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Cultural knowledge of forests and allied tree system management around Mabira Forest Reserve, Uganda

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Abstract The cultural universe is sometimes confusing, surprising and murky, so many cultural maps get drawn, discussed and envisioned. A study was undertaken around Mabira Forest Reserve in central Uganda to identify the trees and shrubs culturally managed on-farm, assess the cultural practices of forest and tree system management and determine the relationship between farmer gender and forest and tree system management. We engaged 203 farmers in focus group discussions and semi-structured interviews to collect data. Qualitative data were jointly evaluated with farmers; quantitative data were analyzed in SPSS 20.0. The results showed a high likelihood for involvement of local people in tree or forest management for economic gain, as timber and fast-growing species were highly ranked. Food and medicinal species were also regarded as important, suggesting high prospects of integrating them into the local farming system or protecting them in the forest. Numerous cultural practices (including rituals, trenching, bark slashing, ring barking, spot weeding and use of organic manure and pesticides) of forest and tree system management were acknowledged. However, their knowledge was mixed and unclear about distinct cultural and supportive arrangements for natural forest and tree restoration. While gender was not a significant cultural attribute for knowledge of the forest and allied tree system management, age substantially affected farmer propensity for various timber products. Also farmer's family size influenced the collection of tree wildings and fodder. We encourage considering gender disparities and livelihood needs including income, during selection of cultural practices for forest and tree restoration.

Keywords Traditional · Cultural ways · Forest management · Indigenous knowledge · Superstition

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Introduction

Knowledge is our understanding and awareness of the world and meaning associated with experience. Knowledge systems are developed through iterations of careful selection and rejection or creation and transformation of philosophies or thoughts and beliefs (Altieri 1991). Every notion or theory, whether scientific or unscientific, is also culturally rooted (Fleck 1979). Warren and Cashman (1988) argued that our experience and knowledge about our environment forms a basis for culture or tradition. Culture or tradition guides decisions in familiar and new situations (Warren and Cashman 1988; Wilson 1991). Viewed in this context, cultural knowledge can be considered "scientific" even though this study did not examine the distinction between science and tradition.

Generally, western science and technologies reflect on traditional or cultural knowledge as a "primitive" and inefficient approach to solving natural and social problems by the poor and the marginalized populations (Agrawal 1995). Yet cultural knowledge is an important natural resource for cost-effective, participatory and sustainable development (Warren 1991). For example, it is the basis for local decision-making in agriculture, health care, food preparation, education and natural resource management (Agrawal 1995). Cultural procedures also preserve valuable local practices, encourage community self-diagnosis, heighten awareness and involve the immediate users in feedback systems. By studying cultural knowledge systems, ecologists have enhanced their knowledge on biodiversity and ecosystem functions. Novel agroecosystem designs have already been modeled on successful traditional farming systems (Altieri 2004). Considering the current global challenges of climate change and food insecurity, the time is right to revisit our cultural "encyclopedia" to mitigate environmental challenges of deforestation and land degradation. After all, we are now almost certain that "scientific" knowledge has independently failed to solve this problem.

In this study, we define a forest as a collection of trees interacting at various levels, while allied tree systems are trees growing independently or integrated on farms or landscape including agroforests, and contributing in various ways to general ecosystem functions and livelihoods. The concept of forests and allied trees as a source of life cannot be isolated from the integrity of nature that corresponds to the integrity of the physical body and cultural personality of local and native people (Saway 2018) or the oncological act of discovering new ways of being, of transforming the ways in which people understand and deal with themselves and the world (Escobar 2010).

Cultures have developed a deep invaluable knowledge base to understand and live in harmony with the environment (Berlin and Berlin 2001). For example, in forestry science, data are usually quantitatively and systematically gathered, unfortunately by people who do not use or depend on the resources they study. Conclusions are thus deduced and decisions made that usually miss or hardly ever highlight important culturally known connections and links (Gombya-Ssembajjwe 2000). Such outsider failures to highlight or recognize existing knowledge or rights are deleterious to the advancement and application of culturally useful concepts (Dove 1990). For this reason, previous studies (e.g., Parrotta et al. 2016; Kandal et al. 2016; Sibelet et al. 2017; Saway 2018) have not adequately explored cultural knowledge of forests and allied tree system management in the context of forest restoration. Yet such complex knowledge systems adapted to local conditions have, for example, helped smallholder farmers to manage harsh environments and to meet their subsistence needs (Alttieri et al. 2017).

Besides being an important source of various foods, forests and allied tree resources provide the material basis for livelihoods to billions of people across the planet (Howard and Nabanoga 2007; Obua et al. 2010; FAO 2012; Parrotta et al. 2016) and provide for over 90% of the livelihood needs in developing countries (Mwavu and Witkowski 2008; Turyahabwe and Banana 2008). We widely understand that sustaining natural forest growth and restoring a degraded forest or related tree systems are essential for ensuring protection of water catchments and maintaining soil fertility, income flow and good health. For example, *Prunus africana* (Hook.f.) Kalkman (Cunningham and Cunningham 1999) and *Warburgia ugandesis* Spraque are widely used medicinal trees in the traditional health practices of sub-Saharan and West African countries (Ngure et al. 2009; Galabuzi et al. 2016). Extracts from *P. africana* bark are effective against prostate gland hypertrophy and benign prostatic hyperplasia; *W. ugandesis*, rich in bioactive compounds and anti-fungal agents (Olila et al. 2002), is used by healers in East Africa to treat malaria, epilepsy, diarrhea, scabies, coughs and ringworm (Galabuzi 2017).

Forest loss and degradation is increasingly a worldwide problem, with net annual estimates of 9.4 million hectares lost by the mid-1990s (WRI 1994; FAO 2001, 2005). But the loss of natural forests and trees in the tropics will do far more than destroy cultures and traditions (Laurance 1999). Much as forests and allied tree systems are renewable, the absence of clear, convenient knowledge systems to facilitate cost-effective maintenance of their ecological functions and services will heighten their degradation (Howard and Nabanoga 2007). In addition, the lack of clarity of cultural knowledge systems hinders their consideration and use as meaningful resources for restoring degraded forests. Traditional or cultural knowledge systems in developing countries are thus currently being eroded or treated as backward, unofficial or primitive, and yet endangered by adopting it covertly into "scientific knowledge" (Latour 1991; Altieri 2004; Parrotta et al. 2006; Collings 2009).

In Uganda in particular, natural forests and allied tree systems are disappearing at a higher rate than the norm (IAC 2003). For instance, the deforestation rate in Uganda at 1.9% is one of the highest in East Africa and is higher in private forests than in protected areas (Obua et al. 2010). In 1890, Uganda's forest and tree vegetation cover was about 10.8 million hectares (Langdale-Brown 1960; FAO 1997) and only about 4.9 million hectares by 2000 (MWLE 2001). About 1.3 million hectares have been lost on private land and 91,000 ha from Protected Areas (PAs) in the last 15 years (Uwimbabazi et al. 2018). Deforestation rate in Uganda is currently at 200,000 ha/year (NARO 2017). A wide collection of cultural knowledge about forests and allied tree system management have been absorbed or suppressed by western science systems of knowledge without recognition of the source. Accordingly, researchers have claimed them as their innovations. The integrity of cultural ways is therefore compromised. Cultural forest-related knowledge has long been known to have important implications for management and conservation of forest biodiversity and identifying valuable genetic resources (Parrotta et al. 2006, 2016; Ouédraogo et al. 2014). Indeed, when cultural knowledge systems were abundantly employed and the only means of protection in tropical countries, forests and allied tree resources were abundant.

As the international community increasingly focuses its attention on achieving the Sustainable Development Goals (SDGs) of the United Nations, particularly Goal 15 on protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, and halting and reversing land degradation and biodiversity loss, traditional knowledge, cultural values, historic perspectives and the means necessary for their enhancement are expected to increasingly help shape policy and forest management practices (Parrotta et al. 2006). Traditional use of trees and other forest plants, forest utilization and management practices such as the use of fire, are an invaluable heritage that needs to be understood and preserved (Agnoletti 2006).

According to González et al. (2012), in rural communities of Western Europe there is a clear connection between popular cultural ideologies and their relationship with nature, especially plants. In Uganda, similar cultural knowledge is labeled inferior or associated with illiteracy and even superstition (Gombya-Ssembajjwe 2000). Superstitious or not, indigenous people are the curators of nature including forests and trees, soil, water and air or their interaction. As such, their cultural maps are useful to trace out the basis of competing natural facts or practices and to reach decisions based on the features of their origin (Watson-Verran and Turnbull 1995).

Management of forests or allied tree system knowledge in Uganda is embedded in community experience and is often linked to spirituality (Gombya-Ssembajjwe 2000). Spirituality in the African context emphasizes concepts such as kinship, unity, mutual respect, collaboration, brotherhood and living in harmony with the environment. It is therefore no surprise that cultural knowledge on natural resource use and conservation has previously gained recognition (Cunningham 1991; Gombya-Ssembajjwe 2000; Becker and Leon 2000; Parrotta et al. 2006; Howard and Nabanoga 2007; Maffi and Woodley 2010; Galabuzi et al. 2016; Kandal et al. 2016; Sibelet et al. 2017; Saway 2018). But scaling up of the cultural principles or practices in natural resource management has been limited by absence of clear documentation or sufficient data to establish baselines. Yet, better insights into traditional knowledge are important in view of the Uganda Forest Policy of 2001 (MWLE 2001). Furthermore, the value of traditional forest-related knowledge and practices is being recognized in many countries and in international policy forums such as the Convention on Biological Diversity and the UN Convention to Combat Desertification (Parrotta et al. 2016). However, the lack of appropriate methods to evaluate cultural knowledge has increased doubt and confusion among stakeholders.

We consider cultural knowledge to be dynamic and adaptive, enabling its users to incorporate innovations that are subjected to the test of time to achieve socioeconomic and environmental sustainability (Parrotta et al. 2006). In the present study, we assessed cultural knowledge on forest and allied tree system management to examine the links between ways of knowing these systems and restoration within Uganda. We focused on communities around the Mabira Forest Reserve (MFR) in central Uganda.

The MFR ecosystem has been influenced by the surrounding people in various ways, and the central government proposal to convert it into a sugarcane plantation (Galabuzi et al. 2014) has escalated illegal activities, threatening the survival of important life-forms and the livelihoods of the indigenous people. There have been limited efforts to restore the degraded forest sites or plant native trees, and the lack of success has been used as an argument by those in favor of converting the forest to a sugarcane plantation. To this effect, protection efforts have become expensive or almost impossible, and degradation has increased.

The situation compelled us to ponder cultural forest and allied tree systems management practices for restoration and whether any relationships existed between socio-economic (e.g., age, education, income, gender, family size) attributes of farmers and their cultural forest and allied tree management practices. Farming systems in areas with unstable economies depend on socioeconomic attributes including gender to thrive (Temperton 2007). Moreover, there are important differences between men's and women's perceptions on and approaches to using and managing forest and allied tree resources (Maginnis et al. 2011). Among the socioeconomic attributes, we payed more attention to gender. By gender, we refer to the social attributes and opportunities associated with being male or female and the relationships between women and men and between girls and boys (Mukasa et al. 2012), including the socially and culturally constructed roles, responsibilities, attributes, opportunities, privileges, status, access to and control over resources and benefits between women and men, boys and girls in a given society (MGLSD 2010). Gender is one of the major factors influencing rights to plant-use and natural resource management (Howard and Nabanoga 2007). The specific objectives of this study were to (1) identify the trees and shrubs culturally managed on-farm, (2) assess cultural practices for forest and the allied tree system management, and (3) determine the relationship between gender and the forest or allied tree system management.

Materials and methods

Study area

Mabira Forest Reserve (MFR), located between 0°24′–0°35′N and 32°52′–33°07′E in central Uganda, is 54 km from Kampala, the capital city of Uganda, and 26 km from Jinja, the second largest city (Fig. 1).

The reserve covers 306 km^2 and is one of the important Protected Areas (PAs) in Uganda with 47% of Uganda's timber species, including four tree species listed by the International Union for Conservation of Nature (IUCN): *Milicia excelsa* (Welw.) C.C.Berg., *Irvingia gabonensis* Aubry-Lecomte ex O'Rorke, Baill., *Lovoa trichilioides* Harms., and *Cordia milenii* Bak. (Davenport et al. 1996). The forest also has 287 species of birds, 23 of small mammals, 218 of butterflies and 97 of moths (Davenport et al. 1996). The MFR ecosystem is an Important Bird Area (IBA) containing 30% (over 300 species) of total bird species found in Uganda. The reserve contains globally threatened species on the IUCN Red List of Threatened Species (version 2016-1): the blue swallow (*Hirundo atrocaerulea*), the papyrus gonolek (*Laniarius mufumbiri*) and Nahan's francolin *(Francolinus nahani)*. The forest contains nine other species found nowhere else in Uganda including the newly discovered Mangabey species (*Lophocebus albigenajohnstoni*) and the short-tailed fruit bat (MWE 2003). MFR is the only block of medium altitude moist semi-deciduous forest type D1 (Langdale-

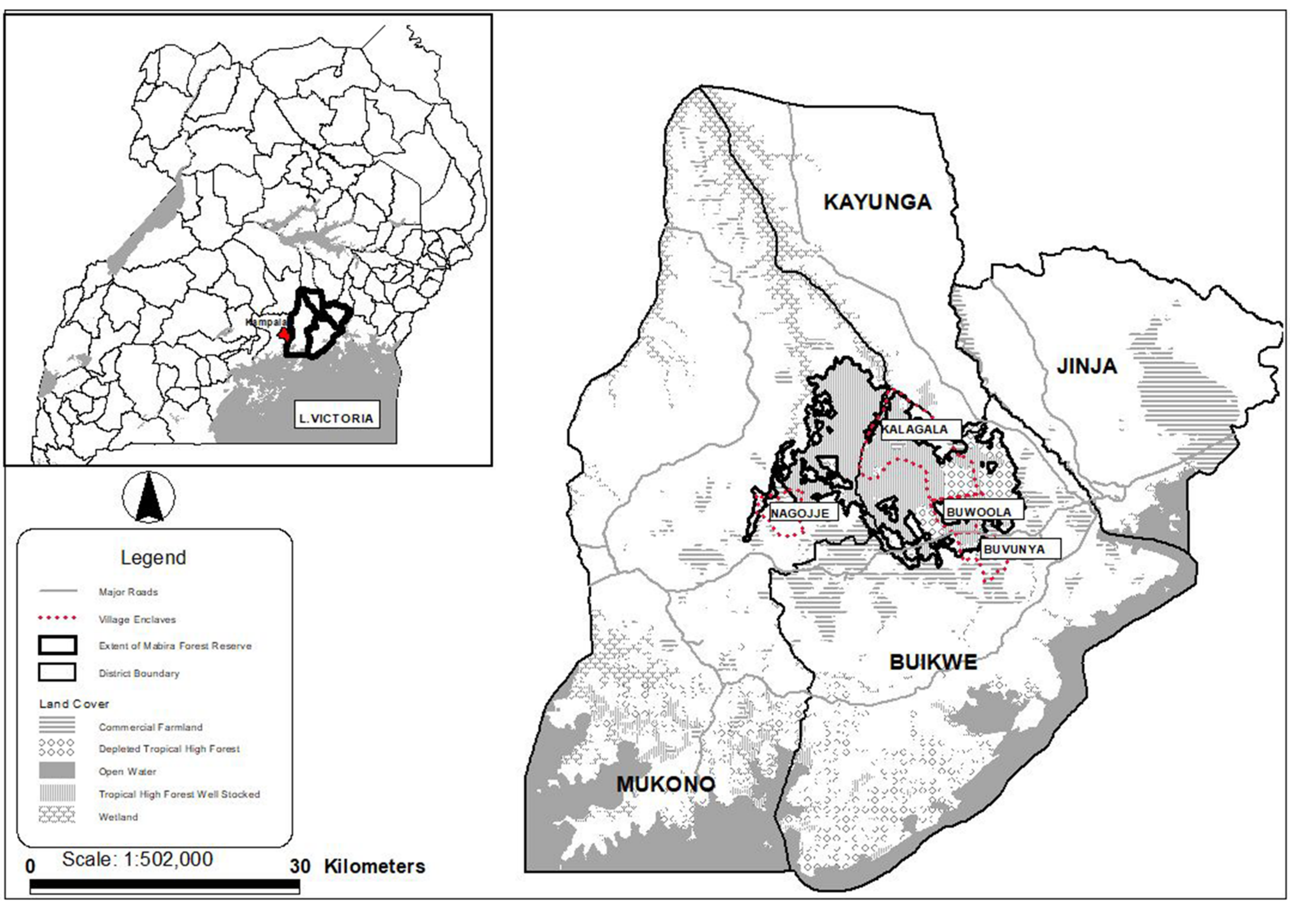

Fig. 1 Location of Mabira Forest Reserve, central Uganda. Geospatial data provided by National Forestry Authority (NFA) 2018

Brown 1960, 1964) in the protected area system, a vegetation type that does not occur in any of the country's national parks or wildlife reserves. An ecological study in 2016 recorded 544 plant species plus *Isachne mauritianum*, a grass species that is uncommon in Uganda (NFA 2016 unpublished). Thirty-one species of small mammals, 12 species of bats and 42 species of amphibians have also been recorded in the Mabira ecosystem.

The forest has greatly been influenced by human activities (i.e., logging, charcoal burning, cultivation and grazing) for over four decades and now is regarded as secondary forest. Most tree species such as *Celtis* spp., *Albizia* spp., *Antiaris toxicalia*, *Chrysophyllum* spp., which are typical of the canopy, and *Funtumia* spp., *Trilepisium* spp. and *Diospyros madagascariense*, typical of the understory, now occur in mature mixed forests.

The forest is the biggest water catchment area within the Lake Victoria region and provides raw materials for construction, textiles, fuels, food, medicine, cosmetics, and utensils, religious and ritualistic artifacts that fulfill most human needs (Howard and Nabanoga 2007). The reliance on forest and or tree resources for these materials in the region, usually leads to degradation (Galabuzi et al. 2014).

Within the past decade (2007–2017), the human population within or surrounding the forest has increased from approximately 120,000 (Galabuzi et al. 2014) to over 200,000 due to immigration of people from Kampala and its suburbs. The cost of living in Kampala and its suburbs has increased to the point where it is no longer affordable to the native poor. Land has been grabbed by a few and the poor or homeless families have been left with few options. The forests on public land including MFR have suffered the consequences. The local population is now a mixture of ethnic groups of the Bantu (e.g., Baganda, Basoga, Banyarwanda, Bagisu, Bakiga, Banyakole, Bagwere, and Batoro) and the Luo (Iteso, Acholi, and Samias).

In this study, the Bantu ethnic tribes were considered to be the native people in this region and comprise up to 70% of the population (Galabuzi et al. 2014). Their languages are related and their beliefs, values, myths, traditions and ways of living are similar or related. Hence, their cultural rituals on forests and allied tree management systems were mainly assessed. The Luo groups on the other hand, resided exclusively in village camps for laborers on the sugarcane plantations and tea estates and in the 27 "village enclaves".

The main economic activities of people living in the study area include ecotourism, trade in local and neighboring markets, tree farming, logging, bricklaying and cultivation of crops such as maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), ground nuts (*Arachis hypogea* L.), sweet potatoes (*Ipomea batatus*), cassava (*Manihot esculenta* Grantz), bananas (*Musa* spp.), pineapple, and vegetables especially *Cleome* and *Amaranthus* spp. Three cash crops including vanilla, khat [*Catha edulis* (Vahl) Forsk.] and coffee are also grown on a small scale.

Extensive tea estates and sugarcane plantations established by the Sugar Corporation of Uganda Limited (SCOUL) are also present. Despite the vast areas of tea and sugarcane, < 1% of the local farmers actually grow these crops (Galabuzi et al. 2014). The extent to which crops other than sugarcane and tea can be grown is limited by scarcity of agricultural land and inability to sustain soil fertility on small (average < 1 ha) farms. Moreover, bricklaying is currently a lucrative business and involves top (agriculturally productive) soils, soil fertility has dwindled and subsequently, food security is threatened especially in the poor households. On-farm cultivation integrated with trees and involvement in natural forest conservation activities were among the important criteria for selecting the study methods.

Methods

We conducted a pilot study involving six village meetings and 18 individual semi-structured interviews with local people. The aim was to build community trust, understand data collection tools, and refine the fieldwork plan, goals that were achieved during the project's initial activities in and around MFR. Results of this preliminary survey are excluded from this article. Data in the main survey were obtained using both qualitative and quantitative methods. Qualitative methods included focus group discussions, key informant interviews and participant observations (Howard and Nabanoga 2007; Sibelet and Mutel 2013). The quantitative methods consisted of individual interviews using a questionnaire. The methods were combined to complement each other and to provide a means of comparing and verifying data obtained using multiple techniques and from different stakeholders.

The participants included field-based staff of the National Forestry Authority (NFA), staff of locally based community organizations and native people living in the forest village enclaves. The community organizations were involved in Collaborative Forest Management (CFM) with the NFA and the local people. The native people were individuals or groups of people that have settled or lived in and around the study area for at least 40 years. The participants had previously been directly involved in the use and management of the forest or exhibited some commonalities in their knowledge of managing forests and allied trees.

For this study, we selected Nkaaga and Buvunya forest enclaves. The enclaves are among the oldest in the study area. In addition, the people living within the study enclaves were directly involved in the management of the reserve, and the forest in these areas was considerably degraded. Also, the indigenous people in Nkaaga enclave were mainly involved in on-farm tree management/conservation, while those in Buvunya enclave were mainly involved in forest management and restoration.

According to Dewi et al. (2005), at least two sampling levels should be considered when studying livelihoods. In this study, participants in both individual and focus group discussions were selected at village/enclave and household levels. At the village level, respondents comprised a population administered by a single Local Council I, while at the household level participants were selected as a sample. At the village level, participants were engaged through focus group discussions (FGDs) to obtain data on general cultural issues on forest/tree uses, management and restoration. A total of eight focus group discussions (120 people), each with 8–15 participants were convened following Merton et al. (1990). The number of FGDs per village varied based on the population and size of the village or level of involvement in tree management and forest restoration efforts.

For each enclave, at least one FGD comprised men and women and the rest were gender-disaggregated for the reason that gender can influence the degree of involvement and freedom of expression (Braga 2001; Nabanoga 2005; Howard and Nabanoga 2007). Participants in the focus group discussions were elderly, youth, men and women of various levels of education. Using a checklist, participants were asked to identify native and exotic trees/shrubs adopted or retained on-farm and cultural tree/forest management and restoration practices known and those that were being practiced within the villages or enclaves in general. Cultural knowledge was reflected in the nature and ways of implementing the practices (Table 1). Data obtained from the FGDs were perceived to be common knowledge and thus shared by most of the inhabitants.

We identified key informants following Braga (2001) and Nabanoga (2005) and conducted follow-up interviews. We selected 12 key informants, at least one from each FGD; they were generally ± 60 years old. In a Ugandan context, cultural knowledge is perceived to be collated with age and is mostly popular among the elderly. Therefore, this category was perceived to be more knowledgeable on cultural forest and allied tree management systems. With the aid of a checklist, informants were asked to reference trees, practices or rituals known for tree/forest management and restoration.

The number of households per enclave among the MFR enclaves ranged from 70 to 300. Nkaaga and Buvunya village enclaves consisted of 70 and 200 households, respectively (UBOS 2007). A total of 84 semi-structured interviews including 30 from Nkaaga and 54 from Buvunya were conducted to obtain data from individual households. This sample size was adequate judging from similar social surveys (Miles and Huberman 1994; Hill 1998).

Within each household, one individual (preferably the household head) was interviewed, but in his/her absence the spouse was interviewed. Some households were headed by women, which is an unusual situation in the central Uganda where men are culturally engendered to be the head of the household. The women are expected to be submissive to their husbands. In the absence of both spouses, the eldest person (over 18 years) found was interviewed.

In this study, gender was calibrated by multiple attributes (including age, biological sex, marital status, and education). In the context of the study area, age and biological sex generally prescribed the roles of, for instance, adult males and females and boys and girls. Marital status and education prescribe the specific tasks of every member in a household and community, respectively. We expected that knowledge or information was correlated with age, while marital status and education affected decision-making and partitioning of resources. Questions were asked in Luganda, the main local language.

Participant observation included visits with key informants to the forest and tree farms to identify trees and record the observable tree/forest management practices that were used. Trees were identified using the field guide to Ugandan Forest Trees by Hamilton (1991) and Katende et al. (1995). Voucher specimens of unidentified plants were collected and taken to Makerere University Herbarium (MHU) for identification.

Data analyses

Data from focus group discussions, key informant interviews and farm visits were analyzed qualitatively. Qualitative data were displayed and matrices developed based on consensus within the participants about the expressed views, explanations or responses, attributes, ideas or reasons. Tree/shrub species lists were displayed and scored together with the respondents based on management practice, place of origin (e.g., exotic/indigenous) and level of usefulness. Data from individual semi-structured interviews were analyzed quantitatively using SPSS 20.0 (IBM, Armonk, NY, USA). Quantitative data summaries from SPSS were transferred to Microsoft (Redmond, WA, USA) Excel for graphical presentation. A Wald χ^2 test was performed to determine the association between the farmer's levels of involvement in tree/forest management with the desire to obtain income. Univariate and multivariate analyses were employed to establish variations among the coefficients of gender, age, education, family size, and marital status. A linear regression model was carried out to

Table 1 Cultural tree management practices, purpose and ways of implementation around the Mabira Forest Reserve, central Uganda

Cultural practice	Characteristics	Purpose/application	Responsible
Spot weeding	Weeds are removed by hand around the tree within about 1-m radius	Hand-weeding minimizes interference with root system of the target tree crop; commonly applied in monocultures	All family members; requires a lot of labor, especially during onset of rains
Root pruning	A sharp object (e.g., pang, axe or hoe) is used to cut roots within 3 m of already established trees; commonly done during the wet season	To minimize competition with other crops and effects of water and nutrient deficiency of injured tree crop	Men; requires a lot of energy moreover, and generally woman are heavily engaged in other farm and household tasks (e.g., collecting firewood, child care, gathering herbs, pitting and sowing seed)
Crown pruning	A few branches of already established trees are removed using a sharp object. A branch is first cut above, then beneath and plucked off	To increase light to small crops within the agro-ecosystem; minimizes risk of injuring the trunk and branches	Men; pruning often entails tree climbing, which by tradition, women are not supposed to climb trees. In an event of an accident, women's bones take long to heal, and women's *gomesi* clothing was not appropriate for tree climbing
Bark slashing	Several wounds are inflicted on trunk or branch of fruit trees; usually done during the wet season	To stimulate flowering and fruiting and minimize water nutrient stress due to injuries	Men, women and children. The fruits are very important for every member of a household in this community. The children need them as a supplement to a daily meal especially during the times of famine
Enrichment planting (tree wildings and seed collection)	Tree wildlings are collected from natural forests and good mother trees scattered over the landscape and planted on farms or degraded forests. Sometimes seeds are gathered and germinated at home or in communal nurseries to supply seedlings	To increase survival and availability of useful tree species to livelihoods	Women collect seedlings of fruit and medicinal plants such as *Kigelia africana*, *Tamarindus indica*, *Carica papaya*, *Artocarpus heterophyllus* and *Carissa edulis*; men collect primary commercial species (e.g., coffee, *Maesopsis eminii* and *Catha edulis*)
Application of organic manures	Cattle dung and various plant materials (mainly coffee and maize husks) are placed in a pit and covered with banana leaves or, in some homesteads, with soil	To minimize scorching from heat generated during decomposition and facilitate nearly immediate release of nutrients after application	Commonly women and men; in some households, only women and children
Application of organic pesticides	Combination of red pepper wood ash, animal or human urine and leaves of *Phytolacca dodecandra* are mixed in a container and left to decay	The decomposition minimizes the acidity level of the materials by allowing degeneration of urea to supply nitrogen	Women and men; application requires care to avoid scorching leaves
Mulching	Weeds and grass are cut and used to cover the soil	To prevent soil erosion, minimize soil water loss and sustain plant nutrient availability	Men generally cut the weeds and grass, children carry them to farms, women do the mulching. In some cases, both men and women cut carry and mulch together

establish the relationship between gender and tree or forest management practices (Hoft et al. 1999).

Results

Trees culturally managed on farms

Up to 40 species, including 32 native and eight exotic trees and shrubs, were encountered on farms. These species belong to 20 families. Moraceae (53%) and Fabaceae (30%) comprised the highest number of individual trees (Table 2). The native trees on-farm included *Ficus natalensis*, *F. exasperata*, *F. mucuso*, *Albizia glabberima*, *A. grandibracteata*, *A. zygia* and *C. edulis*. The exotic trees and shrubs included *Citrus sinensis*, *Eucalyptus grandis*, *Grevillea robusta*, *Mangifera indica*, *Moringa oleifera* and *Broussonetia papyrifera*. During FGDs, timber and fast-growing species were highly ranked. Food and medicinal species were also scored among the most important species on-farm, suggesting that the more uses a species had, the

Table 2 Valuable trees and shrubs planted and/or retained on-farm and used in natural forest restoration around Mabira Forest Reserve

Scientific name	Family	Native or exotic, Local uses
Albizia glabberima (Schumach. & Thonn) Benth.	Fabaceae	N, Timber, firewood, medicine
Albizia grandibracteata Taub	Fabaceae	N, Timber, firewood, medicine
Albizia zygia (DC.) Macbr.	Fabaceae	N, Timber, firewood, medicine
Alstonia boonei De Wild	Apocynaceae	N, Crafts, firewood
Antiaris toxicaria (Rumph. ex Pers.) Lesch.	Moraceae	N, Medicine, timber, bark cloth
Artocarpus heterophyllus Lam.	Moraceae	E, Food (fruits), firewood
Canarium schweinfurthii Engl.	Burseraceae	N, Timber, food (fruits), firewood
Catha edulis (Vahl) Forsk.	Celastraceae	E, Food (leaves) firewood
Celtis mildbraedii Engl.	Ulmaceae	N, Timber, crafts, firewood
Citrus sinensis	Rutaceae	E, Food, firewood, medicine
Cordia africana Lam.	Boraginaceae	N, Timber, firewood
Cordia millenii Bak.	Boraginaceae	N, Timber, firewood
Dracaena fragrans	Ruscaceae	N, Medicine, firewood
Erythrina abyssinica Lam. ex DC.	Fabaceae	N, Medicine, firewood
Eucalyptus grandis	Myrtaceae	E, Timber, firewood, medicine
Ficus exasperata Vahl	Moraceae	N, Firewood, shade, medicine
Ficus mucuso Welw. ex Warb.	Moraceae	N, Firewood, shade, medicine
Ficus natalensis Hochst.	Moraceae	N, Firewood, bark clothing, shade, medicine
Ficus sur	Moraceae	N, Firewood, shade, medicine
Funtumia africana (Benth.) Stapf	Apocynaceae	N, Timber, firewood, medicine
Funtumia elastica (Preuss) Stapf	Apocynaceae	N, Timber, firewood, medicine
Grevillea robusta A.Cunn. ex R.Br.	Proteaceae	E, Timber, firewood, shade
Maesopsis eminii Engl.	Rhamnaceae	N, Timber, firewood, medicine
Mangifera indica	Anacardiaceae	E, Food (fruits), firewood, medicine
Markhamia lutea K. Schum.	Bignonaceae	N, Timber, poles, medicine
Milicia excelsa	Moraceae	N, Timber, firewood, medicine
Monodora myristica (Gaertn.) Dunal	Annonaceae	N, Timber, medicine
Moringa oleifera Lam.	Moringaceae	E, Medicine, soil conservation
Broussonetia papyrifera (L.) Venten	Moraceae	E, Firewood and shade
Spathodea campanulata P.Beauv.	Bignoniaceae	N, Medicine, firewood, shade
Syzigium cordatum Hochst. ex Krauss	Myrtaceae	N, Medicine, firewood
Syzigium cumini (L.) Skeels	Myrtaceae	E, Food (fruits), medicine, firewood
Teclea nobilis Del.	Rutaceae	N, Timber, medicine, firewood
Terminalia ivorensis A.Chev.	Combretaceae	E, Timber, firewood
Persea americana	Lauraceae	E, Food, firewood, shade
Polycias fulva (Hiern) Harms	Araliaceae	N, Timber, shade, firewood
Psidium guajava L.	Myrtaceae	N, Food (fruits), medicine, firewood
Warburgia ugandensis Sprague	Canellaceae	N, Medicine, firewood

N native species retained on-farm, *E* exotic species planted on-farm

The values 1–4 represent the various uses as indicated by participants in FGDs and key informant interviews

higher the prospects of integrating it into the local farming system or intensifying its protection in the forest.

Cultural practices for trees and forest management

Up to 80% of the participants confirmed participation in cultural forest and allied tree system management. Of the 80% that participated in forest or tree management 53% were female and 27% male (Fig. 2); thus, more women were involved in tree farming. For natural forest restoration practices, three knowledge systems were indicated. The majority (56%) combined retention of native tree species and the practice of assisted regeneration or enrichment planting in the forest. For example, wildlings of *M. lutea* were collected and planted along farm boundaries, while *F. natalensis* was generally included on banana and coffee farms. In forest gaps, *M. eminii*, *C. africana*, *T. ivorensis* and *E. grandis* were commonly planted. Other practices included collecting tree seeds and wildings or maintaining native trees/shrubs on-farm for food, medicine, firewood, shade, soil and water conservation, as well as nutrient recycling; especially by species under the *Leguminoseae* family during soil nitrogen fixation.

Generally, there was a very high likelihood ($\chi^2 = 6002.997$, $F = 648.2$, $P = 0.0001$) of individual famers or faming families engaging in tree planting or forest conservation to gain wealth. Also, while gender was not altogether an important factor in determining the nature of forest/tree management practices undertaken, the age of the farmer significantly ($\beta = 0.003$, SE = 0.001, $\varpi = 0.275$, $t = 2.085$, $P = 0.04$) influenced the tendency toward timber harvesting from the natural forest (Fig. 3). In addition, the farmer's family size influenced his/her decision to collect tree wildings ($\beta = 0.009$, SE = 0.004, $\varpi = 0.228$, $t = 2.019$, $P = 0.047$) and fodder ($\beta = 0.12$, SE = 0.004, $\varpi = 300$, $t = 2.652$, $P = 0.01$) whereas collection of materials craft ($\beta = 163$, SE = 0.069, $\varpi = 0.278$, $t = 2.352$, $P = 0.021$) seemed to be also affected by the sex of the participants. Therefore, much as gender showed no significant effect on cultural knowledge practices, some of its qualities independently affected different components of a forest and tree knowledge system or ways of knowing and doing things (Fig. 4).

In the case of on-farm tree management, seven practices were identified (Fig. 5). The most important were spot weeding using hoes (74.7%) for plants with a firm root system and pruning (34.5%) using hands/machetes on plants with a fragile rooting system. The soil around the trees was covered with a mulch of weeds or grass to prevent erosion, minimize soil water loss and sustain fertility. Soil that was heaped around the base of the trees was perceived to promote proper root development. Another practice was the application of organic fertilizer (composed of cattle dung and plant residue from beer brewing, coffee and maize husks and water) left to decay for about 20–30 days. The other tree management strategies included application of organic pesticides (a combination of red pepper (*Capsicum annum*), wood ash and animal urine). The farmers mixed cattle urine with ash, fruits of red pepper and leaves of *P. dodecandra* (L'Herit) in a container to prepare the organic pesticides. A local broom made from *Panicum maximum* K.Schum was used to apply the mixture onto the affected parts of the tree, mainly on fruit trees on-farm. On some farms, pests and diseases were managed by just applying fermented human or cattle urine

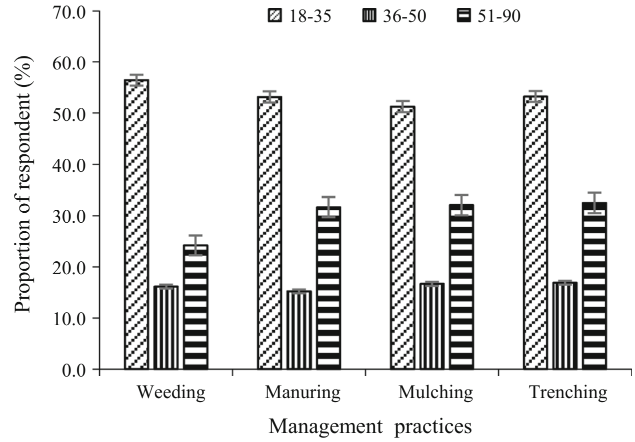

Fig. 3 Proportion of farmers by age involved in cultural tree and forest management practices around the Mabira Forest Reserve, Uganda

Fig. 2 Proportion of men and women involved in tree planting and forest restoration practices around the Mabira Forest Reserve, Uganda

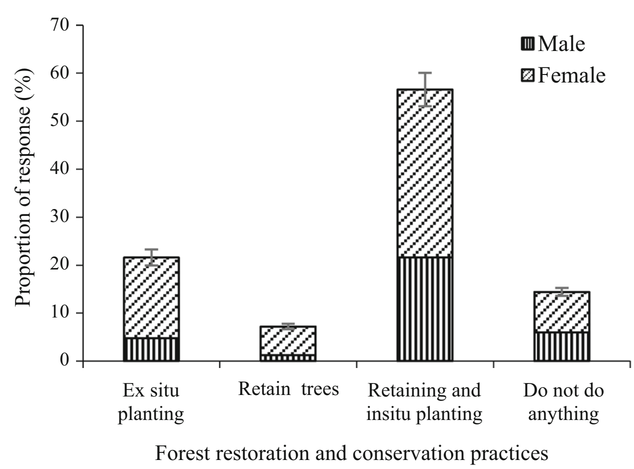

Fig. 4 Level of involvement in traditional natural forest management and restoration practices around the Mabira Forest Reserve, Uganda

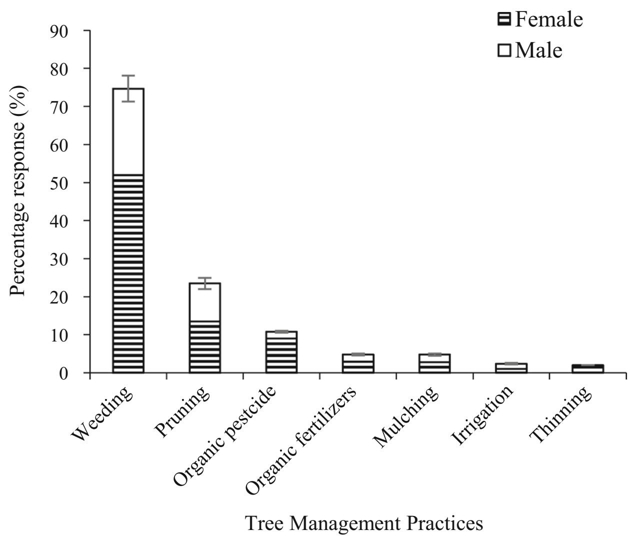

Fig. 5 Farmers level of involvement in cultural tree management practices/strategies around the Mabira Forest Reserve, Uganda

on the infested plant parts. Human urine (especially from women) was preferred to cattle urine. During key informant interviews, the preference of women to men's urine was attributed to the observation that women's urine ferments faster to release nutrients. Moreover, fermented urine was preferred to unfermented because it does not scorch plants. The informants also highlighted that the percentage of farmers using cultural approaches has dropped from about 90% to < 10% in the region. The evolution of "scientific" ways of managing trees and forest is to blame.

The choices of trees on-farm as well as the management practices were not significantly affected by gender. However, the farmers' level of education ($\beta = 0.016$, SE = 0.008, $\varpi = 0.245$, $t = 2.078$, $P = 0.041$) positively influenced the decision to apply organic pesticides. In addition, biological sex of the famers seemed to be relevant regarding the decision to thin ($\beta = 0.081$, SE = 0.039, $\varpi = 0.249$, $t = 2.073$, $P = 0.041$) and weed ($\beta = 0.127$, SE = 0.054, $\varpi = 0.281$, $t = 2.367$, $P = 0.02$) the trees on-farm (Table 3).

The findings from FGDs show that farmers were aware that some tree species were sensitive to slight changes in soil moisture and could quickly wither if the roots were exposed to excessive heat. During thinning, trees with poor growth, disease or pests were removed using machetes. Some undesired trees (e.g., diseased and pest-infested) were ring barked at the base of the trunk. The de-barked area was smeared with salt. While parasitic and epiphytic plants from valued trees was generally removed manually by men, women in some households were administered this practice at heights that could be accessed without climbing. Often, tree pruners on long handles were used. Within the *Ganda* and *Soga* cultures, it is a taboo for a woman or girl child to climb trees because something undesirable would occur; e.g., in the case of fruit trees, fruits would not mature. No "scientific" evidence was obtained to support this assertion.

Thin bark was slashed with a knife, while thick bark was slashed with machetes if immature fruits might drop from the mother tree. This preventive measure was done to drain "excessive" sap or stress the tree. On some farms, nailing was used for the same purpose, especially on fruit trees such as *A. heterophyllus*, *Mangirefa indica* and *P. americana*. Generally, fruiting was believed to be enhanced if a tree is stressed. Steamed banana leaves, commonly used to cover a culturally steamed plantain (*Matooke*) meal, were wrapped around the stem or branch of interest to "induce or sustain flowering". This ritual was traditionally performed by a mother of twins. Again, there was no "logical" explanation for this practice.

Water harvesting trenches were created along farm boundaries and across the hill slopes and steep areas to aid water retention and reduce soil erosion. Trees and shrubs were planted on-farm to enrich or sustain soil fertility. Manure was applied to trees to promote growth where soil fertility was low. *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae), an invasive plant species and *Impereta cylindrical* (L.) Raeuchel (Gramineae) were used to designate fertile and infertile soils, respectively.

Liquid manure was prepared using cattle dung collected in sisal sacks, placed in a container, and mixed with water. The container was covered with banana leaves and the contents left to ferment for at least a week. During fermentation, the mixture was stirred two to three times daily using a stick and, after at least 7 days, the mixture was applied to the field as manure. Liquid manure was used during the dry season, because it was readily absorbed into the soil. On farms located on slopes, solid manure was placed uphill in the direction of the tree to be nourished. At the onset of the rainy season, nutrients were drained into the ditch left around the tree. Solid manure was mainly used in the rainy season because it is broken down by rain into materials ready for plant absorption. It was usually scattered at least 1 m from the base of the trees to avoid scorching or attracting pests.

Green manure, on the other hand, was placed directly near trees, as it is generally considered to be nonscorching. When an individual tree, e.g., *F. natalensis* or *M. eminii* was injured, a banana stem was sliced and tied around the injured part of the tree to prevent loss of water and promote healing. The banana stem is succulent and is able to retain water for 21–60 days depending on the prevailing weather conditions.

Table 3 Coefficients of biological sex, age, education and family size in relation to cultural management practices around the Mabira Forest Reserve, central Uganda

Variable	Factor	Nonstandardized coefficients		Standardized coefficients	*t* value	*P* value
		B	SE	Beta		
Clearing parasites	*x*	1.822	0.146		12.511	0.000
	β	− 0.022	0.065	− 0.041	− 0.343	0.732
	α	0.002	0.002	0.133	0.996	0.322
	μ	0.016	0.008	0.245	2.078	0.041**
	∞	− 0.029	0.044	− 0.094	− 0.662	0.510
	Ω	0.012	0.011	.125	1.087	0.280
Thinning[a]	*x*	1.850	0.087		21.179	0.000
	β	0.081	0.039	0.249	2.073	0.041**
	α	0.001	0.001	0.126	.930	0.355
	μ	− 0.002	0.005	− 0.051	− 0.423	0.674
	∞	− 0.021	0.026	− 0.113	− 0.783	0.436
	Ω	0.002	0.006	0.031	0.267	0.791
Spot weeding[b]	*x*	1.882	0.121		15.587	0.000
	β	0.127	0.054	0.281	2.367	0.020**
	α	0.001	0.002	0.054	0.406	0.686
	μ	− 0.004	0.006	− 0.071	− 0.604	0.548
	∞	− 0.069	0.036	− 0.269	− 1.883	0.063
	Ω	0.003	0.009	0.043	0.371	0.712
Pollarding[c]	*x*	1.908	0.108		17.613	0.000
	β	0.049	0.048	0.124	1.018	0.312
	α	0.000	0.001	0.016	0.117	0.907
	μ	− 0.005	0.006	− 0.108	− 0.889	0.377
	∞	− 0.003	0.033	− 0.012	− 0.082	0.935
	Ω	0.000	0.008	0.002	0.017	0.987
Organic pesticide	*x*	1.849	0.179		10.307	0.000
	β	− 0.023	0.080	− 0.034	− 0.283	0.778
	α	0.002	0.002	0.138	1.006	0.318
	μ	0.000	0.009	− 0.006	− 0.047	0.962
	∞	0.025	0.054	0.067	0.461	0.646
	Ω	− 0.018	0.013	− 0.164	− 1.392	0.168

x constant, *β* biological sex, *α* age, *μ* education *Ω* family size

**Significant values

[a]Culling some plants to create room for growth of others

[b]Clearing weeds around individual plants

[c]Cutting off upper branches of a tree

Discussion and conclusions

Trees and shrubs on farms and in forests

The *Ficus* species are among the most important multipurpose on-farm trees in central Uganda (Nabanoga 2005; Howard and Nabanoga 2007). Consistent with these studies, we found that figs (Moraceae) were among the highest number of tree species encountered on farms. Although Howard and Nabanoga (2007) argued that the figs were planted because they form a principal cultural pillar (e.g. production of bark clothe) of the *Ganda* clans, in the present study their presence suggests that they are easy to propagate and manage, relatively fast growing to supply multiple products (medicine, firewood, bark clothe) and services (e.g. water catchment protection). In addition, the figs are important sources of food for the birds, bats and primates (Tweheyo and Obua 2001) and hence are likely to better facilitate natural forest restoration. Similarly, in Costa Rica, Sibelet et al. (2017) observed that farmers assign economic, ecological and cultural values to trees in pastures, living fences and around farm roads for the products (e.g., timber, fuel wood, fruits for human consumption) and services (e.g., fruits and shelter for birds and wildlife, beauty and aesthetic values) they provide.

Also, as observed by Schippmann et al. (2006), the Fabaceae family was common because it consists of economically important fruit and timber species. This importance also explains the high likelihood of growing Fabaceae trees to generate income found in the present study, mainly through the sale of timber, charcoal and firewood (Katende et al. 1995). Although Laurance (1999) argued that timber harvesting has the potential to encourage tropical forest conservation, in the current study logging was undertaken to earn a living not to facilitate regeneration or conservation.

Albizia species were retained on-farm, to supply timber, charcoal and firewood, while other trees/shrubs such as *C. edulis* were deliberately planted and sold. *C. edulis* (khat) was of major financial importance for most of the farming households, possibly because of a ready market within the Lake Victoria region. Apart from weeding and tending other agricultural crops cultivated with khat, the application of pesticides was the only management practice. The close market and low inputs made khat a profitable forest enterprise.

In Africa, khat cultivation and consumption are deeply rooted in the social and cultural traditions of a majority of communities in Ethiopia, Djibouti, Somalia and Yemen (Getachew 1996; Klingele 1998). In Uganda, *C. edulis* grows in the dry montane forests of the northeast and is also cultivated in some parts of central, western and eastern Uganda. The bark from young shoots is peeled and/or young leaves and shoots are chewed as a sexual stimulant, and it is popular with long-distance truck drivers in Africa (Getachew 1996; Nyamayalwo 2008). It was commonly found on farms around Mabira Forest Reserve, possibly because the site is strategically located along the Kampala-Jinja highway that connects the Busia and Malaba border towns, the major trade routes linking Uganda to Kenya. In addition, the soils are generally fertile and ecologically favorable for khat.

Cultural knowledge of forest and tree system management

In a study on gendered spaces, species and native forest management in Uganda, Nabanoga (2005) highlighted that care, modesty and patience are among the traditional norms expected of women while masculinity and aggression defined the men. Contrary to these observations, some of the practices reported in our study required "masculinity", yet were undertaken by women. Perhaps times have changed, and traditions among the poor forest-dwellers are less important than the need for survival. More men than women move to cities in search of employment (FAO 1995). The women usually stay behind to care for the home, children and farm and must assume traditional roles of men.

As reported in other studies (e.g., Parrotta and Agnoletti 2007; La Rochelle 2000) the erosion of cultures, values, and traditional lifestyles are challenges to traditional knowledge in many parts of the world. While infrastructure development is suspected to have caused a shift in cultural knowledge of plant uses among the Bedouin of the Wadi Allaqi Desert area of Egypt (Kandal et al. 2016), the need for survival is suspected to be the central catalyst for erosion of cultural values in central Uganda.

Forest enrichment planting is the purposeful multiplication of useful tree species (Wiersum 1997). For MFR, *T. ivorensis* and *M. eminii* were used the most because (1) the seeds are easily acquired and propagated, (2) they establish quickly in the field, (3) they grow quickly and (4) they promise higher prospects for timber and therefore income. In a similar way, local people enrich and expand forest islands and gallery forests and rainforests groves in Guinea and Borneo (Leach and Fairhead 1993). On the contrary, Wiersum (1997) studied cases of reconstructed natural forests that comprised mostly cultivated useful trees with few wild trees, herbaceous plants and lianas. Trees in the forest were believed to be naturally self-sustaining and resilient. The native people in the present study hold a similar belief ("gyamera-gyene", meaning that trees grow on their own).

Trees were also planted along farm boundaries within human settlements to protect against the enemies in the Sahel region (Seignebos 1980). Similarly in Guinea, trees were planted around village boundaries (village fortresses) for protection (Leach and Fairhead 1993). This protective practice was also common in the current study; *M. lutea*, a hardwood valued for construction and sculpting in Uganda, was planted along boundaries to secure or protect the farm from intrusive cultivation and provide a reliable source of timber, poles and firewood for the household.

Also, contrary to the findings by Kelkar and Nathan (1991) and Buyinza and Nabalegwa (2007), studies in Burkina Faso, Morocco, Mauritania, Congo and Zimbabwe reported that women have taken over the tasks formerly done by men in addition to their traditional roles (FAO 1995). This observation is supported in the current study where more women were involved in planting or retaining trees on-farm than men. By tradition, men own the land and therefore automatically assume responsibility over the naturally growing trees on this land, consistent with

Nabanoga (2005) and Howard and Nabanoga (2007), in that tree ownership is associated with the rights to inherit, plant, use, gather or harvest, manage and or dispose. To our surprise, this study revealed that women were more involved in tree planting and on-farm conservation than men, suggesting that men have lost interest in tree farming or have resorted to quick and easily manageable enterprises such as the sale of khat (*C. edulis*) in the neighboring towns.

Relationship between gender, tree farming and forest management

In a study to identify the socioeconomic determinants of farmers "adoption of rotational woodlot technology in Uganda", Buyinza et al. (2008) found that gender was significant and positively related to adoption of knowledge on woodlots. They further argued that men were more likely to establish woodlots on their fields than women. The findings of our study contradict these results, possibly because gender was conceptualized and measured differently. While in Buyinza et al. (2008), gender was synonymously used as biological sex, in the current study, a broader spectrum of qualities was employed to calibrate gender.

Fabiyi et al. (1991) and Adesina et al.(2000) argued that because rotational woodlot farming is primarily a tree-based technology, women may be less likely to adopt it because of either a lack of rights to grow trees or a lack of secure land rights. The men therefore, were more likely than women to farm trees. This result probably reflects a traditional bias against women on securing tree- and forest-tenure rights (Masengano 1996; Buyinza et al. 2008). Other studies have found that women are less likely to use new knowledge on tree and forest management.

In our study, the age of the tree farmers (including both the men and women) was found to be related to timber harvesting tendencies probably because different age groups in a community were interested in different forest products. Youth (both genders) were interested in fruits, craft materials, water and firewood, and the men, also acting as the household heads, were attracted to products with economic value, including timber.

In addition, the farming household size influenced collection of tree wildings, suggesting that the more children in a household the easier they could meet labor needs to effectively implement the practice. Also in a Ugandan and perhaps an African context, cultures/societies do not disaggregate the roles and responsibilities of boys and girls. The boys and girls tend to take on similar roles/responsibilities. Collection of craft materials was significantly affected by gender, indicating that craft materials hold more value to women than men in this community. Therefore, different gender qualities may act independently of each other and influence different components of a knowledge system of forest or tree system management.

Limitation of women in decision-making and participation in forestry related matters results in their limited access to forest resources (Buyinza et al. 2008). While Buyinza et al. (2008) perceived that education is expected to have a positive effect on the decision to adopt tree farming, in our study, the farmer's education became relevant when decisions to apply organic manure and pesticides were necessary. In addition, the farmer's gender was also relevant when deciding to undertake thinning and weeding of trees on-farm. Otherwise, trees were traditionally believed to be self-pruning and resilient of weeds and pests. Therefore, no special care was believed to be necessary to grow or manage them well.

In conclusion, a plethora of cultural practices surround the planting and management of forests and trees on farms around the Mabira Forest Reserve. Although not always understood from a logical or scientific perspective, these practices are at the foundation of indigenous/cultural norms and principle. Given the shifting demography on farms, the introduction of exotic timber tree species for commercial harvesting and the differing uses of forest and tree products according to gender, family size, education level and age, the continuity of these practices is uncertain.

The choice of trees to plant or retain on-farm or use for forest enrichment planting reflects the gender disparities and addresses multiple livelihood issues including income. The need to pay school fees, buy food and clothing or obtain medical services always leads farmers to desperate means including expanding agricultural activities into forest frontiers and applying inorganic fertilizers, pesticides and fungicides.

To promote forest restoration and quality tree management systems, we encourage cultural practices that use environmentally sustainable inputs such as the application of organic manure and pesticides to facilitate tree growth and health. Organic manure and pesticides are degradable and ecofriendly, compared to inorganic fertilizer, pesticides, herbicides and fungicides used in conventional management of forest and allied tree systems, and are very important for the Lake Victoria Crescent where the Mabira Forest Reserve plays a significant role as a water catchment area.

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References

Adesina AA, Mbila D, Nkamleu GB, Endamana D (2001) Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. Agric Ecosyst Environ 80:255–265

Agnoletti M (2006) Culture in sustainable forest management: a growing issue. In: Parrotta JA, Agnoletti M, Johann E (eds) Cultural heritage and sustainable forest management: the role of traditional knowledge. Conference proceeding, ministerial conference on protection of forests in Europe, Liaison Unit, Warsaw

Agrawal A (1995) Dismantling the divide between indigenous and scientific knowledge dev change. Dev Change. https://doi.org/10.1111/j.1467-7660.1995.tb00560.x

Altieri MA (1991) Why study traditional agricultural? In: Caroll MA (ed) Agroecology. McGraw-Hill, New York

Altieri MA (2004) Linking ecologists and traditional farmers in search for sustainable agriculture. Front Ecol Environ 2(1):35–42

Alttieri MA, Nicholls CI, Montalba R (2017) Technological approaches to sustainable agriculture at a crossroads: an agroecological perspective. Sustainability 9:349. https://doi.org/10.3390/su9030349

Becker CD, Leon R (2000) Indigenous institutions and forest condition: lessons from the Yuracare. In: Gibson C, McKean M, Ostrom E (eds) People and forests: communities, institutions, and the governance. MIT Press, Cambridge, pp 163–191

Berlin BO, Berlin EA (2001) Improving health care by coupling indigenous and modern medical knowledge: the scientific basis of highland Maya herbal medicine in Chiapas, Mexico. UNESCO World Conference on Science, London, pp 438–439

Braga C (2001) "They're squeezing us!" Matrilineal kinship, power and agricultural policies: case study of Issa Malanga, Niassa Province. In: Waterhouse R, Vijfhuizen C (eds) Strategic women gainful men: gender, land, and natural resources in different rural contexts in Mozambique. Imprensa Universitária, Maputo

Buyinza M, Nabalegwa M (2007) Gender mainstreaming and community participation in plant resource conservation in Buzaya county, Kamuli district, Uganda. Afr J Ecol 45(1):7–12

Buyinza M, Banana AY, Nabanoga G, Ntakimye A (2008) Socio-economic determinants of farmers'adoption of rotational woodlot technology in Kigorobya sub-county, Hoima district, Uganda. S Afr J Agric Ext 37:1–16

Collings N (2009) Environment. In: The state of the world's indigenous peoples. United Nations, New York, pp 84–127

Cunningham AB (1991) Indigenous knowledge and biodiversity: global commons or regional heritage? Cultural Survival Quarterly (Summer): 4 – 8

Cunningham AB, Cunningham M (1999) Profits, prunus, and the prostate: international trade in tropical bark. In: Zerner C (ed) People, plants, and justice: the politics of nature conservation. Columbia University Press, New York, pp 309–329

Davenport TRB, Howard PC, Baltzer M (1996) Biodiversity Report for Mabira, vol 1–33. Forest Department, Kampala

Dewi S, Belcher B, Puntodewo A (2005) Village economic opportunity, forest dependence and rural livelihoods in East Kalimantan, Indonesia. World Dev 33(9):1419–1434

Dove MR (1990) Socio-economic aspects of home gardens in Java. JSAR 21(1):155–163

Escobar A (2010) Territories of difference: place, movements, life, redes. Lat Am Polit Soc. https://doi.org/10.2307/40660508

Fabiyi YL, Idowu EO, Oguntale AE (1991) Land tenure and management constraints to the adoption of alley farming by women in Oyo State of Nigeria. AEXTJ 6(1/2):40–60

FAO (1995) Report of the international expert consultation on non-wood forest products, Yogyakarta, Indonesia, 17–27 January 1995. Non-Wood Forest Products No. 3. Rome

FAO (1997) State of the world's forests. Food and Agriculture Organization of the United Nations, Rome

FAO (2001) Global forest resource assessment 2000: main report. FAO Forestry Paper 140. Food and Agriculture Organization of the United Nations, Rome

FAO (2005) Global forest resources assessment 2005: progress towards sustainable forest management, FAO Forestry Paper 147. FAO, Rome. www.fao.org/forestry/site/32246/en

FAO (2012) State of the world's forests: the first ten issues: In state of the world's forests, Food and Agriculture Organization of the United Nations Rome ISBN 978-92-5-107292-9, http://www.fao.org/docrep/016/i3010e/i3010e01.pdf

Fleck L (1979) Genesis and development of a scientific fact. The University of Chicago Press, Chicago, pp 149–165

Galabuzi C (2017) *Warburgia ugandesis* (African Greenheart): its demand is higher than supply. Miti the farmers magazine for Africa. Better Globe For 34:35–56

Galabuzi C, Eilu G, Mulugo L, Kakudidi E, Tabuti JRS, Sibelet N (2014) Strategies for empowering the local people to participate in forest restoration. Agrofor Syst 88:719–734

Galabuzi C, Nabanoga GN, Ssegawa P, Obua J, Eilu G (2016) Responses to Malaria Incidence in the Sango Bay Forest Reserve, Uganda. Hum Ecol 44(5):607–616. https://doi.org/10.1007/s10745-016-9855-4

Getachew M (1996) The cultivation of and use of Khat among the Oromo of Harar with particular reference to Haromaya Woreda. Addis Ababa University, Addis Ababa

Gombya-Ssembajjwe WS (2000) Sacred forests: an alternative way of conserving forest resources In: Gombya-Ssembajjwe WS, Banana AY (eds) Community based forest resource management in East Africa. Uganda Forestry Resources and Institutions Center (UFRIC) Makerere University Printery Kampala, pp 79–109

González JA, García-Barriuso M, Pardo-De-Santayana M, Amich F (2012) Plant remedies against Witches and the Evil Eye in a Spanish "Witches' Village". Econ Bot 66(1):35–45

Hamilton A (1991) A field guide to Ugandan forest trees. Makerere University Printery, Kampala

Hill R (1998) Interpersonal computing and Technology: An Electric Journal for the 21st Century. ISSN: 1064–4326

Hoft M, Barik SK, Lykke AM (1999) Quantitative ethnobotany: applications of multivariate and statistical analyses in ethnobotany. People and Plants Working Paper 6, UNESCO, Paris

Howard PL, Nabanoga G (2007) Are there customary rights to plants? An inquiry among the Baganda (Uganda) with special attention to gender. World Dev 35(9):1542–1563

IAC (2003) Capacity building in forest certification—Uganda [online]. http://www.gtz.de/capacity_building/english/countries/land68.htm. Accessed 28 Oct 2009

Kandal HA, Yacoub HA, Gerkema MP, Swart JAA (2016) Vanishing knowledge of plant species in the Wadi Allaqi desert area of Egypt. Hum Ecol 44(4):493–504. https://doi.org/10.1007/s10745-016-9826-9

Katende AB, Birnie A, Tegnas BO (1995) Useful trees and shrubs for Uganda, identification, propagation and management for agricultural and pastoral communities. Regional soil conservation unit (RSCU), Nairobi

Kelkar G, Nathan D (1991) Gender and tribe: women, land and forests in Jharkhand. University of Michigan. Digitized, ISBN, 1856490351, 9781856490351

Klingele R (1998) The Hararghie farmers on the crossroad between subsistence and cash economy. Field report. UNDP–EUE

(United Nations Development Program, Emergency Unit Ethiopia)
La Rochelle S (2000) Common property and traditional ecological knowledge: biodiversity conservation in the Sierra Tarahumara, Mexico. M.Sc. Thesis. Natural Resources Institute, University of Manitoba, Winnipeg, Canada
Langdale-Brown I (1960) The vegetation of Uganda. Memoirs, Research Division. Uganda Department of Agriculture, ser. 2, no. 6
Langdale-Brown I, Osmaston HA, Wilson JG (1964) The vegetation of Uganda and its bearing to land-use. Government Printers, Entebbe
Latour B (1991) We have never been modern. Harvard University Press, Cambridge. ISBN 0-674-94838-6
Laurance WF (1999) Reflections on the tropical deforestation crisis. Biol Conserv 91:109–117
Leach M, Fairhead J (1993) Whose social forestry and why? People, trees and managed continuity in Guinea's forest-savanna mosaic. Z Wirtschaftsgeog 37(2):86–101
Maffi L, Woodley E (2010) Bio-cultural diversity conservation: a global sourcebook. Routledge, New York
Maginnis S, Aguilar L, Quesada-Aguilar A (2011) Forests and gender In: Aguilar L, Shaw DMP, Quesada-Aguilar A. (eds). IUCN, Gland, ISBN: 978-2-8317-1428-8
Masengano C (1996) Diffusion of agroforestry technologies. http://www.smu.edu/12user/masagn/agrof. Accessed 2 Apr 2006
Merton RK, Fiske M, Kendall PL (1990) The focused interview: a manual of problems and procedures, 2nd edn. Collier MacMillan, London
MGLSD (2010) Sector performance report. Ministry of Gender, Labour and Social Development, Entebbe
Miles MB, Huberman AM (1994) Qualitative data analysis. Sage, Beverly Hills
Mukasa C, Tibazalika A, Mango A, Muloki HN (2012) Gender and forestry in Uganda: policy, legal and institutional frameworks. Working Paper 89. CIFOR, Bogor, Indonesia
Mwavu EN, Witkowski ETF (2008) Land-use and cover changes (1988–2002) around Budongo forest reserve, NW Uganda: implications for forest and woodland sustainability. Land Degrad Dev 19(6):606–622
MWE (2003) Forest management plan for Mabira Central Forest Reserves (Mabira, Nadagi, Namakupa, Namawanyi/Namananga and Kalagala Falls Central Forest Reserves for the period 2009–2019. Ministry of Water and Environment (MWE), Kampala
MWLE (2001) The Uganda forestry policy. Ministry of Water, Lands and Environment, Kampala
Nabanoga GNK (2005) Transgressing boundaries: spaces, species and gendered indigenous management of forest. Tropical Resource Management Papers, No. 60. ISBN 90-6754-902-9
NARO (2017) Annual report 2016/2017. National Agricultural Research Organization, Entebbe
Ngure PK, Ng'ang'a Z, Ingonga J, Rukunga G, Tonui WK (2009) *In vivo* efficacy of oral and intraperitoneal administration of extracts of *Warburgia ugandensis* (Canellaceae) in experimental treatment of Old World cutaneous leishmaniasis caused by *Leishmania major*. Afri J Trad CompAltern Med 6(2):207–212
Nyamayalwo AK (2008) Farming practices and utilization of *Catha edulis* by local communities in and around Mabira Forest, Central Uganda. Unpublished B.Sc. Dissertation, Makerere University Kampala
Obua J, Agea JG, Ogwal JJ (2010) Status of forests in Uganda. Afr J Ecol 48(4):853–859. https://doi.org/10.1111/j.1365-2028.2010.01217.x
Olila D, Olwa-Odyek Opuda-Asibo J (2002) Screening extracts of *Zanthoxylum chalybeum* and *Warburgia ugandensis* for activity against measles virus (Swartz and Edmonston strains) in vitro. Afri Health Sci 2:2–10
Ouédraogo I, Nacoulma BMI, Hahn K, Thiombiano A (2014) Assessing ecosystem services based on indigenous knowledge in south-eastern Burkina Faso (West Africa). Int J Biodivers Sci Man 10:313–321
Parrotta JA, Agnoletti M (2007) Traditional knowledge, cultural heritage and sustainable forest management. For Ecol Manag 249:1–139
Parrotta JA, Agnoletti M, Johann E (Eds.) (2006) Cultural heritage and sustainable forest management: the role of traditional knowledge. In: Conference proceeding, ministerial conference on protection of forests in Europe, Liaison Unit, Warsaw
Parrotta JA, Agnoletti M, Johann E (2016) Cultural Heritage and sustainable forest management: the role of traditional knowledge. In: Conference proceeding, ministerial conference on protection of forests in Europe, Liaison Unit, Warsaw
Saway VL (2018) Indigenous cultures and forest management. Online 20th–February 2018; 3.04 pm; http://www.fao.org/docrep/ARTICLE/WFC/XII/0841-A2.HTM. Accessed 25 Nov 2018
Schippmann U, Leaman DJ, Cunnigham AB (2006) Cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. In: Bogers RJ, Craker LE, Lange D (eds) Medicinal and aromatic plants, 17th edn. Wageningen UR Frontis Series. Springer, Dordrecht
Seignebos C (1980) Des forticications végétales dans la zone soudano-sahelienne (Chad and Cameroun). In: ORSTROM, L'arbre en Afrique tropicale, la function et le signe. Cah. Science Human 17(3 & 4):191–222
Sibelet N, Mutel M (2013) From hypotheses to variables to investigate. In: Sibelet N, Mutel M, Arragon P, Luye M (eds) Qualitative survey methods applied to natural resource management. Online learning modules. http://enquetes-cirad.iamm.fr/course/view.php?id=3. Accessed 18 Jan 2015
Sibelet N, Chamayou L, Newing H, Montes IG (2017) Perceptions of trees outside forests in cattle pastures: land sharing within the Central Volcanic Talamanca biological corridor, Costa Rica. Hum Ecol. https://doi.org/10.1007/s10745-017-9924-3
Temperton VM (2007) The recent double paradigm shift in restoration ecology. Restor Ecol 15(2):344–347
Turyahabwe N, Banana AY (2008) An overview of history and development of forest policy and legislation in Uganda. Int For Rev 10(4):641–656
Tweheyo M, Obua J (2001) Feeding habits of chimpanzees (*Pan Troglodyte*), red-tail monkeys (*Cercopithecus ascanius schmidti*) and blue monkey (*Cercopithecus mitis stuhlmanii*) on figs in Budongo Forest Reserve, Uganda. Afr J Ecol 39:133–139
UBOS (2007) Uganda population and Housing census 2002, UGA-UBOS-PHC-2002, Ministry of Finance, Planning and Economic Development, 1: 5–31, Kampala Uganada
Uwimbabazi M, Galabuzi C, Kisekka R, Ntakimanye A, Kabonesa B, Musiimenta S, Kiyingi I Agaba H (2018) Factors influencing adoption of Redd+ by small holder farmers in Western Uganda: the case of private forest owners in Hoima District. National Forest Resources Research Institute, Research Report (Unpublished)
Warren DM (1991) Using indigenous knowledge in agricultural development. The International Bank for Reconstruction and Development/The World Bank, Washington
Warren DM, Cashman K (1988) Indigenous knowledge for agriculture and rural development: some practical applications. Indigenous knowledge systems, Washington D.C
Watson-Verran H, Turnbull D (1995) Science and other indigenous knowledge systems. In: Scheila J, Markle GE, Petersen JC, Trevor P (eds) Handbook of science and technology studies. Sage, Thousand Oaks, pp 115–139

Wiersum KF (1997) Indigenous exploitation and management of tropical resources: an evolutionary continuum in forest-people interactions. Agric Ecosyst Environ 63:1–16

Wilson M (1991) The Fulani model of sustainable agriculture. In: African American studies. University of Maryland, Baltimore

WRI (1994) World resources 1994–1995: a guide to the global environment. Oxford University Press, New York

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