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Full Length Research Paper

Plant Species Richness and Structure of Homegarden Agroforestry in Jabithenan District, North-Western Ethiopia

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Abstract
Homegarden agroforestry has believed to be complex multi-strata than other agroforestry system. The aim of this study was to assess species richness, characterize the vertical and horizontal structure of homegarden agroforestry in Jabithenan district, North-western Ethiopia. Two sites purposively and two villages randomly from each site were selected. Vertical and horizontal structure was carried out for 48 homegardens. All woody species and herbaceous species were counted and recorded in 10m x 10m (100m^2) and 2mx2m (4m^2) plots respectively. The average size of homegarden in the Jiga Yelmdar and Mankusa Abdegoma Kebele was 0.3ha and 0.22ha, respectively. A total of 69 plant species (44 woody and 25 herbaceous) belonging to 40 families were recorded in homegarden in the study sites. About 6-8 different species of plants per plot were recorded. The homegarden agroforestry have complex structure both vertically and horizontally, which in turn plays a great role for socio-economical and agro-ecological service to the farmers than non-tree based garden.

Key words: *Multi-strata, Vertical Structure, Horizontal Structure, species richness*

Introduction

To meet the current diverse people's requirement with fixed land in the world in general and in Ethiopia in general is through the application of agroforestry which is more advantageous than monocropping (Mcneely and Schroth, 2006). Land around the farmers house with trees are one of agroforestry practices known to be ecologically sustainable and diversifies livelihood of local community. Homegarden is commonly defined as; land use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop, and animal unit is being intensively managed by family labour (Kumar and Nair, 2006). Here after, the term homegarden and homegarden agroforestry are used interchangeably throughout this paper. Well-designed structure of homegarden agroforestry can give the desired benefit through efficient resource utilization. Therefore studying the general structure is so necessary.

The structure of homegarden in the tropics is based on horizontal and vertical strata. Horizontal structure is determined by localization of each homegarden species with in the garden using farmer's house as a reference. Vertical structure reflects degree of species specialization and complexity (Albuquerque *et al.*, 2005). Despite its vast socio-economic importance, in Ethiopia documentation of homegarden structure is very few. Except the assessment of fruit tree diversity by Fentahun Mengistu (2008), visual characterization by Azene Bekele (2007), socio-ecological importance and species diversity by Ewuketu (2014); no in-depth study was conducted about homegarden structure in Jabithenan district.

In order to maintain agro-ecosystem resilience and to meet the homegarden products for requirements of the people during stress of climatic hazard like drought, flood; scientific information is required. Lack of such scientific knowledge of homegarden agroforestry may let destruction of diverse plant and results loosing of homegarden structure. Without a full determination of species specialization called structure, the role of having structure for rural poor people cannot be fully explained. Therefore this research is aimed at I) assessing the general features of homegarden agroforestry in the study district, and again II) characterize the vertical as well as horizontal structure of homegarden agroforestry in the study district

Materials and Methods

Description of the Study Area

The study was conducted in Jabithenan district, North-western Ethiopia. Geographically the district is found at10^{0}40′northern latitude and37^{0}11′eastern longitude.

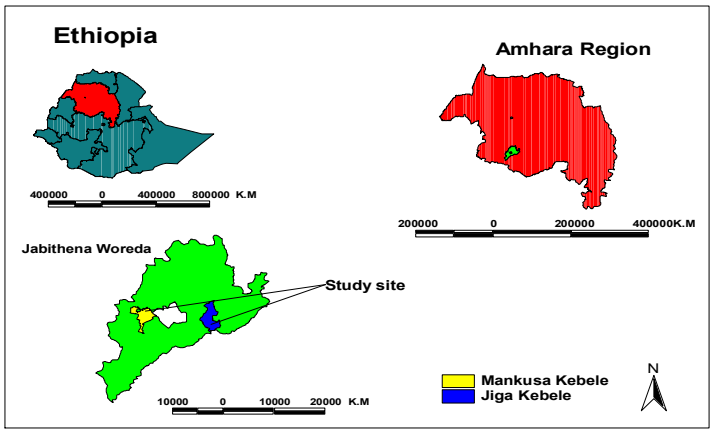


Figure 1: Location of study site at Mankusa Abdegoma and Jiga Yelmdar Kebele, Jabithenan district, Ethiopia.

The topography of the district is generally characterized by flat gentle slope (65%), mountainous (15%), undulating terrain (15%) and valley (5%), with an altitudinal range from 1500 - 2300 m a.s.l. The major soil types found in the district are Vertisol and Nitosol (JWARDO, 2012).

The district falls within midland and lowland agro-ecological zone. The mean annual temperature is about 23 ºC, with a maximum temperature slightly above 32 ºC, down to a minimum of 14 ºC. The mean annual rainfall ranges between 800 – 1250 mm.
The total population is 277,590, of whom 139,616 are males and 137,974 are females. Of this total population, 6% of their population is urban dwellers and the rest 94% are rural dwellers. An estimated population density of the district is about 455.32 people per square kilometers (JAWRDO, 2012).

Historically, the district was covered by dense natural forests, but the distribution of natural forest is declining from time to time, owing to human interference. The common vegetation in the district include, *Croton macrostachys, Ficus sur, Albizia gummifera, Cordia africana, Acacia abyssinica, Rosa abyssinica* and *Erythrina abyssinica* which are found as scattered in most farm lands. While *Eucalyptus* spp and *Gravillea robusta* are grown as boundaries, live fences and woodlots (JWARDO, 2012). Agriculture is the principal source of livelihood for rural population. It is characterized by subsistence mixed farming of rain-fed, irrigated crops, and livestock production together with trees planted as an agroforestry. In the district cereal crops are the staple food crops such as teff (*Eragrostic teff*), maize (*Zea mays*), wheat (*Triticum sativum)* and barley *(Hordeum vulgare)* are the most commonly cultivated crops. Pepper (*Capsicum frutescens)*, sugarcane (*Saccharum officinarum)*, coffee (*Coffea arabica*) and chat (*Chata edulis*) are the dominant cash crops in some sites including the study village (JWARDO, 2012).

Sampling Method
Purposive sampling was employed. Two sites (here after Kebele Administrations, KA) namely, Mankusa Abdegoma and Jiga Yelmdar were selected purposefully based on the extensive presence of HGAF. During reconnaissance survey with district agricultural office and DA, five villages from Mankusa Abdegoma and three villages from Jiga Yelmdar Kebele with extensive presence of homegarden agroforestry were identified. Finally Debohela and Waza villages from Mankusa Abdegoma KA; Atahagne and Tikurwuha villages from Jiga Yelmdar KA were randomly selected. 48 homegardens were used for this study (12 from each village).

Data Collection
Homegarden size (ha), location in relation to the homestead, horizontal arrangement of home-garden units, and plant species in different units was recorded in each garden. Horizontal structure was classified following Millate (1996). Dividing homegarden into four quadrats (home-10metere, 10-20metere, 20-30metere, and 30-40metere) horizontally were employed using farmer's house as a reference and the different species with in a quadrate was recorded. Moreover, the number of vertical strata and the plant species occupying each stratum were recorded following the classification given to tropical homegarden by Fernandez and Nair (1986) and (Fentahun Mengistu,2008). Accordingly 4 vertical strata, <1m, (1-5m], (5-10m] and >10m were used for this stratification. Height measurement was carried out using hypsometer for trees and measuring tape for herbaceous crops and shrubs.

Data Analysis
Data on homegarden horizontal structure was produced on species distribution by functional group and individual species along quadrants and species richness in a bar graph by Microsoft-excel 2010. Similarly, Relative percent frequency (i.e. out of 48 HGAF how many times does a species occurred relative to other species in each quadrant or strata in terms of percentage) of each plant

species was also calculated both for vertical and horizontal structure. Vertical structure of homegarden from Brazil also characterized in this way (Akinnifesi *et al.*, 2010).

Results

General Features Homegarden Agroforestry (HGAF)

The original layout of most gardens was established during the villagization program of the military (Derg) regime. Then after producing cereal crops for some years, in 1992 about19 %, in1995 (67%), and 14% of households in 1996 were integrate perennial trees in their garden and becomes HGAF (n=48). Spatial arrangement of HGAF is variable at the study site. About 74% of HGAF is located in the backyard while a few are located on the side of the homestead. Most of the studied HGAF (67%; n=48) are surrounded by live fence of the species *Eucalyptus camaldulenesis*, *Capparis tomentosa, Rosa abyssinica, Carissa edulis, Combretum molle, Maesa lanceolata, Bersama abyssinica, Acacia nilotica*. The rest 33% are semi-fenced and open.

The overall HGAF size ranged from 0.05 to 0.5 ha (0.1 to 0.5 ha in Jiga Yelmdar and 0.05 to 0.38 ha in Mankusa Abdegoma Kebele). The average size of HGAF in Jiga Yelmdar and Mankusa Abdegoma Kebele is 0.21 ha and 0.16 ha respectively. Most of the surveyed HGAF (63%) in Mankusa Abdegoma and (60 %) in Atahagne village of Jiga Yelmdar kebeles have rectangular shape while the remaining were irregular and square shape.

Homegarden Structure

Horizontal Structure

The horizontal arrangement of plants was assessed in terms of distance that a species located from an individual house within the homegarden. For all sampled HGAF the horizontal structure of species was determined by the owner of household. Generally, the studied homegardens show a distinct horizontal structure arrangements/management zone between herbaceous (close to the residential house) and woody species. Further away mainly in the middle of the gardens, coffee under shade trees and fruits were a typical feature of most of the gardens. In the boarder of the gardens live fence species with spiny stem such as *Rosa abyssinica, Acacia nilotica, Capparis tomentosa* and trees species which serve for fuel, pole and construction like *Eucalyptus camaldunesis* and *Eucalyptus citrodora* were the dominant. In the studied HGAF cereal crops are not common but grow far away from the garden compound (take 2/3 hours). The species recorded in each quadrate was grouped into functional groups and their extent of horizontal distribution was quantified as percent share relative to each other in the 48 studied HGAF (Figure 11). Woody species are highly concentrated in the second quadrate, but fruits are more frequently recorded in the third quadrate. Each individual species is also distributed haphazardly in each quadrat (Figure 9). Species richness varies from quadrate to quadrate indicating decrease with increasing distance from house of respondent HHs (Figure 10).

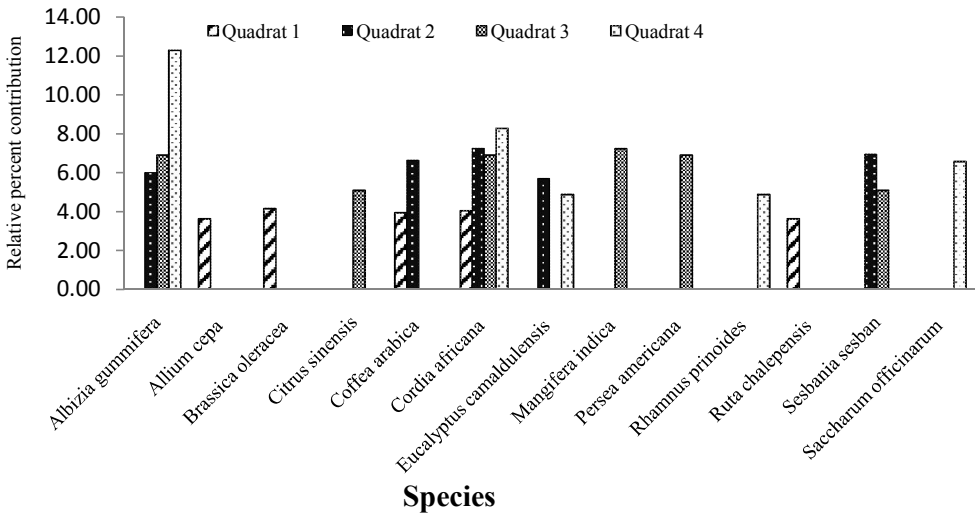


Figure 2: Proportion of top five species per quadrate across horizontal structure of homegarden agroforestry at four villages, Jabithenan district, Ethiopia.

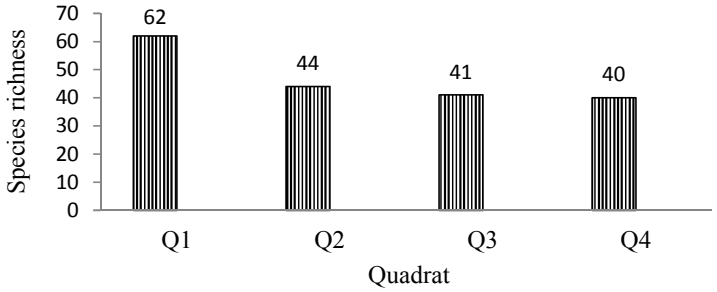
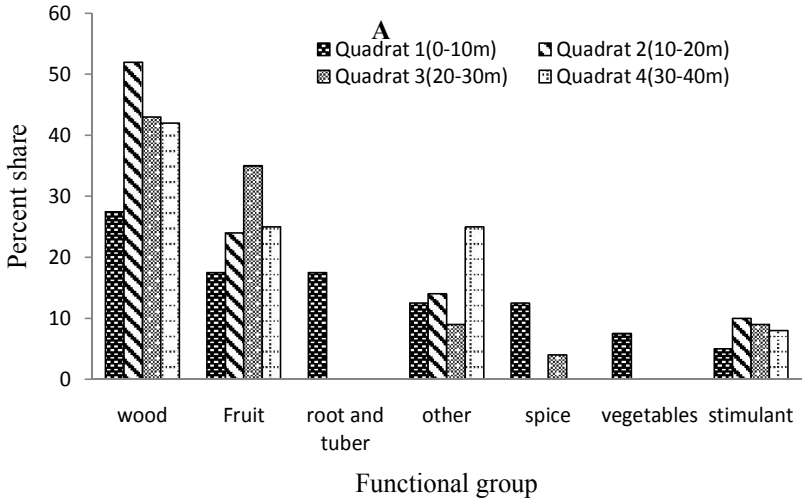


Figure 3: Species richness across all HGAF in each quadrant (Q), Jabithenan district, Ethiopia.



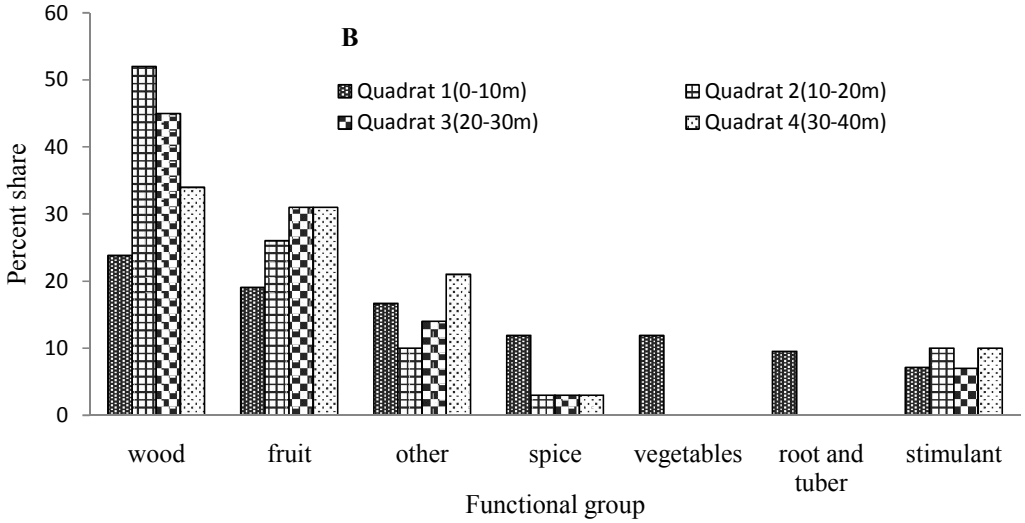


Figure 4: Horizontal structure of different functional groups in Mankusa Abdegoma (A) and Jiga Yelmdar (B) kebeles, Jabithenan district, Ethiopia.

Vertical Structure

Vertical structure of HGAF in an individual household reflects the species degree of specialization and complexity. The studied homegarden is an assemblage of almost multipurpose tree, shrub and herb with some climbers in the boarder.

Accordingly vertical structure in the study homegarden is categorized in to four major strata; upper story (>10m), main canopy (5-10m), shrub layer (1-5m) and bottom layer <1m. Generally, upper story is dominated by shade trees; main canopy by fruit trees; Shrub layer by stimulants (*Coffea arabica* and *Rhamanus prinoides*) and bottom layer by herb species. Particularly each species were distributed in each vertical stratum haphazardly. The upper five most species having higher percentage contribution in each stratum were presented (Figure 13), while the whole species is in the appendix (Appendix 8). Across all HGAF, species richness shows a decreasing pattern towards the upper story (Figure 12).

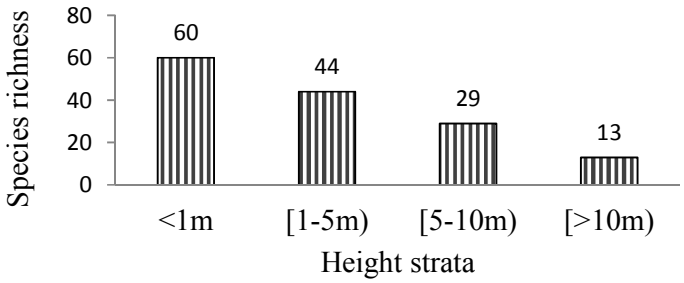


Figure 5: Species richness across all HGAF in each height strata, Jabithenan district, Ethiopia.

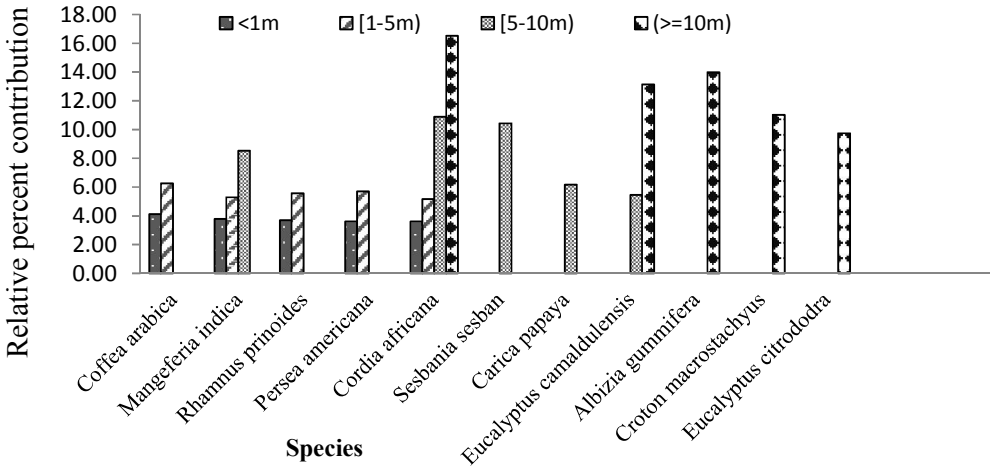


Figure 6: Top five relative percentage contribution of homegarden plant species to different height class across four villages, Jabithenan district, Ethiopia.

Discussion

The study homegarden is known by 'Yegwaro-atkilit' or 'Tegane' in Amharic, the name signifies not only their position but also their proximity to the house. The size of studied homegarden was ranged from 0.05 to 0.5ha. A study from different agro ecology of 10 selected homegarden in tropics/sub-Saharan Africa also confirms that the average sizes of tropical homegardens are less than 0.5ha (Fernandes and Nair, 1986). Other findings from 80 homegarden of upper Assam, India showed the size of homegarden plot ranges from 0.05 up to 0.3ha (Saikia *et al*., 2012), which is in the range of this findings. The size range observed in this study is also considerably larger than the size range reported for most Ethiopian gardens (0.004-0.05ha) (Zemede Asfaw and Ayele Nigatu, 1995); but considerably lower than studies from 150 homegardens (0.44 ha) of western Amhara, Ethiopia (Fentahun Mengistu, 2008). According to Fernandes and Nair (1986), homegardens smaller than one hectare are typical of subsistence agriculture. But, HGAF of the study area are mainly cash-crop based garden.

Most of the studied HGAF was a rectangular shape, which is in line with survey results of Zemede Asfaw and Ayele Nigatu (1995) in most parts of Ethiopia. Since for easy movement of livestock, social and cultural functions front yard is open and most of the studied homegarden was positioned in back yard. Study results from 111 HGAF of Ethiopia from different agro-ecological zone, confirms that most of the homegardens were positioned in the backyard of an individual house (Zemede Asfaw and Ayele Nigatu, 1995) and Fentahun Mengistu (2008) also found this reality from western Amhara of Ethiopia.

Vertical and horizontal structures of many HGAF described in many literatures are highly variable and quite complex. For instance, in the homegarden of Alagoniha and homegarden of Upper Assam in India; the horizontal ordering of plants is distributed randomly without clear species specialization of space (Rico-gray *et al.*, 1990; Saikia *et al.*, 2012). In the study homegarden, vegetables and spices are only restricted to near the house to give special treatment like manuring and occasional

watering (using waste water). To save labor of walking towards the end and manages even simultaneously while performing indoor activity like food cooking or theft is fear to come near to the house, farmers cultivate higher number of species in near their house. *Musa paradisiaca* is planted either near the house, boarder or in the center without shade in areas of water accessibility. This is due to in any circumstances *Musa paradisiaca* doesn't need shade and need more water. This clearly indicates that farmers have knowledge on ecological requirements of a plant species, accumulated over generation. Similar explanation and observation were made in Andaman, India (Pandey, 2006). Fentahun Mengistu (2008), identify three horizontal management zones (spice & vegetable, fruit tree and cereal crops (maize and potato)), with no clear demarcation between them in western Amhara homegarden.

Regarding vertical structure, species were categorized under 4 vertical canopy strata. Most of east African homegardens are also characterized by 3-4 vertical canopy strata-tree layers upper story, herbaceous layer near the ground and intermediate layer in between (Bashir *et al*., 2006). The total number of species in the studied homegarden is higher in the lower strata than others. The study is in line with reports from homegarden of Kerala, Indonesia; but in contrary to homegarden of Andaman, India in which more number of species was found in the third and fourth canopy/strata (Soemarwoto, 1987; Pandey *et al*., 2006). Pandey *et al.* (2006) argued that the gradient of light and relative humidity creates different niches in an ecosystem and influence species richness. Therefore, the complex strata observed in these homegardens could be a reflection of the diversity of services these gardens are designed for. The presence of multi-layer helps for efficient rainfall interception and reduces impact of raindrops in the soil. A relatively constant moisture and temperature level at ground level reduces water stress in period of low rainfall and maintains production. The structure and number of strata is mainly determined by the management and knowledge of the farmer (Clereck and Negreros-Castillo, 2000).

The presence of shade tree is important for effective grain production through reducing temperature and helps for climate change adaptation especially for coffee. Recent study in Brazilian coffee based agroforestry assures that agroforestry provides temperature regulation (ecosystem service) and offers as climate change adaptation for small coffee growers in response to global warming (Helton *et al*., 2012). The report also shows that coffee in a shade gets better quality and has a guarantee for good market price.

Conclusion

The high plant diversity and complexity of structure were found in study homegardens. These multi-strata structures are designed to fulfill a diversity of social, economic and ecological services.

References

Akinnifesi FK., Sileshi G., Joselene D., Moura E.G., Rosel F., Ajayi O.C., Linhares J.F., Akinnifesi A.L., Maria D.A., Rodrigues M.A.,2010. Floristic composition and canopy structure of home-gardens in Sao Luis city, Maranhao state, Brazil. Journal of horticulture and forestry **2**:72-86

Albuquerque U.P., Andrade L.H.C. and Caballero J., 2005. Structure and floristic of homegardens in north-eastern Brazil. Arid environment **62**:491-506

Azene Bekele, 2007. Profitable agroforestry innovations for eastern Africa: experience from 10 agro-climatic Zones of Ethiopia, India, Kenya, Tanzania and Uganda. World agroforestry center (ICRAF), Eastern Africa region.

Bashir J., Eyasu E. and Kebadire M., 2006. Role of agroforestry in improving food security and natural resource management in dry lands: a regional overview. Journal of the dry lands **1**:206- 211

Clereck F. and Negreros-Castillo P., 2000. Plant species of traditional Mayan homegardens of Mexico as analogous for multistrata agroforestry. Agroforestry system **48**:303-317

Fentahun Mengistu, 2008. Fruit tree species in the wild and in homegarden agroforestry: Species composition, diversity and utilization in western Amhara region, Ethiopia. *PhD. Thesis.* Vienna University, Vienna.

Fernandes, E. C. M. and Nair, P. K. R., 1986. An Evolution of the structure and function of tropical homegardens. Agricultural Systems **21**: 279-310.

Helton N., Ron G., Lijebert B., Irene M., Edivania M., Raphael B., Lucas C. and Mirjam P., 2012. Protective shade tree diversity and soil properties in coffee agroforestry system in the Atlantic Rainforest biome. Journal of Agriculture, Ecosystem and Environment **146**:179-196.

JWARDO (Jabithenan Woreda Agriculture and Rural Development Office), 2012. Jabithenan Woreda Agriculture and Rural Development Office, the Annual Report. Jabithenan, Ethiopia.

Kumar B. M., and Nair, P. K. R. 2006. Tropical Home Gardens: A Time-Tested Example of Sustainable Agroforestry. Environmental Experts.

Mcneely A.J. and schroth G., 2006. Agroforestry and biodiversity conservation traditional practices, present dynamics and lessons for the future. Biodiversity and conservation **15**:549-554.

Millate M., Johna B. and Zewege T., 1996. Structure and floristic of Bangladesh homrgardens.Agroforestry systems **33**:263-280

Pandey C., Kanak L., Venkatesh A. and Mehdi R., 2006. Diversity and species structure of homegardens in south Andaman, India. Tropical Ecology **47**:251-258

Rico-Gray, Garica-Franco v., Chemas J.G., puch A. and Sima P., 1990. Species composition, similarity and structure of Maya homegardens in Tixpeual and Tixcacatuyul, Yucatan,mexico. Economic Botany **44**:470-487.

Saikia P., Choudhury B. and Khan M., 2012. Floristic composition and plant utilization pattern in homegarden of upper Assam, India. Journal of tropical ecology **53** :105-118.

Salvatore Y., Gunnar K. and Ringler C., 2011. Estimating the impact of climate change on agriculture in low income countries: Household level evidence from the Nile basin Ethiopia. Journal of Environmental resource Economics **28**:32-43.

Soemarwoto O., 1987. Homegardens: A traditional agroforestry system with promising future. In: Agroforestry a decade of development, Pp. 157-172. (Steppler, H.A and Nair, P.K.R., eds.). ICRAF, Nairobi, Kenya.

World Bank, 2008. Biodiversity climate change and Adaptation. Nature based solutions from the World Bank portfolio. Washington DC, USA.

Zemede Asfaw and Ayele Nigatu, 1995.Home-gardens in Ethiopia: Characteristics and plant diversity. SINET: Ethiopian Journal of Science **18**: 235-266.

Zenebe G., Jesper S., Alemu M. and Atlaw A., 2011.Climate change and the Ethiopian Economy. A computable general Equilibrium Analysis. Environment for Development, Ethiopia.