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The Impact of Urban Home Gardening on Plant Species Conservation and Environmental Sustainability

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Abstract
Home gardens are an important consideration in terms of environmental sustainability and plant species conservation and yet their significance is often unrecognized. This is particularly more relevant in tropical region such as Ethiopia as home gardens have been a way of life for centuries in the region generally and in Mekelle city in particular. The present study tries to examine the urban home garden practices and evaluate their significance towards environmental benefits and plant species conservation in Mekelle city. A total of 89 home gardens were randomly selected for the study. A combination of complete plant inventory, demarcation of plots with 10m*10m for tree plants, 5m*5m for shrubs and 1m* 1m for herbs as well as interview were used to collect data. The result showed that the cultivated land size of sample home gardens ranged from 50-500m^2 with mean 214.16m^2. About 99% of the assessed home gardens were established on open areas of their garden in response to getting more environmental benefits, food and cash to support family. From the total of 72 species that recorded in the home garden, Swiss chard (Beta vulgaris L.),Papaya (Carica papaya L.), Rhamnus prinoides ,Ruta chalepensis, and guava (Psidium guajava) were the most cultivated crops in the home gardens of the study site. The present study exposed that contribution of UHG goes beyond gap filling where, economic important and environmental benefited crops dominated in the home garden. The main advantages of urban home gardening practices are income supplementation, nutritional improvement due to food diversity by providing the urban society with fresh food and its urban environmental guarantee due to conserve plant species diversity and waste utilization. Paying due attention to urban home garden development has significant role in addressing environmental benefits in the future. The availability of water, improved seeds and incidence of pests and insects are the most determinant factors that influence the sustainability of urban home gardening.
Keywords: urban home garden, environmental benefit, plant species diversity, Mekelle, Ethiopia

Introduction

Home-gardens are said to have been parts of human subsistence strategies since the Neolithic period (Soleri and Cleveland, 1989) and they played important roles in the process of early plant domestication and continue to be the avenue for introduction and adaptation of new crops. Urban home gardening under urban agriculture (UA) has played significant role in food security and generating household income. Nevertheless the ability of UA to continuously supply food for the urban poor depends on better planning based on accurate geospatial information to enable sustainable management of the practice (Addo, 2010).

In addition to increasing the social and economic sustainability of food production, they can also contribute to environmental sustainability by decreasing inputs and negative environmental effects of food production. Studies of urban gardens at the household and community level are important to understand how such gardens might make more efficient use of resources and contribute more to household food security. Gardens can also contribute to sustainability at larger scales. Composting at home can significantly reduce household contributions to urban landfill; rainwater harvesting and recycling of gray water can reduce load on urban sewer and water processing; and urban garden production can reduce demand on energy intensive food production, processing and resource-intensive long-range distribution systems (David, 1997).

Several authors have commented on the merits of home-gardens for agro biodiversity conservation of plant genetic resources. Brookfield (2001), indicated that home-gardens are the valuable sources of agro biodiversity notably with regard to plant diversity. Eyzaguirre and Watson (2002), mentioned that home-gardens are refuges for wild species that are threatened in the wild by deforestation and environmental changes. Thus, the significant role of agro biodiversity in functioning of farming systems is meant that we are worried about the loss of genes which are the fundamental blocks of agro biodiversity (Mugwara and Gebre Egziabher, 2002).

UA's ability to do so in general and its sustainability in particular, however, is being threatened by population increase due to natural and rural-urban migration, coupled with urban expansion and infrastructure developments that are challenging with urban farming for available space and scarce resources such as water for irrigation (Gittleman, 2009). According to Tewodros (2007), urban environment is more complex and diverse, and its livelihoods are dynamic. Agricultural producers in urban areas are often discouraged and ignored by the society and in policy reforms. Planners tend to think that urban food growing is disorganized business and have little understanding of peoples' need to grow food in cities (Tewodros, 2007).

Production in the urban areas of Mekelle city like Industry Tabia is clearly oriented towards the

vegetable sector. There is a greater diversity of vegetable crops (13 species found) compared to the peri-urban areas such as Aynalem. Production is dominated by lettuce, potato, tomato, beetroot, pepper, and Swisschard; however, unlike in Aynalem there is no correspondence between most widely grown crops and ranking given by producers (Dereje et al., 2007).

It is imperative to conduct the research and document to find out the opportunities for the purpose of utilization and improvement honey bee sector. Therefore, this study was undertaken;

Materials and methods

Description of study area: Mekelle city,

Mekelle, a rapidly developing city in northern Ethiopia, is located about 780 km from the capital, Addis Ababa. Established nearly 150 years ago by Emperor Yohannes, the city is nestled in Ethiopia's temperate highlands, in the heart of a region that traces its origins back to the ancient Axum Empire that once controlled Red Sea trade (4th century BC – 10 century AD). The city maintains a proud history of many religions, particularly Orthodox Christianity, dating back to the 4th century AD. Mekelle was largely ignored in the latter half of the 20 century by Ethiopia's ruling feudal and socialist governments, but began to experience an economic and cultural rejuvenation with the election of a democratic government in the early1990s (Bryant,2009).

About 2250 ha of cultivable cropland are estimated to be available in the territory under the town's jurisdiction. 6628 households are engaged in urban agriculture mainly in the production of horticulture crops, supplying 27% of products in the town (another 25%of these products originate from surrounding hinterland up to 50 km away (MCPPPO interim unpublished report, 2005).

Geography: - Mekelle is located between 130 32' north latitude and 390 28' east longitude and elevation between 2000 to 2270 m.a.s.l. It is located in the northern highlands of Ethiopia, covering total area of 3500 hectares. The eastern side, Enda-Eyesus ridges are the highest peaks of the city. The major land form of the city territory can be classified into four categories namely: flat to gently sloping, gently sloping to rolling, sloping to moderately steep and steeply to very steeply sloping type. Mekelle's location in the region bordered by Sudan and Eritrea makes it a potential foreign trade harbour centre (MCPPP, 2007).

Population: - The population of Mekelle city is increasing from time to time. The major components of the city inhabitants are small scale merchants, civil servants and daily labourers. The population census of 2007 indicated that the population of Mekelle was 215,914 (110,989 are females and 104,925 are males) and 54,741 household head with 4 average family size per household. Most of this growth is mainly due to in migration (CSA, 2007).

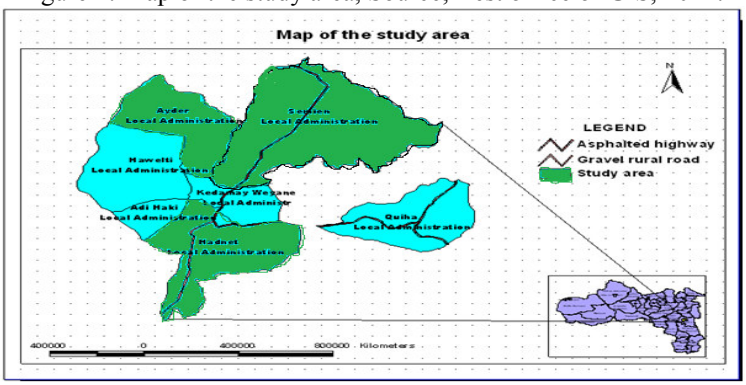
Climate: - Mekelle enjoys a mild climate that can be described as Weina Dega. During the dry season, the days are pleasantly warm and the nights are cool; in the rainy season, both days and nights are cool (MCPPP, 2007).

Rain fall: - there are two rainy seasons namely the Kiremt and Belg. The rain showers falling in the Belg rain season is too low for growth of plants as a whole. The main rain season is Kiremt whereby sufficient rain and moisture is available for plant growth. It is estimated that the average annual rain fall ranges from 579-650 mm. Even though the amount of rain falling in years is not showing significant difference, the erratic nature of the rain in the day records shows variability at once and didn't rain for weeks (MCPPP, 2007).

Temperature: - Mekelle, as part of the globe, is suffering much from global warming aggravated by the neighboring area deforestation and desertification influences. So, in the absence of cooling agent forest in the city and neighboring areas the temperature variation is high even from hour to hour. Out of the four seasons, Kiremt is cooler and Bega is hot. The average maximum temperature per year is 24.1 0c and the minimum is 11.11 0c. There is a time record where the maximum temperature reaches 29.9 0c and the minimum 1.6 0c. This shows that there is high temperature fluctuation. Temperature is high in March-May and low in October-December (MCPPP, 2007).

Wind: - the high wind speed force blown over the bare areas blew up the dust and fine soil very easily. The blown dust and soil are the serious sanitation and health problems to city inhabitants. The easterly windblown from the east during the dry season for a longer period of time in the year (October-March) is the more serious wind.UA in general urban home gardening in particular has a potential role to tackle the disasters of global climate change like gusty wind, higher temperature, water stress, soil erosion, flood and deforestation.

Figure 4: Map of the study area, Source; Rest office of GIS, 2012.



The city is made up of urban and peri-urban areas, and is divided into seven sub-cities which are; Ayder, Semien, Hawelti, Adi-haqqi, Hadnet, Quiha and Qedamay-weyane local administrations. According to Mekelle Urban Agriculture Office unpublished report, in 2011, each of the seven local administrations has urban agriculture offices under their administration. The total land area of Mekelle is 3500 hectare (MCPPP, 2007).

Study site selection and sampling

The presence of well-established traditional home-garden practices, easy accessibility to important accesses and previous study experiences were important factors for considering Mekelle. The three local administrations for the present study were selected (Ayder, Semien including Tabias Industry and Felegda'aro and Hadnet including Tabias Aynalem and Kebele 17) from the seven current merged local administrations due to their significance amount of home gardens (MUAO unpublished report, 2011).

Two stage sampling technique were employed in this study to collect the primary data. Firstly, the three local administrations (LA) (Semien, Ayder and Hadnet) and 6 Tabias (2 from each LA) were purposely selected due to its availability of home gardens. Secondly, the sample home gardening households were selected from each Tabia with a farm size of less than 500m^2 and greater than 30m^2 and the number of households is calculated according to Cochran's (1977), formula.

$$no = \frac{(t)\,2*(p)\,(q)}{(d)\,2} \qquad n1 = \frac{no}{(1+ no\,/\,Population)}$$

Where,

n_0 = required return sample size according to Cochran's formula=15.21

n_1 = required return sample size because sample > 5% of population.

t = value for selected alpha level of .025 in each tail = 1.96. (The alpha level of .05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error).

(p)(q) = estimate of variance = .25. (Maximum possible proportion (.9) * 1- maximum possible proportion (.1) produces maximum possible sample size).

d = acceptable margin of error for proportion being estimated = .05 (error researcher is willing to except). Having in mind these limitations, the sample size was used in order to arrive at the sample size of 89.

Table 1: Distribution of Sample Households by local administration and Tabias

The study area	Selected local administration	Selected Tabia	Number of home garden producers with 30-500m^2	Sample households
Mekelle	Semien	Felegda'aro	243	14
		Industry	618	15
	Ayder	Adiha	280	16
		Kebele 03	457	15
	Hadnet	Aynalem	272	14
		Kebele 17	446	15

Source: Census of Mekelle urban agriculture office, 2010.

Data collection methods

The data for this study were collected from primary and secondary sources. Primary data were being obtained from sample households (community representatives, key informants and experts). They were interviewed to get information on the home garden producer characteristics, resource management (i.e. compost preparation and utilization, waste and water utilization) and home gardening production processes, marketing behavior and product distribution methods, home garden product consumption aspects and constraints faced by producers

through semi- structured interview questionnaires.

Focus Group Discussions (FGDs) and direct field observations were also used as a source of primary data. Respondents were asked also about household demography, land holdings, garden history, and factors affecting the sustainability of the practice in city. Secondary data was obtained from available records, internate, published and unpublished materials.

Data processing and analysis

The quantitative data collected from various sources through interviews, observation, counting and other secondary sources was analyzed by employing version 16 SPSS (Statistical Package for Social Science), Microsoft office excel software and Palanthological (past new 3) software. Descriptive statistics were used to provide a summary statistics related to variables of interest and to examine household demography that benefited through this practice with in household.

To determine home garden product income and consumption effect, number and distribution (%) of sample households by marketable supply of home garden products and how much consumed frequently was also measured. The linear regression analysis was used to see what independent variable was more influenced to income of individual sample households.

Data analyses of species diversity

Frequency: describes the distribution of a species through a stand. It is determined by calculating the percentage of plots / quadrates in a sample area on which a given species occurs.

$$F = \frac{\text{Number of quadrates in which a species occurs x 100}}{\text{Total number of quadrates in the sample}}$$

This was applied to find out the frequency of plant species in the quadrates of home-gardens; where the number of quadrates in which a species occurs was divided by the total number of houses or total number of quadrates respectively and multiplied by 100.

Relative frequency: is the distribution of one species in a sample relative to the distribution of all species.

$$\text{Relative frequenc} = \frac{\text{Frequency of a species in the sample x 100}}{\text{Total frequency of all species in the sample}}$$

This method was applied to calculate the frequency of plant species in the quadrates of 30 home-gardens of the study area divided by the total frequency of all plant species in the sample and multiplied by 100.

Density: is the average number of individuals of a species on a unit area basis.

$$\text{Dencity} = \frac{\text{Number of individuals in the sample}}{\text{Total area of the sample (m2)}}$$

This method was applied to compute the number individuals of tree species in the 30 quadrates of home gardens of the study area divided by the total area of the sample.

Relative density: is the density of one species relative to the density of all species.

$$\text{Relative frequenc} = \frac{\text{Number of individuals of a species in the sample x 100}}{\text{Total number of individuals of all species in the sample}}$$

This method was applied to compute the number individuals of tree species in the quadrates of 30home gardens divided by the total number of individuals of all tree species.

Shannon and Wiener diversity index

Shannon and Wiener (1949) index of species diversity was also applied to quantify species diversity and richness. This method is one of the most widely used approaches to measure the diversity of species.

H'= -Σ (pi ln pi), where H' is Shannon and Wiener diversity index, 'Pi' is the proportion of each species in the sample; 'ln' is the natural logarithm to the base e (log e). Values of the index usually lie between 1.5 and 3.5 although in exceptional cases, the value can exceed 4.5. The higher the value of H', the more diverse the species are within the site. Evenness J is equal to the H' divided by maximum possible diversity i.e. J= H' /H' max, where 'J' is species evenness, H' is Shannon and Wiener diversity index and 'H max' is lnS where Sis the number of species. The values for evenness range from 0 to 1. Equitability near zero shows the site to be dominated by one species, while a value near 1.0 shows it to have equal balance between all species.

Sorensen's similarity coefficient and cluster analysis was tested using the Palanthological software and clustered in to similarity of HHH with spp cultivated with in HG. To determine the factors that govern sustainability of the home garden were evaluated the number and percent distribution of respondents that affected by major factors. The home gardening households were requested to rank the major factors which include aspects like availability of water, incidences of pest and insects, availability of seed and seedlings, land

tenure, availability of farm land, extension service, access to inputs and utilities.

Result and discussion

Demographic and socio economic characteristics of HG households

In addition to that, MUAO unpublished report, (2011) shows that there are over 11,000 of households were participated in urban agriculture and whose livelihoods are associated with farming in the town. According to Federal Democratic Republic of Ethiopia Population Census Commission (2008) population of Mekelle city is about 257, 290, with annual growth rate of 5.4 percent, and an average family size of 5 people (FDREPCC, 2008).

he age of respondents ranged from 35 to 68 years with a mean of 47.3. The great majority of the urban home gardeners (78.4%) belong to the age group above 40 and below 60 years. Only 4.5% households of the selected gardeners are over 60 years of age (Fig 1). On the other hand, the proportion of the urban home garden farmers group below the age of 40 and above the age of 18 years contains about 16.9%. Hence, it is safe to say that most of the participants in the activity belong to the medium age groups. So that the age group between 40 and 60 years is mostly participated on the home gardening practice.

As regards the distribution of the urban home garden farming household heads by sex, males are predominating in the heading of the activity (56.2%). But the 85.4% of female house hold members are participated actively in this practice. This indicates that, the urban female garden members are adapted and practiced by themselves to produce foods from their garden to their kitchen.

Environmental benefits of Urban Home Garden

Urban home garden had the potential of improving the environmental quality of the city in general and the near home garden sites in particular through the recycling of wastes for composting, thus reducing waste management costs, by putting to use vacant areas, by converting degraded and unkempt vacant lots into healthy green areas, thus contributing to city beautification and by promoting organic and other low input technologies for the management of soils, pests, diseases and weeds as well as recycling of waste water in to irrigation. The Table 10 stated that the main type of fertilizer used to boost home garden productivity is farm yard manure. It covered 94.4% from the total fertilizer. It is used whether directly from farm yard to home garden farm or by converting to compost.

Table 10: % of fertilizers and composting material type mostly used by households (n=89)

Type of fertilizer	Frequency	Percent	composting material	Frequency	Percent
farm yard manure	84	94.4	farm yard manure	63	70.8
Compost	4	4.5	waste materials from home garden	23	25.8
artificial fertilizer	1	1.1	waste materials from house	3	3.4
Total	89	100.0	Total	89	100.0

Source: own survey data, 2012.

From the total households that prepared compost 70.8% is used the farm yard manure as main compost material followed by waste materials from home garden beneficiaries(25.8%) as the main composting material and 3.4 of the total compost beneficiaries are used waste materials from house as main composting material. But the pure compost preparation and application is not significant due to less technical support and less awareness about its advantage. The application of artificial fertilizer is low in 1.1% of the total gardeners due to its scarceness in small amount and its expensiveness.

In most low-income countries, rapid urban population growth and unmanaged expansion are degrading the environment of not only cities, but also their surrounding regions. The result is polluted air, water, and soil; increased temperature; soil erosion; sharply diminished biodiversity; and increased vulnerability to disasters such as floods. Urban farming can not only reduce the negative environmental impacts of urban growth, but can even (Jac et al., 2001).

Literatures stated that growing city will produce more and more wastewater and organic wastes. For most cities the disposal of wastes has become a serious problem. Urban agriculture can help to solve such problems by turning urban wastes into a productive resource (RUAF, 2007).

The Mekelle City administration has not been able to collect and disposes of the waste satisfactorily, plus cost recovery poses a critical problem. Solid waste collection services only about 50 percent of households most of the time (Mekelle Municipality, 2008).

The present study were agreed with Jac et al.(2001), the utilization of recycled solid wastes for composting material is a solution for both social, economical and ecological problems of the city in order to have healthy, least cost and beautiful environment. There for, urban home gardening in Mekelle City has the positive role on improving environmental condition. In addition to that, some of the tree and plant species are specifically planted in the home garden to improve the environment around the homestead. These include Dredawa zaff

(Delonix regia), Neem, Auwh'i (Cordia africana), Avecado (Persea americana) Awlie (Olea europaea subsp.) and a number of ornamental plant species (both trees and shrubs). These trees provide shade and clean air for the homestead, and beautify the surroundings.

Plant species diversity in home gardens of the study area

Frequency

The survey of home-gardens in the study area indicated that from the total households in Mekelle town who practiced home-gardening 82% having their home-gardens as front-yards only, 10.1% as back yards and the lower proportion (7.9%) is as side yard . The frequency of home gardens surveyed in the study area by LA is described in (Table 11). The home gardens of the area have different shapes. Some encircle the house; others are square, rectangular or irregular.

Table 11: Frequency and position of home-gardens surveyed in the study area (n=89)

local administration of households	Counted and % from total	position of garden to living home			Total
		front yard	back yard	side yard	
Semien	Count	25	4	1	30
	% of Total	28.1%	4.5%	1.1%	33.7%
Ayder	Count	24	2	4	30
	% of Total	27.0%	2.2%	4.5%	33.7%
Hadnet	Count	24	3	2	29
	% of Total	27.0%	3.4%	2.2%	32.6%
Total	Count	73	9	7	89
	% of Total	82.0%	10.1%	7.9%	100.0%

Source: own survey data, 2012.

The home gardens of Mekelle are generally rich in crop species where a total of 72 cultivated crops are grown with an average of 14.6 crops per farm. Most reports of home gardens indicate the total diversity of plant species including crops, trees, ornamentals, creepers and other herbs. This study is in agreement with the finding of Jensen (1993) found 60 plant species in only one garden of 0.13 hectare, of which 21 were ornamentals. In general, home gardens in the tropical highlands areas such as Mekelle have low plant species diversity because rainfall and temperature conditions are less favorable than in the humid lowland tropical.

In the present study, purposely planted and cultivated crop plants are mostly considered. Some ornamentals, weeds, grasses, side rood trees and shrubs are not included. Out of the total number of 72 crop species, 74% were food crops and spices, the rest 26% were ornamentals and others. The result obtained here is in line with what was reported for the Chagga home gardens (Fernandes et. al., 1984). These authors reported the presence of 58 herbaceous and 13 woody crop plants. In a study conducted in the home gardens of Welayita and Gurage zones of Southern Ethiopia, a total of 60 crop plants were recorded with an average of 14.4 crops per farm (Zemede Asfaw and Zerihun Woldu, 1997). The total number of species as well as the average number of crops per farm in this study is closely similar to what was reported for Welayita and Gurage home gardens. This study presented that from the most abandon species papaya (Carica papaya L.) and (Rhamnus prinoides)were frequented in 88% of the total households which are the higher commonly species and Tomato (Lycopersicon esculentum Mill.) frequented in 54% of the total sample beneficiaries, which is the least frequented species.

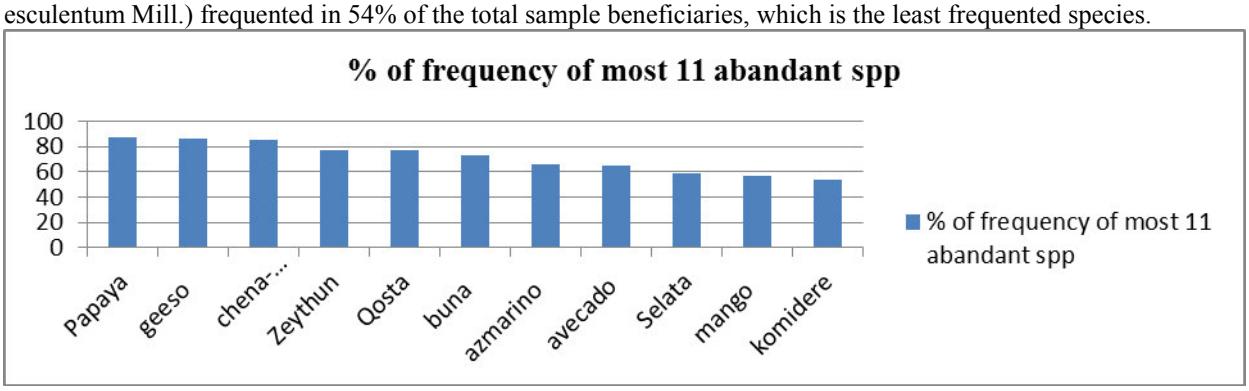


Figure 10: percent of frequency of the most abundance 11 species in the study area

Relative frequency

This method was applied to calculate the frequency of plant species in the quadrates of all selected home-gardens of the study area divided by the total frequency of all plant species in the sample and multiplied by 100 (see table 12).

Table 12: The relative frequency of the most 11 abundance crop species

s/no.	spp local name	scientific name	spp family	freq	RF
1	Papaya	Carica papaya L.		78	4.72
2	geeso	Rhamnus prinoides	Rhamnaceae	77	4.66
3	chena-addam	Ruta chalepensis	Unidentified	76	4.60
4	Zeythun	Psidium guajava	Myrtaceae	69	4.18
5	Qosta	Beta vulgaris L.	Chenopodiaceae	69	4.18
6	buna	Coffea arabica	Rutaceae	65	3.94
7	azmarino	Rosmarinus officinalis L.	Lamiaceae	59	3.57
8	avecado	Persea americana	Lauraceae	58	3.51
9	Selata	Lactuca sativa L.	Asteraceae	52	3.15
10	mango	Mangifera indica	Anacardiaceae	51	3.09
11	komidere	Lycopersicon esculentum Mill.	Solanaceae	48	2.91

The abundance of crops in these gardens is generally uneven because some species, particularly Papaya, geeso (Rhamnus prinoides) and (Ruta chalepensis) are more dominant. The dominance of these crops is due to their wide nutritional, socioeconomic and ecological roles in the systems. Papaya (Carica papaya L.) is the main staple food which is produced in large quantities, while (Rhamnus prinoides) is the major cash crop due to its socioeconomic impact. They can be grown in integration with each other and with other crops. This complex combination of plants plays an important ecological and socioeconomically role by reduction of erosion, provision of organic matter, and regulation of water and temperature.

Density

Density is the average number of individuals of a species on a unit area basis. This method was used to compute the number individuals of tree, shrubs and herb species in the whole quadrates of home gardens of the study area divided by the total area of the sample.

Table 13: Calculated density value of tree species in the study site

species local name	species scientific name	species family	number of spp per 0.3 ha	density of woody spp
Akacha	Acacia saligna	Mimosidea	1	3
Apple	Malus sylvestris Miller	Rosaceae	49	163
Aranshi	Citrus sinensis (L.) Osb.	Rutaceae	36	120
Auwh'i	Cordia africana	Boraginaceae	15	50
Avecado	Persea americana	Lauraceae	52	173
Awlie	Olea europaea subsp. cuspidata	Oleaceae	15	50
Dredawa zaff	Delonix regia	Unidentified	5	17
Enjorie	Morus alba L	Moraceae	11	37
Espathoda	Spathodea campanulata P.	Unidentified	14	47
Gravillia	Grevillea robusta R.Br.	Proteaceae	15	50
Kazmeer	Casimiroa edulis	Rutaceae	17	57
Kokki	Prunus persica	Rosaceae	25	83
Kwih'a	Salix subserrata	Unidentified	3	10
Mango	Mangifera indica	Anacardiaceae	72	240
Nim	Azadirachta indica	Meliaceae	25	83
Qelamitos	Eucalyptus globulus	Myrtaceae	251	837
Shewshewwie	Pinus patula	Pinaceae	15	50
Tikur berbere	Schinus molle L.	Anacardiaceae	8	27
Trngi	Citrus medica L.	Rutaceae	11	37
Tsehdi	Juniperus procera	Cupresaceae	50	167
Zeythun	Psidium guajava	Myrtaceae	149	497

A total of 252, 231 and 356 individuals per 0.3 hectare and 840, 770 and 1187 per hectare of woody species were encountered in the Semien, Ayder and Hadnet local administration respectively. Accordingly, the total densities of woody plants were about 838 per 0.3 hectare and 2797 individuals per hectare in the total plots of selected areas. More than one-fourth of the density was contributed by only one species, A. Eucalyptus

globulus Species and around one-fifth of density was contributed by Psidium guajava. Species such as Acacia saligna, Salix subserrata, Schinus molle L. and Citrus medica L. exhibited very low densities in the study area. The most abundance three woody species in the urban home garden of the study area were Eucalyptus globulus (837no./ha),Psidium guajava (497no./ha) and Mangifera indica(240no./ha).When I compare with study conducted by Yami et al, (2006) revealed that the most abundant woody species in the 29-year old enclosure were Dodonea angustifolia (293 no./ha), Acacia etbaica (225 no./ha), and Euclearacemosa subsp.schimperi (207 no./ha).Even there is a difference in species type with the old enclosure; the urban home gardens have a visible role on conserving woody species in cities.

Relative density

Relative density is the density of one species relative to the density of all species. This method was applied to compute the number individuals of tree species in the quadrates of 30 home gardens divided by the total number of individuals of all tree species. Table 14 indicates that from the tree species identified on the sampled plots Myrtaceae family had been dominated and Eucalyptus globules has the highest relative density (29.9%) fallowed by Psidium guajava (17.8%) and Mangifera indica.

Table 14: The relative diversity of tree species in the study site

spp local name	scientific name	Family	total no. of spp per 30 quadrates	Relative density
Akacha	Acacia saligna	Mimosidea	1	0.11919
Apple	Malus sylvestris Miller	Rosaceae	49	5.840286
Aranshi	Citrus sinensis (L.) Osb.	Rutaceae	36	4.290822
auwh'i	Cordia africana	Boraginaceae	15	1.787843
avecado	Persea americana	Lauraceae	52	6.197855
Awlie	Olea europaea subsp. cuspidata	Oleaceae	15	1.787843
dredawa zaff	Delonix regia	Unidentified	5	0.595948
Enjorie	Morus alba L	Moraceae	11	1.311085
Espathoda	Spathodea campanulata P.	Unidentified	14	1.668653
Gravillia	Grevillea robusta R.Br.	Proteaceae	15	1.787843
kazmeer	Casimiroa edulis	Rutaceae	17	2.026222
Kokki	Prunus persica	Rosaceae	25	2.979738
kwih'a	Salix subserrata	Unidentified	3	0.357569
mango	Mangifera indica	Anacardiaceae	72	8.581645
Nim	Azadirachta indica	Meliaceae	25	2.979738
qelamitos	Eucalyptus globulus	Myrtaceae	251	29.91657
Shewshewwie	Pinus patula	Pinaceae	15	1.787843
Tikur berbere	Schinus molle L.	Anacardiaceae	8	0.953516
Trngi	Citrus medica L.	Rutaceae	11	1.311085
Tsehdi	Juniperus procera	Cupresaceae	50	5.959476
Zeythun	Psidium guajava	Myrtaceae	149	17.75924

Source; own survey data, 2012

Plant Diversity

A total of 72 plant species were recorded from the study area (Appendix I). In terms of the number of plant species in the home-gardens contain, the Rutaceae family placed first with 5 species, followed by Rosaceae and Solanaceae, 4 and 3 respectively. Climbing's had less number of spp and percent of all plant species recorded from the study area are summarized and among them, Carica papaya L. had the highest frequency followed by Rhamnus prinoides and Ruta chalepensis. The figure below also discussed that the most abundant tree species was Eucalyptus globules followed by Psidium guajava and Mangifera indica.

Shannon and Wiener diversity index

Shannon and Wiener (1949) index of species diversity was applied to quantify species diversity with richness. This method is one of the most widely used approaches to measure the diversity of species.

Agro ecosystem diversity and evenness are calculated using the Shannon index (H′), one of the most popular (Brower, 1998), Shannon's index measures both richness (the number of species) and evenness, or how evenly individuals are distributed among species.

Values of the index usually lie between 1.5 and 3.5 although in exceptional cases, the value can exceed 4.5. The higher the value of H', the more diverse the species are within the site. The Shannon indices of tabia

Ayder reached 3.368, followed by Shannon indices of tabia Semien 3.023, and Shannon indices of tabia Hadnet which is 2.911. It is safe to say that, home gardens in Ayder are more diverse than Semien and Hadnet, and home gardens in Hadnet are less diverse.

The evenness values are not high enough to justify uniformity in composition of plant species. This is expected because in agroecosytems not all crops are required in equal volume. For instance, staple food crops that are consumed in large quantities necessarily need a large area of production, whereas crops such as spices that are required in small quantities are grown in smaller spaces. Papaya and geeso (Rhamnus prinoides), which are the key species in the system, accounted in 87.64% and 86.52% households respectively of the total area of crop production at the sampled sites. Swiss chard (Beta vulgaris L.), which is the main cash crop vegetable in the town, it distributed in about 77.53% of the sampled home gardens under the city. This pattern is more or less similar across the whole local administrations of the city.

J was calculated to find the species evenness, Hence that, the values for evenness range from 0 to 1. Equitability near zero shows the site to be dominated by one species, while a value near 1.0 shows it to have equal balance between all species. The calculated J values for the three selected sites in my study are identified as follow. J value of home gardens in Ayder is (0.826), which is greater than J value of home gardens in Semien (0.7727) and J value of home gardens in Hadnet (0.7647). So, the study site has equal balance between all species.

Contribution of functional groups of crops in selected home gardens

A total of 8 functional groups of crops were recognized each represented by 3 to 19 species of crops (Appendix 3) and an average of 5.5 groups were found in each farm. Out of the average number of 14.6 crops per farm, fruits crops contributed 28%, followed by vegetables, roots and tubers as one group (18%), plants for shades and construction materials(18%), live fence and ornamentals (10%), stimulants (8%), medicinal crops (7%), spices (6%) and fodder crops (5%)(Figure 11). It should be noted that this proportion shows the number of crop species in the commodity groups and it doesn't have any relation with their abundance or area coverage in the farms.

The functional group of plants is derived from 28 plant families (Appendix 2). The study reveals that particularly the families Rutaceae and Solanaceae are important in the livelihood of the people in the area. The plant family with the most species used is the Myrtaceae. The most important species in this family are Eucalyptus and globulus Psidium guajava. The family Rutaceae includes the Citrus species that include C. sinensis and C. Limon. Though citruses are supplementary foods, they contribute vitamins and minerals to the diets of the Mekelle people. Citruses also serve as minor cash crops.

The number of crop species grown in a farm is an important indicator of diversity. However, from the utility point of view, it is not only the number that matters, but also the diversity in functions of the crops. In order to fulfill the dietary and cash requirements of the households, food crops composed of carbohydrates, proteins, fat, vitamins, as well as cash crops were fairly represented in the systems. The average number of commodity groups per farm was 5.5 and the variability among the households is not large.

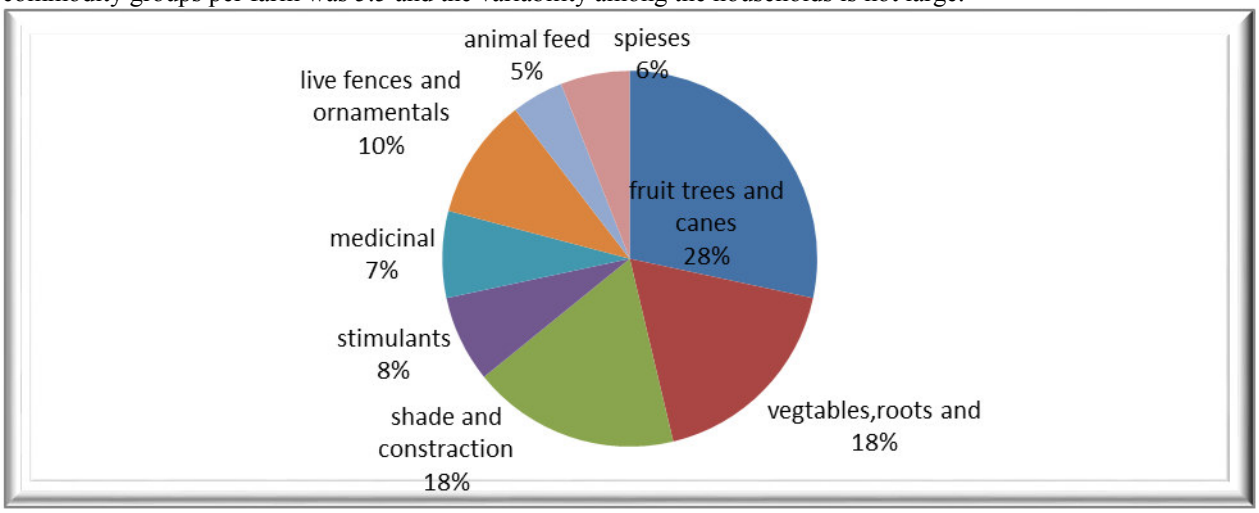


Figure 11: the % of functional group plant species within UHG

The garden flora is composed of vegetables, fruits, ornamentals, live fences, spices, medicinal and other useful plants; according to my study most of ornamental, trees in organizations like church, mosque, etc and crops on the side roads were not included in my results. Among the tree crops shading and ornamental plants were dominated with 46 food crops of the garden, fruits make 11.28%, vegetables 7.52%, root and tuber crops 6.02%, pulses 4.5% and the rest goes for the other categories. For the other useful plant components of the

garden, miscellaneous (31.57%), wild or semi-wild edible plants (5.27%), material for crafts (4.51%), plants with pleasant smell (3.01%), spice plants (2.26%), and with lower proportions that account for the other categories. The stimulants, which account for only 1.50% of the species, are the most important ones as they include the cash crops like Coffea arabica and Catha edulis.

Mekelle home gardens collectively maintain a larger proportion of the useful plants. This diversity can be seen under the eight categories of garden crops within and in the immediate surrounding area of the home garden environment (Table 15).

Table 15: Number of species of useful plants found in and around home gardens

Category of useful plants	**Number of species**				
	Herbs	**Shrubs**	**Trees**	**Climbers**	**Total**
Total Crops purposely cultivated in home gardens	28	14	21	2	65
Traditional medicinal plants found in UHG	18	12	7	1	38
spice and flavor Crops cultivated in HG	4	3	3	0	10
cultivated vegetables found in the HG	12	0	0	1	13
fruits cultivated in the home gardens	0	6	10	1	17
Live fence plants	0	3	11	1	15
Crops cultivated for stimulant purpose	2	3	3	0	8
Wild or cultivated animal feed crops found in HG	10	15	18	1	44
Wild and cultivated Shading and ornamental plants found in the HG	14	9	21	2	46
Total recorded useful plant species	88	65	94	9	256

Source own survey data, 2013

Many introduced ornamentals are not recorded, and multipurpose species have been recounted in multiple categories. When the live fence, shade species and the useful vegetable and fruit species found close to the home gardens are added to the conventional crops, the real magnitude of the species diversity of the home gardens emerges. A complete list of the useful plants of the home garden environment in Mekelle is not available, partly because the surveys are not yet complete and the flora of Mekelle is not well enough known to facilitate their authentic identification.

Sorensen's similarity coefficient and cluster analysis was also analyzed using the Palanthological software. The result is showed that the UHG are clustered in to five similar household with similar spp cultivated with in their home garden (see figure 12).

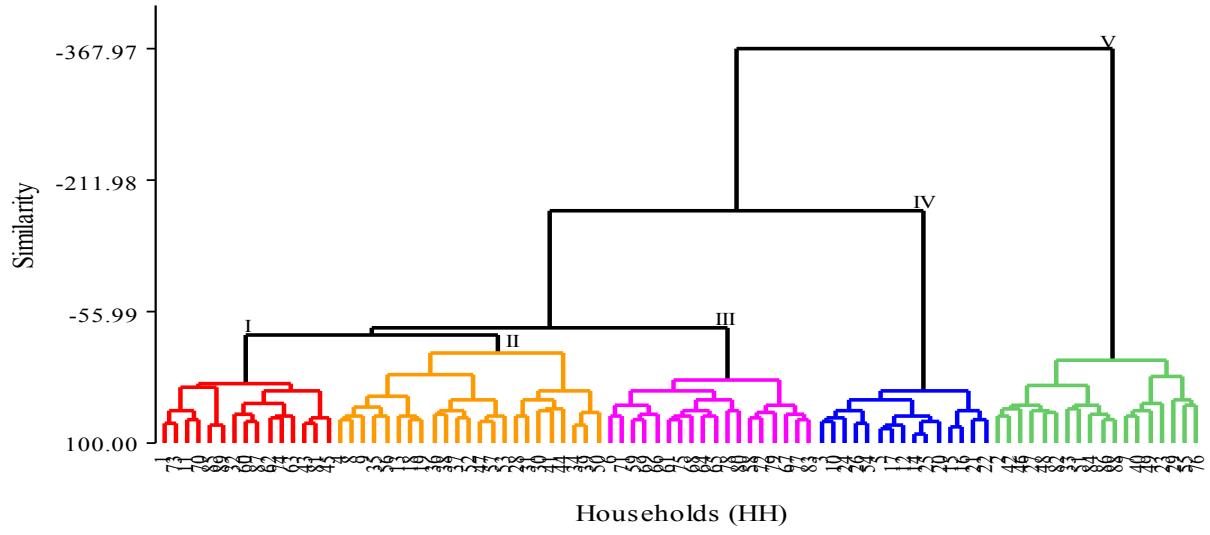


Figure 12 Similarity of households with similar plant spp

Factors influencing sustainability and productivity of UHG

This study tries to identifying the factors that affect sustainability and productivity of urban home garden systems of northern Ethiopia, Mekelle city. Various factors affect the home gardening sustainability and diversity of plant species in the study area. All of the sample household home-garden owners of the area on the average identified more than two factors which they considered to affect continuity of their gardens are water availability, pests/insects, extension support system, land-holding system/land tenure, availability of farm land, availability of fertilizer, availability of seed, availability of seedling and credit services are among the factors

that were frequently mentioned by the owners of home-gardens. Factors that affect home-gardening practice sustainability and respondents' frequencies were given in the following figure.

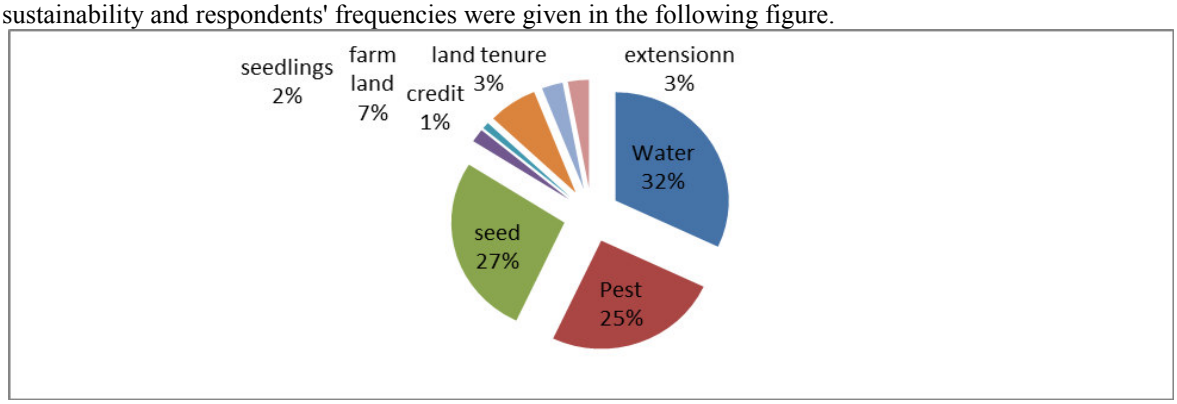


Figure 13: factors affected the sustainability of UHG

The main factor that affected the home garden continuity in the urban areas is shortage of water due to its expensiveness and not constant available throughout the year. It is the main factor that responded by 31.5% of the total sampled households as theirs 1st problem followed by shortage of seeds which is characterized by (shortage of improved and small amount of horticultural crop seeds). Responded by 27% of the total sampled households as theirs 1st problem, incidence of pest/ insects responded by 24.7% of the total sampled households as theirs 1st problem. Credit service is not the main problem for their home garden inputs because; it needs list cost starting capital for home gardening practices. One household only responded credit service as the first factor to continue his home gardening practices. In addition to this shortage of farm land is the 2nd factor to most of respondents and extension service and land tenure are the 3rd factor responded when filling the ranking of problems by the respondents.

Table 16: The factor that affects HG sustainability with its remark by respondents

s. no.	Factors	Frequency	Percent	Remark
1	Water availability	28	31.5	Because, the pipe water is expensive and not constant
2	Pests/insects	22	24.7	Mostly aphids in cabbage, cottony cousin and hedgehog in the larger farms are common
3	Shortage of seeds	24	27.0	Specially improved vegetable seeds with smallest amount
4	Shortage of seedlings	2	2.2	grafted and improved fruit seedlings
5	Credit services	1	1.1	
6	Shortage of farm land	6	6.7	
7	Unclear land right /land tenure/	3	3.4	
8	Extension support	3	3.4	Especially for home gardening practices is very low
	Total	89	100.0	

This study is indicating that among local administration, water availability is different as common problem which leads to broken down most of household's home garden productivity. Similarly, since horticultural products are vulnerable to water access the local administrations are different in vulnerability to water sources due to nature of the sites. Water availability in Semien is the most common problem reflected by 43.3% of the total household who have water problem as the 1st factor fallowed by Hadnet.

Table 17: The factor affects HG sustainability distributed response by local administrations

The main factor that affects home garden sustainability	local administration of households			Total
	Semien	Ayder	Hadnet	
water availability	13	5	10	28
pests/insects	4	7	11	22
shortage of seeds	7	10	7	24
shortage of seedlings	2	0	0	2
credit services	0	1	0	1
shortage of farm land	2	4	0	6
unclear land right /land tenure/	0	3	0	3
extension support	2	0	1	3
Total	30	30	29	89

Source; own survey data, 2013.

Water availability in local administration Ayder is not faced as the common problem because this site has potential of underground water source found the underground water within 4-5m deep as we checked in most home garden owner households. The Table 16 shows that the factors that are mentioned by the sampled households as the 1st factor that faced in their home garden and the frequency of respondents in the selected local administrations. In addition to this incidence of pests and insects is the most common factor in local administration Hadnet and the shortage of improved seeds is the 1st problem in Ayder. In the other hand, there are also measures taken to minimize the mentioned factors such as digging of hall born water, cultural pests and insects' management practice, recycling improved seeds and seedlings within farms, construction of soil and water conservation methods and waste water utilization to irrigation are the most common.

Conclusions

The study exposed that active participants in urban home gardening are middle aged people with having education and large family size. Female household members are mostly activated on the garden management practices improvement of food diversity to household members. The gardens cover species related to health, fence, shade, spiritual and recreation needs, as well as financial income sources. The urban home garden systems of Mekelle city are diverse and complex agro-ecosystems where a total of 72 and an average of 14.6 crop species per home garden of different size and lifecycle are grown in a close association. The abundance of crops is even because average evenness of the site o.787 notably. Swiss chard (Beta vulgaris L.) and Papaya (Carica papaya L.) are the key species in these systems.

A total of 8 functional groups of crops are present in these systems, out of which an average of 5.5 groups exists in each farm. The presence of crops with different functions fulfils the nutritional and monetary needs of the households. The basic food crops, Swiss chard (Beta vulgaris L.) and papaya (Carica papaya L.), which are rich in nutritional value are supplemented by other fruits, vegetables and stimulants in the home garden. This contributes to balanced food diversity, which is necessary for healthy and productive farm families. The income from cash crops of the functional groups contributes to fulfillment of their material and other needs.

The diversity of crops varies among local administrations within the study site. Variation occurs in the diversity and area share of major crops among the selected sample sites. In these sites the share of tree species like akacha, awlie, auwh'i and Tikur berbere were minimize.

Sustainability of urban home gardens depends on deferent factors the main are water availability, seed availability, pests/insects, as well as extension support system.

Recommendations

The plant species conserved within the urban home garden should be given a great care and attention from experts and responsible persons in order to minimize the vulnerability from disasters.

The practice of urban home-gardening which establishes mainly to improvements on the status food diversity through multipurpose species should be given attention by responsible agencies and could be suggested as an alternative plan of action in famine prone areas of the country.

Important contributions of the urban home-gardens with respect to socio economic and environmental benefits should be encouraged by Mekelle Urban Agricultural Office and Environmental Protection Sections to protect from the potential hazards or constraints of the environment such as pollution, stream cuts, erosion, wind speed, higher temperature, rugged topography and quarry.

The functional group of crops in the home garden should be conserved by the Agricultural Office of the town and home gardeners. Because, they are important as sources of food, income, job, quality of nutrition as

well as environmental suitability in the study area.

Giving attention to availability of water, availability of improved seeds and incidence of pests and insects should be made to enhance the sustainability of UHG.

Paying due attention to home garden development has significant role in addressing household food diversity, income generation and plant species diversity in the future.

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