Chapter 4

Critical Comparison of Homegardens of Two Far End Humid Tropic Corners of India: Kerala and Northern Part of West Bengal

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Abstract: Homegardens are crucial for providing a sustainable food supply and are widely recognized worldwide through location-specific species documentation studies and functional diversity assessments. With the incorporation of trees, homegardens further ensure carbon sequestration, efficient nutrient cycling and stability in economic returns. Despite the importance of homegardens, their value assessment in different areas as comparative analysis is scanty and studying which will showcase the potential and adaptiveness of homegardens in the locations and reveals the research gaps. Therefore, the book chapter critically compares homegardens of two humid tropical regions of India, Kerala and the Northern part of West Bengal, located respectively in two biodiversity hotspots, the Western Ghats and Indo-Burman hotspots. Kerala and North Bengal are famous for their high diversity homegardens with multi-storeyed compositions and are accepted by the indigenous communities for their sustenance. However, there are variations in the study pattern and utilization preferences among the homegardens of these two regions. In addition, structural and functional diversity with the carbon sequestration potential of homegardens is discussed with special reference to Kerala and North Bengal in this chapter.

Keywords: Homegardens, Kerala, West Bengal; Functional diversity; Structure; Function

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1. Introduction

Agroforestry systems and practices are recognized globally for their sociocultural, ecological and economic benefits. Agroforestry is a land use system that integrates multiple components of trees, shrubs, herbs, food crops and/or livestock, arranged spatially and temporally in a piece of land (Nair et al., 2021). Homegardens are one of the oldest traditional agroforestry systems, especially in humid tropical regions of the world (Fernandes and Nair, 1986). It is practised mainly among the ethnic indigenous people, primarily for subsistence and sustainable food production (Rajagopal et al., 2021). Nowadays, homegardens are also popular in urban and peri-urban areas due to their significance and aesthetic value. Homegardens are famous for their diverse functions in enhancing biodiversity, ensuring food and nutritional security and sequestering carbon (Subba et al., 2018).

In English, homegardens are synonymous with backyard gardens, household farms, urban food gardens, dooryard gardens, homestead farms, home food gardens, village forest gardens, compound farms, kitchen gardens, domestic food gardens and mixed gardens (Taylor and Lovell, 2014). Furthermore, several local names attained international popularity, such as Chagga and Shamba in East Africa, Huertos Familiares in Central America and Pekarangan and Talunkebun in Java, Indonesia (Nair, 1993, Kumar and Nair, 2004). The multi-layered vertical stratification combined with species and functional diversity gives homegardens the face of a natural forest (Shimrah et al., 2018). Species richness leads to several utilization categories in homegardens such as food, fodder, fuelwood, timber, green manure, medicine and other non-timber forest products that diversify the livelihood options (Salam et al., 2000, Unofia et al., 2012, Hemore and Lemage, 2019). Successively, it helps in generating income and protecting the soil from erosion and fertility

loss. In addition, nitrogen-fixing trees in homegardens enrich soils for better growth of neighbouring annual and perennial crops. Diverse crops and trees with various root forms utilize nutrients efficiently from multiple soil horizons and regulate the nutrient cycle (Verchot et al., 2007). Moreover, homegardens make the agroecosystems resilient to the effects of climate change. Economically, in opposition to the intensive crop loss in monoculture during unexpected disease outbreaks, homegardens secure the income through diversifying the production (Fernandes and Nair, 1990, Sahoo, 2009).

Homegardens occupy the space surrounding the homesteads, and household owners manage them by ensuring their multi-storied structural integrity and intimacy between several components: trees, crops and animals (Kumar and Nair, 2006). Usually, there are three distinct vertical layers in homegardens: lower herbaceous layer, intermediate shrubby layer and upper tree layer (Kafale, 2020). The most demarcating function of the homegardens is providing nourishment through food plants: fruits, vegetables, tubers, rhizomes and leaves (Yinebeb et al., 2022). Moreover, homegardens are storehouses of plants with therapeutic values (Milow et al., 2013).

Homegardens are crucial for livelihood and culture because of their permanency and stability (Linger, 2014). Hence, species selection primarily depends on people's preferences, and species composition is distinct among various location-specific homegardens. Species are mainly selected based on their utilitarian value, followed by ecological and social significance (Kumar and Nair, 2004). Traditional and orally transmitted knowledge often enables the farmer to determine the species and its growth pattern in space and time (Kafale, 2020). Hence, the chapter reviews the homegardens of two far-end locations: Kerala, located in the Western Ghats hotspot region with a rich tradition in homegardens, and the Northern part of West

Bengal (North Bengal), an area with emerging studies on the high diversity of homegardens and are part of eastern Himalayas of Indo-Burman hotspots. Homegarden studies are mandatory to understand the significance, traditional use and need for the conservation of flora combined with their ecological value. Moreover, the review works and comparison will further showcase the potential and scope of such systems that are still unexplored. According to the review by Sharma et al. (2022), homegardens are a vital strategy for achieving sustainable development goals. Most of the reviewed publications in their study highlight the potential of home gardens in achieving the zero-hunger goal (SDG 2), followed by the life on earth goal (SDG 15).

Several studies explored the unique and complex homegardens worldwide to identify the structural and functional dynamics of such energy-intensive, low input (Das and Das, 2005) and high output systems. Based on farming practices and livelihood approaches, the homegarden composition and structure vary (Wiersum, 2006). Hence, the change in rural setup and farming system gradually alter the functions and structure of homegardens in various locations and subsequently make such systems unique.

2. History of Homegardens

Homegardens developed and changed gradually by incorporating desirable crops even during the shortage of lands and steady increase in population. Presumably, homegardens, an ancient practice of agriculture, originated in Southeast Asia around 13000 to 9000 BC with fishing communities in the tropics who settled in river basins due to assurance of fish supply and fertile soil (Sauer, 1969). In other regions, the idea of homegardens may have emerged from the sprouting of plants discarded by hunter-gatherers near their camps. Hence, homegardening practice dates back to settled agriculture, where people

planted desirable species near their houses to ensure better accessibility and continuous supply.

Ramayana and Mahabharata represent the events during 7000 BC and 4000 BC, respectively, illustrating the earliest record of homegardens as Ashok Vatika (Puri and Nair, 2004). As per Hutterer (1984), Javanese homegardens evolved in the seventh millennium BC whereas Kerala homegardens are around 4000 years old. According to Michon (1983), the Javan tree gardening system has been practised since AD 10th century; Randhawa (1980) states that travellers in the early 14th century documented several species from Kerala homegardens: *Piper nigrum, Zingiber officinale* and *Cocos nucifera.*

With this time-tested historical background, homegardens reflect the tradition and culture of the society. Nevertheless, such systems also adapt and transform dynamically over time. Hence, farmers gained wisdom through the changes over centuries to practise and manage homegardens scientifically. However, homegardens are changing from subsistence-oriented to external input dominated systems due to the commercialization of products for better market value, fragmentation of the land and urbanization of rural areas. These causes may adversely affect the existence of homegardens further.

By knowing the economic and social roles of homegardens, researchers started studying them, the earliest one dating back to the 1940s in Indonesia (Terra, 1953, 1958). Subsequently, Nair (1979) and Central Plantation Crops Research Institute researched homegardens of Kerala and Ruthenberg (1980) studied tropical mixed-species cropping systems. International Centre for Research in Agroforestry (ICRAF) augmented the research further by analyzing global agroforestry

systems (Nair, 1987). Studies incorporated new technologies and research findings to expand its scale from species documentation to quantification of ecological functions.

3. Distribution of Homegardens

Despite their origin, homegardens are widely distributed in almost all tropical and sub-tropical ecozones. Homegardens are reported mainly from Southeast Asia, South Asia, Africa, tropical and subtropical China, Central America, the Mediterranean region of Catalonia, the Caribbean and the Pacific Islands (Kumar and Nair, 2004, Nair and Kumar, 2006, Thaman et al., 2006, Marambe et al., 2018, Fitriani and Yuliana, 2021). Within southeast and south Asia, homegardens are well-studied in countries such as Indonesia, Thailand, Bangladesh, Sri Lanka, Philippines, Nepal and India (Wiersum, 2006).

In India, homegardens studies are primarily concentrated in high rainfall areas with a humid climate, such as Kerala, West Bengal, North-Eastern states (Assam, Meghalaya, Mizoram, Arunachal Pradesh, Tripura), Uttarakhand, some parts of Karnataka, Andaman and Nicobar Islands and Tamil Nadu (Kumar, 2003, Das and Das, 2005, Pandey et al., 2007, Panwar and Chakravarty, 2010, Tynsong and Tiwari, 2010, Saikia et al., 2012, Bhat et al., 2014, Debbarma et al., 2016, Rana et al., 2016, Tangjang and Nair, 2016, Shanmugam et al., 2020, Singh and Sahoo, 2021). Homegardens are distinct in each location with characteristic diversity in species, function and structure.

3.1. Kerala Homegardens

From time immemorial, Kerala state is well known for its traditional homegardens (Kunhamu et al., 2015). Compared to many tropical homegardens, species

diversity and abundance are high in the homegardens of Kerala despite their size (Kumar and Nair, 2004). Kumar (2011) reported 473 floral species from 839 homegardens from three districts of Kerala: Thrissur, Palakkad and Malappuram. Homegardens in Kerala were assessed for species diversity (Kumar et al., 1994), nutritive value (Chandrashekara, 2015), structure (George and Christopher, 2020), function (Niyas et al., 2016), dynamics (Peyre et al., 2006a), socioeconomic value (Mohan et al., 2006), biomass and carbon stock (Kumar, 2011, Unnithan et al., 2017).

In 1993, Jose and Shanmugaratnam (1993) reported that homegardens occupied around 88% of the total land hold area and 41% of the arable land in Kerala. According to Peyre et al. (2006b), Kerala homegardens still possess the indigenous nature in 50% of surveyed homegardens. But, the recent studies concern the changeovers that adversely affect the homegarden tradition due to population pressure, land use change and urbanization (Ajeesh et al., 2015, Kunhamu et al., 2015).

3.2. Homegardens in the Northern Part of West Bengal

Subba et al. (2017a) described the homegardens of the Northern part of West Bengal as one of the most diverse and dense in the world by its species richness, diversity, density and basal area. Homegardens of this region has the same potential as those in other humid areas; on account of rich biodiversity, tribal dominance and high rainfall (Panwar and Chakravarty, 2010). Homegardens in this region are dominant with timber trees, vegetables, fruit trees, and ornamental and medicinal plants (Subba et al., 2018). The studies in the North Bengal region mainly pertain to districts Cooch Behar, Jalpaiguri, Alipurduar and Darjeeling. Even though the studies started recently, there is an immense advance in homegarden research in this region that include species

diversity (Sarkar et al. 2020), ethnobotany (Roy et al., 2022), social and economic value (Subba et al., 2017b), fuelwood consumption (Roy et al., 2021) and carbon stock (Pala et al., 2020).

4. Importance of Homegardens

In the era of climate change, environmental disasters and biodiversity loss, homegardens are a local-level measure to sustain life on earth that benefits both people and nature (Nair, 2012). Homegardens are adaptable to various localities with little effort on management, irrespective of the altitude, terrain, land size and topography. The reviews by researchers such as Kumar and Nair (2004), Galhena et al. (2013) and Abdoellah et al. (2020) provide insights by summarising the studies related to homegardens.

Homegardens are self-sustaining agroecosystems with two vital functions: producing multiple products for household consumption and conserving biodiversity for ecosystem balance (Bargali et al., 2019, Vibhuti et al., 2019). For house owners, homegardens do not merely reflect the cultural status but rather showcase resilience, integrity, sustenance and financial stability (Vibhuti et al., 2019). Furthermore, they help to reduce the chances of plant genetic erosion by ensuring the continuous growth and use of desired species (Kafale, 2020).

Homegardens are species-rich agroecosystems. Species richness correlated positively with income, according to the study by Schadegan et al. (2013). Hence, multi-layered homegardens with diverse species significantly contribute to household income and stability. The comparative analysis by Linger (2014) reported the superiority of homegardens over non-tree-based gardens in several factors such as income generation, social status and ecological service. Figure 1 shows the prominence of

homegardens over the conventional agricultural practice in terms of stratification, diversity and sustainability, and they are comparable with the forests.

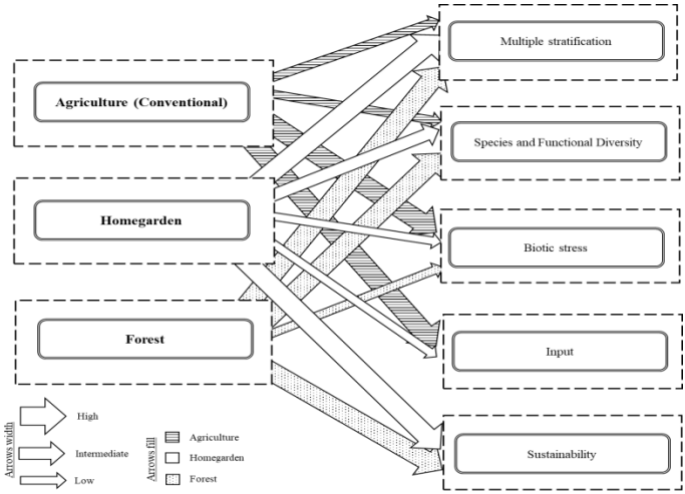

Figure 1. Comparison between conventional agriculture, homegarden and forestry (Modified from Kumar and Nair, 2004)

5. Structure of Homegardens

Homegardens are complex systems with multiple species having different habits and cropping patterns. Therefore, the horizontal or vertical stratification assigns a particular position to the species in homegardens to perish well in their niche (Nair and Sreedharan, 1986). Horizontally, floral components are placed according to the homegarden size, culture, management practices, terrain and distance from the house (Soemarwoto et al., 1985, Zemede and Ayele, 1995, Mendez et al., 2001). The regular trend observed is keeping food and fruit trees in areas that assure easy accessibility (Kumar and Nair, 2004).

Vertical strata in homegarden vary from three to six (Fernandes and Nair, 1986, Kumar et al., 1994, Kafale, 2020), with upper to lower strata in the order of large timber trees, palms, fruit trees, shrubs, crops, herbs and creepers. With the available resources, plants adapt to their particular microclimate according to their light demand. Livestock is also part of the typical homegarden ecosystem. People used to grow cattle and hens, but nowadays, they pertain to rural families (Soemarwoto et al., 1985). The age of the homegarden is another deterministic factor for change in structure; layers and canopies become more distinct and prominent with age (Kumar and Nair, 2004). The configuration of homegarden changes with the management intensity. Heavily managed homegardens with frequent ploughing and litter removal disturb the lower strata (Karyono, 1990, Hochegger, 1998) and change the structure.

6.1. Structure of Kerala Homegardens

Kerala Homegardens are stratified vertically and horizontally and ensure adequate penetration of light and relative humidity to the understorey vegetation (Chandrashekara and Baiju, 2010). In Kerala homegardens, coconut palms act as the architectural frame in the three to four layered multi canopy strata: up to 2 m (herbs, vegetables, grasses and tubers), 2-10 m (fruit trees and banana) and 10-25 m (palms and timber trees) (Jose and Shanmugaratnam 1993). According to Peyre et al. (2006a), old mixed species homegardens that represent typical traditional homegardens are observed with high shrub and herb density and maintained more diversity. The small homegardens are denser than large homegardens since the owners mix multiple strata in close spacing. In addition to the vertical layers, litter layers have a predominant role in the ecological benefits: preventing soil erosion, increasing soil water holding capacity and improving soil structure.

The horizontal structure of Kerala homegardens is determined by the spacing of various vegetation components, particularly coconut (spacing 7.5 × 7.5 m). Even though the plants are arranged haphazardly, each has a particular location according to the household owner's preference. Jose and Shanmugaratnam (1993) described the deliberately placed arecanut, cocoa plants in the middle of four coconut palms, taller trees in borders, trailers on supporting trees, fruit trees and ornamentals near courtyards and shade tolerant plants in available places.

6.2. Structure of North Bengal Homegardens

The complexity of the vertical and horizontal arrangement of components in the Homegardens of the Terai region of West Bengal was documented by Panwar and Chakravarty (2010). Three to five vertical strata are present in the homegardens of North Bengal: dominant (tall trees), codominant (palms), dominated (fruit trees), understorey (vegetables) and herbaceous layers. Moreover, within homegardens, plants are distributed horizontally in three management zones- the outer zone with boundary trees, the inner zone with fruit trees and the innermost zone of vegetables for easy accessibility. On the other hand, homegardens in Darjeeling are much smaller than homegardens in terai. Sarkar et al. (2020) documented five vertical strata in the homegardens of Darjeeling in low, mid and high altitudes: < 2, 2-5, 5-10, 10-18, 18-26 m. Among the strata, species richness was very high in the lower stratum.

7. Species Diversity in Homegardens

Homegardens are recognised widely for their species richness and composition over all other characteristics. The diversity of homegarden in a particular region is unique, and even two nearby homegardens are

heterogeneous while considering the species dominance and richness. Most homegarden studies predominantly document species diversity through diversity indices followed by ecological significance. The multi-layered structure accommodates more species in homegardens than other agroforestry systems (Minale and Wondie, 2021). Moreover, homegardens are biodiverse agricultural ecosystems that preserve several desirable species, including endemic, rare and endangered (Kumar and Nair, 2004). Hence, they are an ex-situ conservation strategy for protecting biodiversity.

The diversity of species depends on the size and structure of homegardens. Some studies reported considerably high species diversity in small homegardens by managing them better to use the space maximum (Kumar et al., 1994, Kumar and Nair, 2004). However, some other studies reported rich diversity in large homegardens because of the extensive availability of space (Ajeesh et al., 2015). Vibhuti et al. (2019) reported high herb density in small homegardens and high tree density in large homegardens and observed a positive correlation between homegarden size and species frequency. Patel et al. (2022) studied homegardens with three disturbance levels (high, medium and low) and observed the high species richness in the lower disturbance homegardens.

Kumar et al. (1994) describe that the homegarden and neighbouring forest plant diversities are comparable. The species that are cultivated in homegardens are according to the need (Christanty et al., 1986, Vogl et al., 2002), although they are the species that may suffer overexploitation in future if not managed well. Homegardens also provide habitats for diverse species other than plants (Bardhan et al., 2012, Eyasu et al., 2020) and enhance land biodiversity more than the surrounding agricultural systems (Gebrehiwot, 2013).

7.1. Diversity in Homegardens of Kerala and North Bengal

Several studies documenting species richness and diversity were carried out in various locations in Kerala (Table 1). Nair and Sreedharan (1986), Kumar et al. (1994), Chandrashekara and Baiju (2010), Kumar (2011) and Kunhamu et al. (2015) documented species richness from homegardens that were 30, 127, 185, 463 and 95, respectively, in number.

Table 1. Number of species reported in the homegarden studies of Kerala and North Bengal

State	Location	SR	References
Kerala	Thrissur, Palakkad, Malappuram	463	Kumar, 2011
	Malappuram	185	Chandrashekara and Baiju, 2010
	Palakkad	182	George and Christopher, 2020
	Thrissur	163	Unnithan et al., 2017
	Palakkad	133	Peyre et al., 2006$_a$
	Kerala	127	Kumar et al., 1994
	Thrissur and Malappuram	127	Niyas et al., 2016
	Wayanad	101	Chandrashekara, 2009
	Palakkad	97	Chandrashekara and Thasini, 2016
	Palakkad, Ernakulam, Thrissur, Malappuram	95	Chandrashekara et al., 1997
	Thiruvananthapuram	95	Ajeesh et al., 2015
	Idukki	66	Padmakumar et al., 2021
	Thiruvananthapuram	27	Chandrashekara, 2015
	Thrissur	23	Vijayan and Gopakumar, 2015
North Bengal	Kalimpong and Darjeeling	260	Sarkar et al., 2020
	Jalpaiguri, Cooch Behar, Darjeeling	142	Subba et al., 2016
	Cooch Behar, Jalpaiguri	74	Panwar and Chakravarty, 2010
	Jalpaiguri	67	Roy et al., 2022
	Cooch Behar, Jalpaiguri	65	Chatterjee et al., 2016
	Alipurduar	63	Giri, 2021
	Cooch Behar	53	Pala et al., 2019$_a$
	Jalpaiguri	41	Roy et al., 2021

SR: Species Richness

The complex nature of homegardens, along with different growing habits and functional categories, diversify such systems even further. Ajeesh et al. (2015) reported 95 species where coconuts were predominant, followed by *Mangifera indica, Psidium guajava, Tectona grandis, Artocarpus heterophyllus* and *Ailanthus triphysa.* In North Bengal, the study by Subba et al. (2018) showed the maximum species richness of a homegarden as 42, where the average homegarden size is 0.51 ha. The most common species of homegardens in these regions is *Areca catechu*. Another prominent feature of diversity in the North Bengal region is the incorporation of livestock. Subba et al. (2018) observed the animals (pig, goat, cow, hens, fish and duck) in 60% of the surveyed homegardens.

8. Function of Homegarden

Homegardens are multifunctional and meet different needs of people without compromising on ecological benefits. They provide timber, fodder, fuel, food (vegetables, spices, cereals, and fruits), manure and medicines (Kefale 2020). Besides, homegardens regulate microclimate, nutrient cycling, carbon sequestration and soil and water quality. Homegardens are one of the vital contributors to income in rural areas. Numerous studies analyzed the economic benefits of homegardens at the household level, predominantly through generating income and employment. Linger (2014) studied the homegardens and non-tree-based gardens of the Jabithenan district to understand the social and economic status and proved the significantly high contribution of homegardens in improving farmer's cash income. Homegardens are the quintessence of economic, ecological and social sustainability (Wiersum 2006). The study by Kabir and Webb (2009) reported the median annual income per household as US$ 832, of which homegardens contribute 6%. On the other hand, Javanese homegardens contribute an average of 21.1% to net family income and Kandyan homegardens 30-50 %

(Mohri et al., 2013). Calvet-Mir et al. (2012) identified and documented ecosystem functions and services from the homegardens of North Eastern Spain and showed that homegardens play a significant role, not only in provisional and regulatory services but also in supporting and cultural services. Culturally, homegardens provide spiritual enrichment from integrated plants with religious value and ensure aesthetic pleasure from the ornamental plants. Crucial functions of homegardens are represented in Figure 2.

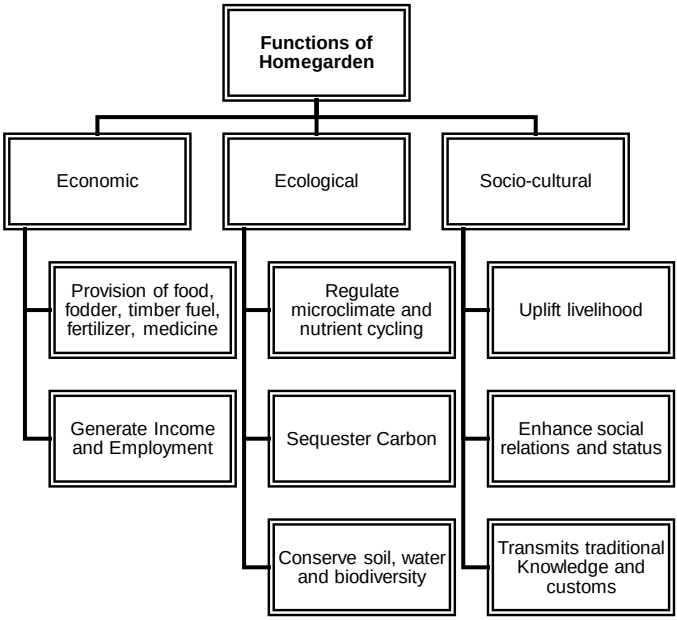

Figure 2. Main functions of homegardens (Modified from Castañeda-Navarrete 2021)

8.1. Functional Diversity in Homegardens of Kerala

Homegardens of Kerala provides multiple benefits, in which researchers evaluated economically important

provisional services more. Peyre et al. (2006b) identified different use categories such as fruits, spices, and nuts, timber, religious, multipurpose and medicinal and showed that each homegarden is unique in terms of function. From 25 homegardens in Kerala, Chandrashekara (2009) reported 101 fruit trees, with 46 of them purposefully cultivated by the owner. Chandrashekra and Thasini (2016) explored the 97 non-crop species in the homegardens of Kerala, which provide nutritious food and medicine and lead to economic welfare. The utilization of homegardens varies with the individuals, location, communities and culture. Niyas et al. (2016) compared the functional attributes of peri-urban and urban homegardens of Kerala. They documented the three use classes (fruits, medicinal plants and timber) from the peri-urban area and two (fruits and ornamental plants) from the urban area. In addition, the size of homegardens and species composition influences the utilization categories.

In Attappady, a tribal settlement area in Kerala, a study was conducted by George and Christopher (2020) to showcase the influence of traditional knowledge in homegarden maintenance. Within the 182 surveyed species, 25% were medicinal, 39% food and 24% ornamental. The study assures the role of tribal homegardens in contributing to livelihood and food security. Homegardens also help to enhance cultural values by empowering women, maintaining good health, conserving traditional knowledge and encouraging equity sharing and justice (Jaslam et al., 2017).

8.2. Functional Diversity of North Bengal Homegardens

Homegardens in the North Bengal region are diverse and rich with traditional knowledge on the use of plants. Subba et al. (2015) reported multiple utilization classes from homegardens such as food, ornamental,

timber, domestic energy and multipurpose species. However, people depend on the homegardens of North Bengal mainly for medicinal and food purposes (Chattarjee et al., 2016). Pala et al. (2019a), in their study from North Bengal homegardens, reported 53 ethnomedical plants that cure 20 different diseases such as gastrointestinal ailments, cough, jaundice and cold. Similarly, the study by Roy et al. (2022) from homegardens of Jalpaiguri noted 67 ethnomedical plants with the capacity to cure 39 diseases, including cancer. Hence, homegardens assure health care while conserving important ethnomedical plants.

Livestock rearing and aquaculture are other distinguishable features of homegardens in North Bengal (Subba, 2014, Subba et al., 2018, Pala et al., 2019b). People utilize the output of homegardens either for food that ensure nutritional supplements or for marketing that uplift them economically. Hence, homegarden practices tremendously contribute to the sustenance of livelihood, especially for people from the poor economic background. Besides, incorporating fuelwood species in homegardens meets the energy requirements of households, and it indirectly reduces the pressure on the natural forests from the damages of fuelwood collection. A study from the 100 homegardens of the Terai region of North Bengal by Roy et al. (2021) documented 41 fuelwood species, which showcases the ability of homegardens to satisfy domestic energy needs without sacrificing natural forest ecosystems.

9. Homegardens in Nutritional Security

Food availability and accessibility are basic human needs, although, with the ever-increasing population size, the food requirement increases drastically worldwide. Nutritional security is the backbone of every society, the lack of which causes imbalance. Hence, to overcome food scarcity sustainably, homegardens are a suitable strategy. They secure food and nutrition from the individual

household level (Galhena et al., 2013). Homegardens, as a sustainable food production system (Abdoellah et al., 2006), maintain the diet and assure health. Homegardens provide nourishments and make nutrient-rich resources more accessible to those who manage them (Buchmann, 2009). Homegarden ensures year-round food production by incorporating annual, biennial and perennial food crops with various age classes (Senanayake et al., 2009).

The intimacy of local food production and homegardens is well studied by various researchers. In the Southern Edo state of Nigeria, Osawaru and Daniel-Ogbe (2012) reported that 73% of the species have potential use as food, in which vegetables and fruits dominate. A study in Central America proved that fruits and vegetables from homegardens supplied nourishments such as Vitamin A, Iodine and Iron (Molina et al., 1993).

The Ethiopian study of homegarden (Yinebeb et al., 2022) confirms their role in overcoming food and nutritional insecurity through fruits, spices, vegetables, cereals and medicinal plants. Homegardens in Sri Lanka assure year-round food security even after the conflicts, particularly for the people living in rural areas (Galhena et al., 2013, Mattsson et al. 2017). Homegardens serve quality products with optimum calories in the Philippine community, as per the study by Wright (2014). The research from mid-land agroclimatic zones of Kerala by Chandrashekara (2015) reported the nutritional value of 27 edible non-crop species and found their substantial contribution in providing nourishment with protein, fibre and other minerals (Table 2).

Contrastingly, homegarden studies assessing nutritional values of the floral components are very scanty from the northern part of west Bengal despite their role in securing family health and diet. Rosyadi et al. (2021)

examined the factors that relate homegarden's capability to meet nutrition to the family members in Jombag regency.

Table 2. Nutrients, their composition and major nutrient rich edible non-crop plants of homegardens (Adapted from Chandrashekara 2015)

Nutrients	Range of nutrient content (mg/g)	Major nutrient rich species
Protein	19.3-54.3	*Cleome viscosa, Remusatia vivipara, Alternanthera bettzickiana, Alternanthera sessilis*
Fat	0.004-0.016	*Remusatia vivipara, Cleome viscosa, Cassia tora, Alternanthera bettzickiana*
Fibre	12.6-49.8	*Diplazium esculentum, Talinum cuneifolium, Remusatia vivipara, Centella asiatica*
Minerals	25.7-58.3	*Cassia tora, Cassia occidentalis, Bacopa monnieri, Remusatia vivipara*
Calcium	3.3-13.3	*Diplazium esculentum, Talinum cuneifolium, Remusatia vivipara, Cassia tora*
Phosphorous	0.3-3.2	*Alternanthera pungens, Amaranthus spinosus, Amaranthus caudatus, Alternanthera sessilis*
Iron	0.2-0.8	*Talinum cuneifolium, Remusatia vivipara, Phyllanthus urinaria, Cassia tora*

The study shows a significant dependence on knowledge and utilization of nutritional value. Another regression-analysis study in homegardens of Mexico confirms a strong connection between diversity of species and food security (Castañeda-Navarrete, 2021). Similarly, the global literature review by Galhena et al. (2013) firmly acknowledges the positive correlation between homegardens and food security. Moreover, there is a further need to widen homegarden assessments by quantitatively estimating their contribution to food security and nutrition.

With the latest market policies, homegardeners prefer commercial crops in limited spaces to assure more economic gain. The study in Indonesia by Abdoellah et al. (2020) highlighted the commercialization effect on food security and found a vast spreading of monoculture practice over traditional homegardens. The study recommends the necessity of immediate action to support

homegardens in policy-level initiatives by agricultural, environmental and rural departments.

10. Carbon Sequestration

The government are protecting forest ecosystems, the enormous terrestrial carbon sink, by enacting laws and policies. However, the increasing concerns over climate change and greenhouse gas emissions pave the path to alternative strategies for sequestering more carbon. Kumar and Nair (2011) recommend the need for carbon storage units with economic, social and ecological value. Hence, homegardens with forest-like structures involving trees as a principal component are the most acceptable option (Saha et al. 2009). Homegardens are more or less permanent structures. Therefore, they sequester carbon in biomass and soil organic carbon (SOC), even in fluctuating environments and assure long-term storage (Albrecht and Kandji 2003). Homegardens assist in climate change adaptation and mitigation in several ways, such as using resources efficiently, enhancing soil and water quality, ameliorating microclimate and diversifying products (Rao et al., 2007).

Homegardens sequester around 1.5 to 3.5 megagrams of carbon per hectare per year (Subba et al., 2018). Not only in rural areas but also urban areas and cities, homegardens play a peculiar role in conserving biodiversity and mitigating climate change. A Survey of 138 homegardens of Jimma city revealed the potential of sequestering 2,877.13 Mg/ha carbon with CO_2 equivalent of 319.57 Mg by the tree components in the system (Mulatu, 2019). However, Padmakumar et al. (2021) reported that urban homegardens store 31.85 ± 2.61 t/ha through biomass carbon sequestration. Some of the studies from various locations that show the carbon sequestration potential of homegardens are shown in Table 3.

The research by Bargali and Bargali (2020) analyzed the connection between the size of homegarden and soil organic carbon (SOC) in the Central Himalayas at various altitudes. Soil organic carbon stock was in the range of 22.56-81.51 tonne carbon per hectare. The study concludes that the contribution to SOC mainly depends on the floral components and management practices, irrespective of the altitudinal variation. On the other hand, Birhane et al. (2020) studied homegardens in different elevation zones in Ethiopia and showed a linear relationship between SOC and elevation. Also, by promoting timber tree growth in homesteads, homegardens reduce the pressure on natural forests and illegal felling (Subba et al., 2018).

Table 3. Location wise documentation of carbon stock value from homegardens

Location	Carbon	Carbon stored*	References
North Bengal	TC	77.61-103.20	Subba et al., 2018
Bangladesh	TBC	53.33	Jaman et al., 2016
Ethiopia	TBC	884.2	Mulatu, 2019
Kerala	AGBC	16-36	Kumar, 2011
Sri Lanka	AGBC	89.98-103.89	Dissanayake et al., 2009
Indonesia	AGBC	35.3	Roshetko et al., 2002
Kerala	SOC	101.5-127.4	Saha et al., 2009
Central Himalaya	SOC	22.56-81.51	Bargali and Bargali, 2020

*Units in Mg ha^{-1}; TC- Total carbon; TBC- Total biomass carbon; AGBC- Above ground biomass carbon; SOC- Soil organic carbon

11. Threats to Homegardens

Homegardens are losing their traditional wealth due to change in people's attitudes and economy, fragmentation of lands and lack of follow-up (Kumar and Nair, 2004, Vibhuti et al., 2019). Factors affecting homegardens adversely are land use change, residence centralization,

ageing of the population and change in living needs (Zhou et al., 2022). Urbanization diminished the area and disrupted the traditional homegarden structure with more ornamental plants (Arifin et al., 1998, Ali et al., 2021). Increasing population fragments the land and reduces the economic outcome, thereby forcing the owners to adopt commercial high-value crops or monoculture that reduces the heterogeneity of homegardens (Kumar and Nair, 2006).

Pollution, climate change and over-exploitation effect traditionality of homegardens (Pushpakumara et al., 2010). Therefore, to save the homegardens from the verge of extinction and pass the traditional knowledge to the young generation, systematic studies and strategies are mandatory. In local and regional level planning, for uplifting people and managing the environment, homegardens are considered a viable option by their provisional services and configuration (Siftova, 2021). People and policymakers should raise awareness of the value of homegardens and their function to popularize their role in sustainability, environmental conservation and food and nutritional security. For that, scientific research that validates the views regarding homegardens should be strengthened more by identifying the research gaps and expert recommendations.

12. Conclusion

The comparative review reveals the peculiar features of homegardens in both Kerala and the Northern part of West Bengal, which harbour traditional homegardens not only as sources of income but also as socio-cultural pride. High species diversity with multiple strata was observed in homegardens of both regions. The comparative study showed the role of homegardens in conserving species, maintaining diversity, providing ecosystem services, and sequestering carbon and confirmed their role in climate

change mitigation and adaptation. The comparison identifies the research gaps in the homegarden studies of both selected locations, especially in the nutrient status assessment of floral components and carbon sequestration. Homegardens are one of the suitable strategies in the concurrent days that search for the solution to end poverty, food insecurity, climate change and biodiversity loss. Regionally, for improving people's livelihood without compromising on ecological roles and benefits, homegardens can be highly recommended at the policy-level planning and implementation.

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