BILINGUAL PUBLISHING GROUP

Journal of Environmental & Earth Sciences
https://journals.bilpubgroup.com/index.php/jees

ARTICLE

Home Gardens into Climate Resilience Strategies: Insights from Tribal Communities in Keonjhar, Odisha

Shusrisangeeta Das [1], ***Damodar Jena*** [1*], ***Priyanka Mishra*** [2], ***Chhayakanta Mishra*** [1], ***Padmalochan Rout*** [1], ***Ganesha Honnesara Subraya*** [1], ***Sukanta Chandra Swain*** [3], ***Ambrish Singh*** [4]

[1] *KIIT School of Rural Management, KIIT Deemed to be University, Bhubaneswar, Odisha 751024, India*
[2] *KIIT School of Architecture & Planning, KIIT Deemed to be University, Bhubaneswar, Odisha 751024, India*
[3] *KIIT School of Economics and Commerce, KIIT Deemed to be University, Bhubaneswar, Odisha 751024, India*
[4] *Department of Applied Sciences and Humanities, Rajkiya Engineering College, Azamgarh, Uttar Pradesh 276201, India*

ABSTRACT

Home gardens serve as a crucial adaptation strategy for tribal communities in Keonjhar district, Odisha, enhancing food security, income generation, and climate resilience. This study examines the role of home gardens in sustaining tribal livelihoods while addressing challenges such as climate variability, soil degradation, and market constraints. Adopting a mixed-methods approach, it integrates the Sustainable Livelihoods Framework (SLF) and socio-ecological resilience theory. Data from 120 tribal households across four villages in Banspal block were collected through structured interviews and focus group discussions. A key innovation lies in integrating indigenous knowledge systems with the Problem Facing Index (PFI) methodology to generate quantified, community-driven insights on climate adaptation barriers. Findings reveal that home gardens contribute around ₹10,000 per season to household income, reducing market dependency by over 70% during crises such as the COVID-19 lockdown. Over 75% of households face high to medium challenges due to climate variability (PFI = 252), soil degradation (PFI = 251), and wildlife intrusions (PFI = 250). Other notable constraints include pests (75%) and poor market access (61.7%). Although 82.5% reported no issue with agricultural inputs, water scarcity remains a seasonal concern for 23%. Despite constraints, home gardens were

*CORRESPONDING AUTHOR:
Damodar Jena, KIIT School of Rural Management, KIIT Deemed to be University, Bhubaneswar, Odisha 751024, India; Email: damodarjena@gmail.com

ARTICLE INFO
Received: 8 May 2025; Revised: 30 May 2025; Accepted: 6 June 2025; Published Online: 23 June 2025
DOI: https://doi.org/10.30564/jees.v7i7.9923

CITATION
Das, S., Jena, D., Mishra, P., 2025. Home Gardens into Climate Resilience Strategies: Insights from Tribal Communities in Keonjhar, Odisha. Journal of Environmental & Earth Sciences. 7(7): 1–15. DOI: https://doi.org/10.30564/jees.v7i7.9923

found to enhance all five SLF capitals: natural, human, social, financial, and physical. The study recommends context-sensitive interventions, including seed distribution, organic inputs, weather-based advisories, and strengthened institutional support. It highlights the potential for scaling home garden models across other marginalized agroecological regions in India and Asia, aligning them with national rural development and climate adaptation programs.

Keywords: Home Garden; Tribal Communities; Climate Resilience; Sustainable Livelihoods; Indigenous Agriculture

1. Introduction

Tribal communities are among the most vulnerable populations in the face of climate change due to their deep reliance on natural resources, marginalization, and habitation in ecologically sensitive landscapes. Their adaptive capacity is further constrained by persistent poverty, social exclusion, geographical isolation, and limited institutional support [1,2]. These structural disadvantages expose them disproportionately to climate-induced stresses such as erratic rainfall, soil degradation, and biodiversity loss.

While large-scale agriculture ensures broader food supply, home gardens have historically served as vital household-level systems for food security, ecological adaptation, and resilience among indigenous communities [3–5]. Home gardens, often called 'kitchen gardens,' are small-scale, diverse cultivation systems that foster plant domestication, conserve biodiversity, and buffer against environmental shocks. They not only provide food but also enhance cultural identity, nutrition, and household self-sufficiency [6–8].

This practice of growing food near home is a time-honoured practice and manifests globally as widespread food production systems in forms of backyards, compound gardens, and kitchen gardens [9–12]. In developed countries like Australia, community gardening is valued for its social and environmental benefits. In contrast, in India and other South Asian nations, household-level gardens dominate due to land tenure patterns and personal preferences, highlighting their importance for food security among low-income families in both urban and rural settings [13].

In Malaysia, in Penang's urban poor communities, home gardens symbolize cultural continuity and social cohesion [14]. Beyond food production, these systems contribute to improved nutrition, income generation, and self-reliance [15,16], offering affordable access to vegetables such as kale, radish, and cauliflower.

Home gardens play a significant role in supporting livelihoods and conserving biodiversity, particularly in developing regions [17]. Among tribal communities, they offer localized climate adaptation strategies and contribute to the UN Sustainable Development Goals (SDGs) such as poverty alleviation and climate action [18–20]. In addition, they provide numerous social benefits, including improved household nutrition and health, women's empowerment and lowering maternal and infant mortality rates, and preservation of indigenous knowledge and cultural heritage [21,22]. Despite their potential, research on optimizing home gardens in tribal settings remains limited. Critical gaps persist in understanding how these systems balance ecological and socio-economic goals, scale up for market integration, and navigate gender disparities [23–25].

This study addresses these gaps through a theoretical lens that integrates the Sustainable Livelihoods Framework (SLF), socio-ecological resilience, agroecology, and indigenous knowledge systems. Together, these frameworks illustrate how home gardens enhance five types of livelihood capital: natural (land, water, biodiversity), human (agricultural skills), social (seed sharing), physical, and financial [26]. Socio-ecological resilience theory emphasizes systems' ability to reorganize and persist amid stress. Home gardens reflect this principle by serving as adaptive spaces where food security, biodiversity, and resilience converge [27]. Similarly, agro-ecology, introduced by W. Albrecht in 1970, promotes diverse, low-input farming that avoids pollutants and supports ecological integrity—principles embodied in tribal home gardens across India [28].

In Odisha's tribal areas, particularly Keonjhar, traditional practices such as intercropping, composting, and the use of botanical pest control methods are rooted in indigenous knowledge and form part of a resilient agro-ecological strategy. These culturally embedded systems often prove more sustainable and effective than externally

imposed interventions [29].

Accordingly, this study aims to explore the role of home gardens in sustaining tribal livelihoods and strengthening climate resilience in Keonjhar, Odisha. It addresses two key research questions:

How do home gardens enhance sustainable livelihoods and climate resilience among tribal communities?

What are the main challenges faced by tribal households in sustaining home gardens?

To address these, the study aims to examine the contribution of home gardens to different livelihood capitals, identifies the ecological and socio-economic challenges faced by tribal households, and explores the role of indigenous agroecological practices for climate adaptation. The research also aligns with several Sustainable Development Goals (SDGs), including poverty reduction (SDG 1), food security (SDG 2), good health and well-being (SDG 3), gender equality (SDG 5), reduced inequality (SDG 10), climate action (SDG 13), responsible consumption (SDG 12), land restoration (SDG 15), and economic growth (SDG 8) [6,16,30,31]. Ultimately, the study highlights the value of indigenous knowledge as a pathway to sustainability and resilience in tribal regions.

2. Materials and Methods

2.1. Study Area

The study region is Keonjhar (also spelled as Kendujhar), one of the 30 administrative districts of Odisha in eastern India. The name 'Kendujhar' is derived from 'Kendu' (East-Indian Ebony) and 'Jhar' (water springs). The district consists of three administrative sub-divisions, 13 tehsils, and 13 administrative blocks. As per Census 2011, 86% of the population resides in rural areas, while 14% live in urban settings. The district has a significant tribal population, with Scheduled Castes (SC) and Scheduled Tribes (ST) comprising 11.4% and 45.4%, respectively, figures that surpass the state averages of 17.1% (SC) and 22.8% (ST).

Geographically, Keonjhar spans from 21.01° N to 22.16° N latitude and 85.18° E to 86.37° E longitude, covering a total area of 8,303 sq. km. It is bordered by Mayurbhanj, Balasore, and Bhadrak on the east, Sundargarh on the west, and Jajpur on the south. The Keonjhar Forest Division lies between 21°37'44"N and 85°37'50"E, characterized by a diverse mix of moist deciduous and semi-evergreen forests. These forests support a wide range of biodiversity and are crucial for the livelihoods of tribal communities that rely on forest resources for both consumption and sale.

The region features two major soil zones, laterite and red soil, shaped by its unique topography, climate, and geo-hydrology. The mean annual rainfall is 1487.7 mm, with over half received during the South-West monsoon months of June to August. The average temperature ranges between 11.5°C and 39.4°C. These ecological conditions significantly influence local flora, farming practices, and natural resource use.

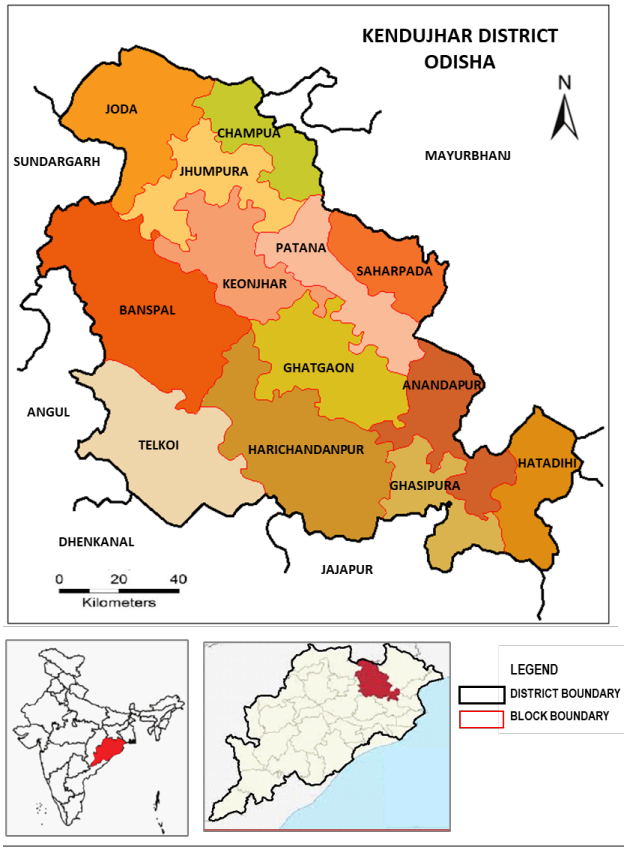

Figure 1. Location Map of the Study Area.

Source: National Informatics Centre, Ministry of Electronics & Information Technology, Government of India.

2.2. Data Collection

Primary data was collected using a multi-stage random sampling technique. The Banspal block in Keonjhar district was selected as the initial study site. In the second stage, four villages, Gonasika, Kadalibadi, Upar Baitarani,

and Guptaganga, were chosen based on their high tribal population density and the communities' potential interest in cultivating locally grown vegetables and cereals. These villages were specifically selected due to their land and water resource availability, despite the limited scientific knowledge among residents regarding climate-resilient crops and their nutritional benefits.

Data was collected through structured interview schedules administered via personal interviews with tribal households. A total of 120 households (n = 120) were surveyed, with 30 from each of the four selected villages, ensuring a representative sample to meet the research objectives and formulate recommendations for promoting year-round vegetable cultivation at the household level.

Figure 2 illustrates how various theories provide a solid foundation for analyzing the multifunctional role of home gardens in tribal livelihoods. They frame home gardens not merely as agricultural spaces but as adaptive systems that respond to environmental, economic, and social vulnerabilities, making them indispensable in climate change adaptation strategies and sustainable development.

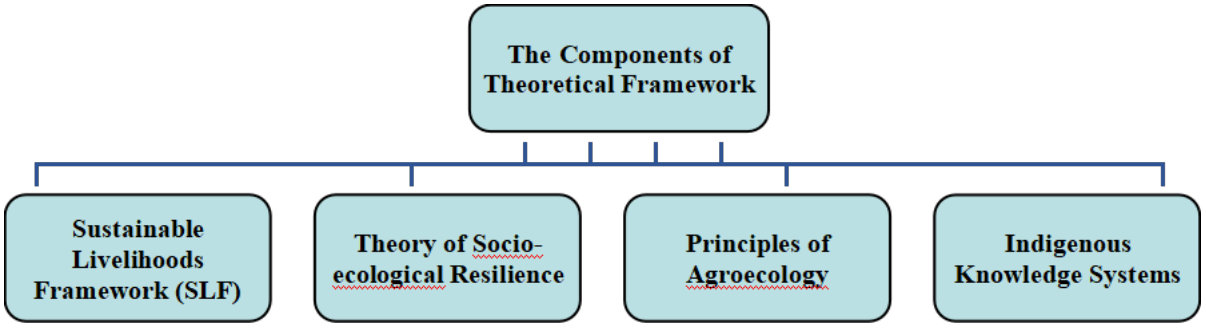

Figure 2. Theoretical Framework of the Study.

A study by Mapara (2009) on Indigenous Knowledge Systems in Zimbabwe highlights the sustained efforts of Indigenous communities to preserve and develop ancestral knowledge [29]. Despite external policies aimed at influencing or controlling their choices, these communities actively reaffirm their identity through such practices [29]. A similar phenomenon is observed among Indigenous populations in the Keonjhar district, where home gardens are cultivated using locally preserved seeds. These communities not only maintain but also improve seed quality through the application of Indigenous knowledge systems. Galhena et al. (2013) examined home gardens as a strategic approach to improving household well-being and food security [21]. Their study found that increased food production and accessibility are key contributors to food security. Home gardens support household nutrition by providing energy-rich and nutrient-dense produce. In a related study conducted in Indonesia, cited by Galhena et al., home gardens accounted for approximately 18% of household calorie consumption and fulfilled a significant portion of protein requirement [21].

Pandey et al. (2017) conducted a study in the Garhwal Himalayas to assess indicators relevant to the Sustainable Livelihoods Framework in the context of climate change adaptation. The research emphasized that households typically make rational choices based on available resources such as labour and financial capital. Livelihood strategies are shaped by a combination of human, social, and financial assets. The decision to establish a home garden, for instance, often depends on the availability of financial and institutional support, making it a viable strategy for mitigating climate-induced livelihood vulnerabilities [20].

Dubey (2023) explored the nutritional and economic impacts of both planned and unplanned home gardening practices. The findings revealed that home gardens yielded an additional return of 34.46%, resulted in a monthly saving of ₹54 on vegetable purchases, and led to annual household savings of up to ₹9,490. These outcomes underscore the significant economic and health benefits of home gardening as a practical response to climate challenges [22]. Aligned with socio-descriptive approaches commonly used in participatory rural studies, this investigation employed a combination of quantitative and qualitative methods to assess the role of home gardens in household resilience. Following methodologies

documented in rural livelihood research [32], the study employed structured interviews combining closed-ended questions, with fixed response options, and open-ended questions that allowed respondents to elaborate on the significance of home gardens in their everyday lives.

The Problem Facing Index (PFI) was used as a diagnostic tool to quantitatively assess and rank the severity of challenges encountered by tribal households engaged in home gardening. Adapted from Alam et al. (2018) and Ali & Hossain (2010), the PFI methodology assigns weighted scores to responses based on a scale of perceived problem severity, generating a composite index that reflects the relative intensity of each challenge [33,34]. The application of PFI is particularly justified in participatory rural research, where it enables the conversion of qualitative perceptions into structured, quantitative data. Grounded in community-reported experiences, the use of PFI complements the study's theoretical foundation, rooted in the Sustainable Livelihoods Framework (SLF) and socio-ecological resilience theory. It offers a systematic lens through which to understand the complex, interlinked livelihood challenges faced by marginalized communities.

2.3. PFI Calculation

To assess the challenges faced by tribal households in home gardening, a set of nine key issues was identified through focused discussion sessions between the researcher and the respondents The respondents were asked to evaluate the importance of these issues using several specific statements. Each statement was assigned a score of 0, 1, 2, or 3, reflecting increasing levels of significance.

The Problem Facing Index (PFI) for households was calculated using the following formula [28]:

$$PFI = Pn \times 0 + Pl \times 1 + Pm \times 2 + Ph \times 3 \quad (1)$$

Where:

Pn = Number of respondents selecting "Not a problem" (score 0)

Pl = Number of respondents selecting "Low problem" (score 1)

Pm = Number of respondents selecting "Moderate problem" (score 2)

Ph = Number of respondents selecting "High problem" (score 3)

The minimum possible PFI value is 0, while the maximum possible value is 360, with a score of 360 indicating the most severe problem faced by tribal households in home gardening.

During the design of the interview schedule, a combination of techniques was used, including closed-ended questions with fixed responses and open-ended questions that allowed household heads to articulate the significance of home gardens for themselves and their families. Focus group discussions were conducted with multiple households, as illustrated in **Figure 3**, during the farming season in December and January. Women engaged in home gardening were key participants, contributing to a deeper understanding of the opportunities and challenges associated with this practice. The inclusion of open-ended questions further facilitated the expression of lived experiences and personal observations, particularly regarding the most important plants cultivated in the study area and the difficulties in accessing suitable seeds. However, several challenges affected the conduct of these discussions like the domestic responsibilities of women, which complicated scheduling, as well as adverse weather and seasonal conditions, which limited the number of focus groups that could be organized.

Figure 3. Focus Group Discussion with Researcher in the Study Area.

3. Results

3.1. Quantitative Analysis

The study's findings highlight the demographic characteristics, vegetable consumption practices, and economic contributions of home gardens among tribal households. These insights help in understanding the role of home gardening as a climate adaptation strategy while identifying key challenges and opportunities for improvement.

Table 1 presents the household size, educational attainment, and vegetable handling practices among respondents. The data indicate that 75% of families had 3-4 members, while smaller families (1-2 members) accounted for only 10%. Larger families of more than five members were relatively uncommon (8%).

Table 1. Demographic Profile of Respondents.

Factors	Category	Percentage (%)
Family size	1–2	10
	3–4	75
	4–5	7
	Above 5	8
Level of education	Illiterate or up to primary (≤5th class)	65
	Secondary (6th–10th class)	25
	Higher Secondary and above (>10th)	10
Cleaning vegetables with water	Yes	70
	No	30
Washing leafy vegetables before cutting	Yes	12
	No	88

Source: Field survey

Education levels were generally low, with 65% of respondents being illiterate or having completed only up to primary education (≤5th grade). A smaller share had attained secondary education (25%), while only 10% had pursued higher secondary or above.

A notable food safety concern was observed in the way vegetables were handled before consumption. 70% of households washed vegetables before cooking, while 30% did not. More critically, 88% of respondents did not wash leafy vegetables before chopping, despite the risk of nutrient loss. Only 12% reported washing leafy greens before cutting. These findings emphasize the need for improved food hygiene awareness and nutritional education programs within these communities.

Table 2 summarizes the primary vegetables cultivated in home gardens, along with the harvest frequency, growth period, and income generated from these crops per agricultural season. The data reveal that vegetables such as cucumber, bhindi (okra), and bottle gourd provided higher earnings, with farmers earning between ₹700 to ₹1,200 per agricultural cycle. Crops like carrot, radish, and coriander generated relatively lower income (₹300–₹500 per cycle), largely due to shorter harvest periods and lower market demand.

Table 2. Key Vegetables Cultivated in Home Gardens and Income Generated.

Plant name	Growth Cycle (Months)	Harvests/Cycle	Household Income per Agricultural Season (₹)
Carrot (*Daucus carota*)	3–4	1	300–400
Cucumber (*Cucumis sativus*)	3–4	8–10	1000–1200
Bhindi (*Abelmoschus esculentus*)	4–5	10–12	700–900
Guar (*Cyamopsis tetragonoloba*)	3–4	5–6	500–600
Luffa (*Luffa acutangula*)	4	5–6	500–600

Table 2. *Cont.*

Plant name	Growth Cycle (Months)	Harvests/Cycle	Household Income per Agricultural Season (₹)
Bitter gourd (*Momordica charantia*)	4–4.5	6–8	400–600
Bottle gourd (*Lagenaria siceraria*)	4–4.5	8–10	700–800
Palak (*Spinacia oleracea*)	2.5–3	5–6	400–500
Coriander (*Coriandrum sativum*)	2–3	5–6	400–500
Radish (*Raphanus sativus*)	1–2	1	300–400
Bobbarlu (*Vigna unguiculata*)	4–5	5–6	300–500

Source: Field survey.

On average, families engaged in home gardening earned ₹10,000 per agricultural season through the sale of surplus produce. These earnings supplemented household income and improved food security, particularly during the COVID-19 pandemic, when access to external food markets was restricted. These findings align with the studies conducted by [35,36], which highlight the role of home gardening in enhancing food availability and economic resilience during crises.

Productivity in home gardens varied with rainfall and pest conditions. Crops like cucumber and okra, which yielded 8-12 harvests, declined during dry spells, while drought-tolerant crops such as bottle gourd performed steadily. Participants reported lower yields for leafy greens like spinach and coriander during erratic rainfall.

Additionally, respondents noted a shift towards organic farming, avoiding the use of chemical pesticides to reduce health risks [37,38]. Discussions with households revealed that home gardens not only provided essential food resources but also reduced dependency on market-bought vegetables, lowering overall household expenses.

Discussions with the households revealed that home garden produce significantly contributes to the family diet, which nearly always includes paddy. Tribal families were encouraged to cultivate plants rich in antioxidants (such as beta-carotene and vitamin C) and those containing essential minerals like magnesium and calcium, which are beneficial for bone health. To enhance dietary diversity, families were guided to increase the inclusion of leafy vegetables in their home gardens [39]. The researcher's guidance significantly increased awareness among the households about the importance of home gardens for addressing economic challenges caused by climate change.

One key advantage of home gardens is their low water requirement, making them ideal for regions experiencing irregular rainfall patterns due to climate change. Discussions with tribal households during focus group sessions revealed that vegetables grown in home gardens typically required less water compared to paddy cultivation. However, the study found a lack of structured home garden models in the area, emphasizing the need to develop sustainable, seasonally adaptable garden plans. A tribal woman from the study shared her experience in adopting an organized home gardening model:

"*I convinced my husband to invest ₹1,000 in growing cauliflower as a single crop in our home garden. After observing the profits we made, my husband expanded the investment to ₹2,000 and introduced additional crops like eggplant. This demonstrates the adoption of an organized model for garden planning and crop selection.*"

The adoption of organic fertilizers, such as farm waste, vermicompost, and kitchen scraps, marks a significant advancement in the agricultural practices of tribal women [40,41]. This transition prioritizes the use of natural inputs over synthetic fertilizers, particularly during the final tilling process, enhancing soil health and fostering a more sustainable farming environment. To combat pest and disease challenges, tribal farmers increasingly depend on locally sourced, plant-based preparations, which serve multiple purposes, including pest control, plant growth enhancement, and nutrient preservation. By incorporating these traditional and sustainable techniques, tribal farmers not only reduce chemical dependency but also enhance soil fertility and crop resilience, ensuring long-term agricultural

sustainability.

Evidence suggests that these methods yield substantial benefits. The methods of integrated pest management techniques, such as yellow sticky traps to capture insect pests, strategically placed bird perches to encourage natural pest control, and the use of marigold trap cropping to repel harmful insects, has led to a considerable reduction in pest populations and an increase in beneficial species. Households that implemented these sustainable pest management strategies reported lower crop damage and increased yields, leading to higher profitability compared to conventional farming methods. Overall, these strategies contribute to sustainable agricultural practices within the community.

3.2. Challenges Faced by Tribal Households in Home Gardening

In the tribal regions of Odisha, households cultivating home gardens encounter challenges unique to their socio-economic circumstances and environmental conditions [42]. Tribal families highlighted the specific issues they face in maintaining home gardens. These difficulties stem from factors such as climate variability, limited agricultural knowledge, and poor access to resources. These challenges were ranked based on the Problem Facing Index (PFI), which reflects both their frequency and intensity across 120 surveyed households, offering both statistical and qualitative insight (**Table 3**).

Table 3. Ranking of Challenges Faced by the Tribal Households in Home Gardening.

Challenges (In Order of Priority) Not At All		Extent Of Problems (%)					Key Drivers
		Not At All	Low	Medium	High	Pfi	
1.	Climate Variability	7.5	16.7	34.2	41.7	252	Erratic Rainfall, Heat Waves, Pest Outbreaks
2.	Degraded Soil	7.5	13.3	41.7	37.5	251	Climate-Induced Erosion, Over-Cultivation
3.	Wildlife Intrusions	6.7	15.0	41.7	36.7	250	Forest Resource Scarcity, Proximity to Villages
4.	Pests And Crop Diseases	6.7	18.3	50.0	25.0	232	Limited Pest Management, Lack of Organic Inputs
5.	Market Barriers	5.0	33.3	25.0	36.7	232	Lack Of Local Markets, Poor Transportation
6.	Poor Access To Government Schemes	25.0	16.7	25.0	33.3	200	Lack Of Awareness, Bureaucratic Complexity
7.	Lack Of Technical Knowledge	25.0	32.5	17.5	25.0	171	Limited Training, Reliance on Traditional Methods
8.	Lack Of Agricultural Inputs	82.5	16.7	0.8	0.0	140	Scarce Access to Seeds, Fertilizers, And Tools
9.	Water Scarcity	40.8	35.8	16.7	6.7	107	Monsoon Dependency, Lack of Irrigation Infrastructure
10.	Gender Inequality	72.5	25.0	0.0	2.5	39	Limited Decision-Making Power, Unequal Resource Access

Source: Field survey;
* Percentages calculated as: (Count / 120) × 100;
** Drivers identified through household interviews and focus groups.

The findings show that the most critical problems are closely interconnected and rooted in systemic vulnerabilities.

Climate variability emerged as the most significant issue, with a PFI score of 252. This challenge was considered highly severe by 41.7% of respondents and of medium concern by another 34.2%, indicating that more

than three-quarters (75.9%) of tribal households are substantially impacted. Participants linked this to erratic rainfall patterns, prolonged dry spells, and increased pest outbreaks, all of which disrupt planting schedules and reduce productivity. As one farmer remarked, "*Changing rainfall patterns and prolonged droughts have reduced our harvest in recent years. Unpredictable rains and our lack of knowledge about weather conditions are our biggest challenges.*"

Closely following was the issue of degraded soil, with a PFI of 251. A total of 37.5% of respondents reported this as a high-level problem and 41.7% considered it of medium severity, making it a concern for nearly 80% of the households. Soil degradation was attributed to long-standing unsustainable cultivation practices combined with climate-induced erosion, resulting in declining fertility. One respondent expressed "*Earlier, the soil was fertile. But now, after continuous cultivation and heavy rains, it's hard to grow even basic vegetables.*"

Wildlife intrusions also featured prominently, with a PFI score of 250. About 36.7% of households rated it as a high concern and 41.7% as medium, meaning over 78% face regular disturbances from wild animals such as boars and monkeys. This issue is particularly pronounced in settlements near forest edges and has a strong gendered dimension, as women, who are primarily responsible for garden maintenance, are more exposed to risks during such intrusions. One respondent from Gonasika shared, "*Monkeys destroy our bottle gourds (Lagenaria siceraria) before we can even pick them.*"

Pests and crop diseases and market barriers were mid-ranked but still significant, both with a PFI of 232. Pests and diseases were rated high by 25.0% and medium by 50.0%, making it a concern for three-fourths (75%) of households. This stems from limited access to pest management tools and a lack of knowledge about organic practices. Market barriers, such as lack of local markets and poor transportation, were also rated high by 36.7% and medium by 25.0%, affecting over 61% of respondents. These barriers prevent households from selling surplus produce, reducing incentives to invest in home gardens.

Challenges like lack of agricultural inputs (PFI = 140) and water scarcity (PFI = 107) were ranked lower. A striking 82.5% of respondents indicated no issue with agricultural inputs, reflecting that these may not be in use or even accessible. For water scarcity, 40.8% reported no problem, suggesting that water stress is seasonal, especially during pre-monsoon months, and localized rather than uniformly experienced across all households.

Finally, gender inequality was the least prioritized challenge (PFI = 39), with only 2.5% rating it as high and 0.0% as medium, whereas 72.5% indicated it was not a concern. However, qualitative data suggest that this may be underreported, as women often lack decision-making power and access to resources despite being the primary caretakers of home gardens.

3.3. Findings From Focus Group Discussions

Focus group discussions (FGDs) were conducted with 34 participants (23 women and 11 men), aged between 25 and 60 years, drawn from four villages, including Gonasika, Kadalibadi, Upar Baitarani, and Guptaganga. The discussions revealed that home gardens contribute significantly to daily household food needs, particularly during the off-season and periods of food scarcity.

3.3.1. Climate Adaptation Strategies

Participants strongly linked erratic rainfall patterns and prolonged droughts to declining harvests. A 55-year-old female respondent from Guptaganga noted: "*Rainfall is no longer predictable. Sometimes it rains too much, and other times not at all. My spinach (Spinacia oleracea) and coriander (Coriandrum sativum) wilt before they're ready for harvest.*" Another farmer from Upar Baitarani highlighted: "*Our carrots (Daucus carota) no longer grow like before. The soil is dry and cracked.*" Respondents from Gonasika reported increased erosion due to heavy rainfall

These experiences underscore the impact of climate variability, ranked as the most critical issue in the PFI analysis (PFI = 252). The observations from FGDs substantiate survey findings that highlight how irregular weather affects planning and productivity. The reliance on traditional practices, such as using cow dung and planting by the lunar calendar, offers some resilience, but participants acknowledged these methods are increasingly insufficient in the face of intensified climate stress.

3.3.2. Economic and Nutritional Impacts

Participants consistently shared how home gardens reduced their dependence on markets, especially during the COVID-19 pandemic. A 42-year-old male participant from Kadalibadi stated: "*During the lockdown, when we couldn't access markets, we survived on our home-grown vegetables and wild leafy greens.*" Similarly, a 48year-old woman from Upar Baitarani explained: "*We grew cauliflower (Brassica oleracea), eggplant (Solanum melongena), and tomato (Solanum lycopersicum), which helped us eat better and save money.*"

These insights reinforce findings from **Table 2**, where home gardens were shown to yield an average seasonal income of ₹10,000. Crops such as cucumber (*Cucumis sativus*) and bhindi (*Abelmoschus esculentus*) were cited as income generators. These qualitative narratives also reflect a growing shift toward organic methods, with households using ash, cow dung, and compost to enhance soil fertility—connecting to broader themes of climate adaptation and agroecological sustainability.

3.3.3. Gender and Decision-Making

The FGDs revealed that women are the primary caretakers of home gardens, yet face structural barriers in decision-making. A 38-year-old woman from Gonasika recounted: "*I convinced my husband to invest ₹1,000 in cauliflower. When it yielded profit, we expanded the garden. But decisions about spending and crop selection were still made by him.*"

Although gender inequality received a lower PFI score (PFI = 39), focus group narratives exposed its deeper implications. Women often lack access to training, technical knowledge, and financial resources despite being the main contributors to food production. This discrepancy illustrates how qualitative data can reveal nuances not fully captured by quantitative surveys, highlighting the need for mixed-methods integration.

Participants expressed a desire for more technical training, improved seed availability, and market access, issues aligned with mid-tier PFI scores like market barriers (PFI = 232) and lack of technical knowledge (PFI = 171). Despite these limitations, there was significant enthusiasm for continuing home gardening, especially when supported by community training or demonstration models.

3.4. Evidence-Based Solutions for Tribal Home Gardens

To enhance the sustainability and productivity of home gardens in tribal areas, targeted interventions are necessary. Based on mixed-methods insights from both the Problem Facing Index (PFI) and focus group discussions, the following sub-sections outline priority strategies:

3.4.1. Top Priority: Climate Adaptations (PFI = 252)

This directly addresses climate variability, the highest-ranked challenge in the PFI. Participants identified erratic rainfall and prolonged droughts as major disruptors of crop productivity. Crops like spinach (Spinacia oleracea), coriander (Coriandrum sativum), and carrot (Daucus carota) were most affected. Focus group data supported the urgency of interventions, such as seed distribution for climate-resilient varieties and short-term relief during extreme weather.

Long-term strategies should focus on integrating weather-monitoring tools and agro-advisory services. For example, introducing mobile-based weather alerts and seasonal planning apps tailored to the tribal context can help farmers make informed decisions. Government-supported programs should prioritize climate-adapted cropping systems and promote rain-fed garden models to reduce vulnerability.

3.4.2. Secondary Priorities: Soil Health & Wild-life Management

These emerged as the second and third highest PFI concerns (PFIs = 251 and 250, respectively). Degraded soil, driven by over-cultivation and climate erosion, calls for community-based composting units and widespread training on mulching, cover crops, and vermicomposting. Pilot demonstrations using chili fences and marigold trap crops showed promise in reducing pest loads and deterring wild animals.

Participants in FGDs recommended community training on organic fertilizers and locally available bio-repellents. High indigenous adoption rates of cover crops,

like Luffa (Luffa acutangula), further support scaling these models. Fencing innovations should combine traditional practices (e.g., thorn hedges) with eco-friendly deterrents.

3.4.3. Addressing Structural Gaps: Gender (PFI = 39) and Markets (PFI = 232)

While gender inequality ranked lowest in the PFI, FGDs revealed significant barriers in decision-making and access to finance and training for women, who are often primary cultivators. Programs should focus on empowering women through targeted agricultural extension, leadership training, and access to women-led farmer producer groups.

Market constraints were a mid-tier challenge. Households cited difficulty in transporting surplus vegetables due to inadequate infrastructure. Solutions include establishing mobile markets, farmer cooperatives, and developing value-added produce lines (e.g., pickles, sun-dried vegetables). Market mapping and creation of producer-consumer linkages can ensure stable demand and reduce post-harvest losses.

These multi-level strategies, grounded in both quantitative PFI scores and qualitative FGD narratives, highlight the interconnected nature of ecological, technical, and social factors in home gardening resilience. Implementation must prioritize integration across short-term relief and long-term sustainability.

These measures can help tribal communities overcome challenges and make home gardens a sustainable source of nutrition, income, and climate adaptation for tribal households.

4. Discussion

This study highlights the vital role of home gardens in building climate resilience and improving the socio-economic well-being of tribal communities in Keonjhar, Odisha. Using the Sustainable Livelihoods Framework (SLF) and socio-ecological resilience theory, the findings illustrate both the strengths and constraints of these systems (**Table 4**).

Table 4. Summary of the Effects of Home Gardening on Sustainable Livelihood Framework (SLF) Capitals in Study Area.

SLF Capital	Enhancement through Home Gardening	Limitations/Constraints
Natural	Use of local land and organic composting enhanced soil fertility; promoted crop diversity	Soil degradation and wildlife intrusion (PFI = 251, 250) reduce productivity
Human	Increased awareness of traditional methods and organic inputs	Lack of formal technical training (PFI = 171)
Social	Community-based seed sharing and group fencing initiatives	Gender inequality restricts decision-making (PFI = 39)
Financial	Seasonal income of ₹10,000; reduced market dependency by ~70%	Poor infrastructure and limited access to markets (PFI = 232)
Physical	Use of household tools and basic irrigation systems	Lack of advanced tools, fencing, and resilient infrastructure

Table 4 clearly illustrates how home gardens intersect with each SLF capital, offering significant enhancements in natural and financial capital, while pointing to persisting systemic limitations, especially in infrastructure, gender equity, and technical training.

The application of socio-ecological resilience theory reveals how tribal communities adapt by modifying traditional practices, such as aligning planting cycles with lunar phases and using indigenous pest repellents. These adaptive capacities, however, need reinforcement through institutional support.

Focus Group Discussions (FGDs) added rich context to the PFI rankings, affirming that climate variability (PFI = 252) was a major driver of multiple stresses, including lower yields and erratic harvest planning. The integration of qualitative narratives helped explain not just what the challenges were, but why they persist and how local knowledge responds to them.

For instance, chili fencing and marigold trap cropping were readily adopted because they aligned with existing knowledge systems, unlike top-down irrigation schemes that lacked community ownership. This demonstrates that

effective interventions must be participatory and context-sensitive.

Comparative studies strengthen these interpretations. Mallick et al. (2024) showed similar benefits of home gardens for dietary resilience and gender empowerment in the Western Ghats [6], while Galhena et al. (2013) in Sri Lanka found that structured home gardening programs improved nutrition and self-reliance [21]. These parallels validate the relevance of such approaches in other socio-ecological settings.

Policy recommendations include integrating home gardens into schemes like MGNREGA and the National Horticulture Mission, promoting women-led farmer groups, and embedding weather forecasting into rural extension services. Both short-term (seed kits, fencing materials) and long-term (weather tech, training) strategies must be deployed.

Future research should include more tribal communities, examine seasonal variability, and track the long-term impact of interventions. Emphasis on documenting community-led innovations will be key for scaling successful models.

Ultimately, home gardens are not merely subsistence systems but socio-ecological systems that can strengthen climate adaptation, nutrition, and rural resilience. Unlocking their full potential requires blending traditional knowledge with targeted support and participatory governance structures.

5. Conclusions

This study demonstrates that home gardens are not merely subsistence plots but scalable and replicable socio-ecological systems that enhance climate resilience, food security, and sustainable livelihoods among tribal communities in Keonjhar, Odisha. By applying the Sustainable Livelihoods Framework (SLF) and socio-ecological resilience theory, the research illustrates how these micro-systems strengthen natural, social, human, financial, and physical capital within vulnerable communities. Notably, these gardens reduced market dependency by over 70% during crisis periods and contributed approximately ₹10,000 per agricultural season to household income.

Despite these benefits, challenges such as climate variability, soil degradation, and wildlife intrusions continue to hinder long-term sustainability, as highlighted by both the Problem Facing Index (PFI) and focus group discussions. Addressing these issues requires a combination of immediate interventions—such as seed kits, organic inputs, and fencing—and long-term strategies including mobile-based weather advisories, decentralized training programs, and a strong emphasis on women's empowerment. Tailored, community-driven interventions rooted in indigenous knowledge will be essential to enhance the resilience and productivity of home gardens.

Scalable and adaptable across similar socioecological contexts in India and South Asia, the home garden model aligns well with national flagship programs such as MGNREGA, Krishi Vikas Yojana, the National Rural Livelihoods Mission (NRLM), and the National Adaptation Fund for Climate Change (NAFCC). Future research should focus on seasonal dynamics, cross-regional replicability, and innovations co-developed with tribal communities to mainstream home gardens as a cornerstone of sustainable, inclusive, and climate-resilient rural development.

Author Contributions

Conceptualization, D.J.; methodology, D.J.; software, A.S.; formal analysis, C.M. and P.R.; investigation, P.R. and S.C.S.; data curation, G.H.S.; writing-original draft preparation, S.D.; writing-review & editing, P.M. and S.C.S. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The authors are solely responsible for the analysis and interpretation of the data presented in this article.

Acknowledgments

The authors acknowledge the unconditional cooperation extended by the respondents in the study area.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Abbass, K., Qasim, M.Z., Song, H., et al., 2022. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental Science and Pollution Research. 29(28), 42539–42559. DOI: https://doi.org/10.1007/s11356-022-19718-6

[2] Core Writing Team, Lee, H., Romero, J., (eds.), 2023. IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC: Geneva, Switzerland. DOI: https://doi.org/10.59327/ipcc/ar6-9789291691647

[3] Korpelainen, H., 2023. The Role of Home Gardens in Promoting Biodiversity and Food Security. Plants. 12(13), 2473. DOI: https://doi.org/10.3390/plants12132473

[4] Cassin, J., Ochoa-Tocachi, B.F., 2021. Learning from indigenous and local knowledge: The deep history of nature-based solutions. In: Cassin, J., Matthews, J.H., Gunn, E.L. (eds.). Nature-based Solutions and Water Security. Elsevier: Amsterdam, Netherlands. pp. 283–335. DOI: https://doi.org/10.1016/B978-0-12-819871-1.00012-9

[5] Singh, P.K., Chudasama, H., 2021. Pathways for climate change adaptations in arid and semi-arid regions. Journal of Cleaner Production. 284, 124744. DOI: https://doi.org/10.1016/j.jclepro.2020.124744

[6] Mallick, M., Singh, P.K., Pandey, R., et al., 2024. Harvesting resilience: Tribal home-gardens as socio-ecological solutions for climate change adaptation and sustainable development in a protected area. Journal of Cleaner Production. 445, 141174. DOI: https://doi.org/10.1016/j.jclepro.2024.141174

[7] Pala, N.A., Sarkar, B.C., Shukla, G., et al., 2019. Floristic composition and utilization of ethnomedicinal plant species in home gardens of the Eastern Himalaya. Journal of Ethnobiology and Ethnomedicine. 15(1), 1–16. DOI: https://doi.org/10.1186/s13002-019-0293-4

[8] Niñez, V.K., 1984. Household gardens: Theoretical considerations on an old survival strategy. International Potato Center: Lima, Peru.

[9] Rowe, W.C., 2009. Kitchen Gardens in Tajikistan: The economic and cultural importance of small-scale private property in a post-Soviet society. Human Ecology. 37, 691–703. DOI: https://doi.org/10.1007/s10745-009-9278-6

[10] Puri, S., Nair, P.K.R., 2004. Agroforestry research for development in India: 25 years of experiences of a national program. Agroforestry Systems. 61(1), 437–452. DOI: https://doi.org/10.1023/B:AGFO.0000029014.66729.e0

[11] Ruthenberg, H., 1981. Farming systems in the tropics, 3rd ed. CABI: Wallingford, UK.

[12] Asaduzzaman, M., Naseem, A., Singla, R., 2011. Benefit-cost assessment of different homestead vegetable gardening on improving household food and nutrition security in rural Bangladesh. Proceedings of the Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting; 24–26 July 2011; Pittsburgh, Pennsylvania, USA. pp. 1–25. DOI: https://doi.org/10.22004/ag.econ.104525

[13] Ghazali, S., 2013. House gardens as a symbol of place, identity and sense of belonging for low-cost flat residents in urbanizing Malaysia. International Journal of Social Science and Humanity. 3(2), 171–175. DOI: https://doi.org/10.7763/IJSSH.2013.V3.221

[14] Rehman, B., Faiza, M., Qaiser, T., et al., 2018. Social Attitudes towards Kitchen Gardening. Journal of Social Sciences (COES&RJ-JSS). 2(1), 27–34. DOI: https://doi.org/10.25255/jss.2013.2.1.27.34

[15] Talukder, A., Pee, S., Taher, A., et al., 2001. Improving food and nutrition security through homestead gardening in rural, urban and periurban areas in Bangladesh. Resource Centre in Urban Agriculture & Forestry, UA-Magazine, 45–46.

[16] Heim, S., Stang, J., Ireland, M., 2009. A Garden Pilot Project Enhances Fruit and Vegetable Consumption among Children. Journal of the American Dietetic Association. 109(7), 1220–1226. DOI: https://doi.org/10.1016/j.jada.2009.04.009

[17] Ivanova, T., Bosseva, Y., Chervenkov, M., et al., 2021. Enough to Feed Ourselves!—Food Plants in Bulgarian Rural Home Gardens. Plants. 10(11), 2520. DOI: https://doi.org/10.3390/plants10112520

[18] Mulia, R., Le, T.T., Tran, N.D., et al., 2022. Policy

Support for Home Gardens in Vietnam Can Link to Sustainable Development Goals. Agriculture. 12(2), 253. DOI: https://doi.org/10.3390/agriculture12020253

[19] Calderón-Contreras, R., White, C.S., 2020. Access as the Means for Understanding Social-Ecological Resilience: Bridging Analytical Frameworks. Society & Natural Resources. 33(2), 205–223. DOI: https://doi.org/10.1080/08941920.2019.1597233

[20] Pandey, R., Jha, S.K., Alatalo, J.M., et al., 2017. Sustainable livelihood framework-based indicators for assessing climate change vulnerability and adaptation for Himalayan communities. Ecological Indicators. 79, 338–346. DOI: https://doi.org/10.1016/j.ecolind.2017.03.047

[21] Galhena, D.H., Freed, R., Maredia, K.M., 2013. Home gardens: A promising approach to enhance household food security and wellbeing. Agriculture & Food Security. 2, 8. DOI: https://doi.org/10.1186/2048-7010-2-8

[22] Dubey, S.D., 2021. Impact of planned and non-planned kitchen gardening for improvement of nutrition and economical benefits of societies. Journal of Pharmacognosy and Phytochemistry. 10(1S), 502–504.

[23] Okvat, H.A., Zautra, A.J., 2011. Community Gardening: A Parsimonious Path to Individual, Community, and Environmental Resilience. American Journal of Community Psychology. 47, 374–387. DOI: https://doi.org/10.1007/s10464-010-9404-z

[24] Tomatis, F., Egerer, M., Correa-Guimaraes, A., et al., 2023. Urban Gardening in a Changing Climate: A Review of Effects, Responses and Adaptation Capacities for Cities. Agriculture. 13(2), 502. DOI: https://doi.org/10.3390/agriculture13020502

[25] Guodaar, L., Kabila, A., Afriyie, K., et al., 2023. Farmers' perceptions of severe climate risks and adaptation interventions in indigenous communities in northern Ghana. International Journal of Disaster Risk Reduction. 95, 103891. DOI: https://doi.org/10.1016/j.ijdrr.2023.103891

[26] Natarajan, N., Newsham, A., Rigg, J., et al., 2022. A sustainable livelihoods framework for the 21st century. World Development. 155, 105898. DOI: https://doi.org/10.1016/j.worlddev.2022.105898

[27] Cretney, R., 2014. Resilience for whom? Emerging critical geographies of socio-ecological resilience. Geography Compass. 8(9), 627–640. DOI: https://doi.org/10.1111/gec3.12154

[28] Wang, H., Qin, L., Huang, L., et al., 2007. Ecological agriculture in China: principles and applications. Advances in Agronomy. 94, 181–208.

[29] Mapara, J., 2009. Indigenous knowledge systems in Zimbabwe: Juxtaposing postcolonial theory. Journal of Pan African Studies. 3(1), 139–155.

[30] Maredia, K.M., Dissanayake, D.H.G., Freed, R., et al., 2023. Building sustainable, resilient, and nutritionally enhanced local food systems through home gardens in developing countries. Development in Practice. 33(7), 852–859. DOI: https://doi.org/10.1080/09614524.2023.2218068

[31] Sharma, R., Mina, U., Kumar, B.M., 2022. Homegarden agroforestry systems in achievement of Sustainable Development Goals. A review. Agronomy for Sustainable Development. 42(3), 44. DOI: https://doi.org/10.1007/s13593-022-00781-9

[32] Chambers, R., 1995. Poverty and livelihoods: whose reality counts?. Environment and Urbanization. 7(1), 173–204.

[33] Alam, M.Z., Islam, M.S., Kabir, M.H., 2018. Problems faced by the bean farmer in selected areas of Pabna district in Bangladesh. Research in Agriculture Livestock and Fisheries. 5(1), 11–18.

[34] Ali, M.S., Hossain, M.M., 2010. Factors influencing the performance of farmers in broiler production of Faridpur District in Bangladesh. World's Poultry Science Journal. 66(1), 123–131. DOI: https://doi.org/10.1017/S0043933910000127

[35] Khan, M.M., Akram, M.T., Janke, R., et al., 2020. Urban Horticulture for Food Secure Cities through and beyond COVID-19. Sustainability. 12(22), 9592. DOI: https://doi.org/10.3390/su12229592

[36] Lal, R., 2020. Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. Food Security. 12(4), 871–876. DOI: https://doi.org/10.1007/s12571-020-01058-3

[37] Jindal, S.K., Dhaliwal, M.S., 2017. Development of vegetable nutrition garden model for diet diversification and improved nutrition security of urban and peri-urban households. International Journal of Horticulture. 7(24), 219–228. DOI: https://doi.org/10.5376/ijh.2017.07.0024

[38] Hansen, L.-S., Kihagi, G.W., Agure, E., et al., 2023. Sustainable home gardens in Western Kenya: A qualitative study for co-designing nutrition-sensitive interventions. Journal of Rural Studies. 103, 103132. DOI: https://doi.org/10.1016/j.jrurstud.2023.103132

[39] Thamilini, J., Wekumbura, C., Mohotti, A.J., et al., 2019. Organized Homegardens Contribute to Micronutrient Intakes and Dietary Diversity of Rural Households in Sri Lanka. Frontiers in Sustainable

Food Systems. 3, 94. DOI: https://doi.org/10.3389/fsufs.2019.00094

[40] Swarnam, T., Velmurugan, A., George, Z., et al., 2014. Integrated farming system for sustainable livelihood in Tribal Areas of Nicobar Island, India. Journal of the Andaman Science Association. 19(1), 19–22.

[41] George, M.V., Christopher, G., 2020. Structure, diversity and utilization of plant species in tribal homegardens of Kerala, India. Agroforestry Systems. 94(1), 297–307. DOI: https://doi.org/10.1007/s10457-019-00393-5

[42] Ogutu, S.O., Mockshell, J., Garrett, J., et al., 2023. Home gardens, household nutrition and income in rural farm households in Odisha, India. Journal of Agricultural Economics. 74(3), 744–763. DOI: https://doi.org/10.1111/1477-9552.12525