Ethnobotanical study of homegarden plants in Sebeta-Awas District of the Oromia Region of Ethiopia to assess use, species diversity and management practices

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Abstract

Background: Homegardens in Ethiopia are currently facing different threats mainly due to genetic erosion, loss of traditional knowledge on their use and management and drought. On the other hand, research and documentation works on homegardens in the country are very limited. There is no previous report indicating conduct of ethnobotanical study on homegardens in selected study district. The present study thus attempted to document knowledge on uses and management practices of homegardens by people in study district.

Methods: The study was conducted in Sebeta-Awas District, Southwestern Shewa Zone of Oromia Region, Ethiopia, between March and September 2009 to assess use, species diversity and conservation status of homegardens in the District. Data were collected using semi-structured interviews as well as through homegarden visits, market surveys and different ranking exercises. For the semi-structured interviews, 42 homegarden owners were selected randomly from seven sampled kebeles (smallest administrative units in Ethiopia), six from each kebele. For different ranking exercises, 14 informants (10 males and 4 females) were sampled using convenient sampling method from among homegarden owners that already participated in semi-structured interviews.

Results: In total, 113 plant species belonging to 46 families were recorded from the study area, of which 45 (39.8 %) were herbs, 34 (30.1 %) were trees, 26 (23.0 %) were shrubs and 8 (7.1 %) were climbers. Fabaceae had the highest number of species, followed by the families Asteraceae, Lamiaceae and Solanaceae. The cash crops Catha edulis, Rhamnus prinoides and Ruta chalepensis were the most frequently encountered homegarden plants. Cupressus lusitanica, Eucalyptus camaldulensis and Faidherbia albida were the most abundant tree species that had the highest densities of occurrence. Of the recorded plant species, 25 % were used as sources of food, 13 % as medicine and 10 % as household tools.

Conclusion: It can be concluded that homegardens in the study area are rich in crops and, therefore, significantly contribute to the agrobiodiversity of the study District, in particular, and Ethiopia, in general.

Keywords: Homegarden, Agrobiodiversity, Local knowledge, Sebeta-Awas, Ethiopia

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Background
Homegardens are commonly defined as a piece of land with a definite boundary surrounding a homestead, being cultivated with a diverse mixture of perennial and annual plant species, arranged in a multilayered vertical structure, often in combination with raising livestock, and managed mainly by household members for subsistence production [1–4]. Homegardens are complex ecosystems close to the house where plants can be closely observed and managed and are convenient place for traditional plant experimentation [5].

Homegardens are important in the conservation of useful plant species since they contain very large numbers of species which are often absent or disappearing from other production systems [6]. Homegardens also provide a wide range of ecological benefits and services and a valuable set of products for the rural poor [6]. Homegardens provide people with supplementary food, fuel and fodder [7]. They are used to grow medicinal, spice, ornamental and stimulant plants [8]. Homegardens are widely spread in the tropical and subtropical regions of Asia [9], Africa [10] and Central and South America [11].

Although there is no direct evidence as to when homegardening started in Ethiopia, based on the antiquity of agriculture, crop composition, oral literature and rich vernacular designations in different local languages, it is assumed to have long history [12]. Homegardening in Ethiopia is estimated to have started as early as 5000 to 7000 years ago, around the time when agriculture started in the country [13, 14]. In relation to the house, Ethiopian homegardens may occupy different positions such as the backyards, frontyards, side yards and yards that almost encircle the house, and have variable shapes and sizes and composition of plant species [12]. In Ethiopia, homegardens are prevalent in the highland areas and mainly accommodate supplementary fruits and vegetables as a principal means of livelihood for households [15–18]. A study [16] indicated that more than 170 crop species belonging to 121 genera and 50 families have been recorded in Ethiopia, of which, the families Fabaceae, Lamiaceae, Poaceae, Rubiaceae, Asteraceae, and Rubiaceae contributed more than 10 species each.

Ethiopia is one of the eight world centers of origin and diversity of agricultural products [19] which is partly the result of in situ conservation of plants traditionally grown in homegardens [12, 17]. However, homegardens are currently threatened mainly due to genetic erosion, loss of traditional knowledge of different management practices, man-made habitat changes, and drought [4, 20]. On the other hand, research and documentation works done on homegardens in Ethiopia are very limited [21–26] and most of them have been conducted in the south and southwestern parts of the country. There is no report indicating the conduct of ethnobotanical study on homegardens of the selected district. The present study thus attempted to gather and document information on the use of plant species and management practices of homegardens by people in Sebeta-Awas District, Southwestern Shewa Zone of Oromia Region, Ethiopia.

Methods
The study area
This study was conducted in Sebeta-Awas District (Fig. 1), Oromia Region, Ethiopia, which is located at a distance of 24 km to 45 km southwest of the capital Addis Ababa. The District has an area of 87,532 ha. It shares borders with Akaki District in the East, Kerssa and Tole districts in the south, Welmera District in the North and Ilu and Ejere districts in the West. The land feature of Sebeta-Awas is characterized by mountains and hills (Wachacha and Hoche mountains) and marshy plains (Furi-Garaa, Gejja Ballachis and Jammo), and is surrounded by Awash water shade in the west [27]. Altitude in the District ranges between 1800 and 3385 m a.s.l (Sabata Awas District Rural and Agricultural Office, unpublished data of 2001).

Agricultural activity is the dominant means of livelihood in Sebeta-Awas District. People in the District use functional categorization to classify their lands, e.g., grazing land, agricultural land, homestead land and forestland. According to annual report of Sebeta-Awas District, Rural and Agricultural Development Office, out of 87,532 ha of land, 73,838 ha (84.4 %) are used for agriculture to cultivate different crops for household consumption and sale in local market, and 3,689 ha (4.2 %) of land is used as grazing area (Sabata Awas District Rural and Agricultural Office, unpublished data of 2006). The District is divided into two agro-ecological zones locally called Baddaa (12 %) and Badda daree (88 %), which means highland and midland areas, respectively (Sabata Awas District Rural and Agricultural Office, unpublished data of 2006). The study area experiences alternating wet and dry seasons. The main rainy season is between June and September and is locally called rooba gaanaa. Light rain occurs between January and March and is locally called rooba arfassa. There is no temperature data for Sebeta-Awas District. Thus temperature data of Alemtena, a nearby district having similar altitude as that of Sebeta-Awas District, was used to compute 10 years (1995 to 2006) annual mean temperature for the study area. The annual mean maximum and minimum temperatures are 25.4 °C and 13.9 °C, respectively. The annual mean maximum and the minimum temperatures were recorded in the months of May and July, respectively. The total mean annual rainfall from 1995 to 2006 is 1054.7 mm and the highest rainfall recorded is for July (National Metrological Service of Ethiopia, unpublished data of 2009).
Selection of study kebeles and homegardens
Reconnaissance survey was conducted in Sebeta-Awas District in January 2009 to select study kebeles (smallest administrative units in Ethiopia) and conduct homegarden surveys. During the reconnaissance survey, seven kebeles (from a total of 42 kebeles in the District) including Dima Guranda, Daley, Dima Magno, Geja Migra, Haro Jilla, Korke and Kotche were randomly selected. In each selected kebele, visits were made to 50 households that were sampled during random walks to check for the presence or absence of homegardens and assess their sizes, shapes and locations with respect to houses.

Selection of informants and ethnobotanical data collection
Ethnobotanical data were collected between March and August 2009 mainly through homegarden tours, market surveys and semi-structured interviews. Interviews were conducted using pre-prepared questions with 42 randomly selected homegarden owners (32 males and 10 females with ages ranging from 35 to 72 years) from the randomly selected seven kebeles, six from each kebele, after receiving their full consent. The homegarden owners involved in the interviews were sampled from the list of households that were found to own homegardens during survey of 350 households (50 from each sampled kebele) to check for the presence or absence of homegardens. All interviews were conducted in Oromo language. During interviews with the informants, attempts were made to document information on the use of homegarden plants for different purposes (household food supply, medicine, shade, aesthetics and ornament, fuel wood production and for income generation) and management practices. Additional data were also gathered through, simple preference ranking, direct matrix ranking and paired comparison exercises [28–30] by involving 14 informants (two from each kebele) between the ages of 40 and 65 (10 males and 4 females). The informants were sampled using convenient sampling method from among homegarden owners that already participated in the semi-structured interviews. The study was conducted in accordance with the Code of Ethics of the International Society of Ethnobiology [31].

Simple preference ranking
During preference ranking exercise, 14 informants were asked to rank seven marketable homegarden plants in Sebeta-Awas District that were found to have the highest...
frequencies and relative frequencies of occurrence and rank them according to their perceived values or desirability following the method of Martin [30]. The integer values 1, 2, 3 and 4 were used whereby the most important plant was given the highest value, while the least important one was assigned with the smallest value. The numbers were then summed for all respondents to come up with an overall ranking.

**Direct matrix ranking**

Direct matrix ranking exercises were conducted by the same 14 informants on six multipurpose tree species as reported during interviews using the approach of Martin [30] to rank them based on their uses as construction material, fertilizer, household tools, charcoal/firewood, shade, live fence and medicine. Informants were asked to assign value to each attribute (5 = best, 4 = very good, 3 = good, 2 = less used, 1 = least used and 0 = not used).

**Paired comparison**

Paired comparison exercises were conducted by the 14 informants following the methods of Martin [30] on five nutraceutical plants (plants used as sources of both food and medicine) as reported during interviews with informants.

**Market survey**

Market survey was conducted in one open market found in Sebeta, an administrative town of the Sebeta-Awas District, to check for availability of marketable homegarden plants. Data were gathered through observation and interaction with sellers and buyers of homegarden products.

**Plant specimen collections and identification**

Specimens of plants recorded as homegarden species were collected, numbered, pressed and dried. They were later identified using taxonomic keys of the Flora of Ethiopia and Eritrea and by comparison with already identified specimens that were deposited at National Herbarium (ETH), Addis Ababa University. The identities of the specimens were authenticated by taxonomists at ETH.

**Data analysis**

Descriptive statistical methods were employed to determine frequencies, relative frequencies, densities and relative densities. Shannon and Wiener index and Sorensen's Index were used to estimate species diversity and similarity, respectively, in sample plots of 15 m x 15 m (225 m²) in homegardens of the 42 randomly selected informants, six from each of the seven selected kebeles.

**Frequency and relative frequency**

Frequencies and relative frequencies were calculated for plants in the sampled homegardens. Frequency describes the distribution of a species throughout the stands. It is determined by calculating the percentage of plots/quadrants in a sample area on which a given species occurs [30].

\[
\text{Frequency} = \frac{\text{quadrants in which a species occurs}}{\text{Total number of quadrants in the sample}} \times 100
\]

Relative frequency is the number of occurrences of a species as a percentage of the total occurrences of all species [30].

\[
\text{Relative frequency} = \frac{\text{Frequency of a species in the sample}}{\text{Total frequency of all species in the sample}} \times 100
\]

**Density and relative density**

Density is the average number of individuals of a species on a unit area basis. It is closely related to abundance but more useful in estimating the importance of a species [30].

| Table 1 Distribution and location of homegardens in the selected seven study kebeles of Sebeta-Awas District |
|---------------------------------------------------------------|
| **Kebeles** | **No. of surveyed houses** | **No. of houses with homegardens** | **Position of homegardens** | **front yard gardens** | **backyard gardens** | **side yard gardens** | **front yard & backyard gardens** | **front yard & side yard gardens** | **backyard & side yard gardens** | **round yard gardens** |
|-------------|-----------------------------|------------------------------------|-----------------------------|------------------------|----------------------|----------------------|-------------------------------|-------------------------------|-------------------------------|------------------------|
| Dima Guranda | 50                          | 39                                 | 5                           | 12                     | -                    | 3                    | -                            | 4                            | 15                            | 1                      |
| Dima Magno  | 50                          | 35                                 | -                           | 18                     | 5                    | -                    | -                            | -                            | 12                            | 1                      |
| Haro Jila   | 50                          | 38                                 | 22                          | 4                      | 10                   | -                    | 7                            | 1                            | -                             | 2                      |
| Dalati      | 50                          | 34                                 | 6                           | 18                     | 2                    | -                    | 7                            | 1                            | -                             | -                      |
| Geja Migra  | 50                          | 33                                 | 4                           | 14                     | -                    | 3                    | 3                            | 8                            | 1                             | -                      |
| Koche       | 50                          | 37                                 | 14                          | 22                     | -                    | -                    | -                            | -                            | 1                             | -                      |
| Korke       | 50                          | 32                                 | -                           | 20                     | -                    | 7                    | -                            | 5                            | -                             | -                      |
| **Total**   | 350                         | 248                                | 29                          | 126                    | 11                   | 23                   | 10                           | 18                           | 31                            | 31                     |
| **%**       | 70.9                        | 8.3                                | 36                          | 3.1                    | 6.6                  | 2.9                  | 5.1                          | 8.9                          |                               | 31                     |
Table 2: Homegarden plants documented from Sebeta-Awas District

| Family            | Scientific name                     | Local name          | Habit   | Indigenous/ exotic | Use                          | Coll. No. |
|-------------------|-------------------------------------|---------------------|---------|-------------------|------------------------------|-----------|
| Acanthaceae       | Justicia schimperiana (Hochst. ex Nees) T.Anders. | Dhummugaa (O) | Shrub   | Indigenous       | Live fence                  | TM75      |
| Alliaceae         | Allium cepa L.                      | Qullubii-diimaa (O) | Herb    | Exotic           | Vegetable                   | TM105     |
| Allium sativum L. | Qululubi-adii (O)                   |                      |         | Exotic           | Vegetable, medicine         | TM76      |
| Amaranthaceae     | Amaranthus hybridus L.              | Orome (O)           | Herb    | Exotic           | Vegetable, weed             | TM32      |
| Achyranthes aspae L. |                          | -                   | Herb    | Indigenous       | Medicine, weed              | TM92      |
| Iresine herbstii Hook. ex. Lindl. |                      | -                   | Herb    | Exotic           | Ornament                    | TM16      |
| Anacardiaceae     | Rhus glutinosa A. Rich              | Xaxeecha (O)        | Tree    | Indigenous       | Fuel wood                   | TM104     |
| Schinus molle L.  |                                    | Alaaltu (O)         | Tree    | Exotic           | Shade, household tool       | TM63      |
| Mangifera indica L. |                          | Mango (O, A, G)    | Tree    | Exotic           | Fruit crop                  | TM45      |
| Annonaceae        | Annona cherimola Mill.             | Gishta (A)          | Tree    | Exotic           | Fruit crop                  | TM87      |
| Apiceae           | Anethum graveolens L.              | -                   | Herb    | Exotic           | Weed                        | TM10      |
| Daucus carota L.  |                                    | Carorot (A)         | Herb    | Indigenous       | Vegetable                   | TM57      |
| Apocynaceae       | Carissa spinarum L.                | Hagarma (O)         | Liana   | Indigenous       | Live fence                  | TM70      |
| Asparagaceae      | Agave americana L.                 | Argissa (O)         | Herb    | Exotic           | Househowd tool              | TM47      |
| Agave sisalina Perrine ex. Engler |                          | Argissa (O)         | Herb    | Exotic           | Househowd tool              | TM79      |
| Asteraceae        | Artemisia absinthum L.             | Arity               | Herb    | Exotic           | Medicine                    | TM24      |
| Conyza pyrophappo Sch. Bip ex A. Rich. |                      | -                   | Herb    | Indigenous       | Ornament                    | TM109     |
| Guizotia schimperi Sch.Bip ex. Walp. |                      | -                   | Herb    | Indigenous       | Weed                        | TM39      |
| Lactuca sativa L. |                                    | Selata (A)          | Herb    | Exotic           | Vegetable                   | TM108     |
| Panthenium hysterothoraphous L. |                      | Faramsiisa (O)     | Herb    | Exotic           | Weed                        | TM107     |
| Sillyburn marianum (L.) Gaertn. |                      | Sokooruu (O)       | Herb    | Exotic           | Weed                        | TM99      |
| Sonchus oleracus L. |                                    | Sokooruu (O)       | Herb    | Exotic           | Weed                        | TM58      |
| Spathodea campanulata P. Beauv. |                      | -                   | Tree    | Exotic           | Shade                       | TM65      |
| Tagetes patula L. |                                    | -                   | Herb    | Exotic           | Ornament                    | TM89      |
| Vernonia amygdalina Del. |                          | Ebichaa (O)        | Shrub   | Indigenous       | Household tool, medicine    | TM19      |
| Boraginaceae      | Cordia africana Lam.               | Wadeechea (O)      | Tree    | Indigenous       | Household tool, shade, medicine | TM15     |
| Brassicaceae      | Brassica carinata A. Br.           | Yeguragiegomen (A) | Herb    | Indigenous       | Vegetable                   | TM111     |
| Brassica oleracea L. |                                    | Goommana (O),      | Herb    | Exotic           | Vegetable                   | TM93, TM101 |
| Cactaceae         | Opuntia cylindrica (Lam.) DC.       | Qulqal (A)          | Shrub   | Exotic           | Live fence                  | TM30      |
| Caricaceae        | Carica papaya L.                   | Papay (A)           | Tree    | Exotic           | Fruit crop, medicine        | TM7       |
| Celastraceae      | Catha edulis (Vahl) Forssk. ex Endl. | Caatii (O)         | Shrub   | Indigenous       | Stimulant                   | TM6       |
| Chenopodiaceae    | Beta vulgaris L.                   | Qosta (A)           | Herb    | Exotic           | Vegetable                   | TM20      |
| Cucurbitaceae     | Cucurbita pepo L.                  | Dabaqua (O)         | Liana   | Exotic           | Vegetable, medicine         | TM46      |
| Lagenaria abysinica (Hook. f.) C. Jeffery |                      | Hadofu (O)         | Liana   | Indigenous       | Household tool              | TM59      |
| Cupresaceae       | Cupressus lusitanica Mill.         | Gaattiraa-faraanjii (O) | Tree | Exotic           | Live fence                  | TM48      |
| Juniperus procera Hochst. ex Endl. |                      | Gatira Habasha (O) | Tree    | Indigenous       | Construction, household tool | TM44      |
| Cyperaceae        | Cyperus rotundus L.                | -                   | Herb    | Indigenous       | Household tool              | TM13      |
| Euphorbiaceae     | Craton macrostachyus Del.          | Bakkania (O)        | Tree    | Indigenous       | Fuel wood, shade, household tool | TM60      |
| Euphorbia ampliphyla Pax. |                      | Adarmee (O)        | Herb    | Indigenous       | Weed                        | TM36      |
| Ricinus communis L. |                                    | Qobbbo (O)         | Herb    | Indigenous       | Household tool              | TM78      |
Table 2: Homegarden plants documented from Sebeta-Awas District (Continued)

| Family          | Species Name                      | Morphology | Use                                                                 | TM     |
|-----------------|-----------------------------------|------------|----------------------------------------------------------------------|--------|
| Fabaceae        | Acacia abyssinica Hochst. ex Benth. | Tree Indigenous | Fuel wood, shade, household tool                                      | TM9    |
|                 | Faidherbia albida (Delile) A. Chev. | Tree Indigenous | Shade, household tool                                                | TM1    |
|                 | Acacia mearnsii De Wild.           | Tree Exotic | Fuel wood                                                            | TM18   |
|                 | Acacia saligna (Labill) Wendl.     | Tree Exotic | Shade                                                                | TM4    |
|                 | Albizia schimperiana Oliv.         | Tree Indigenous | Shade, household tool                                                | TM8    |
|                 | Caesalpinia decapetala (Roth) Alston| Liana Exotic | Live fence                                                           | TM3    |
|                 | Calpurnia aurea (Ait.) Benth.      | Shrub Indigenous | Medicine                                                           | TM68   |
|                 | Erythrina brucei Schweinf.         | Tree Indigenous | Shade                                                                | TM52   |
|                 | Millettia ferruginea (Hochst.) Bak. | Tree Indigenous | Shade, household tool                                                | TM77   |
|                 | Phaseolus lunatus L.               | Liana Exotic | Pulse                                                               | TM49   |
|                 | Phaseolus vulgaris L.              | Liana Exotic | Pulse                                                               | TM71   |
|                 | Senna septentrionalis (Viv.) Irwin & Barnby | Tree Exotic | Fuel wood                                                           | TM17   |
|                 | Sesbania sesban                    | Tree Indigenous | Shade                                                                | TM49   |
|                 | Trifolium tembense Fresen.         | Shrub Indigenous | Weed                                                                | TM112  |
|                 | Vicia faba L.                      | Herb Indigenous | Pulse                                                               | TM110  |
| Flacourtiaceae  | Dasyalis caffra (Hook. f. & Harv.) Hook. f. | Shrub Exotic | Live fence                                                           | TM80   |
| Lamiaceae       | Mentha longifolia (L.) Hudson      | Herb Indigenous | fragrant                                                             | TM40   |
|                 | Mentha puegium L.                  | Herb Indigenous | Spice                                                               | TM94   |
|                 | Ocimum basilicum                   | Herb Exotic | Spice                                                               | TM74   |
|                 | Ocimum lamiifolium Hochst. ex Benth. | Shrub Indigenous | Medicine                                                           | TM66   |
|                 | Ocimum undecimflorum Roth          | Shrub Indigenous | Medicine                                                           | TM100  |
|                 | Osagea integrifolia Benth.         | Shrub Indigenous | Medicine                                                           | TM106  |
|                 | Rosmarinus officinalis L.          | Shrub Exotic | Fragrant                                                             | TM31   |
| Lauraceae       | Persea americana Mill.             | Tree Exotic | Fruit crop                                                           | TM2    |
| Loganiaceae     | Buddleja davidii Franch.           | Shrub Exotic | Live fence                                                           | TM82   |
| Lythraceae      | Punica granatum L.                 | Shrub Exotic | Fruit crop, medicine                                                | TM85   |
| Malvaceae       | Hibiscus sp.                       | Shrub Indigenous | Ornament                                                            | TM25   |
|                 | Malva verticillata L.              | Herb Indigenous | Medicine                                                           | TM64   |
|                 | Sida schippeniada Hochst. ex. A. Rich. | Herb Indigenous | Household tool                                                     | TM103  |
| Moraceae        | Ficus elastica Roxb.               | Tree Exotic | Shade                                                                | TM95   |
|                 | Ficus sur Forssk.                  | Tree Indigenous | Shade                                                                | TM29   |
|                 | Morus alba L.                      | Tree Exotic | Fruit crop                                                           | TM28   |
| Musaceae        | Ensete ventricosum (Welw.) Cheesman.| Herb Indigenous | Medicine, household tool                                             | TM41   |
| Myrtaceae       | Eucalyptus camaldulensis Dehnh.    | Tree Exotic | Construction, fuel wood, live fence                                  | TM5    |
|                 | Eucalyptus globulus Labill.        | Tree Exotic | Construction, medicine                                              | TM27   |
|                 | Myrtus communis L.                 | Herb Exotic | Fragrant                                                             | TM86   |
|                 | Psidium guajava L.                 | Tree Exotic | Fruit crop                                                           | TM53   |
| Nyctaginaceae   | Bougainvillea glabra Choisy        | Liana Exotic | Ornament                                                             | TM51   |
| Oleaceae        | Jasminum abyssinicum Hochst. ex DC. | Liana Indigenous | Medicine                                                           | TM91   |
|                 | Olea europea L. subsp. cuspidata (Wall. ex G. Don) Cif.| Tree Indigenous | Fragrant                                                             | TM22   |
| Phytolaccaceae  | Phytolacca dodcandra L’ Herit.     | Shrub Indigenous | Household tool                                                     | TM81   |
| Pinaceae        | Pinus patula Schiede ex. Schtdl. Cham. | Tree Exotic | Live fence                                                           | TM33   |
| Poaceae         | Arundo donax L.                    | Herb Exotic | Household tool, live fence                                          | TM97   |
Relative density is the number of individuals of a species as a percentage of the total number of individuals of all species in that area [30].

\[
\text{Relative density} = \frac{\text{Number of individuals of a species in the sample}}{\text{Total number of individuals of all species in the sample}} \times 100
\]

Multipurpose trees species occurring in home gardens of the study area were considered in the computation of densities and relative densities.

**Similarity and diversity indices**

Sørenson’s Index of Similarity was used to compare the degree of similarity of species in the 42 homegardens.
randomly selected from the seven study kebeles (6 homegardens in each kebele) based on the species composition of quadrats [32]. It was calculated using the formula 

$$S_s = \frac{2a}{2a + b + c}$$

where $S_s$ = Sorensen’s similarity coefficient, $a$ = number of species common to quadrat, $b$ = number of species in quadrat 1 and $c$ = number of species in quadrats 2. The coefficient values range from 0 (complete dissimilarity) to 1 (total similarity). This method was applied in all the 42 homegardens in the selected kebeles.

The Shannon-Weiner Index [33] was used to calculate and compare species diversity in the 42 homegardens in the seven study kebeles. It was calculated using the formula 

$$H = -\sum_{i=1}^{S} P_i \ln P_i$$

where $H$ = the Shannon diversity index, $P_i$ = fraction of the entire population made up of species $i$, $S$ = numbers of species encountered, $\sum$ = sum from species 1 to species $S$ and ‘ln’ is the natural logarithm to the base $e$ ($\log_e$).

**Results and discussion**

**Distribution, location and plant composition of homegardens**

Out of the 350 houses surveyed in the seven selected kebeles in the study District, 248 (70.9 %) had homegardens, of which 126 (36 %), were located in the backyard (Table 1). Homegardens had different sizes and shapes, and served as animal houses, grain stores and land for growing different plant species. The size of homegardens sampled ranged from 300 m$^2$ to 1200 m$^2$. Distinct variation in size, diversity and composition of species was observed among homegardens. With increasing size of homegardens, more richness of species composition was observed. A similar study conducted in southern Ethiopia [24] revealed that as the size of homegarden increases, so does the diversity of plant species. Concerning distance, some homegardens were located very close to houses, where as others were found at places a bit far from houses (at a walking distance of 5–7 min).

Homegarden plants in the study area were composed of trees, shrubs, herbs and climbers in different strata. They consisted of trees approximately 10 to 15 m tall on the upper strata (e.g., *Cordia Africana*), fruit crops 1 to 10 m tall in the middle strata (e.g., *Citrus sinensis*) and herbaceous plants up to 1 m tall on the ground strata (e.g., *Brassica carinata* and *Cymbopogon citratus*).

**Management of homegardens**

People in the study area have developed homegardens (locally called *eddo*) with considerable diversity and flexibility that support production of major livelihood crops. They have managed to select crops that co-adapt the local environment and that give multiple benefits. Some homegarden owners reported that they grew vegetables during the rainy season as well as the dry season by fetching water from where it is available. Some homegarden owners stated that they continuously manage plants for economic as well as ecological benefits. Crop residues, weeds, ashes and manures were reported to be used as fertilizers in homegardens. Few homegarden owners reported efforts made to reduce soil depletion in erosion-prone areas by planting shrubs (e.g., *Rosmarinus officinalis*) near the homestead.

Homegardens in the study area were open plots, or fenced or semi-fenced areas. Trees and shrubs were used as live fences to protect homegarden plants from predators. Management of homegardens was done through division of labor among family members. Observation and conversation with informants revealed that females played more roles than males in managing homegardens. Females were more involved in weeding, watering and planting, whereas, males’ activity was limited to fencing.

**Table 4** Homegarden nutraceutical plants recorded from the Sebeta-Awas District

| Botanical name     | Part used | Ailment treated                      | Method of preparation and use                        |
|--------------------|-----------|-------------------------------------|------------------------------------------------------|
| *Allium sativum*   | Bulb      | Headache, abdominal cramp and flue  | The bulb is eaten alone and/or pounded together with *Zingiber officinale* |
| *Carica papaya*    | Seed      | Intestinal parasites                | Fresh seeds are eaten                                 |
| *Cucurbita pepo*   | Seed      | Tape worm infection                 | Roasted seeds are chewed and swallowed                |
| *Ensete ventricosum* | Corm    | Broken legs and arms                | The underground part is boiled and eaten              |
| *Punica granatum*  | Leaf      | Tape worm infection                 | Decoction of leaves is drunk                          |
of females in hoeing, weeding, and harvesting has been indicated in works conducted in Tanzania [34] and Ghana [35]. Selection of crops or vegetables for homegardening has been done in consultation with household members although the final decision was left to women. Despite the fact that management of homegardens in the study area was mainly the responsibility of females, as explained by women homegarden owners, access to or control over its benefits depends on the type of production. Men had more control on major income crops (e.g., *Chata edulis*). Minor income generated from crops such as vegetables is controlled by women. In homegardens dominated by subsistence crops, females did most of the work. However, in homegardens dominated by cash crop fruit trees, women’s participation was very minimal. Such a clear gender division in homegarden responsibilities is frequently recorded in the literature, e.g., Vietnam [36] and Mexico [37] and Peru [38].

Exchange of seeds of selected varieties and knowledge among homegarden owners was reported to be common practices in the study area. Exchange of information regarding homegardens among relatives, friends, and neighbors played a role in maintaining local cultural knowledge and practices in the study area. Exchange of plant resources and information among local communities is essential for agrobiodiversity conservation [30].

### Richness and diversity of homegarden plant species

Out of 350 houses visited in the seven selected kebeles, 248 (70.9 %) had homegardens, of which 42 (6 from each kebele) were selected for detailed interview surveys. The interview survey revealed 113 homegarden plant species belonging to 46 families (Table 2) which supports the assertion that homegardens are valuable sources of plant agrobiodiversity [39]. It was found out that the family Fabaceae had the highest number of species (15 spp.), followed by Asteraceae (10 spp.), Lamiaceae (7 spp.), Solanaceae (6 spp.), Poaceae and Rosaceae (5 spp. each), and Myrtaceae and Rutaceae (4 species each). Five families had three species each. Other nine families had 2 species each and 24 families had one species each. Other nine families had 2 species each and 24 families had one species each. A study conducted in Loma and Gena Bosa districts of Ethiopia also reported the high number of homegarden plants belonging to the families of Fabaceae, Asteraceae and Poaceae [8]. Of the total species, 45 (39.8 %), were herbs, 34 (30.1 %) were trees, 26 (23.0 %) were shrubs and 8 (7.1 %) were climbers. *Cupressus lusitanica, Eucalyptus camaldulensis Eucalyptus globules* and *Grevellea robusta* were the canopy tree species. Among shrub species, *Catha edulis, Rosmarinus officinalis* and *Rhamnus prinoides* were the most prominent ones. Of the total reported homegarden plants, 63 (58 %) were found to be exotic species and 51 (48 %) were indigenous species (Table 2). The fact that the majority of homegarden plants were exotic might be attributed to their management suitability. Of the exotic plants, relatively higher number of species (24) was used as food plants and eight species were used as live fence. Relatively higher number of the indigenous plants (13 species) was used as source of medicine and nine species were used as household tools.

### Table 5 Results of paired comparisons on five homegarden nutraceutical plants in Sebeta-Awas District

| Medicinal plant name | Informants (coded R1 to R12) | Total score | Ranking |
|----------------------|-----------------------------|-------------|---------|
| *Allium sativum*     | 3 3 3 4 3 2 2 2 1 2 1 2 | 41          | 1       |
| *Carica papaya*      | 2 1 2 0 1 0 2 3 0 1 1 2 | 18          | 4       |
| *Cucurbita pepo*     | 2 2 2 3 3 3 1 3 3 3 2 0 | 30          | 3       |
| *Ensete ventricosum* | 3 2 4 3 3 4 2 1 3 2 3 2 | 37          | 2       |
| *Punica granatum*    | 1 1 1 1 1 1 0 2 1 1 1 2 | 14          | 5       |

### Table 6 Simple Preference ranking exercise on seven marketable homegarden plants in Sebeta-Awas District with the highest frequencies and relative frequencies of occurrence

| Botanical name | Respondents (R) | Total score | Rank |
|----------------|-----------------|-------------|------|
| *Artemisia absinthium* | 3 2 1 1 1 2 2 2 1 2 1 1 2 | 22          | 7     |
| *Catha edulis* | 7 6 7 7 7 7 7 4 6 7 6 7 | 92          | 1     |
| *Cymbopogon citratus* | 2 1 3 2 2 1 2 3 3 2 2 1 | 26          | 6     |
| *Myrtus communis* | 1 3 2 3 3 3 3 1 2 3 4 3 | 37          | 5     |
| *Rhamnus prinoides* | 5 4 5 5 5 6 5 4 7 5 5 5 | 72          | 3     |
| *Ruta chalepensis* | 4 5 4 4 4 4 5 4 5 4 4 | 60          | 4     |
| *Rosmarinus officinalis* | 6 7 6 6 6 5 6 6 6 7 5 7 | 85          | 2     |

Value 7 was assigned to the most valuable plant while 1 to the least valuable plant.
Of the study kebeles, Dima Guranda had the highest species diversity \((H' = 3.555)\), followed by Haro Jilla \((H' = 3.497)\). The lowest diversity index \((H' = 3.348)\) was computed for Dalety \((H' = 2.890)\) (Table 3). Homegarden owners reported that homegarden species diversity could be related to factors such as access to water, size of homegarden and infestation of plants by pests and weeds. Elsewhere, it was reported that low species diversity could be a result of the shifting from polycultural gardening practices to cultivating few income generating food crops [26].

### Diversity of uses of homegarden species

It was found that food plants (fruits, vegetables, legumes and pulses) constituted 25 %, of the recorded homegarden species (Fig. 2), which is in agreement with findings of studies conducted in Sabata town of Ethiopia [26] and in Loma and Gena Bosa districts of Ethiopia [8] where the most frequently maintained crops in the homegardens of Sabata town were reported to be those that serve as source of food. In the study area, medicinal and household tool plants comprised 13 and 10 % of the total reported plants, respectively.

#### Food plants

Food plants are cultivated in homegardens year round in the study area although most of these plants are available in adequate amount only during the main rainy season (June and September). Five nutraceutical plants were recorded from homegardens in the study area (Table 4). Paired comparison exercise conducted on all the five nutraceutical plants revealed *Allium sativum* and *Ensete ventricosum* as the most important nutraceutical plants (Table 5). The two species are the ones that are commonly used as nutraceuticals in Ethiopia as revealed in studies conducted elsewhere in the country [26, 40].

#### Medicinal plants

People of Sebeta-Awas District are dependent on medicinal plants grown in their homegardens in to partly fulfill their day-to-day health care needs. Twelve percent of the plants recorded from homegardens are medicinal plants. Of the medicinal plants, herbs were the most common used ones, followed by shrubs. Study conducted in homegardens of the Holeta town of Ethiopia also indicated the common use of herbs as sources of medicine [40].

#### Marketed plants

Homegardens support families in generating additional income although income varied with size of the homegardens. Farmers of Sebeta-Awas District who were in close vicinity to roads and local markets (Sebeta and Alemgana) gave priority to grow cash crops such as *Catha edulis*, *Rhamnus prinoides* and *Rosmarinus officinalis* in their homegardens. The role of home gardens in generating income to families in Ethiopia has also been reported by different authors [8, 26, 40, 41]. Focus to grow few cash crops by neglecting other beneficial crops could reduce the diversity of species managed in homegardens. Simple preference ranking exercise conducted on seven marketed homegarden plants in Sebeta-Awas District with the highest frequencies and relative frequencies of occurrence revealed *Catha edulis* as the most valued marketed homegarden plant, followed by *Rosmarinus officinalis and Rhamnus prinoides* (Table 6). The stimulant plant *Catha edulis* has been reported as one of three homegarden

### Table 7: Sorenson’s Index of similarity of homegarden species among seven selected kebeles of Sebeta-Awas District

| Study kebele | DG | DM | HJ | DA | GM | KO | KOC |
|--------------|----|----|----|----|----|----|-----|
| DG           | 1.00 |    |    |    |    |    |     |
| DM           | 0.66 | 1.00 |    |    |    |    |     |
| HJ           | 0.60 | 0.66 | 1.00 |    |    |    |     |
| DA           | 0.73 | 0.72 | 0.66 | 1.00 |    |    |     |
| GM           | 0.58 | 0.50 | 0.57 | 0.66 | 1.00 |    |     |
| KO           | 0.70 | 0.47 | 0.50 | 0.50 | 0.66 | 1.00 |     |
| KOC          | 0.63 | 0.66 | 0.80 | 0.27 | 0.81 | 0.66 | 1.00 |

DG Dima Guranda, HJ Haro Jila, DM Dima Magno, DA Dalety, GM Geja Migira, KO Korke, KOC Kotche

### Table 8: Result of direct matrix ranking exercise conducted on six multipurpose homegarden tree species in Sebeta-Awas District

| Species                  | Cordia africana | Croton macrostachyus | Acacia abyssinica | Acacia albida | Juniperus procera | Eucalyptus globulus |
|--------------------------|-----------------|----------------------|-------------------|---------------|-------------------|---------------------|
| Construction             | 40              | 21                   | 32                | 36            | 64                | 74                  |
| Soil fertility           | 38              | 30                   | 52                | 60            | 28                | -                   |
| Furniture/ Implements    | 65              | 42                   | 48                | 38            | 42                | 28                  |
| Charcoal/ fire wood      | 34              | 26                   | 60                | 56            | 25                | 59                  |
| Shade                    | 48              | 36                   | 50                | 32            | 38                | 24                  |
| Live fence               | 31              | 22                   | 32                | 24            | 66                | 59                  |
| Medicine                 | 35              | 62                   | 26                | 18            | 38                | 63                  |
| Total score              | 291             | 229                  | 300               | 254           | 301               | 307                 |
| Rank                     | 4               | 6                    | 3                 | 5             | 2                 | 1                   |
plants that generate the highest income in Holeta town of Ethiopia [40].

### Similarity among homegardens

Sorenson’s Index of Similarity calculated for homegarden plants in the seven selected kebeles revealed that there is highest similarity between homegardens of Kotche and Geja Migira kebeles, followed by that of Daley and Dina Guranda (Table 7).

### Multipurpose tree species

Local people in the study District grow in their homegardens plants having diverse uses. Direct matrix ranking exercise conducted on six multipurpose tree species selected during ethnobotanical survey showed *Eucalyptus globulus* as the most preferred multipurpose tree species, followed by *Juniperus procera* and *Acacia abyssinica* (Table 8). A direct matrix ranking exercise conducted by respondents in Holeta town of Ethiopia revealed *Juniperus procera* as the most preferred multipurpose tree species in homegardens [40].

### Homegarden plants with the highest frequency of occurrence

Marketed homegarden plants were assessed for their frequencies and relative frequencies of occurrence. It was found out that *Catha edulis* had the highest frequency and relative frequency of occurrence, followed by *Rosmarinus officinalis* and *Rhamnus prinoides*. Seven marketed homegarden plants with the highest frequencies and relative frequencies of occurrence are given in Table 9. Result of another study conducted in Jibithenan District, Ethiopia, showed *Catha edulis* as one of the top five most abundant woody species in homegardens [41].

### Homegarden multipurpose tree species with highest density of occurrence

Among multipurpose tree species in the study area, *Cupressus lusitanica* was found to be the most abundant one with the highest relative density, followed by *Eucalyptus camaldulensis* and *Eucalyptus globulus* (Table 10). The reason for this may be due to the availability of seedlings at local market and nursery sites in the nearby Sabata town. A study [26] revealed *Cupressus lusitanica* as having the highest relative density among homegarden tree species in Sabata town of Ethiopia.

### Factors affecting species diversity and productivity of homegarden plants

Main factors affecting the diversity and productivity of homegardens plants in Sebeta-Awas District have been reported by respondents. These, among others, include lack of access to water, size of the homegarden, and occurrence of pests and weeds. Shortage of water was mentioned as the main constraint in growing homegarden crops. According to the informants, homegardens in the study area were primarily dependent on rain and as a result diversity and productivity of plants was highly affected during the dry season. Water fetching from distant areas and use of irrigation have been reported to be laborious and time-consuming task. As explained by some informants, the effect of pests on some homegarden plants could not be undermined. *Galium aparineoides* and *Parthenium hysterophorus* were among the weeds that affect the diversity and productivity of homegarden plants. As noted by many authors, there are a number of factors affecting development of productive homegardens. These include sociocultural and economic factors [2, 42–46], ecological factors and farmers’ knowledge and awareness [47], access to land [48, 49] and labour inputs [7].

### Conclusions

Homegardens are still playing important role in the overall farming system in Sebeta-Awas District. The fact that the majority of households in the District have homegardens shows that gardening is considered important by farmers as it contributes towards ensuring household food security and income generation. The contribution of

### Table 9

| Botanical name                  | Frequency in percent | Relative frequency in percent |
|---------------------------------|----------------------|------------------------------|
| Artemisia absinthium            | 45.2                 | 1.63                         |
| Catha edulis                    | 80.9                 | 2.94                         |
| Cymbopogon citratus             | 52.3                 | 1.89                         |
| Myrtus communis                 | 47.6                 | 1.73                         |
| Rhamnus prinoides               | 73.8                 | 2.68                         |
| Ruta chalepensis                | 71.4                 | 2.59                         |
| Rosmarinus officinalis          | 78.5                 | 2.85                         |

### Table 10

| Botanical name                  | Abundance/ number | Density | Relative density % |
|---------------------------------|-------------------|---------|--------------------|
| Cupressus lusitanica            | 250               | 0.0264  | 0.0042             |
| Eucalyptus camaldulensis        | 92                | 0.0097  | 0.0015             |
| Acacia albida                   | 23                | 0.0024  | 0.0002             |
| Eucalyptus globulus             | 81                | 0.0085  | 0.0013             |
| Olea europaea subsp. cuspidata  | 29                | 0.0030  | 0.0004             |
| Cordia africana                 | 21                | 0.0022  | 0.0003             |
| Juniperus procera               | 28                | 0.0020  | 0.0003             |
| Grevillea robusta               | 68                | 0.0071  | 0.0011             |
| Acacia abyssinica               | 17                | 0.0017  | 0.0002             |
individual gardens to biodiversity conservation in the study District should also not be underestimated. In addition, homegardens provide important ecological, social, and cultural functions. Species diversity of homegarden plants in Sebeta-Awas District is affected by a number of factors. Water is the main factor limiting species richness and diversity as water is not always sufficiently available. Because of the need for large field crops as well as scarcity of land, there has been over time, decrease in homegarden plot size. People in the study area largely cultivate homegarden plants, which have better market values. Based on findings of the current research, it is recommended that farmers should be encouraged to manage their homegardens as homegardens play important role in ensuring food security and increasing household income. Community members in the study area should, therefore, be made aware of the role of homegarden plants in fulfilling their nutritional and other requirements as many seem to be not very much aware of such fact.

Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
The three authors had significant intellectual contribution towards the design of the study, data collection and analysis and write-up of the manuscript. The authors read and approved the final manuscript.

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