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Species Assortment and Biodiversity Conservation in Homegardens of Bahir Dar City, Ethiopia

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በከተሞች የመኖሪያ ቤት አፀድ ወይም በጓሮ የአትክልት ስፍራ የብዝሃ ህይዎት መኖር በምግብ እጦት መቸገርንና ከምግብ ጋር የተያያዙ የጤንነት ችግሮችን ከመፍታት አኳያ ከፍተኛ ሚና ሊጫዎት ይችላል። ይህንን ግንዛቤ ውስጥ በማስገባት በባህር ዳር ከተማ በጓሮ የአትክልት ስፍራዎች የሚገኙ የሰብል፣ ዕፅዋትና እንስሳት ዓይነቴዎችን ስብጥርና ተለያይነት ለማወቅ ያለመ የዳሰሳ ጥናት ተካሂዶ ነበር። ጥናቱን ለማካሄድ በ7 ክፍለ ከተሞችና በቀድሞ አጠራር 12 ቀበሌዎች ውስጥ ነዋሪ የሆኑ 178 የቤተሰብ ኃላፊዎችን በናሙናነት በመውሰድ ቃለ መጠይቅ የተደረገላቸው ሲሆን፣ በእያንዳንዱ ናሙና የጓሮ የአትክልት ስፍራ የሚገኙ የፍራፍሬ ሰብሎችን ዓይነትና ብዛት፤ የሌሎች ዕፅዋትና እንስሳትን ዓይነት ወይም ብዛት በቆጠራ ለማወቅ ተሞክሯል። የጥናቱ ውጤት እንደሚያስረዳው በናሙናነት በተወሰዱት የጓሮ የአትክልት ስፍራዎች 58 የተለያዩ የዕፅዋት ዓይነቴዎች ማለትም 17 (28.8%) ዓይነት የፍራፍሬ፤ 12 (20%) ልዩ ልዩ ጥቅም ያላቸው ዕፅዋት፣ 11 (18.6%) የአትክልት፣ 11 (18.6%) የመድሀኒትና መዓዛማ፣ 8 (13.6%) የቅመማ ቅመም ወይም ማጣፈጫ ዕፅዋትን ያካተቱ ሆነው ተገኝተዋል። ሰንባች የሆኑ ዕፅዋት ብቻ ተወስደው ሲታዩ ደግሞ በስፋት የተገኘው ማንጎ (20.8%) ሲሆን፣ ዘይቱን (13.4%)፣ አቮካዶ (11.6%)፣ ፓፓያ (11.2%) እና ኒም ወይም ፐርሺያን ላይላክ (9.9%) በቅደም ተከተል ይታያሉ። ከሁሉም በላይ ጥናቱ የተካሄደባቸው የከተማው የጓሮ የአትክልት ስፍራዎች የመድሀኒትና መዓዛማ ዕፅዋትን ጠብቆ ከመያዝ አንፃር ከፍተኛ ዕድል እንደሚሰጡ ለማረጋገጥ ተችሏል። ይሁንና በከተሞች ጫፍ ባሉ የጓሮ አትክልት ስፍራዎች በአትክልትና ፍራፍሬ ሰብሎችና በጫት መካከል የቦታ ሽሚያና የመተካካት አዝማሚያ እንዳለ የታየ በመሆኑ ለወደፊት ትኩረት የሚፈልግ ሆኖ ተገኝቷል። በአጠቃላይ ከጥናቱ ውጤት መረዳት እንደተቻለው የባህርዳር ከተማ የጓሮ የአትክልት ስፍራዎች ብዝሃ ህይዎትን በተለይም ደግሞ በተፈጥሮ በሚገኙበት ስኑ-ምህዳር የመጥፋት አደጋ የተጋረጠባቸውን የዕፅዋት ዝርያዎችን ጭምር አቅቦ ከመያዝና የተለያዩ ጠቀሜታዎችን ከማስገኘት አኳያ ከፍተኛ ሚና እንዳላቸው ተስተውሏል። ስለሆነም ጥናቱ የሚያቀርበው ምክረ ሃሳብ የከተሞች የዕድገት ፕላን ሲነደፍ የከተማ የጓሮ ግብርናን ግንዛቤ ውስጥ በማስገባት ብዝሃ ህይዎት ወዳድ የጓሮ የአትክልት ስፍራዎችን በመፍጠር ተገቢውን የስርዓተ ምህዳር አገልግሎት እንዲሰጡ ማድረግን ታሳቢ ያደረገ እንዲሆን ነው።

Abstract

Biodiversity in urban gardens can play a vital role in the fight against hunger and diet-related health problems. A study was undertaken to assess the species composition and diversity of homegardens in Bahir Dar City. Interviews were administered to 178 sample households residing in 7 Sub-cities covering 12 former kebeles, and inventories made on fruit species in gardens and types of other higher plant and livestock species recorded. The plant component was found to be dominant with 58 higher plant species of various use; 17 fruit (28.8%), 12 miscellaneous-use (20%), 11 vegetable (18.6%), 11 medicinal (18.6%) and 8 spices/condiments (13.6%). The most abundant perennial plant species was mango (20.8%) followed by guava (13.4%), avocado (11.6%), papaya (11.2%) and Persian Lilac (9.9%). Especially, the City gardens were found to offer a unique opportunity for preservation of medicinal & aromatic plants. There however appears a competition and substitution between horticultural and other crops like Chat in the outer city gardens. Generally, the study revealed that the urban gardens are a storehouse of biodiversity including species that run the risk of disappearance in the natural habitat. It is suggested that City development planning considers urban gardening so as to create a biodiversity-friendly gardens that offer a wide range of ecosystem services.

Introduction

Driven by various factors the urban population of Ethiopia is fast growing. It has increased from 3.7% in 1984 to 7.1% in 1994 to 14.2% in 2007 to 19% in 2014 and predicted to climb up to 38% in 2050. Like wise, the urban population of Amhara State grew from 2% in 1984 to 3.7% in 1994 to 7.5% in 2007 and about 16% in 2015 (Schmidt and Mekamu Kedir, 2009; PRB 2015). As urban population expands, so does the urban landscape (Dearborn & Kark, 2009). Consequently, cities are rapidly expanding their territory into the immediate hinterlands to have room for the growing urban population. This has led to conversion of potential agricultural land and a decline of rural land that in turn instigates further migration to cities.

Urbanization directly transforms the local biophysical environment and changes the conditions for organisms living there, generating new selection pressures and adaptations. Accordingly, apart from heavily drawing on natural resources, including water and often consuming prime agricultural land, urbanization is known to have a knock-on effect on biodiversity and ecosystem services (SCBD, 2012). Indeed, among the many human activities that cause habitat loss, urban development produces some of the greatest local extinction rates and frequently eliminates the large majority of native species (Mckinney, M 2002).

Therefore, as urbanization increases and the natural environment become increasingly fragmented, the importance of green spaces for biodiversity conservation grows (Goddard et al. 2010). Even small green spaces in an urban context can provide high impact ecosystem services (Dearborn and Kark, 2009). In this case, the greatest extent of vegetated land in cities is probably contributed by urban gardens (Gaston *et al.,* 2005), which compared to most naturally developing communities, are among the more unusual forms of botanical assemblage where diverse mixtures of both planted and volunteer species, containing a very high proportion of aliens co-exist.

Biodiversity in urban food systems plays a critical role in the fight against hunger and diet-related health problems and is key in developing resilient food systems (SCBD, 2012). Around 15 percent of the world's food is now grown in urban areas (Food Thank, 2015). In Russia, urban land produces 30 % of the total food grown in the country and 80 % of the vegetables. One-half of the vegetables consumed in Havana, Cuba are grown in the town's farms and gardens. Singapore has 10,000 urban farmers who produce 80% of the poultry and 25% of the vegetables consumed (CFSCUAC, 2003). In Dareselam, urban vegetable production was reported to have significant positive contribution for reducing income and non-income poverty (Masashua *et al*., 2012). Hence, urban farming holds a substantial potential in terms of enhancing household food and nutritional security, providing informal employment, income diversification through sales of surplus produce or savings on food expenditures. Moreover, preserving urban biodiversity is recognized for its important role playing in intrinsic value, natural and cultural heritage, sense of place, climate amelioration, noise amelioration, pollution filtration, water-sensitive urban design and human health and wellbeing (McDonnell and Hahs, 2012). Furthermore, urban green spaces contribute to climate-change mitigation through increasing carbon storage and uptake, providing more shade and cooling thereby reducing overall energy consumption, and significantly reducing the urban heat island effect (SCBD, 2012). Consequently, enhancement of biodiversity in urban homegardens is very crucial which its composition and configuration exerts a strong influence on the pools of species that temporarily use, colonize, or persist in urban areas (Smith et al., 2006).

The work reported here is the first attempt to obtain a quantified description of the higher flora and fauna from a range of Bahir Dar city homegardens so as to understand their contributions to biodiversity conservation and use. It specifically looks at species assemblage and how species are represented across gardens, with especial reference to fruit bearing species.

Material and Methods

Description of the Study Area

The study was undertaken in Bahir Dar City (11°35′30′′ N; 37°23′′E), the capital of Amhara State of Ethiopia in 2012/13. The City is set by the southern shore of Lake Tana which is the country's largest lake. The metropolitan area of the City extends up to 25km radius with 4 satellite Cities, and covers a total area of 16,000 hectares (Figure 1). Blue Nile river drains from Lake Tana and placidly flows crossing the city North to South leaving approximately three quarter of the city westward on its long journey to the White Nile River and the Mediterranean Sea. The topography of the City is predominantly flat with an altitude ranging from 1786 to 1870 meters above sea level. The slope varies from close to zero to some 20 % in few hillsides, most parts of the City being below 2 %. The average annual maximum and minimum temperature of Bahir Dar is 26.2°C and 10.9°C, respectively while the mean daily temperature is 18.5°C. The City receives a mean total rainfall of 1224mm per annum that extends between May/June and September/October. The population of the City is estimated at 204,368 (BoFED, 2011).

Research Methodology

The study assessed plant and animal assemblages in a randomly selected 178 homegardens in 7 Sub-cities covering 12 former *kebeles*[1] of Bahir Dar main land City. These include: Gishe Abay (Kebele 1 & 2), Tana (Kebele 3, 15 and 16), Belay Zeleke (Kebeles 7&17), Shum Abo (Kebeles 8, 9 and 10), Hidar 11 (Kebele 11), Shimbit (Kebele 13) and Ginbot 20 (Kebele 14). Data were collected by means of structured and semi-structured interviews, which was administered to sample household head informants. In a guided tour through their gardens complete inventories were carried out on fruit species, while types of other perennial plants species, vegetables, ornamentals, spices and medicinal/aromatic plants and livestock species were also recorded. A free-listing technique was used to elicit the most important fruit species for the growers as per Puri and Vogl (2005).

[1] the smallest administrative unit

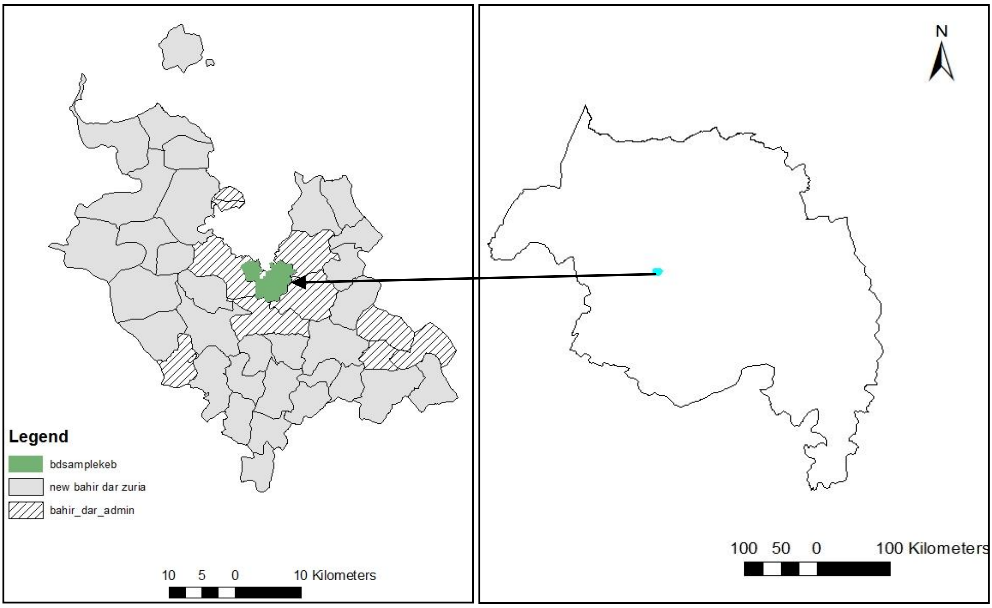

Figure 1. Map of the study area (left: Bahir Dar City; right: The Amhara State)

Data Analysis

Average species richness was calculated using sample-based exact species accumulation curves as per Kindt and Coe (2005). Species relative frequency was calculated as number of gardens with the species divided by the sum of occurrences of all species multiplied by hundred. Fruit species diversity was estimated using Shannon Diversity Index (H) and calculated as (Magurran, 1988):

$H = -\Sigma Pi * \ln Pi$

where, H = Shannon Diversity Index; Pi = proportion of individuals found in the i^{th} species; ln = is the natural logarithm of this proportion

Fruit species Evenness (E) was calculated as the ratio of observed diversity to maximum diversity as Pielou (1969):

$E: \frac{H'}{\ln S}$

where, H′ = Shannon diversity index; S = species richness; ln = is the natural logarithm of this proportion

The relative abundance of fruit species was calculated as percentage of a species out of the total abundance of all fruit species and depicted using rank-abundance curves. Rényi diversity profiles were calculated following Kindt et al. (2006) to order and rank Kebeles in fruit species diversity.

Rényi diversity profiles:

$H\alpha = \frac{\ln \Sigma Pi\alpha}{1-\alpha}$

where, $H\alpha$ = Rényi diversity profile; Pi = proportional abundance of a species;α = scale parameter with values 0, 0.25, 0.5, 1, 2, 4, 8 and ∞. The values at α = 0, 1, 2 and ∞ correspond to species richness, Shannon diversity index, reciprocal Simpson and Berger-Parker diversity indices

Species composition similarities of Kebeles (Beta Diversity) was judged using Sorenson index proposed for qualitative data as (Magurran, 1988):

$$D = \frac{2J}{A+B}$$

; where, D = distance; j = the number of species found in both sites; a = the number of species in site A, and b = the number of species in site B. The results were then subtracted from unity to display in terms of dissimilarity value.

Smith's saliency index was calculated by listing species by each informant and ranking inversely, and dividing the inverted rank of each species by the number of species in the free-list (Puri and Vogl, 2005).

Data were analyzed using statistical softwares: ANTHROPAC 4.0 (Borgatti, 1992) and Biodiversity R. package (Kindt and Coe, 2005) built on the free R 2.1.1 statistical program and its contributing packages (R Development Core Team, 2005). Because of the small sample size the two Kebeles of Gishe Abay sub-city were merged and considered as one Kebele during analysis.

Results and Discussion

Species spectrum

As mixed farming practice is commonplace with the majority of rural neighbourhood farms, so was the case in Bahir Dar City gardens. The homegarden species portifolio showed that annual and perennial plants and livestock species are in chorus with a greater prominence of the perennial plants component. The plant component composed of a total of 58 higher plant species with 5 major use categories; viz, 17 fruit bearing species(28.8%), 12 miscellaneous-use species (20%), 11 vegetable species (18.6%), 11 medicinal species (18.6%), 8 spice/condiment species (13.6%) as well as several ornamental species. There is a widely held notion that increasing trend of urbanization accelerates biodiversity loss (Akinnifesi et al., 2010) and that disturbed or man-made landscapes generally harbour less species than natural ecosystems. Contrary to this assumption, however, this study suggested that urban gardens in Bahir Dar City are rather quite rich in higher plant species. This might be related to its age since the older the city is the richer. Although its origin can be traced back to 16th century modern urban development in Bahir Dar was started in the mid 1990's which is enough time to develp mature gardens housing moderate level of species richness. Putting all perennial plant species together, the most abundant species was mango (20.8%) followed by guava (13.4%), avocado (11.6%), papaya (11.2%) and Persian Lilac (9.9%). The dominance of fruit bearing species is consistent with Akinnifesi et al. (2010) in Săo Lùis City of Brazil which may suggest urban gardens are primarily used for economic fuctions.

Fruit crops

Fruit Species Richness

Seventeen fruit species were recorded in 171 (96%; n=178) fruit growing gardens of 26332m^2 total area that are represented by ten families. Rutaceae emerged the most dominant family to which 41.2% of the species are belonged. Eight families are represented each by a single species while the Rosaceae family is represented by two species, peach and apple (Table 1). The dominance of Rutaceae family in home gardens has been previously reported at Zeghe gardens (Alemnew et al., 2007), southern Ethiopia gardens (Belachew et al., 2003) and western Amhara gardens (Fentahun and Hager, 2008) which is perhaps related to wider adaptation and long history of citrus species in the country.

Table 1. Relative abundance and frequency of fruit species in Bahir Dar City homegardens

Scientific name	Common name	Family name	Absolute Frequency (%) n=171	Relative Frequency (%) n=575
Mangifera indica L	Mango	Anacardiacae	88.30	26.26
Persea americana Mill.	Avocado	Lauraceae	49.12	14.61
Psidium guajava L.	Guava	Myrtaceae	56.73	16.87
Musa paradisiaca L.	Banana	Musaceae	22.81	6.78
Carica papaya(Linn)	Papaya	Caricaceae	47.37	14.09
Casimiroa edulis L.	White Sapotae	Rutaceae	14.04	4.17
Citrus aurantifolia Swingle	Lime	Rutaceae	25.15	7.48
Citrus aurantium L.	Sour orange	Rutaceae	1.17	0.35
Citrus sinensis Osbeck	Sweet orange	Rutaceae	12.87	3.83
Annona squamosa L.	Custard Apple	Annonaceae	4.68	1.39
Punica granatum L.	Pomegranate	Punicaceae	6.43	1.91
Citrus reticulata L.	Mandarin	Rutaceae	1.17	0.35
Prunus persica L.	Peach	Rosaceae	2.92	0.87
Passiflora edulis	Passion Fruit	Passifloraceae	0.58	0.17
Citrus limon Burm.	Lemon	Rutaceae	1.17	0.35
Malus domestica	Apple	Rosaceae	1.17	0.35
Citrus medica L.	Citron	Rutaceae	0.58	0.17

Since the total number of species of two gardens combined is not always equal to the sum of the species on the two gardens, species accumulation curves were used to portray the average pooled species richness when all gardens are combined together. Accordingly, as shown in figure 2, after 15 gardens are combined 10 of the 17 species have already been captured while after half of the gardens are accumulated 15 of the species were captured. The accumulation curve reached an asymptote by the 119th garden indicating that the sampling effort has been sufficient to collect most of the species present. Generally, the result indicates that there is a relatively small species turnover among gardens across Kebeles.

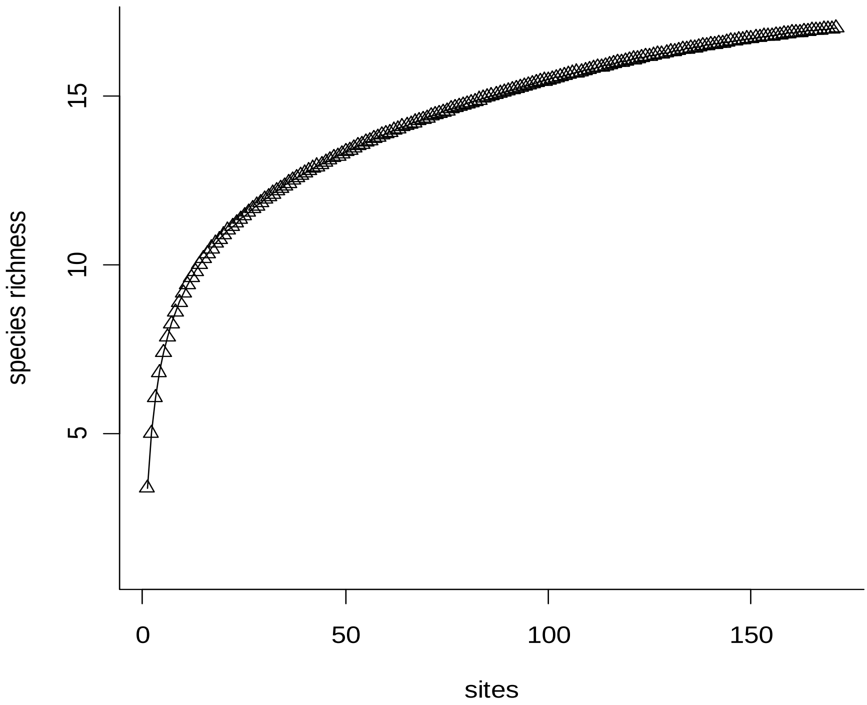

Figure 2: Fruit species accumulation curve for 171 gardens of Bahir Dar city

The mean number of fruit species per garden was found to be 3.4± 1.6 SD and ranged between 1 and 9 species. Some 78% of the gardens possess 4 or less species (data not shown). At Kebele level, the mean species richness was 10.17 and ranged between 8 and 13. The mean number of fruit species per kebele was 3.21 and ranged from 1.87 at Kebele 17 to 4.0 at Kebele 11. The higher number of fruit species at Kebele 11 is perhaps because it is a relatively lately urbanized area that still tends to have a rural setting compared to Kebele 14, which is in downtown (Table 2).

Table 2. Fruit species richness and diversity of gardens in Bahir Dar City

Parameter	Kebele											
	1&2	3	7	8	9	10	11	13	14	15	16	17
Sample size	10	15	15	15	15	15	15	15	18	15	15	15
Mean no. of species per garden	2.7	3.27	2.87	3.53	3.4	3.47	4	3.67	3.67	3.2	2.87	1.87
species richness	8	11	10	13	10	10	11	9	11	11	9	9
Species abundance	75	108	87	136	221	94	128	493	181	101	104	54
Shannon Diversity Index	1.63	1.97	1.86	2.01	1.73	1.79	1.72	0.89	1.64	1.62	1.74	1.62
Eveness	0.64	0.65	0.64	0.58	0.56	0.60	0.51	0.27	0.47	0.46	0.63	0.56

Fruit Tree Species Abundance and Frequency

The average number of fruit trees of all species per garden of all kebeles (N=171) was 1782, and ranged from as low as one to as high as 218 trees with a mean abundance of 10.4±20.3SD. Some 70% of the gardens contain 7 or less number of fruit trees (data not shown). Likewise, the average fruit abundance per Kebele was 8.74 and varied between 3.18 at Kebele 17 to 29 at Kebele 13. The higher fruit abundance at kebele 13 than Kebele 17 is because of the fact that the outer ages of Kebele 13 are yet dominated by peri-urban settings. Generally, the results revealed that Bahir Dar City home gardens have good level of fruit species richness even better than the surrounding rural *kebeles* where only 15 species were recorded in a previous study (Fentahun and Hager, 2008). This study disagrees with McKinney (2002) who stated that the lowest species diversities along the urban-rural gradient occur in the intensively "built" environments of the urban core. Rather species composition in Bahir Dar city does not show pronounced change along the urban-rural gradient that species did not become proportionately less common toward the urban core.

The steepness and the sharp decline of the rank-abundance curve after a few species in Figure 3 shows that there is uneven distribution of fruit species across gardens. Accordingly, only a few species occur in greater abundances, highly abundant and reltively most frequent species being mango (48.4% & 26.3%), guava (12.3% &16.9%), avocado (12.3% & 14.7%%) and papaya (11.7% & 14.1%) that are grown by 88.3%, 56.7%, 49.1% and 47.4% of the gardeners, respectively (Table 2). This finding is in agreement with Fentahun and Hager (2008) who had reported similar trends in the surrounding rural home gardens. The average number of fruit trees per garden was 5.1, 1.4, 1.3 and 1.2 for mango, guava, avocado and papaya, respectively. Likewise, the free list results corroborate that mango; avocado, banana, papaya, and guava have higher salience values of 40.9, 19.3, 11.5, 10.4 and 10.4%, respectively demonstrating that these are more preferred fruit species by the gardeners justifying their higher abundance and frequency. This is instructive that fruit development interventions in Bahir Dar home gardens might need to give priority to these fruit species. The prominence of these species can generally be explained by the warmer climate of Bahir Dar that favors their growing, and perhaps simplicity of their propagation as they are customarily regenerated from seeds and wildlings not a recommended practice though.

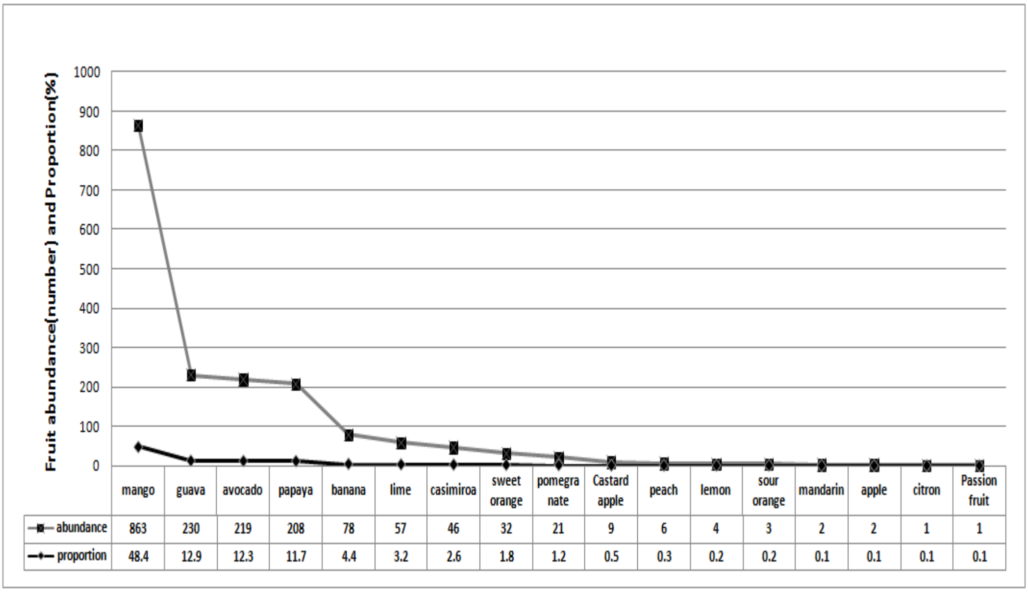

Figure 3: Rank abundance (number) and proportion (%) of fruit species in Bahir Dar City homegardens (N=1782)

Fruit Species diversity

Diversity indices are known to provide important information about rarity and commonness of species in a community by offering a summary of richness and evenness in a single statistic. In the present study, the Shannon diversity index for the entire gardens was calculated at 1.86 (Table 2) which is about 65.7% of the maximum possible value that would have been obtained had all species occurred at equal frequency (2.83) which suggests a moderate level of diversity. Kebele 8 with a Shannon diversity index of 2.01 appears to be the most diverse while Kebele 13 recorded the least fruit diversity (0.89). This was further elucidated in figure 4 by the Rényi diversity profiles. In diversity profiles a site of higher diversity than a second site will have a diversity profile that is everywhere above the profile of the second site (Tóthmérész, 1995). In this regard, comparison of fruit species diversity among Kebeles based on Rényi Diversity Profiles revealed that most of the Kebeles could not be discretely ordered in species diversity. Nevertheless, for its lowest profile Kebele 13 is a site with the lowest species diversity while Kebele 8 for its higher profile above most of the sites appears to be a site of highest species diversity. In terms of fruit species evenness, as shown in table 2, Kebele 3 appears most even (0.65) while Kebele 13 is most uneven (0.27).

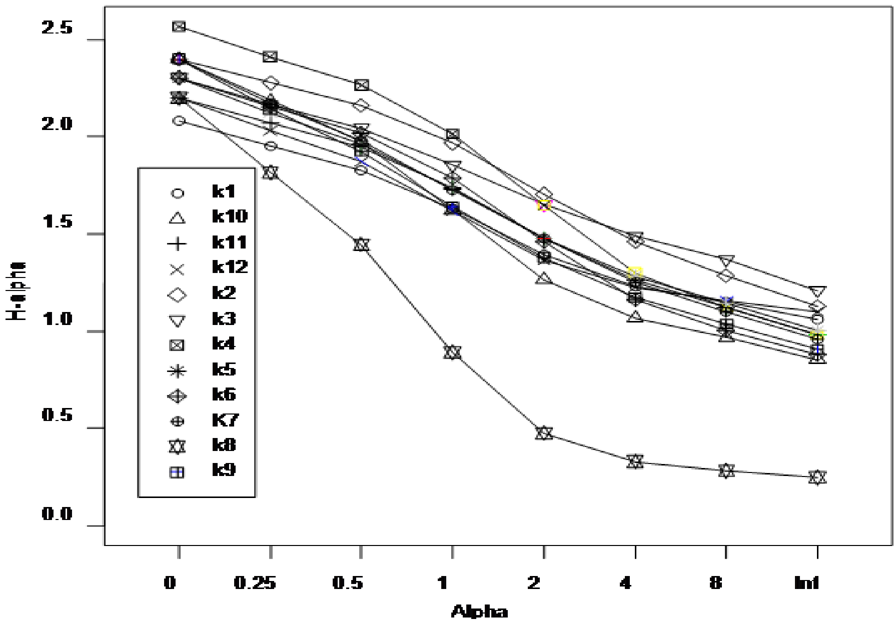

Figure 4: Rényi species diversity profiles for Kebeles based on 100 randomizations (*K1= 1&2; K2= 3; K3=7; K4=8; K5=9; K6=10; K7=11; K8=13; K9=14; K10=15; K11=16; K12= 17*)

Fruit species composition similarity of Kebeles

Table 3 demonstrates species composition similarities and differences of Kebeles drawing from the binary data of presence/absence of fruit species. Accordingly, by recording a relatively lower dissimilarity value, Kebele 3 is most similar in its species composition with Kebele 7(12%). On the other hand, species composition of Kebele 13 is quite different from Kebele 17 (84%) and several other Kebeles like 1&2, 3, 8, 9, 10 and 11. Several factors such as agro-ecological conditions and socio-cultural factors can play role in species similarities and differences (Zemede and Ayele, 1995). In the present study, the similarity tends to follow a pattern of physical closeness of sites which might be explained by cultural resemblance of the people. For instance, Kebeles 3 and 7 by having shorter physical distances in between they tend to have greater species similarities while more distant Kebles like 13 and 17 recorded greater species dissimilarities.

Table 3: Dissimilarity among fruit growing Kebeles based on Sorenson distance

Kebele	1&2	3	7	8	9	10	11	130	14	15	16
3	0.31										
7	0.26	0.12									
8	0.39	0.24	0.32								
9	0.51	0.39	0.44	0.32							
10	0.28	0.19	0.23	0.18	0.41						
11	0.38	0.22	0.27	0.19	0.31	0.25					
13	0.80	0.70	0.73	0.64	0.50	0.71	0.64				
14	0.57	0.39	0.42	0.34	0.27	0.43	0.23	0.55			
15	0.22	0.26	0.33	0.27	0.39	0.21	0.28	074	0.46		
16	0.37	0.14	0.18	0.24	0.38	0.21	0.17	0.68	0.33	0.31	
17	0.21	0.37	0.29	0.45	0.61	0.36	0.44	0.84	0.60	0.32	0.44

Miscellaneous-use tree species

It was found out that 128 of the gardners (71.9%, N=178) grow/keep one or more types of perrenial tree species of miscellaneous uses (Table 4). The most ubiquitous species being *Melia azedrach* L. grown by 56.3% of the gardeners followed by *Cordia africana* Lam. (23.4%) and Eucalyptus species (11.7%), which are grown for their versatile values including for their shade services. Some other trees like *Spathodea nilotica* Seem., *Jacaranda mimosifolia* D. Don, and *Delonix regia* Boj ex Hock are grown mainly for their ornamentation as well as shade values. These trees are planted with no regard to economic benefits, however. These, species, though grown not to no avail, take much of the space that could have been used for growing most profitable economic but also multipurpose value species. *Vernonia amygdalina* Del. is typically used in local brew making process. Non-native species are reported to become proportionately more common toward the urban core (McKinney, 2002). This study is consistent with this statement that most miscellaneous-use category species grown, except perhaps Cordia and Bitter leaf, are exotic. One possible reason for the widespread presence of such exotic species in urban gardens is that many native species cannot thrive in the most urbanized areas since environmental changes in urban areas are dramatic and only a subset of native species can cope with such environmental shifts (Dearborn and Kark, 2009) which constitutes biotic homogenization that threatens to reduce the biological uniqueness of local ecosystems (McKinney, 2002). Another explanation might be that people have easy access to exotic planting materials as they are often available in the market.

Table 4. Relative and absolute frequencies of miscellaneous-use tree species in Bahir Dar City home gardens

Scientific name	Common name	Relative frequency (%)	Absolute frequency (%)
		n=150	n=128
Melia azedarach L.	Persian Lilac	48.00	56.25
Cordia africana Lam.	East African Cordia	20.00	23.44
Eucalyptus spp.	Eucalyptus	10.00	11.72
Vernonia amygdalina Del.	Bitter leaf	5.33	6.25
Grevillea robusta A.Cunn. Ex R. Br.	Silky Oak	3.33	3.91
Spathodea nilotica Seem.	African Tulip Tree	3.33	3.91
Morus alba L.	Mulberry	0.67	0.78
Croton macrostachyus Hochst	Broad-leaved croton	1.33	1.56
Milletia ferruginea Hochst	Milletia	1.33	1.56
Jacaranda mimosifolia D.Don	Jacaranda	0.67	0.78
Casuarina equistifolia L.	Australian Pine	1.33	1.56
Sesbania sesban(L) Merr.	Sesbania	3.33	3.91
Rhicinus communis L.	Castor Oil	0.67	0.78
Delonix regia (Boj ex Hock) Raf.	Flamboyant	0.67	0.78

Vegetables

With the rise of urban population and dwindling land, vegetables are expected to serve one source of income and healthy food for urbanites. For instance, Bernholt et al. (2009) found out that annual vegetables are dominant in Niamey gardens of Niger. In the present study, however, despite the relatively low start-up investment, ease of growing, and fitness for intensive urban farming, vegetables were found to be very scarce in Bahr

Dar City gardens. Only 29 (16.3%, n=178) of the gardeners were found to grow the 10 vegetable species recorded. The majority (37.9%) grow swisschard followed by garlic (27.6%), lettuce (24.1%) and Ethiopian mustard (20.7%), Table 5. Consequently, the potential contribution of vegetables to food, nutrition and income generation remains unexploited. Therefore, there is a need to increase vegetables in urban gardens if not in mono-crops as inter-crops with perennials so that the urban dwellers have a more balanced diet while widening the biodiversity.

Spices and condiments

Some 8 crops of spice and condiment category were recorded grown by more than half of the gardners (51.1%, 91 gardens; n= 178). The dominant species were found to be Fringed rue and Basil with absolute and relative frequencies of 82.4% & 51.0 % and 40.7% & 25.2%, respectively (Table 5). Most of the spice plants are meant for household use. Some of these spice crops are also often used for their medicinal values. If they are taken seriously these crops can also be an important foundation for income generation.

Medicinal and aromatic plants

More than half of the gardners (51.7%, 92 gardens) possess one or more species of medicinal plants of common knowledge. Not surprisingly, a species known as *Ocimum lamiifolium* Hochst. ex Benth, was found grown in close to half (69.8%, 81 gardens) of the gardens (Table 5). This is a very versatile folk medicine plant of common knowledge most popular among the community. It is increasingly evident that medicinal plants are dwindling in the rural landscape, where they have been normally collected from the wild, the most serious proximate threats generally being habitat loss, habitat degradation and over-harvesting (Hamilton, 1997). Hence, besides health and income benefits, Bahir Dar City gardens are offering a unique opportunity for preservation and sustainable use of medicinal/aromatic plants. The special significance of medicinal plants in conservation stems from the major cultural, livelihood or economic roles that they play in many people's lives (Hamilton, 2004). This suggests that recognition of the cultural values associated with medicinal plants can significantly boost biodiversity conservation efforts even in cities.

Table 5. Relative and absolute frequencies of vegetables, medicinal and spice plants in Bahir Dar City home gardens

Scientific name	Common name	Relative frequency (%)	Absolute frequency (%)
Vegetables		n=46	n=29
Brassica carinata A.Br.	Ethiopian Mustard	13.04	20.69
Brassica oleracea L.	Cabbage	6.52	10.34
Lactuca sativa L.	Lettuce	15.22	24.14
Beta vulgaris var. *cicla*	Swisschard	23.91	37.93
Allium sativum L.	Garlic	17.39	27.59
Allium cepa var ascalonicum	Shallot	2.17	3.45
Capsicum frutescens L.	Hot pepper	8.70	13.79
Ipomoea batatas Lam.	Sweet Potato	2.17	3.45
Lycopersicon esculentum Mill	Tomato	2.17	3.45
Fragaria ananassa Weston	Strawberry	2.17	3.45
Zea mays L.	Maize (green cob)	6.52	10.34
Medicinal plants		n=116	n=92
Ocimum lamiifolium Hochest. Ex Benth	Basil	69.83	88.04
Plumbago zeylanica L.	White Leadwort	5.17	6.52
Withania somnifera Dunal	Winter cherry	5.17	6.52
Aloe sp.	Aloe	0.86	1.09
Rumex nervosus Vahl	Rumex	0.86	1.09
Zehneria scabra (L.F)Sond.	Creeping wild cucumber	6.90	8.70
Artemisia afra Jacq.ex Willd	African wormwood	4.31	5.43
Otostegia integrifolia Benth	Otostegia	3.45	4.35
Kalenchoe sp.	Miracle leaf	0.86	1.09
Cymbopogon citrates (DCex Nees)Stapf	Lemon grass	1.72	2.17
Nicotina tabacum L.	Tobacco	0.86	1.09
Spices/Condiments		n=147	n=91
Ruta chalepensis L.	Fringed Rue	51.02	82.42
Ocimum species	Basil	25.17	40.66
Rosmarinus officinialis L.	Rosmary	10.88	17.58
Zingiber officinale L.	Ginger	6.12	9.89
Mentha piperita L.	Peppermint	2.72	4.40
Thymus schimperi Ron.	Thyme	1.36	2.20
Foeniculum vulgare Mill.	Fennel	1.36	2.20
Coriander sativum L.	Coriander	1.36	2.20

Other economic plant species

Grown in the gardens were also some four vital cash generating crop species (Figure 5). Close to half of the gardeners (88, 49.4%) possess one or more of *Rhamnus prinoides* L'Hér., *Coffea arabica* L., *Catha edulis* (Vahl) Forssk. ex End and *Saccharum officinarum* L. (Figure 2). In terms of relative frequencies, the majority (49%) grow coffee followed by Rhamnus (38%). Since this group of crops fetch a high rate of return they have got a high fervour among the gardeners and every one sought to have if garden space was not limiting than fruit crops of longer conception period and currently a relatively lower price. Consequently, there appears a competition between horticultural crops and these cash generating crops resulting in a very strong substitution effect between especially *chat* and horticultural crops in the peripheries and outer City. Arabica coffee has its home in Ethiopia and is a leading export commodity that is also relished at every home on a daily basis and generates income from sale. Several gardeners (10%) especially those towards the periphery of the City grow *chat* which is a recent introduction into the area that is claimed to provide an euphoric feeling and has a rewarding market. Unfortunately, however, because of its narcotic and hallucination effect it has the potential to addict people to, meddle with health, and work efficiency. Rhamnus, locally known as "*Gesho*" is an important ingredient for brewing local drinks that has also a higher market value. Of course, the indirect values of these crops for biodiversity conservation and provision of ecosystem services is also immense. Hence, a fair balance needs to be kept between cash generating crops and fruit crops through improving the competitiveness of the latter.

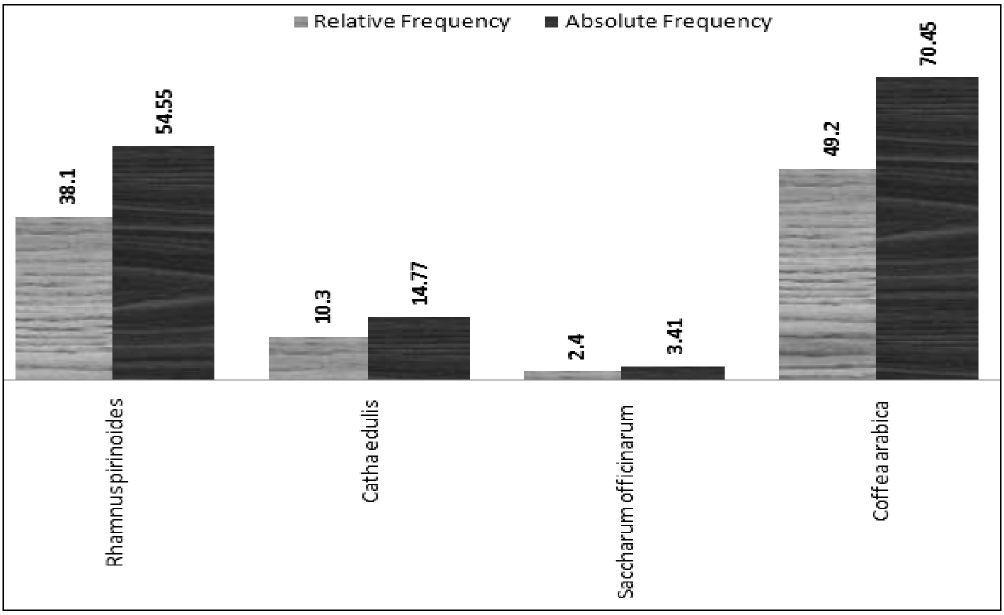

Figure 5: Relative and absolute frequencies (%) of cash crop species in Bahir Dar City homegardens

Animals

The results revealed that in the majority of gardeners (85.4%) animals are not a component, and when they are present, they are limited to a few species; cattle, sheep, scavenging chicken and bees. Of the 26(14.6%) gardens possessing livestock the majority of them (80%) rear chicken followed by sheep (10%), Figure 6. While Bahir Dar is a lake shore City, however, it is inopportune that artisanal aquaculture practice is lacking among the sampled homegardens. Generally, the livestock component is much overlooked in the urban household gardens. This might be because of space limitation or hostility percieved between crops and animals or between animal species themselves like bees and small animals. A major problem with livestock raising in Bahir Dar City is that almost animals are for a major part free ranging which could bring a disasterous impact on City infrastructure, biodiversity, etc. This needs to be improved through promoting controlled husbandary practices and adequate provision of animal feeds.

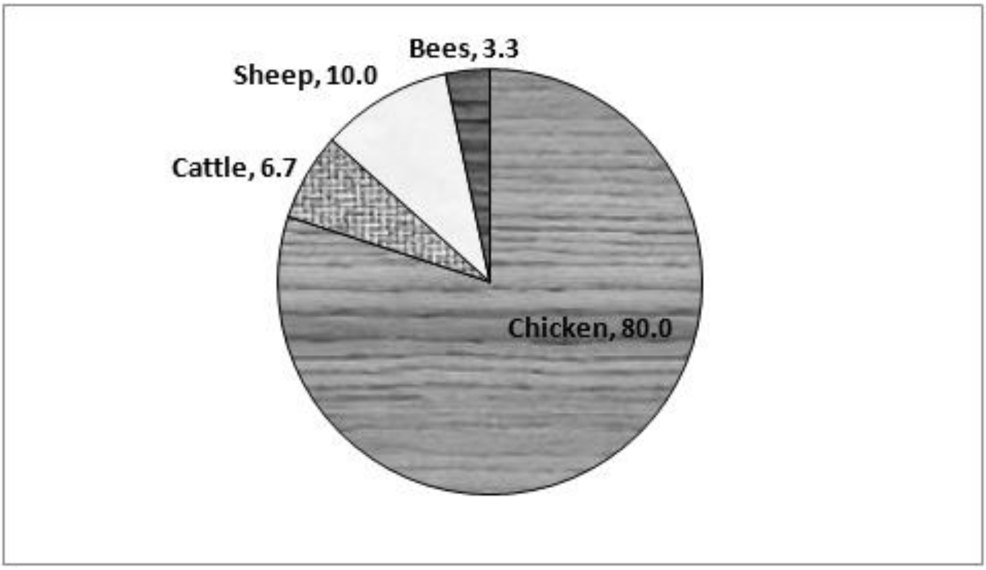

Figure 6: Percent households possessing livestock species in Bahir Dar City (N=26)

Conclusions and Recommendations

Bahir Dar City gardens were found to house a relatively good level of biodiversity especially with perennial crops diversity. There exist also a very commendable practice of maintaining quite a good number of spices and medicinal plants which are dwindling or facing a risk of disappearance in the natural habitat. Nevertheless, vegetables and livestock are less represented in homegardens. Besides, garden crops as horticultural crops are facing stiff competition and substitution from species as *chat* that are, more economic but detrimental to health, especially in the peripherial gardens that would sooner or later lead to a dominance of a few more profitable species that negatively affects plant diversity.

In conclusion, urban gardens in Bahir Dar City have unleashed potential and a good future prospect for poverty reduction and biodiversity conservation. To effectively realize the potential of urban gardening however support to owners in terms of technical knowhow and access to and choice of appropriate planting material is needed. Besides, lest the gaden diversity is dominated by a few species maintaing every garden species more productive and remunerative and enriching with species of versatile functions is important. Gardeners need also to be encouraged to enhance vegetable prodution and livestock husbadary while putting urban livestock husbandry by-law in place and effective promlugation is needed. Most of all, urban gardening needs to be part of the City development plan, and during construction activities as much native vegetation as possible should be maintained so as to create biodiversity-friendly gardens.

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