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Assessing use-values and relative importance of trees for livelihood values and their potentials for environmental protection in Southern Burkina Faso

Daniel Etongo • Ida Nadia S. Djenontin • Markku Kanninen • Edinam K. Glover

Abstract

Empirical ethnobotanical studies in Burkina Faso and the Sahel apply unmodified use-value methods, which often fail to capture uses of plants within and across categories. These methods mask both the relative uses and local people's 'true' knowledge of plant species. This study addresses these methodological weaknesses by assessing plant use-values within and across eight use categories for livelihood values and their potentials for environmental protection amongst 48 informants, selected through a stratified random technique. The research is two-fold: (i) to document and identify the conservation status of plant species, , and (ii) to assess local knowledge and perceived importance of the most easily found plant species in relation to informant's age, gender, ethnicity, and location. Seventy three plant species belonging to 24 families were recorded on fields, fallows and forests. The most easily found 30 species belonged to 14 families of which Combretaceae, Mimosodeae, Caesalpinioideae and Anacardiaceae dominated. Results show that *Adansonia digitata, Parkia biglobosa,Vitellaria paradoxa*, and *Balanites aegyptiaca*, were more valued for livelihood benefits, while *Adansonia digitata*, *Tamarindus indica* and *Ficus thonningii* received more value for their potentials in environmental protection. Local knowledge was unevenly distributed and showed significant differences at the 0.01% level among gender, age, ethnicity and study village. The relative importance of plant uses goes beyond nutrition and potentials in environmental protection and can provide valuable information for creating local markets for such goods. Three species belonging to different families were identified as vulnerable and considered priority for conservation. The design of conservation and development projects should consider creating opportunities for knowledge sharing that will not only improve knowledge but provide better understanding of local priorities based on socio-cultural and economic factors.

Keywords: Ethnobotanical survey; Use-value; ANOVA; Use categories; Southern Burkina Faso

1 Introduction

The international community has recently begun to acknowledge important facts regarding (i) the existence of 'local' or 'indigenous' forest management systems, (ii) the significant role played by biological resources in the lives and livelihoods of indigenous and local peoples, and (iii) the vital contributions of traditional knowledge systems to these communities (Amiott 2003:3) and to the sustainability of local natural resources, including forests.

Recognition of the various roles of traditional knowledge systems gained momentum at the Earth Summit in Rio de Janeiro in 1992. During the summit, world's nations indicated interest in uniting concerns for biological and cultural diversity— including traditional knowledge systems— in its efforts to conserve the world's biodiversity (Wiersema 2003). In particular, Article 8(j) of the CBD, exhorts all contracting parties to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity…'' (CBD 1992).

Local knowledge is widely considered to be of high value in understanding the ecological processes that foster the sustainable management of resources and the conservation of biodiversity (Berkes et al. 2000; Huntington 2000; Olsson and Folke 2001; Kepe 2008). Local knowledge and practices must be analyzed and understood so that appropriate management practices can be developed that incorporate scientific and local knowledge (Berkes and Folke 2002). Understanding the different ways local people use plant species is important for researchers and development agencies when determining conservation priorities (Garibaldi and Turner 2004; Ayantunde et al. 2008). Use-value has been advocated as a quantitative tool to assess the local knowledge of individual species and families of plants amongst local people. In this report, local knowledge and indigenous knowledge are used interchangeably.

Given the magnitude of the effects of climate variability and other global change polemics such as food insecurity and livelihood strategies, local knowledge of the uses of indigenous plants is invaluable to smallholder farmers, governments, non-governmental organizations (NGOs), policy makers, researchers, and etc. in sub-Saharan Africa and the Sahel in particular. Unfortunately, local knowledge is not uniformly distributed, but accumulates over time as local people interact daily with their environment (Ghimire et al. 2004; Ayantunde et al. 2008). Traditional knowledge and practices differ across age group, gender, ethnicity and location, as reflected by diverse plant usage in diet, material for craft and construction, medicine, for regreening purposes, and etc. Factors that influence local knowledge differences among individuals in a community include social and economic status, roles and responsibilities in the home and community, profession, effective knowledge transfer, and the level of education of the people involved, among others (Holt 2005; Ayantunde et al. 2008).

In the Sahel, plant species are multipurpose (Lykke 2000a; Lykke 2000b; Hamilton et al. 2003; Wezel 2004; Ayantunde et al. 2008; Paré et al. 2010; Sop et al. 2012), providing products and services to local people (Ræbild et al. 2007; Kepe 2008). In Burkina Faso plants are harvested and processed locally to fulfill households' daily needs (Nikiema 2005). Different parts of a plant can be used for different purposes, and some species have more uses than others (Garibaldi and Turner 2004). Not all of a plant's uses are known by everyone in a community, because knowledge accumulates with time and is influenced by other factors. But the use-value method created within the context of the ecological apparency hypothesis (EAH) predicts that, the apparent plants (i.e. the most easily found in the vegetation) would be the most commonly collected and use by people (de Lucena et al. 2012). Collection of such plants does not mean equal knowledge for different uses because socio-cultural and economic activities are important in the acquisition of local knowledge.

Apart from differences in socio-cultural and economic status of individuals, which might affect local knowledge, more important are the methods used to study this local knowledge. Although the number of ethnobotanical studies in Burkina Faso has increased during the last decade (Hahn-Hadjali & Thiombiano 2000; Wezel and Haigis 2000; Taïta 2003; Kristensen and Balslev 2003; Lykke et al. 2004; Belem et al. 2007; Paré et al. 2010; Sop et al. 2012; Zizka et al. 2015), these studies cannot identify plants that have more than one usage within a single use category. For example, food, medicine, construction, and etc. are use categories employed in the above studies, but the methods applied failed to capture multiple uses of plants that occur both within and across use categories. Some studies in Burkina Faso (Kristensen and Balslev 2003; Sop et al. 2012) and the Sahel (Ayantunde et al. 2008) have applied the unmodified tree use-value method (Phillips and Gentry 1993). Though this method does allow for quantification, the perceived differences in plant knowledge among the community are not captured. For example, a plant used for craft might also be used in five other categories and still be used as medicine to cure ten different ailments. These studies do not reveal such details, and the relative importance of plants cannot be fully captured.

The current study applies the “relative use-value method” modified to capture the multiple uses of plants within and across use categories (Rossato et al. 1999; Silva and Albuquerque 2004; modified from Phillips and Gentry 1993). It is employed to measure the total number of plant uses that one informant knows relative to the average knowledge among all informants. Its advantage is the ability to quantify and compare local knowledge within and across categories. Ethnobotanical knowledge can provide valuable information about the different uses of a single species within and across use categories (Wezel and Lykke 2006). This method overcomes the challenge of ‘hidden’ knowledge not captured by other methods while revealing the ‘true’ knowledge of informants on the local uses of plant species.

Against this background, and in order to provide information on overall species diversity, the objectives of this study were: (i) to document plant species in the study area and identify their status for conservation based on IUCN classifications , and (ii) to assess the use-values of the most easily found 30 species across age, gender, ethnicity and location among the following use categories: food, fodder, wood fuel, medicine, income, construction, craft, environmental, and spiritual values.

2 Materials and methods

2.1 Description of study area

This study was carried out in the Ziro province of southern Burkina Faso in three villages, namely: Cassou, Dao and Kou located in the Cassou, Gao and Bakata districts, respectively (Fig. 1). This province covers an area of 2,380.13 km² with an average altitude of 300 m a.s.l. and consists of settlements, croplands, woodlands, and community managed forests. The phytogeography of the country shows that this region is located in the South-Sudanian eco-region with an annual rainfall and temperature range of 800-900 mm and 30-40°C, respectively, with seasonal peaks of 45°C during the month of March and April. The area is characterized by low relief and homogenous soil types including silt-clay cambisols, sandy lixisols and loamy ferric luvisols (Driessen et al. 2001). The average population density was estimated at 28 persons/km² (INSD 2007). In terms of socio-economic and environmental variables such as rainfall, soil types and temperature, this region is fairly homogenous (Paré et al., 2008; Ouedraogo et al., 2009).

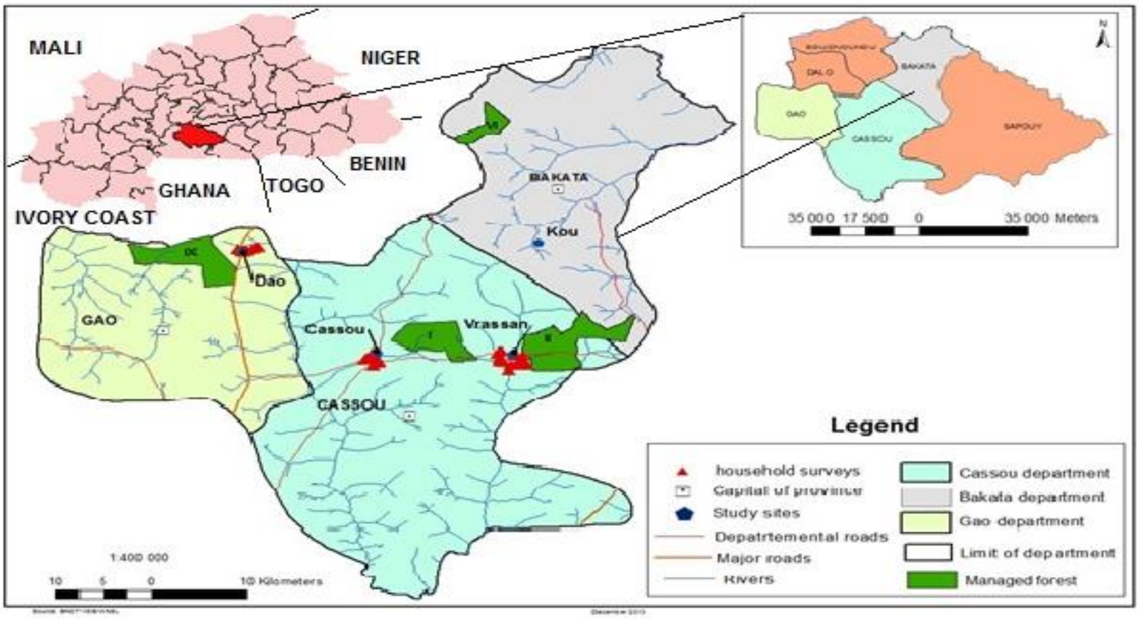


Fig. 1 Map of the study area showing community forest in green

Some of the plant species found in the parklands of the study area include *Afzelia africana* Sm., *Khaya senegalensis* A. Juss. *Pterocarpus erinaceus* Lam., *Vitellaria paradoxa* C. F. Gaertn, *Parkia biglobosa* (Jacq.) R. Br. ex G. Don., and *Tamarindus indica* L. The following ethnic groups are found in the study sites: Gourounsi, Mossi and Fulani of which the last two are migrant ethnic groups from the central and northern region respectively. The farming system involves cultivation of cereals and other livelihood activities such as extraction of fuelwood, forest products and ranching (Paré et al. 2008).

2.2 Ethnobotanical survey

First, the woody species in the fields, fallows, forests, and plantations were identified during an inventory of 135 plots of 0.5 ha, together with a tree walk of 15km in the study area. The purpose of the inventory was to document plant species found in the study area while the tree walk is to confirm the most easily found species in relation to the EAH. Each of the study village had 45 plots that were randomly selected on fields, fallows and forests. Specimens were collected between November 2013 – March 2014 and August 2014 by the first author together with a research technician, the youth leader and a villager who has knowledge on plant species in the region. Leaves of all the selected plant species were fixed in an exercise book for subsequent interviews. The research technician is from this region; he communicates in the three local languages effectively and knows both the local and scientific names of plants in this region. The leaves of plants were presented to informants for identification, facilitated by the research technician, who then linked the local names to scientific names.

Secondly, the aims of the research were explained to the participants of a focus group discussion (FGD) organized with the chief, the youth leader, the women leader and a representative from the Mossi and Fulani ethnic groups. This gave a total of 15 participants from the three villages.

During the FGD, the 30 most exploited woody species identified by past studies (Kristensen and Lykke 2003; Paré et al. 2010) in the region were discussed with the participants. These studies guided the 15 participants to list 30 species commonly used in the study area. Only two species appeared differently in one of the villages while two of the villages had all 30 of the same species. This slight difference was ignored since one of the objectives was to assess 30 species, and the common list was used.

Furthermore, with the assistance of the youth leaders, 48 informants with uneven age group distribution were randomly selected from the Gourounsi, Mossi and Fulani ethnic groups with 50% male and 50% female. All the men were household heads while 5 of the women were household heads. Because it was difficult to find female headed households, 19 women were interviewed from male headed households. All of the informants were 20 years and above.

Different ethnic and age groups were selected, because local knowledge is unevenly distributed and differs with age, gender, ethnicity, education and location (Hanazaki et al. 2000; Luoga et al. 2000; Dovie et al. 2008). The distribution of ethnic groups were identified as follows during the FGD: Cassou Department (Gourounsi = 60%, Mossi = 35% and Fulani = 5%), Dao (Gourounsi = 25%, Mossi = 50% and Fulani = 25%) and Kou (Gourounsi = 35%, Mossi = 50% and Fulani = 15%). The latter two groups are migrants while the former is indigenous. Using semi-structured questionnaires, the 48 informants were asked the following questions for the selected species:

- To identify each of the species.
- To mention the number of known uses for a species within the following categories: food, fodder, wood fuel, medicine, income, construction, craft and other uses.
- To mention multiple uses within and across the eight categories.
- To mention species with potentials for environmental protection in relation to soil improvement, erosion control, wind, and fire break.

The interviews lasted between 1-2 hours each, and a total of 48 questionnaires were administered to cover the uses of plant species for livelihood and potentials for environmental protection. The survey was conducted twice (event 1 and 2) with each of the 48 respondents on separate days. This was to allow time to capture as much as possible the local knowledge held by individuals in the communities.

2.3 Quantitative ethnobotany approach

The use-value (UV) method (Rossato et al. 1999; Silva et al. 2004; modified from Phillips and Gentry 1993) was adopted for this study as follows:

Formula 1: Species use-value for one informant

$UV_{is} = \sum U_{is}/n_{is}$

Where: U_{is} = the number of uses mentioned for species s by informant i for a given species and

n_{is} = the number of 'events' in which informant i cited a use for species s.

Formula 2: Species use-value for one species across all informants

$UV_{s} = \sum UV_{is}/n_{i}$

Where n_{s} = total number of participants interviewed for species s. Sum the informant use-values for a species and divide by the total number of informants. This method is flexible for handling qualitative data, which are easy to quantify and assess local knowledge (Wezel 2004; Wezel and Lykke 2006). It captures all the known uses by an individual for a plant within a use category (e.g. plants can be used for different ailments within the use category of medicine).The weakness of this method is woody species that are important but have few uses are not captured e.g. woody species preferred for fuelwood may not have many other uses that affect the use-value. Despite this weakness, the method is perceived to be objective, reproducible and allow for hypothesis testing, and therefore is considered to be an appropriate method for statistical analysis (Hoffman and Gallaher 2007; Ayantunde et al. 2009).

2.4 Statistical analysis

The local knowledge of each interviewee was calculated for the selected species in each of the eight use categories using the modified use-value method. Using STATA, the following analyses were conducted: a descriptive analysis of use-value within and across groups, one-way ANOVA tests with either equal or unequal variances for age, gender, ethnicity, and study village of the respondents, and post hoc multiple comparison tests were performed for all groups except gender (not suitable for two variables/group), to show the differences in local knowledge amongst groups.

The data collected on species considered threatened during the FGD were analyzed qualitatively and presented as percentages.

3 Results

3.1 Species diversity, plant status and environmental considerations

A total of 73 species belonging to 24 families (Appendix 1.1) were documented in the fields, fallows and surrounding forests of the study villages. The most dominant families for all identified species are Combretaceae, followed by Caesalpinioidea and Mimosoideae. Overall, the 30 species selected for use-value estimations belonged to 15 families, but the most represented families were Caesalpinioideae (42.86%), Anacardiaceae and Combretaceae (28.57%), and Mimosoideae (21.43%) (Appendix 1.2). Though the most represented plant families among the documented and selected species did not differ significantly, other families that were less represented became more important when use-values estimates for livelihood were considered. Plant families with higher use-values for livelihood included Malvaceae, Sapotaceae, Mimosoideae and Balanitaceae in decreasing order.

Based on IUCN classifications, the 30 selected species were assessed for their conservation status. Out of the 15 families of selected plant species, 13 families consisting of 80% of the 30 species are not evaluated (NE) according to IUCN classification (Appendix 1.2). In addition, 10% of the selected species based on same classifications are vulnerable (VU), 6.7% of least concern (LC) and 3.3% data deficient (DD). These VU species belongs to three different plant families and include *Afzelia africana Khaya senegalensis and Vitellaria paradoxa.*

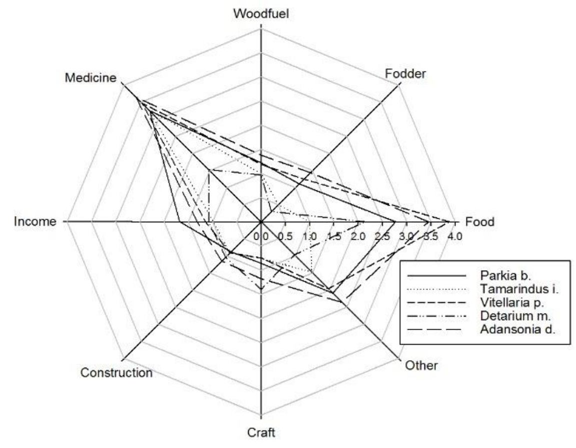
Plants with potentials for environmental protection in this study focused on plants' perceived contribute to soil improvement, erosion control, fire breaks, and wind breaks. Information gathered during the FGD indicated that the Caesalpinioidea and Bombacaceae plant families have potentials for environmental protection than other plant families. For soil improvement, *Adansonia digitata* was perceived to be most useful followed by *Parkia biglobosa*, *Vitellaria paradoxa* and *Piliostigma thonningii*. The decaying wood and leaves of *Adansonia digitata* produce huge amounts of biomass, which is spread on fields as fertilizer. Apart from *Adansonia digitata*, the other three species also contribute fruit, tree back and leave fall biomass for soil improvement. Respondents also revealed that *Ziziphus mauritiana* and *Pterocarpus erinaceus* were considered more useful than other species as wind break. On the other hand, *Tamarindus indica* was valued most useful as a fire break, because no grass will grow under the tree. For erosion control, *Ficus thonningii*, *Bombax costatum,* *Afzelia africana,* and *Azadirachta indica* from the families Moraceae, Malvaceae , Caesalpinioideae and Meliaceae were most valued because they thrive in poorer soils compared to others.

The use-values for the selected species showed three of the most important species in the eight use categories as follows: food (*Vitellaria paradoxa, Adansonia digitata* and *Parkia biglobosa*), fodder (*Balanites aegyptiaca, Adansonia digitata* and *Vitellaria paradoxa*), wood fuel (*Adansonia digitata, Parkia biglobosa* and *Vitellaria paradoxa*), medicine (*Adansonia digitata, Vitellaria paradoxa* and *Daniellia oliveri*), income (*Parkia biglobosa, Afzelia africana* and *Adansonia digitata*), construction (*Pterocarpus erinaceus, Azadirachta indica* and *Diospyros mespiliformis*), craft (*Balanites aegyptiaca , Afzelia africana* and *Ficus sycomorus*), potentials for environmental protection (*Adansonia digitata, Parkia biglobosa* and *Vitellaria paradoxa*) and spiritual (*Annona senegalensis, Afzelia africana* and *Ficus sycomorus*).

3.2 Local knowledge and relative importance of woody species based on use-value

For each of the 30 selected species, there was a significant difference at the 0.01% level in the mean usages across the use categories. This means that local knowledge varied significantly when considering a specific woody species (Fig. 2 & Appendix 2).

2a)



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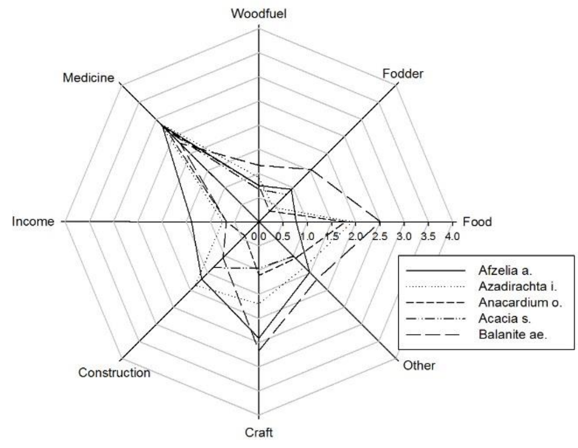

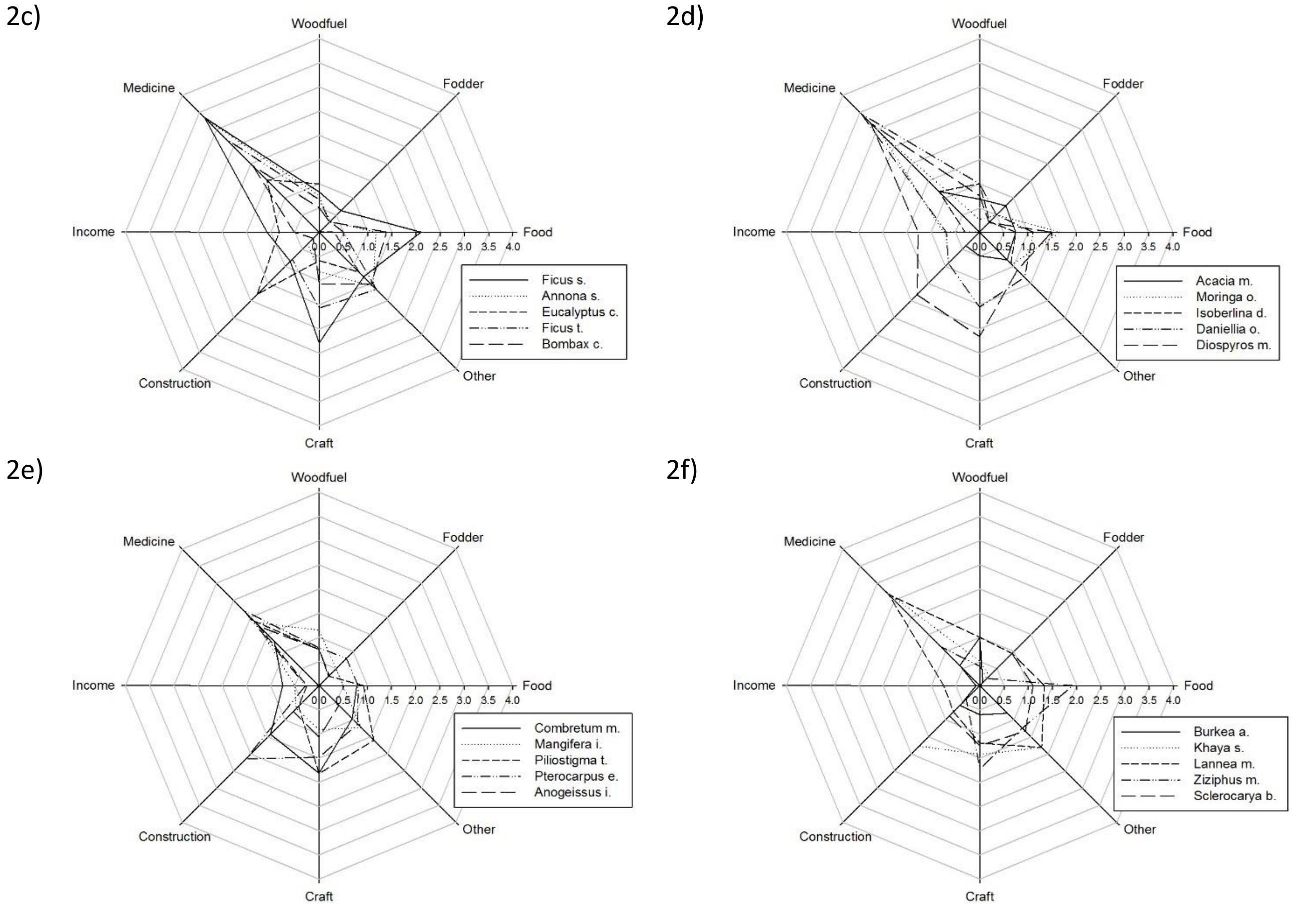

Fig. 2 Relative use-values of the 30 selected species in eight categories

Results (Fig. 2) show that the 30 species have many uses as medicine, food, craft, others, construction, and etc. in decreasing order of uses within categories. Overall local knowledge revealed the different uses of plants within the study area, although some plants had no uses in some categories. The relative importance of plant species were seen in the number of uses they had within and across categories. The use-values for the selected species ranged from 0.08-0.33 for all eight use categories. Based on the overall use-value results (Appendix 2), the following species were considered to be most relatively important in decreasing order: *Adansonia digitata, Vitellaria paradoxa, Parkia biglobosa, Balanites aegyptiaca, Ficus sycomorus, Afzelia Africana, Diospyros mespiliformis, Azadirachta indica* and *Daniellia oliveri.* These species were found to provide multiple uses within and across each of the eight use categories (Fig. 2) providing socio-cultural, economic and their potentials for ecological benefits to the local population.

3.3 Effect of age, gender, ethnicity, and location on local knowledge

Effect of Age on local knowledge

The three age groups in our study (Table 1) showed differences in local knowledge among all the use categories (Fig. 3a & 3b).

Table 1 Age group distribution of respondents

Age groups	Frequency	Percent	Cumulative Frequency
20-40 years (Young)	17	35.42	35.42
41-60 years (Intermediate)	19	39.58	75
61-80 years (Elderly)	12	25	100
Total	48	100	

The elderly age group was more knowledgeable about plant uses in all eight use categories, followed by the intermediate and young age groups. Results indicate that local knowledge increases with age as individuals in a community continue to interact with the environment. The variation of local knowledge shows a significant difference at 0.01% level among the different age groups (Appendix 3&4). Use-value shows significant differences in the following use categories: food, medicine, construction, craft, and other uses among all age groups (Fig. 3b).

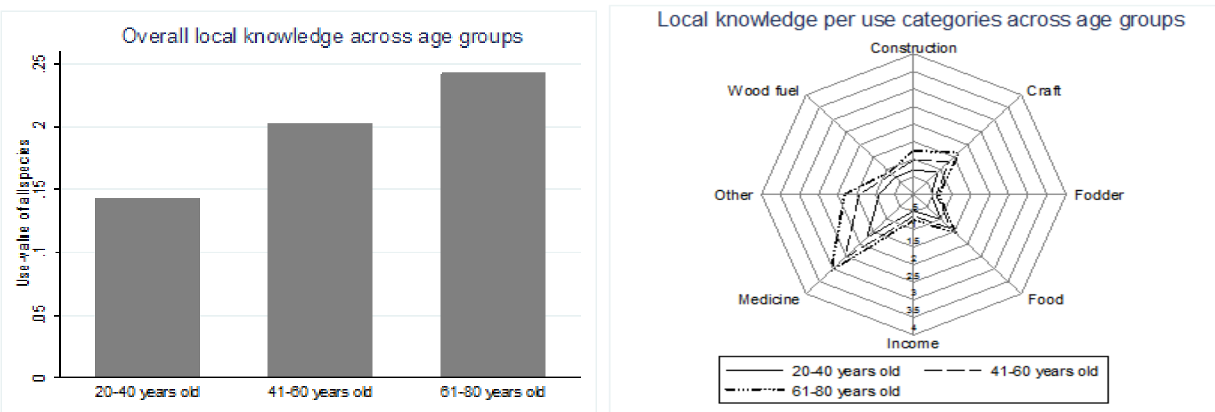

Fig. 3a & 3b Effect of age on local knowledge across use categories

Effect of gender on local knowledge

Local knowledge of selected plant species showed a significant difference at the 0.01% level between genders (Appendix 3&4). The overall use showed differences in local knowledge for men and women (Fig. 4a) with men having more knowledge than women in the following use categories: medicine, craft, others and construction (Fig. 4b). Local knowledge on food, fodder, wood fuel and income was fairly the same for men and women. Traditional doctors were mostly men are had more knowledge on medicinal uses of plant to cure different ailments. In addition, construction of homes and craft work is done mostly by men who know which species are best suited for such purpose.

Fig. 4a & 4b Effect of gender on local knowledge across use categories

Effect of ethnicity on local knowledge

Ethnicity had a significant effect ($P<0.01$) on the local knowledge of plant uses in the eight use categories (Appendix 3&4). The Gourounsi ethnic group showed more local knowledge of plant species followed by the Fulani and Mossi (Fig. 5a). The Gourounsi ethnic group is indigenous and was more knowledgeable of plant uses for medicine, crafts and other uses (Fig. 5b).

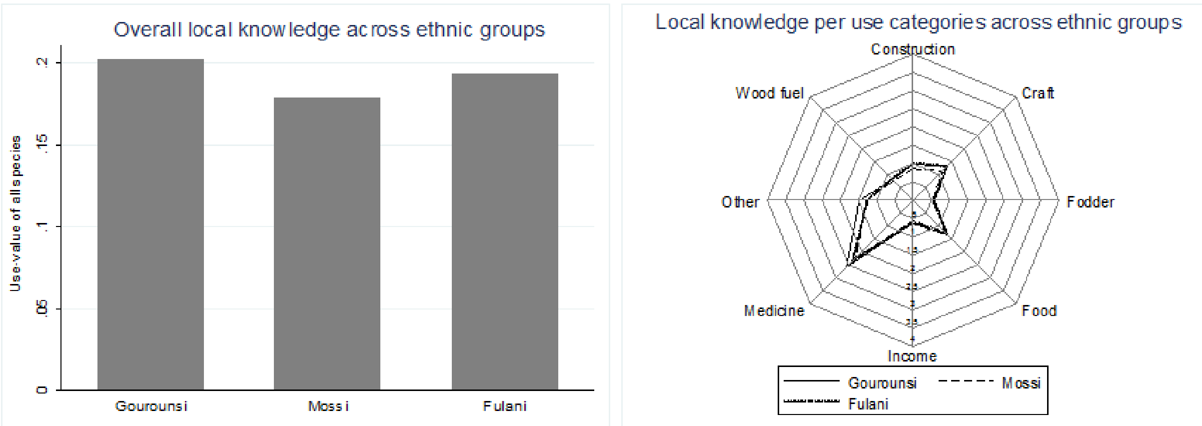

Fig. 5a & 5b Effect of ethnicity on local knowledge across use categories

The Fulani are mostly cattle herders, and they recognized more fodder species than other groups due to daily interactions with their environment in search of fodder. This group also possesses knowledge of animal husbandry, but their increasing sedentarization to cultivate land for food crops might affect knowledge transfer to future generation.

Effect of location on local knowledge

Local knowledge showed significant differences ($P<0.01$) among the three study villages (Appendix 3&4). Differences in local knowledge between respondents from Cassou and Dao villages were not significant, but Kou village showed significant differences (Fig. 6a). These differences are seen in the following use categories: wood fuel, medicine, construction, craft and other uses (Fig. 6b).

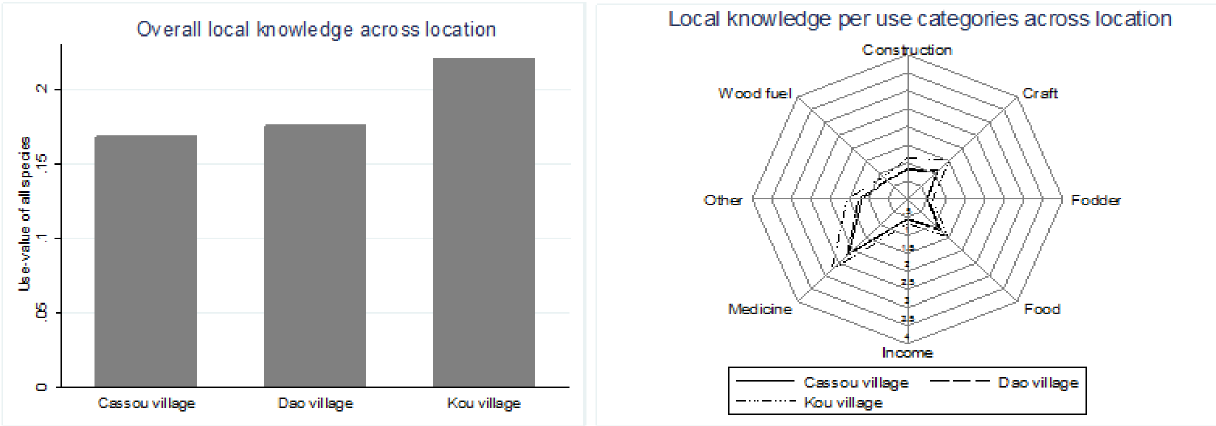

Fig. 6a & 6b Effect of location on local knowledge across use categories

Kou village is poorly connected by roads compared to the other villages, and over 70% of the respondents in this village lived in farm houses. Some of the farm houses are found close to the forests, which provides residents opportunities to interact more frequently with the environment compared to those living far from their farms and forests.

4 Discussion

4.1 Species diversity, priority for conservation and environmental considerations

The recorded total of 73 plant species belonging to 24 families in the study villages shows little variation from studies conducted in the western, southern and sub-Sahelian regions of Burkina Faso (Taïta 2003; Paré et al. 2010; Sop et al. 2012). Two other studies in the same country around the Nazinga Game Ranch and the ‘Parc National Kaboré Tambi recorded 110 and 134 plant species (Kristensen and Balslev 2003; Belem et al. 2007). The differences in the number of species show that villages close to national parks benefit from tree resources that are protected. A study in the Sahel (Ayantunde et al. 2008) shows that local knowledge can vary within a region or country due to the following reasons: plant species are not uniformly distributed and the number of known species differs with reality e.g. studies based solely on interviews might not capture species that are locally extinct.

Based on IUCN classification 80% of the 30 selected species are not evaluated (NE), 10% are vulnerable (VU), 6.7% of least concern (LC) and 3.3% data deficient (DD). These VU species belongs to three different plant families and include *Afzelia africana, Khaya senegalensis and Vitellaria paradoxa.* The specie *Afzelia africana* is one of the most preferred fodder species and increase in livestock number does not allow sufficient time for regrowth. A study by Kristensen and Balslev (2003) indicates an increase in total livestock numbers in Southern Burkina Faso, which is a threat to important fodder species. In addition to livestock, it is perceived that activities such as agribusiness development, field expansion and fuelwood exploitation threatens parkland species such as *Khaya senegalensis* and *Vitellaria paradoxa*. Our findings corroborated other studies in Burkina Faso that mention similar species as threatened and suggest giving these species conservation priority (Paré et al. 2010; Sop et al. 2012).

On environmental considerations, this study suggests that farmers' knowledge of tree use was not limited to only providing food, but also included their potentials in improving soil fertility, checking soil erosion, mitigating wind, and controlling fire outbreak. Studies in the African Sahel also report that indigenous knowledge systems (Nyong et al. 2007) of tree crop management (Tougiani et al. 2009) are used extensively to reduce environmental vulnerability.

4.2. Local knowledge and relative importance of plant use

Plant species are multipurpose, and commonly have more than one use including food, fodder, wood fuel, medicine, income, construction, craft and other uses. These findings are consistent with other studies in Burkina Faso that show variations in local knowledge across 5-7 use categories (Lykke 2000a; Byg and Balslev 2001; Taïta 2003; Kristensen and Balslev 2003; Belem et al. 2007; Paré et al. 2010; Sop et al. 2012). More than half (56.66%) of the 30 selected species were reported to have at least one use in all eight categories, while 43.33% had uses in 5-7 categories. Plant species had more uses as medicine compared to the other seven categories. This confirmed past studies in Burkina Faso (Kristensen and Balslev 2003; Paré et al. 2010) and the Sahel (Ayantunde et al. 2008), where plant usage as medicine dominated other use categories. The plant family Caesalpinioideae was dominant in usage among the selected species. This pattern is similar to other studies conducted in Burkina Faso, where the dominant plant species are from the same family (Paré et al. 2010; Sop et al. 2012).

Some species appeared in four (*Vitellaria paradoxa* and *Parkia biglobosa*) and five (*Adansonia digitata*) different use categories, respectively. The species considered most important based on use-values are *Adansonia digitata, Vitellaria paradoxa, Parkia biglobosa* and *Balanites aegyptiaca* having overall use-values of ≥ 13. This result differed from a study conducted in the sub-Sahel of Burkina Faso in which *Lannea microcarpa* received the highest usage ranking (Sop et al. 2012). Though the results of this study do not have the exact same species ranking of relative importance reported by other studies in Burkina Faso (Hahn-Hadjali and Thiombiano 2001; Kristensen and Balslev 2003; Taïta 2003; Nikiema 2005; Paré et al. 2010; Sop et al. 2012) and the dry lands (Teklehaimanot 2004; Jama et al. 2008; Faye et al. 2010), important species are recurrent. The slight differences in ranking may be linked to the methods used and the number and types of use categories considered.

4.2 Effect of age, gender, ethnicity and location on local knowledge

Effect of Age

The findings of the current study suggest that the elderly age group had more knowledge about plant uses than the adult and young age group. The findings of the current study enhance previous studies in West African Sahel, where the age of the individual influences their knowledge of local plants and their uses (Wezel and Haigis 2000; Kristensen and Balslev 2003; Lykke et al. 2004 Paré et al. 2010; Sop et al. 2012). According to Ayantunde et al. (2008), continuous interaction with the natural environment increases local knowledge of plants, which tends to accumulate over time. Age was found to be important in seven out of the eight use categories, except fodder. Furthermore, other attribute influence the accumulation of local knowledge such as change of generation, occupation, etc. The young and intermediate age groups of the Fulani ethnic group are more involved in cattle rearing that the elderly age group. This implies that cattle herders irrespective of their ages have the same knowledge of fodder species. The results for fodder species are similar to that of Lykke et al. (2004) in which age had no direct bearing on local knowledge in five Fulani villages in the North-Sahelian area of Burkina Faso.

Another study in the Sahel indicates that Fulani between the ages of 10-30 years recognize more species than other ethnic group members of the same age (Ayantunde et al. 2008). Differences might occur when local knowledge is considered across ethnic groups. Another use category with significant differences was food. In this study, fruits were included in the use category of food. The results of the current study fail to confirm the findings of Hanazaki et al. (2000) in which informant age did not affect use of edible fruits, because local knowledge of edible fruits was obtained before the age of 36. Results are expected to differ when use categories are constructed differently.

Effect of Gender

The overall local knowledge of plant species showed that men have more knowledge than women in the following use categories: medicine, construction, craft and other uses (environmental protection and spiritual values). These results differ from that of Lykke et al. (2004), where gender specific differences were not observed in local knowledge distribution. Their study focuses on one ethnic group, the Fulani, whose main activity is cattle herding of which important fodder species are known men and women. Other studies in the Sahel have shown that although gender had no effect on the recognition of medicinal and food species, men tend to identify higher number of species used for forage, construction and firewood (Ayantunde et al. 2008). In Burkina Faso, men are considered more knowledgeable on species used for construction and women have more knowledge on species used for food (Taïta 2003; Paré et al. 2010), while other studies have found that men list more plants in five out of six use categories (Sop et al. 2012) except for medicine (Ricker 2002; Lucena et al. 2007; Sop et al. 2012).

The unmodified use-value method (Phillips and Gentry, 1993) is commonly used to assess local knowledge, but fails to capture the number of possible uses for a species within and across categories. The present study used the modified use-value method (Rossato et al. 1999; Silva et al. 2004), which captures multiple uses of species within and across categories. Men were able to mention up to 10 ailment cured by a species (e.g. *Adansonia digitata*), which they also used for other purposes than women. The number of uses for food mentioned (included in the use category of food are fruits, condiments, etc.) was not significantly difference between genders for all 30 species. The conclusion that women are more knowledgeable than men, especially of fruit trees (Lucena et al. 2007), was not supported in the current study. This may be due to the following reasons: (i) limited number of species considered (30) for ethnobotanical knowledge, (ii) few fruit trees are found amongst the selected species and are common on parklands.

Effect of Ethnicity

The Gourounsi had more overall knowledge of the selected species, followed by the Fulani and Mossi groups. The Gourounsi are the indigenous ethnic group and have lived in thi region for centuries, closely interacting with their environment, which has contributed to a gradual accumulation of knowledge over time. The findings of the current study reinforce those of

Kristensen and Balslev (2003), who found that the Gourounsi people live in intimate relation with the savanna surrounding their villages. Ethnicity is considered to influence the use of plants within and across communities more than other factors (Gouwakinnou et al. 2011). This is because ethnicity goes beyond belonging to a cultural group or way of life, and includes cultural beliefs, taboos, rituals, ideology of social groups, and etc.

The Fulani had more knowledge on plant species than the Mossi because of their daily interactions with the environment in search of fodder. The results from the FGD suggest that classroom education is not a priority for the Fulani, and before the age of 12 they become knowledgeable on important fodder species as they accompany their fathers in search of fodder. Cattle herders are expected to be more knowledgeable on plant uses than other groups because local knowledge tends to accumulate over time (Ayantunde et al. 2008). This was not the situation in the current study, because the 30 selected species included less than three herbaceous plants most commonly used as fodder. Another study indicated that pastoralists use plants in diverse ways and can be more selective of preferred species for various uses (Sop et al. 2012). Other studies in Burkina Faso (Paré et al. 2010; Sop et al. 2012) indicated a significance difference in local knowledge among ethnic groups; however, in neighboring Niger no effect on the use of plant species was observed (Ayantunde et al. 2009).

Location

Respondents in Kou village were more knowledgeable than those in Dao and Cassou. The same species were used in assessing local knowledge; therefore, the differences among the study villages are possibly due to the effect of knowledge accumulation over time. Kou village is remote, and has little or no emigration from other villages. In contrast, Dao and Cassou have good roads and a steady migration of people in and out of these villages. The results of the current study are consistent with a study in Niger, which found consistent of local knowledge over time (Ayantunde et al. 2008). However, it contrasts the findings of Dovie et al. (2008), who found no significant differences in local knowledge among 9 South African villages.

5 Conclusions

This study documented plant species from which 30 species commonly used were assessed for their use-value in eight use categories. Based on IUCN classification, 80% of the 30 species have not been evaluated, 10% are vulnerable, 6.7% of least concern while 3.3% are data deficient. The three vulnerable species include the following: *Afzelia africana, Khaya senegalensis* and *Vitellaria* *paradoxa*. Thus, these species should be considered as priority for conservation. In addition, the use-value results show differences in plant knowledge among age groups, ethnic groups, study sites, and between genders. These differences are likely to be influence by activities and knowledge transfer from one generation to another. Overall, local knowledge transfer was not evenly distributed, and for all species, men, the elderly age group and the Gourounsi ethnic group were more knowledgeable. Species such as *Adansonia digitata*, *Parkia biglobosa*, *Vitellaria paradoxa*, and *Balanites aegyptiaca* were known to have more uses and considered more important than other species for local livelihood. On the other hand, *Adansonia digitata*, *Tamarindus indica* and *Ficus thonningii* were consider for their potentials in environmental protection, because of their contributions to soil improvement, fire and wind breaks and erosion control.

Local knowledge of plant species is important not only for livelihood improvement, but also for the provision of ecosystem services that are critical in a fast changing environment like the Sahel. However, majority of the selected species have not been evaluated and lack a recognized referencing system to assess their status for conservation. Furthermore, the potentials of some plant species can be utilize to improve environmental protection such as soil improvement, erosion control, fire and wind breaks. Policy makers, NGOs and development agencies should consider rangeland development strategies that include trees species utilized in traditional land management. Training programs organized as part of capacity building for farmers should provide a platform for sharing traditional knowledge. This will create opportunities for effective knowledge transfer that benefits all stakeholders involved in the design and implementation of conservation and development projects, including local people.

Appendix 1.

Appendix 1.1. List of species identified on fields, fallows and forests in the study villages

Scientific name	Family	Scientific name	Family
Acacia dudgeoni Craib	Mimosoideae	*Lannea acida* A.Rich.	Anacardiaceae
Acacia macrostachya Reichenb. ex DC	Mimosoideae	*Lannea microcarpa* Engl. & K. Krause	Anacardiaceae
Acacia pennata (L.) Willd	Mimosoideae	*Lannea velutina* A. Rich	Anacardiaceae
Acacia seyal Delile	Mimosoideae	*Lonchocarpus laxiflorus* (Wild.) DC.	Faboideae
Acacia sieberiana DC.	Mimosoideae	*Mangifera indica* L.	Anacardiaceae
Adansonia digitata L.	Malvaceae	*Moringa oleifera*	Moringaceae
Afzelia africana Sm.	Leguminosae	*Parkia biglobosa* (Jacq.) R.Br. ExG.Don.	Mimosoideae
Albizia chevalieri Harms	Mimosoideae	*Psidium guajava* L.	Myrtaceae
Anogeissus leiocarpa Guill. & Perr.	Combretaceae	*Piliostigma reticulatum* (DC.) Hochst	Caesalpinioideae

Anacardium occidentale L.	Anacardiaceae	*Piliostigma thonningii* Milne-Redh.	Caesalpinioideae
Annona senegalensis Pers.	Annonaceae	*Prosopis africana* (Guilt & Perr.) Taub.	Mimosoideae
Annona squamosa L.	Annonaceae	*Pterocarpus erinaceus* Lam.	Caesalpinioideae
Azadirachta indica A. Juss.	Meliaceae	*Pteleopsis suberosa* Engl. & Diels	Combretaceae
Balanites aegyptiaca (Poir.) DC.	Balanitaceae	*Sclerocarya birrea* Hochst.	Anacardiaceae
Bombax costatum Pellegr. & Vuillet	Malvaceae	*Securidaca longepedunculata* Fresen.	Polygalaceae
Burkea africana Hook	Combretaceae	*Securinega virosa* (Willd.) Baill.	Euphorbiaceae
Cassia sieberiana DC.	Caesalpinioideae	*Sterculia setigera* Delile	Sterculiaceae
Citrus limon L. Burm. f.	Rutaceae	*Strychnos spinosa* Lam.	Loganiaceae
Citrus sinensis Osbeck	Rutaceae	*Tamarindus indica* L.	Caesalpinioideae
Combretum collinum Fresen.	Combretaceae	*Terminalia avicenniodes* Guilt. & Perr.	Combretaceae
Combretum fragrans F. Hoffm.	Combretaceae	*Terminalia laxiflora* Engl.	Combretaceae
Combretum glutinosum Guill & Perr.	Combretaceae	*Terminalia macroptera* Guilt. & Perr.	Combretaceae
Combretum micranthum G.Don	Combretaceae	*Trichilia emetic* Vahl	Meliaceae
Combretum molle R.Br. ex G.Don	Combretaceae	*Vitellaria paradoxa* C.F. Gaertn.	Sapotaceae
Combretum nigricans L.ex Guill&Perr.	Combretaceae	*Vitex doniana* Sweet.	Verbenaceae
Crossopteryx febrifuga Benth.	Rubiaceae	*Ximenia americana* L.	Olacaceae
Daniellia oliveri (Rolfe) Hutch.&Dalzie.	Caesalpinioideae	*Ziziphus mauritiana* Lam.	Rhamnaceae
Detarium microcarpum Guill. & Perr.	Combretaceae		
Diospyros mespiliformis Hochst.ex ADC	Ebenaceae		
Eucalyptus camaldulensis Dehn	Myrtaceae		
Entada Africana Guill.& Perr.	Caesalpinioideae		
Feretia apodanthera Delile	Rubiaceae		
Ficus glumosa Delile	Moraceae		
Ficus thonningii Blume	Moraceae		
Ficus platyphylla Delile	Moraceae		
Ficus sur Forssk	Moraceae		
Ficus sycomorus (Miquel) C.C.Berg	Moraceae		
Gardenia erubescens Stapf & Hutch.	Rubiaceae		
Gardenia ternifolia Schumach.& Thonn.	Rubiaceae		
Gmelina arborea Roxb	Verbanaceae		
Guiera senegalensis J.F. Gmel.	Combretaceae		
Hannoa undulata Planch	Simaroubaceae		
Hexalobus monopetalus Eng. Et Diels.	Annonaceae		
Isoberlinia doka Craib & Stapf	Caesalpinioideae		
Jatropha gossypifolia L.	Euphorbiaceae		
Khaya senegalensis A. Juss	Meliaceae		

Appendix 1.2. Thirty most easily found plant species and their conservation status based on IUCN classification

Scientific name	**Family**	**Plant status**
Acacia macrostachya Reichenb. ex DC	Mimosoideae	NE
Acacia seyal Delile	Mimosoideae	NE
Adansonia digitata L.	Malvaceae	NE
Afzelia africana Sm.	Leguminosae	VU
Anogeissus leiocarpa Guill. & Perr.	Combretaceae	NE
Anacardium occidentale L.	Anacardiaceae	NE
Annona senegalensis Pers.	Annonaceae	NE
Azadirachta indica A. Juss.	Meliaceae	NE
Balanites aegyptiaca (Poir.) DC.	Balanitaceae	NE
Bombax costatum Pellegr. & Vuillet	Malvaceae	NE
Burkea africana Hook	Combretaceae	NE
Combretum micranthum G.Don	Combretaceae	NE
Daniellia oliveri (Rolfe) Hutch.&Dalzie.	Caesalpinioideae	NE
Detarium microcarpum Guill. & Perr.	Combretaceae	LC

Diospyros mespiliformis Hochst.ex ADC	Ebenaceae	NE
Eucalyptus camaldulensis Dehn	Myrtaceae	NE
Ficus thonningii Blume	Moraceae	NE
Ficus sycomorus (Miquel) C.C.Berg	Moraceae	NE
Isoberlinia doka Craib & Stapf	Caesalpinioideae	LC
Khaya senegalensis A. Juss	Meliaceae	VU
Lannea microcarpa Engl. & K. Krause	Anacardiaceae	NE
Mangifera indica L.	Anacardiaceae	DD
Moringa oleifera	Moringaceae	NE
Parkia biglobosa (Jacq.) R.Br. ExG.Don.	Mimosoideae	NE
Piliostigma thonningii Milne-Redh.	Caesalpinioideae	NE
Pterocarpus erinaceus Lam.	Caesalpinioideae	NE
Sclerocarya birrea Hochst.	Anacardiaceae	NE
Tamarindus indica L.	Caesalpinioideae	NE
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae	VU
Ziziphus mauritiana Lam.	Rhamnaceae	NE

Extinct (EX), Extinct in the wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least concern (LC), Data Deficient (DD) and Not Evaluated (NE)

Appendix 2: Use-value results of the 30 selected plant species

Use categories		Food	Fodder	Wood fuel	Medicine	Income	Construction	Craft	Others	Total Uses	Use-values
Parkia biglobosa (N=48)		2.77	1.11	1.22	3.25	1.68	0.88	0.86	2.09	13.86	0.29
Tamarindus indica (N=48)		1.00	0.50	1.00	3.28	0.99	0.92	0.76	1.48	9.93	0.21
Vitellaria paradoxa (N=48)		3.88	1.25	1.19	3.48	1.15	0.91	0.75	1.96	14.55	0.30
Detarium microcarpum (N=48)		2.14	0.30	0.97	1.53	1.08	1.04	1.40	0.97	9.43	0.20
Adansonia digitata (N=48)		3.45	1.44	1.38	3.65	1.32	1.15	1.18	2.36	15.92	0.33
Afzelia Africana (N=48)		0.77	0.95	0.75	2.82	1.39	1.67	2.41	1.48	12.23	0.25
Azadirachta indica (N=48)		1.93	0.42	0.92	2.88	0.75	1.86	1.70	1.33	11.78	0.25
Anacardium occidentale (N=48)		1.79	0.31	0.75	2.72	0.67	0.41	1.11	1.07	8.83	0.18
Acacia seyal (N=48)		0.00	0.80	0.67	2.65	0.00	1.34	0.96	1.01	7.43	0.15
Balanite aegyptiaca (N=48)		2.51	1.53	1.17	2.30	0.67	1.05	2.67	1.69	13.58	0.28
Ficus sycomorus (N=48)		2.10	0.63	0.83	3.35	1.08	0.85	2.29	1.30	12.45	0.26
Annona senegalensis (N=48)		1.17	0.31	0.75	3.28	0.00	0.34	0.82	1.58	8.26	0.17
Eucalyptus camaldulensis (N=48)		0.31	0.01	1.00	1.53	0.83	1.82	0.59	1.17	7.27	0.15
Ficus thonningii (N=48)		0.50	0.31	0.67	2.73	0.00	0.79	1.57	1.67	8.24	0.17
Bombax costatum (N=48)		1.39	0.30	0.50	1.94	0.52	0.18	1.08	1.52	7.43	0.15
Acacia macrostachya (N=48)		0.75	0.77	0.68	1.19	0.00	0.40	0.49	0.81	5.08	0.11
Moringa oleifera (N=48)		1.67	0.50	0.26	2.89	0.75	0.00	0.00	0.95	7.01	0.15
Isoberlina doka (N=48)		0.75	0.30	1.00	1.19	0.30	0.00	0.00	0.92	4.46	0.09
Daniellia olivera (N=48)		1.11	0.50	1.00	3.46	0.69	0.91	1.55	1.32	10.54	0.22
Diospyros mespiliformis (N=48)		1.49	0.28	0.75	3.18	1.27	1.83	2.16	1.11	12.07	0.25
Combretum micranthum (N=48)		0.78	0.00	0.00	1.31	0.75	1.42	1.81	0.97	7.04	0.15
Mangifera indica (N=48)		0.50	0.50	1.15	1.85	0.50	0.67	0.91	1.23	7.30	0.15
Piliostigma thonningii (N=48)		0.92	0.28	0.75	1.89	0.25	0.60	1.82	1.60	8.11	0.17
Pterocarpus erinaceus (N=48)		0.81	0.80	0.78	2.21	0.28	2.14	1.48	1.13	9.63	0.20
Anogeissus leiocarpus (N=48)		0.01	0.30	0.75	1.73	0.00	0.75	1.07	0.58	5.20	0.11
Burkea Africana (N=48)		0.00	0.08	1.00	0.59	0.08	0.58	0.60	0.81	3.76	0.08
Khaya senegalensis (N=48)		0.00	0.28	0.50	2.79	0.00	1.77	1.42	1.81	8.57	0.18
Lannea microcarpa (N=48)		1.33	0.94	1.00	2.67	0.75	0.77	1.19	1.81	10.46	0.22
Ziziphus mauritiana (N=48)		1.92	0.21	0.40	1.14	0.00	0.40	1.72	1.24	7.01	0.15
Sclerocarya birrea (N=48)		1.10	0.94	0.00	2.33	0.00	0.89	1.24	1.33	7.83	0.16
Total (N=1440)		1.29	0.56	0.79	2.39	0.59	0.94	1.25	1.34	9.18	0.19
One-way ANOVA test with either equal or unequal variance	F	130.47	112.61	75.38	30.11	96.31	49.78	31.8	13.77	30.23	30.23
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Appendix 3: Differences in local knowledge (Use-value) of all species among Gender, Ethnicity, Age groups, and study Villages

Dependent variable		Freq.	Mean	F [1]	Prob. [1]
Gender as factor 1					
Use-value[#]	Female	720	0.17086227	60.19	0.0000
	Male	720	0.21145833		
	Total	1440	0.1911603		
Ethnicity as factor 2					
Use-value	Fulani	360	0.19302662	7.37	0.0007
	Gourounsi	540	0.20225694		
	Mossi	540	0.17881944		
	Total	1440	0.1911603		
Age as factor 3					
Use-value[#]	20-40 years	510	0.14279003	126.92	0.0000
	41-60 years	570	0.20184576		
	61-80 years	360	0.2427662		
	Total	1440	0.1911603		
Study Villages as factor 4					
Use-value	Cassou	360	0.16857639	41.08	0.0000
	Dao	540	0.17604167		
	Kou	540	0.22133488		
	Total	1440	0.1911603		

Notes:
[1] One-way ANOVA test of variable "UV" with either equal or unequal variances
[#] Variable violates the Bartlett's test (Homogeneity of variances): assumption of homogeneity of variance is not met.

Appendix 4: Multiple comparison Scheffe tests for variable "UV" among, Ethnicity, study Villages, and Age groups

Dependent Variable & Factors' modalities			Mean Difference (I-J)	Sig.
Use-value & Gender	Male	Female	0.040596	0.000
Use-value & Ethnicity	Mossi	Gourounsi	-0.023438	0.001
	Fulani	Gourounsi	-0.00923	0.405
	Fulani	Mossi	0.014207	0.118
Use-value & Location	Dao	Cassou	0.007465	0.539
	Kou	Cassou	0.052758	0.000
	Kou	Dao	0.045293	0.000
Use-value & Age	41-60 years old	20-40 years old	0.059056	0.000
	61-80 years old	20-40 years old	0.099976	0.000
	61-80 years old	41-60 years old	0.04092	0.000

Multiple comparison Games &Howell test for variable "UV" among Age groups and Gender

	UV	Diff.	Std.Err	t	adj. P>t
Age	Group 2 vs Group 1	0.0590557	0.0054751	10.79	0.000
	Group 3 vs Group 1	0.0999762	0.0065191	15.34	0.000
	Group 3 vs Group 2	0.0409204	0.0067089	6.1	0.000
Gender	Not applicable (only 2 levels)				

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