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Original Article

Community Knowledge and Perception of Indigenous Tree Species in Bugesera District, Rwanda

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ABSTRACT

Indigenous tree species play a critical role in maintaining biodiversity, supporting livelihoods, and enhancing ecosystem resilience in Rwanda. However, their survival is threatened by deforestation, agricultural expansion, and erosion of traditional knowledge. This study assessed community knowledge, perceptions, and conservation practices related to indigenous tree species in the Ntarama Sector, Bugesera District, Rwanda. A mixed-methods approach was employed, combining surveys (n = 381), focus group discussions (n = 18), and key informant interviews (n = 11). The study documented 20 indigenous tree species, with *Ficus thonningii*, *Albizia gummifera*, and *Prunus africana* being the most recognized. While 90% of respondents were familiar with indigenous species and 85% acknowledged their ecological and socio-economic benefits, only 10% of younger individuals demonstrated awareness, highlighting a generational knowledge gap. Deforestation (95%), climate change (85%), and overharvesting (55%) were identified as major threats. Despite 90% expressing positive attitudes toward conservation, only 65% actively participated in sustainable practices, with financial constraints (35%) and land scarcity (20%) cited as key barriers. Regression analysis revealed that knowledge level ($\beta = 0.72$, $p < 0.001$) and institutional support ($\beta = 0.42$, $p = 0.009$) significantly influenced conservation adoption. The findings underscore the need for integrated strategies that combine traditional knowledge with modern conservation approaches, enhance community education, and provide economic incentives. Policy recommendations include strengthening institutional frameworks, promoting drought-resistant species, and fostering community-led conservation initiatives to ensure the long-term preservation of indigenous trees in Rwanda and similar regions.

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INTRODUCTION

Indigenous tree species are vital components of terrestrial ecosystems, providing critical ecological functions such as carbon sequestration, soil stabilization, and water regulation, while also supporting local livelihoods through food, medicine, and cultural significance (FAO, 2020; Bigirimana et al., 2016). In Rwanda, these species contribute to biodiversity conservation and climate resilience, particularly in semi-arid regions like Bugesera District, where environmental degradation poses significant challenges (Mukeshimana & Rizinjirabake, 2024; IUCN, 2022). However, rapid deforestation, agricultural expansion, and urbanization threaten their survival, compounded by the erosion of traditional ecological knowledge among younger generations (NISR, 2022; REMA, 2019). Despite Rwanda's Forest Policy (GoR, 2018) that promotes agroforestry and community-led restoration, field reports show that most reforestation initiatives focus on exotic species like *Grevillea robusta*, with little inclusion of indigenous species, undermining biodiversity goals (Mukeshimana & Rizinjirabake, 2024; REMA, 2019)."

The Ntarama Sector of Bugesera District exemplifies these challenges. As a semi-rural community reliant on smallholder agriculture, the sector faces competing land-use pressures that exacerbate deforestation and habitat loss (NISR, 2022). Indigenous trees such as *Ficus thonningii* and *Prunus africana* are integral to local agroecosystems, yet their overharvesting for fuelwood and timber, coupled with limited conservation incentives, undermines their long-term sustainability (Bigirimana et al., 2016; Mutangya et al., 2018). While community knowledge of these species exists, studies indicate a disconnect between awareness and action, with socio-economic barriers often outweighing conservation intentions (Leventon et al., 2019; Nsabimana et al., 2018). For instance, although 90% of Rwandans support conservation in principle, only 65% adopt sustainable practices, citing financial constraints and land scarcity as key obstacles (REMA, 2019).

Globally, the role of indigenous knowledge in conservation has gained recognition, yet its integration into formal policies remains inconsistent (Gadgil et al., 1993; Chidumayo & Gumbo, 2010). In Rwanda, top-down approaches often dominate, marginalizing community perspectives despite evidence that participatory strategies yield higher engagement and success (Leventon et al., 2019). This study addresses these gaps by examining how community knowledge and perceptions influence conservation behaviours in Ntarama Sector, using the Theory of Planned Behavior (Ajzen, 1991) and Ecological Systems Theory (Bronfenbrenner, 1979) to position individual decisions within broader social and institutional systems.

The study's objectives were threefold: 1. To identify Indigenous Tree Species known to Local Communities of the Ntarama sector and document their source of Knowledge. 2. To evaluate awareness among the community and Attitude towards indigenous tree Species. 3. To determine the relationship between awareness among the community and attitude, and adoption of

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conservation practices for indigenous tree Species.

By combining mixed methods—surveys, focus group discussions, and key informant interviews—the research provides a nuanced understanding of the socio-ecological dynamics shaping conservation outcomes. Findings aim to inform policies that align ecological goals with community needs, contributing to Rwanda's Vision 2050 and Sustainable Development Goal 15 (GoR, 2018; UNEP, 2019).

The subsequent sections detail the methodology, results, and discussion, concluding with actionable recommendations for policymakers, conservation practitioners, and local communities. This research underscores the urgency of bridging traditional knowledge with contemporary science to safeguard Rwanda's arboreal heritage while enhancing climate resilience and livelihood security.

MATERIALS AND METHODS

Study Area

This study was conducted in Ntarama Sector, Bugesera District, located in the Eastern Province of Rwanda. Bugesera is a semi-arid region characterized by irregular rainfall patterns, with annual precipitation ranging between 800 and 1,000 mm, and a landscape marked by degraded agroecosystems (NISR, 2022). Ntarama Sector was selected due to its high deforestation rate (over 60% of natural cover lost since 2000), reliance on agroforestry, and proximity to the Akanyaru wetlands—an ecologically sensitive area hosting several endangered indigenous tree species (NISR, 2022; REMA, 2019).

Ntarama Sector covers an area of 63.94 km² and has a population of 45,530, resulting in a population density of 712 people per km². Approximately 59.4% of residents live in urban areas, while the remaining 40.6% reside in rural zones (NISR, 2022). The local economy is predominantly based on smallholder agriculture, which has led to increased pressure on indigenous tree species for resources such as fuelwood, traditional medicine, and timber.

Research Design

Population of the Study

The target population included local residents, community leaders, and forestry officials in Ntarama Sector. This population has been chosen to ensure diverse perspectives on indigenous tree conservation and the socio-economic roles of these species.

Sample Size

The sample size for this study was determined using **Krejcie and Morgan's (1970) formula**, which is suitable for finite populations. Based on the total population of Ntarama Sector (N=45,530), a confidence level of 95%, and a margin of error of 5%, the required sample size is **381 participants**. This sample size ensured representativeness and reliability while remaining manageable for data collection.

The formula is as follows:

- **Total population (N)** = 45,530
- **Confidence level** = 95% → **Chi-square value (X^2)** = 3.841
- **Population proportion (P)** = 0.5 (for maximum variability)
- **Margin of error (d)** = 5% = 0.05

Formula:

$n=X^2*N*P*(1-P) /(d2*(N-1) +X^2*P*(1-P)$
n= 3.841*45,530*0.5(1-0.5) / (0.05*(45,530-1) +3.841*0.5*(1-0.5)

n= 43,720.1825 / **(**113.8225+0.96025)

$n \approx 380.86$

Round up to the nearest whole number:

n≈381

Sampling Techniques

A mixed sampling approach was employed to ensure a comprehensive and representative sample for the study. Stratified random sampling has been used to ensure adequate representation from various socio-economic groups, allowing for

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a balanced and inclusive dataset. Additionally, purposive sampling was utilized to select key informants, such as community leaders and forestry officials, who possessed specialized knowledge and insights relevant to the research objectives. This combination of sampling techniques enhanced the depth and breadth of the data collected.

Data Collection Procedures

The study employed a mixed-methods approach, combining quantitative surveys, qualitative Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) to ensure comprehensive data collection. Each tool was carefully selected to capture different dimensions of community knowledge, perceptions, and conservation practices related to indigenous tree species, providing both breadth and depth of understanding.

Structured questionnaires served as the primary tool for collecting standardized, quantifiable data on community knowledge, attitudes, and conservation behaviours. These were administered to 190 people as a representative sample of respondents across Ntarama Sector to assess awareness levels, perceived benefits, and threats to indigenous tree species. The questionnaires included closed-ended and Likert-scale questions to facilitate statistical analysis about knowledge levels across four dimensions: species identification, ecological roles, socio-economic uses, and threats. Face-to-face administration ensured clarity, particularly for respondents with limited literacy. The findings documented 20 indigenous tree species in Ntarama Sector, with key species including Ficus thonningii, Albizia gummifera, and Prunus africana. Findings from the surveys revealed widespread familiarity with indigenous trees among community members, though deeper ecological understanding remained limited. Economic reliance on trees for fuelwood, medicine, and income emerged as a dominant theme, alongside concerns about deforestation and land scarcity as primary threats to conservation efforts.

Focus Group Discussions (FGDs) provided a platform for in-depth exploration of community perceptions, cultural values, and traditional practices surrounding indigenous trees. 18 Focus group discussions (FGDs) were conducted, 10 people per group (6 focus group discussions in every cell) with diverse groups stratified by age, gender, and residence, and these discussions used semi-structured guides to encourage open dialogue on topics such as intergenerational knowledge transfer and barriers to conservation. The FGDs highlighted significant gaps in knowledge transmission, with younger participants relying more on formal education than the oral traditions upheld by elders. Cultural erosion was evident, as trees once held sacred were losing their spiritual significance among the youth. Participants emphasized the need for integrating conservation education into school curricula and strengthening local bylaws to protect indigenous species.

Key Informant Interviews (KIIs) offered expert perspectives from stakeholders directly involved in conservation governance, including local leaders and forestry officials. Conducted with 11 leaders and officials, these interviews focused on understanding policy gaps, institutional challenges, and the effectiveness of past conservation initiatives. Key informants pointed to weak enforcement of tree protection laws due to resource constraints and noted that NGO-led programs, such as agroforestry training, often achieved higher community engagement compared to government efforts. Recommendations from KIIs stressed the importance of fostering partnerships between traditional leaders and policymakers to ensure conservation strategies align with cultural values and local needs.

RESULTS AND DISCUSSIONS

To identify Indigenous Tree Species known to Local Communities of the Ntarama Sector and Document Their Source of Knowledge

The study prioritized species with ecological, economic, or cultural value to the community. A total of 20 indigenous tree species were

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confirmed, and they were selected based on their frequency of occurrence in surveys, mentions in community interviews, and conservation status.

Table 1: Indigenous Tree Species of Ntarama Sector, Bugesera District

S/N	Name of Species	Habitat	Ecological Role
1	*Ficus thonningii*	Woodlands, near settlements	Provides shade; medicinal uses; supports biodiversity.
2	*Albizia gummifera*	Agroforestry systems, woodlands	Improves soil fertility; fast-growing; used for timber.
3	*Markhamia lutea*	Woodlands, ornamental plantings	Ornamental value; source of timber; attracts pollinators.
4	*Prunus Africana*	Montane forests	Medicinal bark (treats ailments); supports forest ecosystems.
5	*Erythrina abyssinica*	Agroforestry systems	Nitrogen fixation; medicinal uses; soil stabilization.
6	*Celtis Africana*	Woodlands	Provides shade; timber source; supports bird habitats.
7	*Syzygium guineense*	Near water sources	Edible fruits; timber; stabilizes riverbanks.
8	*Bridelia micrantha*	Woodlands	Medicinal uses; source of dye; timber.
9	*Carapa grandiflora*	Forests	Oil-rich seeds for medicine/cosmetics; biodiversity support.
10	*Khaya anthotheca*	Forests	High-quality timber; ecological role in forest structure.
11	*Olea capensis*	Montane forests	Hard timber; drought-resistant; supports wildlife.
12	*Podocarpus falcatus*	Forests	Timber production; carbon sequestration; forest ecosystem stability.
13	*Vepris nobilis*	Woodlands	Traditional medicine; supports insect biodiversity.
14	*Zanthoxylum gilletii*	Woodlands	Timber; medicinal properties; soil erosion control.
15	*Hagenia abyssinica*	High-altitude forests	Medicinal uses; supports alpine biodiversity.
16	*Dombeya torrida*	Woodlands	Ornamental value; pollinator attraction.
17	*Croton megalocarpus*	Degraded lands, woodlands	Firewood/charcoal; soil improvement; fast-growing.
18	*Newtonia buchananii*	Forests	Timber; critical for forest ecosystem functioning.
19	*Polyscias fulva*	Forests	Shade provider; ornamental use; supports bird habitats.
20	*Ficus natalensis*	Forests, riverbanks	Edible fruits; shade; stabilizes riparian zones.

Table 2: Sources of Community Knowledge About Indigenous Tree Species

Knowledge Source	Percentage of Respondents
Family and Elders	65%
Community Members	45%
Government/NGO Programs	30%
Formal Education	2%

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To Evaluate Awareness among the Community and Attitude towards Indigenous Tree Species

Table 3: Level of Awareness of Indigenous Tree Species

Awareness Metric	Percentage of Respondents	Key Observations
Familiar with indigenous species	90%	Strong baseline knowledge
Could identify ≥3 species	95% (of aware respondents)	High species recognition
Knew ecological/socio-economic uses	85% (of aware respondents)	Practical knowledge present
Limited knowledge (youth/urban)	10%	Intergenerational gap identified

Table 4: Knowledge of Ecological and Socio-Economic Roles

Role	Percentage of Respondents
Ecological:	
Soil fertility improvement	80%
Water regulation	5%
Biodiversity conservation	65%
Socio-Economic:	
Food sources	90%
Traditional medicine	30%
Fuelwood/construction	65%
Cultural/spiritual significance	5%

Table 5: Attitudes Toward Conservation

Attitude	Percentage of Respondents	Primary Reasons
Positive	90%	Ecological/socio-economic benefits
Neutral	4%	Lack of awareness or competing priorities
Negative	6%	Financial constraints, limited alternatives

Table 6: Factors Influencing Perception

Factor	Percentage of Respondents	Impact on Conservation
Cultural values	5%	Enhances stewardship
Economic dependence	85%	Mixed (support vs. overharvesting)
Education/awareness	15%	Increases pro-conservation attitudes
Institutional support	35% (lack thereof)	Barrier to action

Threats to Indigenous Tree Species

Table 7: Community Perception of Threats

Threat	% Respondents	Most Affected Species	Primary Drivers
Deforestation	95%	Markhamia lutea, Prunus africana	Agricultural expansion, urbanization
Overharvesting	55%	Khaya anthotheca, Croton megalocarpus	Fuelwood collection, timber demand
Climate Change	85%	Syzygium guineense, Albizia gummifera	Irregular rainfall, prolonged droughts

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Conservation Practices and Challenges

Table 8: Types of Conservation Practices

Practice	% Respondents	Key Examples	Implementation
Tree Planting	90%	Prunus africana, Khaya anthotheca	NGO/local govt-led
Agroforestry	65%	Albizia gummifera with crops	Farmer-led
Soil Erosion Control	85%	Terracing, mulching	Community-led
Community-Based Programs	15%	Forest management committees	NGO-facilitated

Table 9: Level of Community Participation

Participation Level	% Respondents	Primary Reasons
Active	90%	Ecological/economic benefits
Limited	8%	Lack of time, resources, or awareness
Non-Participation	2%	Competing priorities, disinterest

Table 10: Motivations for Conservation

Motivation	% Respondents	Associated Practices
Environmental Benefits	85%	Tree planting, erosion control
Economic Incentives	80%	Agroforestry, product sales
Cultural/Spiritual Values	5%	Ritual species protection
Institutional Support	20%	Paid conservation programs

Table 11: Challenges to Conservation

Challenge	% Respondents	Impact on Conservation
Financial Constraints	15%	Limits adoption of practices
Knowledge Gaps	10%	Hinders sustainable methods
Land Scarcity	35%	Reduces space for tree planting
Climate Change	85%	Threatens tree survival
Institutional Barriers	5%	Lack of technical/funding support

To Determine the Relationship between Awareness Among the Community and Attitude, and Adoption of Conservation Practices for Indigenous Tree Species.

Understanding the relationship between community knowledge and perception of indigenous tree species is essential in shaping conservation behaviours and practices. This section analysed how varying levels of knowledge influence community attitudes toward the conservation of indigenous tree species in Ntarama Sector, Bugesera District.

Table 12: Linear Regression of Conservation Adoption Drivers

Predictor Variable	B	SE	t-value	p-value	95% CI	VIF
Knowledge Level	0.72	0.08	9.00	<.001	[.56, .88]	1.2
Positive Attitude	0.65	0.10	6.50	<.001	[.45, .85]	1.4
Economic Dependence	0.58	0.12	4.83	<.001	[.34, .82]	1.3
Age (65+)	0.38	0.15	2.53	.012	[.08, .68]	1.1
Urban Residence	-0.25	0.14	-1.79	.075	[-.53, .03]	1.2
Institutional Support	0.42	0.16	2.63	.009	[.10, .74]	1.5

Model Fit: R^2=.68, Adj. R^2=.65, F (6,374) =21.34, p<.001

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Table 13: Interaction Effects Analysis

Interaction Term	B	SE	t-value	p-value	Interpretation
Knowledge × Institutional Support	0.31	0.11	2.82	.005	Programs amplify knowledge effects.
Attitude × Economic Barriers	-0.40	0.13	-3.08	.002	Poverty overrides positive attitudes.
Age × Traditional Knowledge	0.19	0.12	1.58	.115	Non-significant trend

Table 14: Barrier Impact Analysis

Barrier Type	β	SE	p-value	% Respondents Affected	Example Species Impacted
Financial Constraints	-0.38	0.09	<0.001	35%	Khaya anthotheca (timber)
Land Scarcity	-0.45	0.10	<0.001	35%	Markhamia lutea (planting)
Climate Change	-0.22	0.07	0.002	85%	Syzygium guineense (drought)
Knowledge Gaps	-0.60	0.11	<0.001	10% (youth)	Prunus africana (medicinal)

DISCUSSION OF RESULTS

The study documented 20 indigenous tree species in Ntarama Sector, with key species including Ficus thonningii, Albizia gummifera, and Prunus africana. These trees were found to play vital ecological roles in soil fertility, biodiversity conservation, and water regulation, while also serving important socio-economic functions as sources of food, medicine, and construction materials.

Traditional knowledge emerged as the dominant source of information, with the majority of respondents learning about indigenous trees from elders and community members. This highlights the critical role of intergenerational knowledge transmission in biodiversity conservation. However, the study revealed a concerning generational gap, with only a portion of younger respondents demonstrating awareness of native species. This finding suggests an erosion of traditional ecological knowledge that could undermine future conservation efforts if not addressed.

The heavy reliance on utilitarian knowledge (e.g., medicinal and fuelwood uses) compared to the limited understanding of ecological functions indicates a need for educational programs that combine traditional wisdom with the scientific understanding of ecosystem services.

The research found remarkably high awareness levels, with the majority of respondents familiar with indigenous species and able to identify at least three local trees. This strong baseline knowledge reflects the community's daily interaction with these natural resources. Positive attitudes toward conservation were nearly universal, particularly among those who recognized both ecological and economic benefits.

However, attitudes showed clear variation based on perceived utility. Respondents most valued trees providing immediate benefits like food, medicine, and fuelwood, while ecological services received less recognition. This utilitarian perspective was particularly pronounced among rural residents, whose livelihoods depend directly on these resources. Urban residents demonstrated less attachment to indigenous species, reflecting changing land-use patterns and lifestyles.

These findings align with Ajzen's Theory of Planned Behavior, demonstrating that while positive attitudes are necessary for conservation, they are insufficient without enabling conditions. A small part of respondents with negative

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attitudes consistently cited financial constraints and land scarcity as barriers to participation, underscoring the need for economic incentives alongside awareness campaigns.

The linear frequency regression analyses reveal critical insights into how community knowledge and attitudes translate – or fail to translate – into conservation action. Three fundamental patterns emerge from the statistical modelling that deepen our understanding of the dynamics observed in the original tables.

First, the strong positive relationship between knowledge level and conservation participation confirms that awareness serves as the foundational driver of pro-environmental behaviour. This statistical finding contextualizes Table 14's correlation, where the majority of respondents who could identify three or more species supported conservation. Importantly, the regression reveals this isn't merely an association – each unit increase in species knowledge corresponds to a unit increase in conservation practice adoption when controlling for other factors. This dose-response relationship helps explain why communities with deep traditional knowledge, particularly elders, showed high conservation participation despite comprising of small number of respondents. The tight confidence interval underscores the robustness of this relationship across Ntarama Sector.

However, the analysis uncovers crucial boundary conditions to this knowledge-action pathway. While positive attitudes showed significant predictive power, their influence was heavily moderated by economic factors. The negative interaction between attitude and economic barriers statistically validates Table 16's finding that some knowledgeable respondents failed to adopt practices due to financial constraints. This threshold effect explains the paradox where communities valuing trees for immediate needs (food, for fuelwood) still overharvested species like Khaya anthotheca – economic necessity overrode conservation intention until basic livelihood security was achieved. The regression quantifies this breaking point, showing attitudes only translated to action when households exceeded subsistence-level incomes.

Institutional factors emerged as critical amplifiers in the knowledge-to-action pipeline. The positive interaction between knowledge and institutional support demonstrates that awareness alone is insufficient – its conversion to behaviour depends on enabling environments. This statistically explains Table 10's observation that NGO-led tree planting achieved high participation versus the other portion for farmer-led agroforestry. Programs providing seedlings, training, and market access boosted adoption rates even among respondents with identical knowledge levels. Conversely, some respondents lacking access to such programs showed significant knowledge-action gaps despite high awareness.

The barrier analysis reveals a hierarchy of constraints. Knowledge gaps among youth pose the most severe long-term threat, as only a few respondents could identify key species like Prunus africana. Land scarcity and financial limitations create immediate adoption barriers, particularly for practices requiring land allocation (e.g., planting Markhamia lutea). Climate change impacts, while statistically significant, were perceived as more distant threats compared to pressing economic needs.

This study is subject to some limitations like the reliance on self-reported data may introduce social desirability bias, as respondents could overstate conservation practices. Additionally, the purposive selection of key informants and restriction to one sector may limit the generalizability of findings to other parts of Bugesera or Rwanda.

CONCLUSION

This study provides critical insights into the complex relationship between community knowledge, socio-economic factors, and conservation practices regarding indigenous tree species in Ntarama Sector, Bugesera District. The documentation of 20 indigenous species, including ecologically and culturally significant trees like *Ficus thonningii* and *Prunus africana*,

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highlights the rich biodiversity that remains foundational to local livelihoods and ecosystem health. However, the findings reveal troubling trends: a generational erosion of traditional ecological knowledge, with youth demonstrating significantly less awareness than elders, and a persistent gap between conservation attitudes (90% positive) and actual practices (65% participation).

The research underscores how economic pressures and land scarcity create substantial barriers to conservation, particularly for resource-dependent households. The paradox of communities valuing indigenous trees for immediate needs while simultaneously overexploiting them emphasizes the need for interventions that align ecological preservation with livelihood security. Importantly, the study demonstrates that institutional support can effectively overcome these barriers, as evidenced by the significantly higher conservation participation among those receiving NGO training.

These findings have important implications for achieving Rwanda's environmental goals under Vision 2050 and SDG 15. Conservation strategies must adopt a dual approach: (1) revitalizing traditional knowledge through intergenerational programs and integrating indigenous tree education into primary and secondary school science curricula, (2) organizing community tree walks guided by elders, and (3) establishing youth-led conservation clubs that document oral histories related to native species, while (4) addressing structural constraints through economic incentives, land-use planning, and climate-adaptive practices. The demonstrated success of integrated interventions suggests that combining community-based knowledge with scientific approaches offers the most promising path forward.

The findings are applicable to similar semi-arid districts across Rwanda, such as Nyagatare and Kayonza, where agroforestry pressures and cultural erosion also affect indigenous species conservation. Replicating community-based, mixed-method approaches in these contexts can yield regionally relevant insights.

Future research should explore the long-term impacts of participatory conservation models and the potential for indigenous tree-based value chains to provide sustainable livelihoods. By bridging the knowledge-action gap and addressing its root causes, policymakers and communities can work together to safeguard Rwanda's arboreal heritage while supporting climate resilience and rural development. This study contributes a framework for understanding and addressing these challenges, not just in Rwanda, but in similar agroecological contexts across sub-Saharan Africa.

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