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Ethnobotanical knowledge of home garden plant species and its effect on home garden plant diversity in Thies region of Senegal

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Abstract
Home gardens are the first source of immediate contact between people and plants since the gardens are within homesteads. Most home garden studies in Senegal concentrate on food security and economic benefits; no research has been carried out on the social and ecological contexts of home gardening in Senegal. It is therefore necessary to evaluate the way people interact with the home garden plants and how such an interface influences plant diversity. The objective of this study is to evaluate the ethnobotanical knowledge associated to home garden plants and its effect on plant diversity conservation in home gardens. A sample of 30 home gardens was selected from the three main departments of the region and was used to collect plant species data. Data were collected from informants who were selected basing on recommendations from village leaders. Techniques used were plant inventory, participatory observations and individual interviews. Species nomenclature was based on Senegal analytical flora and the world plant list; comparison of effect between different variables was analyzed in analytical software R using simple linear regression analysis. A total of 96 plant species were identified; all species were found to be useful plants divided into eight functional groups. Fifty-four percent (54%) were food species, 40% medicinal, 32% ornamental, 14% commercial, 7% fodder, 4% sacred, 4% ceremonial and 3% cosmetic. *Citrus limon* was the most frequent (80%) and preferred species in the home gardens. Food plant species are the most diversified, abundant and rich use category. There is a relationship between uses of species and species diversity (P value < 0.001). Species diversity in the home gardens increases as the spectrum of use increases; thus, species with more than one use were highly diversified; people prefer multipurpose species for multiple benefits. This study expresses home gardens as diversified agroecosystems for sustainable biodiversity conservation of useful plant species.

Keywords Functional plant groups · Home gardens · Plant species diversity · Sustainable biodiversity conservation

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1 Introduction

Ethnobotany is the systematic understanding of the relationships between plants and people (Keniger et al. 2013). People cannot survive without the existence of plants since they are the main producers in the food supply chain, and also people rely on plants for multiple values such as clothes, medicine, shelter among others (Freeman et al. 2012; Buchmann 2009). Different values are attributed to different plant species in different communities. Home gardens are one of the most important study areas for ethnobotanists because they are the first source of immediate contact between people and plants since the gardens are within homesteads. It is therefore easy to evaluate the relationship between people and the plants in the home gardens. As farmers adopt more of intensive farming systems, the diversity of plant species in agriculture fields decreases (Scales and Marsden 2008; Kumar and Nair 2004). This acts as a threat to plant diversity and creates need for intensive research on better agriculture systems which can meet the needs of the gardener as well as ensuring environmental sustainability through conservation of biological diversity besides providing other ecosystem functions.

In many countries, home gardens provide multiple goods to the people (Reta 2016; Keller 2010; Buchmann 2009). Home gardens consist of multiple plant growth habits (trees, shrubs and herbaceous), growing in or adjacent to a homestead (Nair 2006). The effect of cultural, economic and social values on plant composition and diversity in home gardens has received little attention (Schneider 2010; Eyzaguirre 2006; Perales and Brush 2005; Alexiades and Wood 2002), yet it is mostly the cultural, social and economic values which people associate to different plant species that can explain the differences in species composition among home gardens. Houses with a surrounding garden are a rare feature in Senegal, and it is only common in the agriculture regions; this is because of the semi-desert climatic conditions that hinder plant growth, and it is only the agricultural regions which receive moderate rainfall that can support plant growth and development (Sene et al. 2019). In Senegal, only a few ornamental plants can be found in the homes and mostly in urban areas (Birane et al. 2019). The use of home garden plants in other countries has been studied by many authors (Bill et al. 2019; Gray et al. 2014; Calvet-Mir et al. 2012; Freeman et al. 2012; Frison et al. 2011; Keller 2010), but little information is available about home gardens in Senegal and the few home garden studies in Senegal concentrate on only food security and economic benefits (Maillard 2018; Sposito 2010; Ba and Ba 2007; Marek et al. 1990; Brun et al.1989), no information is available about the interaction of people with the home garden plants. This study evaluated the ethnobotanical knowledge associated to home garden plants and its effect on plant diversity conservation in home gardens.

2 Materials and methods

This study was conducted in Thies, one of the 14 administrative regions of Senegal, a semi desert West African country, bordered by the Atlantic Ocean. Thies region is located in the western part 70 km from the capital Dakar (ANSD 2009). It lies between latitude 14°50′03″ North and longitude 17°06′21″ West and covers an area of 6,601 km^2. It is bordered by Louga region in the north, Fatick region in the south, Diourbel region in the East and Dakar the capital in the West. The climate of the region is subjected to the influence of the maritime trade winds and the harmattan. The rainfall record shows a rainfall that runs

from June to November. The average rainfall ranges from about 300 to 800 mm (ANSD 2018). Thies region is divided into three main departments that is Tivaoune, Mbour and Thies (Fig. 1). The study was conducted from June 2019 to January 2020; the period

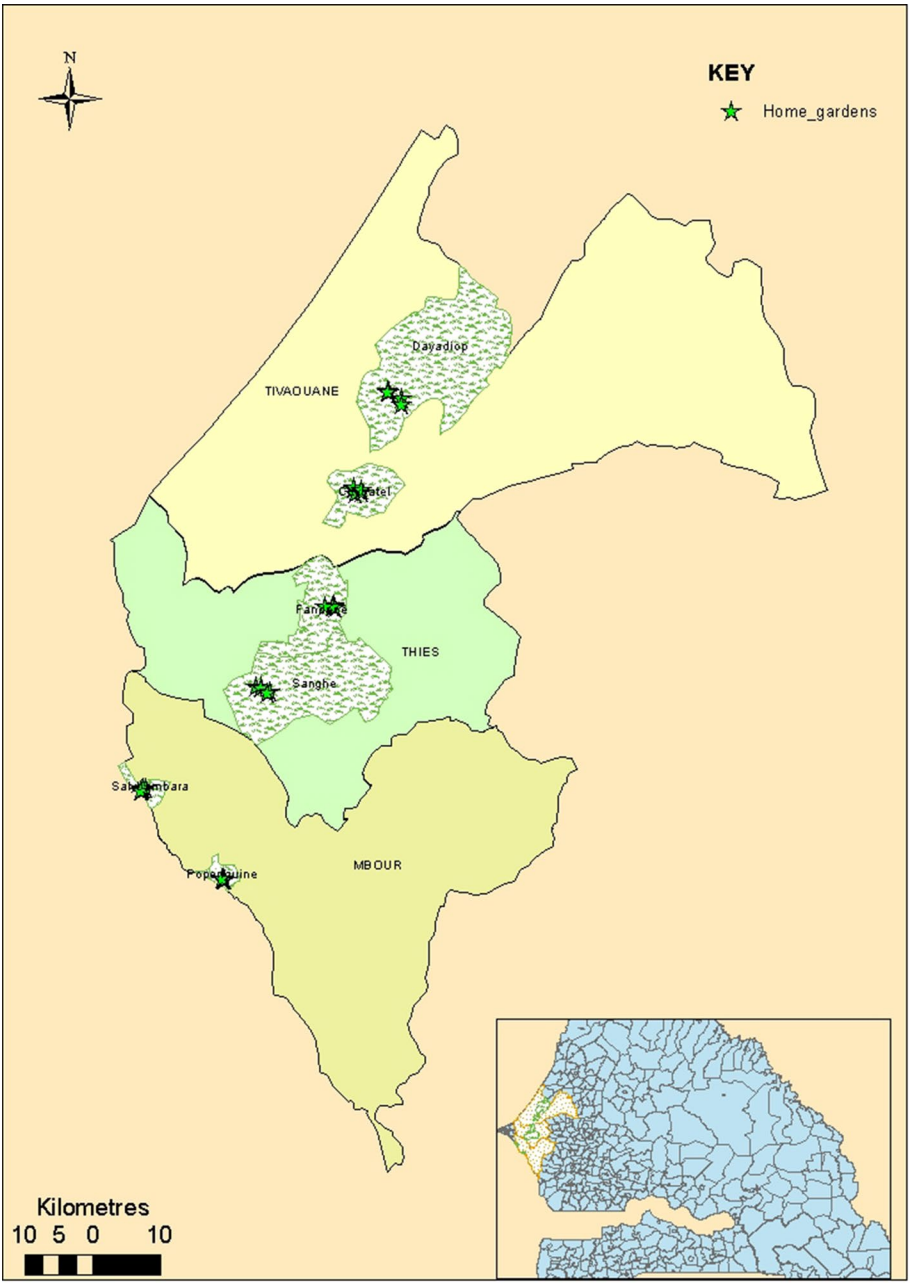

Fig. 1 Map of Thies region showing sampled home gardens

chosen was adequate for evaluating the effect of ethnobotanical knowledge on plant conservation in the home gardens of Thies region.

The methodology of sampling for data collection included plant inventories to identify the plant species in the home gardens, participatory observations and individual interviews to assess the ethnobotanical knowledge attached to the plant species. The sampling design for selecting villages and respondents was based on a non-probability approach, and a snowball sampling technique (Waldorf and Biernacki 1981) was applied at multiple stages for selecting villages and respondents. In the first step, the person responsible for agriculture production in the entire region was contacted at the regional DRDR (Directions Régionales de Développement Rural) to identify and get contact information for the agriculture responsible persons in each department. Thereafter, the responsible person in each department identified two villages which are actively involved in home gardening (villages with the highest percentage of home gardening activities) of which the village leaders were contacted to identify households with home gardens. The choice of home gardens was based on size (biggest) and species diversity (at least 5 species); gardens were chosen with the help of gardeners who would give reference on the next garden basing on the above main factors. The distance between home gardens was at a minimum of 100 m to avoid collection of overwrapped data. Samples of five (5) home gardens were selected in each village. This gives a total of 10 home gardens in each department and 30 home gardens for the entire region.

For each home garden visited, the details of the gardener were recorded such as age, gender, religious affiliation, ethnicity among others. The names of the observed species were recorded as given by the gardener in either the local language or French, and it was recorded exactly as stated by the gardener in order to reduce the risk of misinterpreting the informant's statements. Whenever the respondent did not name a particular plant, a blank space would be left for the vernacular name. The gardener was interviewed using a questionnaire with both open and closed questions. Closed questions were used on information with limited responses required, and open-ended questions were applied where in-depth views were required and to questions with divergent views. The questionnaire was pretested and reviewed by the researcher and supervisor before being administered to the respondents.

Species nomenclature was based on Senegal analytical flora (Berhaut 1967) and the world plant list (Kalwij 2012). Comparison of effect between different variables was analyzed in analytical software R (R Core Team 2019) using simple linear regression analysis at 5% level of significance.

3 Results

3.1 Demographic characteristics of the respondents

Thies is a multi-ethnic region; during the study five ethnic groups were recorded in the area, and all were involved in the study as active respondents. The study population was dominated by the Serere with the highest percentage score of 60%, followed by Wolof 20%, Peul 13% and the least being Bambara and Diola each with 3%. All the gardeners were found to be belonging to a particular religious group that is, 77% Muslim and 23% Christians. The highest number of Christians was found in the department of Thies unlike Tivaoune and Mbour. The gardeners were 73% men and 27% women, with the age ranging from 23 to 70 years and the average age of 45 years. Among all the gardeners, 63% were

able to acquire formal education at different levels of instruction; thus, 23% had primary education, 40% at college & higher levels, and 37% were illiterate.

3.2 Effect of gardener's age on home garden species diversity

This study indicates that the effect of gardeners age on number of plant species in the garden is not statistically significant (P value = 0.068); diversified gardens can belong to old or young gardeners irrespective of the age. However, there is a positive correlation between age of the gardener and number of species in the home garden. The more diversified gardens belonged to gardeners above the age of 30 (Fig. 2).

3.3 Major use categories of Home garden plant species

A total of 96 plant species were recorded in the home gardens of Thies region; of these 54 have already been cited in the Senegal flora while the other 42 have not been listed and could have been introduced to Senegal (exotic species). All the recorded home garden plants were useful species identified and placed into eight use categories (Table1). From these use categories, 52 (54%) were food species, 38 (40%) medicinal, 31 (32%) ornamental, 13 (14%) commercial, 7 (7%) fodder, sacred and ceremonial having an equal number of species 4(4%) and 3 (3%) cosmetic species (Fig. 3). In this case, plant species with more than one use value have been recounted under each use category. Despite the low diversity of the sacred plant species (*Calotropis procera, Catharanthus roseus*, *Phoenix dactylifera*, *Borassus akeassii*), they are highly treasured, and the respondents could willingly provide only limited information on these species and strict restrictions on getting in contact with these plants more so those considered as sources of blessings (*Phoenix dactylifera*, *Borassus akeassii, Catharanthus roseus*).

3.4 Most important species in each department

Citrus limon was the most important species in most of the home gardens with the highest percentage of preference in all the three departments (Table 2). In the department of Tivaoune,

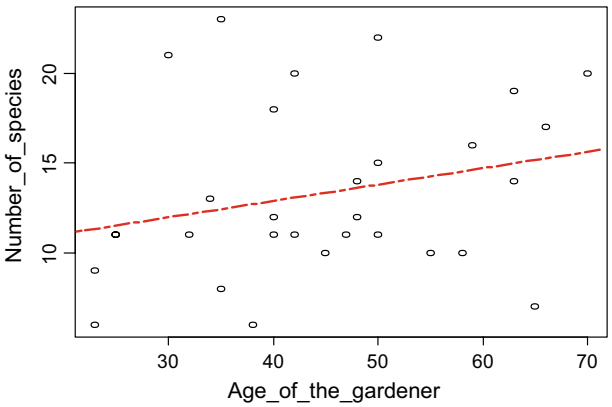

Fig. 2 Effect of gardener's age on number of species in the garden

Table 1 Major use categories of home garden plant species

Family	Species	Uses mentioned	% Freq
Amaryllidaceae	*Hippeastrum andreanum* Baker	Orn	3
Anacardiaceae	*Anacardium occidentale* L	Fd,Md	7
Anacardiaceae	*Mangifera indica* L	Fd,Md,Cm	73
Annonaceae	*Annona muricata* L	Fd,Md	1
Annonaceae	*Annona squamosa* L	Fd,Md	30
Apocynaceae	*Calotropis procera (Aiton) W. T. Aiton*	Md,Sc	23
Apocynaceae	*Catharanthus roseus (L.) G. Don*	Orn,Sc	23
Apocynaceae	*Plumeria pudica* Jacq	Orn	10
Araceae	*Caladium bicolor* (Aiton) Vent	Orn	3
Araliaceae	*Polyscias balfouriana* (André) L.H.Bailey	Orn	10
Arecaceae	*Borassus akeassii* Bayton, Ouédr. & Guinko	Fd,Md,Cm,Cr,Sc	3
Arecaceae	*Cocos nucifera* L	Fd,Md	20
Arecaceae	*Phoenix dactylifera* L	Fd,Sc	13
Arecaceae	*Roystonea regia* (Kunth) O.F.Cook	Orn	3
Asparagaceae	*Asparagus aethiopicus* L	Orn	3
Asparagaceae	*Beaucarnea recurvata* Lem	Orn	3
Asparagaceae	*Sansevieria trifasciata* Prain	Md,Orn	17
Asparagaceae	*Yucca aloifolia* L	Orn	3
Asphodelaceae	*Aloe vera (L.) Burm.f*	Md,Cos	27
Asteraceae	*Lactuca sativa* L	Fd	3
Asteraceae	*Sphagneticola trilobata* (L.) Pruski	Orn	3
Bignoniaceae	*Kigelia africana* (Lam.) Benth	Fd,Md	3
Bignoniaceae	*Stereospermum kunthianum* Cham	Md	3
Boraginaceae	*Cordia sebestena* L	Orn	13
Cactaceae	*Cactus acanthophlegmus* (Lehm.) Kuntze	Orn	3
Caricaceae	*Carica papaya* L	Fd,Md	40
Combretaceae	*Combretum micranthum* G.Don	Fd,Md	3
Combretaceae	*Terminalia catappa* L	Fd	10
Combretaceae	*Terminalia mantaly* H.Perrier	Orn,Fdr	10
Convolvulaceae	*Convolvulus tricolor* L	Md,Orn	7
Convolvulaceae	*Ipomoea batatas* (L.) Lam	Fd	3
Cucurbitaceae	*Citrullus lanatus (Thumb)*	Fd	3
Cucurbitaceae	*Cucumis melo* L	Fd	3
Cucurbitaceae	*Cucurbita maxima* Duchesne	Fd,Cm	17
Cucurbitaceae	*Lagenaria siceraria* (Molina) Standl	Fd,Md,Cm	13
Cycadaceae	*Cycas revoluta* Thunb	Orn	7
Euphorbiaceae	*Codiaeum variegatum* (L.) Rumph. ex A.Juss	Orn	7
Euphorbiaceae	*Euphorbia milii* Des Moul	Orn	13
Euphorbiaceae	*Euphorbia tithymaloides* L	Orn	7
Euphorbiaceae	*Jatropha curcas* L	Md	7
Euphorbiaceae	*Manihot esculenta* Crantz	Fd	10
Euphorbiaceae	*Ricinus communis* L	Cr,Orn	7
Fabaceae	*Arachis hypogaea* L	Fd	3
Fabaceae	*Caesalpinia pulcherrima* (L.) Sw	Orn	3

Table 1 (continued)

Family	Species	Uses mentioned	% Freq
Fabaceae	Cordyla pinnata (Lepr. ex A. Rich.) Milne-Redh	Fd	3
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	Fdr	3
Fabaceae	*Parkinsonia aculeata* L	Orn	3
Fabaceae	*Prosopis glandulosa Torr*	Md,Cm,Fdr	10
Fabaceae	Senna occidentalis (L.) Link	Md,Cr	13
Fabaceae	*Tamarindus indica* L	Fd	3
Fabaceae	*Vigna unguiculata (L.) Walp*	Fd,Cm,Fdr	20
Lamiaceae	*Gmelina arborea Roxb*	Md	7
Lamiaceae	*Mentha alaica* Boriss	Orn	10
Lamiaceae	*Ocimum basilicum* L	Fd,Md	27
Lamiaceae	*Volkameria inermis* L	Orn	3
Lauraceae	*Persea americana* Mill	Fd	7
Lythraceae	*Lawsonia inermis* L	Cos,Orn	7
Lythraceae	*Punica granatum* L	Fd,Md	23
Malvaceae	*Abelmoschus esculentus (L.) Moench*	Fd,Md,Cm	27
Malvaceae	*Adansonia digitata* L	Fd	7
Malvaceae	*Cola nitida (Vent.) Schott & Endl*	Fd,Md	3
Malvaceae	*Gossypium barbadense L*	Md,Cr,Cos	7
Malvaceae	*Grewia damine* Gaertn	Fd,Md	3
Malvaceae	*Hibiscus sabdariffa L*	Fd,Md,Cm	50
Meliaceae	*Azadirachta indica* A.Juss	Fdr,Md	20
Moraceae	*Ficus retusa L*	Fdr,Orn	3
Moraceae	*Ficus vogeliana* (Miq.) Miq	Fdr	7
Moringaceae	*Moringa oleifera* Lam	Fd,Md,Cm	50
Musaceae	*Musa acuminata* Colla	Fd,Md	33
Myrtaceae	*Eucalyptus alba* Reinw. ex Blume	Md	3
Myrtaceae	*Psidium guajava* L	Fd,Md	33
Myrtaceae	*Syzygium guineense* (Willd.) DC	Fd	3
Nyctaginaceae	*Bougainvillea glabra* Choisy	Orn	7
Nyctaginaceae	*Bougainvillea spectabilis* Willd	Orn	3
Oleaceae	*Olea europaea* L	Fd	3
Pandanaceae	*Pandanus utilis* Bory	Orn	7
Passifloraceae	*Passiflora edulis* Sims	Fd	3
Pedaliaceae	*Ceratotheca sesamoides* Endl	Fd	3
Pedaliaceae	*Rogeria adenophylla* J.Gay ex Delile	Md	3
Phyllanthaceae	*Phyllanthus acidus* (L.) Skeels	Fd,Orn	10
Poaceae	*Andropogon abyssinicus* R.Br. ex Fresen	Orn	3
Poaceae	*Cymbopogon citratus* (DC.) Stapf	Fd,Md	3
Poaceae	*Sorghum bicolor* (L.) Moench	Fd	3
Poaceae	*Zea mays* L	Fd	3
Polygonaceae	*Coccoloba uvifera* (L.) L	Fd	3
Rhamnaceae	*Ziziphus jujuba* Mill	Fd,Md,Cm	23
Rutaceae	*Citrus*×*aurantium* L	Fd,Md	23
Rutaceae	*Citrus limon* (L.) Osbeck	Fd,Md,Cm	80

Table 1 (continued)

Family	Species	Uses mentioned	% Freq
Rutaceae	*Citrus maxima* (Burm.) Merr	Fd,Md	20
Rutaceae	*Citrus reticulata* Blanco	Fd	27
Sapindaceae	*Lepisanthes senegalensis* (Poir.) Leenh	Fd	3
Sapotaceae	*Manilkara zapota* (L.) P.Royen	Fd	17
Solanaceae	*Capsicum annuum L*	Fd,Md,Cm,	27
Solanaceae	*Solanum lycopersicum* L	Fd,Cm	50
Solanaceae	*Solanum melongena* L	Fd	7
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	Fd	10

Fd food, *Fdr* fodder, *Orn* ornamental, *Md* medicinal, *Sc* sacred, *Cm* commercial, *Cr* ceremonial, *Cos* cosmetics

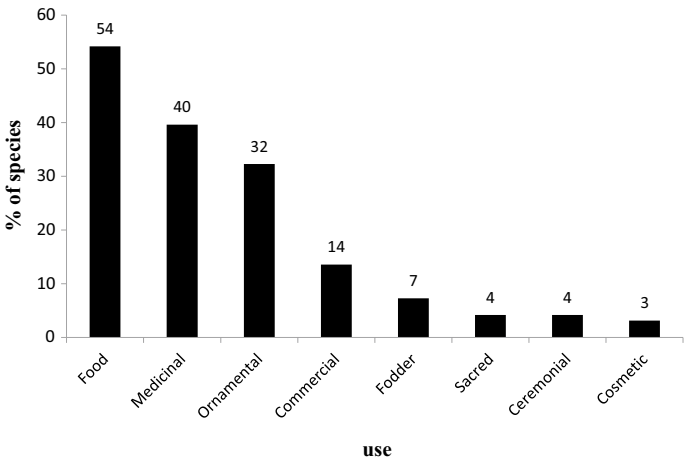

Fig. 3 Functional groups of home garden plant species

Table 2 The ten most important species in each department

MBOUR	% preference	TIVAOUANE	% preference	THIES	% preference
Citrus limon	80	*Citrus limon*	90	*Citrus limon*	90
Mangifera indica	70	*Annona muricata*	90	*Hibiscus sabdariffa*	80
Annona muricata	70	*Mangifera indica*	70	*Mangifera indica*	60
Moringa oleifera	50	*Solanum lycopersicum*	50	*Moringa oleifera*	60
Hibiscus sabdariffa	40	*Citrus reticulata*	50	*Aloe vera*	50
Punica granatum	40	*Musa acuminata*	50	*Annona muricata*	50
Aloe vera	40	*Moringa oleifera*	40	*Abelmoschus esculentus*	50
Psidium guajava	40	*Citrus maxima*	40	*Carica papaya*	40
Cocos nucifera	40	*Ocimum basilicum*	40	*Psidium guajava*	40
Ocimum basilicum	40	*Carica papaya*	40	*Annona squamosa*	40

Annona muricata was as well highly preferred as *Citrus limon,* both having the same level of preference. All the species said to be very important to the gardeners are food species.

3.5 Effect of plant uses on plant diversity

There is a relationship between uses of species and species diversity (P value < 0.001) in the home gardens. Multipurpose species have a very high frequency compared to species with one or two uses (Fig. 4). Species with multiple uses were *Borassus akeassii*, *Capsicum annuum*, *Vigna unguiculata*, *Prosopis glandulosa*, *Hibiscus sabdariffa*, *Abelmoschus esculentus*, G*ossypium barbadense*, *Citrus limon, Moringa oleifera*, *Mangifera indica*, *Lagenaria siceraria*, and *Ziziphus jujuba*. *Borassus akeassii* had the highest number of uses (5) but with a low frequency. The coefficient of correlation indicates that every single increase in the number of uses of a species increases the species frequency (coefficient = 1.005).

4 Discussion

4.1 Ethnobotanical knowledge associated to home garden plants

The results indicate that the studied home gardens are managed by men and women. Thus, there is sharing of responsibility which is important because sufficient labor is made available to conduct the home garden activities. This is contrary to most home garden studies that present home gardens to be managed by women, (Larios et al. 2013; Gray et al. 2014; Zemede 2004; Oakley 2004; Howard 2006). The most useful plant species in the home gardens of Thies region were food plants followed by medicinal plants. Food plant species are the most diversified, abundant and rich use category. This shows that most households in this region largely depend on home gardens for food. Thus they grow plants which can meet their basic needs; this can help to reduce on the daily food expenses since it can simply be produced in the home compound, and this promotes home gardening in the region. These results are in line with (Kebebew 2018) who presents edible plants as the most cultivated plants in home gardens. All the medicinal plants recorded were for treating human ailments; therefore, home gardens at a large extent can supply people with food

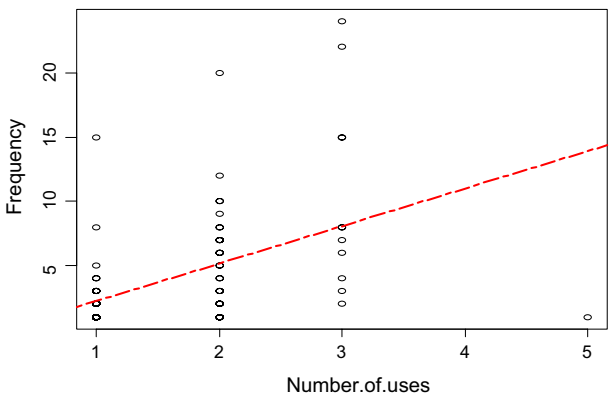

Fig. 4 The effect of species uses on species diversity

and medicine. This is explained in the study findings of (Camara et al. 2018; Tappan et al. 2000; Ilboudo 1992) which present Plant resources as a basis of man's survival in most of the regions of Senegal and other studies which have expressed home gardens as a solution to food insecurity (Sposito 2010; Blanckaert et al. 2004; Brun et al. 1989). This study explains that home gardens are a source of multiple values to the gardener.

4.2 Effect of ethnobotanical knowledge on plant species diversity in the home gardens

The results of the study indicate that the effect of gardener's age on the number of species in the garden is not statistically significant; thus, even younger gardeners could also have more diversified gardens irrespective of the age. Species with more than one use were highly diversified; therefore, gardeners grow more of species with multiple benefits to meet their needs. *Borassus akeassii* had the highest number of uses 5(63%) but with a low frequency, and this was linked to the inability of the gardeners to purchase its planting material since it is expensive and cannot easily be got through seed sharing among households; this is evidenced by the study findings of (Guarino and Hoogendijk 2004) which explain that plant species whose planting materials are easily shared among households are more diversified in home gardens. *Citrus limon* is a multipurpose species, and the study results indicate that it is the most preferred species in the region. This is believed to be a contributing factor to its high diversity in each department and the entire region at large (80% regional percentage frequency). Each species recorded in the home gardens was at least of a specific use to the gardener, and the mostly preferred species (food species) are among the diversified species in the region; therefore, home garden plant diversity conservation can be effective basically with useful plant species. This is in line with various studies which have expressed home gardens as multi-functional farming systems (Jana and Roy 2020; Shukla et al. 2017; Calvet-Mir et al. 2012; Kim et al. 2016; Dey et al. 2014; Mattsson et al. 2015); this study confirms home gardens as a resource for conservation of useful plant species more so edible plants since the most diversified species are multipurpose species and the most diversified functional group is that of food species.

5 Conclusion

This study indicates that home gardens are diversified agroecosystems for conservation of useful plant species. Home gardens equally contributes to community health improvement through the use of herbal medicine and also contribute to the household income through savings from food and medical expenses as well as selling the surplus yield from the home gardens. Multipurpose species are the most preferred species in the home gardens because they provide multiple benefits to the gardener. Home garden plant diversity is influenced by socioeconomic factors according the use of the species in local people's subsistence. This study recommends that spaces around homes despite their sizes should be used for gardening in order to promote sustainable ecosystem functioning through the human plant interaction; this will promote plant diversity conservation in the human environment as well as contribute to food production, thus enhancing food security which is a major challenge in Senegal and in many developing countries.

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Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to declare.

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