by conservation challenges (Sileshi et al., 2023). Factors such as climate change (Mjaika, 2022), habitat loss, pollution, and overexploitation of forests pose significant risks. Preserving the socioeconomic and ecological values of mushrooms requires raising awareness about responsible forest use and implementing sustainable conservation practices (Tarafder et al., 2024; Thunberg, 2024; Bhati, 2025). Moreover, limited attention has been given to promoting the uses and nutritional value of wild edible mushrooms, particularly in DRC (D'haen et al., 2019). More efforts are needed to increase public awareness, disseminate knowledge, and establish systematic conservation and management strategies (Shalimov et al., 2019; Zhao et al., 2020).

Enhancing local capacity through training programmes and awareness campaigns is essential for promoting sustainable mushroom management and conservation. Areas surrounding Garamba National Park, such as the Modo Missa Game Reserve, have faced significant challenges from human activities such as poaching, wildlife resource collection, mining, and timber cutting

(Roncero-Ramos and Delgado-Andrade, 2017; Sevindik et al., 2023). Encouraging mushroom farming can help alleviate poverty, improve food security, create jobs, and reduce pressure on protected areas. Addressing these challenges and developing sustainable strategies for the diversity and conservation of wild edible mushrooms is crucial for safeguarding food security and unlocking socioeconomic opportunities through the use of edible mushrooms in the region (McKnight et al., 2021; Lu et al., 2025).

Garamba National Park, Democratic Republic of Congo (DRC), is recognized as one of the most diverse ecosystems in Africa. Previous studies in that region have largely concentrated on megafauna conservation, poaching pressures, and governance challenges, with limited attention to non-timber forest products such as wild edible mushrooms. For instance, UNESCO's State of Conservation reports emphasized threats from armed conflict and illegal hunting, while African Parks' monitoring programs highlighted elephants 'recovery and species translocations but overlooked hidden biodiversity and ethnomycological resources (Bhati, 2025; Hyde et al., 2019).

Recent ethnomycological studies in Central Africa have documented traditional knowledge and dietary importance of wild mushrooms (Sileshi et al., 2023), yet these remain geographically restricted and do not extend to the Modo Missa Game Reserve. Moreover, existing studies often lack detailed ecological assessments of fungal diversity and conservation status, thereby limiting understanding of how mushroom resources contribute to local food security, cultural heritage, and ecosystem resilience (Desjardin, 2014; Dube et al., 2021; Kabacia and Muchane, 2023; Falk and Hagsten, 2025). This gap underscores the need for site-specific studies that integrate biodiversity surveys with conservation perspectives. Hence, the study addresses this limitation by assessing the diversity and conservation of wild edible mushrooms in the Modo Missa Game

Reserve, the area surrounding Garamba National Park (Smith, 2018). The study is significant to expand the basic knowledge of fungal resources in the DRC and to reinforce their role in both community health systems and forest ecosystem sustainability (Smith, 2018).

Documenting traditional knowledge and practices related to wild edible mushrooms collection, preparation, and utilization is crucial for engaging local communities and indigenous groups in the effort of hidden biodiversity conservation (Batubenga et al., 2021; Kabacia and Muchane, 2023). Furthermore, laboratory optimization and ex-situ conservation of mushrooms are increasingly recognized as essential strategies for safeguarding fungal biodiversity, as they enable the maintenance of viable cultures, genetic resources, and bioactive compounds outside natural habitats, thereby complementing in-situ conservation efforts.

MATERIAL AND METHODS

Description of the study site

Description of the study area Modo Missa Game Reserve is part of the Garamba Complex in northeastern Democratic Republic of the Congo (DRC), located east of Garamba National Park (Fig.1) and neighboring other hunting areas such as the Gangala na Bodio and Azande reserves (Linder et al., 2024). It is listed in the World Database on Protected Areas under ID 555781117. The reserve lies within the Garamba landscape, defined by latitudes 3.5°- 4.1° N and longitudes 29.1°- 29.5° E, with terrain ranging from 700 to 1,065 meters above sea level. Ecologically, Modo Missa shares the Garamba region's savanna grassland, characterized by tall grasses, scattered trees, and intermittent woodland. Gallery forests are found along rivers and depressions, while surrounding hunting areas include deciduous woodland and riparian forest

components. The wider Garamba Complex features a forest- savanna mosaic (Sudano-Guinean savanna) where woodland, grassland, and gallery forest intersect, supporting both forest-edge species and savanna specialists (Smith, 2018;D’haen et al., 2019).

The reserve lies within a tropical savanna climate, with a distinct wet season from May to October and a pronounced dry season from November to April. Annual rainfall across the Garamba Complex averages between 1,200 and 1,600 mm, supporting grassy savannas and forest patches, with high temperatures maintained year-round and cooler nights during the dry season. The Modo-Missa Reserve encompasses an area of approximately 1.83 km² (D’haen et al., 2019). The local climate is characterized by average daytime temperatures ranging between 25 and 30 °C, with slight decreases during the night. Relative humidity remains moderately high, averaging around 50%(Mateso et al., 2024). The reserve was formally established in 1938 and later recognized as part of the UNESCO World Heritage network in 1980. Modo Missa, together with Azande and Gangala na Bodio, acts as a buffer zone for Garamba National Park, preserving habitat connectivity, seasonal wildlife movements, and ecological integrity across the broader landscape (Mateso et al., 2024).

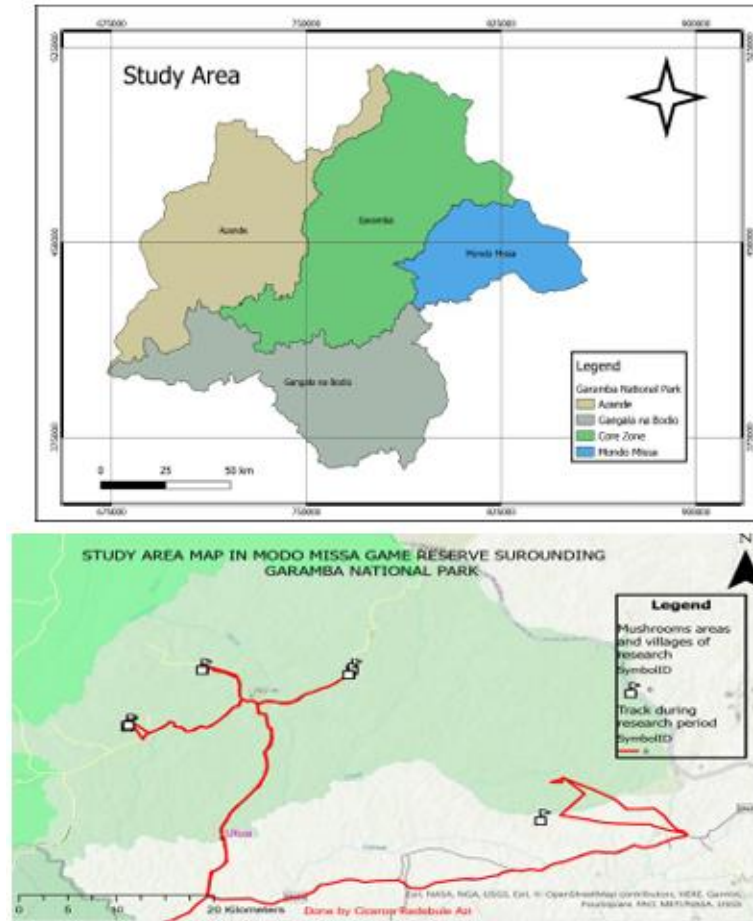


Figure 1. Location of the study site and location of sampling sites in Modo Missa Game Reserve, Democratic Republic of Congo.

Sampling technique and sample size determination

The total population across the four localities of Gbere, Tekadje, Leema, and Buru of Modo Missa is 1,448 people distributed in 324 households. Buru has the highest population of 760 people and the highest number of households, totaling 152. The second is Gbere with 304 people and 76 households, Tekadje presented 248 people in 62 households, while Leema presented the smallest population of 136 people in 34 households. The average household size is 4 people per household in Gbere, Tekadje, and Leema, while Buru has a slightly higher average of 5 people

per household. Overall, the average household size across all four localities is approximately 4.47 people per household (Table 1).

Table 1: Distribution of population and sample size by locality (Author Field Survey, 2023)

Localities	Population	Households	Sample size
Gbere	304	76	17
Tekadje	248	62	15
Leema	136	34	8
Buru	760	152	36
Total	1448	324	76

The total population considered in this study is 324 households from four localities in Modo Missa. Factors such as age, gender, and location were considered to ensure that the whole population was represented. Yamane's formula: $n = N/(1+N(e)^2)$ was used to determine the sample size of respondents from the total population, where n is the total sample size, N is the total population or households, and e is the margin of error (0.1). Therefore, the sample size in this study (n) = $324 / [1+324(0.1)^2] = 76.42 \approx 76$ households (Boyd, 2022). To obtain individual respondents from the locality or the sample size within localities, the Neyman allocation formula: $n_i = (N_i * n)/N$. was used. Where n_i : sample size from the stratum (locality), N_i : population size in the stratum, n : study's sample size, N : target population size as summarized in the table above (Table 1).

Data collection method and analysis

Wild edible mushrooms were sampled using a plot-based purposive sampling method in Modo Missa Game Reserve. Sampling plots were established in representative habitat types (forest, woodland, savanna, and forest edge) where mushroom occurrence was known or expected based

on vegetation structure, substrate availability, and local ecological knowledge (Mjaika, 2022). Field surveys and direct observations were performed, and identification was based on morphological characteristics such as cap shape and color (Mateso et al., 2024). Taxonomic identification was conducted based on morphological characteristics cap morphology (cap color, cap surface, cap margin, cap diameter, cap size, structure), gill morphology and attachment (gills shape and color), stipe (stalk) morphology (stipe length), volva morphology and rings (annulus) presence as described earlier (Wembodinga et al., 2024). This helped to differentiate edible species from inedible or toxic ones by observing carefully those traits as well as smelling the odour (McKnight et al., 2021).

Additionally, habitat, substrate and vegetation types were also recorded for each wild edible mushroom collected to provide ecological context, facilitate interpretation of species distribution patterns, and assess the influence of environmental factors on mushroom diversity and occurrence (Sila and Koaze, 2025). Details such as morphological characteristics, sampling location, habitat type, and associated plant and substrate types were recorded with the assistance of residents and reference books (Irakiza et al., 2021). Information for each species was cross-checked with reference manuals (“*The Agaricales in Modern Taxonomy*, 4th Edition” and “*Identification of mushrooms - Getting started*”), and local ecological knowledge to ensure accurate species identity (Degreef et al., 2016; Milenge Kamalebo et al., 2018).

Questionnaires and interview for respondents were carried out where local leaders and community members were interviewed to gather information on edible mushroom conservation measures and strategies. Questionnaires were randomly distributed in households across villages to ensure representation of the entire population within Modo-Missa Game Reserve. Through the

questionnaires, traditional knowledge regarding the harvesting and uses of edible mushrooms was collected, including the types harvested, seasonal availability, cultural practices, and their socio-economic significance, along with factors hindering conservation efforts (Boa, 2007; Cheng et al., 2019). Responses were expected to be concise, typically requiring a "yes" or "no". Insights were also sought on possible strategies and measures the local communities could propose to conserve this valuable resource, emphasizing the importance of understanding community perspectives and engaging them in conservation for sustainable mushroom management (Dejene et al., 2023). Data analysis was conducted using R software version 4.5.2 (available at <https://cran.r-project.org/bin/windows/base/>) and ArcGIS Pro (pro.arcgis.com).

RESULTS

Socio-demographic characteristics of respondents

Socio-demographic characteristics of respondents are summarized in Fig. 2. This part of the results analysis includes the general background information of respondents from Modo Missa Ame Reserve. It covers their sex, age, occupation, and educational level. A total of 76 questionnaires were distributed out of a population of 324. The complete set of 76 questionnaires was collected without incidence, ensuring no loss or damage. Accordingly, frequency and percentage values for each variable were used to present the socio-demographic data. The educational background of respondents revealed that the largest proportion had attained primary education (29.4%), followed by those categorized under "other" forms of education (26.3%). Vocational education (19.2%) and holders of A₂ diploma or secondary school graduates (18.2%) represented moderate shares, while university graduates accounted for the smallest group (6.8%). This distribution indicated that most respondents possess relatively low levels of formal education, with higher education being rare (Fig. 2a). In terms of occupation, farming was the

dominant livelihood, reported by 53.7% of respondents. Traders constituted 23%, while public employees accounted for 20.3%. Handicraftsmen were the least represented, at only 3%. These findings highlight the central role of agriculture in the community, with trade and public employment serving as secondary sources of income (Fig. 2b).

Age distribution showed that respondents were predominantly in the 30–40-year category (25.3%), followed by those aged 18–29 years (17.2%) and 41–51 years (15.2%). Older age groups were less represented, with 6.8% in the 52–62-year range and 13.2% above 62 years. A notable proportion (22.3%) fell into the “other/unspecified” category. Overall, the sample was skewed toward younger and middle-aged adults, with relatively few elderly participants (Fig. 2c). Gender distribution was nearly balanced, with males comprising 51.7% and females 48.3%. This slight male majority suggests that both genders were fairly equally represented in the study population (Fig. 2 d).

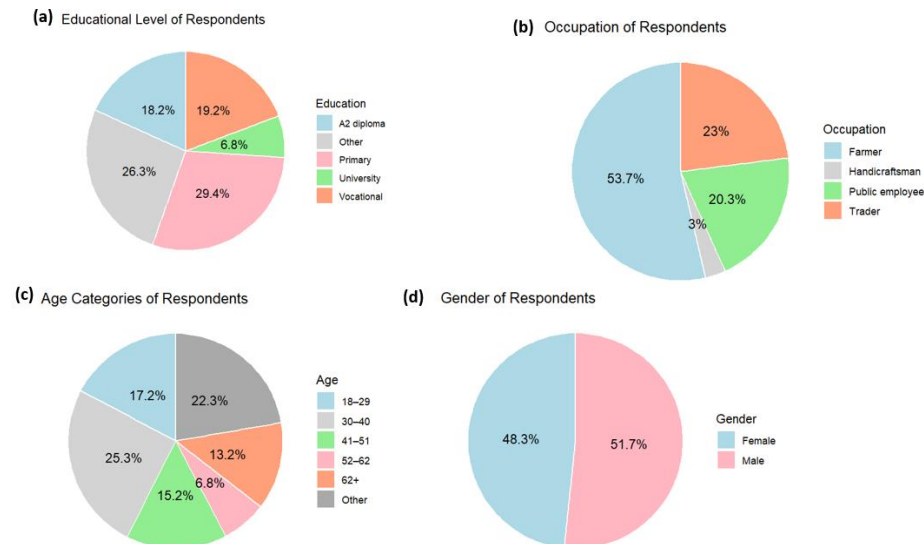


Figure 2. Demographic results of respondents on limiting factors of wild edible mushrooms utilization and conservation, management and conservation measures for wild edible mushrooms in Modo Missa Game Reserve, Democratic Republic of the Congo (DRC).

Diversity indices and distribution of wild edible mushrooms

The analysis of edible mushroom diversity in the Modo-Missa Game Reserve recorded a species richness (S) of 9. The Shannon–Wiener index (H') was 2.13, indicating moderate diversity. Simpson's index (1- D) was 0.875, showing high diversity with low dominance. The evenness value (E) was 0.915, confirming that species were fairly evenly distributed across the reserve. The abundance of wild edible mushroom species varied across the surveyed habitat types (Fig.3). Forest/fallow and forest/woodland habitats supported species such as *Schizophyllum commune* and *Lentinus squarrosulus*, while termite-associated species such as *Termitomyces* spp. were more abundant in savanna woodland and savanna/forest edge habitats. Statistical analysis using Fisher's Exact Test indicated no significant association between mushroom species occurrence and habitat type ($p = 1$), suggesting that the distribution of these species was largely independent of habitat in the study area.

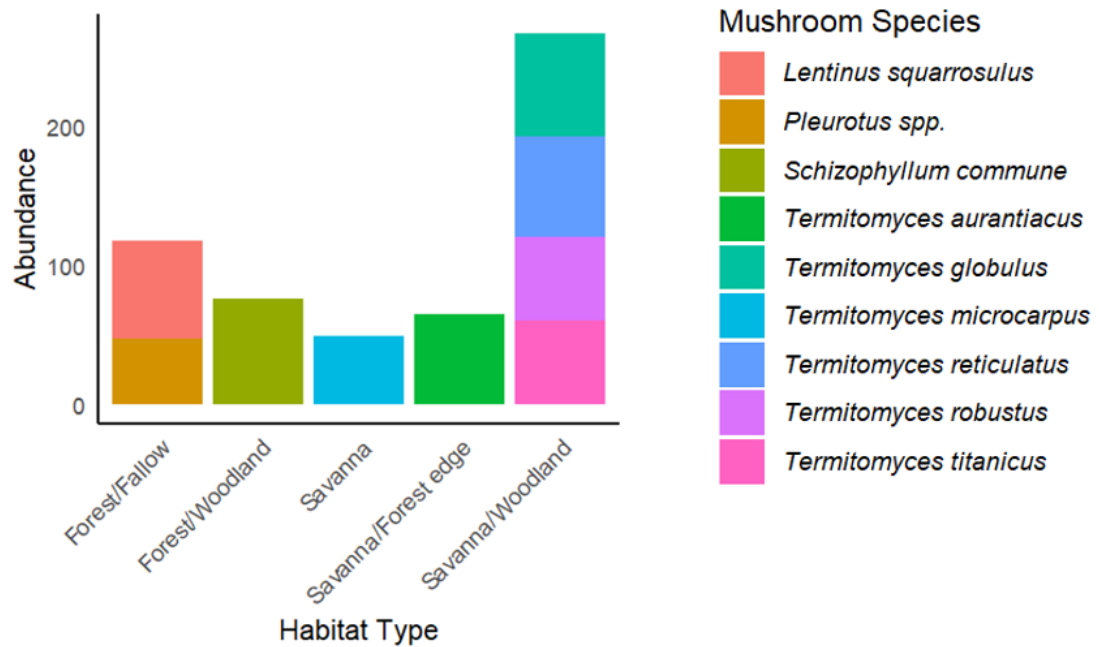


Figure 3. Abundance of wild edible mushroom species across different habitat types in Modo Missa Game Reserve. Species names are shown in the legend, and abundances represent the number of individuals collected per habitat.



Figure 4. Pictures of wild edible mushroom species identified in Modo Misa Game Reserve, Democratic Republic of Congo (Image taken by Ciceron Redebule, 2023)

Limiting factors of wild edible mushrooms utilization and conservation

From the Fig. 5, respondents identified a range of challenges affecting the sustainable use and conservation of wild edible mushrooms. The most frequently cited issues included the use of pesticides and fire in agriculture (7.3%), climate change (6.9%), air and soil pollution (6.5%), low public awareness (6.2%), and insufficient training (6.0%). Additional concerns were inadequate cultivation skills (5.8%), habitat destruction (5.6%), and deforestation (5.4%). Socioeconomic barriers such as poor primary infrastructure (5.1%), insufficient external support from government or private sector (4.9%), limited market access (4.7%), and limited capital (4.5%) were also noted. Less commonly mentioned were ignorance of mushroom importance (4.2%) and the availability of alternative protein sources such as meat and fish (4.0%).

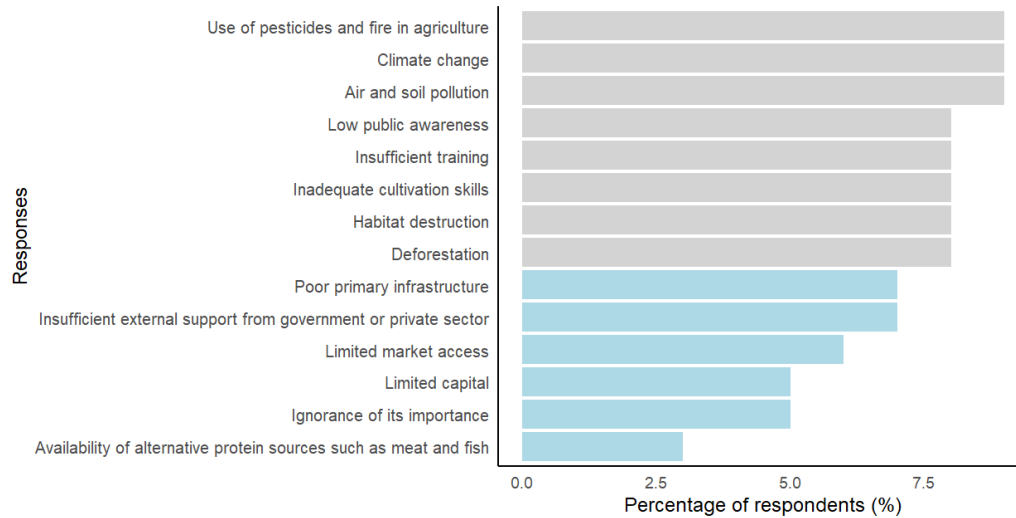


Figure 5. Socioeconomic and environmental constraints affecting the use and conservation of wild edible mushrooms in the Modo Missa Reserve, Democratic Republic of the Congo (DRC).

Relative importance of proposed management and conservation measures

The results on the relative importance of proposed management and conservation measures were summarized in Fig.6. Respondents proposed several measures to enhance the sustainable harvesting and conservation of wild edible mushrooms. The most frequently recommended actions included protection of natural habitats (9.8%), development of a comprehensive list of forest plant species producing edible mushrooms (9.4%), and documentation of animal species that consume mushrooms (9.0%). Other notable suggestions were implementation of controlled harvesting practices (8.7%), creation of an authorized list of edible mushroom species (8.3%), and compilation of poisonous and medicinal mushroom species (8.0%). Additional measures included signposting of illegal mushroom harvesting (7.6%) and bushfires (7.2%), regulation of mushroom spore culture methods (6.9%), formal recognition of mushroom collectors (6.5%), promotion of mushroom cultivation (6.2%), and publication of annual reports on harvested mushrooms (5.9%).

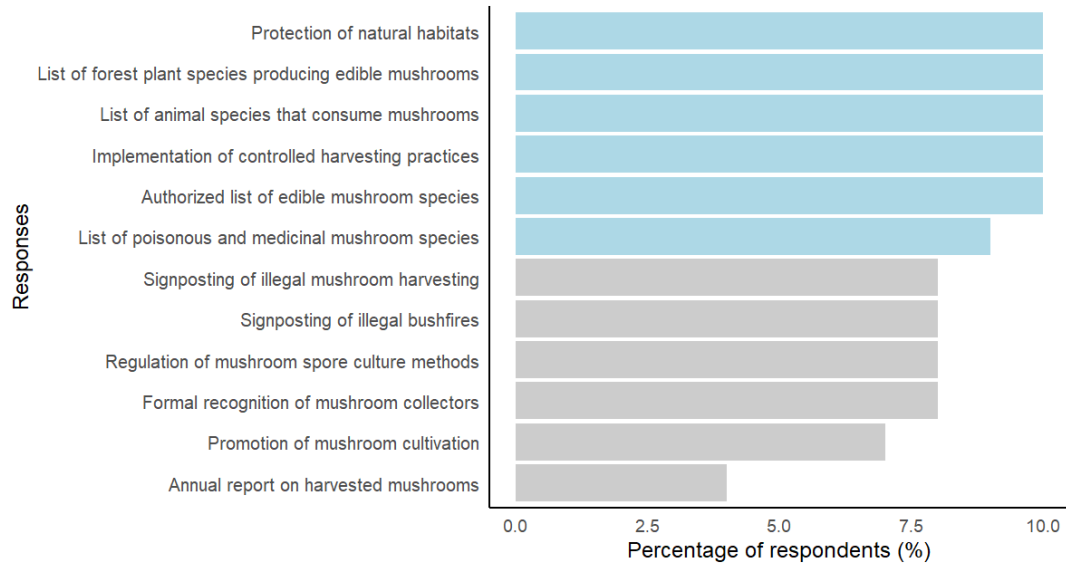


Figure 6. Proposed management and conservation measures for wild edible mushrooms, as perceived by respondents (%) in Modo Missa Game Reserve, Democratic Republic of the Congo (DRC)

DISCUSSION

Socio-demographic profile and its implications for resource engagement

The socio-demographic composition of respondents provides critical insight into the community's capacity and orientation toward utilization and conservation of wild edible mushroom in Modo Missa Game Reserve. Drawing parallels with recent findings by Fernandes et al. (2021), who emphasized the role of education and livelihood in shaping environmental attitudes and participation, the present study reveals a predominantly low-education population, with 29.4% having attained only primary education and just 6.8% holding university degrees (Fig. 2). This educational profile may limit access to formal conservation knowledge and restrict engagement with policy frameworks, echoing concerns raised in similar rural contexts (Fernandes et al., 2021).

Occupational data further underscored the community's dependence on agriculture, with 53.7% of respondents identifying as farmers. This aligns with the broader pattern observed in southern African community-based natural resources management initiatives, where farming communities are both key stakeholders and primary beneficiaries of sustainable forest resource use (Irakiza et al., 2021). The presence of traders (23%) and public employees (20.3%) suggests a modest diversification of livelihoods, though the marginal representation of handicraftsmen (3%) points to underutilized cultural and artisanal potential. Age distribution was skewed toward economically active groups, particularly those aged 30-40 years (25.3%), followed by younger adults (18-29 years, 17.2%). This demographic structure is favorable for participatory conservation, as younger and middle-aged individuals are more likely to engage in community-based initiatives and adaptive practices. However, the 22.3% classified as "other/unspecified" warrants further scrutiny, as it may obscure vulnerable or disengaged subgroups (Fig.2).

Gender representation was nearly balanced, with males at 51.7% and females at 48.3%, suggesting equitable participation potential (Fig.2). This is particularly relevant given the increasing recognition of gender-inclusive approaches in natural resource governance, as highlighted in recent participatory models (Siteo and Pinto, 2024). Collectively, these findings suggest that while the community possesses a strong agricultural base and a relatively youthful population, targeted interventions, particularly in education and capacity-building, are essential to enhance effective engagement in sustainable resource management.

Edible wild mushroom diversity and distribution across Modo Missa Game Reserve

The diversity analysis conducted in the Modo Missa Game Reserve revealed a species richness (S) of 9, with a Shannon–Wiener index (H') of 2.13, indicating moderate diversity. The Simpson's index (1-D) of 0.875 suggested high diversity with low dominance, while the evenness value (E = 0.915) confirmed that species were fairly evenly distributed across the reserve. These results are consistent with broader studies of wild edible fungi in Africa, which often report moderate to high diversity and relatively balanced species distributions in forested ecosystems (Sileshi et al., 2023).

Species abundance varied across habitat types. Forest/fallow and forest/woodland habitats supported species such as *Schizophyllum commune* and *Lentinus squarrosulus*, while termite-associated *Termitomyces* spp. were more abundant in savanna woodland and savanna/forest edge habitats (Fig.3 and 4). This ecological partitioning reflects the well-documented association of *Termitomyces* with termite mounds, a relationship observed across Eastern and Central Africa (Mjaika et al., 2023). However, statistical analysis using Fisher's Exact Test indicated no significant association between mushroom species occurrence and habitat type ($p = 1$), suggesting that distribution patterns in Modo Missa may be influenced more by microhabitat conditions and seasonal variability than by broad habitat categories (Siteo and Pinto, 2024). Across the reviewed studies, there is a strong consensus that the democratic DRC is a global hotspot for indigenous food, particularly wild edible mushrooms, owing to its vast forest ecosystems and high biodiversity. The SADC study by Kazige et al. (2022) highlights that indigenous plant and animal foods, especially edible fungi, play a critical role in food security,

nutritional security and household income for rural and urban households, yet remain underutilized and weakly integrated into formal food systems in the country.

The survey further highlighted community recognition of mushrooms as naturally occurring resources, with uses ranging from food to medicine. The dominance of *Schizophyllum commune* (13% of identified species) is notable, as this species thrives in humid forest environments on decaying wood (Fig.3). Its prevalence in Modo Missa aligns with findings from Mjaika et al. (2023), who reported widespread occurrence of *Schizophyllum commune* and other edible fungi across the Democratic Republic of Congo. Similarly, Kazige et al. (2022) emphasized the importance of continuous exploration and identification of fungal species across both dry and rainy seasons, underscoring the dynamic nature of mushroom diversity in African landscapes. These results demonstrated that wild edible mushrooms in Modo Missa exhibited moderate diversity, balanced distribution, and habitat-specific abundance patterns. They also strengthened the broader literature that highlights the ecological importance of fungi in forest and savanna systems, while also pointing to the need for sustained monitoring and documentation. Such efforts are critical not only for biodiversity conservation but also for safeguarding the nutritional and medicinal values of these underutilized resources (Sileshi et al., 2023).

The systematic review by Mjaika (2022) provides quantitative evidence of this richness, documents over 377 edible mushroom species in DRC, far exceeding neighbouring countries in Southern and Central Africa. This underscores the DRC's central role in regional mycological biodiversity. However, the study also reveals fragmented documentation, uneven geographic coverage, and growing threats from habitat loss and overharvesting. A study by Mpunge et al. (2025) focused on the value chain research from the Virunga landscape from demonstrates that

wild and cultivated mushrooms are important non-timber forest products (NTFPS) supporting livelihoods, particularly for rural communities living adjacent to protected areas. Despite their economic potential, value chains remain informal and poorly coordinated and constrained by limited processing, storage, and market access. Kamalebo et al. (2018) ethnobiological evidence from Tshopo province demonstrated that traditional knowledge strongly governs mushroom identification, harvesting and consumption, with fungi valued for nutrition, medicine and cultural identity. However, this knowledge is rapidly eroding due to generational shifts and a lack of formal documentation. A complementary ecological study in Lake Kivu by Munyaneza (2018) reinforces the importance of riparian and forest ecosystems in sustainable mushroom diversity, emphasizing transboundary conservation relevance between DRC and Rwanda.

Challenges to edible wild mushroom utilization and conservation

The study identified a range of challenges constraining the sustainable utilization and conservation of wild edible mushrooms in Modo Missa. Respondents most frequently cited the use of pesticides and fire in agriculture (7.3%), climate change (6.9%), and air and soil pollution (6.5%) as major threats (Fig.5). These findings are consistent with broader evidence that anthropogenic pressures, particularly unsustainable farming practices and climate variability, are key drivers of biodiversity loss in fungal communities (Sileshi et al., 2023). Low public awareness (6.2%) and insufficient training (6.0%) further limit community capacity to engage in sustainable harvesting, while inadequate cultivation skills (5.8%), habitat destruction (5.6%), and deforestation (5.4%) highlight ecological vulnerabilities. Socioeconomic barriers, including poor infrastructure (5.1%), limited external support (4.9%), restricted market access (4.7%), and lack of capital (4.5%), mirror structural constraints observed in other rural contexts where wild foods remain undervalued despite their nutritional and economic potential. Less frequently mentioned

factors, such as ignorance of mushroom importance (4.2%) and reliance on alternative protein sources (4.0%), underscore cultural and dietary dynamics that may reduce mushroom utilization (Foyet, 2024).

Proposed conservation strategies for edible wild mushrooms

In response to these limitations, respondents proposed a suite of conservation measures. The most frequently recommended actions included protection of natural habitats (9.8%), development of comprehensive lists of forest plant species producing edible mushrooms (9.4%), and documentation of animal species that consume mushrooms (9.0%) (Fig.6). These strategies align with findings by Gorenflo and Romaine (2021) and, Siteo and Pinto (2024), who emphasized the broader health benefits of forests and the importance of mitigating human–wildlife conflicts to safeguard natural resources. Other notable measures such as controlled harvesting (8.7%), authorized lists of edible species (8.3%), and compilation of poisonous and medicinal mushrooms (8.0%), reflect community awareness of both ecological and health dimensions. Additional proposals, including signposting illegal harvesting and bushfires, regulating spore culture methods, and formally recognizing mushroom collectors, highlight the need for institutional support and governance frameworks (Mjaika, 2022; Siteo and Pinto, 2024; Bhati, 2025).

An apparent lack of knowledge about mushroom cultivation necessitates prioritizing in-situ conservation while gradually introducing ex-situ techniques. This gap underscores the importance of community engagement and education initiatives, particularly in regions where research remains limited. Similar calls have been made in India and Central Africa, where participatory approaches have proven effective in enhancing conservation outcomes (Mjaika,

2022). Legal frameworks, such as Law No. 14 of the DRC National Constitution, reinforce the need for structured governance to restrict unauthorized access to protected areas and ensure biodiversity documentation. Expanding on these findings, comprehensive conservation strategies must encompass environmental protection, community engagement, and education initiatives. Efforts to mitigate pollution, address climate change impacts, and promote sustainable agricultural practices are crucial for conserving mushroom habitats (Hickisch et al., 2019; MJAIKA, 2021; Gorenflo and Romaine, 2021). Moreover, raising awareness among local communities about the ecological significance of mushrooms and their role in biodiversity conservation is essential for fostering long-term stewardship of natural resources (Crosier et al., 2025).

CONCLUSION AND RECOMMENDATIONS

This study in the Modo Missa Reserve, the area surrounding Garamba National Park, highlighted the complexity of conserving wild edible mushrooms and the intricate links between environmental factors, human activities, and biodiversity. The findings demonstrate that air and soil pollution, climate change impacts, deforestation, and insufficient institutional support are major threats to mushroom habitats.

Limited community knowledge of mushroom cultivation, rooted in historical neglect of research and awareness initiatives, has reinforced the perception that mushrooms naturally thrive without human intervention. Despite these challenges, local communities recognize the importance of protecting wild habitats and have expressed interest in mushroom farming as a strategy to conserve wild species while enhancing food security.

The socio-demographic profile of respondents offers further insight into the community's capacity for resource engagement. With most respondents having only primary education and a heavy reliance on agriculture, the community's knowledge base and livelihood focus influence both opportunities and challenges for mushroom conservation. The youthful age structure and nearly balanced gender ratio suggest potential for inclusive participation in conservation initiatives, while limited higher education highlights the need for targeted capacity development. These demographic realities emphasize that effective conservation strategies must be adapted to local contexts, incorporating education, livelihood diversification, and gender-sensitive approaches to boost engagement. Moderate species richness, high diversity, and a balanced distribution of wild edible mushrooms across Modo Missa were observed. Habitat-specific abundance patterns, such as the prevalence of *Schizophyllum commune* in forest environments and *Termitomyces* spp. in savannah habitats, reflect ecological partitioning consistent with broader African studies. These findings underline the ecological significance of fungi in forest and savannah systems and highlight the necessity for ongoing monitoring to protect their nutritional and medicinal values.

Drawing from these insights, several targeted actions are recommended. First, awareness campaigns should be launched to educate communities about the nutritional and economic benefits of mushroom cultivation, emphasizing its potential to provide year-round food and create employment opportunities. Second, training programs are needed to equip local communities with practical skills in cultivation techniques and sustainable harvesting practices. Third, comprehensive studies should be conducted to document mushroom biodiversity, inform conservation policies, and guide both in-situ and ex-situ conservation strategies. Such studies

should account for seasonal fluctuations in mushroom availability, requiring extended study durations to capture reliable ecological data.

Finally, collaborative efforts among policymakers, conservation managers, NGOs, enterprises, and scientists are essential to integrate community-driven initiatives with formal conservation frameworks. By combining education, livelihood diversification, and scientific research, stakeholders can foster sustainable mushroom utilization, strengthen local resilience, and contribute to biodiversity conservation. This holistic approach aligns with broader goals of environmental stewardship and socio-economic development, ensuring that edible mushrooms remain available for future generations while supporting the well-being of communities dependent on natural resources in and around Garamba National Park.

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