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Home Garden Agroforestry as a Nature-Based Solution for Climate Change Adaptation: A Review

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ABSTRACT

A multifunctional home garden agroforestry ecosystem is a Nature-based solution (NbS) for climate change adaptation. The ability of home gardens to store carbon and enhance carbon sequestration is crucial for mitigating the influence of climate change on ecosystems. Numerous studies have investigated several aspects of traditional home gardens. However, little research has examined its contribution towards climate change adaptation and mitigation. Using the PRISMA approach, we reviewed existing studies on NbS and the functional diversity of home gardens. We examined the importance of these micro-ecosystems as a pathway for climate change adaptation. This analysis revealed that NbS are an effective means of combating climate change. Ecosystem-based adaptation involves conserving, sustainably managing, and restoring ecosystems to reduce the harmful impacts of climate change. Home gardens reflect traditional culture and ecological knowledge, ensuring the availability of ethnic foods. There is a need to encourage both rural and urban populations to maintain home gardens and conserve existing ecosystems. Our findings suggest that, given the significant contributions and benefits of home gardens, they should be considered an ecosystem-based adaptation for restoration and carbon sequestration, and hence an NbS for climate change adaptation.

Key words: Home gardens, Agroforestry, Ecosystem-based adaptation, Nature-based Solutions (NbS), Climate change adaptation

INTRODUCTION

According to the International Centre for Research in Agroforestry (ICRAF), agroforestry is a collective term for land-use systems and technologies in which woody perennials (trees, shrubs, bamboos, etc.) are deliberately used alongside crops and/or in a temporal sequence (Nair 1993). The main agroforestry practices are improved fallows, *taungya*, home gardens, alley cropping, growing multipurpose trees and shrubs on farmland, boundary planting, farm woodlots, orchards or tree gardens, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture, and apiculture with trees (Nair 1993, Sinclair 1999). Home garden-agroforestry is a mixed farming system in which multipurpose trees and shrubs are managed alongside annual and perennial crops and livestock in areas near individual houses. It is a very common form of land use worldwide, especially in tropical and subtropical regions. Home gardens, also called homestead gardening, are known as *"baira"* in Bangladesh, *"pekarangan"* in Indonesia, *"xochichinalco"* in Mexico, and *"baree"* in Assam, India.

While 'gardening' is defined as the activity of working, growing, and taking care of plants and keeping the garden attractive (Gillard 2001), gardens are available in different forms based on the purpose at the household level, viz., *kitchen garden* (the growing of fruits and vegetables in the backyard of a house by using kitchen wastewater). It is also called a nutrition garden, vegetable garden, herb garden (where herbs used for cooking and medicinal properties are grown to meet the needs of different ethnic groups in various geographic areas). There are *indoor gardens* (greenery created indoors using potted plants and other elements under controlled conditions, such as greenhouses and nurseries); *rooftop gardens* or green roofs (located on the rooftops of buildings or terraces instead of the ground, also known as terrace gardens; they can provide food, temperature regulation, hydrological benefits, and architectural enhancement); *hydroponic gardens* (growing crops or medicinal plants without soil by using water-based mineral nutrient solutions in an artificial environment); *flower gardens* (also called floral gardens, where flowers are cultivated to attract pollinators such as bees, butterflies, and birds, facilitating pollination and plant reproduction); *container gardens or pot gardening* (growing plants like flowers and vegetables in containers instead of planting them in the ground), urban gardens (located within city or town areas, including parks, rooftops, balconies, community centres, schoolyards, or indoor spaces); and *water gardens* (also called aquatic gardens, where ponds or lakes serve as central elements with aquatic plants and sometimes fish). Community gardens are collections of allotments where individuals or families manage a single plot, allowing for high spatial and temporal turnover of vegetation (Philpott et al. 2020).

Traditional home gardens, also known as backyard gardens, kitchen gardens, dooryard gardens, and household gardens, are a type of traditional agroecosystem located close to dwellings that contain diverse species with different purposes and promote ecological sustainability (Hamilton and Hamilton 2006, Peyre et al. 2006). Home gardens are especially important in rural areas and regions inhabited by indigenous societies, where they play a vital role in livelihoods (Barbhuyia et al. 2016). Traditional home gardens have complex structures, diverse floristic composition, and multiple functions, low input including labour and money, and ecological and socioeconomic sustainability (Huai and Hamilton 2009, Mattsson et al. 2013, Siyum and Tassew 2019, Gifawesen et al. 2020). Tangjang and Arunachalam (2009, 2017) surveyed traditional home gardens in Nirjuli, Ziro, Doimukh, Arunachal Pradesh, and Harmuti, Assam. They found that the species grown in these sites contain wood for

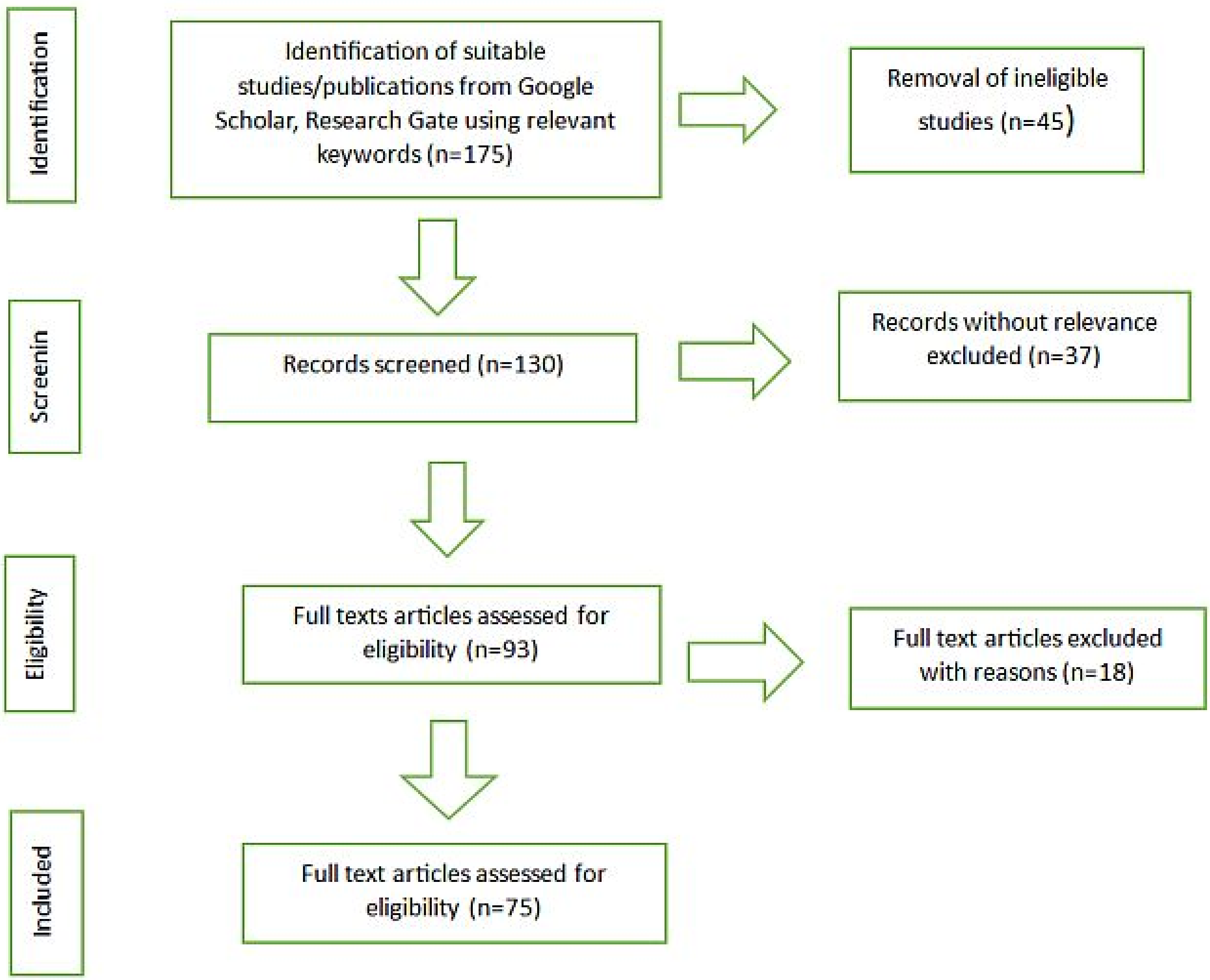

Figure 1. Flowchart of the methodology used for identification of studies for systematic review

building materials, food products, medicinal and horticultural produce, and materials for handicrafts. A total of 73 plant species of economic, social, and cultural value, belonging to 27 families, were recorded in the home gardens of the Tangkhul community in Manipur, indicating the extensive indigenous knowledge they have developed for biodiversity conservation (Shimrah et al. 2018). The objectives of this review are to explore the socioeconomic and ecological roles of home gardens and to analyse how they can serve as a nature-based solution for climate change adaptation by examining existing literature on nature-based solutions and the functions of home gardens.

METHODOLOGY

The review was conducted as a systematic literature review, which is a reliable framework, and is reported in accordance with the PRISMA guidelines. This research used a review of academic journal articles, conference papers, the internet, and textbooks, and downloaded several articles from research databases, including Scopus, Web of Science, and Google Scholar. We compiled works that make inferences about home gardens, ecosystem-based adaptation, gardening, and nature-based solutions. A large number of publications were found, but based on the study's purpose, 93 articles were selected from the database. After reading the titles, abstracts and the entire research paper, 75 articles were used in this investigation. To guide the review process, a PRISMA flow diagram (Fig. 1) is included to illustrate the identification, screening, eligibility, and inclusion stages of the study selection.

FUNCTIONS OF HOME GARDEN AGROFORESTRY

Home gardens, like other ecosystems, have a wide range of material and non-material functions, including provisioning (food, medicinal, fodder, etc.), cultural (social cohesion, recreational, symbolic, etc.), supporting (biodiversity), and regulating services (air purification, pollination mitigation, local climate regulation, maintenance of soil fertility, etc. (Camps-Calvet et al. 2016, Cameron and Hitchmough 2016, King and Shackleton 2020). In developing countries, home gardens play a key role in providing food security (Asaduzzaman 2011) and nutrition security (Singh et al. 2021, Saediman et al. 2021) to the economically weaker sections of society. Suri (2020) observed that community gardens enhance dietary diversity and provide a sustainable model for food security and nutrition, helping combat malnutrition at the household or community level. UNICEF's community-led nutrition gardens in the state of Chhattisgarh, India, set a good example by improving nutrition levels, livelihoods, and food security indicators, and reducing the incidence of diseases associated with malnutrition (Namgyal 2024). Table 1 summarises the characteristics of a few studies on the functions of home gardens.

Recreational functions

Gardening at the household level promotes physical and mental health by providing opportunities for exercise, meaningful human-nature interactions, increased consumption of fresh products, and better health than non-gardeners (Kingsley et al. 2009, Soga et al. 2017). Chalmin-Pui et al. (2021) concluded that more frequent gardening (i.e., 2-3 times per week) was associated with reduced perceived stress, increased subjective well-being, and higher self-reported physical activity levels.

Biodiversity conservation functions

Home gardens are hotspots of in situ and ex situ agrobiodiversity conservation, serving as germplasm banks for many crops and other economically important plants (Das and Das 2005, Baig et al. 2008, Huai and Hamilton 2009). It also has the potential to increase biodiversity in the agricultural landscape while reducing habitat loss and fragmentation (Bardhan et al. 2012). They are sites of conservation for endangered and culturally significant species, such as Agarwood, *Euphorbia splendens* (Bathow), and traditional pesticides (Sharma et al. 2022, 2024). High species diversity in agroforestry home gardens plays a key role in complex, sustainable land-use systems (De Zoysa 2022). Saikia et al. (2012) and Saikia and Khan (2014) recorded 294 plant species in 80 home gardens across 17 villages in Upper Assam, India (Fig. 2). Blanckaert et al. (2009) recorded 233 plant species in 30 home gardens from the village of San Rafael Coxcatlán, Mexico. Bhatt

Table 1. Summary of characteristics of some studies on the multifunctional home gardens

References	Aim of the study	Conclusions of the study
Ali et al.(2021)	The aim of the study was to measure the level of urbanization and to assess the changes in the structure and function of home garden vegetation by comparing the current data with those of the previous studies.	The researcher concluded that the study sites are moderately or highly urbanized. The dynamics of home gardens have increased the composition of non-ornamental species, mostly fruit plants in all research sites.
Avilez-Lopez et al.(2020)	The aim of the study was to analyze how owners' knowledge of home garden multifunctionality functions links to home garden agrobiodiversity.	The result of the study concluded that rich agrobiodiversity of home gardens cherished by rural families is positively correlated with Home Garden owners' broad multifunctionality knowledge in the ecological and economic dynamics.
Betemariyam et al.(2020)	The aim of the study was to demonstrate empirically the carbon stocks of home garden and adjacent coffee-based agroforestry systems practiced at Mana district, southwestern Ethiopia	The study revealed that the agroforestry systems can be Carbon sinks in agricultural landscapes and support local livelihoods.
Chalmin-Pui et al.(2021)	This research explored why residents in study sites engaged with gardening and the extent to which they recognized any health benefits from the activity.	The results showed that the perceived health benefits increasing in line with frequency of gardening activities.
Diekmann et al. (2018)	This study evaluates the contributions of urban gardens in Santa Clara County, California, to food security.	The findings of the study demonstrate the nutritional contributions that urban gardens make and it also highlight the importance that low-income gardeners have access to food that aligns with their cultural and ethical values.
De Zoysa (2022)	This study attempted to analyze the scientific basis of households' practices and to develop strategies for the promotion of sustainable agroforestry home gardens in Matara district of Sri Lanka.	The study revealed that scientific basis of household practices in agroforestry home gardens is moderate in selection of appropriate trees and plants, and management of trees and plant healthcare.
Ferrer et al.(2021)	The work aimed to evaluate domestication effects on the genetic structure of three species in remnant forests and home gardens within two climatic regions of the Peninsula of Yucatan.	The study concluded that domestication has preserved the genetic diversity of the three species.
Hong and Zimmer (2022)	The goal of the research was to explore the role of home gardens in local ethnobotany in the context of habitat conversion and land use change.	The findings confirm previous research that home gardens contribute to conservation of useful plant diversity in the region.

References	Aim of the study	Conclusions of the study
Huai and Hamilton (2009)	This paper review studies on the structural characteristics, functions and dynamics of traditional home gardens.	The researchers concluded that the characteristics and functions of traditional home gardens are closely related to many factors such as their geographic location and the cultural backgrounds and socio-economic conditions of their owners.
Hume et al. (2022)	The aim of this work was to systematically review the evidence on effects of community gardens.	The study concluded that community gardening is associated with higher fruit and vegetable intake, positive psychosocial and community outcomes, but poor evidence quality suggests the effects of community gardening may be overestimated
Kumar et al. (2022)	This study aimed to investigate the species diversity in the traditional home gardens in the Berung village, Arunachal Pradesh and their traditional uses by the locals.	The study revealed that home gardens of Berung village are depositories of diverse plant resources of o both economic and ecological significance.
Mihu et al. (2021)	The researchers aimed to investigate if the native communities of the Mishmi, Arunachal Pradesh conserved native indigenous tree species in their home gardens.	The researchers found that at present native trees constituted just 37% of the total tree population in the home gardens.
Ogundiran et al. (2013)	The aim of the study was to examine the relationship between home gardening and household food security in the study area.	Results of the study showed that home garden play a crucial role in providing food security in rural household.
Reang et al. (2022)	This research aimed to study the tree species composition and diversity under different Traditional Agroforestry Systems practiced by the ethnic communities of southern Assam and Mizoram, Northeast India	The researchers concluded that the study demonstrated the importance of Traditional Agroforestry systems in conserving biodiversity and its role in biomass accretion.
Ramli et al. (2021)	The aim of the study was to analyze the status of plant diversity and their utilization in home gardens.	The findings of the study indicate that home gardens are suitable places for conservation of critically endangered plants.
Saikia and Khan (2014)	The aim of the study was to study the ecological features of *Aquiralia malaccensis* Lam. in home gardens of upper Assam, northeast India.	The widespread cultivation of *Aquiralia malaccensis* in upper Assam, northeast India, offers a potential ex-situ reservoir for the future conservation and management of this threatened tree.
Sharma et al. (2024)	The study aimed to analyze the role of home garden in agrobiodiversity conservation.	The result highlights that Homegardens in the study site is indeed acting as high agrobiodiversity hotspot.

References	Aim of the study	Conclusions of the study
Sharma et al. (2022)	This review paper aimed at analyzing the role of home garden in the achievement of 17 Sustainable Development Goals.	The results of this study highlights that home garden can potentially contribute to the achievement of Sustainable Development Goals.
Tangjang and Arunachalam (2017)	The study was carried out considering the role of plant species in traditional home gardens for sustainability.	The study revealed that the local practitioners Knowledge System (IKS) are conserving natural resources and are achieving sustainability. The study also reveals that traditional that traditional home gardens can be a valuable tool for in-situ conservation of plant species and maintaining ecosystem functioning.

et al. (2014) recorded 210 plant species across 50 home gardens in 10 villages in Karwar, India. Ramli et al. (2021) recorded 207 useful plant species distributed across 169 genera and 78 families from 40 home gardens in Kampung Masjid Ijok, Malaysia. Trinh et al. (2003) reported that in Vietnam, the number of species in home gardens ranged from 12 to 103, with an average of 0.7 to 2.7 per 100 m^2. Hong and Zimmer (2022), while studying 131 home gardens on Jeju Island, South Korea, reported that home gardens harbour a significant portion of useful wild plants known to the region that were being lost due to deforestation. In Mexico, home gardens are known as “Solares Mayas”, in which native species are preserved, cultured, and used (Ramirez-Barajas and Calme 2015). Ferrer et al. (2021) reported that cultivating *B. alicastrum*, *C. dodecandra,* and *S. purpurea* in Mayan home gardens supports their genetic conservation, which is of particular interest given local and regional threats to the tropical forests of the Yucatan Peninsula.

Ecosystem services

Home gardens offer numerous environmental and ecological benefits. It plays a vital role in climate change mitigation by providing diverse food sources, improving ecosystem services, alleviating pressure on natural forests, enhancing soil health and ornamental plants, and conserving freshwater resources to sustain human life. This increases resilience against climate impacts while supporting household income and food security (Gifawesen et al. 2020). They provide essential ecosystem services, including the supply of agricultural and forest products, climate regulation, carbon storage, environmental cleansing, pest control, pollination, biodiversity protection, and landscape cultural services (Liu et al. 2023, Sarkar et al. 2019). Liu et al. (2023) highlight that home gardens play a significant role in delivering vital ecosystem services that benefit both the environment and residents’ welfare. The study assesses the home garden system in the Chengdu Plain, emphasising its importance as an agricultural heritage and a sustainable land-use pattern. It also notes that urbanisation and land-use changes have negatively impacted home gardens, leading to declines in their numbers, area, and ecosystem service value over the past decade. The total ecosystem service value of home gardens is estimated at approximately USD 30,562.70 million annually, comprising contributions from various services: regulating services (37.90%), cultural services (32.45%), provisioning services (15.46%), and supporting services (14.19%). The study underscores the need for targeted protection strategies, especially in areas identified as critical for conservation.

Socioeconomic functions

Home gardening has been recognised for positively impacting local communities' socioeconomic conditions by strengthening social cohesion and supporting the local economy. This includes increasing financial revenue and reducing poverty risk factors (Santos et al. 2022). The most basic social benefit of home gardens is their direct role in enhancing household food security by increasing the availability, accessibility, and utilisation of food products (Galhena et al. 2013). Garbole (2025) noted that Enset-based home gardens notably enhance agrobiodiversity and sustainable food production compared to parkland agroforestry in semi-arid regions. It also promotes agricultural extension services to educate farmers about the benefits of diverse agroforestry practices and emphasises effective management techniques. Linger (2014) studied the socioeconomic features of home garden agroforestry, which provides fuelwood, leading to reduced removal of farm-crop residual biomass, decreased reliance on animal dung for fuel, and lower investment in organic fertiliser. The species in these home garden systems supplement household food and income.

Carbon sequestration function

Agroforestry offers the greatest potential for carbon sequestration because it can be implemented in agricultural lands as well as in reforestation programs. It has been promoted as a strategy for carbon sequestration under afforestation and reforestation initiatives within the Clean Development Mechanisms of the Kyoto Protocol (Watson and Eyzaguirre 2002, Smith et al. 2007) and is particularly well-suited for REDD+ (Reducing emissions from deforestation and forest degradation in developing countries), which accumulates carbon through sustainable forest management, conservation, and afforestation and reforestation efforts. Jose and Bardhan (2012) studied home gardens in the Monaragala District of Sri Lanka and found that home gardens stored 13 Megagrams of carbon per hectare, with a wide range (1 to 56 Mg ha^{-1}) due to the variety of trees. Betemariyam et al. (2020) conducted a study in the Mana district of Ethiopia, affirming that home garden agroforestry systems help reduce emissions and enhance carbon sinks on the agricultural landscape while supporting local livelihoods.

LINKING MULTIFUNCTIONAL HOME GARDENS, AN ECOSYSTEM-BASED ADAPTATION, AS A NATURE-BASED SOLUTION FOR CLIMATE CHANGE ADAPTATION

The European Commission introduced the term Nature-based Solutions (NbS) in 2015 and defines it as solutions inspired by and supported by nature that are cost-effective, provide environmental, social, and economic benefits simultaneously, and help build resilience (Anonymous 2015). Such solutions bring more diverse natural features and processes into cities, landscapes, and seascapes through locally adapted, resource-efficient, and systematic interventions. The EU Adaptation Strategy, updated in 2021, emphasizes ecosystem-based approaches, especially Nature-based Solutions (Kopsieker et al. 2021). The International Union for Conservation of Nature (IUCN) coined the first global definition of Nature-based Solutions in 2016, defining it as actions to protect, sustainably manage, and restore natural or modified ecosystems that effectively and adaptively address societal challenges while providing benefits to human well-being and biodiversity (Cohen-Shacham et al. 2016). Since its introduction, the concept of NbS has attracted significant interest worldwide in the scientific community. These solutions are essential for achieving Sustainable Development Goal 1: Sustainable Cities and Communities. The 2016 UNFCCC Paris Agreement recognizes the importance of ecosystems for mitigation and adaptation, including references to ecosystems, forests, and natural resources (Seddon et al. 2020). The 2019 UN Climate Action Summit highlighted

Figure 2. Home gardens of Assam, India: (a) Trees+crops+livestocks in the home garden; (b) Trees providing shade to tea plantation in home garden and regulating mesoclimate; and (c) Trees along boundaries of home garden and acting as wind barriers (Photo: Porsia Guha Thakurata)

Nature-based Solutions as an effective means of combating climate change. Nature-based solutions can be classified into three types based on the scale of intervention: Type 1 involves minimal intervention in ecosystems, aiming to maintain or enhance the delivery of ecosystem services within and beyond protected areas. Type 2 includes developing sustainable, multifunctional ecosystems and landscapes through innovative planning of agricultural areas to enhance their multifunctionality, utilising existing agrobiodiversity, and employing approaches to improve tree species and genetic diversity to boost forest resilience to extreme events. Type 3 involves extensive ecosystem management through artificial systems, such as green roofs, green corridors, and constructed wetlands, especially in urban areas, to help regulate temperature.

Technically, two approaches to nature-based solutions are being followed. They are *ecological engineering* and *ecosystem-based adaptations*. Ecological engineering uses the principles of ecology and engineering to predict, design, construct, or restore, and manage ecosystems. Ecological Engineering helps create or restore ecosystems through practices such as wetlands, stormwater management, wetland treatment, community reforestation, and mine land restoration. Ecosystem-based adaptation is a type of Nature-based Solution that supports human adaptation to climate change by leveraging biodiversity and ecosystem services. Ecosystem-based adaptation involves conserving, sustainably managing, and restoring ecosystems to reduce the harmful impacts of climate change. Agroforestry in Ethiopia has reduced erosion, increased soil fertility, increased precipitation, and reduced temperatures (Torralba et al. 2016). A combination of afforestation, reforestation, and conservation of existing natural forests over 25 years in the Payeng Lake basin halved heavy soil erosion, increased net carbon sequestration by 5-fold, and increased local farmers' net income by 6-fold (Huang et al. 2012).

After reviewing the existing literature on functions of home gardens (Table 2), it can be deduced that home gardens have much potential as:

1. It can reduce deforestation and pressure on the forest by providing fuelwood grown on farms.
2. It can restore soil fertility (using Nitrogen Fixing Trees and shrubs);
3. It can provide food security by producing fruits, vegetables, nuts, and edible oils.
4. It can reduce poverty by increasing incomes through the production of agroforestry products for home consumption and the market.
5. It can provide empowerment to women.
6. It has the potential to control dust and erosion.
7. It can help in maintaining ecological balance.
8. It can help with soil conservation and the maintenance of biodiversity.
9. It can help during excess rainfall by absorbing the excess water; and
10. It has the potential for carbon sequestration.

Home gardens are the perfect habitat for certain insects and pollinators (Liu et al. 2018), which

Table 2. Some studies on home gardens with practical findings

Study area	Functions	Practical implications/findings	References
Benin, West Africa	Socio-ecological drivers of home garden	Home gardens support agrobiodiversity conservation strategies. Gender influences home garden functions and management.	Gbedomon et al. (2017)
Ethiopia	Ecological	Provides food, income, and medicinal resources for households. Enhances biodiversity and ecological conservation in rural areas.	Kewessa (2020)
Brahmaputra Valley, Assam	Sustaining local ecosystems	Traditional homestead agroforestry systems contribute to rural food security and livelihoods. Factors such as floods and changing behavior threaten the sustainability of these systems.	Saha et al. (2021)
Bure District of Southwest Ethiopia	Biodiversity conservation	Promotes biodiversity conservation in home garden agroforestry systems.Encourages awareness for maintaining diverse native plant species.	Weldebirhan et al. (2023)
Indonesia	Ecosystem services	Agroforestry enhances food security for rural households. Promotes healthier eating habits and sustainable food supplies.	Yusriadi et al. (2024)

provides essential support for food security and ecosystem stability (Lautenbach et al. 2012), preserving the soil structure and preventing soil erosion (Linger 2014), cycling soil nutrients (Reetsch et al. 2020) and preserving soil organic matter (Mohri et al. 2013). Major benefits of home garden agroforestry as Climate Change Adaptation include enhanced water retention, reduced vulnerability to droughts and improved food security. Tree roots in home gardens provide soil cover, reduce soil erosion, conserve soil moisture, and improve water availability for crops. Trees in home gardens act as windbreaks, reducing crop damage and supporting biodiversity conservation. A home garden enhances soil health by improving fertility, structure, and moisture retention. Trees and shrubs add organic matter to the soil through leaf litter, root biomass and decomposing plant material (Mulatu and Bayata 2025). This organic matter enriches the soil with nutrients and improves its structure and water-holding capacity. Trees create shaded areas, thereby regulating the microclimate and reducing heat stress in crops and livestock. Trees in home gardens also diversify income through tree products such as fruits and timber, thus providing livelihood security to smallholder farmers.

Given the significant contributions and benefits of home gardens, they are considered an Ecosystem-based adaptation for ecosystem restoration and carbon sequestration, and hence an NbS for climate change mitigation and adaptation. Multifunctional home garden agroforestry ecosystems should be promoted as nature-based solutions for carbon sequestration. The ability of home gardens to store and enhance carbon sequestration is critical for climate change mitigation. Carbon assimilated by woody perennials in home gardens is transported belowground via root growth and organic matter turnover, augmenting the soil organic carbon pool. Bamboo, widely grown in home gardens in tropical and subtropical areas, has a high potential to mitigate global warming through carbon sequestration (Barua et al. 2019).

DISCUSSION

Climate change is a long-term (usually 30-year) change in the average weather patterns that have defined the local, regional, and global climate. Despite increasing awareness of climate change, greenhouse gas emissions are continuously rising. The daily level of carbon dioxide in the atmosphere in April 2026 is 431-433 parts per million (ppm) as measured in the Mauna Loa Observatory. Fossil fuels- coal, oil and gas are considered to be the largest contributors to global climate change. As greenhouse gas emissions rise, they trap the sun's heat, causing Earth to warm and, therefore, leading to climate change. Changing precipitation and temperature patterns cause hotter temperatures, destructive storms, drought, and rising sea levels, threatening the existence of local biota. Climate Change is a global issue, but local communities can focus on solving their own climate problems. Two strategies address climate change: Climate Change Adaptation (CCA) and Climate Change Mitigation (CCM). CCA is the process or action that helps people adjust to the current and future effects of climate change. CCA strategies include building sea walls and improving drainage to protect against flooding; breeding drought-resistant crops; establishing early warning systems for extreme weather events; and using nature-based solutions such as restoring wetlands. In many places, agroforestry is used as a nature-based solution to mitigate riverbank erosion through riparian buffers, bioengineering, live-plant revetments, terracing, and wetland restoration. Multifunctional home gardens (tree + crop systems + livestock) can be considered as natural solutions for mitigating and adapting to climate change.

The UN-ESCAP has recommended promoting sustainable home or kitchen gardening as an effective social protection strategy, integrated with health and nutrition education. Kitchen gardens empower women, provide food security, support poverty alleviation, and generate economic returns. Thus, they are useful in achieving Sustainable Development Goals 1 (No Poverty), 2 (Zero Hunger), and 3 (Good health and well-being). By combining the ecological wisdom of villagers with scientific knowledge, higher home garden productivity may be achieved without causing substantial environmental degradation (Millat-e-Mustafa et al. 2000). Home gardens reflect traditional culture and ecological knowledge and ensure the availability of ethnic food items. Home garden agroforestry can reduce land-use emissions and strengthen farmers' resilience to the impacts of climate change.

A study in Sri Lanka has revealed that households engage in conservation practices that significantly regulate and enhance soil, nutrients, water, and biodiversity in home gardens (Jeyavanan et al. 2017). De Zoysa (2022), while studying home gardens in Matara district, Sri Lanka, concluded that owners of small home gardens are concerned with the scientific basis requirements of plants and drought, and disease-resistant varieties, while showing little concern for growing the right plants in the right place and selecting appropriate trees and plants. The agrobiodiversity of home gardens depends on continuous management, experimentation, cultivation, organisation, knowledge transmission, and the motivations of their owners (Kumar and Nair 2000). Ali et al. (2021) reported that the increase in urbanisation in West Java, Indonesia, affected home garden area and vegetation structure. Due to a decrease in the area of home gardens, the number of species and individual plants has decreased. There is a loss of home garden biodiversity in many places because of (i) conversion of agricultural land to non-agricultural activities; (ii) introduction of exotic/improved varieties, ignoring site suitability; (iii) degradation of soil by using chemical fertilizers, pesticides, etc., and (iv) lack of conservation efforts.

Approximately 55% of the world's population lives in urban areas, and by 2050, 68% is expected to live in cities (Gumey et al. 2022). Urbanisation has positive impacts on a country's economic growth and brings significant benefits, such as employment, education, innovation, welfare, social structure, and institutions (Ochoa et al. 2018). However, rapid urbanisation has caused environmental degradation, climate change, poverty, and injustice, and has altered land use, ecosystem diversity, watershed hydrology, and the biogeochemical cycle through waste disposal (Lin et al. 2015, Schneider et al. 2015, Kalantari et al. 2017).

High investments are being made to increase carbon sequestration using nature-based solutions in urban areas (Pereira et al. 2024). However, existing ecosystems, such as home gardens, are not given the importance they deserve. There is a need to encourage both rural and urban populations to maintain home gardens, and conserve existing ecosystems. The protection and restoration of intact ecosystems can play an important role in improving biodiversity and societal well-being, as well as in mitigating climate change.

CONCLUSIONS

This review aimed to discuss the multifunctionality of home gardens, Nature-based Solutions, and Ecosystem-based Adaptation by examining the published literature. The age-old practice of agroforestry should be valued and protected, and strategies should be developed to promote sustainable home garden agroforestry systems. It allowed the adaptation and domestication of plants to extreme or specific ecological conditions, thus contributing to the diversification of cultivated plants. In conclusion, protecting and restoring existing home garden ecosystems is better for climate change adaptation than afforestation or the construction of wetlands, etc. Ecosystems such as home garden agroforestry, with a high capacity for carbon storage, should be adopted as a Nature-based Solution for climate change adaptation in urban and peri-urban areas. Home gardens have value and potential to enhance food security and livelihoods. Numerous initiatives have been launched by governmental, nongovernmental, and international organisations in many developing countries that provide support and build local capacity to enhance productivity and scale up home garden activities. Future work should focus on assessing the socioeconomic and ecological functions of home gardens. There is also a need for a biodiversity assessment of the available home gardens to support biodiversity conservation. This review identifies the role of multifunctional home gardens in climate change adaptation and highlights environmental and socioeconomic benefits.

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