Article

Tree Species Diversity and Socio-economic Perspectives of the Urban (Food) Forest of Accra, Ghana

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Abstract:

In Africa, 80% of households in urban areas are food insecure and is coupled with a dramatically changing urban food culture towards increased consumption of sugary and fatty foods. Consequently, incidences of obesity and undernourishment in many African cities are becoming escalating. Urban and peri-urban forestry emerges as a complementary measure to contribute towards elimination of urban hunger and improved nutritional security. However, there is scanty knowledge about the composition, diversity and socioeconomic contributions of urban food trees in African cities and this hinders policy discussions integrating urban forestry into the food security discourse. This paper examines the diversity and composition of the urban forest and food trees of Accra and sheds light on perceptions of urbanites regarding food tree cultivation and availability in the city. Using a mixed methods approach, about 105 respondents in six neighbourhoods of Accra were interviewed while over 200 100-m^2 plots were surveyed across five land use types.

Twenty-two out of the 70 woody species in Accra are edible. The food tree abundance in the city is about half of the total number of trees enumerated. The species richness and abundance of the edible trees and all trees in the city were significantly different among land use types ($p<0.0001$) and neighbourhood types ($p<0.0001$). The diversity of food bearing tree species was much higher in the poorer neighbourhoods than in the wealthier neighbourhoods. Respondents in wealthier neighbourhoods indicated that tree and fruit tree cover of the city was generally low and showed greater interests in cultivating fruit trees and expanding urban forest cover than poorer neighbourhoods. These findings demonstrate the need for urban food policy reforms that integrate urban grown tree foods in the urban food system/culture.

Keywords: species, edible, food bearing, diversity, neighborhoods, urban forest

1. Introduction

Malnutrition, poverty and food insecurity, once thought to be characteristic of rural areas, have become prevalent in cities of rapidly urbanizing regions such as Africa (1). About 40% of Africa's urban population lives below the poverty line while an estimated 72% lives in slums (2,3). Furthermore, 4 out of every 5 urban households in Africa are food insecure with the urban poor being the most severely affected (1) and about one-fifth of them spend up to 70% of their income on food (4). Incorporating edible tree food cultivation and conservation in the urban landscape and within human settlements could enhance food security and complement traditional food security strategies including agriculture (5,6). However, data about the contribution of trees/forests to food and nutritional security especially in urban areas are lacking or at best scanty and fragmentary.

Urbanization has massive implications for food security in cities of many developing countries. Up to 3 and 9% of prime agricultural lands and food production, respectively will be loss due to urbanization in Africa by 2030 (7). Owing to unsustainable agricultural practices such as Swidden agriculture coupled with climate change, existing agricultural lands are becoming marginal and unproductive with evidence of low crop yields (8). In addition agricultural labour force is expected to decline at the same time that densification will cause further depletion of urban green spaces(9,10). These transformations have inspired donor aided importation of cereals to sustain the burgeoning urban populations in many West African countries (11). Consequently, there is rapid evolution of the urban food culture towards increased consumption of cheap fast foods, high in sugars and fats (12,13). Increased consumption of fast foods and traditional staples of cereals, roots and tubers are gradually resulting in increased cases of malnutrition: obesity and stunting (13). About 2 million children under 5 within West Africa are overweight while 5.9 million of them are wasted with stunting reportedly increasing by 17% between 2000 and 2016 (14). Food and nutritional insecurity is more severe in some urban areas than in rural areas (15). Addressing these challenges require locally relevant knowledge, supportive policies and optimal physical and social environments (16).

Incidentally, one target of the sustainable development goals is to eliminate hunger and all its forms by 2030. Similarly, the African Union Summit, at Malabo in 2014, adopted the declaration to end hunger by doubling agricultural productivity levels and eliminating child malnutrition by 2025 (17). However, there is growing evidence agricultural strategies alone fall short of eliminating hunger, result in unbalanced diets that lack nutritional diversity, enhance exposure of the most vulnerable groups to volatile food prices, and fail to recognize the long-term consequences of intensified agricultural systems (18). In parallel, there is growing evidence that forest and tree-based systems can play significant roles in complementing agricultural production in the food security discourse. Food security also includes nutrition security – access to food which ensures adequate macro - and micronutrient intake without excessive intake of calories (19).

Forest products complement agricultural food systems by directly providing a diversity of healthy foods rich in micronutrients and fiber but low in sodium and refined fats and sugar, foods that are culturally valued and integral to the local food systems and food sovereignty, foods that fill seasonal or cyclical food gaps and serve as safety nets or buffers in critical times of food shortage (19). Forest within cities directly supply fruits, vegetables, seeds, oils, and nuts, which provide essential nutrients including vitamins and minerals (20). Urban forestry indirectly supplies food through urban apiculture, silvopastoral practices (e.g. *Piper nigrum*), taungya systems, snail and grasscutter farming (20). Urban agroforestry is a promising option that could be integrated into a broader concept of urban food forestry (21,22) to sustain food security and environmental wellbeing. The inclusion of trees in food and nutrition security is fairly recent (5). Moreover, few studies have characterized urban food tree species diversity and composition within cities in West Africa (23,24), despite evidence that children who live in areas with high forest/tree cover enjoy greater dietary diversity and nutritious foods (25).

Ghana, like most countries in sub-Saharan Africa (SSA), is undergoing rapid urbanization with her urban population (which now stands at 54%) projected to increase to 75% by 2050 (26,27). Increases

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in human population lead to urban sprawl, which results in loss of agricultural and natural vegetation cover. For example, between 2000 and 2010, about 6% of the agricultural and forest lands in southern Ghana was converted to urban cover in response to the rising human population and demand for accommodation (28). Besides, food insecurity in Ghana is most prevalent in urban areas (29) with urban diets being more of animal, sugary and fatty foods and less of fruits and vegetables (12,30). A recent survey revealed that about 2 out every 3 school-age children in urban Ghana experience at least one nutritional deficit: either being stunted, underweight or anaemic with Calcium intake among them being very low (31). However, to date, there is no known study on the perceptions, composition and diversity of urban food tree species across the variety of land uses and neighborhood types in this country.

Thus, the present study assessed the (edible) tree species diversity and composition of Accra and its potential to contribute to food security needs of urbanites. More specifically, the study analyses the woody edible tree species diversity and composition among neighborhood types and land uses in Accra. It also examines the perceptions of urbanites regarding the level of awareness and interests to cultivate and preserve urban forest for food cultivation. Determining the perceptions of urbanites about the urban forests and the stocks of urban forest diversity and composition is relevant to developing strategies to curb food security and environmental injustices in cities in developing countries.

2. Materials and Methods

2.1 Study area

The study was conducted in Accra (5°35′′ N, 0°60′′ W), Ghana (Figure 1). Accra is the capital of Ghana and is located on the Gulf of Guinea. It has a total land area of more than 250 km^2 and a population of about 2.27 million (27). The greater Accra Metropolitan area (AMA) is estimated to have a population of 4 million. It is a cosmopolitan city that is socioeconomically stratified. Five distinct wealth classes: poorest, lower middle class, middle class, upper middle class, and high class were recently characterized in the city based on neighborhood environmental quality (32). Neighborhood socioeconomic conditions have also been shown to correlate strongly with neighborhood vegetation cover where poorer neighborhoods are less green and the vice versa (33). The six study neighborhoods lie on a line from the coast towards the northern boundaries of AMA: Jamestown /Ushertown (JT), Asylum Down (AD), Kanda (KN), Nima (NM), Roman Ridge (RR), and East Legon (EL). JT is one of the oldest neighborhoods of Accra and lies between the coast and Accra business center; AD and NM are located approximately 3 km inland, separated by Ring Road central. The Kanda highway separates NM and KN. RR and EL are approximately 5 and 10 km inland and lye west and north of the Accra International Airport, respectively.

Accra is in the equatorial climatic region, one of the driest regions in Ghana. Its mean annual precipitation and temperature are about 809 mm and 26.6°C, respectively (34). Monthly average precipitation ranges between 0mm in the dry season (December – March) to 150 mm in the rainy season (May – October). Monthly average temperatures range between 24.5°C (August) and 28°C (March). The humidity is generally high, 65 – 95%.

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Savannah grasslands and thickets were the dominant vegetation type in the Accra plains prior to recent urbanization. Originally, a dry semi-deciduous forest of the "south-east outlier type" was the natural vegetation cover of the Accra plains. Over several millennia, human activities have successfully transformed this dry forest into its present savannah outlook (35).

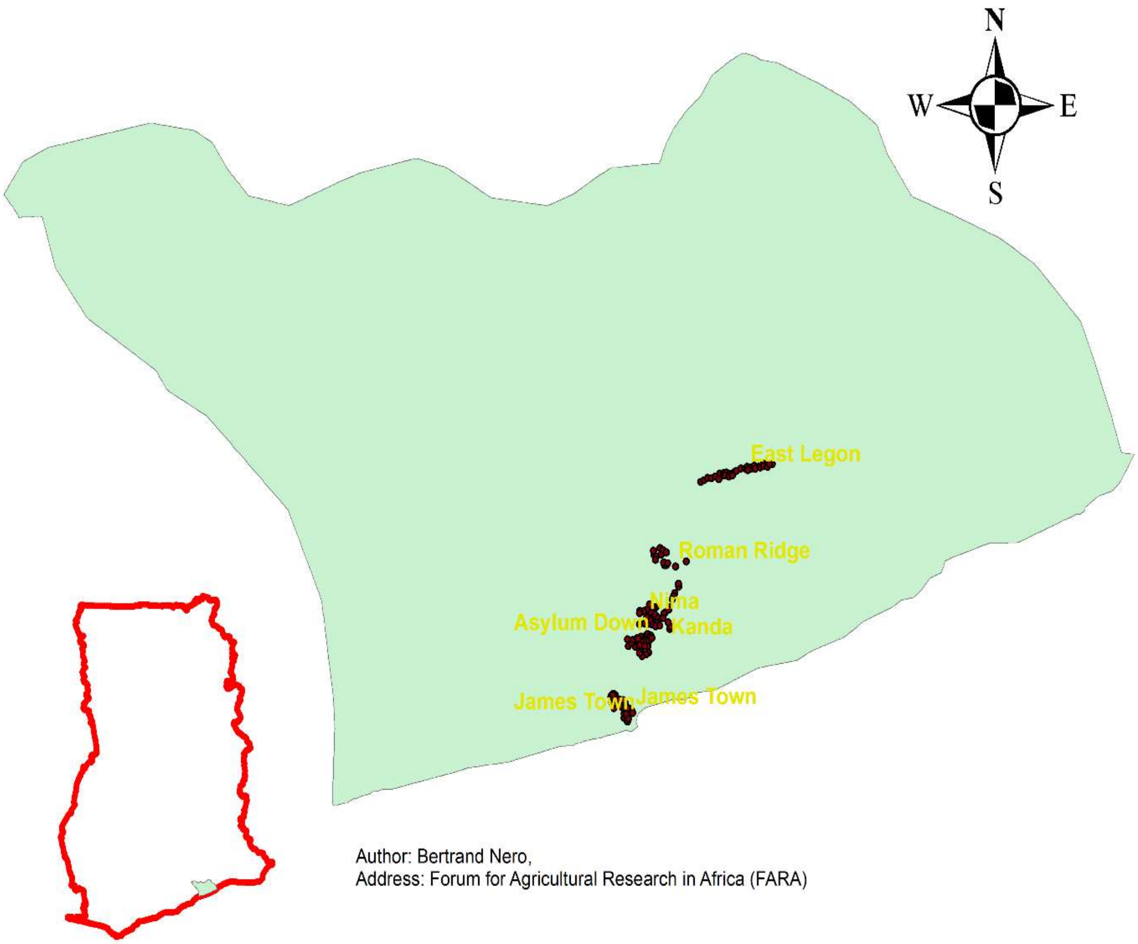

Figure 1.0 A map of Accra showing the neighborhoods where data was collected.

The study employed mixed methods approach in gathering the data. Mixed methods is a research approach in which researchers collect, analyze, and integrate quantitative and qualitative data in a single study or a sustained long-term project (36). The basis of this approach in this study is contingent upon the fact that the research questions are best addressed by complementing both quantitative and qualitative data. The quantitative data are collected through vegetation inventory while semi-structured questionnaires were used to collect qualitative data. Gathering both qualitative and quantitative data aided the generation of multiple perspectives about the contribution of urban forests to urban food security in Accra.

2.2 Vegetation sampling design

Plots were located in Accra by a stratified random sampling design (Figure 1) in 2017 as part of the urban biomass study in Ghana. Stratification was based on the relative homogeneity of the physiognomic units of land uses. Five land uses: home gardens (HG), cemeteries/sacred grooves (C), public parks (PP), institutional compounds (IC), and streets (S) were recognized and subsequently inventoried. Land uses were identified with the aid of land use maps and google earth images.
A total of 200 relevés and five streets were surveyed. Sample areas were 100 m^2 in the parks and cemeteries while entire areas of institutional compounds and home gardens were surveyed. The trees and shrubs within each relevé were counted by species and the number recorded. All trees were identified to the species level with the aid of tree identification experts and published tree identification guides such as those by Hawthorne and Gyakari (37) and Oteng-Amoako (38). Samples of unidentified and unknown tree species were collected and processed following standard taxonomic procedures and subsequently forwarded to University of Ghana and Forestry Research Institute of Ghana herbaria. The selection of home gardens followed the systematic approach described below under the socioeconomic survey section.

2.3 Socioeconomic survey
Data on urbanites perceptions and use of urban forest trees for food and interests to cultivate and promote and urban food forestry was collected by means of semi-structured and structured interviews and observations. Respondents were drawn from three classes of neighborhoods: high income, middle income, and low income were interviewed between September and November 2017. JT and NM were selected in the low income category, KN and AD in the middle income neighborhood and EL and RR in the high income neighborhood (32,39,40). Within each neighborhood, a systematic sampling approach was adopted in selecting the households for the socioeconomic survey. Transects were randomly laid across the neighborhood. For each transect, a house was randomly selected within 50 m radius at the starting point and subsequently every 200 m along the transect (Figure 2). One adult individual present in the selected house was interviewed.

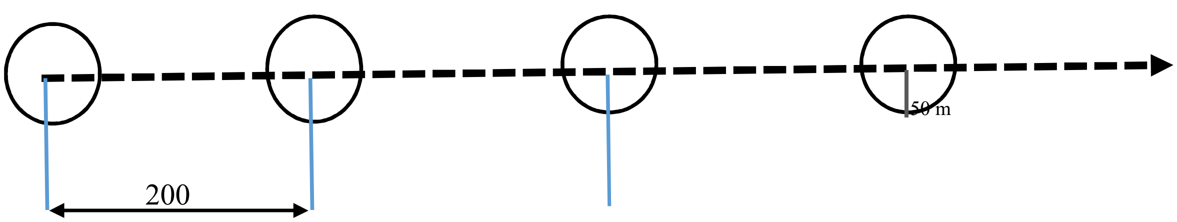

Figure 2. A sketch of a transect (arrowed broken line) indicating hypothetical locations (circles with solid lines) where samples were randomly drawn from. Distance between the centers of the circles is roughly 200 m. The radius of each circle is 50m. Diagram is not drawn to scale.

Overall, 96 individuals or representatives of urban households were interviewed (Table 1). The demographic characteristics of the respondents are presented in Table 1. About 55% of respondents were females. Also, 44% of respondents resided in low income neighborhoods, 30% in high income neighborhoods and the rest in middle income neighborhoods. About 17% of the respondents lived in government owned houses, 23% in rented private houses while 60% lived in family/self-owned

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houses. Roughly 62% are in informal employment, 33% are formerly employed while 5% are unemployed. The educational background of respondents consisted of 37% secondary, 30% tertiary, 30% primary or basic education and the rest have never been to school.

Table 1. Socio-economic characteristics of the study sample, N = 96.

Socio-economic variables		Number	percent (%)
Neighborhood characteristics	High income	29	30.21
	Middle income	25	26.04
	Low income	42	43.75
Gender	Female	53	55.21
	Male	43	44.79
House ownership	Family	57	59.38
	Government	17	17.17
	Rented	22	22.92
Age range	20 - 40	54	56.25
	40 – 60	32	33.33
	>60	10	10.42
Employment	Formal	32	33.33
	Informal	59	61.46
	Unemployed	05	5.21
Education	Primary	29	30.21
	Secondary	35	36.46
	Tertiary	29	30.21
	Uneducated	03	03.13

Verbal informal consent of was obtained from each individual who participated in the study, and the researchers adhered to appropriate international ethical guidelines. The aim and purpose of the study was explained to selected participants. The questionnaire used during interviews was designed to gather data about the socioeconomic characteristics of respondents, their interests to cultivate fruit trees, promote urban forestry, as well as their views about the urban forest and fruit tree cover in the city. The common tree fruits consumed among urbanites were also investigated. In addition, trees and shrubs present in the compounds of the selected houses were inventoried.

2.4 Data analysis

Patterns of species diversity were analyzed using two types of diversity, that is, **α**-diversity and β-diversity, and also evenness. Two aspects of **α**-diversity were analyzed, the first being species richness (S) which is defined as the number of species per unit sample plot or land use. Because S can be exaggerated by the presence of rare species, **α**-diversity was also measured with the Simpson's diversity index (D). It is a weighted expression of species richness and abundance of each species in the population and is calculated as

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$$D = 1 - \frac{\sum n(n-1)}{N(N-1)} \quad (1)$$

Where Σ = summation (total), n = number of individuals of each species, and N = the total number of individuals of all species in the population.

Evenness, defined as the relative abundance of species per unit area was used to measure the similarity of relative abundance of species within sample plots. It was estimated with the Pielou's evenness index (J) as

$$J = \frac{H}{S} \quad (2)$$

Where H = Shannon diversity index and S is as previously defined.

Chi-square test was conducted to abundance, S, D, and J among land use and neighborhood types using SAS.

Beta (β) diversity was calculated to determine species turnover or the extent to which species diversity differs among land uses and neighborhood types within Accra. Various measures of β-diversity have been proposed. However, in the present study, Whittaker's diversity index (β_w) was used because it is widely regarded as a simple but highly effective measure of β-diversity (41). *It was calculated as:*

$$B_w = Stotal/Save \quad (3)$$

*Where S_{total} = overall species richness of the city and S_{ave} = **α**-diversity for each land use or neighborhood type.*

In addition, Correspondence analysis was applied to the data to illustrate floristic relationships between plant communities, land uses and neighborhood types. Neighborhood type and land use type were considered nominal variables while species abundance was a continuous variable. Analysis was conducted for all species and food bearing tree species in Accra. Desk study was used to extract nutrient concentrations of some of the essential micronutrients supplied by these food bearing trees within Accra.

Descriptive statistics, such as percentages and frequencies, were used to analyze the data obtained from the questionnaires. Bar charts were generated using Microsoft excel. In addition, we used a binomial generalized linear model (GLM) to determine whether respondent socioeconomic characteristics influence their views about urban fruit tree cover and interest to promote urban food forestry in Accra. More specifically, logistic regression was used to find out whether neighborhood type and other socioeconomic variables had effect on the interest to cultivate fruit trees and promote urban forestry. The dependent variable is binary: 1 if the respondent is interested in cultivating trees and 0 otherwise. Binary response data can be accommodated using a fixed-effects or random-effects logit model:

$$\text{Logit}(Y_i) = \text{LN}(p/1\text{-}p) = B_0 + B_1X_1 + B_2X_2 + \ldots\ldots.. + X_nB_n \quad (4)$$

Where Y_{ij} denotes the ith survey response in the jth neighborhood type, B0 and B1 are coefficients to be estimated in the regression step, Xi,j is a vector of independent variables (e.g. neighborhood type, household size, sex of respondents etc).

Materials and Methods should be described with sufficient details to allow others to replicate and build on published results. Please note that publication of your manuscript implicates that you must make all materials, data, computer code, and protocols associated with the publication available to readers. Please disclose at the submission stage any restrictions on the availability of materials or information. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited.

Research manuscripts reporting large datasets that are deposited in a publicly available database should specify where the data have been deposited and provide the relevant accession numbers. If the accession numbers have not yet been obtained at the time of submission, please state that they will be provided during review. They must be provided prior to publication.

Interventionary studies involving animals or humans, and other studies require ethical approval must list the authority that provided approval and the corresponding ethical approval code.

3. Results

3.1. Overall woody species diversity

A total of 798 trees and shrubs belonging to 70 species and 30 families were recorded during the period of survey. There was significant difference in species richness ((χ^2_4 = 33.4, p<0.0001) and abundance (χ^2_4 = 362.4, p<0.0001) for all trees among land use types (Table 2), although only the latter was significantly different (χ^2_4= 267.8, p<0.0001) with respect to neighborhood types (Table 3). Home gardens (HG) and institutional compounds (IC) had the highest Simpson's diversity index and Pieluo's evenness values among other land uses. Similarly, low income neighborhoods had the highest Simpson's index and Pieluo's evenness of 0.96 and 0.93, respectively among neighborhood types (Table 3).

Table 2. Woody tree species richness, abundance, Simpson's diversity index and Pieluo's Evenness among land uses in Accra.

Land use	Richness	Abundance	Simpson's D	Pieluo's Evenness
Cemetery	12.0	68.0	0.496	1.247
Institutional compound	33.0	144.0	0.957	2.945
Home garden	47.0	368.0	0.945	3.149
Park	29.0	91.0	0.910	2.800
Street	12.0	127.0	0.829	1.870
Accra total	70.0	798.0	0.950	3.337
Chisq (χ^2)	33.4	362.36	0.163	0.406
p-value	<0.**0001**	<0.**0001**	0.997	0.982

Table 3. Woody tree species richness, abundance, Simpson's diversity index and Pieluo's Evenness among neighborhood types in Accra.

Neighborhood	Abundance	Richness	Simpson's Index	Pieluo's Evenness, J
High income	502	42	0.93	0.80
Middle income	215	33	0.92	0.86
Low income	131	35	0.96	0.93
Chisq (χ^2)	267.8	1.22	0.001	0.01
p-value	**<0.0001**	0.544	0.999	0.995

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3.2 Edible tree species diversity

About half of the total number of trees enumerated in this study were edible (i.e. leaves or fruits) and belonged to 22 species and 17 families. Both edible species richness and abundance were significantly different among land uses (Table 4) while the former was not significantly different among neighborhood types (Table 5). Cemetery had the highest Simpson's index and Pieluo's evenness values of 0.905 and 0.963, respectively owing to its relatively low species richness and abundance. Meanwhile, edible trees constituted only 10% of all the trees in cemeteries while the highest proportion of edible trees among land uses was 66% in home gardens. The Simpson's diversity index and Pieluo's evenness were highest in low income neighborhoods compared to other neighborhood types (Table 5).

Table 4. Food bearing tree diversity of different land use types in Accra, Ghana

Land use	Richness	Abundance	Simpson's D	Pieluo's J	Percent fruit trees	Percent fruit tree species
Cemetery	5.0	7.0	0.905	0.963	10.3	41.7
IC	12.0	76.0	0.877	0.873	52.8	36.4
HG	19.0	243.0	0.889	0.821	66.0	40.4
Park	7.0	19.0	0.819	0.868	20.9	24.1
Street	3.0	43.0	0.135	0.271	33.9	25.0
Total	22.0	388.0	0.867	0.761	48.6	31.4
Chisq (χ^2)	17.9	476.6	0.606	0.4063	56.3	08.5
p-value	**0.0013**	**<0.0001**	0.962	0.982	**<0.0001**	**0.0758**

IC = Institutional compound, HG = Home garden

Table 5. Edible tree species diversity and abundance among neighborhood types in Accra.

Neighborhood	Abundance	Richness	Simpson's Index	Pieluo's (J) Evenness
High income	198	13	0.93	0.80
Middle income	122	12	0.92	0.85
Low income	69	16	0.96	0.90
Chisq (χ^2)	64.8	0.634	0.00	0.01
p-value	**<0.0001**	0.728	0.999	0.997

3.3 Species composition and Beta diversity of edible tree species

Woody species of various land uses in Accra are separated using CA (Figure 2). Dimension 1 explained 33.82% of the variation and appears to be determined by species such *Veitchia merrily*, *Zanthoxylum zanthoxyloides, Plumera alba*, in the parks and *Millingtonia hortensis*, Khaya senegalensis, on the streets land use; while dimension 2 explained 30.7% of the variation and is determined more by food bearing tree species such as *Persea americana*, *Vernonia amygdalina*, *Moringa oleifera*, *Elaeis*

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guineensis, etc in the home gardens and in the *Millingtonia hortensis*, *Albizia lebbeck* in streets. Institutional compounds and home gardens grouped together, as did parks and cemeteries, with streets lying completely separated from these groups.

Woody species separations among neighborhood types followed a different pattern (Figure 3). Dimension 1 explained 57.2% of the variation and was influenced more by low income and high income neighborhoods. Dimension 2 explained 42.8% of the variation and was determined more by the middle income neighborhoods. Species such as *Artocarpus incisus*, *Cassia spectabilis*, *Citrus reticulata*, *Citrus lemonii*, as well as *Musa* spp, *Vernonia amygdalina*, *Gliricidia sepium* etc also strongly influence dimension 2.

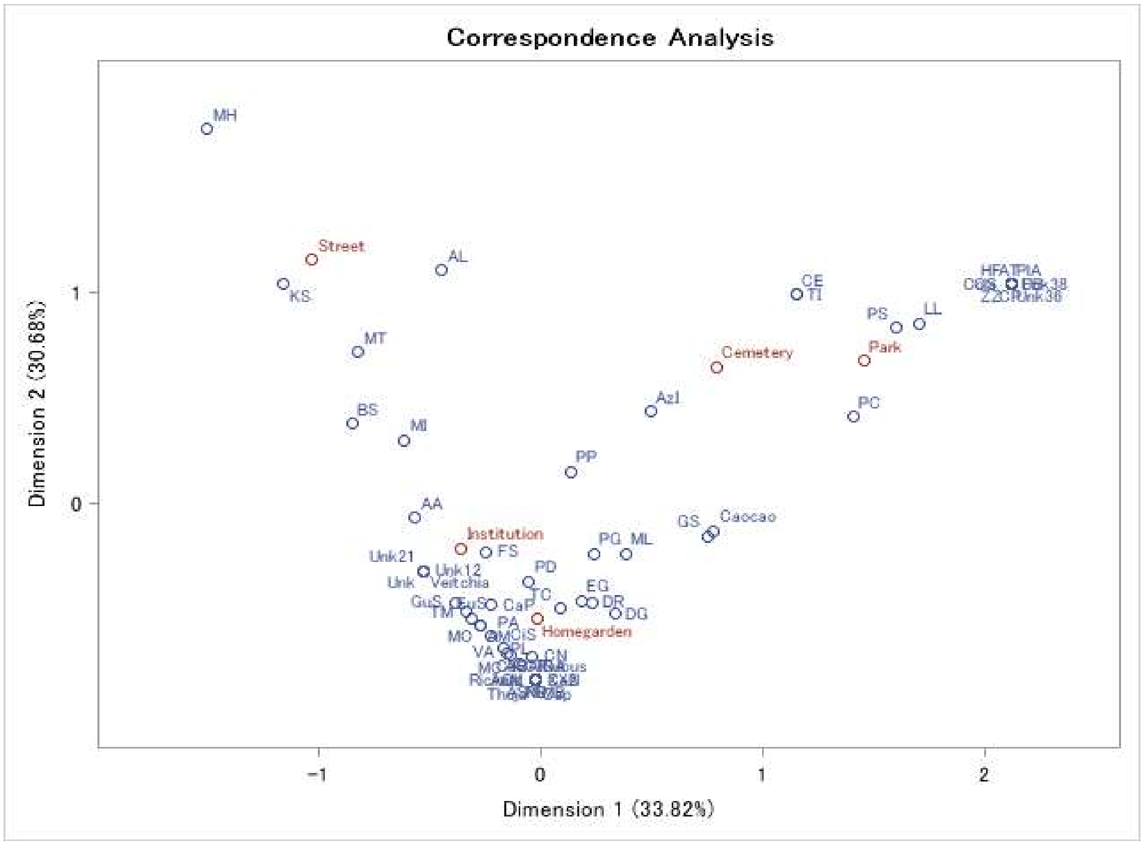

Figure 2. Correspondence analysis biplot of woody species among land uses in Accra.

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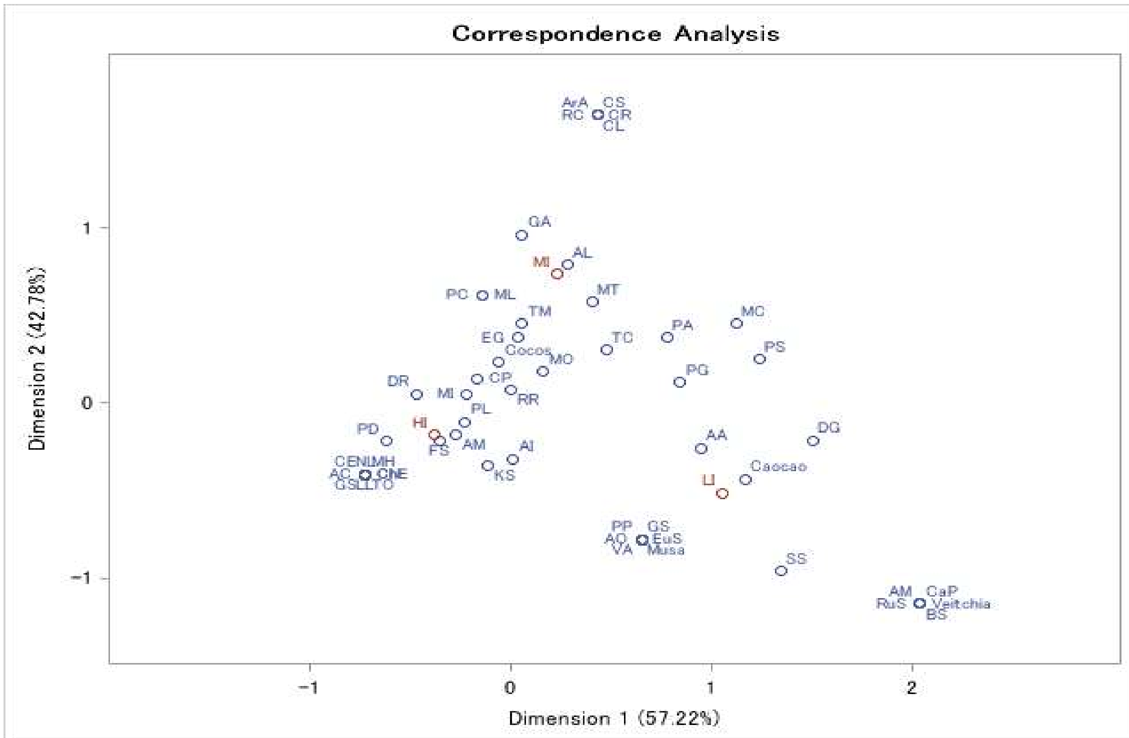

Figure 3. Canonical analysis biplot of species in three neighborhood types in Accra. HI – high income, MI – middle income, and LI – lower income neighborhood types.

Beta diversity analysis revealed that 75% of the species in the cemetery were similar to those of institutional compounds (IC) and home gardens while only 50 and 58% were similar to those of streets and parks, respectively. In contrast, 30 and 42% of species in IC were found streets and parks respectively whereas 76% were in home gardens. About 75 and 55% of species in streets and parks, respectively were in home gardens while 50% of species in streets were also in home gardens. As a consequence of these similarities, Beta (β_w) diversity estimates between land uses were not severely different, ranging between 1.4 (IC and HG) and 1.7 (HG and street, park and street etc).

3.4 Nutrient composition some common urban food tree species of Accra

The most common food bearing tree species in the survey based on abundance included; *Mangifera indica* (mango), *Elaeis guineensis* (palmn nut), *Cocos nucifera* (coconut), *Carica papaya* (pawpaw), *Terminalia catappa* (India almon), *Moringa oleifera*. The five least abundant food bearing tree species in the city were; *Tamarindus indica*, *Artocarpus incisus*, *Citrus lemonii*, C. *reticulata*, and *Blighia sapida*.

The food bearing tree species together contain a range of assorted major and micronutrients including vitamins essential for human wellbeing. Tree foods were consumed directly as fruit pulp, leaves, nuts, seeds, juices like coconut water while others required further processing before being consumed. All the species enumerated are high in proteins, carbohydrates, crude fiber, crude fat, ash and moisture contents, although these vary among species. On average protein, carbohydrate, fiber, fat, ash and moisture content were respectively, 8.12, 39.5, 12.64, 10.3, 4.8, and 27.4 g/g. this indicates that tree foods could play critical roles in meeting the dietary needs of urbanites. In addition, the common minerals in the fruits, leaves, and seeds of these tree species included Calcium (Ca), potassium (K), Sodium (Na), Magnesium (Mg), Zinc (Zn), Iron (Fe), Iodine (I), Copper (Cu), Manganese (Mn), Molybdenum (Mo) and what have. At least half of the food tree species listed in Accra supply 8 of the nutrients above (Table 6). At least ten tree species can supply Cu and Mn while only two species; *Dialium guineensis* and *Elaeis guineensis* supply Iodine. Furthermore, a few of the tree species listed in Accra have the potential to supply Niacin, Riboflavin, Thiamine, vitamins K, E, C, and A. Leaves and fruits of *Vernonia amygdalina*, *Tamarindus indica*, and *Annona muricata* can supply Niacin. Mean concentrations of each mineral nutrient and the number of tree species bearing these nutrients are shown (Table 6). There are wide variations in the nutritional composition and concentrations of these nutrient elements among species.

3.5 Perceptions of urban forest cover and interest to promote urban forestry in Accra

In total, 58 of the 96 respondents (60%) expressed interest in cultivating food trees and promoting urban forest expansion activities in Accra. The results show that neighborhood type and perceptions about the food tree/forest cover of Accra significantly influenced the likelihood of one being interested in cultivating trees (Table 7). Results of the odd ratio analysis further revealed that people in high income and middle income neighborhoods were respectively 22 and 7 times more likely to be interested in cultivating food/forest trees in Accra compared to people in low income/slum neighborhoods. Overall interest to cultivate food bearing trees in the high income, middle income, and low income neighborhoods was respectively 69, 56, and 57% of the respondents interviewed. Similarly, people who perceived the city to be low in forest/tree cover were more likely than not to be interested in cultivating forest/food trees compared to people who perceived the tree cover of Accra to be high.

Level of awareness of urban forestry and urban food forestry in Accra was examined. Qualitative results revealed that level of awareness was only marginally different for both males and females (Figure 4). Nearly 100% of both male and female respondent were enthusiastic about promotion of urban forestry in Accra. The perception of people in high income neighborhoods about the forest and fruit forest cover of Accra as well as the enthusiasm to promote urban forestry was higher than in the other neighborhood types (Figure 5). About 57 and 54% of respondents in low income neighborhoods had some level of awareness of urban forest and urban food forest cover of Accra, respectively. Low income neighborhoods were the least likely to promote urban forestry (95%) compared to other neighborhood types.

Table 6. Mean, minimum, and maximum micronutrient composition as well as number of species values of tree species of Accra, Ghana

	Niacin	K	Ca	P	Zinc	Na	Mg	Fe	Cu	Mn	Iodine (I)
Number of species	3.0	14.0	16.0	12.0	15.0	13.0	19.0	16.0	10.0	10.0	2.0
Proportion of sampled fruit trees	14.3	66.7	76.2	57.1	71.4	61.9	90.5	76.2	47.6	47.6	9.5
Mean	1.2	275.3	62.8	232.5	21.2	40.2	54.8	4.1	8.9	5.3	18.8
Min	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3
Max	1.9	673.5	250.1	1411.0	193.9	169.5	347.0	16.2	70.3	29.2	33.3

K – potassium, Ca – Calcium, P – Phosphorous, Zn – Zinc, Na – Sodium, Mg – Magnesium, Fe – Iron, Cu – Copper, Mn – Manganese,

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Table 7. Logistic regression results of the factors influencing interest to cultivate food-bearing trees in Accra, Ghana

Variable	DF	Wald Chi-Square	Pr > ChiSq
X1 – Neighborhood type	2	6.8959	**0.0318****
X2 – House ownership	3	0.3936	0.9416
X3 – Age range	2	0.8703	0.6472
X4 – Sex of respondent	1	0.1161	0.7333
X5 – Household size	16	6.7629	0.9776
X6 – Employment of household head	2	2.4212	0.2980
X7 – Level of education of respondent	3	3.5376	0.3159
X9 – Satisfaction with quality and quantity of food	1	1.4275	0.2322
X10 – Vegetation cover of Accra	1	1.4547	0.2278
X11 – Food / Fruit tree cover of Accra	1	7.0229	**0.0080*****
X12 – Vegetation cover of your neighborhood	3	5.5055	0.1383

**(*) significant at p=0.05

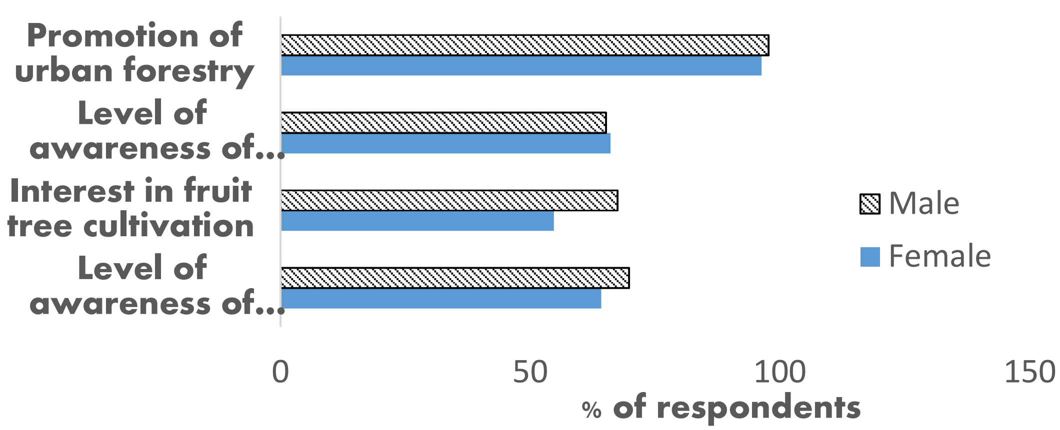

Figure 4. Views of male and female respondents about attributes of urban forestry in Accra.

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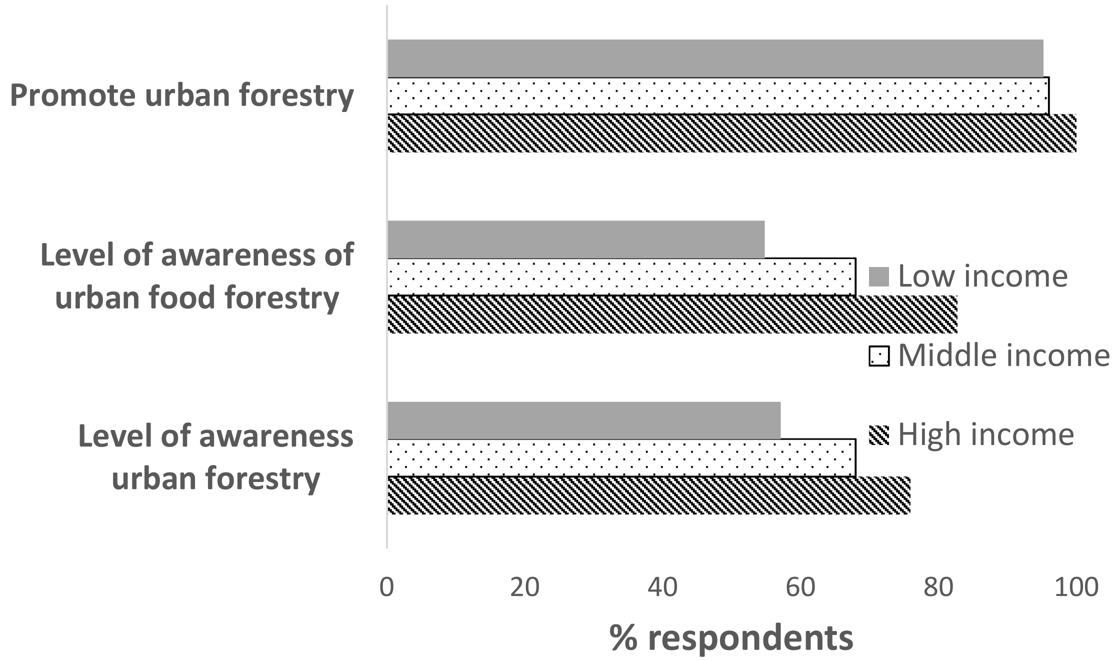

Figure 5. Views of respondents about level of awareness of the urban forest and promotion of urban forestry among neighborhood types in Accra, Ghana.

4. Discussion

4.1 Forest and food tree species composition and diversity

In the current study, we found that the city of Accra supports a fairly high amount of woody species diversity and that this diversity was significantly stratified among the vegetated land use types and neighborhood types (Tables 2 and 3). We further found that species such as *Azadirachta indica* (neem), *Mangifera indica* (Mango), *Elaeis guineensis* (palm), *Cocos nucifera* (Coconut) and *Polyalthia* spp (weeping willow) were the top five most common species in the city. These findings are consistent with findings of floral diversity studies in Abuja and the Valley View University campus, near Accra where woody species richness of 69 and 53 were respectively observed (35,42). However, species richness and diversity of the current study was lower than the 176 species and Shannon index of 3.70 reported in Kumasi (43) and the 297 tree species in Lome, Togo (44). The relatively high diversity and richness values in Accra, conform with recent findings that cities in Africa support extremely high diversity even when compared to neighboring natural forest (42–45). Although cities are typically located in biodiversity hotspots (46)(46,47), hence their high diversity, intercity disparities in diversity and species richness are inherent in the morphology and age of the city, the natural ecological factors as well as building and population densities. Accra is located in the coastal savannah zone with many of the (common) species recorded in the current study classified as savannah species (35,48). Hence, its relatively lower richness and diversity values compared to cities located in high forest zones and possibly with lower population and building densities.

The within city differences in woody species diversity and richness among land uses may be ascribed to several factors, including governance, ecological, socioeconomic conditions as well as the culture of the people. Home gardens harbor the most species diversity and compositional differences. Species richness and diversity of home gardens in Accra are similar to those of home gardens in cities such as Rio Claro, Brazil (49) and directly manifest their multifunctional and structural complexities (50), underpinned by various socio-ecological constraints (49,51). Home gardens in Accra are varied in sizes and severely fragmented and maintained for alimentary, fuelwood, aesthetics, and environmental conservation purposes. Consequently, their diversity reflects the diversity of individuals and their interests residing in the city. On the other hand parks, streets and cemeteries are directly under the control and management of the local government. Diversity in these land uses are comparatively lower because they were planted with a few exotic tree species for specific limited functions. While cemeteries were predominated by *Azadirachta indica*, the most common species in parks and on streets were respectively *Gliricidia sepium* and *Millingtonia hortensis*. Their primary functions are recreation (aesthetics), shade and environmental conservation.

The current study also found that species abundance and richness was much higher in high income neighborhoods compared to other neighborhood types while the reverse was true for Simpson's diversity index and Pieluo's evenness. These findings corroborate previous studies that found that high income neighborhoods had more biodiversity than low income neighborhoods (52,53). This coupled with the low tree cover in low income neighborhoods should be an issue of concern for policy makers as residents in these low income neighborhoods are less likely to access and enjoy sufficient environmental benefits emanating from urban forest and tree diversity in these third world cities.

4.2 Urban forest tree diversity and food/ nutritional security

Residents of Accra, like their compatriots in other West African cities have a low fruit and vegetable consumption culture (12). While high fruit and vegetable prices deprive many (lack of access) of their preferred balance diet, unavailability of food resources can constraint food security in a given area. In the light of this we explored the availability and distribution of food bearing tree species in three neighborhoods of Accra. It was found that 31% of tree species and nearly 50% of all trees enumerated were food bearing (Table 4). About 51% of these food trees were in the high income neighborhoods, with 18% in low income neighborhoods. In contrast, food tree diversity was highest in the low income neighborhoods compared to the other neighborhood types. Similar to the findings of the present study, 18 food bearing species were recorded on the campus of University of Port-Harcourt (23,24). The findings are also consistent with findings that plant species useful for food, medicines and other provisioning services were more frequently found in gardens of poorer residents than in those of wealthier residents(51). Considering that increasing neighborhood wealth correlates with increasing vegetation cover (33), we surmise that the low tree abundance in low income neighborhoods may be due to lack of space due to legacy effects of past development and lack of interests to cultivate/manage trees. Whereas poorer urbanites maintain small home gardens for provisioning of basic services such as alimentary, medicinal, income, livelihood services which reflect their (urbanites) rural origins and cultural heritage, the relatively wealthier class invest in large home

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gardens for their aesthetic and recreational functions (49,51). These disparities in green cover and food tree populations among neighborhood types could have dire tree food availability consequences especially in low income neighborhoods where over 70% of their income is mostly spent on purchasing staple foods. The foregoing emphasizes the need for scientists and policy makers to consider judicious and scientific policies that ensure equity in the distribution of green spaces and biodiversity among neighborhoods in order to avoid issues of resources and environmental injustice (10). In low income neighborhoods, opportunities exists to plant food bearing trees along streets, within some family house compounds and on the pockets of bare areas dotted around the neighborhoods.

Analysis of the nutrient contents and composition of food components of these tree species revealed that they can supply a humongous amount of basic nutrients (proteins, carbohydrates, fats, fiber), vitamins and mineral nutrients. Average nutrient concentrations of the selected minerals found in trees were fairly high (Table 6). Our findings corroborate observations by the FAO that, home gardens provide families with non-staples they require all year round (54) and forest trees products are usually higher in nutrient contents than domesticated crops and staples (18). However, evidence of resource availability does not necessarily imply access and utilization. In urban Ghana, diets tend to be dominated by animal-based products of rice, pasta, meat and fish mixed and less of fruits and vegetables (12,30). Among adults, such dietary diversification reduces the risk of communicable diseases such as type 2 diabetes etc although this is only partially true in sub-Saharan African cities (55). About 67% school-age children in parts of Accra are malnourished, suffering at least one nutritional deficit of being stunted, underweight or anaemic (31). Although energy intake of these school kids was adequate, there was conspicuously low calcium intake (31). Moreover, deficiencies in minerals such as Iron, Zinc and Vitamin A in urban diets around the world are not uncommon (56). Findings of our present study further reveals that, 76% of food tree species contain high concentrations of Ca (0.05 – 250 mg/100g), 76% contain Iron (0.0009 – 16.1 mg/100g) and 71% contain zinc (0.0003 – 193 mg/100g). Urban forest tree species therefore serve as 1) a source of a diversity of healthy food, high in micronutrients and fiber and low in fats and sugars, 2) high in food of cultural value and contribute significantly to the local food systems and sovereignty, and 3 help to fill seasonal and cyclical food gaps and act as "safety net" when there is shortage (19). Besides urban food trees can provide several ecosystem services and goods. In a pilot experiment in Bobo Dioulasso, Burkina Faso, mango and cashew plantations reduced run-off co-efficient by 4% (reduction in flood risks and increased infiltration), sequestered over 1835.56 tons of CO_2 per ha significantly reduced ambient temperatures (57). The urban and peri-urban agriculture and forestry (UPAF) has the potential to contribute to 6% of the monthly food expenditures of the households engaged in it and hence increases resilience of poor urban households. Considering these wide range of benefits, we suggest populating school compounds and open spaces in cities, particularly Accra, with food bearing trees and encouraging the consumption of these fruits among urbanites. Policies and strategies to expand the urban food forest cover, extend shelf-life of fruits and enhance the consumption of fruits in Ghanaian and African cities are critical.

4.3 Perceptions and interests to grow urban food forest

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Restoring, protecting, and enhancing green infrastructure (forest and woodlands) in urban areas are not only ecologically and socially desirable, they are also economically viable (58). As outlined above, the urban forest has the potential to provide a myriad of ecosystem goods and services; food security, climate regulation, aesthetics, regulation of storm run-off and reduction in erosion and other supporting services etc (59,60). Within Africa, research on social and economic aspects of urban forestry are quiet limited (61). Our present study revealed that perceptions about the level of awareness of the urban forest in Accra and the willingness to promote urban forestry did not differ significantly among key socioeconomic variables i.e. gender, sex of respondents, neighborhood type, type of house ownership, household size. At least 70% of the respondents in the high income neighborhoods thought there is high awareness of urban forest(ry) in the city with about 70% of residents with high school education and below asserting likewise. However, the probability to cultivate food bearing trees in the city was significantly influenced by the neighborhood wealth status and one's view about the forest cover (Table 7). These findings agree with findings that 99% of respondents in Ibadan were aware of the urban forest, its benefits and values to their wellbeing and expressed strong interest to preserve urban forest cover (62). Proximity to trees/forests and the perceived (dis)incentives associated with forest are strong determines of perceptions about the urban forest (62,63). Within the Ayawaso East submteropolis of Accra, residents of relatively denser forested areas rank and prioritize urban forest higher than their compatriots in less dense forested areas (64). Since high income neighborhoods of most cities are considerably higher in forest/green cover than other neighborhood types (10,33,65), the perceptions of respondents in high income neighborhoods in the present study are not out of place.

Why the less educated respondents believe there is high awareness level of the urban forest in the city is rather difficult to substantiate since a lot of these people were located in the low income and middle income neighborhoods where tree cover is relatively low. We believe however, the issue is down to misinformation and lack of adequate knowledge about what constitutes an urban forest. These urbanites may have been deluded by the presence of the few trees in their neighborhoods, coupled with past developmental legacies where old towns such as James/Usher Town were built devoid of green cover (66). Since colonial times such neighborhoods as Nima and James Town have been developed haphazardly either with limited planning or overstepping existing plans and laws. These historical patterns, unavailability of space, customary land use systems, and believes about a city without nature may have shaped the views of residents in neighborhoods with less forest cover that the few trees in their neighborhoods were enough to meet their basic life quality needs. The situation creates a need for expanding formal educational programs as well as education about trees and forests in cities among residents of particularly low income neighborhoods in Accra. Educational programs must be multicultural in character, conducted in the local languages using several media platforms, and above all connect people with their trees and green spaces both physically and psychologically (67).

Our findings that residents of high and middle income neighborhoods were more likely to plant trees than low income neighborhoods corroborate previous findings. In one city each in Nigeria and Congo D.R., 90% and 86% of respondents respectively indicated their preference to cultivate trees in urban areas and were willing to participate in public tree planting programs (68,69). People who are well educated, have relatively high income and may live in areas with sufficient land area around their houses, therefore are more likely to cultivate trees or participate in public tree planting programs (65,68,70). High and middle income neighborhoods in Accra are occupied by the elites and the wealthy classes of society who have a good judgement of the value of trees and have the resources to plant and care for trees within their homesteads.

Some studies have concluded that people in neighbourhoods that are relatively deprived (low income and education levels) are less likely to participate in public tree planting programs (65,71). Why people in low income neighborhoods seem to be less interested in tree cultivation include 1) lack of space to plant trees, 2) benefits of trees take too long to be realized, 3) trees interfere with building foundations and roofs, 4) tree waste such as falling litter are expensive and time consuming to clean and 5) some perceive trees or forest in human settlements to be associated with negative incentives such as serving as hideouts for criminals, habitats for dangerous pests.

5. Conclusions

The study assessed the perceptions and diversity of urban forest of Accra and its potential to contribute to food security in cities in developing countries. About 31% of woody species and nearly half of all trees enumerated have the potential to provide food either as fruits, seeds, nuts, leaves, oils and many others. Home gardens harbor the highest species richness with high income neighborhoods having high abundance of trees while the highest diversity values for food tree species were found in low income neighborhoods. In addition, it was observed that these woody species can serve as sources of several major and micronutrients as well as vitamins essential to addressing hidden hunger issues which frequently hounds urbanites in developing countries owing to the changing food culture, high food prices and over reliant on traditional staples. In particular, more than 70% of food tree species in the city could supply critical nutrients such as Fe, Zn, Mo, I and Ca. It is concluded that the urban forest is a vital sources of food and delicate nutrients and could play a critical role in complementing traditional agricultural practices in the fight against urban food insecurity and malnutrition in Africa.

However, urban food tree diversity is spatially stratified among neighborhood types, a situation that could lead to environmental and food security injustices. Low income neighborhoods are particularly disadvantaged in this regard. Therefore, widening socioeconomic inequalities in the city will worsen environmental inequality (32) and by default the inequality in the distribution of the urban forest cover. Policies and strategies to address the food insecurity through urban forestry must be directed at reducing income and educational inequalities as well as engaging in massive public and private tree planting exercises in all neighborhoods. Because tree food production is seasonal, in order to ensure the availability of tree foods all year round it is important to consider the food production seasons of species when selecting species for urban food forest cultivation. Innovative strategies could be adopted to avoid seasonal food and nutritional insecurities within the urban landscape.

The present study restricted its scope to tree products and the perceptions of tree cover and interest to cultivate trees in the city of Accra. A complete perspective of the potential and contribution of urban trees to food security requires a thorough analysis of intra and intercity urban forest and food security relations. Deliberate policies in favor of food tree cultivation or urban food forestry as part of measures to address urban food insecurity should be a national and regional priority in Africa. Policies to reduce income and educational inequality in cities are critical to sustaining greener cities ideals enshrined in the sustainable development goals.

Plans for follow up research include; studies to experimentally monitor tree growth responses with respect to these neighborhood characteristics and what factors influence participation in tree planting programs within cities in these developing countries. Urban forest structure and diversity relationship to urban health will be another area of primary research focus.

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