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Diversity and use of food species grown in homegardens in semi-arid and arid areas of Gujarat state, western India

BACHELOR'S THESIS

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Declaration

I hereby declare that this thesis was composed by myself, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA, and that this work has not been submitted for any other degree or professional qualification except as specified.

Prague, Date- 15/05/2020

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Abstract

Homegardens represent the traditional land-use system, which has been recognized by households, researchers, or policymakers as a keystone of agrobiodiversity conservation, ensuring food security and improving the resilience of livelihood. The purpose of this study was to document the current status of agrobiodiversity in homegardens from the Gujarat state in the western part of India and to analyse potential effects of both household and homegarden characteristics on species composition, use, and richness. A standard questionnaire was used to collect data from 38 households on plant species, household characteristics, homegarden characteristics, and level of market orientation. Selected homegardens were categorized as commercial and non-commercial based on a percentage of plant species utilization in order to capture current tendencies in the "commercialization" of agriculture. The results indicate that commercial homegardens (n=26) have different structures and utilization on selecting plant species compare to non-commercial ones (n=12). Standard agrobiodiversity indices (Shannon-Wiener, Margalef, and Simpson's) show that plant species diversity in non-commercial homegardens is higher than in commercial ones. A total number of 50 plant species were identified in targeted gardens, most of them were used as a food. Furthermore, homegarden size has a rather reverse effect on agrobiodiversity as well. Homegardens with less than 0.25 ha land size seemed to have better biodiversity value compare to larger ones. Interestingly, more aged homegardens were less diverse as well. Additionally, no significant impact farming experience of the household head on biodiversity was observed. A positive impact on agrobiodiversity was associated with high literacy rates and keeping livestock within homegardens. Generally, based on our results, selected homegardens in the Gujarat state are particularly used for the production of food species, which are predominantly sold on the markets. More studies are however needed to understand how particular species are utilised at the household level with respect to commercialization and how continuous specialization on markets would affect overall agrobiodiversity and traditional knowledge on local species use.

Key words: market orientation, agrobiodiversity, homegarden characteristics, household characteristics**.**

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1. Preface

There has been an increasing requirement for flourishing or healthier life situations and accessible association with nature in developed countries, which motivated sustainable land use arrangement and conventional agriculture products. Which is competent for attachment to consumer towards his own tradition and nature of his territory and his cultural traditions. In some countries, local governmental authority is providing a financial allowance to motivate some gardener or conservator for horticulture in their own home garden (HMG) for a long time. In developed countries, numerous inhabitants have taken one way for food-producing which are on various land or household (HH) places like garden, terrace, roof, and place near their house or some time sharing with a neighbour. In some regions and states allocate unutilized public land or space for native persons, community, students, and sometimes old or senior citizens for gardening or land use farming. Various NGOs and communities are taking part to encourage people from different promoting activities to explaining the importance of biodiversity in homegarden with interchanging native plant species and growing it (Galluzzi et al. 2010).

The new tendency toward extensive agriculture which resolute a moderate simplification of agriculture structure and scenery, in which plant species are cultivated and abrasion of advanced understanding regarding agriculture exercise (Birol et al. 2005). Substitution of the rural region previously utilizes for producing amenity from grazing, gardening, and also wooded places by monocultures which have to create exhaustion of wild plant species, native plant species, and also earliest plant species (Negri 2005). Homegardens are considered as a preservation system or a gene reservoir where adaptable species have been cultivated. Additionally, in home garden work assortment, household male and female members play a key role in planting till consumption or selling. South Asian country in Nepal, there was research on home garden plant species richness above 10 to 15 years which indicated the disappearance of 20 plant species and reveal more 11 plant species under possibility to extinction, largely the reason behind that is switching or changing the design of land use system and unavailability of native seed for homegardens (Sunwar et al. 2006). In homegardens, there is a positive tendency to keep supporting rural gardeners to keep preserving biodiversity. In the developing world, nourish value of native species, abandon or neglected plant species has been evaluating, and growing practice in the home garden encourages to pledge for nutrient and vitamin ingestion

(Odhav et al. 2007). Initiation of commercial and food growing homegardens mostly establish for native plant species and local plant seed structure. The urban growth areas are one of the main instruments with an aspect of creating metropolis additional or more sustainable and giving marginal division to residents for strengthening their traditions recognition, nutritious food items with employment possibilities (van Veenhuizen 2006).

Native conventional or traditional plant species which has been slowly eliminating cultivation from various commercial homegardens, and the reason behind that is the unavailability of consistency, firmness or stability, and characteristic. Freshly European union has taken an initial step towards redesigning their ordinance, about legitimize promoting and interchanging of seeds of native species. Which can help to decrease the chance of genetic depletion and providing a wide possibility for the remaining of the small-scale land-use system to sustain biodiversity. Some specialists and professionals have suggested about few leading concerns on home garden arrangements and design of particularly biodiversity, for underutilized plant species mainly, measure and effect of species selection, and also solidity of biodiversity with its reaction over switching new tendency towards agriculture. Preservation possibility of the various home garden is revealing possibilities to disciplinary research which including various researchers from different expertise. A better comprehension of the component which effects and enable biodiversity in various homegardens are enabling preservation, various researchers and societies are conserving and promoting major knowledge and assets with conserving diversity, sustainability and agro-ecosystem deliver to environment and persons on earth (Galluzzi et al. 2010). The future of Traditional home garden including biodiversity mainly depends on development occurring in economic and geographic conditions. In the whole world, there is a new tendency regarding an extensive agricultural land use system, which regulates the moderate process of understanding landscape and agriculture system where various plant species are cultivated with an advanced understanding of land use farming system (Agbogidi & Adolor 2013). The home garden is one of the sources for ecological and surroundings welfare. Which performs as a dominant element for making use of eco-friendly methods for agrological products, natural assets, and biodiversity preservation. Normally home garden mainly in tropical countries having livestock and diverse type of plant species (Galhena et al. 2013).

India is located in southern Asia and is the second most populated country in the world after continental China. Despite rapid changes in the structure of the economy, the agriculture sector has an important part in the national economy. In India, people are living in rural and remote parts of the country. More ever elders of that community are doubtful on hold back from traditions and domestication of such a plant species (Rehamn and Sultana 2012). There have been lots of definitions of homegardens developed so far. Nevertheless, most general one describes them as the land-use system near farmer house with a mixture of annual and perennial plant species has been grown for either subsistence or commercial purposes (Vogl & Vogl-Lukasser 2003).

However, there are farmers in rural communities that consider home garden preservation for new generations as a very important part of the traditional knowledge system. Home garden purposes can be different as per farmer's requirements like economic, ecological, social, and cultural as well. As stated earlier, one of the roles that home garden play in the farmers' livelihood is to generate additional income for the households. The economic purpose of the home garden depends on criteria like if plants are planted for their own consumption or for commercial production, size of the home garden, market availability, demands of that plants which being grown (Christanty & Abdoellah 1986). The recognition of the home garden as a land-use farming system which is furthermore a dominant reserve for local biodiversity. Also, it has freshly guide capability to study this land-use system in order to make an understanding of management as well as for the preservation of biodiversity. This is evident that in developing countries homegardens are also seen as a status symbol. Households with own home garden are considered as a wealthier (Agbogidi & Adolor 2013).

There has been very limited research on the relationship between characteristics of household and home garden. household characteristics such as household size, landholding, economic status, and landholdings have an effect on home garden production characteristics, species diversity, or level of commercialization (Méndez et al. 2001). This research is about the relationship between home garden agrobiodiversity and household characteristics in four districts in the Gujarat state in India. Homegardens in every region of India are unrepeatable with their diversity in species. some are new domesticated as well in that region and also with different other dominant species. In

western India, a home garden is called ‘ghar bagicho’, which is a park with different species near home (Sunwar et al. 2006).

2. Literature review

2.1 Biodiversity as a foundation for sustainable development

Genes, an ecosystem of region, and species are including in biodiversity. Biodiversity is described as the variation and variability between living species and also ecological compound where they happen (Bahadur et al. 2015). A biodiversity is a unit that has structure, and which is vary from a complete ecosystem. Biodiversity is studied and explain in three various ecosystems, like genetic diversity, species diversity, and also its richness and abundance.

A combination of biodiversity of ecosystems together with anthropic influence usually refers to agrobiodiversity, which creates species diversity in farming systems. One of these farming systems most acknowledged for agrobiodiversity is homegardens. Species diversity in homegarden defines as a floristic richness with benefactions to the economy, nutrition, and also to cultural identification. Genetic diversity in homegarden between various biological species delivers facility and goods which promote ecosystem functioning, production, and also confrontation. Therefore, it becomes a key concept for agro-ecology and also for sustainable agriculture (Agbogidi & Adolor 2013). Biodiversity is one of the ways to control or reduce climate change, food security, improves the farmer society to market access, and also increase ecological balance at homegarden level (Bucheli & Bokelmann 2017). Perennial, semi-perennial, wild species, annual and biannual species or plants in land use system with biodiversity allow the farmer's household to produce different products on a daily, weekly, yearly, and as well as long term basis. Homegarden is like a treasury for biodiversity which is recognized via complete inter regulation study of their agro-biodiversity but it if not yet confirm if local farmers still have the understanding to save this system or not. The connection between nature and people is a large range of queries related to the importance of traditional farming knowledge (Idohou et al. 2014).

Biodiversity is not just assisting in improve agriculture production but It is also helping through evolving disease resilience diversity for human (Bahadur et al. 2015). In

homegardens, the diversity of species is favourable from the nutritional perspective. Species from the homegarden contribute additionally to vitamins, minerals, and also carbohydrates (Torquebiau 1992). Some species of plants from homegarden are also providing non-food items like fuelwood, building material, and also for spiritual purposes. For the preservation of biodiversity, the habitat or surrounding services that homegarden are supplying have barely freshly got attention from agroforestry and preservation researchers (Odhav et al. 2007). Many researchers have discovered about homegarden and agroforestry system regards to preservation of biodiversity, via site preservation like decrease in pressure on residue land or forest, supplying of appropriate place or land for fauna and flora on the farm and homegarden and also preservation for conifer species on-farm (Atta-Krah et al. 2004).

For the preservation aspect, the household size of a farmer in homegarden (HMG) is fairly under which would be advantageous for the farmer. There are two interconnected factors that require to be investigated to maintain diversity in homegarden. Which is how a farmer in HMG sustains that compact population as well as a genetic indication of that compact population. Some farmers in HMG over smaller and bigger time period they like to preserve planting materials and seeds. This process probably neutrally unsteady processes because their population of species is less but seasons not likely to be repeatable or same. But at the same time, some farmers are using this preservation method for long enough, so some species are themselves adaptable. That is why it is a farmer's knowledge and the decision to use old material or seeds with new material. Also, with the scale to which society or community carries on the same scale of material that is a drive to future generations. Allocation or distribution of biodiversity between native cultivar on various homegardens are between native varieties and also between field and the local community. The method in which biodiversity is separated between and inside various homegarden, societies, or range, layout important facts about not only areas where biodiversity has been divided but also by whom it maintains and with which process. Primary research has shown that there is always a distinction towards crop species allocation. Homegardens are maintaining lots of varieties of native species compared to large scale farming systems and in homegarden. Also, there has been always some species that are not available on the large farming system (Agbogidi & Adolor 2013). The size of homegarden is one of the elements which affect biodiversity. Biodiversity and

homegarden size have a reverse connection. Many kinds of research indicate that biodiversity is elevating when homegarden size is smaller. Utilization of the Homegarden area is more concentrated which is driven by a gardener, which connects diverse demands from that area of the garden (Kunhamu 2015)

2.2 Socio-economic aspect related to biodiversity

In the homegarden, there are connections between biodiversity found, and limited socio-economic elements like a source of income, homegarden age, number of household members, homegarden size, access to the market because of some reasons. On the other hand, there are also no relationship between biodiversity and some socio-economic elements like land ownership, household type, literacy rate within a household, and also homegarden use (Agbogidi & Adolor 2013). Benefaction of socio-economic elements in creating and preserving species biodiversity in homegardens has been getting some curiosity (Bates 2007). The diversity of the ecosystem has an effect on people's cultures which they belong to and also in-homegarden. It is usually a farmer's economic value which sometimes describes contrast within the neighbouring homegarden or farm. In homegardens, sometimes a farmer's family or community are spending free time which makes homegarden into a culture establish area where ethnobotanical capability is lively conserve. Some species and plants are preserving better since there is a remarkable priority in household or society traditions. Homegarden diversity and socio-economic position are normally reflecting in the biodiversity of homegarden species (Agbogidi & Adolor 2013).

There is a majority of experienced gardeners who are loyal to some plant species, which they inherited from their ancestors. Information regarding gardening is the knowledge which farmer in a community has been developed. Modification and experience are established in a local environment and culture (Vogl & Vogl-Lukasser 2003). Information is applicable to decrease threats and preserve biodiversity with culture within the community. With a reduction in traditional farming knowledge and expertise in plant management, there are chances to face troubles in the future regards to preservation aspect. Homegarden and its role as a storehouse of biodiversity is recognized, but it is still inclusive and inter regulated for their biodiversity (Galluzzi et al. 2010). Homegarden

has two purposes mainly like biodiversity and production as a main sustainable agroecosystem. There is a risk for genetic erosion to species wealth or resources, which is convenient for agriculture benefits. Common socio-economic benefits from homegarden is a direct benefaction to household via utilization and obtainability of agriculture product (Semu 2018).

2.3 Homegardens – Traditional farming system and biodiversity hotspot

In the developing world, homegardens are one of the main sources of food products for household consumption. Homegardens are a small-scale supportive land use agriculture system, which has been accepted by households to acquire useful food products. Thus, homegardens are considered to increase nutrition security and provide additional income, mainly in small-scale around the globe. At the household level, homegarden is one of the sources for food security, production or own consumption. That is why homegarden have been always suited for maintaining the food security of the household. Homegardens are more productive and main producing elements for delivering different household's fundamental needs like fuel, medicine, food, and others involving hiring of elders and females from the household (Shajaat Ali 2005).

There has been early research on homegarden in Indonesia by some Netherlands researchers. In that research, there have been substantial benefactions for homegarden purpose, socio-economic with cultural importance, homegarden structure feature, definitions, homegarden configuration, and also for plant species listing (Galhena et al. 2013). Homegardens are introduced for the plantation of small scale in the land which can be near, around, or next from farmer's household. Also, it refers to mixed harvesting structure, which is surrounded with various plant species like spice, fruits, vegetable, herbs, ornamental, building material and also sometimes with livestock who is playing a big role as an optional source for income and for consumption. Homegarden has five fundamental features like HMG accommodate the high amount of diverse plant species, the main source of household income is not from HMG production, HMG located near or walking distance from farmer house, HMG inhabited land is rather small and also with

a rather small production structure so poor person can enter easily. Homegarden is compact everlasting supportive agriculture structure built by the home gardeners to fulfil and supply agriculture services for his family. Mainly homegardens in developing countries are producing or growing agriculture products just for their own household requirement (Galhena et al. 2013). Household head or farmer can also expand their homegarden area for cultivating more plant species for alternate use as per market requirement. In the global era, there has been a drastic change in agriculture with acceptance of new technology, profit-orientation practices, and demands from the market, which leads to adaptation for the agroecosystem where homegarden is also included (Kabir & Webb 2009).

In developed or rich countries, there is increasing importance about nutritious food and relation with nature which has led towards traditional and sustainable agriculture products (Agbogidi & Adolor 2013). There are also some advantages from homegardens, which improve biodiversity with increasing food production via HMG, better food security, improvement in surrounding with water recycling, and improve or maintain biodiversity, advantages from species diversity. Homegarden size differs within gardener to the gardener with a minimum half land size of their total land, but if the gardener doesn't have any other agriculture land then may size of that homegarden differ as well. Homegarden may determine by their terrestrial distinction like partition around household land, livestock waste, fences, cookery waste, and also with some organic matter which has a significant impact on productivity and biodiversity of homegarden (Galhena et al. 2013). Every homegarden is different from some characteristics, their structure, HMG aspect, and also purpose which depends on household members, HMG position, accessible capital, labour force availability, and of course HH member eagerness towards HMG (Christanty & Abdoellah 1986).

The mass population suffers from hunger and malnutrition are located in developing countries with poor living standard (Galhena et al. 2013). The world tendency with regards to huge lamina agriculture influence slowly simpler for land use system and agriculture system, Where agriculture crops have been produced with abrasion of experienced expertise connected to farming exercise (Agbogidi & Adolor 2013). One time rural area was used for different agriculture land-use systems like livestock

production, gardening, wooded or forest area and pastures. Additionally, at the same time wild species, primary or earlier species and domestic species exhaustion created by monocultures (Negri 2005). For the organization of homegarden labour play an important part. In some households (HH), farmer families play sometimes major roles as help or labour which totally depends on their financial condition and their limit to bear expenses (Fernandes & Nair 1986). Nature has the same effects on homegarden as an agriculture farm, which is floods and dough. In spite of the reality that the gardening process requires minor knowledge of agriculture or farming but HH members with some expertise can reduce HMG loss or negative impact. Homegarden can be one of the ways to get access to freshly food products without reaching to the supermarket , it is also one of the ways to save money with time without going anywhere to buy a product. For the environment aspect, homegarden giving a possibility to get a positive effect. Also, household compostable waste can be useable as a natural substance, but the use of chemical fertilizer can decrease and contaminate of groundwater from homegardens (Agbogidi & Adolor 2013). Some gardeners within HMGs are also active in various other alternative sources of income, as a source of nutrients and proteins from aquaculture ponds, beekeeping, and sometimes also mushroom growing (Galhena et al. 2013). The price of products from homegardens can be explained by the market price. Resources for homegardens can be regulated from financial benefaction to the economical pattern of garden-like transport value, natural and chemical substance for garden, seed, employ, household labour and expenditure on equipment for gardening (Paul Sharon 2012).

The gardening approach towards nourishment, its knowledge, and its expertise (like which plant species include required nutrients and how to make food which sustains its nutrients) can involve through combine homegarden training. Which includes fertilizer or compost production, an organization for disease and pest, utilization and distribution of seeds, crop rotation, and also cultivating bed arrangements. There is increasing research on homegarden involvement in the successful utilization of healthy food within rural household mainly in developing countries (Baliki et al. 2019). For homegarden biodiversity and structure, a vast range of elements is connected which are eminence, closeness to a forest, economic necessity, knowledge, past experience, culture, and tradition (Kabir & Webb 2009). Human to nature connection is mainly depending on gardener knowledge which effects on the decision about homegarden expenditure. It is

also affected to improve the gardener lifestyle via his better managing strategies. Through bad financial and plant situations, homegarden is giving substitute livelihood to gardeners or farmers. In many households, homegardens are essential origin in terms of the economy and self-sustaining (Salam et al. 2000). The financial situation of households in a rural area mainly depends on their agriculture products and utilization of them. Large numbers of farmers in India are depending on various homegardens for their food security and ecological welfare which affects their daily lifestyle. Agriculture activities in India are working out in high rainfall, humid weather conditions (Kunhamu 2015). There was research on homegarden in the north-eastern region of India, which are famous for their gardening and its importance for the household. The north-eastern region called Mizoram which is well known for accommodate new and vast numbers of plant varieties as per plant species utilization. In some parts of India, homegardens are progressing with their local process from slash and burn. Agriculture practices in India have been identified by gardeners and farmers as a positive effect with the preservation of native plant species, nutrition food, food security, and also a stable source of income. Mainly in the north-eastern region of India terrain type is a slope which is mainly an acceptable perspective for reducing soil abrasion. This is also flexible for ecological rehabilitation and agriculture productivity. In that region, gardeners are cultivating not only indigenous and native plant species but also annual and biennial plant species. This kind of land use system is effectual, active with diverse kinds of plant species including trees, shrubs, and herbs. In spite of native plant species richness and significance, that plant species structure in that land-use system is still badly perceived in that slope terrain. Additionally, inside excessive condition gardening, land use systems begin to be influencing. In this kind of undeveloped state of India water from rain is the main source for plant species in homegarden (Bargali 2016).

For understanding how homegarden provides a platform to preserve biodiversity, all elements influencing its classification inside and over homegarden. Advancement and resilience of biodiversity above time to be recognized. For that reason, a study on homegarden preservation is encountering issues regarding clarity on the minimal size of preservation or conservation area, which are required to preserve various types of plant species. One time this preservation area established then it can be used and observed for biodiversity (Negri 2005). More than a hundred independent plant species are rarely held

in any homegarden, also main dominant species and inhabitants size is extremely relying on plant species. Since the disparity in terms of between and within plant species diversity, Researchers, in general, agree that elected preservation unit or homegarden should insert not only one preservation unit but more preservation unit under one ecologic zone (Lawrence 2002). For designing preservation areas, the genetic formation of the homegarden population and especially locally domesticated plant species can be used for it. Perhaps the main element which affects development or evaluation of biodiversity is the selection of species. Farmer's selection is an active farming exercise that relies on various variables like plant species, local market pressure, gardening plot size, and change to rely on opportunities. There is an effect on preference in homegarden crop biodiversity which depends on Crop seeds and its gene flow increase. Additional or more biodiversity possible to obtain from the nearest homegarden where their gardener allocates their own seeds to another gardener (Galluzzi et al. 2010). However, in homegarden there has been a new drift towards the supportive movement to persons to keep preserve biodiversity in rural or urban homegarden in developing countries. In homegarden, the biodiversity of species is not dissimilar from various classification which affects the accessibility of capital, plant species selection from gardener, plant species available on his garden, and dependent on weather conditions (Senanayake et al. 2010).

Preservation possibilities in various home gardens reveal chances related to more than one branch of research study, which includes geneticist, sociologist, ecologist, botanist, and also an anthropologist. A better comprehension of the elements which effects biodiversity inside the territory of household or garden, this authorizes researchers and scientists to promote and sustain conservation knowledge and biological assets (Galluzzi et al. 2010)

2.4 Homegarden and household characteristics connection

Studies on homegardens are in limited numbers with their consequences with regards to household lifestyle, economical benefits, and ecology (Kabir & Webb 2009). Homegardens also serves as a safety net for a farmer, which is supplying another option of an income for the farmer in a hard time like crop failure in the farm. In the household economy, the homegarden part could rely on the element of product and utilization of

products with the nature of the product. Research has reported on benefaction from homegarden to the household economy. The contribution of homegardens to household income in south Asian countries was documented between 6 to 54% (Mohan Kumar et al. 1994).

Generally, homegardens could provide up to 50% of the fruits, tubers, yams, herbs, and vegetable species. Plant species such as spice and culinary herbs are mainly utilized for taste enhances, substance for add flavour for food, and tea (WinklerPrins & de Souza 2005). Additionally, the combination of poultry and livestock venture into homegarden strengthens nutritional food security for a household family with various items like meat, eggs, and milk. Which is one of the main sources of protein obtained from animal (Galhena et al. 2013). Homegarden can be one of the sources for economic benefit by encouraging rural growth and entrepreneurship. Additionally, they can provide economic benefits to households via agriculture products produce within homegarden and sell into the local market, money received from that agriculture products can use to start additional agriculture industry or start any other rural gardening service (Galluzzi et al. 2010). Earning from different agriculture products like vegetables, livestock products, fruits, and others are giving a permit to household members to spend on further gardening services, education, saving, and as well as on food items. Homegardens are largely encouraged by many other developing countries as a tool for poverty alleviation with the way of income. Homegardens are seen as supportive of the small production system which can be a composition of the well-organized commercial venture with the cultivation of high-value animal products and crops (Ranasinghe 2009). There has been ground research on assessing the possibility of economic benefaction to households and locally as well as social development (Lindgreen & Lindgreen 2004). The reality for homegarden is they needed lesser resources and lesser cost function, which is especially principle for poor households with less access for building inputs. Still, there is an estimation regarding relative livestock and rigorous plant species that can create the same amount of income as per unit land area cultivate system. Where a limitation of land has existence, their advanced tools, or cultivating system which has been used to make well-organized use of small space (Devendra & Thomas 2002).

2.5 Homegarden contribution to household food security and income generation

Homegardens save cash expenditures on food and other farm products, such as medicine, construction material, fuel, and ornaments. When The profit from the homegardens are increase, then also there is a possibility from household to invest money to get higher homegarden production (Blaylock & Gallo 1983). According to one research, a household with homegarden generally less depends on the local market for their own use around 3.2% of total consumption but household without homegarden is dependent on the local market around 97.5%. In addition to less expenditure on food and agriculture products, homegarden farmers can earn a reasonable amount of money from sales of agriculture and livestock production. One project in Bangladesh unveils that household receives 14.8% money of total monthly earning from homegarden, but that percentage of production can be expanding from 14% to 25% minimum after the introduction of various varieties of fruits and vegetable species (Paul Sharon 2012).

Main employ labour from the household in homegardens are women with high knowledge of agriculture activities. Additionally, still because of lack of resources within households, production from homegardens are contemplating as additive rather than principle root for household income or consumption (Shajaat Ali 2005). Also increased household earnings from their homegarden proceed in the future for advancement in the socioeconomic status of the household. Increased income by a gardener from their homegardens is a cause of the dominant group and active involvement. Accessibility to water is also one of the key factors for homegarden, but in the rural areas where water is not easily available there two or three extra hours work from household members in homegarden can help to contribute financially for the fulfilment of the requirement. In a south-eastern country, Indonesia homegarden provides approximately 25% of earnings for the household. One research in India discovers that agriculture production and earnings in small homegarden compare to the larger farming systems are higher like the average profit of 84 INR per m^2 (Paul Sharon 2012).

Nutrition biodiversity can extend from homegarden by various types of crop species. Supplemental food can be bought via savings from households and also via earnings from homegarden. Household is spending some amount of earnings from homegarden products on education, gardening capital, and also on food (Paul Sharon 2012). In homegarden organizing and managing female household members are playing a main important role. Also, there is a bigger role in the decision making process about homegarden with household consumption. As per the study, female labour from the household who is participating, they have higher self-assurance compare to non-contributor in homegarden. During difficult conditions with regards to the financial and nutritional setbacks, household have to turn into further self-supporting. Different research with various methods has used to see the financial or economical influence on various homegarden in south Asian countries. This research determines spending on food in the household from the outcome in homegardens. The food spending explained as the purpose of territory, the position of household in inner-city, earnings, land or house ownership, seasonality, household structure element, and food distribution to the guest. The possible capital or saving on food spending was deliberated as the distinction between anticipated food spending when household homegarden production was positive and zero (Blaylock & Gallo 1983). In homegarden, various plant species diversity is categorically connected with household head farming or gardening experience, the financial situation of household, expenditure on homegarden and homegarden terrain, and soil condition. Homegarden plant species and tree species richness are affected by land size and time invest from homegarden connected via the financial condition of household and expenditure on homegarden. Local market or district market matters when farmers and gardeners are cultivating plant species for the commercial gardens. Homegarden earnings are connected via road connectivity towards the local market, the financial condition of household, homegarden distance to local agriculture market, and gardener personal experience about farming (Kabir et al. 2016).

3. Aims of the thesis

Overall aim of the thesis was to quantify food plant species diversity in homegardens located in semi-arid and/or arid areas of Gujarat state and to analyse whether and how it is affected by both household and homegarden characteristics.

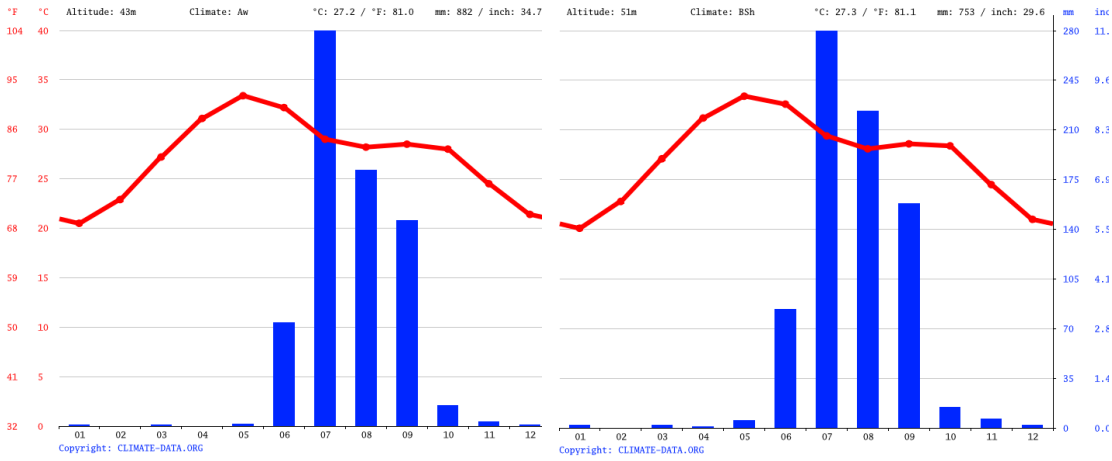
Specific objectives were:

a) to document useful species that were grown in selected homegardens and to quantify diversity of that species;
b) to document household characteristics and homegarden characteristics
c) to analyse potential relation(s) between species diversity and main homegardens and household characteristics

4. Methodology

4.1 Study area characteristics

In India, Western part of region called Gujarat, which is situated on the Arabian sea with total surface area of 1,96,02,400 ha. Gujarat is 10th highest populated region in India representing 5% of the total population. There are total 6,685.38 ha cultivable land in Gujarat state. Study area contains sandy loam and some place also deep black clayey soil. The region is surrounded by Pakistan on northwest, Indian regions of Madya Pradesh to the east part, Rajasthan to the north part and Maharashtra to the southeast part of Gujarat (Chinnasamy et al. 2015). Study area region is coming under semi-arid and arid climate zone (Figure 1).



a) Tropical savanna climate b) Semi-arid climate

Figure 1. Climate zones in focused study sites.

Source: Climatedata.org

The study area contains of total seven various place in villages, cities and towns around 3 districts in central part of Gujarat state in India (Figure 2). Study area region has two main rivers which are Tapi and Narmada and this basin is one of the main sources of water for agriculture activities. The drainage area for this river is Gulf of Khambhat but still most of the water for agriculture activities are comes from various canal network. The sardar Sarovar canal project (SSP) is the main and biggest canal network in Gujarat

state which covers 18,450 km^2 total area. It provides water for drinking and agriculture activities to 15 different districts and 3112 villages. Also, other canal networks which provide water mainly for irrigation like mahi, Karjan, damnganga and ukai in southern and central part of Gujarat state. Main cultivated crops are paddy rice, tobacco, bajra, cotton and sugar cane. This study area is coming under mainly subtropical climate region. The climatic seasons in study area region are mainly cold season, summer season and rainy season. The cold season portion in this part of study area during year are from November to February with topmost temperature range between 24ºC and 8ºC; summer season portion during year are from March to May with topmost temperature range between 32ºC to 46ºC; study area region are also experience rainfall from June to September with annual rainfall ranges between 800 to 1000 mm (Patel et al. 2020).

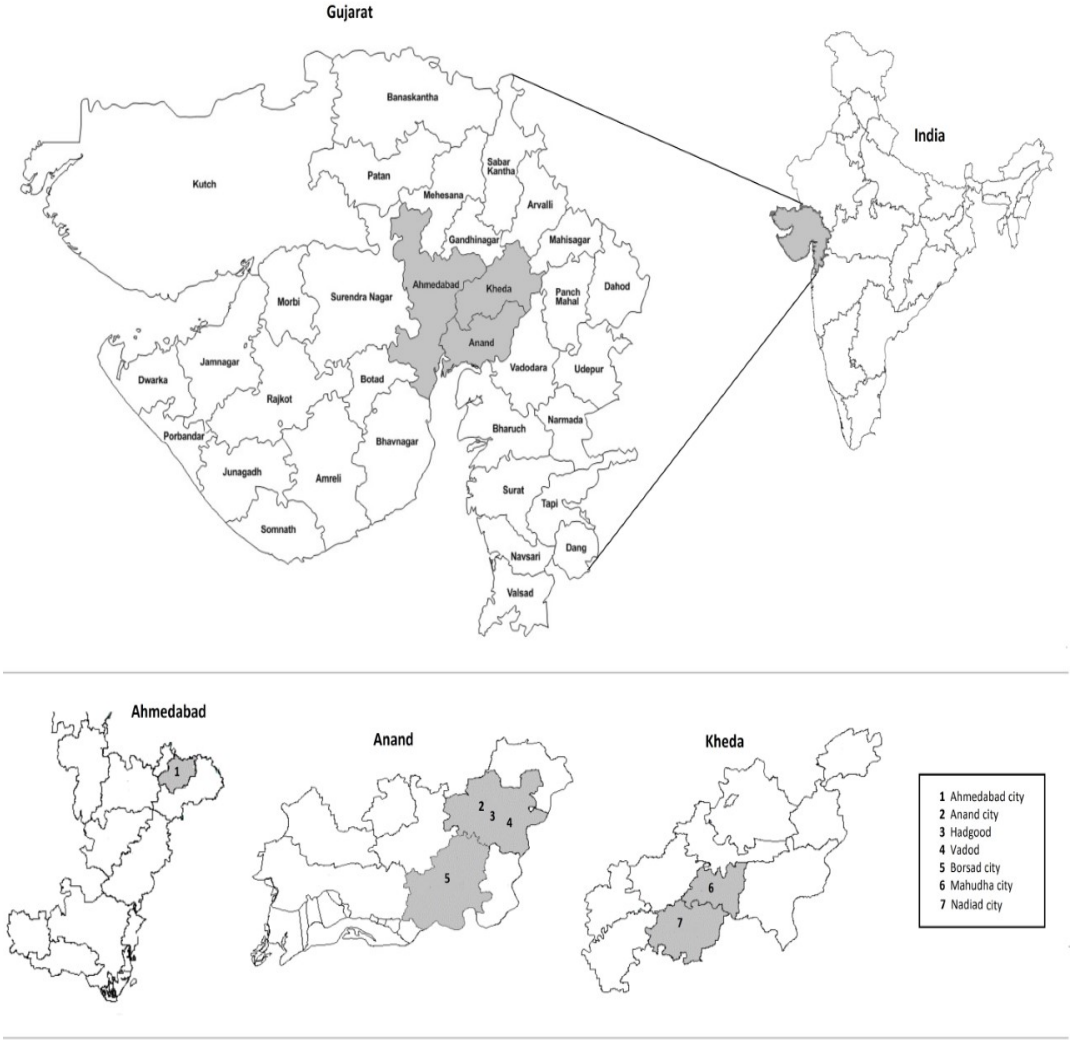


Figure 2. Study area with seven locations used for data collection.

Gujarat economy has grown annually around 8-9% since 2012 and per capita income is about twice of national level.

Gujarat has one of the highest levels of urbanisation in the country, with more than 40% of people living in urban areas, however population density exceeding 300 persons per km^2 is bellow national average.

4.2 Data collection and sampling techniques

The study area consisted of three districts and seven different villages – Ahmedabad, Anand, Hadgood, Vadod, Borsad, Mahudha, and Nadiad, located in Ahmedabad, Anand and Kheda districts of Gujarat state in western India (see Figure 2).

Before household survey started, interviews with various stakeholders, such as farmers, local leaders or elder household members were carried out in order to better understand local homegardens in terms of their structure, management, history and utilisation of their production.

For data collection total number of 38 household with homegardens were selected through snowball and purposive sampling methods. Household with homegardens were selected via transect walks, key informants and snowball sampling (Naderifar et al. 2017). Questionnaire consisted of 33 questions, which were related to socioeconomic, demographic, biophysical and homegarden characteristics (for variables see Table 1).

Plant species, their structure and also composition from various homegardens were documented from a vegetation survey. Each plant species apart from ornamental species mentioned by respondents was noted and identified by either gardener or household head and in some cases, we also took help from local farmers. That questions were like species name in local language, number of individuals, part of use, purpose of use, who decided to grow that species, processing of production, access of local market for selling and if farmer want to increase plant species in his homegarden or not. In the next step, household head and members were main respondents regards to household and homegarden characteristics.

For the purpose of the study, classification of homegardens into commercial and non-commercial was done based on number of products sold to the market (Abdoellah et al. 2006). In homegardens, if agriculture products were utilized and consume by household members or family then we described as a non-commercial homegarden; and if agriculture products were produced for selling in local markets or to other places then we described as a commercial homegardens.

Table 1. Various characteristics used in the study

Socioeconomic variables	Demographic variables	Biophysical variables	Homegarden variables
land Ownership (rented, inherited, purchased, govt or project, not clear ownership)	Household size	Market availability (Yes=1)	Species
Size of plantation land	HH gender and age structure	Type of livestock	Number of individual species
Main source of Income	Years of schooling	Numbers of livestock	Part of use
estimated contribution of homegarden to household income (INR)	Origin of household head (born in the village =1)	Reason to have livestock	Purpose of use
If yes, working on homegarden (yes=1)	Living in HH permanently (yes=1)		Processing of agricultural products (yes=1)
If yes, having off-farm job (yes=1)	Gardening experience (years)		Selling (yes/no), if yes (%)
remittances received by HH (Indian rupee)	Gardening experience (from whom he/she learn?)		Place of selling (if yes,% and price)
selling in local market (if yes, % and price)			Would like to grow more (+,++), same (=) or less (-,- -) in the future
			Species numbers compare to past
			Homegarden size (ha)
			type of land (farm, plantation, homegarden, forest)

4.3 Data analysis

After the interview, data were checked whether they are complete and data collection process was not terminated until everything was clear and collected. Data were entered into Microsoft Excel Software for MacBook, cleaned, summarized, and coded.

Data were analysed via various methods. Firstly, agrobiodiversity was quantified via standard indices, Shannon Wiener Diversity Index, Margalef Species Richness Index, and Simpson's Diversity Index (Vlkova et al. 2011).

Shannon Wiener Diversity Index is calculated via following formula (Magurran 1988).

$$H = -\sum_{i=1}^{R} p_i \ln p_i \quad (1)$$

p_i proportion of the species relative to the total number of plants.

Secondly, household data were transferred into standard indicators used in Farming Systems Approach (Vlkova et al. 2011).

Margalef diversity index is calculated via following formula (Magurran 1988).

$$DMg = \frac{S-1}{In(N)} \quad (2)$$

S the number of species, N total number of individuals in the sample.

Simpsons diversity index is calculated via following formula (Mohan et al. 2007).

$$D = \frac{\Sigma n\,(n-1)}{N(N-1)} \quad (3)$$

In order to identify potential linkages between agrobiodiversity and household and homegardens characteristics simple regression was applied. We used simple non-linear regression to identify effect of main household and homegarden characteristics on agrobiodiversity in this thesis (Matthews 2014).

5. Results

5.1 Diversity and use of species

Selected homegardens were involved with perennials and annual plant species were predominantly used as a food. In surveyed homegardens, total 50 various plant species were reported within 38 homegardens (see Table 2). From all recorded plant species, as per purpose of use were reported such as for food purpose (52%) in which vegetables, fruits and eatable traditional plants included, medicine and spiritual purpose (14%), as a spice (12%), for beverage purposes (4%), as a material for construction (2%), oil producing plant (4%) and for decoration and for fresh air (12%) recorded as per collected data. The part for use in plant species such as a leaf, seed, whole plant, fruit, flower, stem and environmental use were reported. Some plant species were also recorded as a dual proposes like cotton (*Gossypium L.*) for oil and cloth making, groundnut (*Arachis hypogaea*) for oil and food purpose, asopalav (*Polyalthia longifolia*), areca palm (*Dypsis lutescens*), aglaonema (*Aglaonema nitidum*), spider plant (*Chlorophytum comosum*), money plant (*Epipremnum aureum*) for fresh air and for decoration purpose and coconut tree (*Cocos nucifera*) for food and beverage purposes.

Table 2. Ethnobotanical data on Plant species with English and scientific name derived from data collection.

Local name of species	Scientific name of species	Part for use	Purpose of use
Aglaonema	*Aglaonema commutatum Schott*	Environmental uses	Fresh air, decoration purposes
Ajwain plant	*Trachyspermum ammi*	Leaf, seed	Spice
Aloevera plant	*Aloe barbadensis miller*	Whole plant	Medicine
Areca palm	*Dypsis lutescens*	Environmental uses	Fresh air, decoration purposes
Asopalav	*Polyalthia longifolia*	Environmental uses	fresh air, decoration purposes
Bamboo tree	*Bambasideae*	Whole plant	Construction material
Banana plant	*Musa* sp.	Leaf, fruit	Food
Bell paper plant	*Capsicum annuum L.*	Fruit	Food
Bitter guard plant	*Momordica charantia*	Fruit	Food

Local name of species	Scientific name of species	Part for use	Purpose of use
Black mustard plant	*Brassica nigra L.*	Seed	Spice
Bodhi tree	*Ficus religiosa*	Leaf	Spiritual
Bor (ber) fruit tree	*Ziziphas mauritiana*	Fruit	Food
Bottlegourd plant	*Lagenaria siceraria*	Fruit	Food
Carrot plant	*Daucus carota* subsp. *Sativas*	Leaf, fruit	Food
Coconut tree	*Cocos nucifera*	Leaf, fruit	Food, beverage
Coriender plant	*Coriandrum sativum*	Whole plant	Food
Cotton plant	*Gossypium L.*	Leaf, fruit	Cloths, oil
Cumin plant	*Cuminum cyminum*	Leaf, fruit	Spice
Curry leaf plant	*Murraya koenigii*	Leaf	Spice
Drumstick tree	*Moringa oleifera*	Fruit	Food
Elephant Ears	*Colocasia esculenta L.*	Leaf	Food
Elephant foot jam	*Amorphophallus paeoniifolius*	Whole plant	Food
Fennel plant	*Foeniculam vulgare*	Seed	Spice
Frayrany manjack (gunda)	*Cordia myxa L.*	Fruit	Food
Green chilli plant	*Capsicum annuum L.*	Fruit	Spice
Groundnut Plant	*Arachis hypogaea*	Fruit	CLoths, oil
Guava tree	*Psidium guajava*	Fruit	Food
Hibiscus plant	*Hibisous rosa-sinensis*	Flower	Spiritual
Holy Basil	*Ocimum tenuiflarum*	Whole plant	Medicine
Jamun tree	*Syzygium cumini*	Fruit	Food
Lemon tree	*Citrus limon L.*	Leaf, fruit	Food
Madras thorn	*Pithecellobium dulce*	Fruit	Food
Malabar nut plant	*Justicia adhatoda*	Whole plant	Medicine
Mango tree	*Mangifera indica L.*	Fruit	Food
Money plant	*Epipremnum aureum*	Environmental uses	Fresh air, decoration purposes
Neem tree	*Azadirachta indica*	Leaf, stem	medicine
Night blooming jashmine	*Cestrum nocturnum*	Flower	Spiritual
Onion plant	*Allium cepa*	Fruit	Food
Papaya tree	*Carica papaya*	Fruit	Food
Pearl millet plant	*Pennisetum glaucum L.*	seed	Food
Pineapple plant	*Ananas comosus*	Fruit	Food

Local name of species	Scientific name of species	Part for use	Purpose of use
Potatoe plant	*Solanum tuberosum*	Fruit	Food
Pumkin plant	*Cucurbita pepo*	Fruit	Food
Sapodilla tree	*Manikara zapota*	Fruit	Food
Spider plant	*Chlorophytum comosum*	Environmental uses	Fresh air, decoration purposes
Sugar apple tree	*Annona squamosa*	Fruit	Food
Tomato plant	*Solanum lycopersicum L.*	Fruit	Food
Tover plant	*Cajanus cajan*	Seed	Food
Wheat plant	*Triticum aestivum*	Seed	Food
Wild mint plant	*Mentha arvensis L.*	Whole plant	Food

5.2 Homegarden characteristics

Average size of targeted homegardens was 0.23 ha, varying from 0.13 ha to 0.65 ha (see Table 3 for more detailed statistics). With regards to homegarden age, there were homegarden from min five years age to max 58 years of age. Out of 38 homegardens, there were total 30 homegardens reported with market availability from their homegardens and rest of eight homegardens were reported with no market availability or far from their homegardens. A total of 26 homegardens were identified as a commercial homegarden as per species utilization. However, all 38 homegardens were recorded with flat terrain as per respondents. A total number of 36 households with homegarden were reported as their own homegardens and rest of two households were reported as a rented. With regards to total numbers of species, from min 4 species to max 10 species with 7.35 mean no. of species were reported from homegardens. However, the mean Simpson's diversity and evenness index within all 38 recorded homegardens were reported highest among other diversity and evenness index such as a Shannon-wiener (2.59 mean value) and Margalef (1.45 mean value) with 2.81 mean value.

Table 3. Overview of homegarden characteristics

Variable	Unit of measure	Mean	Standard deviation	Minimum value	Maximum value	Coefficient of variation
Homegarden size	ha	0.23	± 0.13	0.13	0.65	61.08%
Homegarden age	Years (yrs)	21.59	± 13.30	5.00	58.00	61.59%
Access to market	Yes=1,No=2	1.22	± 0.42	1.00	2.00	34.31%
Homegarden commercial	Yes=1,No=2	1.32	± 0.47	1.00	2.00	35.84%
Homegarden terrain	Flat=1,Slope=2	1.00	± 1.00	1.00	1.00	16.66%
Homegarden ownership	Own=1,Rent=2	1.05	± 0.23	1.00	2.00	21.75%
Plant species count	Numbers	7.35	± 1.46	4.00	10.00	19.82%
Shannon-Wiener	Value	2.59	± 1.35	0.02	4.25	52.18%
Margalef	Value	1.45	± 0.69	0.36	2.63	47.94%
Simpson's	Value	2.80	± 1.78	1.40	6.88	63.54%

5.3 Household characteristics

Household size differed with average size of 4.65 members and from min size with three members to max size with eight members (see table 4). The age of household heads differed within 38 households from min age of 36 to max age of 69 (average age of household head = 42.6). A majority of HH head are male (95%) and residents in their HH. Majority of HH heads are literate with average 12.51 years of study. With regards to HH head farming experience, it also differed between homegardens from 5years of experience to 42years. From collected data, HH members which born in village were from min zero members within HH to max eight members within HH. Household members who is working in their homegardens or farms were reported with min one member working in HG (31.6%), two members working in HG (63.1%) and max three members working in HG (5.3%). Also, number of labour force in HH were from 2 labours to 5 labours in each HG, such as two labours (31.6%), three labours (26.3%), four labours (34.2%) and five labours (7.9%). Dependent members in households were with average 1.49 members and max six dependent members in HH. The number of livestock assets within HH were reported from min no livestock availability to max 13 livestock (heads) during my data collection. Our data shows that livestock were used as a working animal, for meat production, dairy items, eggs, for ploughing, breeding purposes as well as a working animal.

Table 4. Overview of household characteristics

Variable	Unit of measure	Mean	Standard deviation	Minimum value	Maximum value	Coefficient of variation
HH size	Numbers	4.65	± 1.31	3.00	8.00	28.33%
HH head age	years	42.73	± 10.20	26.00	69.00	23.87%
HH head gender	Male=1,Female=2	1.05	± 0.23	1.00	2.00	21.75%
HH head year of schooling	years	12.51	± 2.56	5.00	17.00	20.43%
HH head farming experience	years	17.59	± 9.68	5.00	42.00	55.03%
HH members born in village	Numbers	2.81	± 1.84	0.00	8.00	65.41%

Variable	Unit of measure	Mean	Standard deviation	Minimum value	Maximum value	Coefficient of variation
HH members working in HMG	Numbers	1.73	± 0.56	1.00	3.00	32.39%
HH labour force	Numbers	3.16	± 0.99	2.00	5.00	31.19%
HH dependent members	Numbers	1.49	± 1.35	0.00	6.00	90.56%
Livestock assets	Heads	2.92	± 4.22	0.00	13.00	44.54%

5.4 Diversity quantified of reported plant species within homegardens

Apart from plant species overview, we also quantified agrobiodiversity on 50 various plant species within 38 homegardens. Biodiversity within all identified homegardens were differ as per type of homegardens (commercial and non-commercial homegardens). According to table 5, with the same numbers of plant species and three various diversity indexes, there were difference between average diversity values within all three diversity indexes. The Shannon-Wiener diversity index values were highest among other diversity indexes and Simpson's diversity index values were lowest among all other diversity indexes (Table 5).

Table 5. Diversity quantified within all reported plant species.

Diversity index	Total No. of plant species	Mean	Standard deviation	Minimum value	Maximum value	Coefficient of variation
Shanon-Wienner	50	2.52	± 1.38	0.02	4.25	0.55%
Margalef	50	1.43	± 0.69	0.36	2.63	0.48%
Simpson's	50	0.59	± 0.31	0.01	0.91	0.52%

5.5 Associations between homegarden size and richness and evenness of species

Effect of homegarden size on richness and the evenness of species was poor in larger size homegardens compare to smaller size homegardens (figure 2 and figure 3). Additionally, with less than 0.20 ha homegarden size, there were more species richness and evenness reported. The commercial homegardens (Max size = 0.65 ha) were identified with larger

size compare to non-commercial homegardens (Max size = 0.35 ha). The commercial homegardens were reported with total 32 species which was 36% less compared to non-commercial homegardens. The max value for diversity index were differed within three different indexes, such as 4.25 in Shannon-Wiener and 2.63 in Margalef diversity index which was from same non-commercial homegarden. Additionally, the max value in Simpson's diversity index was much higher like 6.96 from non-commercial homegarden. The regression values were differed between all three indexes such as, 0.2823 in Shannon-Wiener, 0.4423 in Margalef and 0.1528 in Simpson's index. However, in all diversity indexes, with increasing in size of homegardens, there were drastic decrease reported.

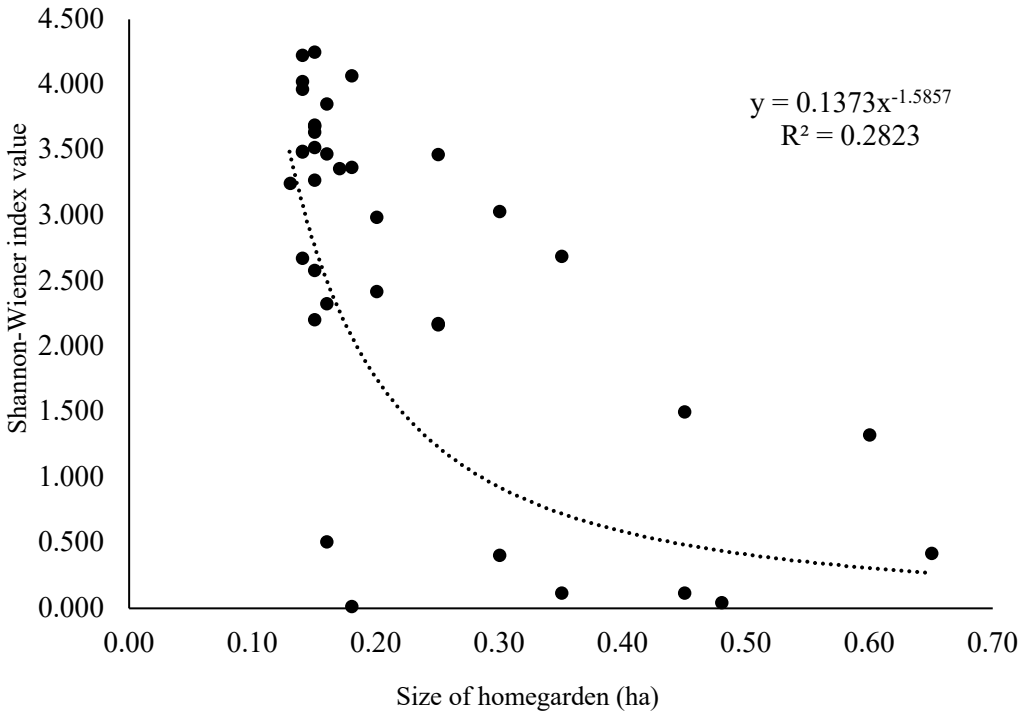


Figure 3. Effect of homegarden size on richness and the evenness of species (Shannon-Wiener index value).

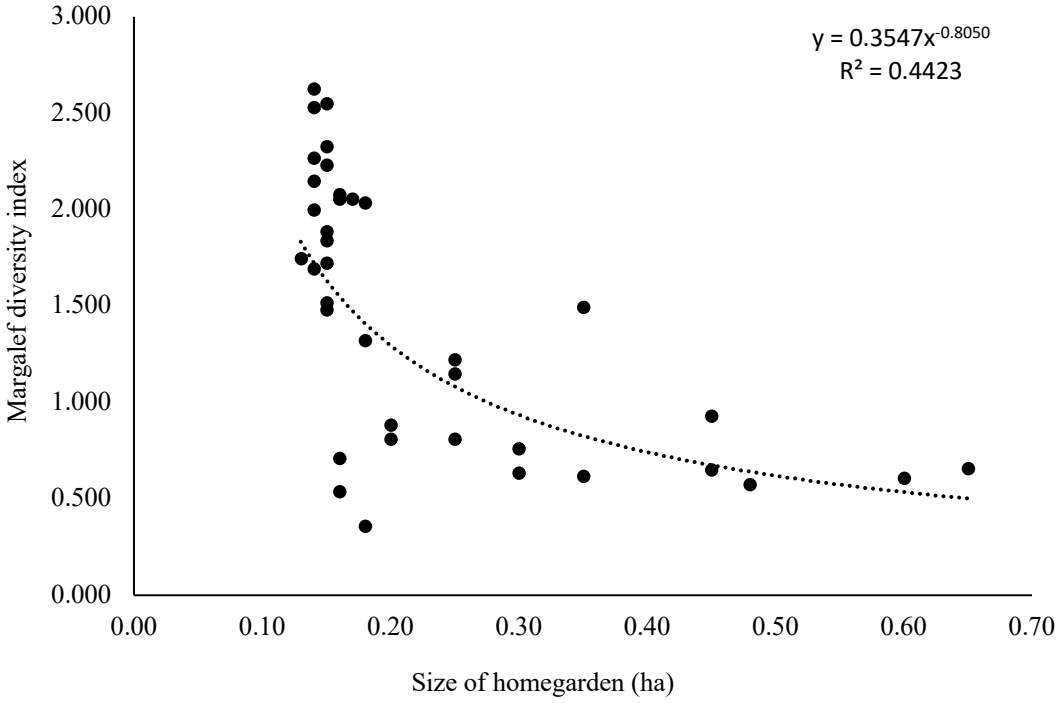


Figure 4. Effect of homegarden size on richness and the evenness of species (Margalef index value).

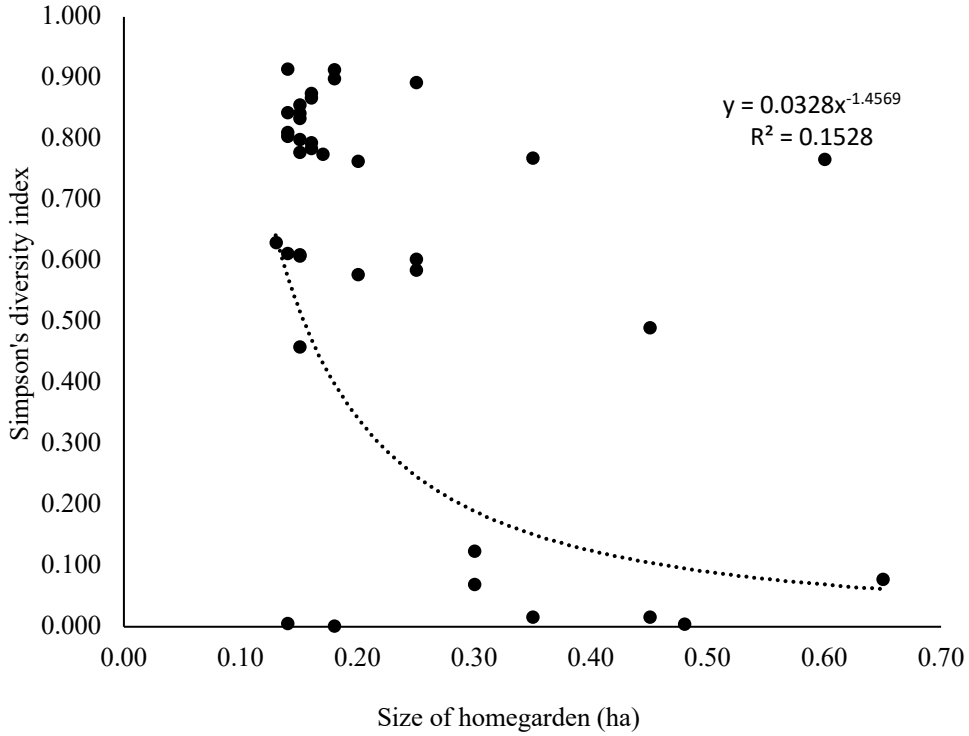


Figure 5. Effect of homegarden size on richness and the evenness of species (Simpson's index value).

5.6 Associations between homegarden age and useful species diversity

The two variations such as a homegarden age (years) and plant species diversity as per three diversity indexes (Shannon-Wiener index, Margalef index and Simpson's index) were differ within all selected homegardens. There were total 38 homegardens from 5 years to 58 years include with all three diversity indexes value (Figure 5, 6, and 7). The regression values within all three diversity indexes were differ such as, 0.01 in Shannon-Wiener index, 0.08 in Margalef index and 0.03 in Simpson's index. However, in Shannon-wiener and Margalef index, with an increasing in age of homegardens there were decrease in biodiversity within selected homegardens (for more details see figure 5 and figure 6). Additionally, with regards to relationship between Simpson's diversity index and age of homegardens, there was no any relation found between two variables (Figure 7).

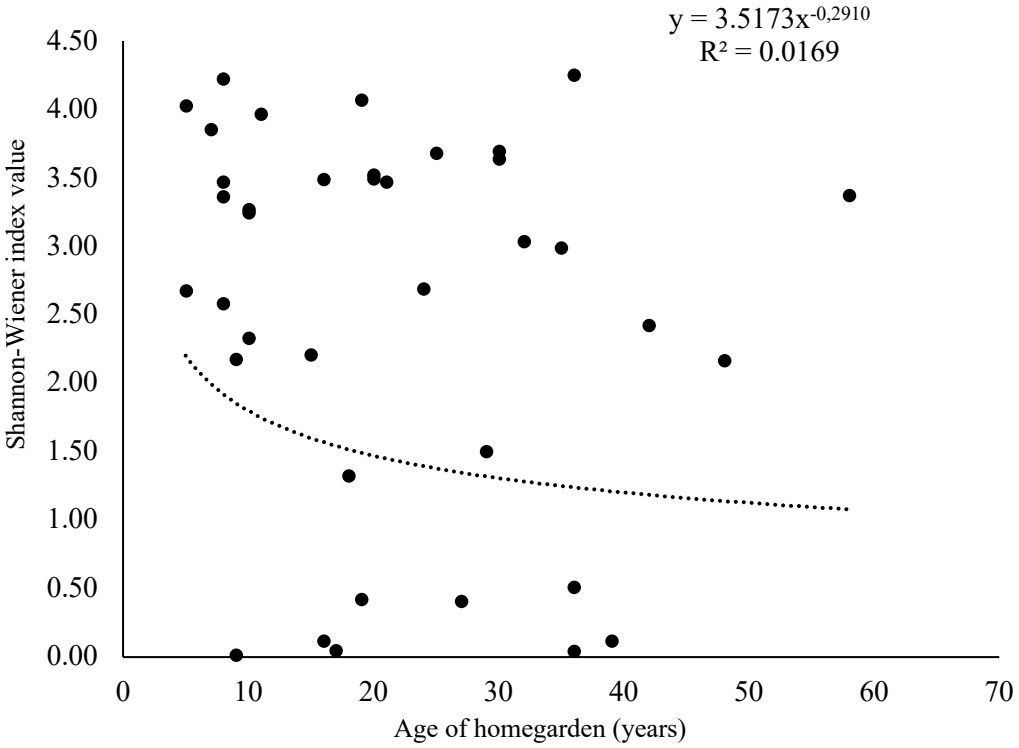


Figure 6. Effect of homegarden age on usefull species diversity (Shannon-Wiener index value).

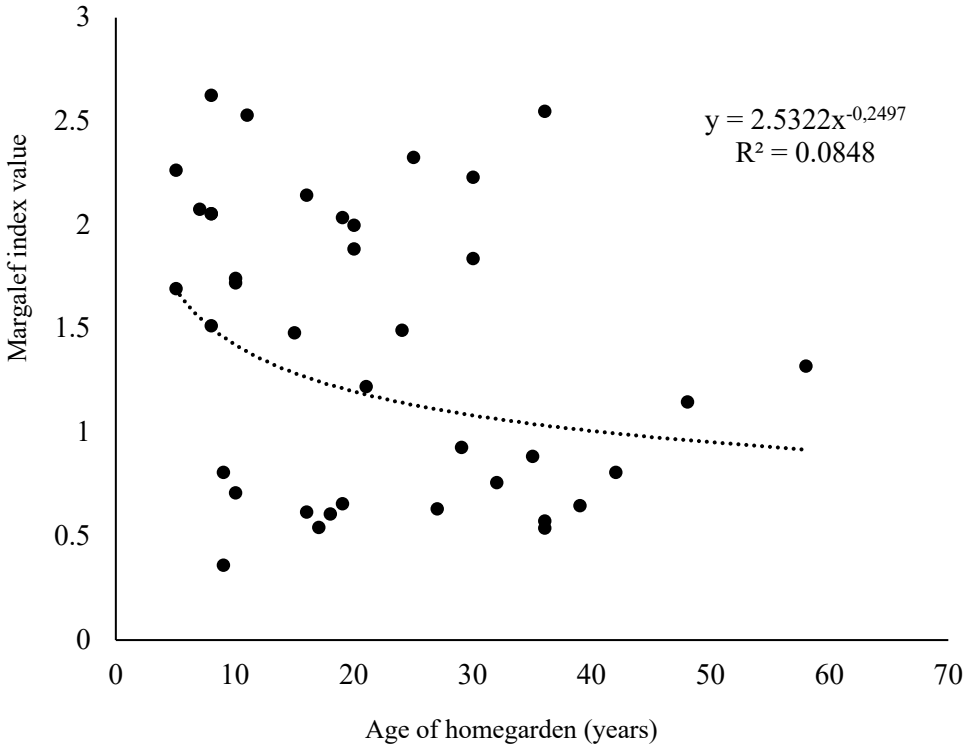


Figure 7. Effect of homegarden age on usefull species diversity (Margalef index value).

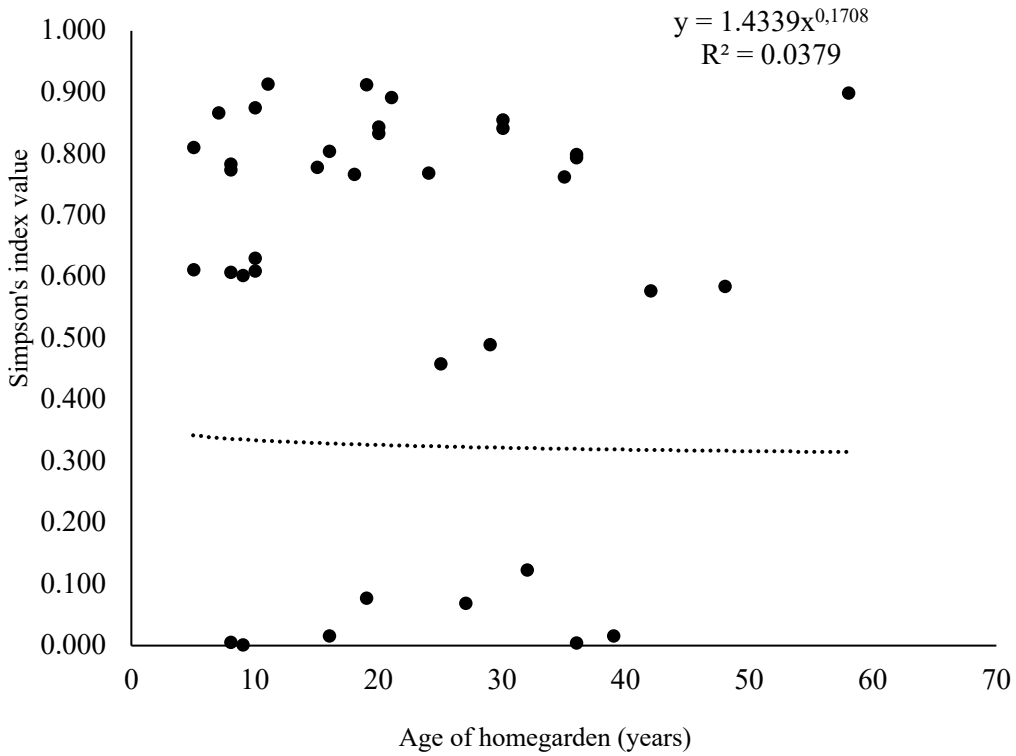


Figure 8. Effect of homegarden age on usefull species diversity (Simpson's index value).

5.7 Associations between household head farming experience and useful species diversity

The household farming experience were differed from 5 years to 42 years. The relationship between household head farming experience and plant species diversity were differ between all three diversity indexes such as regression value 0.02 in Shannon-Wiener diversity index, 0.09 in Margalef diversity index and 0.00 in Simpson's diversity index. As per values in Shannon-Wiener and Margalef diversity indexes, there were decrease of species diversity with the increase in household head farming experience. On the other hand, according to figure 10, Simpson's diversity index values and household head farming experience had no positive or negative effect on plant species richness and evenness.

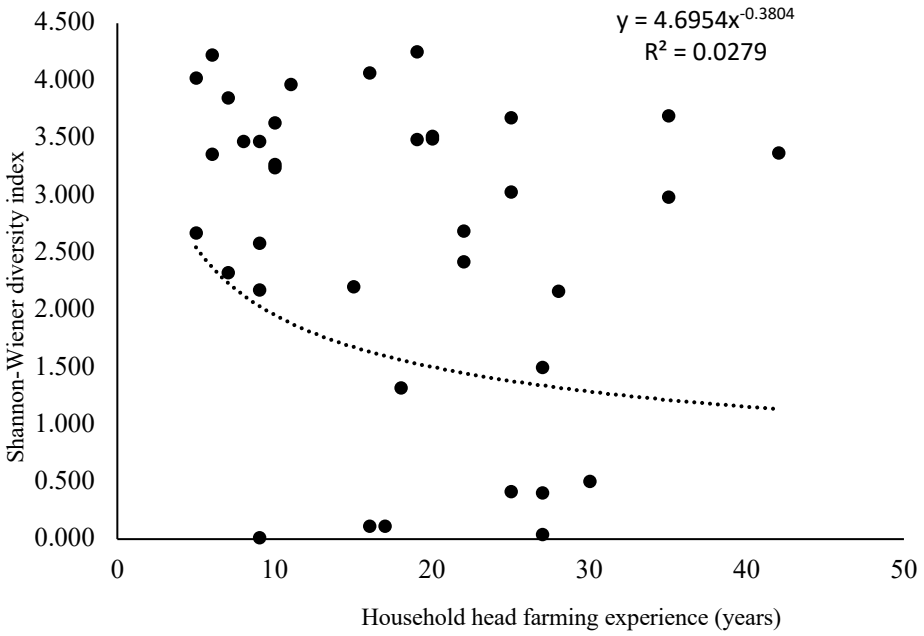


Figure 9. Effect of household head farming experience on useful species diversity (Shannon-Wiener index value).

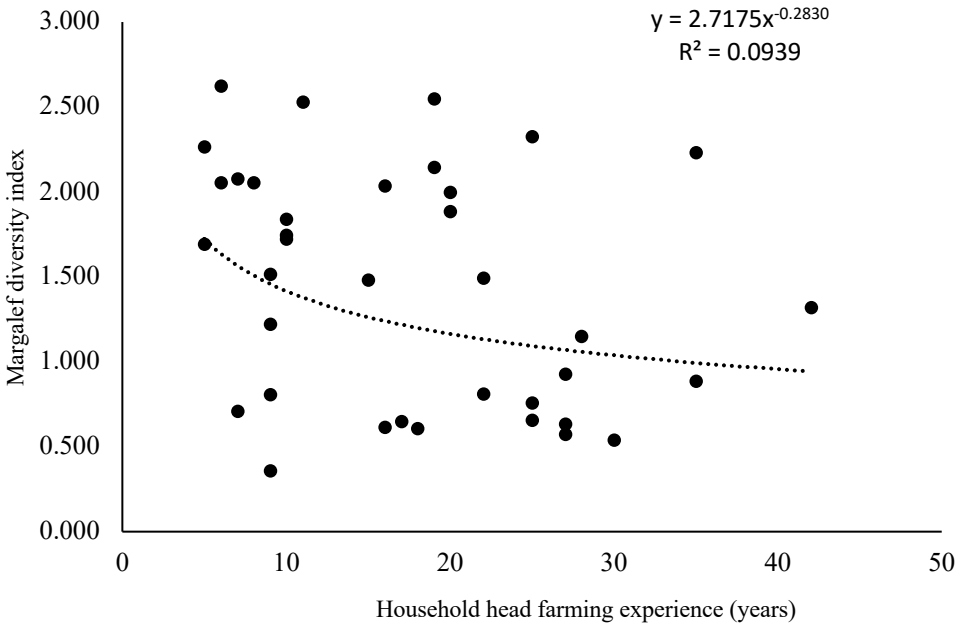


Figure 10. Effect of household head farming experience on useful species diversity (Margalef index value).

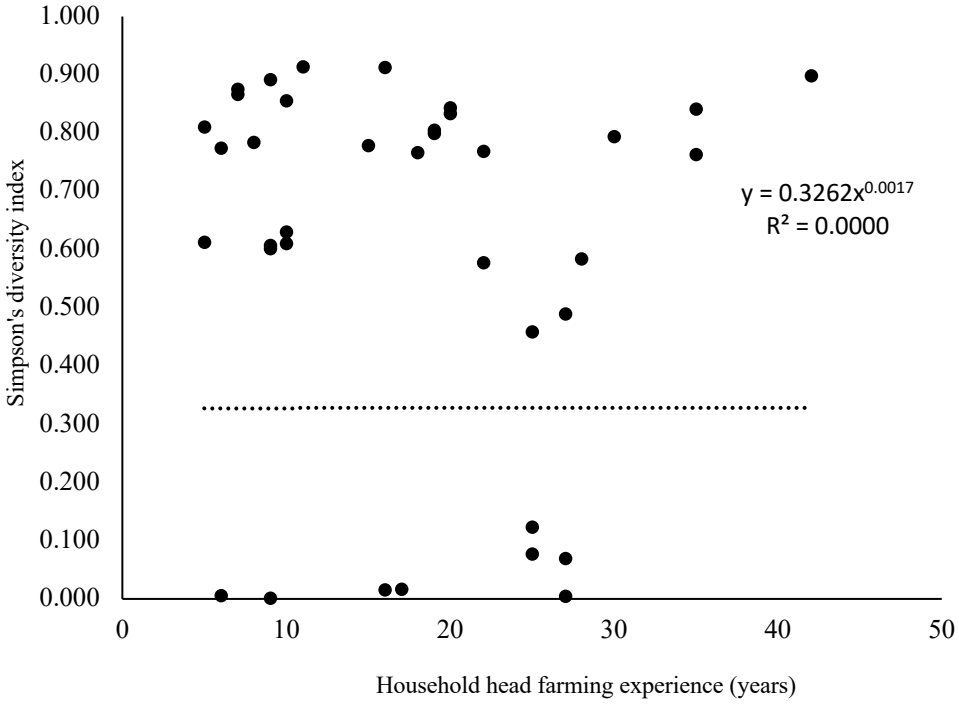


Figure 11. Effect of household head farming experience on useful species diversity (Simpson's index value)

6. Discussion

Homegardens are supplying better social and ecological situation for higher production and preservation of biodiversity, which leads to Darwinism of plant genetic resources (Agbogidi & Adolor 2013). According to the previous study, the researcher had claimed that the mean numbers of plant species were not varied remarkably within both types of homegardens (commercial and non-commercial). Additionally, many plant species were identified in both types of homegardens and the floristic structure of commercial homegardens was distinguished by rising just the number of cash crop species with dropping biodiversity index (Abdoellah et al. 2006). After data examine or analysed from selected homegardens, we did find many species that were identified in both types of homegardens, but we did not find some of cash crop species from commercial homegardens to non-commercial homegardens. Also derived from our data, we found that out of 3 various diversity indexes (Shannon-wiener, Margalef, and Simpson diversity index) there were two types of diversity indexes in which non-commercial homegardens has better plant species richness and evenness compare to commercial homegardens. According to Sabastian et al. (2014), the farming experience of the gardener or household head and household size had an impact on homegarden structure. However, from our data, we did not find any effect of household size on homegarden structure, but high literacy rate within household and gardener or household head farming experience did effect homegarden structure and plant species richness and evenness. Oppositely, according to Tesfaye Abebe (2005), education, age, and gender of the gardener or household heads does not have any impact on plant species richness and evenness in the homegardens. This can be possible because of absence in variations such as in-household education, age, and gender within household heads. From our selected homegardens, the household characteristics had an impact on the homegarden structure. This can be because of with more farming experience and age of household head, there were less richness and evenness in plant species with better homegardens structure.

In the homegardens, species richness and evenness have positive connections with the financial condition within the household. As per Kabir & Webb (2009), in the plant richness and evenness (biodiversity) of homegarden, there has been always influenced by household financial condition and pattern. Additionally, as per Tesfaye Abebe (2005),

plant species richness, evenness, and household income has positive connection such as with better financial household condition presumed to cultivate more plant species then poor financial household condition. Also, gardeners or household heads with the larger sizes of land, income, and supplementary labour force from their households can sustain more plant species in the homegardens. After analysing our data, we can say that with the increase in land size, income and supplementary labour force, there were higher plant species richness and evenness, but on the other hand, it can be depends on the type of homegardens (Commercial and non-commercial homegardens). According to the researcher, with other sources of household income, there were negative effects on homegardens. Additionally, the source of income rather than homegarden and agriculture activities there were negative effects which were leads to reduced income from homegardens (Kabir et al. 2016). During our data collection as per respondents, with increased other sources of income rather than agriculture activities, there were less cultivated plant species compare to past within homegardens.

According to Wiersum (1982), There was a lack of connection between plant species in homegarden and homegarden size. For our study area, plant species richness and evenness in homegarden decrease with the increased homegarden size. As per respondents during data collection, in larger sized homegarden, there were more cash crops compare to smaller homegarden size which could affect plant species richness and evenness. According to Kabir & Webb (2009), Household head or gardener allot a substantial amount of homegarden size towards cash crops which leads to low species richness and evenness. Oppositely, commercial and subsistence homegardens normally encountered low plant species richness and evenness regards to homegarden size. This is right in our study, because in commercial and subsistence homegardens where gardeners or household heads make a deliberate attempt to increase the cash crop species within their homegarden to increase their income with respect to the market requirements. According to researchers, with the availability of labour from their household or hired leaning on household size and homegarden land size, there is a positive effect on plant species richness and evenness (Méndez et al. 2001). From our research, we have discovered that input from labour force has different outcomes as per homegarden type. The commercial homegardens had a positive effect from labour input which was connected with higher income possibility and more cash crop species. Additionally, in the non-commercial

homegardens, there was a positive outcome from labour input which was resulted in better plane species richness and evenness. According to Abdoellah et al. (2006), availability of the market from homegarden has an impact on plant species richness and evenness as per household head or gardener's aspiration or objectives from their homegardens. As per respondents from our research, they did mention about the importance of market availability but as per the type of homegardens. Additionally, commercial types of homegardens were positively influenced by market availability which was resulted mainly in more income and more cash crop cultivation. Oppositely, in the non-commercial homegardens, there was not much influence from market availability.

Commercial homegarden has authorized households to expand their source of income, on the other hand, from commercial homegarden there has been also a negative effect on less plant species diversity (Kabir et al. 2016). From our research, there were also some commercial homegardens with a high amount of plant species richness and evenness, because of the gardener or household head were interested also to cultivate few species for their own household consumption. The structure of homegardens can be affected by socio-economic, ecological, and physical conditions (Abdoellah et al. 2006). However, from our study, we discovered that with the same ecological, physical, and socio-economic conditions there was not the same structure within types of homegardens. Additionally, such as in commercial homegarden had different vegetation structure then non-commercial homegardens. According to Sunwar et al. (2006), earnings from commercial homegardens were tended to be used for their own consumption and various rituals. From our study area, respondents were reported that income generated from their homegardens were used for various things such as for buying fertilizer, plant seeds, instruments for gardening, items for households and also for their own consumption within household. According to Kumar & Nair (2006), particularly with the commercialization of homegarden, there were reduced cultured values such as various plant species which were allocated before for neighbour and other households now reduced. However, within selected all 38 homegardens, there were no issues were reported which were connected to reduction of cultural value. On the other hand, there were some species which were cultivated before for own utilization and distributed within communities are now reduced because of land utilization for especially cash crop species.

7. Conclusions

This study describes useful plant species available with English and scientific names in homegardens, homegarden characteristics, household characteristics, and analyse relations between species diversity and main homegarden and household characteristics. A study area located in the western region of India called Gujarat. A total number of 50 various plant species reported in total 38 homegardens with part (species) of use and purpose of use. Homegardens were categorized as a commercial and non-commercial as per plant species utilization. We used a total of three diversity indexes to find biodiversity values within selected homegardens such as Shannon-Wiener, Margalef, and Simpson's diversity index. With the increase in homegarden size, there was a decrease in species diversity. Also, we found that with increase of homegarden age, there was a decrease in species richness and evenness. However, we did not find any relation between household head farming experience with species diversity. As per respondents, there was a positive impact with availability of livestock within homegardens because of more benefits such as dairy products, eggs, optional sources of income, and other purposes. There was better diversity results in smaller size non-commercial homegardens then larger commercial homegardens. Additionally, commercial homegardens were reported with larger size and fewer plant species and also lesser diversity compared to non-commercial homegardens. In the surveyed non-commercial homegardens, there were more local species compared to commercial homegardens in which gardeners concentrate more on cash crop plant species. Lastly, we can see that from homegarden there are lots of benefits with regards to biodiversity preservation, agriculture production as well as socio-economical.

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7. Annex

Annex 1. Questionnaire for homegarden species and household and homegarden characteristics Gujarat state (western region of INDIA)

1. farmer/gardener/owner –

2. date of birth-

3. village/City/region-

4. household members information-

Table 1 Household characteristics

HH member (Number)	Gender	Age (Years)	Years of schooling (years) or Finished education	Living in HH permanently (yes=1)	If yes, working on farm (yes=1)	Farm experience (years)	If yes, working in household (yes=1)	If yes, having off-farm job (yes=1)	If yes, working on home-garden (yes=1)	Gardening experience (years)	Gardening experience (from whom he/she learn?)

Note: Use "*" to indicate household head. Indicate "**" to indicate responsible person for homegarden.

Table 2 Household capital resources (livestock)

Type	Heads count	Reason to have
		□ draft animal, □ working animal, □ dung, □ milk, □ meat, □ eggs, □ young animals, □ services (ploughing for other farmers, breeding etc.)

Table 3 Household land resources

Type	Size (ha)	Ownership (rented, inherited, purchased, govt or project, not clear ownership)	Market (yes or percentage)
Farm			
Plantation			
Lake/pond			
Forest			
Garden			

Table 4 Homegarden characteristics and commercialization

Species (Name)	Who decided to grow?	Number of individuals	Part of use	Purpose of use	Selling (yes/no), if yes (%)	Local market (if yes, % and price)	Would like to grow more (+,++), same (=) or less (-,- -) in the future?

Note:

Part of use: find in the literature, but usually leaf, stem, root etc.
Purpose of use: again literature, but let the farmer tell you, what we will classify …market is not a purpose!!!!! Food, Drink, Medicine, Construction …one product/species may have more mode of uses.
Future production …+ more ++ much more, - less, - - much less

5 Final questions

1. Do your household receive any remittances (money transfers from relatives)?

2. Are you growing now more or less species compare to the past?

4. Any other source of income except gardening?

5. Main source of income?