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Woody species composition and diversity in homegardens in Bekoji town, Southeast Ethiopia

Dejene Nigatu Beyene[1]* and Debela Hunde[2]

[1]Natural Resource Management Department, College of Agriculture and Natural Resource, Mada Walabu University, Ethiopia.
[2]Natural Resource Management Department, College of Agriculture and Veterinary Science, Jimma University, Ethiopia.

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This study assessed the role of urban homegardens in woody species conservation in Bekoji town, southeast Ethiopia. Ninety-six homegardens were identified using multistage sampling technique. Woody species inventory was made in 3103 m × 10 m quadrants. Shannon and Weaver diversity index (H`), reciprocal of Simpson diversity index (1-D), evenness index (J`) and Margalef richness index (Dmg) were computed to determine alpha diversity. Homegardens' and their owners' characteristics were characterized using semi-structured questionnaire. Multivariate linear regression analysis was used to test associations between the attributes and diversity indices. Thirty families containing 49 woody species were identified. Fabaceae, Rosaceae, and Myrtaceae were the most abundant family. *Eucalyptus globules* and *Cupressus lusitanica* were dominant exotic species. *Vernonia amygdalina*, *Brucea antidysenterica*, *Olea europaea* and *Lippia abyssinica* were most abundant native species. The value of H`, J`, Dmg and 1-D were 1.60, 0.80, 2.11 and 0.94, respectively. Woody species diversity in homegardens positively associated with age and area of homegardens. These results imply magnificent contribution of old and large homegardens in conservation of woody species specifically natives. Therefore, management decisions on reducing dominancy of exotic species through seedlings supply and encouraging homegarden owners to plant multipurpose native species are important to maintain species diversity.

Key words: Urban ecosystem, woody species, native species, species diversity, urban forest.

INTRODUCTION

Homegardens play crucial role in conservation of biodiversity in both urban and rural landscapes. Urban homegardens are dominated by diverse native and introduced trees and shrubs species that substantially contribute to species diversity (Goddard et al., 2010; Nielsen et al., 2014). They also conserve genetic materials of native plant species (Kumar and Nair, 2004) and endangered and vulnerable plant species (Akinnifesi et al., 2010; Schmidt et al., 2014), and serve as experimental areas for new species (Smith et al., 2013). On the contrary, other studies report habitat loss and local loss or low level of native biodiversity due to increasing urbanization (Knapp et al., 2010; Lin and Fuller, 2013; Ávila et al., 2017), and dominance of

*Corresponding author. E-mail: dwude2018@gmail.com. Tel: +251911642793.

nonnative species (Ávila et al., 2017) in urban areas. However, few studies have justified this ambiguity.

Inventory of biodiversity in different ecosystems and land uses resolves such ambiguity and ensures sustainable uses of bioresources. Article 7(a) of the Convention on Biological Diversity also encourages countries to identify components of biological diversity for its conservation and sustainable use (United Nations, 1992). In support of this, various studies conducted species inventory in homegardens in different part of the world. For instance, Sperling and Lortie (2010) conducted plant species inventory in backyard garden in Toronto. In tropical country, different studies identified plant species in urban homegardens (Winkler Prins, 2002; González-García and Sal, 2008). In Ethiopia, previous studies assessed plant species (Habtamu and Zemede, 2011, Mekonnen et al., 2014, Mengistu and Alemayehu, 2017), and woody species (Amberber et al., 2014) in homegardens. Though homegardens are common in urban areas, there is scarcity of information about the role of urban homegardens in small towns in biodiversity conservation. Scholars also noticed that the diversity of plant species significantly vary among location and societal groups since the choice and conservation of plants species depends upon the personal preference, benefits of the plants, diversity of cultural and socioeconomic characteristics of the people who manage gardens (Blanckaert et al., 2004; Eichemberg et al., 2009; van Heezik et al., 2014). Moreover, the greater prevalence of human interferences in urban areas contributes for woody species introductions and prevalence of non-native species in urban homegardens. Therefore, it can be hypothesized that greater woody species diversity exists in urban homegardens, with a greater number of non-native species as compared to native species. However, there is no scientific evidence that justifies this assumption in urban landscapes. Thus, this study aimed to assess woody species composition and diversity in Bekoji town, Oromia National Regional State, southeast Ethiopia. Specifically, the study aimed to (1) assess composition and diversity of woody species conserved in homegardens, (2) assess the contribution of urban homegardens in conservation of native woody species, and (3) identify socioeconomic factors and homegardens characteristics that associate with woody species diversity in the study area.

MATERIALS AND METHODS

Description of the study area

This study was conducted in Bekoji town, Limu Bilbilo district, Arsi zone, Oromia National Regional State, Ethiopia (Figure 1). The town is located between 7° 32' 24'' - 7° 34' 28'' N and 39° 13' 15'' - 39° 19' 02'' E. The town has two kebeles (administration hierarchy next to municipality) in which each is classified into three zones and nine Gots. The town is established on 3409 ha of land with elevation ranges from 2370 to 2660 masl. Most parts of Bekoji town, including the central, southern, eastern and western parts, are characterized by flat to gently sloping topography, while the northern parts of the town is characterized by hilly landscape which include “forteno hill”.

The climate in Bekoji town is traditionally categorized as dega (temperate) with mean annual temperature of 14°C. The town receives bimodal rainfall during the spring (Belg) and summer (Meher) with mean annual rainfall of around 1090 mm (Assen and Yilma, 2010). The main rainy season occurs from June to October while the other occurs from March to May. Major soil types are Nitisols (*“Biyyee diimaa”* in “Afan Oromo”), Vertisols and Umbrisols (Assen and Yilma, 2010). The original vegetation in the study area is characterized by green areas, which include roadside plantation, homegardens, trees in institutional compounds and small-scale plantations.

The total population of Bekoji town was 17,7419 of which males were 8,831 and females were 8,910 in the year 2007 (CSA, 2007). The population in the town was projected to be 19 876 in 2017 by Bekoji town municipality. The main economic activities of the population in the town are employment, commerce, agriculture and small-scale manufacturing enterprises (Bekoji Town Municipality Report, 2018).

Study designs

In this study, household based cross-sectional study design was used to address the objectives of this study. The study population of this study is the homegardens, which encompass woody plant species in Bekoji town. While the target population were homegardens established on privately owned landholdings managed by households in the town.

Sampling techniques

First, reconnaissance survey was made to study the nature, distribution and woody plant species composition of homegardens in Bekoji town. Household heads were used as sampling frame to conduct woody species inventory at homegarden level and to identify factors associated with woody species diversity in homegardens. The number of sample households was determined by using the formula of Kothari (2004):

$$n = \frac{z^2 \cdot p \cdot q}{e^2}$$

where Z is the standard value at a 95% confidence level (1.96), p is the proportion of households who own homegardens with woody species (0.8), q is the proportion of households who have no woody trees in their homegardens (0.2) and e is the mergional error accepted in the study (8%= 0.08). Thus, the sample size was 96 households. The mean age of the respondents was 49.5 years with minimum and maximum age of 25 and 81 years, respectively. The age classes of sample households are presented in Table 1.

Following administrative hierarchy in Bekoji town, multistage random sampling technique was used to identify sample homegardens. The town has two kebeles in which each has three zones. Each zone also has three Gots (the smallest administration unit) that resulted in 18 Gots in the town. Hence, one *Gots* from each zone were selected by simple random sampling technique using lottery method (Figure 2). Then, list of household heads that had trees in their homegardens of at least with 30 m^2 area were developed through assistance of *Got* administrators. Then after, sample size was proportionally allocated to the selected *Gots* based on the number of households who owns the required

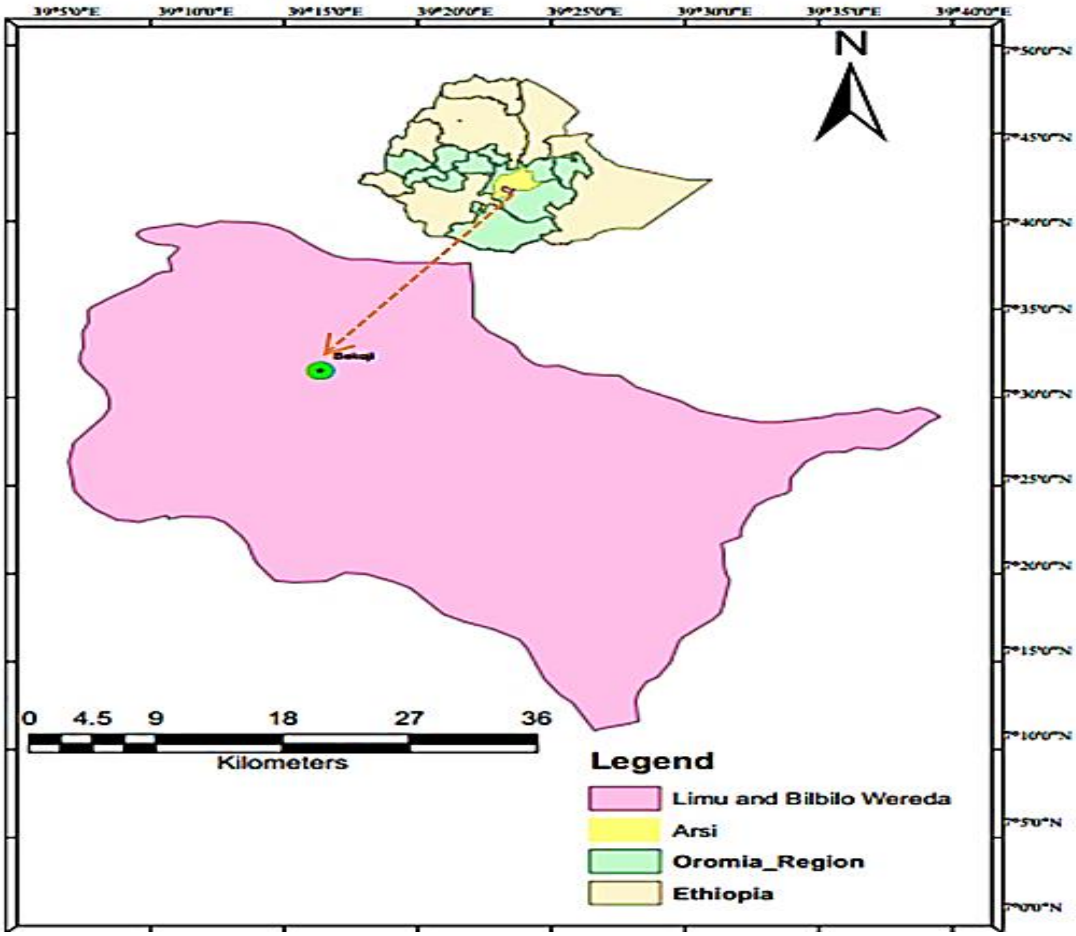

Figure 1. Map of the study area.

Table 1. Age class distribution of sample household heads.

Age classes	Frequency	Percent
25-38	37	25.0
39-52	51	34.5
53-66	41	27.7
67-81	19	12.8
Total	148	100.0

homegardens. Finally, sample household heads were identified by using systematic random sampling technique using the list. Amberber et al. (2014) and Regassa (2013) used similar sample size to undertake plant species inventory in homegardens of Holeta and Hawasa towns, Ethiopia. Thus, the homegardens of the selected households were taken as sample homegardens for woody plant species inventory.

Data collection techniques

Data collection was made from 15 September to 20 October in 2018. At each household, a vegetation survey in sample plot of 3 m × 10 m established at the sides, front yard or the backyard were conducted by participating household heads. Woody plant inventory was performed in line with procedures used by previous studies (van Heezik et al., 2014; Vila-Ruiz et al., 2014; Surat and Yaman, 2017). All woody species (that is, trees, shrubs, palms) present in each sample plot were identified by local names or botanical names and labeled as native or exotic using information from household heads, local informants, previous findings and reference books. Data pertaining to the total landholdings, area and age of each homegarden and the characteristics of the owner such as occupation, education level and number of family were also collected using Appendix 1. They were also used as influential factor by van Heezik et al. (2014). The botanical name was not

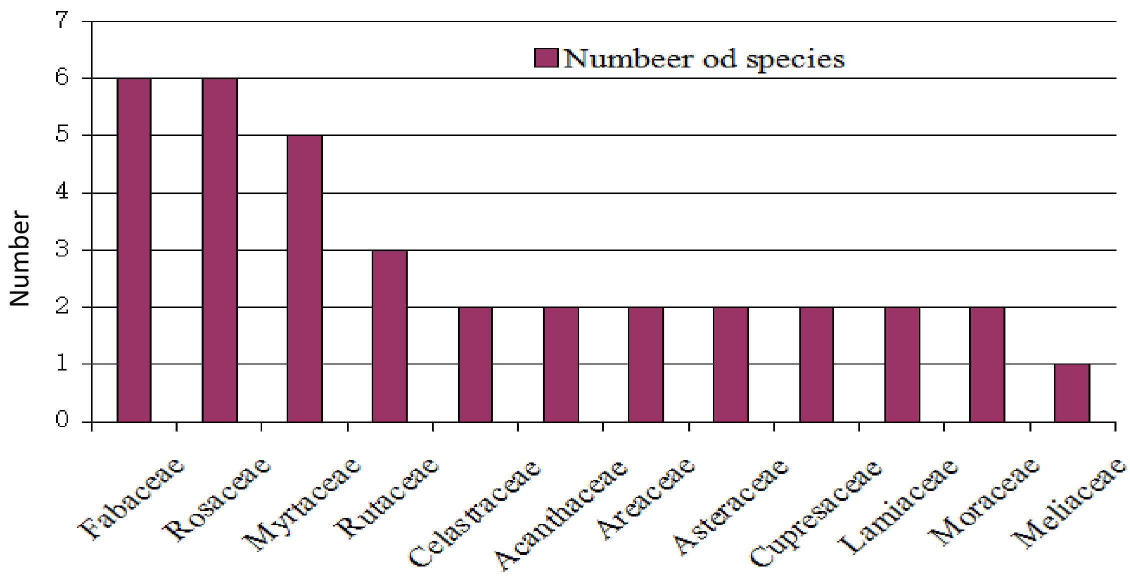

Figure 2. Families with two and more woody species in homegardens.

identified in the field using reference books (Hedberg et al., 2009).

Data analysis techniques

The identified woody species were first classified into botanical families. The diversity indices such as Shannon and Weiner diversity index (Shannon and Weiner, 1949), evenness index (Pielou, 1975), richness index (Margalef, 1958) and Jaccard Similarity index (Krebs, 1989) were computed using Microsoft Excel 2016. Similarly, they were also used by previous studies to measure plant species diversity in homegardens (Shukla et al., 2017; Surat and Yaman, 2017). The richness of woody species was calculated by using the ‘Margalef’s index of richness’ indx (D_{mg}) as (Margalef, 1958):

$$D_{mg} = \frac{(S-1)}{\ln N}$$

where S is the total number of species and N is the total number of individuals.

Equitability index (Pielou, 1975) was calculated as, where H′ is the Shannon diversity index; lnS is the natural log of the total number of species (S) sampled in each land uses. Thus, J` assumes a value between 0 and 1, with 1 being complete evenness.

To measure diversity, the Shannon index (H`) of woody species in homegardens and institutional compounds was calculated as (Shannon and Weaver, 1949):

$$H' = -\sum_i^s p_i \, In \, p_i$$

where pi = ni/N; ni is the number of individual trees present for species i, N is the total number of individuals, and S is the total number of species.

The Shannon index was complemented with the Simpson index (D) which is a useful index for relatively small samples as recommended by Magurran (2004). The Simpson's reciprocal index developed for sampling without replacement was calculated as:

$$D = 1 - \left(\sum_{i=1}^{s} \frac{ni(ni-1)}{N(N-1)}\right).$$

where S, n and N are defined as mentioned earlier. The value of D ranges b/n 0 and 1, 0 indicates a monoculture.

Pearson correlation analysis was used to identify presence of relationship between woody plant diversity and homegarden age, size, and owner’s characteristics (age, education level, sex, number of family, occupation, and distance from nursery site). Multivariate linear regression analysis was used to identify covariates for woody species diversity in homegardens in the study area. All statistical analyses were undertaken using SPSS version 20.

RESULTS AND DISCUSSION

Sample household description

The homegardens in Bekoji town were owned by both male (84.5%) and female (15.5%) headed households. They have one to nine family members with average family size of five. This result agrees with the average family size of 4.5 and 4.3 in Basia and Paalkot, in India (Shukla et al., 2017).

The homegarden owners have engaged on different occupations in the study area where majority were farmer, employee and merchant (Figure 3; left). The education level of household heads ranges from illiterate to first-degree (Figure 3; right). Homegarden owners studied elementary education (19.8%), high school (26.9%), preparatory (12.2%) and first degree (11.7%). In addition, around 22% of the household heads were illiterate.

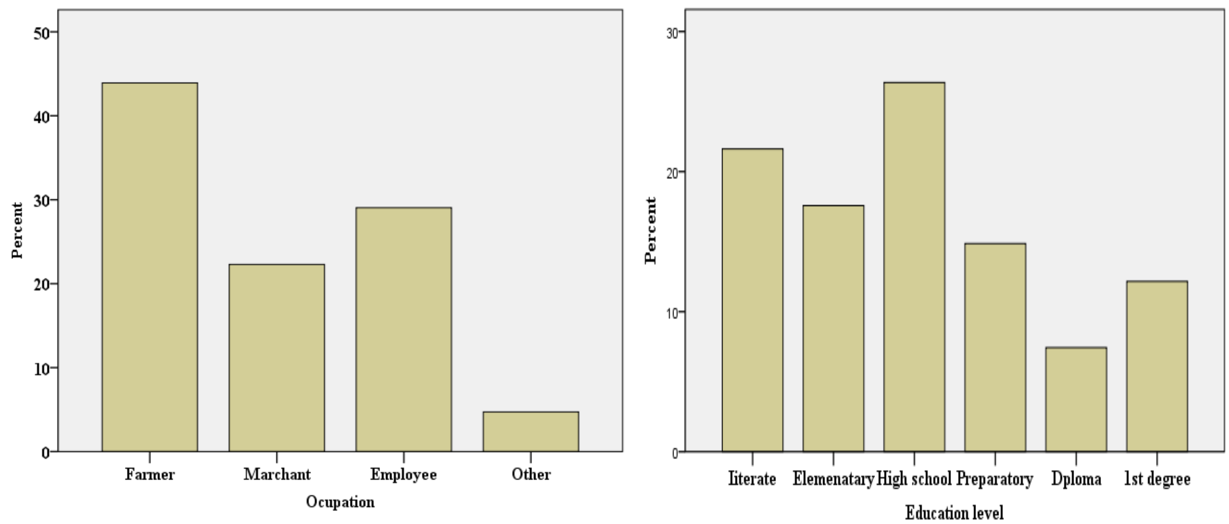

Figure 3. Occupation (left) and education level (right) of homegarden owners in the study area.

Table 2. Description of homegardens in the study area.

Homegarden characteristics	Mean
Homegarden age (year)	27.06
Homegarden area (m^2)/household	490.09
Number of sample (N)	148

The homegardens in the study area had age varied from 1 to 110 years with an average age of about 27 years. The average area per homegarden was 409 m^2. The area of homegardens in the study area varied from 120 to 4375 m^2 (Table 2). It is higher than the range of homegardens from 300 to 1200 m^2 reported by Mekonnen et al. (2015) in Sebeta-Awas district, Ethiopia. This might be due to variation in land allocation in the two urban areas.

Woody species planting and seedling sources

Homegardens owners grow woody species along boundary of land holdings and in frontyard, backyard and side of the house depending on the available free spaces in their landholdings. They used various techniques to grow woody plants (Table 3). Most of homegardens (97%) were established through planting majority of woody species. The seedlings were predominantly obtained from market (55%) but supplemented by government nurseries and seedling raised by family. Similarly, Regassa (2013) declares that the main source of planting materials in the study homegardens in Hawassa City were market (45%), seedlings produced by family (27.5%). However, some species such as *Vernonia amygdalina, Calpurnia aurea, Brucea antidysenterica* and *Vernonia leopoldi* were naturally regenerated in homegardens from the seed dispersed from mother trees in the surrounding areas. Moreover, the residents used cuttings to propagate *Erythrina brucei* and *Casimiroa edulis.*

Woody species composition in homegardens

In the study area, 30 families of woody species were identified in homegardens (Appendix 2). Fabaceae, Rosaceae, and Myrtaceae were the most abundant family, which encompassed six to five woody species (Figure 2). The homegardens contained about 49 woody species. Similarly, Amberber et al. (2014) identified more woody species (60) in Holeta town. Mengistu and Alemayehu (2017) also reported 58 higher plant species in Bahir Dar city. Of the woody species in the study area, 26 (53%) and 23 (47%) were categorized as shrub and tree life forms, respectively. Similarly, Amberber et al. (2014) found 32 (53%) tree species and 28 (47%) shrub species of woody plants in Holeta town. The low number of woody species in the study area may relate with the reliance of residents on planting socioeconomically important woody species.

Table 3. Woody plant establishment and seedling sources in homegardens in the study area.

Who established the woody plant?	**Total (%)**
Established by household or institution	93 (96.88)
Retained from previous land use	1 (1.04)
Naturally regenerated	2 (2.08)
Total	96 (100.0)
Where the seedlings of woody plants were obtained?	
Market	82 (55.21)
Government nursery	20 (20.83)
Raised by family member	23 (23.96)
Total	96 (100.0)

Urban homegardens in the study area maintained different woody species. Figure 4 depicted that *Eucalyptus globulus, Cupressus lusitanica, V. amygdalina, B. antidysenterica, Cytisus proliferus, Olea europaea* and *Lippia abyssinica* were frequently recorded woody species in homegardens in the study area. They were recorded in 28 to 50% of homegardens. *E. globulus* (Figure 4a) and *Cupressus lusitanica* were the most frequent exotic woody species while *V. amygdalina, B. antidysenterica, O. europaea* and *L. abyssinica* were the most abundant and multipurpose native woody species in the homegardens. *Juniperus procera* (Figure 4b) and *Hagenia abyssinica* were rarely recorded in homegardens due to rarely availability of seed and seedling of the former and cultural taboo of planting the later species. The number of individual plants and species grown in homegarden in Bekoji town depends on socio-cultural values of the species to the family. Similarly, Luck et al. (2009) noted that the quantity of plants available in a homegarden is related to social, cultural, economic and environmental values.

Woody species richness and diversity in homegardens

The value of equitability index (J`), Margalef's index of richness (Dmg), the reciprocal of Simpson index (1-D) and Shannon diversity index (H`) of homegardens were 0.80, 3.28, 0.94, and 3.14, respectively. The higher value of Dmg and J` indicated homegardens are rich in woody species and individuals of woody species evenly distributed in urban homegardens in Bekoji town. The value of 1-D indicated that there is 93% likelihood that two individuals randomly taken from homegardens belongs two different species. The higher values of H` and 1-D in this study indicated high species diversity in urban homegardens. On the contrary, Mattsson et al. (2013) reported lower value of H` in homegardens in Sri Lanka. Generally, the aforementioned alpha indices revealed that homegardens exhibited even distribution of individuals among species, and woody species diversity. Similarly, others reported that the higher the value indexes indicates the greater the species richness within the locations (Magurran, 2004, Mattsson et al., 2013; Agbelade et al., 2016). This might attribute to multiple ecosystem services demands of residents encouraging them to plant diverse woody species in homegardens that play a vital role in *in situ* conservation of woody species.

Native woody species conservation in urban homegardens

Bekoji town is playing significant role in conservation of native and exotic woody species. Of the woody species recorded in Bekoji town, 51.0 and 49% were native and exotic woody species (Appendix 1 and Table 4). The average number of native species per homegarden was 3.4 ±0.61 in the town. Contrary to this finding, different studies reported that urban plant communities typically include large numbers of introduced or exotic (non-native) species, which may outnumber those that are native. For example, in UK gardens, about 30% of garden plants were native and 70% exotic (Loram et al., 2008), while in New Zealand, in the city of Auckland, Northern North Island, 29% of front garden trees were recorded as native (Meurk et al., 2009). In gardens in Hong Kong, 81.9% of tree species were exotic, and they comprised 91.1% of the total tree count (Zhang and Jim, 2014). Similarly, van Heezik et al. (2014) identified 34.4% native and 66.3% exotic woody species in urban domestic garden in southern temperate New Zealand. The difference might be due to the difference in sociocultural condition of the residents in the study area and the other studies. For example, the comparable number of native and exotic woody species in urban landscape in this study might relate with the variation in the preference of woody species by residents and the neighborhood influence in adoption of woody species in the town. Moreover, it was observed that the residents in Bekoji town grow woody species that provide multiple purposes

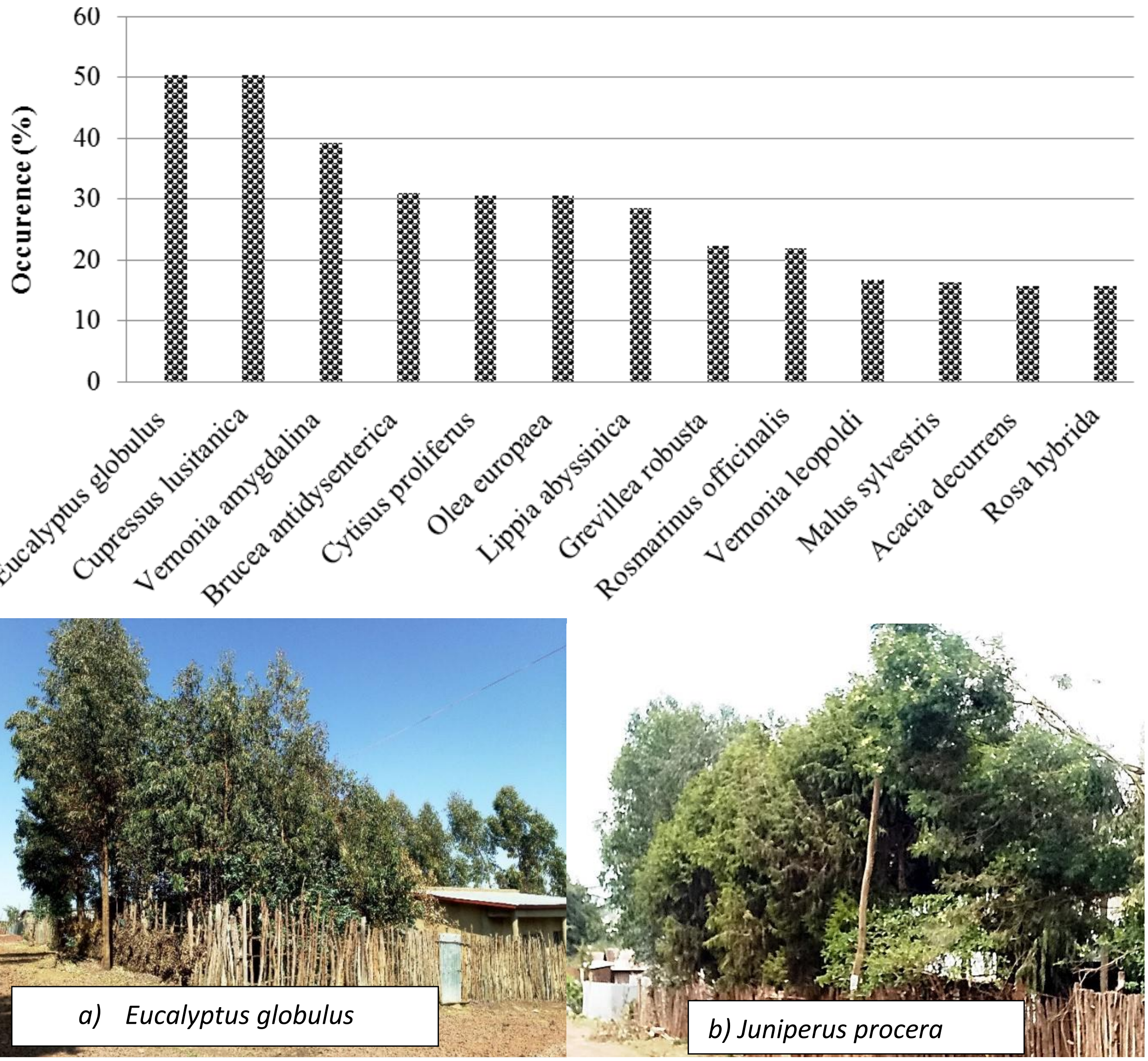

Figure 4. Woody species with the highest frequency of occurrence (upper), dominant (a) and rarely abundant (b) in homegardens in Bekoji town.

Table 4. Native species conservation role of urban homegardens.

Woody species categories		Number	Percentage	Mean per homegarden
Origin	Native	25	51.02	3.4 ±0.61[a]
	Exotic	24	48.98	3.01± 0.04[a]
Life form	Tree	26	53.06	-
	Shrub	23	46.84	-
Total		49	100	-

(aesthetic, spices and income) for the family and the species that they are familiar with. On the contrary, Kareiva et al. (2007) revealed that urban residents prefer exotic species because of more tolerant of common urban stresses, such as compact and limited soil, are often fast growing, and have showy flowers.

The aforementioned results clearly declare the magnificent contribution of urban homegardens in

Table 5. Factors associated with woody species diversity in the study area.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
Shannon diversity index						
1	Constant	1.139	0.064		17.696	0.000
	Homegarden area	0.003	0.001	0.308	3.895	0.000
2	Constant	0.990	0.088		11.217	0.000
	Homegarden area	0.002	0.001	0.271	3.418	0.001
	Homegarden age	0.006	0.003	0.192	2.428	0.016
Equitability index (J`)						
1	Constant	0.669	0.030		22.014	0.000
	Homegarden age	0.003	0.001	0.257	3.206	0.002
Simpson index (1-D)						
1	Constant	5.063	0.378		13.398	0.000
	Homegarden area	0.019	0.004	0.367	4.745	0.000
Margalef's Richness index						
1	Constant	1.261	0.088		14.343	0.000
	Homegarden area	0.003	0.001	0.279	3.497	0.001

Source: Survey data analysis.

conservation of native woody species. In support of this, different studies confirmed the importance of homegardens as conservation refuges for native plant species (Akinnifesi et al., 2010; Pozi et al., 2013; Schmidt et al., 2014; Chalker-Scott, 2015). This situation also reveals the greatest motives of homegardens owners in conservation of native woody species.

Determinants of woody species diversity in urban homegardens

Woody species diversity in urban homegardens may be affected by different factors. Multivariate linear regression analysis result revealed that the diversity of woody species in homegardens in Bekoji town associated with age and area of homegardens. Table 5 depicted that H` was positively and significantly correlated with age and area of homegardens. On the other hand, evenness and richness were positively and significantly associated with homegarden age (Table 5). This confirms that homegardens which have sufficient place and time for planting woody species and collecting large number of seedlings from different sources maintain more diverse system.

These imply that woody species diversity increases with increase in area and age of homegardens in the study area. Previous study also reported a positive relationship between size of homegarden area and species richness. For instance, studies declared that large gardens tend to have more trees (Smith et al., 2005; Kirkpatrick et al., 2012). That is the older and the larger the homegarden is the more diverse and richer in woody species they are. In line with this, previous studies revealed that diversity in homegarden is by large controlled by ecological and socio-economic factors such as homegarden size and age of gardens (Kumar and Nair, 2006). Householders that have been in their residence for long periods can demonstrate stronger relationships between preferences for traits and the species in their gardens because they have had sufficient time to create a garden in line with their vision (Kendal et al., 2012; van Heezik et al., 2014).

CONCLUSION AND RECOMMENDATION

Urban homegardens in the study area maintained diverse woody species in which native species outnumbered the exotic species. This confirmed significant role of urban homegardens in conservation of native woody species by serving as a refuge in urban landscape. The dominance of population of *E. globulus* and *C. lustanica* over other woody species in the study area revealed that homegarden owners need those species that provide higher socio-economic benefits with available seedlings which thereof lead to homogenization of homegardens by few species. Because of this, consultation of homegardens owners on maintenance of native multipurpose woody species is crucial to improve woody species conservation role of homegardens and the benefit accrued form the system by residents. There is also a need for introduction of ecologically friendly species that compensate the benefit (economic and domestic values) obtained from the two species via government nursery as per the preference of the owners as the seedlings provided in the market are predominantly of exotic species. Moreover, as this study was carried out in a single town and considers few factors associated with woody species diversity, there is a need for further studies that will consider geographical gradients, more socioeconomic and environmental variables to generalize the findings for the entire urban landscapes in southeast highlands.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Agbelade AD, Onyekwelu JC, Apogbona O (2016). Assessment of Urban tree species population and diversity in Ibadan, Nigeria. Environmental and Ecology Research 4(4):185-192.

Akinnifesi FK, Sileshi GW, Ajayi OC, Akinnifesi AI, de Moura EG, Linhares, JFP, Rodrigues I (2010). Biodiversity of the urban homegardens of So Luis City, Northeastern Brazil. Urban Ecosystems 13:129-146.

Amberber M, Argaw M, Asfaw Z (2014). The role of homegardens for in situ conservation of plant biodiversity in Holeta Town, Oromia National Regional State, Ethiopia. International Journal of Biodiversity and Conservation 6(1):8-16.

Assen M, Yilma S (2010). Characteristics and classification of the soils of Gonde Micro Catchment, Arsi Highlands, Ethiopia. Ethiopia Journal of Science 33(2):101-116.

Ávila JVC, de Mello AS, Beretta M E, Trevisan R, Fiaschi P, Hanazaki N (2017). Agrobiodiversity and in situ conservation in Quilombola homegardens with different intensities of urbanization. Acta Botanica Brasilica 31(1):1-10.

Blanckaert I, Swennen RL, Flores MP, López RR, Saade RL (2004). Floristic composition, plant uses and management practices in homegardens of San Rafael Coxcatlán, Valley of Tehuacán-Cuicatlán, Mexico. Journal of Arid Environments 57:39-62.

Chalker-Scott L (2015). Nonnative, Noninvasive Woody Species Can Enhance Urban Landscape Biodiversity. Arboriculture and Urban Forestry 41(4):173-186.

Central Statistics Agency (CSA) (2007). The Population and Housing Census of Ethiopia. Addis Ababa, Ethiopia.

Eichemberg MT, Amorozo MCM, de Moura LC (2009). Species composition and plant use in old urban homegardens in Rio Claro, Southeast of Brazil. Acta Botanica Brasilica 23:4-18.

Hedberg I, Friis I, Persson E (2009). Flora of Ethiopia and Eritrea Vol. 8. General part and index to Volumes 1-7. The National Herbarium, Addis Ababa and Uppsala.

Goddard MA, Dougill AJ, Benton TG (2010). Scaling up from gardens: Biodiversity conservation in urban environments. Trends in Ecology and Evolution 25(2):90-98.

González-García A, Sal A (2008). Private urban greenspaces or patios as a key element in the urban ecology of tropical Central America. Human Ecology 36(2):291-300.

Habtamu H, Zemede A (2011). Home-gardens and agrobiodiversity conservation in Sabata Town, Oromia National Regional State, Ethiopia. Ethiopia Journal of Science 34(1):1-16.

Kareiva P, Watts S, McDonald R, Boucher T (2007). Domesticated nature: shaping landscapes & ecosystems for human welfare. Science 316:1866-1869.

Kendal D, Williams KJH, Williams NSG (2012). Plant traits link people's plant preferences to the composition of their gardens. Landscape and Urban Planning 105:34-42.

Kirkpatrick JA, Davison A, Daniels GD (2012). Resident attitudes towards trees influence the planting and removal of different types of trees in eastern Australian cities. Landscape and Urban Planning 107:147-158.

Knapp S, Kühn I, Stolle J, Klotz S (2010). Changes in the functional composition of a Central European urban flora over three centuries. Perspectives in Plant Ecology, Evolution and Systematics 12:235-244.

Kothari CR (2004). Research methodology: methods and techniques. Fourth edition. Wishwa prakashan. Delhi, India.

Krebs CJ (1989). Ecological Methodology. Harper Collins, New York. P 654.

Kumar BM, Nair PR (2004). The enigma of tropical homegardens. Agroforestry System 61(3):135-152.

Kumar BM, Nair PKR (2006). Tropical homegardens: A time-tested example of sustainable agroforestry, Heidelberg, Springer.

Lin BB, Fuller RA (2013) Sharing or sparing? How should we grow the world's cities? Journal of Applied Ecology 50:1161-1168.

Loram A, Warren PH, Gaston KJ (2008). Urban domestic gardens (XIV): the characteristics of gardens in five cities. Environmental Management 42:361-376.

Luck GW, Smallbone LT, O'Brien R (2009). Socioeconomics and vegetation change in urban ecosystems: patterns in space and time. Ecosystems 12:604-620.

Magurran AE (2004). Measuring Biological Diversity. Blackwell Science, Oxford, UK.

Margalef R (1958). Temporal succession and spatial heterogeneity in phytoplankton. In: Buzzati-Traverso (ed.). Perspectives in Marine biology (pp. 323347). University of California Press, Berkeley.

Mattsson E, Ostwald M, Nissanka SP, Marambe B (2013). Homegardens as a multi-functional land use strategy in Sri Lanka with focus on carbon sequestration. AMBIO 42:892-902.

Mekonnen A, Mekuria A, Zemede A (2014). The role of homegardens for in situ conservation of plant biodiversity in Holeta Town, Oromia National Regional State, Ethiopia. International Journal of Biodiversity Conservation 6(1):8-16.

Mekonnen T, Giday M, Kelbessa E (2015). Ethnobotanical study of homegarden plants in Sebeta-Awas District of the Oromia Region of Ethiopia to assess use, species diversity and management practices. Journal of Ethnobiology and Ethnomedicine 11(64):1-15.

Mengistu F, Alemayehu M (2017). Species Assortment and Biodiversity Conservation in Homegardens of Bahir Dar City. Ethiopia Journal of Agricultural Science 27(2):31-48.

Meurk CD, Zvyagna N, Gardner RO, Forrester G, Wilcox M, Hall G, North H, Belliss S, Whaley K, Sykes B, Cooper J, O'Halloran K (2009). Environmental, social and spatial determinants of urban arboreal character in Auckland, New Zealand. In McDonnell MJ, Hahs AK, Breuste JH (eds). Ecology of towns and cities: a comparative approach. Cambridge University Press, Cambridge, UK.

Nielsen AB, Annerstedt M, Maruthaveeranand S, Konijnendijk CC (2014). Species richness in urban parks and its drivers: A review of empirical evidence. Urban Ecosystems 17:305-327.

Pielou E C (1975). Ecological Diversity. New York: John Wiley.

Pozi M, Sorayya M, Nur Shahidah M, Ong HC (2013). Diversity of plants tended or cultivated in Orang Asli homegardens in Negeri

Sembilan, Peninsular Malaysia. Human Ecology 41:325-331.
Regassa R (2013). Assessment of indigenous knowledge of medicinal plant practice and mode of service delivery in Hawassa city, southern Ethiopia. Journal of Medicinal Plants Research 7(9):517-535.
Schmidt KJ, Poppendieck HH, Jensen K (2014). Effects of urban structure on plant species richness in a large European city. Urban Ecosystems 17:427-444.
Shannon CE, Weaver W (1949). The Mathematical Theory of Communication. University of Illinois Press, Urbana, Illinois.
Shukla G, Kumari VA, Chakravarty S (2017). Plant diversity, structure and uses of the plants in homegarden of Jharkhand, India. Indian Journal of Tropical Biodiversity 25(1):40-50.
Smith RM, Gaston KJ, Warren PH, Thompson K (2005). Urban domestic gardens (V): Relationships between land cover composition, housing and landscape. Landscape Ecology 20(2):235-253.
Smith VM, Greene RB, Silbernagel J (2013). The social and spatial dynamics of community food production: a landscape approach to policy and program development. Land Scape Ecology 28(7):1415-1426.
Sperling C, Lortie C (2010). The importance of urban backgardens on plant and invertebrate recruitment: A field microcosm experiment. Urban Ecosystems 13(2):223-235.
Surat H, Yaman YK (2017). Evaluation of plant species in homegardens: A case study of Batumi city (Adjara). Turkish Journal of Forestry 18(1):11-20.
United Nations (1992). Convention on Biological Diversity. UNCED, Rio.
van Heezik YM, Freeman C, Porter S, Dickinson KJM (2014). Native and exotic woody vegetation communities in domestic gardens in relation to social and environmental factors. Ecology and Society 19(4):17. www.ecologyandsociety.org/.../art17/ES-2014-6978.pdf
Vila-Ruiz C, Meléndez-Ackerman P, Santiago-Bartolomei E, Garcia-Montiel RD, Lastra L, Figuerola CE, FumeroCaban J (2014). Plant species richness and abundance in residential yards across a tropical watershed: implications for urban sustainability. Ecology and Society 19(3):22. http://dx.doi.org/10.5751/ES-06164-190322.
Winkler Prins AGA (2002). House-lot gardens in Santarém, Pará, Brazil: Linking rural with urban. Urban Ecosystems 6(1-2):43-65.
Zhang H, Jim CY (2014). Species diversity and performance assessment of trees in domestic gardens. Landscape and Urban Planning 128:23-34.

APPENDIX

Appendix 1. **Data collection format for woody species inventory in Bekoji Town**

This is data collection format used to collect information on household head and homegarden characteristics, woody species in homegardens in Bekoji town. This format is field by data collectors in the field.

General Information

1. **Zone:** ________________ Got**:** _________________
2. **Respondent ID**: _________ **Household head age:** _______ **Number of family:** _________
3. **Occupation:** Farmer ☐ Merchant ☐ Government employee ☐

Employee in small scale industry ☐ Mention if any _______________

4. **Education level of household head:** ___________________________

Homegarden Characteristics

5. **Age / establishment Date:** _________
6. **Homegarden area**: ____________
7. **Plants establishment:** Planted by household ☐ Retained from previous land use ☐ Naturally regenerated ☐
8. **Seedling sources**: Market ☐ Government nursery ☐ Raised by family member ☐

Naturally regenerated ☐

Record the answer of the following question in Table one

9. What are woody plant species grown in your homegarden? Make inventory with family member.
10. What is the origin of woody species (exotic or native to Bekoji)?

Table 1. Woody species in homegardens or institutional compounds in Bekoji town.

Name of woody plant species		Individuals per homegarden	Origin (N or E)	Purpose
Local	Botanical			

n= Native; E= Exotic.

Appendix 2. List of woody species in urban homegardens in Bekoji town.

Family	Botanical name	Local name	Life form	Origin
Acanthaceae	*Vernonia leopoldi (Sch. Bip. ex walp.) Vatke*	Reji (Ameraaroo)	S	N
Acanthaceae	*Justicia schimperiana (Hochst. ex Nees) T.Anders.*	Sensel (A), Dhummugaa (O)	S	N
Anacardiaceae	*Schinus molle L.*	Qundo berbere (A)	T	E
Araliaceae	*Polyscias fulva*	Yezinjero wenber (A)	T	N
Areaceae	*Washingtonia filifera L.*	Zenbaba (A)	S	E
Areaceae	*Phoenix reclinata Jacq*	Zenbaba (A)	S	N
Asteraceae	*Mikaniopsis clematoides*	Digita (A)	S	N
Asteraceae	*Vernonia amygdalina Del.*	Grawa (A), Eebicha (O)	T	N
Bignoniaceae	*Spathodea campanulata Beauv.*	Yechaka nebelbal (A)	T	N
Boraginaceae	*Cordia africana Lam.*	Wanza (A), Wadeesa (O)	T	N
Casuarinaceae	*Casuarina eequisetifolia L.*	Shiwshiwe (A)	T	E
Celastraceae	*Catha edulis (Vahl) Forssk. ex Endl.*	Khat (A), Caatii (O)	S	E
Cupresaceae	*Juniperus procera Hochst. ex Endl.*	Yabesha tsid (A), Gatira Habasha (O)	T	N
Cupresaceae	*Cupressus lusitanica Mill.*	Yeferenji tsid (A), Gaattiraa–faraanjii (O)	T	E
Euphorbiacaeae	*Croton macrostachyus Del.*	Bisana (A), Bakkanisa (O)	T	N
Fabaceae	*Acacia decurrens Willd.j*	Akacha (A)	T	E

Appendix 2. Contd.

Fabaceae	*Calpurnia aurea (Ait.) Benth.*	Digeita (A), Ceekataa (O)	S	N
Fabaceae	*Erythrina brucei Schweinf.*	Korch (A), Walensuu (O)	T	N
Fabaceae	*Acacia melanoxylon R.Br*	Omedla (A)	T	E
Fabaceae	*Cytisus proliferus L.f.*	Yemeno zaf (A)	T	E
Flacourtiaceae	*Dovyalis caffra (Hook. f. & Harv.) Hook. f.*	Koshim (A), Koshoomii (O)	S	N
Guttiferae	*Hypericum revolutum Vahl*	Amija (A), Garambaa (O)	T	N
Lamiaceae	*Ocimum lamiifolium Hochst. ex Benth.*	Demakse (A)	S	N
Lamiaceae	*Rosmarinus officinalis L.*	Yesiga metibesha (A)	S	E
Lauraceae	*Persea americana Mill.*	Abukado (A, O)	T	E
Meliaceae	*Azadirachta indica*	-	T	E
Meliaceae	*Ekebegia capensis Sparm.*	Somboo(O)	T	N
Mimosoideae	*Luenaena leucocephala (lam.) De Wit.*	-	S	E
Moraceae	*Morus alba L.*	Enjori (A)	S	N
Moraceae	*Ficus sur Forssk.*	Shola (A), Harbuu (O)	T	N
Myrsinaceae	*Maesa lanceolata Forssk*	Abbayyii (O)	S	N
Myrtaceae	*Myrtus communis L.*	Ades (A)	S	N
Myrtaceae	*Callistemon citrinus (Curtis) Stapf.*	-	S	E
Myrtaceae	*Eucalyptus camaldulensis Dehnh.*	Key bahirzaf (A)	T	E
Myrtaceae	*Eucalyptus globulus Labill.*	Neci beharzaf (A), Bargamo-adii (O)	T	E
Myrtaceae	*Psidium guajava L.*	Zeyitun (A)	S	E
Oleaceae	*Olea europaea L. subsp. Cuspidata (Wall. ex G. Don) Cif.*	Weyira (A), Ejersa (O)	T	N
Pinaceae	*Pinus patula Schiede ex. Schltdl. Cham.*	-	T	E
Podocarpaceae	*Podocarpus falcatus (Thunbr.)R.B.ex.Mirb*	Zigba (A)	T	N
Proteaceae	*Grevillea robusta R. Br.*	-	T	E
Rhamnaceae	*Rhamnus prinoides L' Herit.*	Gesho (A)	S	N
Rosaceae	*Malus sylvestris Miller Apple*	Apple	S	E
Rosaceae	*Jacaranda mimosifolia D.Don.*	-	T	E
Rosaceae	*Prunus persica (L.) Batsch*	Kok (A)	S	E
Rosaceae	*Hagenia abyssinica (Bruce) J. F. Gmel.*	Koso (A), Heexoo (O)	T	N
Rosaceae	*Prunus x domestica L.*	Prim	S	E
Rosaceae	*Rosa abyssinica Lindley*	Qega (A) IngooXoo (O)	S	N
Rosaceae	*Rosa hybrida L.*	Tsigereda (A)	S	E
Rubiaceae	*Coffea arabica L.*	Buna (A, O)	S	N
Rutaceae	*Citrus sinensis (L.) Osb.*	Birtukan A), Burtukaana (O)	S	E
Rutaceae	*Casimiroa edulis La Llave*	Kasmiro (A, O)	T	E
Rutaceae	*Citrus aurantifolia (Christm.) Swingle*	Lomi (A)	S	E
Salicaceae	*Salix subserrata Willd*	Aleltu (O)	T	N
Simarobaceae	*Brucea antidysenterica J. F Mill.*	Amfar (A), Adaaddoo (O)	T	N
Verbenaceae	*Lippia abyssinica (Otto & A. Dietr.) Cufod.*	Koseret (A), Kuusaayee (O)	S	N

A =Amharic, O = “Afaan Oromoo”, S= Shrub, T= Tree, N= Native and E = Exotic.