Farmers' perceptions of the diversity and role of native woody species in the agroecosystems of central and northern Burundi

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Research

Abstract

Background: Agroecosystems may serve as important refuges for native biodiversity in landscapes where natural forests have been severely reduced. However, the diversity and local importance of native woody species outside protected areas remain poorly documented in Burundi. This study assessed native woody species in four agroecosystems and identified species relevant to local livelihoods, biodiversity conservation, and ecological restoration.

Methods: An ethnobotanical survey was conducted among 180 farmers in Makebuko, Bugenyuzi, Muyinga, and Busiga using semi-structured interviews and the walk-in-the-woods approach. Native woody species and their uses were documented, while reported uses were classified into regulating, provisioning, and cultural ecosystem services, as well as land-management practices.

Results: Overall, 52 native woody species representing 40 genera and 25 families were recorded, with Fabaceae being the most diverse family (19.2%). Thirty-five species (67.3%) were recognized as useful by local communities. Regulating services accounted for 48% of use reports followed by provisioning (32.4%). Shade provision, fuelwood, windbreaks, erosion control, and soil fertility improvement were the most frequently reported uses. Ten species combined high cultural importance with locally perceived declines, highlighting their potential relevance for conservation and restoration.

Conclusions: This study demonstrates that agroecosystems outside protected areas can retain substantial native woody diversity while providing multiple ecosystem services. Highly valued multipurpose species that are locally perceived as

declining represent potential priorities for conservation and ecological restoration. Integrating farmers' ecological knowledge with scientific assessments into agroforestry and community-based restoration planning can strengthen biodiversity conservation, maintain locally valued ecosystem functions, and support sustainable livelihoods in Burundi.

Keywords: Ethnobotany, Native woody species, ecosystem services, ecological restoration, agroecosystems, Burundi

Background

Biodiversity underpins ecosystem functioning and human well-being by providing a wide range of ecosystem services that are essential for food security, climate regulation, soil fertility, and the resilience of production systems (IPBES 2019, MEA 2005). In agroecosystems, biological diversity contributes to agricultural productivity, ecological stability, and landscape sustainability by supporting provisioning, regulating, and cultural ecosystem services (Jose 2009, Kazemi *et al.* 2018, Plieninger *et al.* 2019, Torralba *et al.* 2016, Udawatta *et al*. 2019). However, agricultural intensification, deforestation, habitat fragmentation, and infrastructure expansion have caused an unprecedented decline in global biodiversity, thereby compromising ecosystem functioning and reducing the capacity of ecosystems to withstand environmental disturbances (Erisman *et al.* 2016, Feledyn-Szewczyk *et al.* 2016, IPBES 2019, Pimm *et al.* 1995).

In tropical regions, agricultural landscapes occupy an increasingly substantial proportion of the land surface and can play an important role in biodiversity conservation (Perfecto & Vandermeer 2008, Tscharntke *et al.* 2005). Trees retained in agroecosystems provide numerous ecological functions, including soil erosion control, soil fertility enhancement, carbon sequestration, microclimate regulation, and biodiversity conservation (Bhagwat *et al.* 2008, Jose 2009, Santos *et al.* 2019, Torralba *et al.* 2016). They also supply essential goods and ecosystem services to rural communities while contributing to the restoration of degraded landscapes (Boinot *et al.* 2022, Perfecto & Vandermeer 2010).

Previous studies have investigated the diversity and ecological roles of woody species in agroecosystems across Latin America and Africa, including Brazil (Santos *et al.* 2019), Nicaragua (Sistla *et al.* 2016), and Ethiopia (Endale *et al.* 2016, Esquivel *et al.* 2023 Kassa *et al.* 2023, Legesse & Negash 2021, Molla & Kewessa 2015, Tazebew & Asfaw 2018). In Burundi, however, research has focused primarily on communities living adjacent to protected areas (Bimenyimana *et al.* 2023, Masharabu *et al.* 2014, Ndayishimiye *et al.* 2018, Ndayizeye *et al.* 2020). By contrast, ethnobotanical studies in highly human-modified agroecosystems located far from protected areas remain poorly documented, despite representing the dominant rural landscapes of the country and harboring the last remnants of native woody flora (Masharabu *et al.* 2017).

Within these agricultural landscapes, native trees are generally maintained as scattered individuals, hedgerows, or small woodland patches because of their multiple uses and agronomic benefits (Carrière 2002, Masharabu *et al.* 2014). Nevertheless, their diversity, their importance to local communities, and their contribution to biodiversity conservation remain insufficiently documented, limiting their integration into national ecological restoration and agroforestry development strategies. The objectives of this study were to (i) inventory the native woody species occurring in the agroecosystems of Makebuko, Bugenyuzi, Muyinga, and Busiga; (ii) assess their importance to local communities through the ecosystem goods and services they provide; and (iii) identify potential species for biodiversity conservation and ecological restoration. The findings are expected to improve current knowledge of plant biodiversity in Burundi's agricultural landscapes and provide a scientific basis for promoting the integration of native woody species into degraded land restoration and sustainable agroforestry programs.

Materials and Methods

Study area

This study was conducted through an ethnobotanical survey of native woody species in four agroecosystems of Makebuko, Bugenyuzi, Muyinga, and Busiga, all located in central and northern Burundi (Fig. 1). The sampled sites are situated between 2°47′43″ and 3°38′40″ S latitude and 29°57′49″ and 30°21′49″ E longitude, at elevations ranging from 1698 to 1730 m above sea level. These agroecosystems belong to Burundi's Central Plateau, which is characterized by a landscape of deeply dissected hills, a tropical highland climate (17-20 °C; 1200-1500 mm annual rainfall), and soils of variable fertility that are highly susceptible to erosion due to intense anthropogenic pressure (MINEAGRIE 2025). They are among the most densely populated rural areas in the country, where livelihoods depend primarily on intensive smallholder farming combining food crop production with coffee cultivation (RGPHAE 2024).

Land use is overwhelmingly dominated by agroecosystems, while natural forests have almost entirely disappeared and have been replaced by croplands, settlements, and plantations of exotic tree species, mainly *Eucalyptus* spp., *Grevillea robusta*, and *Cedrela* spp. Native woody species persist mainly as scattered trees, live fences, and small woodland patches deliberately retained by farmers because of their multiple ecological and socioeconomic functions (Jose 2009, Masharabu *et al.* 2014, Torralba *et al.* 2016). The selected agroecosystems are representative of highly human-modified sites located far from Burundi's major protected areas, a landscape context that has received little scientific attention (Masharabu *et al.* 2017). Investigating these agricultural landscapes is therefore essential for improving our understanding of the role of native trees in biodiversity conservation and ecosystem service provision outside protected areas, where a substantial proportion of tropical biodiversity is now found (Barrios *et al.* 2017, Chazdon *et al.* 2009, Perfecto & Vandermeer 2010, Santos *et al.* 2022).

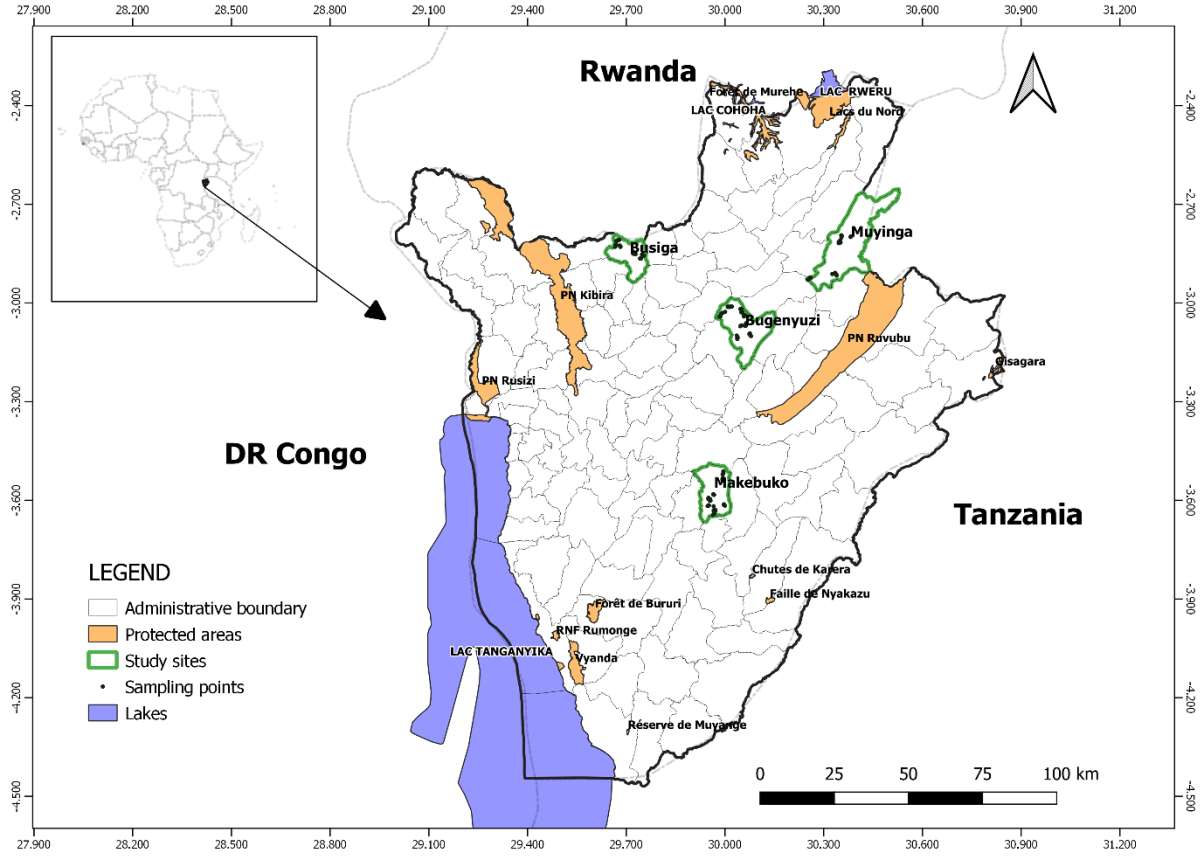

Figure 1. Map of Burundi showing the major protected areas, study agroecosystems, and sampling points

Data collection

Information on native woody species occurring in agricultural landscapes was collected through semi-structured interviews with farmers during January 2024. In each village, preliminary meetings were held with the local authorities to facilitate activity planning and introduce the research team to the participating households. A total of 180 farmers, including 55 from Makebuko, 50 from Bugenyuzi, 31 from Muyinga and 44 from Busiga (Table 1), were interviewed to document the diversity and importance of native woody species within their farming systems. Participants were selected with the assistance of local community leaders, following a snowball sampling approach (Goodman 1961), and each interview was conducted individually.

During each interview, respondents were asked to list all native woody species they knew and to describe the importance of each species in their locality. Reported uses included construction timber, fuelwood, handicraft materials, medicinal uses, shade, erosion control, windbreaks, soil fertility improvement, live fencing, boundary demarcation, social uses, and other functions. Interviews followed the walk-in-the-woods approach (Phillips & Gentry 1993a), during which each respondent guided the interviewer through the surrounding landscape to identify the cited species in situ. Photographs of the species were taken in their natural habitats (Fig. 2) to confirm their occurrence, support taxonomic verification and facilitate the identification of species that could not be identified immediately in the field. Selected photographs were retained as digital photographic vouchers in the photographic archives of the University of Burundi Herbarium (BJA). However, photographic

documentation has been recognized as a useful alternative or complement to conventional herbarium vouchers in ethnobotanical research, particularly when collecting plant material is impractical (Gómez-Bellver et *al.* 2020, Greene *et al.* 2023, LaFrankie & Chua 2015). Thus, for this study, woody species were operationally defined as perennial plants with persistent, self-supporting stems or trunks, including trees, shrubs, subshrubs with lignified basal stems, and arborescent monocots (Cornelissen *et al*. 2003, Pérez-Harguindeguy *et al*. 2013). Species with entirely herbaceous stems or succulent, non-lignified stems were excluded. Growth forms were also verified using Plants of the World Online (Royal Botanic Gardens 2026). Each interview was conducted in local language/Kirundi and took between 20 and 30 minutes. All data were collected using the KoboCollect mobile application.



Figure 2. Some photographs of selected woody species documented during ethnobotanical interviews in the study agroecosystems: (a) *Polyscias fulva*, (b) *Markhamia lutea*, (c) *Kigelia africana*, (d) *Maesa lanceolata*, (e) *Ficus ingens*, (f) *Gymnanthemum amygdalinum* and (g) *Cordia africana*

Botanical identification

Species were identified in the field using the local Kirundi names provided by interviewees. When immediate identification was not possible, field photographs were reviewed in consultation with botanical experts to support species identification (Greene *et al.* 2023, Łuczaj 2010, Thomas *et al.* 2007). Local reference floras were also consulted (Habiyaremye & Nzigidahera 2016, Nzigidahera 2000, Nzigidahera *et al.* 2020). Scientific names were verified using the Plants of the World Online (Royal Botanic Gardens 2026) database following the Angiosperm Phylogeny Group (APG IV 2016).

Data analysis

Floristic diversity was assessed using species richness (S), defined as the total number of species recorded within each of the four study agroecosystems. Similarity among the studied agroecosystems based on species presence-absence was evaluated by hierarchical cluster analysis using MVSP version 3.22 (Multi-Variate Statistical Package) with the Jaccard similarity coefficient. This coefficient ranges from 0, indicating no species shared between two sites, to 1, indicating complete similarity in species composition. The cultural importance of each species was assessed using the Cultural Importance Index (CI) proposed by Tardío and Pardo-de-Santayana (2008) and, recently used by Fremout *et al.* (2021):

$$CI = \sum_{u=u_1}^{U_{NC}} \sum_{i=i_1}^{i_N} \frac{UR_{ui}}{N}$$

Where $\mathbf{UR_{ui}}$ represents the use report of use category u by informant i, **N** is the total number of informants, and **NC** is the total number of use categories. This index ranks species according to both the diversity and frequency of their reported uses, thereby identifying the species of greatest importance for conservation and ecological restoration (de Albuquerque *et al.*

2009). Furthermore, when considering a single use category, the CI is equal to the relative frequency of citation (RFC) for that use category. The CI index is equivalent to the simplified version of the use value index (UV), proposed by Phillips and Gentry (1993a, 1993b), and Tardío and Pardo-de-Santayana (2008).

Following the Common International Classification of Ecosystem Services (CICES) (Haines-young & Potschin 2018), the reported uses categories of native woody species were grouped into provisioning (construction timber, fuelwood, handicraft materials, and medicinal use), regulating (shade, erosion control, windbreaks, soil fertility improvement) and cultural services including social uses. Live fencing and boundary demarcation were classified separately as land-management practices because these reported functions do not necessarily correspond to final ecosystem services under CICES. This additional analytical category was introduced to distinguish ecosystem contributions from the direct, practical uses of native woody species reported by local communities, while maintaining consistency with the conceptual framework of CICES (Haines-Young & Potschin 2018). To assess the consistency between the locally perceived environmental uses, land-management practices and species decline with available scientific knowledge, relevant literature (Abdulrahaman *et al.* 2013, Alemayehu *et al.* 2016, Bimenyimana *et al.* 2023, Borba *et al.* 2021, Dumont *et al.* 2015, Ekawati & Aziz 2016, FAO 2012, Masharabu *et al.* 2014 & 2017, Ndayambaje & Mohren 2011, Nzigidahera 2000, Oginosako *et al.* 2006, PKR Nair 1985, Sauvadet *et al.* 2020, Tebkew *et al.* 2023, Van Noordwijk *et al.* 2011), and agroforestree and useful trees databases (FAO 2026, Fern 2014, Kindt & Innocent 2016, Kuria et *al.* 2017ab & 2020, Muthuri *et al.* 2023, Orwa *et al.* 2009, SANBI 2026) were consulted. Further details are provided in supplementary file (Table S1). For species covered by existing studies or database records, locally reported uses and perceived declines were assessed against the available evidence and classified as consistent or inconsistent. For species for which no relevant scientific evidence was found, the outcome was recorded as "no information found".

Statistical test

A nonlinear power regression, fitted using Microsoft Excel and recently used by Haq *et al.* (2023), was used to describe the relationships between species richness and the recorded botanical families. This relationship was modelled using the power function ($y=ax^b$), where (x) represents family rank and (y) the number of species per family. The use of nonlinear regression methods is described by Bates and Watts (1988). Data normality was assessed using the Kolmogorov-Smirnov test (Frank J. Massey 1951), while homogeneity of variances was evaluated using Levene's test (Brown & Forsythe 1974, Iachine *et al.* 2010, Zhou *et al.* 2023). After verifying these assumptions, one-way analysis of variance (ANOVA) was conducted to compare species richness across surveyed sites within the four agroecosystems (Fisher 1925, Montgomery 2019). In addition, the relationship between the number of recorded species and the number of use reports across use categories was examined using Pearson's correlation coefficient (Pearson 1896). Statistical analyses were performed using IBM SPSS Statistics version 25.0 (IBM corp. 2017).

Results

Socio-demographic characteristics of the respondents

A total of 180 farmers participated in the study, including 149 men (82.8%) and 31 women (17.2%). All respondents were primarily engaged in agriculture, particularly coffee farming. In addition, three participants combined farming with trading activities and one was a civil servant, indicating that some participants combined farming with other income-generating or professional activities. Respondents' age ranged from 26 to 105 years, with a mean age of 54.4 ± 12.8 years and a median age of 55 years (Table 1). The age distribution showed slight positive skewness (0.21), indicating a relatively balanced distribution with a modest predominance of respondents older than the mean age. The kurtosis value (0.37) suggested an approximately normal distribution.

Diversity of native woody species in the agroecosystems

The ethnobotanical inventory recorded 52 native woody species belonging to 40 genera and 25 botanical families. The plants listed and their properties (family name, scientific name, local name, use categories, and sites) are grouped in Table 2. Fabaceae was the most species-rich family, comprising 10 species (19.2%), followed by Moraceae with six species (11.5%), and Euphorbiaceae and Lamiaceae, each represented by four species (7.7%). A clear relationship ($y = 9.1637x^{-0.753}$; $R^2 = 0.9256$) between family and species pattern was observed (Fig. 3), indicating a steep decline in species richness from the highest-ranked families to the less species-rich families. The high coefficient of determination suggests that the power function provides a good fit to the observed distribution, with 92.56% of the variation in the number of species per family explained by the fitted model.

Table 1. Socio-demographic characteristics of the 180 farmers interviewed in the surveyed agroecosystems.

Demographic features	Makebuko	Bugenyuzi	Muyinga	Busiga	Across study agroecosystems
Total respondents (n)	55	50	31	44	180
Gender (n)					
Male	41	40	29	39	149
Female	14	10	2	5	31
Ages (years)					
Mean ± SD	58.4 ± 12.8	54.6 ± 14.1	52.4 ± 11	50.6 ± 11.5	54.4 ± 12.8
Median	61	53	50	50	55
Range	26 - 87	29 - 105	36 - 80	29 - 72	26 - 105
Skewness	-0.48	0.72	0.46	-0.09	0.21
Kurtosis value	0.07	1.8	-0.35	-0.72	0.37
Additional occupations (n)					
Shopkeepers	-	3	-	-	3
Civil servant	-	1	-	-	1
Other	-	2	-	-	2

Notes: Values are presented as numbers (n), means ± standard deviations (SD), medians, or ranges, as appropriate. A dash (-) indicates that no respondent was recorded in the corresponding category. Additional occupations refer to activities reported alongside farming, where applicable.

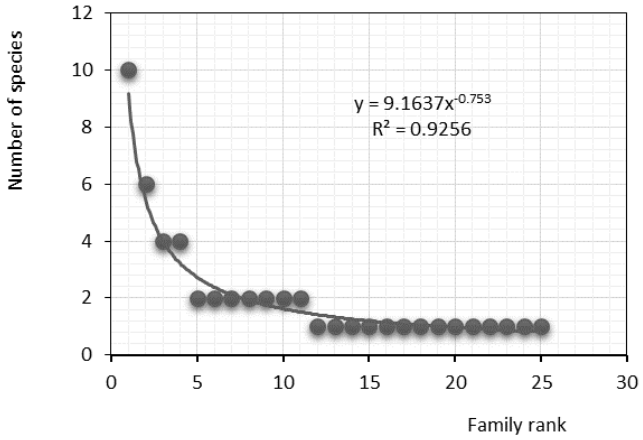

Figure 3. Relationship between families and species pattern in the four studied agroecosystems

Species richness (S) ranged from 26 to 37 species among the study sites. The highest richness was recorded in Makebuko (37 species), followed by Muyinga (33 species), Busiga (28 species), and Bugenyuzi (26 species). However, one-way ANOVA indicated that these differences were not statistically significant ($F = 0.398$, $p = 0.756$).

Floristic similarity based on the Jaccard coefficient revealed two main species assemblages (Fig. 4). The highest similarity was observed between Busiga and Bugenyuzi ($J = 0.588$), whereas Makebuko and Muyinga formed a second cluster with relatively high floristic similarity ($J = 0.522$).

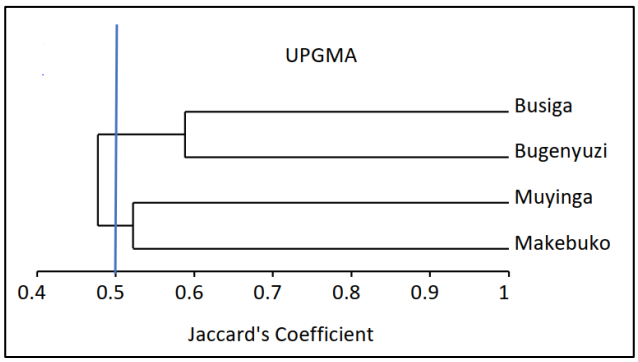

Figure 4. Dendrogram showing floristic similarity among the studied agroecosystems based on the presence-absence of native woody species

Table 2. List of woody species recorded in the agroecosystems of Bugenyuzi (1), Busiga (2), Makebuko (3), and Muyinga (4), together with their reported use categories.

Family	Scientific name	Local name	IUCN status	Use categories reported	Sites
Acanthaceae	*Acanthus polystachyus* Delile	*Igitovu*	NE	-	1, 2, 3, 4
Anacardiaceae	*Searsia natalensis* (Bernh. ex Krauss) F.A.Barkley	*Umusagara*	LC	-	3, 4
Anisophylleaceae	*Anisophyllea boehmii* Engl.	*Umushindwe*	NE	Fu	3
Annonaceae	*Annona senegalensis* Pers.	*Umukanda*	LC	-	4
Araliaceae	*Polyscias fulva* (Hiern) Harms	*Umwungo*	LC	-	2
Asparagaceae	*Dracaena afromontana* Mildbr.	*Inganigani*	LC	Co, Fu, Me, Fe, Sh, Wb, Bo, Lf, Cu	1, 2, 3, 4
	Dracaena steudneri Engl.	*Igitongati*	LC	Co, Me, Fe, Sh, Bo, Lf, Cu	1, 2, 3, 4
Asteraceae	*Gymnanthemum amygdalinum* (Delile) Sch.Bip.	*Umubirizi*	LC	Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	1, 2, 3, 4
	Solanecio mannii (Hook.f.) C.Jeffrey	*Umutagari*	LC	Fe	1, 2, 3, 4
Bignoniaceae	*Kigelia africana* (Lam.) Benth.	*Umuremeramabere*	LC	-	3
	Markhamia lutea (Benth.) K.Schum.	*Umusave*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	1, 2, 3, 4
Boraginaceae	*Cordia africana* Lam.	*Umuvugangoma*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	1, 2, 4
Cannabaceae	*Trema orientale* (L.) Blume	*Umurwampore*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Lf, To	1, 3, 4
Chrysobalanaceae	*Parinari curatellifolia* Planch. ex Benth.	*Umunazi*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf	1, 2, 3, 4
Combretaceae	*Combretum collinum* Fresen.	*Umukoyoyo*	LC	-	4
	Combretum molle R.Br. ex G.Don	*Umurama*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, To	3, 4
Euphorbiaceae	*Euphorbia candelabrum* Trémaux ex Kotschy	*Igihahe*	LC	-	1, 2
	Euphorbia sp	*Imambura*	-	-	3, 4
	Euphorbia tirucalli L.	*Umunyari*	LC	Fu, Me, Sh, Wb, Ec, Bo, Lf	2, 3, 4
	Euphorbia umbellata (Pax) Bruyns	*Umukoni*	NE	Fu, Bo, Lf	1, 2, 3
Fabaceae	*Albizia adianthifolia* (Schumach.) W.Wight	*Umusebeyi*	LC	Co, Fu, Fe, Sh, Wb, Ec, Bo, Lf, To	1, 2, 3, 4
	Albizia antunesiana Harms	*Umusaramvuzo*	LC	-	4
	Dalbergia nitidula Welw. ex Baker	*Umuyigi*	LC	-	3
	Entada abyssinica Steud. ex A.Rich.	*Umusange*	LC	-	1, 4
	Erythrina abyssinica Lam.	*Umurinzi*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	1, 2, 3, 4
	Millettia dura Dunn	*Umuyogoro*	LC	Co, Fu, Fe, Sh, Wb, Bo, Cu, To	4
	Pericopsis angolensis (Baker) Meeuwen	*Umubanga*	LC	Me, Sh, Wb, Ec, Lf	3, 4
	Sesbania sesban (L.) Merr.	*Umunyegenyege*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec	2
	Tephrosia vogelii Hook.f.	*Ntibuhunwa*	LC	-	2
	Vachellia sieberiana (DC.) Kyal. & Boatwr.	*Umunyinya*	LC	Co, Fu, Me, Fe, Wb, Ec, Bo, Lf, Cu, To	1, 2, 3, 4
Gentianaceae	*Anthocleista schweinfurthii* Gilg	*Umurungambare*	LC	-	2, 4
Hypericaceae	*Harungana madagascariensis* Lam. ex Poir.	*Umushayishayi*	LC	Fu	1, 2, 4

	Psorospermum febrifugum Spach	*Umukubarwa*	LC	Me, Fe, Sh, Wb, Ec	4
Lamiaceae	*Clerodendrum johnstonii* Oliv.	*Umunyankuru*	LC	Me, Sh	2, 3
	Clerodendrum rotundifolium Oliv.	*Ikiziranyenzi*	LC	To	3, 4
	Coleus amboinicus Lour.	*Umuravumba*	NE	Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf	1, 2, 3
	Coleus barbatus (Andrews) Benth. ex G.Don	*Igicuncu*	NE	Me, Lf, Cu	3
Moraceae	*Ficus asperifolia* Miq.	*Umuseno*	LC	-	1, 3
	Ficus ingens (Miq.) Miq.	*Umuvumuvumu*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	1, 2, 3, 4
	Ficus laurifolia Lam.	*Igikobekobe*	NE	Co, Fu, Fe, Sh, Wb, Ec, Bo, Lf, To	1, 2, 3, 4
	Ficus thonningii Blume	*Umumanda*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	1, 2, 3, 4
	Ficus trichopoda Baker	*Umuhororo*	LC	Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	2, 3, 4
	Ficus vallis-choudae Delile	*Igikuyu*	NE	Fu, Fe, Sh, Wb, Ec, Bo, Lf, To	1, 2, 3
Myrtaceae	*Syzygium cordatum* Hochst. ex C.Krauss	*Umugoti*	LC	Fu, Wb	1
Phyllanthaceae	*Bridelia brideliifolia* (Pax) Fedde	*Umugimbu*	LC	-	2
Primulaceae	*Maesa lanceolata* Forssk.	*Umuhangahanga*	LC	Fu, Me, Lf	1, 3, 4
Rhamnaceae	*Maesopsis eminii* Engl.	*Umuhumure*	LC	Co, Fu, Me, Fe, Sh, Wb, Ec, Bo, Lf, Cu, To	1, 2, 3, 4
Rubiaceae	*Hymenodictyon floribundum* (Hochst. & Steud.) B.L.Rob.	*Umwamira*	LC	-	3
	Pavetta ternifolia Hiern	*Umunyamabuye*	NE	-	3
Sapindaceae	*Allophylus africanus* P.Beauv.	*Umuvumereza*	LC	Fu, Me	3
	Dodonaea viscosa Jacq.	*Umusasa*	LC	Fu, Fe, Sh, Wb, Ec	1, 3, 4
Solanaceae	*Solanum aculeastrum* Dunal	*Umutobotobo*	LC	Fu, Me, Lf	3

Notes. Me = traditional medicine; Co = construction timber; To = tools; Fu = fuelwood; Lf = live fence; Cu = cultural uses; Ec = erosion control; Fe = soil fertility improvement; Wb = windbreak; Sh = shade; Bo = boundary demarcation; IUCN = International Union for Conservation of Nature; NE = Not Evaluated; LC = Least Concern; A dash (-) indicates either that the available data were insufficient to determine the species' conservation status according to the IUCN Red List criteria or that no use was reported for the species, despite its occurrence in the study agroecosystems

Ecosystem goods and services provided by native woody species

Among the 52 recorded species, 35 (67.3%) were recognized by local communities as providing at least one useful function (Table 2). Among the ecosystem service categories, regulating services accounted for 48% of all use reports followed by provisioning services (32.4%) (Table 3). The most frequently reported uses were shade provision (206 use reports; 13.3%), fuelwood (205; 13.2%), windbreaks (194; 12.5%), erosion control (173; 11.2%), and soil fertility improvement (171; 11.0%). Live fence (125; 8.1%) and boundary demarcation (85; 5.5%) were also commonly reported. In terms of species richness within each use category, fuelwood involved the largest number of species (28 species), followed by shade provision (25 species) and windbreaks (24 species). Pearson's correlation analysis revealed a significant positive relationship between the number of use reports and the number of species associated with each use category (r = 0.654, p = 0.029).

Table 3. Ecosystem service categories provided by native woody species.

Ecosystem service category	Use category	Number of species	Use reports	
			Number of use reports	Percentage (%)
Provisioning services (32.4%)	Fuelwood	28	205	13.2
	Tools	16	144	9.3
	Medicine	24	84	5.4
	Construction timber	16	69	4.5
Regulating services (48%)	Shade	25	206	13.3
	Windbreaks	24	194	12.5
	Erosion control	21	173	11.2
	Soil fertility improvement	23	171	11.0
Cultural services (6.1%)	Cultural uses	13	94	6.1
Land-management practices (13.5%)	Live fence	23	125	8.1
	Boundary demarcation	19	85	5.5

The Cultural Importance Index (CI) revealed substantial variation in the relative importance of native woody species. *Ficus ingens* (Moraceae) had the highest CI value (3.02) (Fig. 5). It was reported across all eleven use categories, with particularly high contributions to shade (CI = 0.41), windbreaks (CI = 0.40), soil fertility improvement (CI = 0.38), fuelwood (CI = 0.38), erosion control (CI = 0.37), and tool (CI = 0.34). *Markhamia lutea* (Bignoniaceae) ranked second (CI = 0.93), mainly because of its importance for shade (CI = 0.13), windbreaks (CI = 0.13), erosion control (CI = 0.12), and fuelwood production (CI = 0.12). Other species with high cultural importance included *Ficus thonningii* (Moraceae), *Erythrina abyssinica* (Fabaceae), *Maesopsis eminii* (Rhamnaceae), *Ficus trichopoda* (Moraceae), *Euphorbia tirucalli* (Euphorbiaceae), *Parinari curatellifolia* (Chrysobalanaceae), *Cordia africana* (Boraginaceae), and *Gymnanthemum amygdalinum* (Asteraceae). These species were associated with multiple ecosystem service categories, particularly regulating services (shade, windbreaks, erosion control, and soil fertility improvement), as well as provisioning services such as fuelwood, construction timber, traditional medicine, and tool production, in addition to cultural uses.

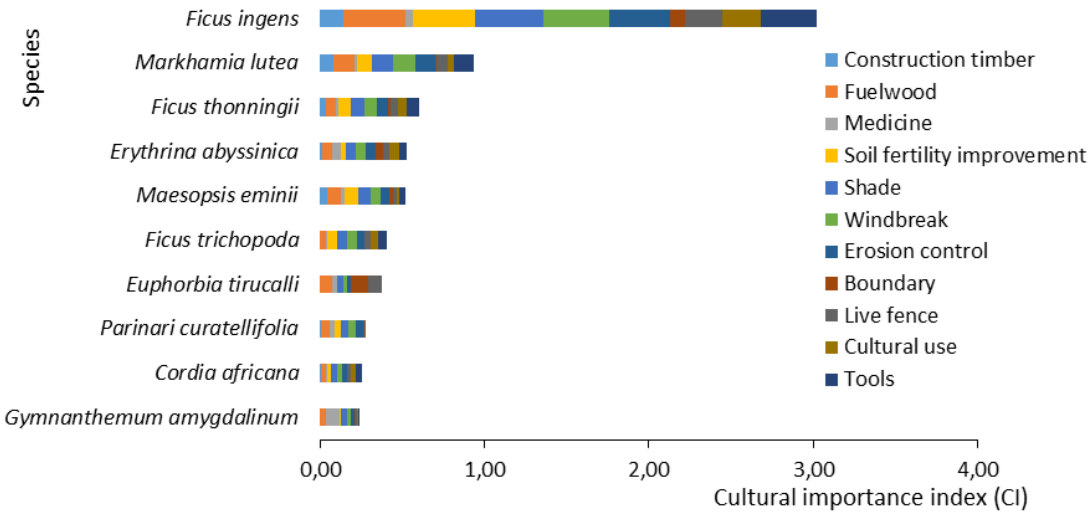

Figure 5. Cultural Importance Index (CI) of the ten most valuable native woody species across different ecosystem service categories.

Conservation status of native woody species

Among the native woody species recognized as useful by local communities, 22 species were identified by farmers as declining within the studied agroecosystems. These species include *Ficus ingens*, *Erythrina abyssinica*, *Parinari curatellifolia*, *Ficus laurifolia* (Moraceae), *Markhamia lutea*, *Vachellia sieberiana* (Fabaceae), *Cordia africana*, *Ficus thonningii*, *Dracaena afromontana* (Asparagaceae), *Dracaena steudneri* (Asparagaceae), *Euphorbia tirucalli*, *Ficus trichopoda*, *Gymnanthemum amygdalinum*, *Maesopsis eminii*, *Coleus amboinicus* (Lamiaceae), *Trema orientale* (Cannabaceae), *Albizia adianthifolia* (Fabaceae), *Anisophyllea boehmii* (Anisophylleaceae), *Millettia dura* (Fabaceae), *Coleus barbatus* (Lamiaceae), *Solanecio mannii* (Asteraceae), and *Syzygium cordatum* (Myrtaceae). According to the IUCN red list, all of these species are currently classified as Least Concern (LC) and are therefore not considered globally threatened (Table 2).

Comparative analysis of species functions and conservation status with scientific knowledge

Comparison of local ecological knowledge with the available scientific evidence revealed a high level of concordance for the majority of functions attributed to the recorded species and their perceived conservation status. Detailed information is provided in supplementary file (Table S1). However, the shading function showed the highest level of concordance, with 20 species for which local knowledge was consistent with the scientific literature, compared with one species for which an inconsistency was identified and four species for which no corresponding scientific information was available (Fig. 6). Soil fertility improvement also showed a high level of concordance, with 15 species for which local knowledge was consistent with scientific evidence, one species showing an inconsistency, and seven species for which no comparable scientific information was available. For erosion control, local knowledge was consistent with scientific evidence for 13 species, while no comparable scientific information was available for eight species. The live-fence function showed concordance for 13 species, whereas no comparable scientific information was available for 10 species. Similarly, boundary delimitation showed concordance for nine species, with 10 species lacking comparable scientific information. For the windbreak function, 10 species showed concordance between local and scientific knowledge, while 14 species had no corresponding scientific information.

Finally, regarding threat status, local knowledge was consistent with the available scientific evidence for 13 species, whereas no comparable scientific information was available for nine species (Fig. 6). Overall, these findings indicated a strong correspondence between local ecological knowledge and the available scientific evidence, while also highlighting substantial gaps in the scientific documentation of several species and their locally recognized functions.

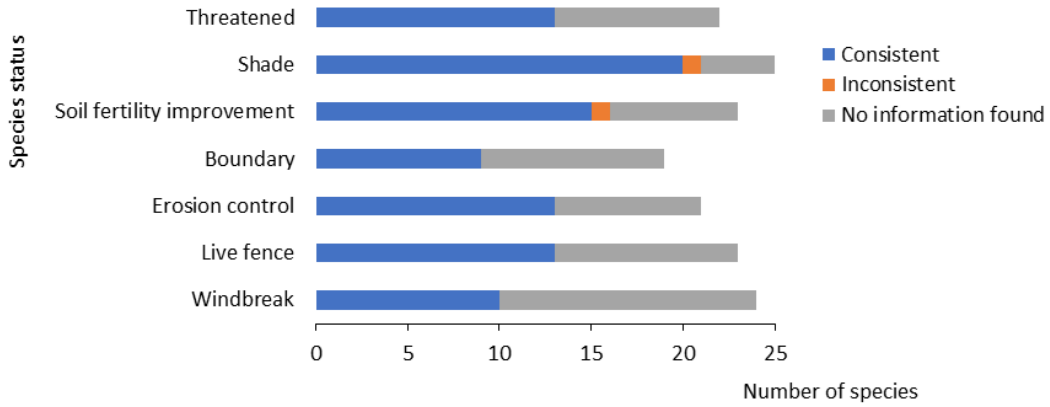

Figure 6. Comparison of local ecological knowledge with available scientific evidence on the regulating uses, land-management practices and local perceived threat status of the studied woody species.

Discussion

Diversity of native woody species in the agroecosystems

The inventory of 52 native woody species belonging to 40 genera and 25 botanical families confirms that the agroecosystems of central and northern Burundi continue to serve as important refuges for plant biodiversity despite extensive human disturbance. This level of species richness is comparable to that reported in several African agricultural landscapes, where woody species diversity generally ranges from 51 to 77 species (Endale *et al.* 2016, Masharabu *et al.* 2014, Masharabu *et al.* 2017, Molla & Kewessa 2015). These findings suggest that farmers' practices of retaining selected trees during land clearing contribute substantially to the persistence of native woody flora.

The predominance of Fabaceae (19.2%) is consistent with observations from many tropical agroecosystems, where this family is favored because of its capacity for biological nitrogen fixation, relatively rapid growth, and high tolerance to anthropogenic disturbances (Jose 2009). Moraceae, the second most represented family, is also recognized for its ecological importance in African agricultural landscapes, particularly species of the genus Ficus, which play a key role in maintaining plant-animal interactions by providing food resources during periods of seasonal scarcity (Diop *et al.* 2012, Sawadogo *et al.* 2025, Shanahan *et al.* 2001).

The observed differences in species richness among study sites may reflect variations in land-use history as well as farmers' preferences for particular useful tree species (Jakovac *et al.* 2021, Torralba *et al.* 2016). The relatively high species richness recorded in Makebuko may indicate better preservation of remnant native trees or greater diversification of agroforestry management practices.

Floristic similarity analysis identified two relatively distinct species assemblages. The high similarity between Busiga and Bugenyuzi (Jaccard = 0.588) suggests comparable ecological conditions and agricultural practices, whereas the affinity between Makebuko and Muyinga may reflect similar historical land-use trajectories. Nevertheless, the moderate similarity coefficients indicate that each agroecosystem maintains a distinctive species composition, highlighting the need for locally adapted conservation strategies rather than uniform management approaches.

These findings support previous studies by Masharabu *et al.* (2014, 2017), which emphasized that isolated trees remaining in agricultural fields often represent the last remnants of Burundi's original forest vegetation and constitute an essential component of biodiversity conservation outside of protected areas.

Ecosystem goods and services provided by native woody species

Our results demonstrate that native woody species primarily provide regulating ecosystem services (48%) followed by provisioning services (32.4%). These findings are consistent with those reported by Ndayizeye *et al.* (2020) and indicate that local communities strongly recognize the ecological functions of trees within agricultural landscapes. The most frequently cited ecosystem services included shade provision, fuelwood production, wind protection, erosion control, and soil fertility improvement. These functions have been widely documented in the agroforestry literature. Trees improve crop microclimates, reduce evaporative water losses, decrease wind velocity, and stabilize soils through their extensive root systems (Jose 2009, Kestel *et al.* 2026, Kuyah *et al.* 2016, Majaura *et al.* 2026, Torralba *et al.* 2016, Udawatta *et al.* 2019).

The high importance assigned to erosion control is particularly relevant in Burundi, where steep mountainous landscapes are highly vulnerable to water erosion. By reducing surface runoff, enhancing water infiltration, and limiting the loss of fertile topsoil, trees contribute directly to the long-term sustainability of agricultural production systems (Benegas *et al.* 2021, FAO & ITPS 2015).

The relatively low proportion of cultural services (6.1%) does not necessarily indicate that native trees have limited social importance. Instead, it may reflect the gradual transformation of traditional practices and local ecological knowledge associated with rural modernization. Previous studies have shown that cultural values associated with woody species are cited less frequently by younger generations than uses directly related to livelihoods, reflecting a gradual erosion of traditional ecological knowledge and changing sociocultural practices (Aswani *et al.* 2018, Reyes-garcía *et al.* 2013).

The Cultural Importance Index highlighted ten species of particular importance (Fig. 5), with *Ficus ingens* ranking first because it was reported across all identified use categories. This exceptional versatility reinforces the ecological role of Ficus species as keystone species in tropical agricultural landscapes. Beyond their multiple socioeconomic uses, Ficus species produce fruits almost continuously throughout the year, thereby providing a critical food resource for numerous bird species, bats, and other frugivorous animals, and contributing to the maintenance of ecological networks (Shanahan *et al.* 2001).

Similarly, *Markhamia lutea* emerged as a highly multifunctional species, particularly valued for its regulating ecosystem services, making it a potential candidate for agroecosystem restoration programs. The socioeconomic importance of both species, especially as sources of fuelwood, construction timber, and traditional medicines, has also been documented by Ndayizeye *et al.* (2020). The high medicinal value attributed to *Gymnanthemum amygdalinum* is consistent with the findings of Havyarimana *et al.* (2023), who highlighted its importance in the traditional treatment of malaria in Burundi. Collectively, these findings demonstrate that native woody species should not be regarded solely as providers of forest products but also

as essential ecological infrastructure supporting the functioning and resilience of agricultural landscapes, consistent with the conclusions of the Millennium Ecosystem Assessment (MEA 2005) and IPBES (2019).

Implications for the conservation of native woody diversity in agroecosystems

The occurrence of more than fifty native woody species within cultivated landscapes highlighted the potential of agroecosystems to contribute to biodiversity conservation beyond protected areas. In tropical regions, where agricultural land increasingly dominates the landscape, maintaining native trees within farms can provide complementary habitats for biodiversity while sustaining important ecosystem services (Bhagwat *et al.* 2008, Perfecto & Vandermeer 2010).

Species with the highest Cultural Importance Index values represented potential candidates for conservation and ecological restoration because their multifunctionality and high local use value may encourage farmers to retain them within agricultural landscapes. This is particularly relevant when culturally important species are also perceived as declining, as their conservation could benefit both biodiversity and local livelihoods.

In the present study, 22 native woody species were perceived by farmers as declining across the study areas. These perceptions may be associated with increasing demand for wood resources, repeated cultivation of agricultural plots and agricultural expansion. Similar pressures have been documented elsewhere in East Africa. In Uganda, Sassen *et al.* (2015) reported that fuelwood collection contributed to the depletion of preferred tree species, while Graham *et al.* (2022) documented the removal of indigenous trees from smallholder farms for timber, fuelwood, and to create space for crops in the Mount Elgon region. Similarly, Shumi *et al.* (2019) reported overharvesting of important timber and pole species in southwestern Ethiopia. In Tanzania, Mwampamba and Schwartz (2011) found that prolonged cultivation constrained forest recovery in fallow lands in the Eastern Arc Mountains. Although these studies suggest that resource extraction and land-use change may contribute to the decline of native woody vegetation, the 22 species identified in our study should be considered potential local conservation priorities rather than confirmed cases of population decline. Their classification as Least Concern (LC) at the global level (IUCN 2026) does not necessarily indicate stable populations within the study agroecosystems, since global assessments may not capture changes occurring at finer spatial scales (IUCN 2012, IUCN Standards & Petitions Committee 2024). Local ecological knowledge can therefore complement formal conservation assessments by documenting changes in species abundance, availability, and distribution experienced by resource users (McElwee *et al.* 2020). Nevertheless, these perceived declines require validation through field inventories, population monitoring, and natural regeneration assessments.

The comparison between farmers' ecological knowledge and available scientific evidence revealed substantial agreement regarding several ecological functions, particularly shading, soil fertility improvement and erosion control. Concordance was also observed for live fencing, boundary delimitation, windbreak functions, and perceived threat status. These results supported the value of farmers' knowledge as a complementary source of ecological information for conservation planning. However, the comparison also revealed substantial gaps in scientific documentation. Several locally recognized functions lacked corresponding scientific information, particularly windbreak, live-fence and boundary-delimitation functions. These gaps highlighted the need for further ecological and ethnobotanical research to document and evaluate locally recognized functions rather than interpreting the absence of scientific evidence as evidence of absence. Integrating scientific assessments with local ecological knowledge could consequently provide a more comprehensive basis for species prioritization, and participatory conservation and restoration planning (Berkes 2018, IPBES 2019, Reyes-garcía *et al.* 2018).

From a management perspective, these findings supported greater incorporation of native multifunctional trees into agroforestry systems and agricultural landscapes. Retaining mature native trees, protecting natural regeneration, and promoting the cultivation of suitable native species could contribute to biodiversity conservation while supporting soil protection, microclimate regulation, erosion control, and household resource provision (Bhagwat *et al.* 2008, De Beenhouwer *et al.* 2013). In Burundi, where tree-based systems remain strongly associated with exotic species, increasing the use and regeneration of suitable native species could diversify agroforestry systems and strengthen their ecological functions (Gann *et al.* 2019, Jose 2009, Udawatta *et al.* 2019). Practical measures such as establishing community-based nurseries, involving farmers in species selection, using locally sourced planting material, and supporting assisted natural regeneration could facilitate the propagation and recovery of priority native species. These measures would also help maintain ecosystem services and livelihood benefits valued by local communities (Chazdon & Guariguata 2016, FAO & WRI 2019, Gann *et al.* 2019, Santos *et al.* 2022).

The findings therefore support an approach to agroecosystem management that combines farmers' ecological knowledge, scientific assessments, and community participation. However, because this study relied primarily on farmers' perceptions and reported uses, it did not directly quantify population trends, regeneration rates, species survival, or the ecological

effectiveness of the reported functions. Future research should therefore combine participatory monitoring with systematic vegetation inventories, regeneration surveys, and field-based assessments of the ecological performance of priority species across different agroecological settings. Participatory trials and community-based restoration initiatives could also help identify species that are both ecologically suitable and socially valued. Such efforts would provide a stronger evidence base for locally adapted restoration strategies and support the long-term conservation of native woody resources and rural livelihoods in Burundi.

Conclusions

This study demonstrated that the agroecosystems of central and northern Burundi supported substantial native woody diversity despite intensive agricultural use, highlighting their complementary role in biodiversity conservation outside of protected areas. Native trees provided a broad range of ecosystem services, particularly regulating services such as shading, erosion control, wind protection and soil fertility improvement, while also contributing to provisioning and cultural needs.

Species with high cultural importance and perceived locally as declining emerged as potential candidates for biodiversity conservation and restoration priorities, as their multifunctionality and perceived vulnerability may encourage farmers to retain them within agricultural landscapes. The strong concordance between farmers' knowledge and available scientific evidence further demonstrated the value of local knowledge for conservation planning. However, gaps in scientific documentation and the absence of direct measurements of population trends and ecological performance highlight the need to complement participatory approaches with vegetation inventories, regeneration monitoring and field-based ecological assessments. Conservation priorities should therefore consider not only global conservation assessments but also local evidence of species decline, ecological functions and cultural importance.

Overall, strengthening agroforestry and community-based restoration initiatives that promote the retention, natural regeneration and planting of multifunctional native woody species could provide a practical pathway for reconciling biodiversity conservation with agricultural production. Integrating farmers' ecological knowledge, scientific assessments and participatory management into these initiatives could contribute to conserving native woody resources, maintaining locally valued ecosystem functions, enhancing agricultural landscape resilience and sustaining rural livelihoods in Burundi.

Declarations

List of abbreviations: CI = Cultural Importance Index; Me = traditional medicine; Co = construction timber; To = tools; Fu = fuelwood; Lf = live fence; Cu = cultural uses; Ec = erosion control; Fe = soil fertility; Wb = windbreak; Sh = shade; Bo = boundary demarcation; IUCN = International Union for Conservation of Nature; NE = Not Evaluated; LC = Least Concern

Ethics approval and consent to participate: Prior authorization was obtained from the relevant communal authorities at each study site through the issuance and signing of official mission orders. Informed consent was subsequently obtained from local authorities and each informant prior to data collection. All relevant authorities and participants were fully informed about the objectives of the study, the importance of the data collected, and their contribution to the research. All native and useful tree species occurring in the agroecosystems of the study area were documented.

Consent for publication: Not applicable

Availability of data and materials: The article includes all figures and tables supporting the findings of this study. The underlying datasets generated and/or analyzed during the study are available from the corresponding author upon reasonable request.

Competing interests: The authors declare no competing interests.

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Author contributions: A.N. was the principal investigator of this study and contributed to all stages of the research, including conceptualization and study design, data collection and formal analysis, interpretation of the results, and writing of first draft, review and editing the manuscript. M.R.M.E., N.S.Y. and J.N. participated in the conceptualization and study design, supervision, interpretation of the results, critical review of important intellectual and technical content, N.N. and T.M. contributed to the critical review of important intellectual and technical content. All authors read and approved the final manuscript.

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Supplementary file

Table S1. Comparison between local ecological knowledge and available scientific knowledge regarding the perceived regulating uses, land-management practices and threat status of the studied woody species.

Scientific name	Status	Local citation	Consistency	Supporting references
Albizia adianthifolia (Schumach.) W.Wight	Threatened	1	Consistent	Nzigidahera (2000)
	Soil fertility improvement	3	Consistent	Kindt and Innocent (2016)
	Shade	3	Consistent	Sauvadet *et al.* (2020)
	Windbreak	3	No information found	
	Erosion control	3	Consistent	Fern (2014)
	Boundary demarcation	1	No information found	
	Live fence	2	No information found	
Anisophyllea boehmii Engl.	Threatened	1	No information found	
Clerodendrum johnstonii Oliv.	Shade	1	No information found	
Combretum molle R.Br. ex G.Don	Soil fertility improvement	1	Consistent	Kindt and Innocent (2016)
	Shade	1	Consistent	Orwa *et al.* (2009)
	Windbreak	1	No information found	
	Erosion control	1	No information found	
Cordia africana Lam.	Threatened	5	Consistent	FAO (2012), Alemayehu *et al.* (2016)
	Soil fertility improvement	5	Consistent	Alemayehu *et al.* (2016), Tebkew *et al.* (2023), Kindt and Innocent (2016)
	Windbreak	6	Consistent	Tebkew *et al.* (2023)
	Shade	6	Consistent	Tebkew *et al.* (2023), Alemayehu *et al.* (2016), Kindt and Innocent (2016)
	Erosion control	5	Consistent	Tebkew *et al.* (2023), Alemayehu *et al.* (2016),
	Boundary demarcation	1	Consistent	Kindt and Innocent (2016)
	Live fence	3	Consistent	Tebkew *et al.* (2023)
Dodonaea viscosa Jacq.	Soil fertility improvement	1	Consistent	Muthuri *et al.* (2023), Kuria et *al.* (2017a)
	Shade	2	Consistent	Muthuri *et al.* (2023), Kuria et *al.* (2017a)
	Windbreak	2	Consistent	Kindt and Innocent (2016)
	Erosion control	2	Consistent	Kindt and Innocent (2016)

Dracaena afromontana Mildbr.	Threatened	2	No information found	
	Soil fertility improvement	1	No information found	
	Shade	2	No information found	
	Windbreak	2	No information found	
	Boundary demarcation	13	Consistent	Ndayambaje and Mohren (2011)
	Live fence	9	Consistent	Kuria *et al.* (2017b)
Dracaena steudneri Engl.	Threatened	2	Consistent	Masharabu *et al.* (2014)
	Soil fertility improvement	2	No information found	
	Shade	1	Consistent	Kindt and Innocent (2016)
	Boundary demarcation	2	No information found	
	Live fence	2	No information found	
Erythrina abyssinica Lam.	Threatened	8	Consistent	Masharabu *et al.* (2014)
	Soil fertility improvement	6	Consistent	Kindt and Innocent (2016)
	Shade	11	Consistent	Kuria *et al.* (2017a)
	Windbreak	11	Consistent	PKR Nair (1985)
	Erosion control	11	Consistent	Kuria *et al.* (2017a)
	Boundary demarcation	8	Consistent	Kuria *et al.* (2017a)
	Live fence	7	Consistent	Tebkew *et al.* (2023), Kindt and Innocent (2016)
Euphorbia tirucalli L.	Threatened	2	No information found	
	Shade	7	Consistent	Kuria *et al.* (2017a)
	Windbreak	5	Consistent	Tebkew *et al.* (2023)
	Erosion control	4	Consistent	Kuria *et al.* (2017b)
	Boundary demarcation	18	Consistent	Kindt and Innocent (2016)
	Live fence	15	Consistent	Tebkew *et al.* (2023), Kindt and Innocent (2016)
Euphorbia umbellata (Pax) Bruyns	Boundary demarcation	2	No information found	
	Live fence	1	No information found	
Ficus ingens (Miq.) Miq.	Threatened	21	Consistent	Bimenyimana *et al.* (2023)
	Soil fertility improvement	69	No information found	
	Shade	74	Consistent	SANBI (2026)
	Windbreak	72	No information found	

	Erosion control	67	No information found	
	Boundary demarcation	16	No information found	
	Live fence	41	No information found	
Ficus laurifolia Lam.	Threatened	6	Consistent	Masharabu *et al.* (2014)
	Soil fertility improvement	6	No information found	
	Shade	7	Consistent	Kuria *et al.* (2017a)
	Boundary demarcation	1	No information found	
	Windbreak	5	No information found	
	Erosion control	4	No information found	
	Live fence	1	Consistent	Kuria *et al.* (2017a)
Ficus thonningii Blume	Threatened	3	Consistent	Bimenyimana *et al.* (2023)
	Soil fertility improvement	13	Consistent	Orwa *et al.* (2009), Dumont *et al.* (2015)
	Shade	15	Consistent	Orwa *et al.* (2009), Dumont *et al.* (2015), Tebkew *et al.* (2023)
	Windbreak	14	Consistent	Orwa *et al.* (2009), Tebkew *et al.* (2023)
	Erosion control	13	Consistent	orwa *et al.* (2009), Tebkew *et al.* (2023)
	Boundary demarcation	2	Consistent	Kuria *et al.* (2017b)
	Live fence	8	Consistent	Tebkew *et al.* (2023)
Ficus trichopoda Baker	Threatened	2	No information found	
	Soil fertility improvement	11	No information found	
	Shade	11	Consistent	Abdulrahaman *et al.* (2013)
	Windbreak	11	No information found	
	Erosion control	8	Consistent	SANBI (2026)
	Boundary demarcation	1	No information found	
	Live fence	6	No information found	
Ficus vallis-choudae Delile	Soil fertility improvement	2	Consistent	Dumont *et al.* (2015), Tebkew *et al.* (2023)
	Shade	3	Consistent	Dumont *et al.* (2015) Tebkew *et al.* (2023)
	Windbreak	2	No information found	
	Erosion control	1	Consistent	Tebkew *et al.* (2023)
	Boundary demarcation	1	No information found	

	Live fence	1	Consistent	Tebkew *et al.* (2023)
Gymnanthemum amygdalinum (Delile) Sch.Bip.	Threatened	2	No information found	
	Soil fertility improvement	2	Consistent	Kindt and Innocent (2016)
	Shade	6	Consistent	Tebkew *et al.* (2023)
	Erosion control	4	Consistent	Kindt and Innocent (2016)
	Windbreak	5	No information found	
	Boundary demarcation	1	Consistent	https://pfaf.org/user/
	Live fence	1	Consistent	Tebkew *et al.* (2023), Kindt and Innocent (2016)
Maesa lanceolata Forssk.	Live fence	1	No information found	
Maesopsis eminii Engl.	Threatened	2	Consistent	FAO (2012)
	Soil fertility improvement	15	Consistent	Van Noordwijk *et al.* (2011)
	Shade	13	Consistent	Van Noordwijk *et al.* (2011), Kindt and Innocent (2016)
	Windbreak	11	Consistent	Van Noordwijk *et al.* (2011)
	Erosion control	10	Consistent	Van Noordwijk *et al.* (2011)
	Boundary demarcation	4	Consistent	Van Noordwijk *et al.* (2011)
	Live fence	4	Consistent	Kuria *et al.* (2020)
Markhamia lutea (Benth.) K.Schum.	Threatened	6	Consistent	Masharabu *et al.* (2014), FAO (2012),
	Soil fertility improvement	17	Consistent	Van Noordwijk *et al.* (2011), Kindt and Innocent (2016)
	Shade	23	Consistent	Van Noordwijk *et al.* (2011), Kindt and Innocent (2016)
	Windbreak	24	Consistent	Van Noordwijk *et al.* (2011), Kindt and Innocent (2016)
	Erosion control	22	Consistent	Van Noordwijk *et al.* (2011), Kindt and Innocent (2016)
	Boundary demarcation	2	Consistent	Van Noordwijk *et al.* (2011), Kindt and Innocent (2016)
	Live fence	12	No information found	
Millettia dura Dunn	Threatened	1	Consistent	Masharabu *et al.* (2014)
	Soil fertility improvement	1	Consistent	Kindt and Innocent (2016)
	Shade	1	Consistent	Orwa *et al.* (2009)
	Windbreak	1	No information found	
	Boundary demarcation	1	No information found	
Parinari curatellifolia Planch. ex Benth.	Threatened	7	No information found	
	Soil fertility improvement	7	Consistent	Orwa *et al.* (2009)

	Shade	8	Consistent	Kindt and Innocent (2016)
	Windbreak	8	No information found	
	Erosion control	8	No information found	
	Boundary demarcation	2	No information found	
	Live fence	1	No information found	
Pericopsis angolensis (Baker) Meeuwen	Shade	1	No information found	
	Windbreak	1	No information found	
	Erosion control	1	No information found	
	Live fence	1	No information found	
Coleus amboinicus Lour.	Threatened	2	No information found	
	Soil fertility improvement	2	Inconsistent	Borba *et al.* (2021)
	Shade	2	Inconsistent	Ekawati and Aziz (2016)
	Windbreak	1	No information found	
	Erosion control	1	No information found	
	Boundary demarcation	5	No information found	
	Live fence	4	No information found	
Coleus barbatus (Andrews) Benth. ex G.Don	Threatened	1	No information found	
	Live fence	1	Consistent	Oginosako *et al.* (2006)
Psorospermum febrifugum Spach	Soil fertility improvement	1	No information found	
	Shade	1	No information found	
	Windbreak	1	No information found	
	Erosion control	1	No information found	
Sesbania sesban (L.) Merr.	Soil fertility improvement	1	Consistent	Tebkew *et al.* (2023), Orwa *et al.* (2009)
	Shade	1	Consistent	Tebkew *et al.* (2023), Orwa *et al.* (2009)
	Windbreak	1	Consistent	Orwa *et al.* (2009)
	Erosion control	1	No information found	
Solanecio mannii (Hook.f.) C.Jeffrey	Threatened	1	No information found	
	Soil fertility improvement	1	No information found	
Solanum aculeastrum Dunal	Live fence	1	Consistent	SANBI (2026)
Syzygium cordatum Hochst. ex C.Krauss	Threatened	1	Consistent	Masharabu *et al.* (2017), FAO (2012)

	Windbreak	1	No information found	
Trema orientale (L.) Blume	Threatened	2	Consistent	Bimenyimana *et al.* (2023)
	Soil fertility improvement	1	Consistent	Kindt and Innocent (2016)
	Shade	2	Consistent	Kindt and Innocent (2016)
	Windbreak	2	Consistent	The Macadamia (2020)
	Erosion control	1	Consistent	Kindt and Innocent (2016)
	Live fence	1	Consistent	FAO (2026)
Vachellia sieberiana (DC.) Kyal. & Boatwr.	Threatened	6	Consistent	Bimenyimana *et al.* (2023)
	Soil fertility improvement	3	Consistent	Kindt and Innocent (2016)
	Shade	4	Consistent	Orwa *et al.* (2009)
	Windbreak	4	Consistent	Orwa *et al.* (2009), Fern (2014)
	Erosion control	5	Consistent	Kuria *et al.* (2017a)
	Boundary demarcation	4	Consistent	Kuria *et al.* 2017a)
	Live fence	2	Consistent	Kuria *et al.* (2017a)