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Structure, Floristic Composition and Ethnobotany of Rural Homegardens in the New-Juaben Municipality of Ghana

Master's Thesis

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Declaration

I, Priscilla Kwarteng Owusu declare that I have done this thesis (Structure, Floristic Composition And Ethnobotany Of Rural Homegardens In The New-Juaben Municipality Of Ghana) independently, all texts are original unless quoted and fully referenced according to the Citation rules of my faculty (FTA).

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Abstract

This study examines the design, floristic makeup and ethnobotanical value of home gardens in Ghana's New Juaben District. Home gardens are a crucial part of traditional agricultural land use practices in Ghana and have enormous cultural and ecological value. Data from 50 home gardens in the New Juaben District was collected using a semi-structured questionnaire in order to assess the floristic composition and diversity of plant species. Ethnobotanical knowledge of home gardeners on the uses of plant species on their plots was also collected.

Findings showed that there are a variety of home gardens in the district, with fruits, vegetables, cocoa and timber plants making up the majority of the plant life. Sixty-six plants species were identified in all with an average abundance of 173.59 and an average biodiversity index of 1.02 (Shanon-wiener). We also found that, biodiversity was negatively influenced by the age and size of home gardens. However, biodiversity improved as gardeners gained more experience. A number of notable plant species with high cultural and medicinal purposes such as *F. exasperate, K. pinnata, M. lucida, and T. tetraptera* were also documented from the study. The fruits, leaves, seeds, roots and trunks were used by many for food, medicine and/or for commercial purposes.

The results of this study may be significant for preserving plant diversity and promoting sustainable agricultural methods in Ghana. In addition to highlighting the value of home gardens to the individual home gardeners and cultural traditions, the study sheds light on more impactful benefits of home gardens such as food security, climate change mitigation and rural development.

Keywords; biodiversity, food security, semi-structured questionnaire, biodiversity index, abundance,

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Abbreviations

FAO - Food and Agricultural Organization

HG - Home gardens

KNUST - Kwame Nkrumah University of Science and Technology of Ghana

LBC - Licensed Buying Company

MOFA - Ministry of Food and Agriculture (Ghana)

MLNR - Ministry of Lands and Natural Resources of Ghana

UNEP - United Nations Environment Programme

1. INTRODUCTION

1.1 Home gardening and contribution to food security

The vast majority of people in the world live under sub-standard conditions with between 702 and 828 million people facing hunger (FAO 2022). With the human population now over 8 billion and rapidly rising, hunger and food insecurity continues to challenge global sustainable development (Sasson 2012; Worldometer 2023). By 2050, the global population is expected to hit 10 billion. This means that, in order to feed everyone, it will take 56% more food than is produced in the world today, according to the United Nations Environment Programme (UNEP 2020). According to UNEP, policies should be formulated based on multi-stakeholder collaboration to address food production systems holistically by valuing natural capital, supporting sustainable land use, preventing pollution and environmental degradation and giving farmers the financial means to develop more sustainable models. These efforts will be needed to cover food waste, food lost and more importantly daily caloric requirements in order to catch up with the population (Parfitt et al. 2010). Home gardens (HGs) are one of the basic means to enhance food security and income generation especially for rural inhabitants who are also the most vunerable to hunger and malnurtition (Galhena et al. 2013).

Generally, home gardening refers to the cultivation on a small portion of land around the household or within a walking distance from the family home (Galhena et al. 2013). Home gardens can also be described as a mixed cropping system that encompasses vegetables, fruits, plantation crops, spices, herbs, ornamental and medicinal plants as well as livestock that can serve as a supplementary source of food and income. Kumar and Nair (2004), although admitting that there is no simple definition of a home garden, also defined a homegarden as a combination of trees and other crops, sometimes in association with domestic animals, around homesteads whose cultivation is fully or partially committed to vegetables, fruits, and herbs primarily for domestic consumption. The structure of home gardens could vary depending on climatic conditions and the availability of land, waterbodies, forests, fauna and other natural resources. Similarly, depending on the needs of gardeners, home gardens are established to be useful to owners.

Recent years have seen a rise in interest in home gardening, which has had a profound effect on many facets of society. Home gardening has come to be recognized as an important activity with a variety of beneficial effects; ranging from encouraging environmental sustainability to offering health advantages. Home gardening has a tremendous positive impact on both individual and collective health. It enhances food security and can help prevent chronic diseases like obesity and diabetes by giving access to fresh, locally grown fruits and vegetables (Lundeen et al. 2017). The recent sedentary lifestyle of majority of the population increases the chance of developing health problems, but gardening could help promote physical exercise, which can increase overall fitness levels (Cress et al. 2005). Home gardening has been demonstrated to lower stress levels and enhance mental health, both of which can improve general wellbeing. Besides being good for health and the environment, home gardening is also profitable (Behe et al. 2010; Laube et al. 2012). Gardeners may cut their reliance on store-bought fruit and save money on their grocery costs by growing their own food. Gardening can again encourage small-scale entrepreneurship through the sale of vegetables and other garden products (Galhena et al. 2013). Home gardens have become dominant in many parts of the world due to all the above reasons.

Home gardens are an integral part of the Ghanaian culture and contribute significantly to food security, employment, rural development and national development as a whole (Yiridoe & Anchirinah 2005; Galhena et al. 2013). In all areas of Ghana; urban or rural, forest or savannah, home gardens are of great importance to the social and cultural well-being of families (Akrofi et al. 2010). Home gardens are commonly established on marginal in Ghana (Galhena et al. 2013). The size of home gardens may vary but is usually less than a hectare in Ghana (Owusu et al. 1994; Galhena et al. 2013). Home gardens are usually established for subsistence in Ghana just as it is in many other developing countries and developed countries. Many home gardens have a diverse number of plant species present for purposes such as medicine, food, timber, shade, spices, spiritual purposes and other provisioning purposes. In Ghana, home garden management is commonly dependent on the available family labor (Galhena et al. 2013). Occasionally however, depending on the market orientation of a home garden, additional labor is hired for maintenance (Mitchell & Hastad 2004; Galhena et al. 2013). Home gardens are not devoid of challenges. Like any other agricultural production system, home gardens may be vulnerable to harsh environmental conditions such as drought and floods. Other constraints are access to suitable and sufficient land, access to capital or credit, access to water, seeds and other inputs, weak extension and advisory services, access to labor and to markets (Rajagopal et al. 2021). The majority of these limitations are because of the lack of active involvement in development of the land use systems by policy makers and their insufficient understanding of home gardening.

1.2 Background of home gardening

Home gardening, also referred to as backyard gardening or domestic gardening, is the activity of cultivating plants for one's own use or to sell in and around one's home or land (Kumar 2015). Home gardening has a long history that dates back to when people first started growing plants for food and healing (Ferris et al. 2001). The land use system has always provided important support especially for rural dwellers and continues to do so today.

According to archeological evidence, home gardening was a common practice in ancient civilizations like Egypt, Greece, Rome, and China (Angelakis et al. 2020). Monks and nobles were the principal home gardeners in medieval Europe, growing herbs and vegetables for both culinary and medical uses. The wealthy developed magnificent gardens filled with exotic plants and flowers throughout the Renaissance period, which increased home gardening's appeal to the ordinary. Throughout Europe and North America, home gardening rose in popularity during the late 19th and early 20th centuries. Although the elite in society continued to dominate in gardening, many ventured into the activity due to its prestige and usefulness. In the United States, home gardening was continually encouraged during World Wars I and II in order to enhance access to food at all times (food security) by the entire population.

Due to a rise in interest in healthy eating, local food production, and sustainable living, home gardening has seen a recent popularity boom. By minimizing the distance that food has to travel to reach consumers, it is also thought to be a means to minimize carbon emissions (carbon footprint) (Edwards-Jones 2010). Home gardening can be carried out on a small or large scale, such as in a backyard or community garden or in containers on a balcony. In either case, home gardens are started for commercial and/or subsistence purposes depending on the needs of the gardeners and the resources available.

As the population generally increases, the majority of the growth will occur primarily in developing nations (FAO 2022). Almost 70% of the world's population will live in urban areas as urbanization picks up speed (49 percent today) (FAO 2022). Feeding the rapidly increasing population with their urban lifestyle will continue to be more difficult due to the heavy food wasting nature of the urban population. Producing enough food will depend heavily on interventions in the agricultural industry geared towards the efficiency and effectiveness of various land use systems. Home gardening will be important to bridge the gap and cater for a significant portion of the population.

1.3 History of home gardening in Ghana

In Ghana, home gardening has a long history that dates back to the earliest civilizations, when individuals grew food only for their families and traded in barter. Garden owners only traded one farm product for another (barter trade), and there was no legal tender involved (Abass & Adraki 2014). Agriculture was a vital aspect of life and grew to become an important source of income for many families in Ghana's traditional society (McManus et al. 2012; Naamwintome & Bagson 2013). Women performed the majority of the work involved in home gardening, including planting, weeding, and harvesting of crops such as yams, cassava and maize (Carr 2008). These crops were largely farmed for subsistence, and the farmers used the harvest to feed their families.

Home gardening grew in popularity during colonial times when European powers introduced cash crops like cocoa, coffee, and rubber to the nation. Large-scale plantations were also established as a result of colonization, but small-scale farmers were also inspired to grow their own crops for subsistence. Home gardening increased in popularity among urban and peri-urban areas in the 20th century as a way to supplement household earnings and guarantee access to fresh produce. In order to increase food security and advance sustainable agriculture, the Ghanaian government also promoted home gardening.

Today, home gardening continues to be a significant component of Ghanaian agriculture, supplying fresh vegetables and serving as a source of income for many people (De Bon et al. 2009). Through numerous initiatives and programs, including the Planting for Food and Jobs (PFJ) program, which seeks to boost agricultural output and enhance national food security, the government advocates for home gardening (MOFA 2021).

1.4 Characteristics of home gardens in Ghana (structure and floristic composition)

In Ghana, home gardens are sophisticated agroforestry systems with a variety of trees, shrubs, herbs, and other plants. These home gardens can have a variety of structures and floral arrangements based on the area, cultural customs and ecological conditions. Nonetheless, home gardens in Ghana share a few similar traits. The typical structure of home gardens frequently has multiple strata or levels of plants, which include:

- Canopy layer: Tall trees that give shade and cover for the home garden make up the layer known as the canopy. In this layer, trees, including mango (*Mangifera indica* L.), avocado (*Persea Americana* Mill.), and citrus (*Citrus* spp. L.) are frequently found.
- Understorey layer: This layer, which develops below the canopy layer, is made up of smaller trees and plants. In this layer, it's typical to find plants like coffee (*Coffea Arabica* L.), plantains (*Musa paradisiaca* L.), and cocoa (*Theobroma cacao* L.) (Moravec et al. 2014; Rutten et al. 2015; George & Christopher 2020).
- Shrub layer: The shrub layer serves as a transition between the understorey layer and the herbaceous layer and is made up of low-growing shrubs. In this layer, it is typical to find plants like the hibiscus (*Hibiscus rosa-sinensis* L.) and cassava (*Manihot esculenta* Crantz.) (Moravec et al. 2014; Rutten et al. 2015; George & Christopher 2020).
- Herbaceous layer: Grass, herbs, and other low-growing plants comprise this layer. In this layer, it is typical to find vegetables like okra (*Abelmoschus esculentus* (L.) Moench.), tomato (*Solanum lycopersicum* L.), and pepper (*Capsicum annuum* L.) (Moravec et al. 2014; Rutten et al. 2015; George & Christopher 2020).

Home gardens in Ghana include a variety of floral compositions based on their geographic location, cultural customs, and environmental factors. Nonetheless, some frequent species discovered in home gardens includes:

- Fruit trees: Mango (*M. indica*), papaya (*C. papaya*), *Citrus* spp., and avocado (*P. americana*) trees are examples of fruit trees.
- Timber trees: Mahogany (*Swietenia macrophylla* King.), teak (*Tectona grandis* L.), and ebony (*Diospyros spp*. L.) are three types of timber trees.
- Oil crops: Shea butter (*Vitellaria paradoxa* C.F.Gaertn.), coconut (*C. nucifera*), and oil palm (*Elaeis guineensis* Jacq.) are examples of oil crops.
- Medical plants: Aloe vera (*Aloe barbadensis* Miller), moringa (*Moringa oleifera* Lam.), and ginger (*Zingiber officinale* Roscoe.) are all considered medicinal plants.

- Vegetables: Tomato (*S. lycopersicum*), eggplant (*S. melongena*), and okra (*Abelmoschus esculentus* (L.) Moench.) are examples of vegetables.

Overall, home gardens' floristic composition reflects the value of traditional foods and the variety of agroforestry techniques that have evolved over time in the country. A great variety of wildlife, including beneficial insects, birds, and small mammals, is supported by the home garden's multi-layered structures, and this is important for climate change mitigation, especially in recent times (Mitchell & Hastad 2004).

1.5 General structure of home gardens

Home gardens are typically designed to make the best use of the area that is available while also encouraging the efficient use of resources like water, soil, and fertilizers. Some typical components of home gardens are;

- Garden beds: they are typically raised and constructed out of different materials like wood, brick, or stone. The beds are used to cultivate a variety of crops and are often set up so that planting, weeding and harvesting are made simple (Smith et al. 2005).
- Paths: pathways are essential for navigating the landscape easily and performing maintenance tasks. They are typically composed of concrete, stone or gravel (Smith et al. 2005; Baliki et al. 2019).
- Trellises and supports: Climbing plants like tomatoes, beans and cucumbers are supported by the use of trellises and supports. They are often constructed from durable materials like bamboo (Inocian & Nuneza 2015).
- Residential gardens frequently have a space set aside for composting organic waste such as grass clippings, leaves and food leftovers. Compost is used to boost the health of the plants and the soil.
- Watering system: To guarantee that plants receive enough water in places with little rainfall, home gardens may need an irrigation system. Watering cans can be used for manual irrigation, while drip irrigation systems can be used automatically (Hla & Scherer 2003; Yiridoe & Anchirinah 2005).

Generally, the layout of home gardens is created to maximize the use of available space and resources while also encouraging strong plant development and abundant crop production.

1.5.1 Vertical and horizontal structure of homegardens

Depending on the community's cultural, ecological, and economic environment, home gardens can have a variety of layouts and structures. Home gardens, however, often have two basic dimensions: the vertical structure and the horizontal structure.

In home gardens, the layering of vegetation from the ground to the canopy is referred to as the vertical structure (Moravec et al. 2014; Rutten et al. 2015; George & Christopher 2020). Root crops, groundcovers, herbs, shrubs, smaller trees, and bigger canopy trees are examples of the various vegetational strata. By maximizing the use of light and nutrients, establishing microclimates, and boosting biodiversity, this vertical structure offers a variety of advantages. The vertical structure is usually categorized into three main strata; the lower stratum, which is anything less than 3 meters (vegetables, herbs and other plants). The middle stratum is usually between 3 and 5 meters, and the upper stratum is part of the plot that is higher than 5 meters. This classification is also done by Albuquerque et al. (2005) and will similarly be employed for the purpose of discussing this study.

The horizontal structure of homegardens refers to the spatial arrangement of vegetation, including the placement of different plant species and their interrelationships. Plants in a home garden are frequently set up in a mixed-cropping design, where many species are interplanted in the same area. This horizontal structure also helps the garden become more diverse and more resistant to pests and illnesses. The overall vertical and horizontal organization of home gardens contributes to the development of a dynamic and complex ecosystem that sustains the livelihoods of millions of people throughout the world.

1.5.2 Horizontal structure of homegardens in Ghana

Ghanaian home gardens often have a less sophisticated horizontal structure as plants are organized in a flat, layered pattern depending on the purposes of the variety of plant species identified in the home garden. Most useful plants are usually maintained or grown around the edges of the plot and the middle of the plots are mainly filled will large trees that provide shade but take up too much space and prevents other crops from thriving. Since gardeners try to make the best use of the available ground, home gardens in Ghana are frequently compact, rich and abundant for their sizes depening on the market orientation, age of farm and other factors (Kuusaana & Eledi 2015; Giller et al. 2021).

Several layers of vegetation make up the horizontal structure of home gardens in Ghana. Tall trees like palm trees, make up the upper tier of the garden, providing shade and acting as a canopy in the structure. Shorter trees and shrubs that grow beneath the tree canopy offer additional shade and support for climbing plants whiles receiving shade from trees with larger canopies.

Vegetables and other crops like cassava, yams and maize make up the home garden's middle tier. These crops are normally interplanted with legumes like beans or cowpeas to add nitrogen and other nutrients to the soil. They can be grown in rows or on small plots. Ground cover plants like herbs, spices, and medicinal plants make up the home garden's bottom layer. Moreover to adding to the household's food and medical supply, these plants aid in preventing soil erosion.

Generally, home gardens' horizontal design reflects the necessity to maintain a variety of crops and plant types to suit household needs while also maximizing the productivity of the small plots of land.

1.5.3 Vertical structure of home gardens in Ghana

Depending on factors including climate, soil type, and cultural practices in a particular region, the precise layers and arrangements of plants may differ, but there are some characteristics of the vertical structure of home gardens in Ghana that are typical (Nero & Anning 2018; Kumar & Kunhamu 2022);

- Canopy layer: The topmost layer of the garden is known as the canopy, and it is made up of tall trees like fruit trees, oil palm trees, and shade trees. These trees provide a supply of fruits, nuts, and other products, as well as shade and protection for the other plant levels.
- Subcanopy layer: Shorter trees and shrubs, like those found in the sub-canopy layer, include coffee, cocoa, and cassava. Further, to provide additional shade and safety for the lower strata, these plants can be used to produce food or other goods.
- Herbaceous layer: Plants used for food, spices, and medicine are all part of this layer, which is composed of both annual and perennial herbs. These plants can be interplanted with different types of vegetation or cultivated in rows.

- Groundcover layer: This layer is made up of low-growing plants like creeping herbs and groundcovers that help control weeds and prevent soil erosion.
- Root layer: This layer is made up of underground-grown root vegetables like yams and sweet potatoes.

While diverse plant species are cultivated in the same place and benefit from each other, Ghanaian home gardens' vertical design enables the efficient use of resources. Also, the variety of plants in home gardens can improve soil health, lessen pest and disease issues and give people a good source of income and food security as is already mentioned.

1.6 Integration of home gardening in urban areas

With an increase in population comes an increase in food requirements in metropolitan areas, as is already established in previous paragraphs. Yet, Ghana's urban areas continue to cut down productive agricultural land, as is the case for many developing nations. Too much emphasis is put on the construction of roads, buildings, and markets whiles neglecting natural resources in the name of development. For urban dwellers to be able to feed even themselves, agricultural land in urban areas, particularly home gardens, must be preserved. Home gardening can be adopted even in populated areas: in backyards of homes and open spaces around offices. In the rural areas where lands are more accessible, lands are not used efficiently. This is due to the lack of expertise in the management of a proper and beneficial home garden. Benefits associated with biodiversity are often missed as many farmers or gardeners lack the knowledge of benefits or are wrongly inspired into monoculture for commercial reasons. Home gardens have the potential to promote household food production as well as ecological services whiles providing aesthetic value to rural and urban areas alike (Galhena et al. 2013). Although home gardens are often small in size, they have the ability to enhance household nutrition by making high-quality and hygienic foods available at lower costs to gardeners (Patel et al. 2013; Amayi 2016).

1.7 Challenges with home gardening

Ghana's home gardening industry has a number of challenges and opportunities, such as unpredictable rainfall patterns coupled with inaccessible irrigation systems, poor soils, pests and diseases (Akrofi et al. 2008; Appiah et al. 2009; Domínguez-Hernández et al. 2022). These challenges prevent gardeners from being effective or efficient in production and demoralize individuals who may have wanted to enter home gardening. The impact of climate change has also been felt severely and hinders the optimum productivity of home gardens.

Besides the natural adverse conditions, most of which are intensified as a result of global warming and climate change, lack of information and skills is another important challenge for Ghanaian home gardeners. Local gardeners are unable to cultivate and maintain a diverse range of plant species especially exotic kinds, since they are simply not aware of the right practices required and they lack access to good inputs such as seeds, fertilizers and pesticides. As a result, many gardeners fall on a few basic plant species that they know well, such as *Musa* spp, *M. esculenta* and *D. alata.* This, however, affects the richness and diversity of plant species needed to mitigate the changing climatic conditions. Home gardeners also have limited access to markets, which makes it challenging for them to sell their products and make a profit.

All these challenges mean that there is much room for improvement. The government and other stakeholders must work together to provide training, access to resources and marketing possibilities for gardeners in order to mitigate these issues effectively.

1.8 Ethnobotany

Although ethnobotany is a young field of study, its social and scientific functions are becoming more clearly defined, and the scientific community now widely acknowledges the value of ethnobotany as a supplement to management and conservation plans at the local and regional levels (Davis 1995). Ethnobotany has proven to be a challenging term to define since its inception in the early 19th century. Initially, it was simply characterized as, the use of plants by indigenous people. Over the past century, attention has however shifted to include aspects of plant perception, management and dependence on plants that are mutually dependent on humans (Albuquerque et al. 2005). According to Davis (1995), ethnobotany is the study of the relationships between plants and people, which involves documenting and describing the various uses of plants in different cultures and the ways in which those uses are embedded in social, economic, religious, and political systems.

For the preservation of traditional plant knowledge and the diversity of plants, as well as for comprehending the interactions between people and the natural environment, ethnobotanical literature is crucial. Also, ethnobotanical knowledge can help with the creation of environmentally friendly methods for managing and using plants, as well as with the creation of novel pharmaceuticals and other goods based on conventional plant knowledge.

1.8.1 Ethnobotanical knowledge of plants in Ghana

Ghanaians have a long tradition of using plants for a variety of purposes, including therapeutic, gastronomic and spiritual ones (Karunamoorthi et al. 2013; SO et al. 2018; Abukari et al. 2022). Traditional healers and herbalists have worked to pass down knowledge of plants from one generation to another by teaching their children at infancy the uses of various plant parts. For instance;

Neem tree (*Azadirachta indica* A.Juss.): The neem tree's leaves, bark and seeds are used for numerous purposes mainly medicinal. Neem is used to cure a variety of illnesses, including respiratory diseases, malaria and skin conditions. Neem leaves and/or bark is simply harvested and boiled in water and the extract is consumed to cure stomach ache, malaria and fever. Following the outbreak of the Covid-19 pandemic, many in Ghana believed the neem tree to be capable of preventing and/or curing infected persons. This was however not scientifically backed by research and any evidence of infected individuals who were cured by the neem tree is still arguable.

Adansonia digitate L., often known as the African baobab, is a tree that grows in Ghana and is used for both food and medicine. The fruit which grows mainly in the savannah region, is rich in vitamin C and can be used to treat fever, diarrhea and other conditions. In the savannah region of Ghana, the local inhabitants also make smoothies and local ice cream from powder extracted from the dry fruit. NGOs export baobab into Europe and other countries also to be processed into a variety of edible products (jams, oils etc.) and even for use in body lotions. According to (Kamatou et al. 2011; Rahul et al. 2015; Giller et al. 2021), the baobab fruit is seven times richer in vitamin C than *Citrus sinensis* (L.) Osbeck.

Shea butter tree (*Vitellaria paradoxa* C.F.Gaertn.): A native of West Africa, the shea butter tree is used in Ghana for its therapeutic benefits as well as as a source of butter for food and cosmetics. The butter is used to hydrate and preserve the skin since it is rich in fatty acids. Senna (*Cassia senna* (L.) Link.) is also a medicinal herb that is used in Ghana to treat digestive problems like constipation. Tea and extracts are made from the plant's leaves and pods. The moringa (*M. oleifera*) tree's leaves, seeds, and pods are desired for their therapeutic and dietary benefits. High in vitamins and minerals, moringa is used to alleviate inflammation, malnutrition, and other health issues.

Solanum erianthum D. Don. leaves are used for leukorrhea because it is believed that they can help the body get rid of pollutants through the urine. In addition to being used to treat hemorrhoids, the leaves are known to induce abortion in pregnant women. For headache the leaves are heated and put on the forehead. Dysentery, fever, diarrhea, digestive issues and excruciating body pains can all be treated with a root decoction from the plant. The root bark is also used to treat arthritis and acts as an anti-inflammatory agent. Due to its laxative and diuretic properties, some locals are known to cure leprosy, sexually transmitted infections and malaria. On top of the medical benefits, the plant is believed to provide spiritual protection for people who care for it and know how to use it. All these are but a handful of the numerous plants that are used in Ghana for their therapeutic, gastronomic and spiritual benefits. The knowledge of these plants has been passed down through generations and continues to play a significant role in Ghanaian culture.

2. AIMS OF THE STUDY

This research was conducted to add up to limited present literature on structure, floristic composition and ethnobotanical knowledge of home gardens in Ghana. The work will evaluate the floristic composition of home gardens, which is essential to address issues of inventory and documentation of species composition and biodiversity (Bogale 2017). Moreover, knowledge of the critical elements influencing biodiversity in home gardens will be obtained (Perales et al. 2005; Galluzzi et al. 2010). Ethnobotanical knowledge of gardeners will also be collected in order to assess how impactful home gardens are in the livelihoods of households and societies in terms of food, medicine and other provisioning services. Results from this study will be helpful in developing appropriate strategies for effective management of home gardens as they can be valuable biological resources for food security.

The general aim of the study is to determine the structure, floristic composition and ethnobotanical knowledge of homegardens in Ghana using the New Juaben municipality as the study area. The specific objectives are;

- To assess the floristic homogeneity or variation of home gardens (HGs) in the study area.
- To evaluate variables or components that influences biodiversity in the HGs.
- To evaluate the ethnobotanical knowledge of HG owners and uses of plant species in HGs.

3. METHODOLOGY

3.1 Study area

The study area was the New-Juaben Municipal. The population of the New Juaben Municipal is 218,457. The municipal is known for its rich fertile agricultural land and is suitable for small to medium-scale farming, cattle rearing and poultry as well as home gardening (HGs). The municipal is found in the semi-deciduous rain forest climatic zone with a bi-modal rainy season of between 1200mm and 1700mm (Kaba et al. 2020). The dry season is relatively shorter than in most parts of the country. The average humidity is between 70% and 80%, whiles the temperature is generally high between 20C and 30C (Oduro et al. 2021). The vegetation is dominated by hardwood trees with high economic value, such as *Alstonia bonei* De Wild., *Morinda lucida* Benth., *Ceiba pentandra* (L.) Gaertn., *Antaris Africana* Engl. and *Triplochinton scleroxylon* K.Schum. The presence of these economic trees has heightened the rate of lumbering and hence the rapid loss of natural vegetation. Common important food crops in the area are *Musa* spp, *M. esculenta* and *D. rotundata.* The predominant source of livelihood in the area is farming due to the rich nature of the soil.

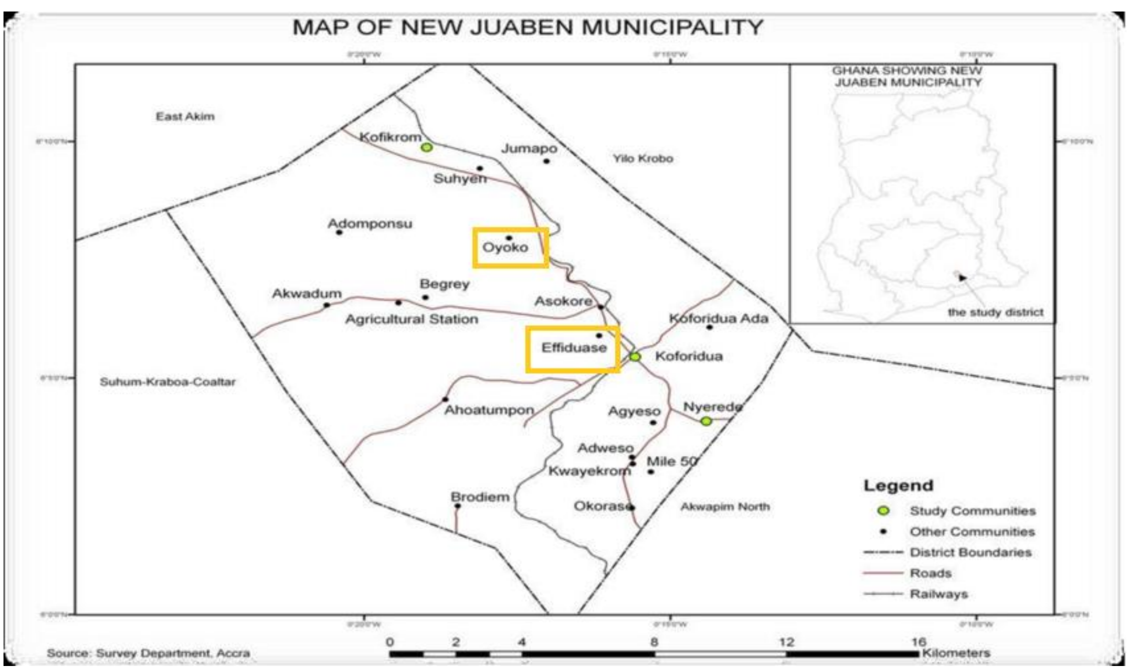

Figure 1 – Map of study area

3.2 Data collection

The data used for this survey was collected from December 2022 to February 2023 from 50 gardeners in 2 communities in the district (Oyoko and Effiduase). The data for this study was collected by 2 enumerators who were trained on the aims and general design of the research. The enumerators employed were students from the Agricultural Department of the University of Science and Technology in Ghana. Training was delivered to the enumerators on collection of information regarding the number of species, abundance and ethnobotanical knowledge of respondents. Enumerators were again trained on the how to assess the horizontal structure of the various HGs using the house of the owner as reference point. Training on the vertical structure of the HGs were also given to enumerators, considering the arrangement of plant species in the home gardens in their various strata.

Through direct observation and semi-structured interviews with gardeners (14 female and 36 male), information about gardeners and their gardens were inventoried from each community. The interviews were conducted in a local dialect (Twi) and then recorded in English by enumerators. Each respondent visited both their homes and gardens at least once. First of all, a semi-structured questionnaire was used to collect information on socioeconomic characteristics (age of gardener, gender, education, ethnicity, marital status, household size and primary occupation) and garden information (age of HG, size of HG, terrain, market orientation and distance to market). Information on the floristic composition of HGs was also recorded using the questionnaire. Next, the ethnobotanical knowledge of plant species cultivated in HGs was also collected according to specific plants and their main purposes alongside the uses of the specific plant parts (leaves, branches, roots, bark, seeds, trunk, stem, flowers etc.). All information collected was then recorded in a field notebook.

Plant species were then grouped according to 4 main categories according to their kind; fruit, timber, roots and tuber and others (Figure 2), as was done by Akrofi et al. (2008) using a radar chart. The "Other" category consisted of plant species that did not fall under any of the first 3 categories; vegetables (*S. lycopersicum*), grains (*Z. mays*), spices (*Z. officinale*) and other plant species. These plants were not abundant enough to be represented individually. Plant species were again grouped according to their primary purposes, as identified from the questionnaire that was administered. The main purposes were grouped into five main purposes (edible, medicinal, commercial, shade and other provisioning purposes) (Figure 3). The commercial purposes identified were primarily the sale of trees as timber and the sale of cocoa. Other provisioning purposes identified were; fodder, spiritual purposes, fuel, spices etc.

All plant species that were identified on HGs were recorded except for weeds which respondents did not have any use. Plant names were originally recorded in *Twi*, and the taxonomic identification was made by local taxonomists, namely Prof. JVK Afun from University of Science and Technology of Ghana and Mr. Assiko Asumadu from Forestry Research Institute of Ghana.

3.3 Data analysis

Data was gathered on every species that was present in the HGs in order to evaluate the floristic homogeneity or variance of HGs for the first objective. Individual plant species' abundance, richness and biodiversity indexes were analysed using excel and presented in a table as was done by Albuquerque et al. (2005). For the purpose of calculating the relative abundance, richness, mean density and biodiversity of individual HGs, the total number of plant species and the individual occurrences were documented from all 50 respondents. The horizontal and vertical arrangement of the species served as the foundation for the description of the gardens' structure (Rutten et al. 2015). The location of each species in the garden was used to determine the horizontal structure, using the farmer's house as a point of reference. The arrangement of the vegetation of the homegardens was similarly described using multi-layer strata; 1-3 m lower stratum, 3-5 m mid-stratum and 5-7 m upper stratum (Nero & Anning 2018; Kumar & Kunhamu 2022).

In the second objective, a linear regression was used to assess factors that influence biodiversity in HGs. Shanon-wiener, Margalef and Simpson's index were calculated and used as the dependent variables for the model, whiles gender, age of respondent, education, household size, experience, size of HG, market distance, distance, age of HG, occupation of homegardener, household head gender, terrain, ethnicity and marital status were used as explanatory (Abdoellah et al. 2006; Smith et al. 2006; Akrofi et al. 2008; Bardhan et al. 2012; Clarke et al. 2014). Additional emphasis was then put on the factors that were identified as significant amongst the explanatory variables according to the regression model (size of HG, age of HG and Experience). These variables were then grouped into two parts using the mean as a mid-point in order to properly explain how more or less of the variable influenced biodiversity and even other explanatory variables (Table 3). The size of HG was grouped as ≥2 ha and <2 ha, age of HG was also grouped as ≥5yrs and <5yrs, while the experience of a gardener was also grouped as ≥5yrs and <5yrs. The three variables were finally shown in a scatter diagram to give a graphical depiction of their causality with the various biodiversity indexes.

The third objective was finally analysed using a simple table to describe each plant specie identified, the primary purpose, parts that are useful to gardeners and the uses of the plant part.

3.3.1 Number of species

The number of species (*S*) is basically the total number of individual plant species identified in all home gardens that were visited. For example, during the data collection, 50 of *P. americana*, 30 of *X. sagittifolium* and 10 of *P.s discoideus* in a HG would be counted as 3 species for that home garden; *P. americana, X. sagittifolium* and *P. discoideus (one each).*

3.3.2 Mean species density

The mean species density is the number of individual species that exist within a given quadrant. In our study, it was calculated as number of species *(S)* per 100m^2 quadrant (Table 2).

3.3.3 Mean abundance

Abundance (*A*) represents the number of all individuals of all species identified in a home garden. For example, in a HG that has 20 individual presence of *T. cacao*, 30 of *Z. mays* and 30 of *Musa* spp, the abundance was calculated as 20 + 30 + 30 = 80. The mean abundance was finally calculated as the abundance per number or individual species identified

The formula is represented as;

$$\boldsymbol{\Sigma}\ \mathbf{N}/\boldsymbol{S}$$

Where *N* is the total number of plants in a given HG (or abundance) and *S* is the number of individual plant species. In this study, Σ*N or (A)* = 14602 and *S*=66 (Table 2).

3.3.4 Shanon-wiener index

The standard statistical methods were used to calculate biodiversity data using MS Office Excel. Shanon-wiener index (H) was calculated as;

$$H = -\Sigma pi * ln(pi)$$

Where: $\boldsymbol{H}$: Shanon-wiener index, $\boldsymbol{\Sigma}$: A Greek symbol that means "sum", $\boldsymbol{ln}$: Natural log, $\boldsymbol{pi}$: The proportion of the entire community made up of species ($\boldsymbol{i}$).

The diversity of species in a given community increases with increasing H value. The diversity decreases as H value increases. A community with a value of H = 0 only contains one species.

3.3.5 Margalef index

Species richness or Margalef index (DMg) was also calculated as;

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

Where: "$\boldsymbol{MR}$" is Margalef index, "$\boldsymbol{S}$" the number of species, "$\boldsymbol{N}$" is the total number of individuals in the sample

3.3.6 Simpson's index

Simpson's diversity index **(D)** was also calculated as;

$$D = \Sigma ni(ni - 1) \ / \ N(N - 1)$$

Where; "$\boldsymbol{D}$" is Simpson's diversity index, "***ni***" is the number of organisms that belong to species (***i***) and "***N***" is the total number of organisms.

3.3.7 Ethnobotanical knowledge (objective 3)

Ethnobotanical knowledge of home gardeners was analysed using a descriptive table. All species identified during the survey had a purpose for their respective home gardeners. Out of the 66 identified species, 26 (39%) were primarily for edible purposes, 5 (8%) were primarily for medicinal purposes, 26 (39%) were also for commercial purposes primarily, 4 (6%) for shade and 5 (8%) were primarily for other provisioning purposes such as for spiritual protection. These groupings were done as has been done by Clarke et al. (2014).

3.4 Summary of respondents and homegardens (HGs)

Table 1 shows a summary of the data that was collected from the 50 home gardens. The average biodiversity indexes for the sample were 1.05 (Shanon-wiener), 0.95 (Margalef) and 0.54 (Simpsons). The average experience of home gardeners from the sample was 4.9 years, with a minimum of 2 years and a maximum of 14 years. This means that the majority of the respondents were inexperienced with home gardening. The average age of home gardens was 5.56 years, and the average size was 2.07 ha. Male home gardeners were the majority (72%) as well as male household heads (78%). Most home gardens (82%) were also on flat lands and respondents were mostly subsistence oriented (64%).

Table 1 - Summary of variables

N=50	Minimum	Maximum	Mean	Std. Deviation
Shanon-wiener index (H)	0.49	1.91	1.05	0.32
Margalef index (MR)	0.22	1.90	0.95	0.35
Simpsons index (S)	0.26	0.83	0.54	0.15
Age of respondent (Years)	29.00	65.00	44.80	7.77
Education (years)	0.00	12.00	4.64	3.50
Household size	3.00	10.00	5.90	1.52
Experience (years)	2.00	14.00	4.90	2.68
Age-HG (years)	2.00	16.00	5.56	3.45
Size-HG (ha)	0.300	12.0	2.07	1.74
Market distance (km)	2.08	16.67	11.27	3.59
Home distance (km)	0.00	1.25	0.80	0.35
Gender of homegardener (Male)			72.00%	
Household head gender (Male)			78.00%	
Terain (Flat)			82.00%	
Market orientation (Subsistence)			64.00%	
Marital status (Married)			70.00%	
Ethnicity (Ashanti)			56.00%	

4. RESULTS

4.1 Categorization of plant species

Figure 2 is a description of the dataset in terms of the plant species that were identified from the field survey. Out of 66 species, 13 (19.7%) fruit species were identified. Some of the identified fruit species were *C. papaya* and *C. sinensis*.

The highest number of different plant species identified were timber species as is indicated in the figure. Out of 66 plant species identified in the whole survey, 32 (48.48%) were timber species, according to Figure 2.

Roots and tuber species identified in the survey was 4 (Figure 2), comprising of *D. rotundata*, *X.a sagittifolium*, *M. esculenta* and *C. esculenta*. Other species that were recorded comprised generally of vegetables (*S. lycopersicum*), grains (*Z. mays*), spices (*Z. officinale*) and other plant species.

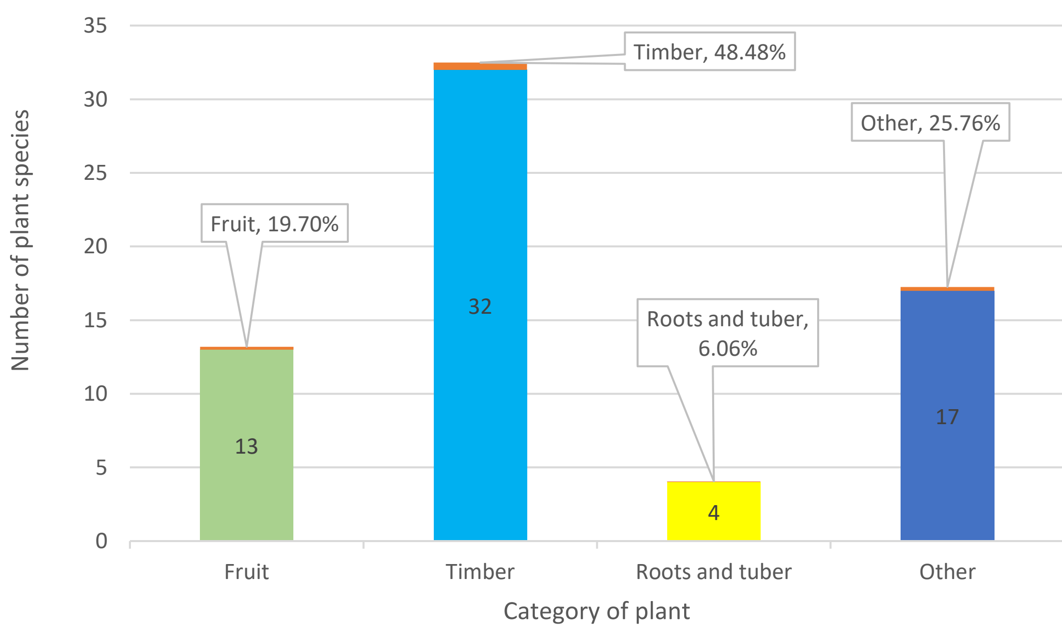

Figure 2- Categorisation of plant species identified

Figure 3 also shows identified plant species categorized based on their primary purposes. Most HGs comprised plant species that were primarily grown or maintained for edible or commercial purposes. Out of the 66 identified species, 39.39% were used as food (Edible) whiles the same number of species was used for commercial purposes as is shown in Figure 3. Medicinal plant species and shade-providing purposes accounted for 7.58% and 6.06%, respectively. Plant species that were used for other provisioning purposes such as spiritual purposes, spices, fodder, broom, pistol and furniture making accounted for 7.58% of the 66 identified species.

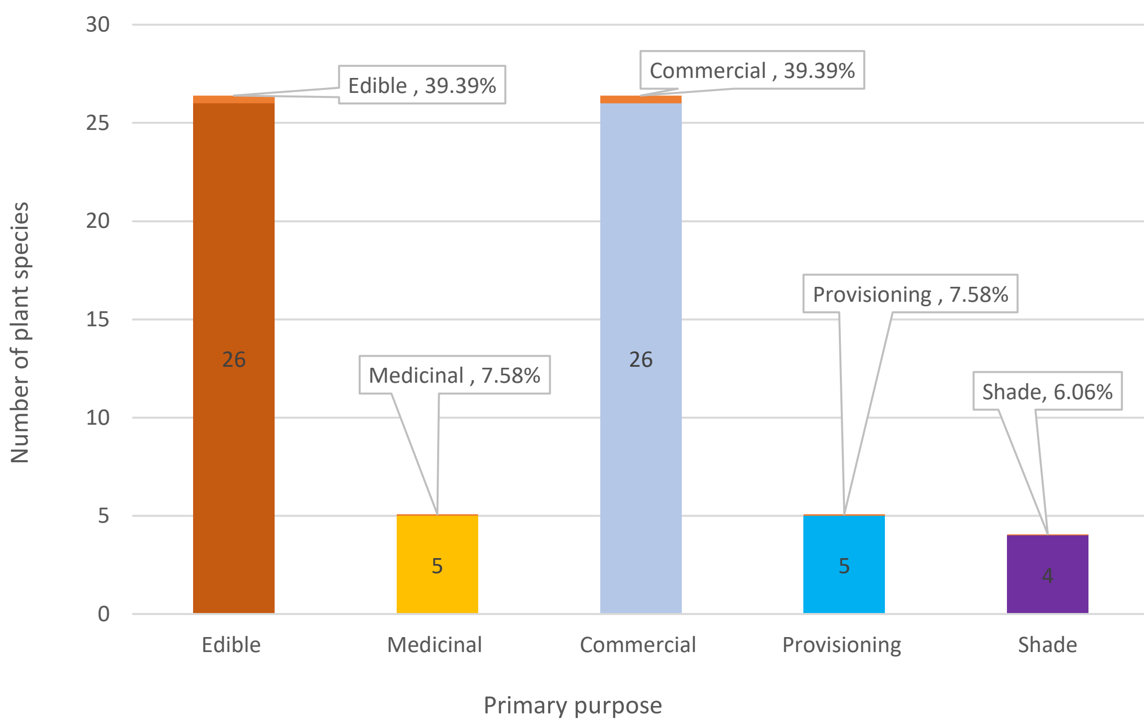

Figure 3 - Categorisation according to primary purpose

4.2 Structure of the home gardens (Objective 1)

The homegardens studied represented complex structures with a generally multilayered configuration. The garden areas varied in shape and size, but were most commonly rectangular and occupied an area between 30m^2 and 1200m^2 (mean of 207m^2 and standard deviation of 174m^2).

Within the horizontal space that is available, the species grown in HGs are spread. In particular, fruit trees like *P. americana* and *C. papaya* are among the species that home gardeners either cultivate or preserve. Plants that are intentionally conserved for spiritual purposes, used as food or as medicine was usually left around the edges of the home gardens to enhance access. The most abundant plant species were for edible or commercial purposes (Figure 2). Some home gardeners resided in the center of their HGs whiles others lived a few kilometres away. The average distance between the house and the HG was 0.8km for all 50 respondents (Table 1). The maximum distance was 1.25 (Table 1). Timber species were also strategically spread through the HGs in order to provide shade in the garden. Timber species were rarely cut immature due to their commercial and medicinal importance. Home gardeners also preserved specific tree species around the edges to supply fodder to livestock (*F. exasperata*). The majority of home gardens were on a flatland (82%) due to the natural topography of the area.

In terms of the vertical structure, HGs were separated into three strata, as was done by Albuquerque et al. (2005). The lower stratum (1-3m) was made up of fruit trees (*A. muricata, M. indica, C. nucifera*), medicinal plants (*B. buonopozense*), spiritual plants (*K. pinnata*), vegetables, spices (*Z. officinale*), root and tuber species, *T. cacao* and dominated by both *Musa* spp. The middle stratum (3–7 m) is created by a combination of several species. The majority of the trees in the upper stratum were between 7 and 12 meters tall, comprising mainly timber species such *as P. angolensis, S. macrophylla, C. gigantea, F. elastica, A. ferruginea, P. subcordata, G. ehie, M. lucida and F. capensis* most of which double in use as medicinal plants.

4.2.1 Floristic composition- Objective 1

Sixty-six plant species belonging to 40 different families were encountered in the study area (Table 2). The most represented families were *Malvaceae* (5/40) and *Fabaceae* (5/40). The most cited plant species in the study area was *Musa* spp.(88%) *T. cacao* (62%), *E. guineensis* (54%) and *M. esculenta* (50%) as is shown in Table 4. The majority of the plant species (59) were cited in less than 7 HGs (10%). Some of these were *C. mildbraedii* (3), *S. campanulata* (3) and *O. basilicum* (1).

The richest HGs amongst the sample had a total of 9 different species whiles the poorest had two species. However, the mean number of species per HGs was 5.96, as indicated in Table 2 below. The minimum plant density per 100m^2 of the HG was 0.15, while the highest tree density was 10.43, and the average was 1.75 (Table 2). The most abundant HGs also had an abundance of 225.5, and the least abundant was 5, with a mean abundance per HG of 221.24 ((Table 2).

In terms of biodiversity, the average index for all 50 HGs was 1.05, 0.95 and 0.54 for Shanon-wiener, Margalef and Simpson's indexes, respectively (Table 2). The HGs with the highest Shannon-wiener index representing both evenness and abundance of species had an index of 1.91, but the same HGs did not have the highest index for the other two biodiversity indexes. The minimum HGs also had a Shanon-wiener index of 0.49 but were not the least biodiverse HGs considering Margalef and Simpson's index.

Margalef index representing the richness of the HG varied between 0.22 and 1.9, while Simpson's index, which also represents the probability that two individual species randomly selected from the sample will belong to the same species, also varied between 0.26 and 0.83.

Table 2 - Summary of floristic composition of all HGs in the study area

Observed Characteristics	**Mean (N=50)**
Total number of observed species	66
Mean number of sepcies/homegarden	5.96
Mean species density/homegarden	1.75
Mean abundance/homegarden	221.24
Shanon-wiener index (H)	1.05
Margalef index (MR)	0.95
Simpsons index (S)	0.54

4.1 Factors that influence biodiversity - Objective 2

Factors that were considered to potentially influence biodiversity in a linear regression were; gender, age of respondent, education, household size, experience, size of home garden, market distance, home distance, , age of home garden, occupation of homegardener, household head gender, terrain, ethnicity and marital status (Appendix II). According to the results, the size of HG, age of HG and experience were the significant factors that influenced biodiversity (Shanon-wiener, Margalef and/or Simpson's indexes).

Subsequently, the three explanatory variables, size of HG, age of HG and experience, were individually grouped into two parts according to their means. Based on the mean size of HG of the data set, the two groups that were generated were HG ≥ 2ha and HG < 2ha. Home gardens larger than or equal to 2ha were considered as commercial. The second group (HG <2ha) was also termed as subsistent (Table 3). In comparison, larger HGs (commercial) had the least number of observed species (48) as compared to smaller HGs (52). The mean abundance, however was higher for larger HGs (173.59) as compared to smaller HGs (119.53). Comparing biodiversity indexes, smaller HGs were more diverse than larger HGs in terms of evenness, abundance and richness (H,MR,S) (Table 3). Age of HG and Experience were also highest in larger HGs (commercial); 6.14 years and 5.17, respectively (Table 3).

Age of Garden was also grouped into Older (≥5 years) and younger HGs (<5 years). According to the results as presented in Table 3, older HGs had a more observed number of species (50) as compared to younger ones. The mean number of species per HG was therefore, higher for the same group (2.5). The mean abundance was higher for younger HGs (250.42) than for older HGs (68.46). In terms of biodiversity, younger HGs had the highest level of evenness and abundance (H) as is shown in Table 3 (1.06). Richness (MR) was highest in older HGs (1.13) as against younger HGs (0.84). Simpson index was also highest in younger farms than older farms. Size of HG and experience were also both highest in older HGs; 2.65 and 7.2 years (Table 3) respectively.

The experience was also grouped into experienced (≥5 years) and inexperienced home gardeners (<5years). Experienced home gardeners had a higher number of species (54). Inexperienced home gardeners had the highest mean abundance per home garden (236.8) against experienced home gardeners (68.69). Considering biodiversity, H, MR and S were all the highest in experienced home gardeners' HGs; 1.13, 1.19 and 0.56, respectively (Table 3). Experienced home gardeners also had bigger HG sizes (2.72) and older HGs (8.94 years).

Table 3 - Categorization of factors that influence biodiversity

Category	Group 1	Group 2
1. Size of HG	Commercial(≥2ha) (N=29)	Subsistence (< 2ha) (N=21)
Total number of observed species	48	52
Mean number of sepcies/homegarden	1.66	2.48
Mean abundance/homegarden	173.59	119.53
Shanon-wiener index (H)	1.02	1.1
Margalef index (MR)	0.9	1.04
Simpsons index (S)	0.52	0.57
Age of Garden	6.14	4.76
Experience	5.17	4.52
2. Age of HG	Older HGs (≥5 yrs) (N=20)	Younger HGs (<5yrs) (N=30)
Total number of observed species	50	43
Mean number of sepcies/homegarden	2.5	1.43
Mean abundance/homegarden	68.46	250.42
Shanon-wiener index (H)	1.04	1.06
Margalef index (MR)	1.13	0.84
Simpsons index (S)	0.52	0.56
Homegarden size	2.65	1.68
Experience	7.2	3.37
3. Experience	Experienced (≥5 yrs) (N=18)	Inexperience (<5yrs) (N=32)
Total number of observed species	54	46
Mean number of sepcies/homegarden	3	1.44
Mean abundance/homegarden	68.69	236.8
Shanon-wiener index (H)	1.13	1.01
Margalef index (MR)	1.19	0.82
Simpsons index (S)	0.56	0.53
Homegarden size	2.72	1.7
Age of Garden	8.94	3.67

4.1.1 Scatter plots

According to the scatter plot in Figure 4 the size of a home garden has a significant negative influence on Shanon-wiener index (*H*). This means that the bigger the size of HG, the less evenly abundant the plant species were and vice versa.

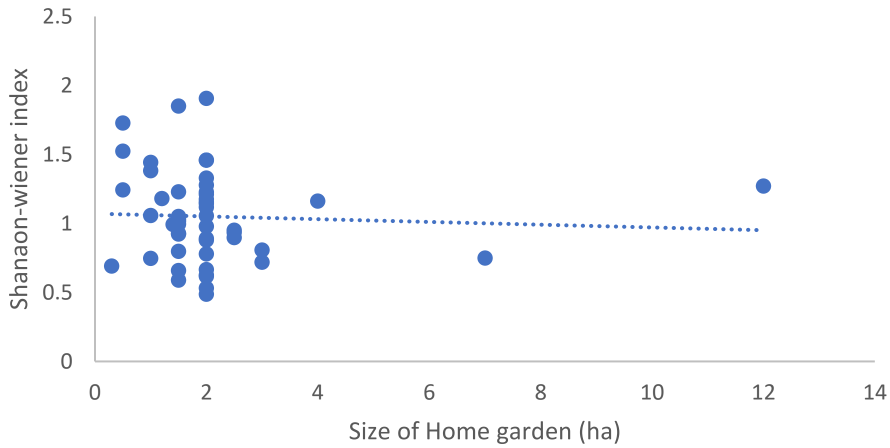

Figure 4 – The influence of size of HG on Shanon-wiener index

Figure 5 also depicts a negative relationship between the age of home gardens and Simpon's index, as is already established in Table 3.

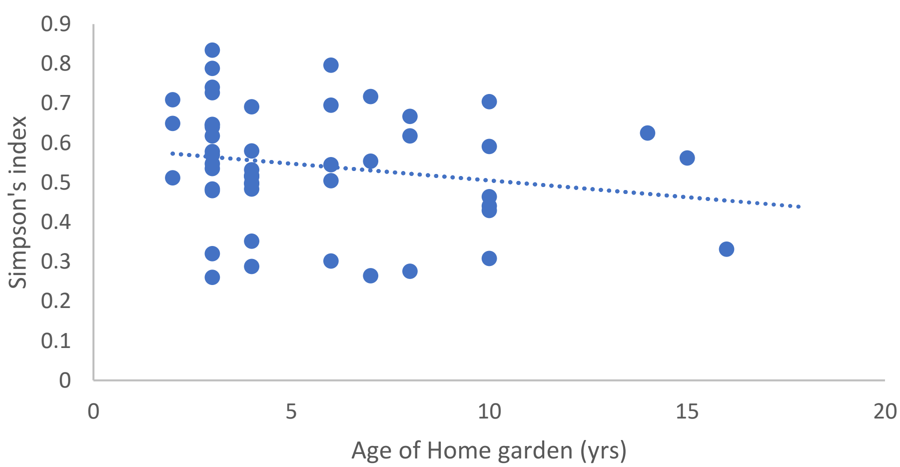

Figure 5 – The influence of age of HG on Simpson's index

Figure 6 also shows the relationship between home gardening experience and Shanon-wiener index. Unlike the other two variables, experience has a positive relationship with biodiversity and is depicted with the upwards tilt of the line from the left to the right side of the scatter plot.

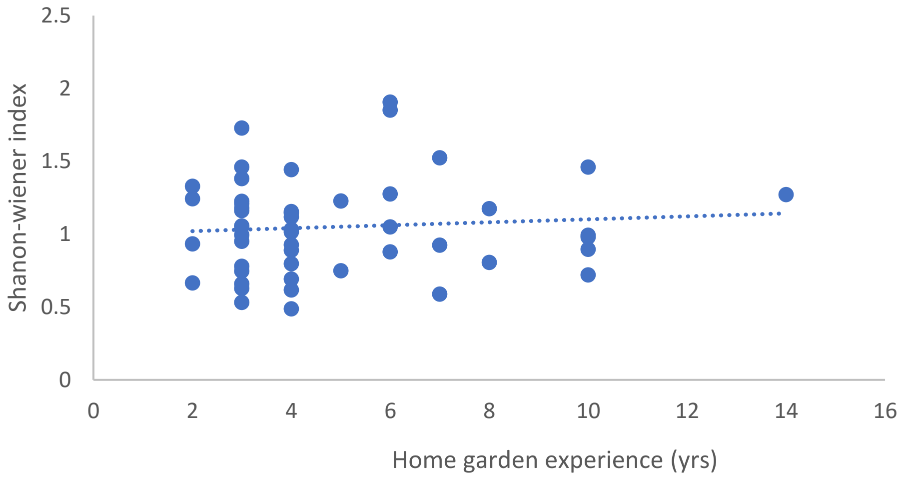

Figure 6 – Influence of experience on Shanon-wiener index

4.2 Ethnobotanical knowledge of home gardeners

As indicated in Figure 1Figure 2, most plant species identified were used for edible purposes (39.39%) or for commercial purposes (39.39%) by HG owners. For edible purposes plant parts that were used by home gardeners were, leaves, fruits, seeds, roots and stems. These plant parts are indicated with L (leaf), F (fruit), T (trunk), S (seed), B (bark), St (stem), R (root) and Fl (flower). These parts were used for food, beverages and spices. For commercial purposes, the trunk of tree species were used for timber and cocoa beans was sold to licenced cocoa buyers (LBCs) for export. Other plant species were also used for shade and other provisioning purposes representing 6.06% and 7.58% of the sample (50), respectively. The most representative families of plant species were Malvaceae (5), Fabaceae (5), Moraceae (3), Apocynaceae (3), and Rubiaceae (3).

The frequency of citation per plant specie is also available for all 66 species (289 citations). Twenty-three (23) plant species were reported once, 18 plant species cited twice, 17 cited in 3-5 home gardens, 2 cited in 6-9 farms and 6 cited more frequently (>10 HGs) (Table 4). The most cultivated plant species (highest citation) was Musa spp (44), T. cacao (31), E. guineensis (27), M. esculenta (25) and C. esculenta (11). Some of the species with the most used parts were C. nucifera, E. guineensis, B. buonopozense, F. exasperate and K. Pinnata.

Table 4 - Ethnobotanical knowledge of parts of plants

Scientific name	Family	Local name	Primary purpose	Parts	Uses	Citation	Citation %
Musa spp. Linnaeus	Musaceae	Borde	Edible	L, F, R	Food,Fd, M	44	88.00%
Tectona grandis Linnaeus	Verbenaceae	Tik	Commercial	L, B, T	M, T	2	4.00%
Cocos nucifera Linnaeus	Arecaceae	Kube	Edible	L, R Fl, F, T	S, M, R, Food, Seat	12	24.00%
Dioscorea rotundata Poir.	Dioscoreaceae	Bayere	Edible	R	Food	5	10.00%
Elaeis guineensis Jacq.	Arecaceae	Abe	Edible	L, S F, T	Fd, Broom, Basket, Oil, Wine	27	54.00%
Xanthosoma sagittifolium (L). Scott	Araceae	Brobbeh	Edible	R	Food	1	2.00%
Manihot esculenta Crantz	Euphorbiaceae	Bankye	Edible	L, R	Fd, Food	25	50.00%
Annona muricata L.	Annonaceae	Aple	Edible	F	Food	3	6.00%
Mangifera indica L.	Anacardiaceae	Amango	Edible	B, F	Food, M	5	10.00%
Carica papaya L.	Caricacea	Boorfere	Edible	L, S Fruit	Food, M	5	10.00%
Persea Americana Mill.	Lauraceae	Paya	Edible	B	Food	4	8.00%
Cola acuminate (P. Beauv.) Schott & Endl.	Malvaceae	Bise	Edible	L, R S	Food, M	1	2.00%
Spathodea campanulata P. Beauv.	Bignoniaceae	Akuakuanisuo	Shade	L, T	S, T	1	2.00%
Colocasia esculenta (L). Scott	Araceae	Bankene	Edible	L, R	Food	11	22.00%
Phyllanthus discoideus Muell. Arg	Phyllanthaceae	Papeah	Medicine	B	M	1	2.00%
Zea mays L.	Poaceae	Aburo	Edible	S	Food	3	6.00%
Theobroma cacao L.	Malvaceae	Cocoa	Commercial	S, F	Beans, Manure	31	62.00%
Terminalia superba Engl. & Diels	Combretaceae	Framo	Commercial	B, T	M, T	2	4.00%

Scientific name	Family	Local name	Primary purpose	Parts	Uses	Citation	Citation %
Celtis mildbraedii Engl.	Cannabaceae	Esa	Commercial	T	Pistol,	3	6.00%
Milicia excels (Welw.) C.C. Berg.	Moraceae	Odum	Commercial	L, R	T, M	3	6.00%
Cleistopholis patens (Benth.) Engl.	Annonaceae	Nkyene ne Ngo	Shade	L	M	3	6.00%
Antiaris toxicaria Lesch.	Moraceae	Foto	Commercial	T	T, S	3	6.00%
Alstonia boonei De Wild.	Apocynaceae	Nyame dua	Commercial	B, T	M, T	6	12.00%
Ceiba pentandra (L.) Gaertn.	Malvaceae	Onyina	Commercial	T	T	1	2.00%
Capsicum annuum L.	Solanaceae	Mako	Edible	F	Food	5	10.00%
Solanum lycopersicum L.	Solanaceae	Ntoos	Edible	F	Food	3	6.00%
Citrus sinensis (L.) Osbeck.	Rutaceae	Ankaa	Edible	S, F	Food, Medicine	5	10.00%
Pterygota macrocarpa (K. Schum.) Harms.	Fabaceae	Koto	Commercial	T	T	1	2.00%
Tetrapleura tetraptera (Schum. & Thonn.) Taub.	Fabaceae	Prekese	Medicine	S, B	Food, Medicine	2	4.00%
Ocimum basilicum L.	Lamiaceae	Nunum	Medicine	L	M	1	2.00%
Azadirachta indica A.Juss.	Meliaceae	Gyene gyene	Medicine	L	M	1	2.00%
Terminalia ivorensis A.Chev.	Combretaceae	Emire	Shade	T	T	9	18.00%
Saccharum officinarum L.	Poaceae	Ahwede	Edible	St	Food	5	10.00%
Musa spp. L.	Musaceae	Kwadu	Edible	F	Food	2	4.00%
Bombax buonopozense P.Beauv.	Malvaceae	Agaata	Shade	L, T	M, T, Soap	2	4.00%
Morinda lucida Benth.	Rubiaceae	Konkroma	Commercial	L	M, T	4	8.00%
Ficus capennsis Thunb.	Moraceae	Kotreamfo	Commercial	T	T	2	4.00%
Carapa procera DC.	Meliaceae	Kwakuo Bise	Edible	F	Food	1	2.00%
Myrianthus arboreus P.Beauv.	Moraceae	Nyankuma	Commercial	T	T	2	4.00%
Pycnanthus angolensis (Welw.) Warb.	Myristicaceae	Otie	Commercial	T	T	2	4.00%
Swietenia macrophylla King	Meliaceae	Mahogany	Commercial	T	T	2	4.00%
Cola gigantean A.Chev.	Malvaceae	Watapuo	Commercial	T	T	2	4.00%
Mansonia altissima A.Chev.	Sterculiaceae	Mansonia	Commercial	T	T	1	2.00%

Scientific name	Family	Local name	Primary purpose	Parts	Uses	Citation	Citation %
Funtumia elastic (Stapf) Hutch.	Apocynaceae	Ofuntum	Commercial	T	T	2	4.00%
Albizia ferruginea (Guill. & Perr.) Benth.	Fabaceae	Owiemfuo samina	Commercial	T	T	3	6.00%
Psydrax subcordata (Hochst.) Bridson	Rubiaceae	Gyapam	Commercial	T	T	1	2.00%
Guibourtia ehie (A. Chev.) J. Leonard	Fabaceae	Hyedua	Commercial	T	T	1	2.00%
Musanga cecropioides R. Br.	Cecropiaceae	Odwuma	Commercial	T	T	1	2.00%
Piptadeniastrum africanum (Hook. f.) Brenan	Fabaceae	Dahoma	Commercial	T	T	2	4.00%
Aningeria spp	Fabaceae	Asanfina	Commercial	T	T	1	2.00%
Ananas comosus (L.) Merr.	Bromeliaceae	Abrobe	Edible	F	Food	3	6.00%
Solanum melongena L.	Solanaceae	Nyadoa	Edible	F	Food	2	4.00%
Rauwolfia vomitoria Afzel. ex R. Br.	Apocynaceae	Kakapenpen	Commercial	T	T	2	4.00%
Zingiber officinale Roscoe	Zingiberaceae	Akakaduro	Edible	R	M, Spice	1	2.00%
Anacardium occidentale L.	Anacardiaceae	Atea	Edible	F	Food	2	4.00%
Solanum torvum Sw.	Solanaceae	Abeduru	Edible	F	Food, M	1	2.00%
Ficus exasperate Vahl	Moraceae	Nyankyerenee	Provisioning	L, St	Fd, S, sponge	1	2.00%
Alchornea cordifolia (Schumach.) Müll. Arg.	Euphorbiaceae,	Ogyama	Provisioning	F	Food	1	2.00%
Slanum erianthum D. Don	Solanaceae	Pepedieruo	Provisioning	L	M, Sp	1	2.00%
Abelmoschus esculentus (L.) Moench	Malvaceae	Nkruma	Edible	F	Food	2	4.00%
Hymenostegia afzelii (Hook.f.) K.Schum.	Melastomataceae	Dahoma	Medicine	B	M	2	4.00%
Nauclea diderrichii (De Wild.) Merr.	Rubiaceae	Abaku	Commercial	T	T	2	4.00%
Psidium guajava L.	Myrtaceae	Agava	Edible	S, F	Food, M	1	2.00%
Cresentia cujete L.	Bignoniaceae	Kontoadua	Provisioning	F	Calabash	1	2.00%
Kalanchoe Pinnata (Lam.) Pers.	Crassulaceae	Tamiawu	Provisioning	L	M, Sp	1	2.00%
Triplochiton scleroxylon K. Schum.	Sterculiaceae	Wawa	Commercial	T	T	1	2.00%

Conventions

* Parts: L (leaf), F (fruit), T (trunk), S (seed), B (bark), St (stem), R (root) and Fl (flower)

* Uses: Fd (fodder), M (medicine), T (timber), Sp (spititual protection) and S (shade)

5. DISCUSSION

5.1 Nature of home gardens

According to findings from the survey, choice of crops grown in homegardens are highly motivated by their primary purposes. Edible crops and commercial crops were the most predominant species that were identified from the survey (Figure 2). This is because home gardeners are more interested and hence knowledgeable in growing plants that can either be consumed or sold (Albuquerque et al. 2005; Galhena et al. 2013). This was also consistent with Rammohan et al. (2019) who analysed home gardens as a predictor of food security. Crops with the highest citations in our study; *Musa spp* (44), *E. guineensis* (27) and *M. esculenta* (25) were all planted or maintained primarily to provide food for the owners' family.

Commercial plants were equally as predominant as edible plants. These plants although not cited many (considering individual citings), constituted a variety of species that all together formed a large part of species identified from the survey. Whereas edible species were more abundant, commercial plants were diversified; considering the study area as a whole. The high numbers of commercial plants (26/66) is understandable because rural areas are dominated by residents who depend on farm or garden products as a important source of household income (Rahaman et al. 2015). This means that HGs have the potential to enhance living standard of owners. Among commercial plant species that were identified, *T. cacao* was the most abundant as home gardeners in the area were mostly involved in cocoa beans production. *A. boonei* and *M. excels* were also commonly cited commercial timber species. This is also because these tree species alongside others are distributed free of charge by the government and other agencies to communities in order to enhance biodiversity and/or serve as shade trees. In 2021 during the maiden edition of the green Ghana initiative for instance, 7 million tree seedlings were given freely to individuals who were willing to plant and care for it (MLNR 2021).

Medicinal provisioning plant species were cited five (5) times each (Figure 2). Medicinal plants recorded a low number of citations because the categorization was done according to primary purposes. However, Table 4 which gives more details about ethnobotanical knowledge, shows that more plant species doubled in purpose as medicinal plants although they were primarily not planted because of their healing abilities. Primary medicinal plants identified from the survey were *P. discoideus, T. tetraptera, O. basilicum, A. indica* and *H. afzelii.* Although not scientifically tested, these plants were known to cure fever, malaria, ulcer, diarrhea, stomach ache and heal wounds. *T. tetraptera* is important for management and/or control of an array of human ailments, including arthritis and other inflammatory conditions, asthma, hypertension, epilepsy, diabetes mellitus, schistosomiasis and for other healing purposes according to Oloyede & Salawu (2018) and Alaribe et al. (2020). In terms of provisioning services such as spiritual protection, fodder, wind breaks and other purposes, five (5) plant species were identified to have been planted specifically for these purposes (*F. exasperate, A. cordifolia, S. erianthum, C. cujete* and *K. Pinnata*). Other plant species were also noticed to have been planted or maintained in HGs due to their ability to provide shade. *Terminalia spp* for instance was usually adopted by homegardeners who wanted to provide a good amount of shade for smaller shade loving plant species.

5.2 Structure of home gardens

The structure of HGs identified in the survey was also notably dependent on the needs of owners. Several of the HGs documented had sophisticated, although highly varying vertical structures. Homegardens' layout and vertical structure appeared to be closely tied to their intended use; with homegardens dominated by food crops typically displaying only the two lowest strata as was noticed by Albuquerque et al. (2005). Owners who were more interested in edible plant species usually had only a handful of trees in the upper stratum (7-12m) of the vertical structure maintained for specific reasons such as use for medicinal or spiritual purposes. Other home gardens that were more invested in commercial planting had plant species (*T. cacoa* and timber) occupying the middle and upper strata with a few food crops such as *D. rotundata* and *M. esculenta* intercropped in the HG. Fraser (2011) also noticed that commercial plants were planted in the middle of home gardens in Brazil.

According to Fernandes & Nair (1986), socioeconomic and market demands, as well as environmental conditions and dietary preferences all influence the horizontal spread of species in a home garden. Similar circumstances was observed by Kehlenbeck (2007) regarding how home gardens were set up. The horizontal arrangement of plant species in the study area appeared to be much more random as was also observed by Albuquerque et al. (2005) a study. Due to the rapid rise in the population, there were only a few HG owners (8%) who lived on-site. Most HG owners, however lived a few kilometers away from their HGs. The average distance from HG to owners' houses was 0.8km (Table 1). Generally, identified HG's also had a thicker canopy cover in the center of the plot due to the presence of large shade providing trees. Around the edges were also fruit crops and medicinal crops.

5.3 Floristic composition of home gardens

Among all HGs observed, there was a total of 66 species with an average of 5.6 species per HG and 1.75 species density. This means that, for each HG there was an average of approximately 5.6 different species whiles for each $100m^2$ there was an average of 1.75 different species. The mean abundance of the study area reported at 221.24 (Table 2) also shows that, on the average, each home garden had 221.24 plants present irrespective of the kinds of plants or number of species.

Biodiversity indeces employed in the study also shows that, the study are was more even and abundant than rich as Shanon-wiener index showed the highest index amongst all three (3) biodiversity indeces (1.05) and Simpson's index showed the least biodiversity score (0.54). This was understandable considering the abundance rate and species density as presented in Table 2. Margalef index also showed a biodiversity score of 0.95 (Table 2).

5.4 Elements that determined plant diversity in home gardens

Considering factors that influenced biodiversity, three (3) variables were encounted as significant; *size of HG, age of HG* and *experience of home garden owners* according to a liner regression model unlike found by Gbedomon et al. (2015). However, according to Smith et al. (2005) garden area had a negative influence on species richness. According to our findings, size of HG negatively influenced Margalef index (Appendix II). This means that the large the home gardens in the area, the less biodiversity. Bigger gardens frequently demand more space and may necessitate the clearance of natural areas like woodlands, meadows or grasslands (Wilby et al., 2006). In an effort to maximize yields, larger gardens may also rely on monoculture practices, where only one or a few types of crops are grown in a given area. This can lead to a decline in biodiversity as it reduces the diversity of plants and reduces the availability of food and shelter for insects and other animals (Ratnadass et al., 2012). Larger gardens may again be more likely to introduce non-native species, which can outcompete or displace native species and disrupt the natural balance of ecosystems. This may result in a fall in biodiversity and a reduction in resource availability.

Age of HG also showed negative significant effect on the richness of home gardens in the study area as Simpson's index dropped with an increase in age (Appendix II). This is also understandable because, it was observed from the survey that older HGs were over-exploited. Over time, the soil in a garden can become depleted of nutrients and organic matter, making it less hospitable to a diverse range of plants (Singh et al., 2021). This can lead to a decline in biodiversity as fewer species are able to thrive in the soil. Older gardens may also be more susceptible to invasive plant species that can outcompete native plants (Singh et al., 2021). Also, older gardens may have a more limited range of plants, as gardeners tend to stick with plants they know and trust. This can lead to a reduction in plant diversity. Owners of younger HGs were more willing to include variety of species in the HG whiles the vice versa is true for owners of older HGs.

Another significant factor that influenced HGs was the experience of HG owners. According to the regression model (Appendix II), HGs with experienced owners had higher biodiversity. This is also reasonable since with experience, HG owners understand the importance of HGs especially in their daily lives. Experienced home gardeners tend to select plants that are well-suited to their local environment, which can provide food and habitat for a variety of livestock, wildlife such as birds, bees, butterflies and other pollinators. Experienced home gardeners often pay close attention to soil health, which can promote the growth of healthy plants and a healthy ecosystem. Healthy soil can support a diverse range of microorganisms that are important for nutrient cycling and can help prevent soil erosion. Experienced home gardeners are often skilled at managing pests and diseases without resorting to harmful chemicals. This can help promote a healthy ecosystem by minimizing the negative impact of pesticides on beneficial insects and other wildlife. Experienced home gardeners may also play an important role in educating others about the importance of biodiversity and how to create a garden that supports a healthy ecosystem. This can help spread awareness and encourage others to take action to support biodiversity in their own gardens and communities. Similarly findings were made by Niles et al. (2021) who identified tha experienced home gardeners enhance productivity and resource efficiency.

5.5 Knowledge and use of identified species

Findings from field survey shows that in terms of ethnobotanical knowledge, HG owners are aware of the uses of parts of plant species such as leaves, fruits, seed, root, bark and trunk. These parts depending on plant is used for food, medicine, fodder, timber, soap, broom, calabash, pistil or for spiritual purposes. Timber species were more abundant and were mainly cultivated or maintained for commercial purposes Albuquerque et al. (2005). Fruits and vegetables apart from being consumed also had medicinal purposes. For instance *P. guajava, C. acuminate, C. papaya* were identified as key in stomach pain relief and fever. Leaves, bark and seeds of these fruits were boiled and consumed as pain relief formulas. Roots and tuber crops such as *M. esculenta, C. esculenta* and *D.rotundata* also formed a significant part of HG owners diets. Another important plant specie that provided food, fodder and medicine for owners was *Musa* spp which recorded the highest citations amongs all identified species (Table 4).

6. CONCLUSION

The study takes inventory of the the structure and floristic composition of home gardens and the ethnobotanical knowledge of home garden owners in New Juaben district. The structure of home gardens was analysed based on the vertical arrangement of plant species in three (3) strata depending on which plant species were predominant. The horizontal structure of HGs was also assessed using the HGs house as reference point and considering the area of coverage of plant species in the HGs. Using the Shanon-wiener, Margalef, and Simpons indeces, the relative abundance, richness and evenness of plant species in HGs was examined and presented in a table. Factors that influenced biodiversity was also assessed using a linear regression model. In all, 66 plant species were documented from 50 home gardens. The ethnobotanical knowledge of HG owners regarding all 66 plant species is also documented and presented in a table with the number of individual plant citations.

Despite the fact that species diversity and richness were relatively low, the surveyed home gardens serve as significant repositories of local food plant species that supplement family diets, improve households' socioeconomic standing and may even play a significant role in the domestication and in-situ preservation of useful plants. Factors that influenced biodiversity negatively were age of HG, size of HG. Experience of HG owners however had a positive impact on biodiversity.

HG owners chose plant species to adopt based their needs. According to the findings, food and commercialization were the primary driving needs that influenced choice of plant species. HG owners were either not aware or were not influenced by other key benefits of plant species such as biodiversity conservation and ecosystem improvement.

Based on our findings, we recommend that, local farmers are encouraged to build more favorable and diversified home gardens utilizing traditional local crop species rather than focusing on commercializing the home garden in order to revive the species variety. We also recommend that HG owners are educated on the benefits of HGs in terms of climate change mitigation.

In conclusion, a variety of factors, including some that are not wholly peculiar, affect the morphological and functional variables found in home gardens in the New Juaben region. Families from the area are shifting from agriculture, which has intensified a decline in the area's agroforestry and land-use practices. Despite the variation in the level of production, home gardens continue to play a significant role in maintaining these people's food security. The low biodiversity in the region is also due to general lack of political interest as well as a lack of scientific knowledge regarding the general benefit of variety of plant species. With keen attention and effort from the government and other stakeholders, home gardens can help in food security, income generation and overall enhancement in rural communities.

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8. APPENDIX

8.1.1 Appendix I

INTERVIEW SCHEDULE FOR HOUSEHOLD HEADS

STRUCTURE, FLORISTIC COMPOSITION AND ETHNOBOTANY OF RURAL HOMEGARDENS IN THE NEW-JUABEN MUNICIPALITY OF GHANA

Consent

The purpose of this survey is to help me gather knowledge on homegardens. This questionnaire is strictly for academic purposes and the response given will be treated with a high level of anonymity. I humbly request that you answer the following questions and I will be happy to answer any questions you may have for me too.

I will also like to seek your consent to record this conversation for the primary researcher who is currently directing the data collection from abroad. This will enhance her understanding for a more comprehensive discussion. Please feel free to tell me to stop with the recording or interview at any point you feel unease or uncomfortable.

Thank You

Name of Respondent………… Community………… Date………

8.1.2 SECTION A:

General Information about Caretaker

1. Gender of respondent Male [ ] Female [ ]
2. How old are you (primary caretaker)?
3. How many years have you been in school?
4. Which ethnic group do you belong to?
5. Are you married? Yes [ ] No [ ]
6. How many individuals are in this household?
7. What is the gender of the household head? Male [ ] Female [ ]
8. What is your primary occupation?

8.1.3 SECTION B

Description of Homegardens

9. How long have you been the caretaker of a homegarden?
10. What is the age of the homegarden?
11. What is the size of the homegarden?
12. Terrain of the homegarden? Flat land [ ] Slope [ ]
13. Is the homegarden for commercial purpose or subsistence? subsistence [ ] commercial [ ]
14. Distance to market

8.1.4 SECTION C:

Table 5- Floristic composition of homegarden and ethnobotanical knowledge

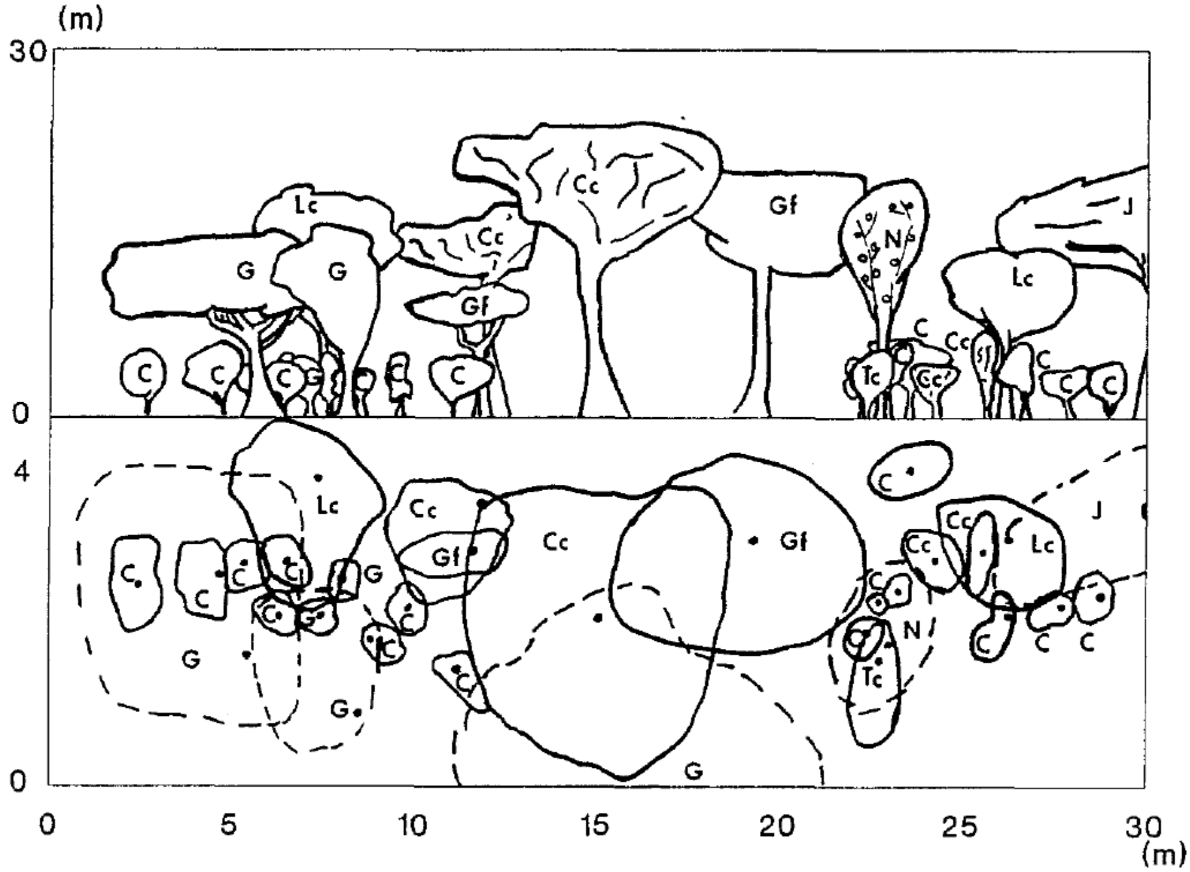
Number	**Name of plant**	**Number present**	(1)Fruits (2)Timber (3)Roots and Tuber (4)Other	**Primary purpose** (1)Edible/ (2)Medicinal/ (3)Commercial (4)Provisioning (5)Shade	(1)Perenial / (2)Annual	**Plant part**	**Specific uses** Describe how each part is used
1						Leaves	
						Branches	
						Roots	
						Bark	
						Seeds	
						Trunk	
						Stem	
						Flowers	

8.1.5 SECTION E:

Vertical and Horrizontal arrangement of the household

Enumerators to sketch both arrangement types on the same page of an A4 sheet and take a picture of the garden.

Sample



Vertical arrangement on top and horizontal at the bottom

8.2 Appendix II

Table 6 - Regression results for factors that influence biodiversity (SW, MG,S)

	Shanon-wiener				Margalef				Simpson			
	B	Std. Error	t	sig.	B	Std. Error	t	Sig.	B	Std. Error	t	Sig.
(Constant)	1.484	0.492	3.019	0.005	1.559	0.516	3.018	0.005	0.778	0.220	3.529	0.001
Gender	-0.133	0.138	-0.963	0.342	-0.029	0.145	-0.196	0.846	-0.049	0.062	-0.790	0.435
Age of respondent	-0.007	0.008	-0.858	0.397	-0.009	0.008	-1.126	0.268	-0.002	0.003	-0.611	0.545
Education	-0.015	0.018	-0.822	0.417	-0.008	0.019	-0.432	0.668	-0.006	0.008	-0.682	0.500
Household size	0.002	0.039	0.061	0.952	-0.018	0.041	-0.437	0.665	0.005	0.017	0.261	0.795
Experience	0.061	0.031	1.947	**0.060***	0.066	0.033	2.012	**0.052***	**0.024**	**0.014**	**1.731**	**0.092***
Size-HG	-0.016	0.035	-0.469	**0.642**	-0.074	0.037	-2.009	**0.052***	**-0.006**	**0.016**	**-0.373**	**0.711**
Market distance	0.010	0.016	0.614	0.543	-0.012	0.017	-0.725	0.473	0.005	0.007	0.700	0.488
Home distance	-0.124	0.165	-0.749	0.459	-0.137	0.174	-0.791	0.434	-0.057	0.074	-0.774	0.444
Age-HG	-0.034	0.024	-1.401	**0.170**	0.026	0.025	1.017	**0.316**	**-0.020**	**0.011**	**-1.897**	**0.066***
Occupation	-0.037	0.108	-0.347	0.730	-0.089	0.113	-0.786	0.437	-0.016	0.048	-0.329	0.744
HouseholdHead gender	-0.169	0.135	-1.258	0.217	-0.024	0.141	-0.169	0.867	-0.088	0.060	-1.467	0.151
Terrain	0.218	0.140	1.553	0.129	0.073	0.147	0.498	0.621	0.069	0.063	1.104	0.277
Ethnicity	-0.011	0.027	-0.415	0.680	0.003	0.028	0.118	0.907	-0.010	0.012	-0.834	0.410
Marital status	-0.067	0.120	-0.560	0.579	-0.055	0.126	-0.438	0.664	-0.075	0.054	-1.407	0.168

8.3 Pictures from sampled Home gardens


Adu Agyapong George


Sosu Kwashiegah


Amina Bimoaba

8.4 Pant uses

E. guineensis fronds used for local baskets

Celtis mildbraedii branches used as pistol for pounding