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Climate-Smart Biodiversity Agroecological Tourism Gardens (CBATG): A Sustainable Model for Climate Resilience and Rural Development

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ABSTRACT

The Climate-Smart Biodiversity Agroecological Tourism Gardens (CBATG) is a new methodology dealing with the problems of climate change, biodiversity loss, and rural poverty simultaneously. In this study, we present CBATG as a model of eco-sustainable development that combines climate-smart agriculture, biodiversity enhancement, and agro-tourism to build resilient socio-ecological systems. Using a systematic review of selected case studies and policy documents, we show how CBATGs can increase carbon capture in agroforestry, reduce the population of endangered species through habitat restoration, and improve alternative income opportunities for the community through eco- tourism. This construction supports'

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works of the United Nations' Sustainable Development Goals (SDGs) such as 13, 15, and 8. Most importantly, our research indicates the prerequisite conditions of successful CBATG implementation as: (1) funding from all sectors, (2) bottom-up community engagement design, and (3) positive-cum-initiatives from government networks. Others include poorly defined land rights and insufficient political will or regulations which we solve with our policy recommendations. Straddling the boundary between development and conservation gives vulnerable regions across the globe a strategic outline for sustainable rural development using CBATGs.

Keywords: Agroecological Tourism Biodiversity Conservation, Community Livelihoods Climate Resilience, Carbon Sequestration, Ecotourism, Sustainable Rural Development

Introduction

Climate Crisis and Ecological Imperatives: The Urgency for Transformative Solutions

The concurrent crises of climate change and biodiversity loss represent existential threats to global ecosystems and human wellbeing, with particularly severe implications for developing nations like Pakistan. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2022) underscores that South Asia has become a climate hotspot, experiencing intensified monsoon variability, glacial retreat, and extreme heat events that directly threaten agricultural productivity and food security. Parallel to these climatic challenges, the 2021 FAO State of Biodiversity for Food and Agriculture report reveals alarming rates of species extinction and genetic erosion, with approximately 33% of soils globally degraded due to unsustainable farming practices.

Pakistan's agricultural sector exemplifies this dual crisis, contributing nearly 43% of the country's employment while simultaneously accounting for significant environmental degradation (World Bank, 2023). Conventional farming methods, characterized by monoculture systems, excessive chemical inputs, and inefficient water use, have depleted 60% of Pakistan's arable land while generating 18% of national greenhouse gas emissions (Pakistan Economic Survey, 2022). This unsustainable paradigm has created a vicious cycle where climate stressors reduce yields, prompting further expansion into fragile ecosystems, thereby accelerating biodiversity loss.

The imperative for transformative agricultural models has never been more critical. Recent scholarship on nature-based solutions (Cohen-Shacham et al., 2019) demonstrates that integrated approaches combining climate adaptation, biodiversity conservation, and livelihood support can yield 40-60% greater resilience outcomes compared to sectoral interventions. The United Nations Decade on Ecosystem Restoration (2021-2030) specifically calls for innovations that reconcile production with conservation, particularly in vulnerable agro-ecosystems like those found across Pakistan's diverse ecological zones from the Himalayan highlands to the Indus delta.

Within this context, Climate-Smart Biodiversity Agroecological Tourism Gardens (CBATGs) emerge as a potentially transformative model. These systems build upon three evidence-based pillars:

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Agroecological intensification (sensu Altieri & Nicholls, 2018) that enhances yields through ecological processes rather than external inputs

Biodiversity corridors that maintain ecosystem services while providing climate refugia for native species

Community-centric ecotourism that generates alternative income streams while fostering environmental stewardship

The conceptual innovation of CBATGs lies in their synergistic integration of these typically siloed approaches, offering a comprehensive framework to address SDGs 2 (Zero Hunger), 13 (Climate Action), and 15 (Life on Land) simultaneously. This study positions CBATGs as both a mitigation strategy - through carbon sequestration in perennial vegetation - and an adaptation measure via diversified livelihood options that reduce smallholder vulnerability to climate shocks.

Definition and Significance of Climate-Smart Biodiversity Agroecological Tourism Gardens (CBATGs)

CBATGs or "Climate-Smart Biodiversity Agroecological Tourism Gardens" is a new model of Biodiversity Conservation and Sustainable Land Use Systems incorporating three agroecological components: (1) healing the land through regenerative farming that includes polycultures, organic inputs, and water-saving methods; (2) conservation of biodiversity through habitat improvement, the growing of indigenous ecosystem services boosting species, and ecological civics restoration which enhance ecosystem resilience towards disturbances; and (3) eco-tourism which diversifies income by transforming agricultural areas into amusement and education hubs (Altieri & Nicholls, 2018; UNEP, 2022). These targeted ecosystem approaches achieve multifunctionality on the one hand and mitigation and adaptation prospects on the other hand, capturing 2–5 tons of CO_2 per hectare per year (Mbow et al., 2019), boosting pollinator populations by 30–50% when compared to conventional farms (Kremen & Merenlender, 2018), and increasing household income by 20–40% due to tourism-related activities (FAO, 2023). CBATGs put into action the "nature-positive solutions" strategy underscored by the UN Decade on Ecosystem Restoration (2021–2030), whereby simultaneously addressing SDG 13 (Climate Action) through smart carbon practices, SDG 15 (Life on Land) through biodiversity conservation, and SDG 8 (Decent Work) by green employment opportunities in the rural areas.

Their transformative potential stems from integrating the two worlds of production and conservation, creating a sustainable balance between ecosystem health and human benefit — especially for climate vulnerable nations such as Pakistan where 65 percent of the population is dependent on agriculture in the face of rising ecological pressures (World Bank, 2023).

Research Problem and Questions

Despite their potential, CBATGs remain understudied, with limited empirical evidence on their scalability, socio-economic viability, and ecological efficacy. This study addresses the following questions:

How do CBATGs contribute to climate resilience and biodiversity conservation?

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What are the key challenges and success factors in implementing CBATGs?
How can policymakers and local communities leverage CBATGs for sustainable development?

Objectives of the Study

Analyze the ecological and socio-economic benefits of CBATGs.
Evaluate case studies of existing CBATG models.
Provide policy recommendations for upscaling CBATGs in vulnerable regions.

Scope and Limitations

The study focuses on CBATGs in tropical and subtropical regions, with data drawn from peer-reviewed literature, field reports, and stakeholder interviews. Limitations include the scarcity of long-term impact studies and regional variability in implementation.

Research Methodology

This study uses a qualitative research approach to understand Climate-Smart Biodiversity Agroecological Tourism Gardens (CBATGs) in Pakistan's three agroecological zones: the agroforestry systems of Punjab, the mountain terraces of Khyber Pakhtunkhwa, and the deltaic regions of Sindh. These were chosen because they are susceptible to climate change and have potential for sustainable tourism development. Participants were purposefully selected, including 15-20 traditional agroecology smallholder farmers, 5-10 rural eco-tourism business people (5 government/NGO representatives from climate/agriculture policy sectors), and snowball sampling was also used to locate other key informants. Data collection included multiple semi-structured interviews (30-45 minutes) about challenges and benefits of adopting CBATGs, field observations of agroecological practices and tourism infrastructure, and 2-3 focus groups with farmer cooperatives to assess community impac ts ensuring data triangulation. The analytical framework used was qualitative thematic analysis (Braun & Clarke, 2006) on socioecological outcomes using NVivo for coding transcripts and field notes, while a comparative case study analysis was conducted against Pakistan's policy context. By using this methodology, I gained insights into the potential and challenges of CBATGs in Pakistan's environment.

Literature Review

Climate Smart Agriculture and Biodiversity Conversation

Climate-smart agriculture has developed as a strategy for tackling the multi-faceted issues of food security, climate change, and sustainability simultaneously. It is summarized in its definition: "sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change, and reducing and/or removing green-house gas emissions where possible" (Keesstra et al., 2023). This approach has three sides to it: agricultural systems need to transform in order to satisfy the increasing food needs, and at the same time address the climate challenges.
The landscape approach is core to the effectiveness of CSA practices. As Scherr et al. point out, "For agricultural systems to achieve climate-smart objectives, including

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improved food security and rural livelihoods as well as climate change adaptation and mitigation, they often need to take a landscape approach; they must become 'climate-smart landscapes'"(Scherr et al., 2012). This landscape view captures the need for farm-based actions to be integrated with ecosystem-based management to realize the full potential of the benefits.

Combining biodiversity conservation with CSA is becoming increasingly crucial because of the evidence that claims diersified agricultural systems have better resilience to climate stress. Agricultural biodiversity's genetic, species, and ecosystem facets enhance productivity, adaptability, and resilience at the system (Villanueva et al., 2017). As kumari et al

Remember, "Management of field margins and forest fragments that provide habitat for pollinators adjacent to agricultural fields stabilizes pollination services" (Kumari et al., 2019). This serves as an example of how safeguarding biological diversity can enhance agricultural productivity.

Agroecology is considered as one of the milestones of the climate-smart approaches and is spearheaded by methods such as agroforestry. "Agroforestry is considered to be one of climate-smart, environmentally benign and agroecological practices that has been... found to mitigate climate change adversities while fostering adaptation, enhancing resilience, and attenuating vulnerability especially in smallholder farming systems" (Awazi, 2022). These mixed systems with trees planted alongside crops or livestock have a wide variety of advantages like carbon capture, soil, and biodiversity improvement.

No-till farming, cover cropping, and crop rotation are examples of conservation agriculture as another key CSA practice. These practices "improve soil structure, increase organic matter, and enhance soil microbial activity which leads to healthier soils more resilient to climate stresses" (Abid et al., 2023). In the same vein, zero budget natural farming has also been noted for being "a climate resilient farming system that is capable of enhancing food and nutritional security while enabling farmers to increase soil fertility and yields at lower costs" (Dev et al., 2023). These climate-smart practices are situational and require tailored-differentiated approaches instead of uniform strategies.

More and more studies stress that CSA techniques should be customized to meet local needs and some scholars advocate shifting from climate-smart to climate-resilient agriculture, as this deals better with socioeconomic factors (El-Ramady et al., 2024). (Hellin et al., 2023). This change in approach teaches us that sustainable agricultural systems, indeed, has to incorporate not only technical factors but also social justice and wellbeing. Incorporation of Climate Smart Agriculture (CSA) with other land use opens avenues for enhanced synergies. As an instance, "nature-based tourism as an alternative livelihood activity in and around conservation areas" can further boost agricultural production (Mukhi et al., 2020). Such approaches aids in the achievement of rural income diversification and biodiversity conservation. In summary, climate smart agriculture offers an entire package because it integrates agricultural productivity, climate resilience, and biodiversity conservation. Through proper CSA practices, agricultural systems are able to endure climate shocks without compromising the ecological balance required for sustaining food production (Freyer et al., 2021) (Rashid et al., 2021).

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Garden as biodiversity and Agroecological Hubs

Gardens play a crucial role in agroecosystems because they help sustain biodiversity and aid in the conservation of diverse species and the adoption of eco-friendly farming methods. Also, historical gardens serve as reservoirs of numerous native and culturally important plant species that have disappeared from primary cultivation zones ecosystems; these gardens maintain such substantial ecological relics (Funsten et al., 2020; Arteaga et al., 2020, Prigioniero et al., 2020). They also support different plant communities, including herbs, grasses, and important trees, which contribute to the formation of microhabitats that enhance ecological stability (Funsten et al., 2020).

Incorporating agroecological concepts within garden settings augments vital ecosystem functions, such as productivity through reduction of environmental risks. These concepts promote diversity in crops, soil richness, and water sustainability (Heider et al., 2023; Elevitch et al., 2018). There is documented proof that such interventions contribute to resource-conscious sustainable food systems (Melchior et al., 2021). This approach aims to eliminate single-crop practices in favor of multifaceted, resilient food production systems that bolster regional food security and elevate cultivation in robust, localized centers (Melchior et al., 2021).

The term “agroecology territories” captures a region’s socio-territorial development area to describe how landscape level planning needs to be integrated for useful sustainable transitions (Xu et al., 2024; Adamides, 2020; Bhat et al., 2021). Remote sensing, GIS, digital soil mapping, and other technological aids improve the accuracy of resource application and biodiversity impact mitigation (Bhat et al., 2021). These adjustments and technological advancements imply greater responsibility on the ecosystem and reduced resource wasting(Qazi et al., 2022; Azadi et al., 2023).

Permaculture, regenerative agriculture, and conservation agriculture are among the sustainable approaches taught through agroecological gardens (Khanal et al., 2023). “Hanafi et al., (2023) states the emergence of policy appreciation regarding organic farming and integrated pest management focusing on their significance for the environmental sustainability and food security is worth noting.

Combining tree species with crops aims to establish ecological balance and sustainable production, which helps to further achieve biodiversity objectives with stronger soil and water management (Xu et al., 2024). According to Melchior et al., (2021), such strategies improved both ecosystems and livelihoods and have changed policies towards supporting these types of ecosystems-sustainable initiatives.

As climate change becomes more severe, gardens that use agroecological methods provide adaptive answers. Ecosystem services helps manage risks: enhance resilience, inform adaptive practices as well as aid in agriculture using advanced data analytics and climate modeling (Xu et al., 2024; Balyan et al., 2024; Akanbi et al., 2024). Thus, these gardens are critical to climate smart landscapes where both mitigation and adaption strategies are integrated for enduring sustainability.

Eco-tourism integration in Agriculture Ecosystem

Combining eco-tourism with agriculture provides an innovative way of creating multifunctional systems for landscapes that are both environmentally friendly and beneficial to rural societies. Nature-based tourism enhances the economic development of rural communities by offering alternative employment opportunities,

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which helps sustain agriculture (Mukhi et al., 2020). Ecotourism fosters a landscape approach to land management by facilitating the integration of various land uses and engaging different actors who can benefit sustainably.

Eco-tourism that features sustainable farming practices like nature farming can provide additional income and improve climate-smart agricultural systems. Research emphasizes agritourism as an integral part of farming, coupled with integrated farming, agroforestry, and ecosystem-based approaches to enhance sustainable farming (Çakmakçı et al., 2023). The inclusion of climate-smart agriculture with tourism leads to the establishment of diversified farms owing to the augmentation of economic efficiency and profitability (Çakmakçı et al., 2023).

Strategically defined parameters for eco-tourism in agricultural contexts are designed to ensure maximum benefits of sustainability without undermining biodiversity. Well-designed programs use inventive conservation techniques and minimal-impact habitat restoration to protect natural ecosystems and mitigate climate change impacts (Zhang et al., 2024). These programs help empower the local populations and foster community-based tourism, thus supporting economic diversification, inclusion, and equity within the host communities (Zhang et al., 2024).

For integrating ecological considerations in tourism-agriculture systems, having multiple dimensions of sustainability requires a comprehensive approach.

Agroecology, agricultural sustainability, permaculture, conservation and climate-smart agriculture, and even tourism, biodiversity, and agroecosystem services all pertain to Khanal et al., 2023. The foundation is interdisciplinary which shows the difficulty of managing monoculture crops alongside integrating tourism.

Ecotourism analytics in agriculture advance innovation and social unity, along with aid in promoting resilience and social well-being to improve equity within vulnerable sociocultural scenarios (Zhang et al., 2024). Industry insiders and leaders might change their views on what current paradigms and global best practices look like, if integrated agricultural tourism systems adopt a more all-encompassing, equitable, resilient sustainability model for stakeholders (Zhang et al., 2024; Madandola et al., 2023).

Put together nature and eco-tourism and it creates agriculture tourism which offers the opportunity to enhance the farming landscape to help the rural community and the environment at the same time. Nature-based tourism serves as an aid to sustainable agriculture by optimizing available resources and creating alternative source of income alongside fostering economic growth (Mukhi et al., 2020). This approach encourages a shift from sectoral to multi-stakeholder land management where cooperation towards shared sustainability goals becomes the focus. Climate-smart agricultural practices are additional to esthetic agronomy and eco-tourism ventures that promote active, sustainable farming and diversify the income.

The role of agritourism, integrated farming systems, agroforestry, and ecosystem approaches in sustainable farming practices is essential, as emphasized by (Çakmakçı et al., 2023). The incorporation of climate-smart agriculture alongside tourism activities enhances the diversification of these farms and leads to improved economic performance and profitability (Çakmakçı et al., 2023). In agricultural contexts, the implementation of eco-tourism has to be carefully planned to maximize the sustainability benefits for an area. Such programs implement innovative approaches to

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biodiversity conservation, climate change mitigation, ecosystem protection, and the creation and management of nature reserves through sustainable resource use (Zhang et al., 2024). Along with this, these initiatives help foster economic diversity, inclusivity, equity, and social change in host communities through local empowerment, job creation, and the development of community-based tourism (Zhang et al., 2024). There is the need for a thorough approach to the integration of ecological principles into tourism-agriculture systems that considers various dimensions of sustainability. Such concepts include agroecology, agricultural sustainable development, food sovereignty, permaculture, conservation agriculture, climate-smart agriculture, tourism, biodiversity, and services provided by agroecosystems (Khanal et al., 2023). The complex relationships of food production, biological variety, and tourism activities give rise to this multidisciplinary foundation. Sociocultural wellbeing and cohesion along with equity are enabled and ecotourism related innovations and sustainability emerge in agricultural smart ecotourism frameworks (Zhang et al., 2024). In accepting these ideals, integrated agro-ecological tourism systems have the potential to transform industry paradigms for stakeholders, cultivating and inspiring best practices worldwide, leading to a sustainable, equitable, and resilient future for all (Zhang et al., 2024; Madandola et al., 2023).

Table 1: Ecological Benefits of CBATGs in Comparative Perspective

Indicator	CBATG Performance	Conventional Farms	Source	Location
Carbon Sequestration (t CO_2/ha/yr)	3.8 ± 0.6	1.2 ± 0.3	Mbow et al. (2019)	Punjab, Pakistan
Pollinator Species Richness	42 species	28 species	Our field data (2023)	KP, Pakistan
Soil Organic Matter (%)	3.1 ± 0.4	1.7 ± 0.2	Pakistan Soil Survey (2022)	Sindh, Pakistan
Water Use Efficiency (kg yield/mm water)	8.7	5.2	IWMI (2023)	

As shown in Table 1, empirical evidence demonstrates that Climate-Smart Biodiversity Agroecological Tourism Gardens (CBATGs) unlike traditional farming, showcase significant ecological advantages on multiple sustainability measures. These benefits are also translated into lower operating costs for CBATGs's carbon emissions due to captured emissions being 3.2 times higher (3.8 ± 0.6 t CO_2/ha/yr) compared to conventional farms (1.2 ± 0.3 t CO_2/ha/yr) due to perennial vegetation and organic soil management practices as noted by Mbow et al., 2019. Biodiversity metrics show that CBATGs in Khyber Pakhtunkhwa are supporting greater pollinator biodiversity compared to other regions with 42 species of pollinators supported (with 28 species being the average as per 2023 field data), supporting the positive effects of

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floral diversification and pesticide free management. Soil health evaluations in Sindh (Pakistan Soil Survey, 2022) also indicate that CBATGs are surpassing other systems in terms of soil organic matter (3.1% vs 1.7%) by 82%, which explains the drought resilience noted in other studies. Most importantly, IWMI (2023) highlights that CBATGs are more efficient in water productivity achieving 67% greater water use efficiency (8.7 kg yield/mm water vs 5.2 kg/mm), which is crucial for Pakistan amid water scarcity. All this data underlines these systems as multi-functional interventions designed to lower emissions, conserve biodiversity, and improve carbon sequestration efforts leading to more efficient resource use compared to traditional systems where they performed worse by 50-300% on key environmental performance indicators.
The similarities of these findings among different agroecological regions of Punjab, KP, and Sindh indicate a high degree of adaptability of this model in agricultural activities across various regions of Pakistan.

Rural Development and Sustainability Outcomes of the CBATG Model

The Community-Based Agro eco-tourism (CBATG) model achieves several key sustainability outcomes contributing to rural development and environmental stewardship:
Diverse Economic Activities, Opening New Job Opportunities: The implementation Eco-tourism and sustainable agriculture bolsters the local economy and helps rural areas become more economically stable (Adisa et al., 2024; Çakmakçı et al., 2023).
Quantifiable Value of Biodiversity and Ecosystem Benefits: Rural ecosystem health is supported by practices such as agroforestry that balance ecosystems (Adisa et al., 2024; Melchior et al., 2021).
Climate Change Mitigation, Impacts, and Adaptation: Smart technologies and other climate-resilient methods sustain rural livelihoods under climate change stress (Adisa et al., 2024; El-Ramady et al., 2024).
Food Production and Self Sufficiency: The employment of climate-smart agriculture (CSA) enhances productivity, income, food security and efficiency of water use for irrigation (Çakmakçı et al., 2023; Dev et al., 2023).
Empowering target populations increases social inclusion and equity: Strong community engagement and job opportunities through well-designed programs promote economic diversification, inclusion, and equity (Zhang et al., 2024).
Preservation of Natural Resources and Protection of the Environment: Assessment of resource management and carbon sequestration using agroecological techniques (Freyer et al., 2021).
Social-Ecological Systems Knowledge: Adaptation strategies such as climate change adaptation can be developed and implemented using the local indigenous people's knowledge together with modern technology (Imoro et al., 2021).
Supporting Policies and Transformational Change: Effective CBATG methods have the potential to spur change towards agriculture, socioeconomic equity, and climate resilient policies (Melchior et al., 2021; El-Ramady et al., 2024; Hellin et al., 2023).
The CBATG model integrates the economic, environmental, and social factors of climate change to construct a resilient rural development framework.

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Findings and Discussion

The study highlighted important ecological advantages of CBATGs, noting that in Punjab, polyculture farms had 30% higher diversity of pollinators compared to monoculture farms, and agroforestry plots in Khyber Pakhtunkhwa had carbon capture of 2.5 tons CO_2/ha/year which contributes to climate mitigation efforts. CBATGs also showed positive socio-economic impacts, creating 5-8 seasonal employment opportunities per hectare due to eco-tourism and organic farming ventures, with 70% of the participating farmers reporting improved food self-sufficiency due to diversified crop farming. However, a number of issues surfaced, including insufficient policies in agriculture and tourism domains for Pakistan, the increasing climatic vulnerability illustrated by the 2022 floods which scrubbed 40% of Sindh's eco-tourism infrastructure, and chronic budget shortfalls for sustainable agriculture programs. The research also noted important trade-offs like soil compaction from tourism-related activities in highly trafficked zones, and significant synergies like reported honey-based income beekeeping systems that augmented pollination services provided by 60% of surveyed farmers. These results highlight the Integrated Climate Resilience and Rural Development potential of CBATGs while showing the need for proactive management strategies to better balance ecological and socioeconomic opportunities, risks, and challenges.

Table 2: Socioeconomic Impacts of CBATG Implementation

Metric	Pre-CBATG (2018)	Post-CBATG (2023)	Change (%)	Source
Household Income (USD/yr)	$1,250	$1,870	+49.6%	Our survey data
Women's Employment	12%	34%	+183%	UNDP Pakistan (2023)
Tourism Revenue (USD/ha)	$0	$320	N/A	PTDC Annual Report (2023)
Crop Diversity Index	2.1	4.7	+124%	FAO Agrobiodiversity Index

Tables 2 indicate that, his socioeconomic indicators show that there are improvements in various fields after the CBATG implementation. Incomes of the households are reported to increase by 49.6% (from 1,250to1, 250to1, 870/year), indicating that the model brings direct financial advantages to the families. According to our field surveys conducted in 2023, the most remarkable change occurred in the employment of women which rose by 183 percentage points from 12% to 34%. This indicates a change brought through CBATGs for gender inclusion into economies of rural areas (UNDP Pakistan, 2023). Agro-tourism development provides new sources of income where pilot sites reached $320/ha in tourism income with none existing previously, as stated in the 2023 PTDC report. There was also notable improvement in agricultural resilience as this was marked by the 124% increase in the Crop Diversity Index (from 2.1 to 4.7 species), which is a positive sign for food security and risks diversification

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(FAO Agrobiodiversity Index). All these outcomes confirm CBATGs intention in multidimensional poverty alleviation, however some indicators show challenges in integration that caused different rates of change; the suspicious sharp increase in women employment is likely due to focused programming while the muted increase in income indicates other barriers to market access. The absence of prior values in tourism clearly illustrates CBATGs significance in increasing value chains within regionally agriculturally based economies.

Table 3: Climate Vulnerability Assessment

Risk Factor	CBATG Sites	Control Sites	Data Source
Flood Damage (% area affected)	18%	42%	NDMA 2022 Report
Drought Resilience (crop survival rate)	78%	53%	PCRWR 2023 Study
Heat Stress Tolerance (crop yield loss)	12%	29%	PMD Climate Bulletin

Table 3 show that, the comparative study of climate risks for CBATG and conventional sites show that CBATG model had significant resilience advantages. Flood-affected areas in CBATG sites (18%) were less than half that in control sites (42%). This was noted in the NDMA 2022 Report which shows how agroecological features like contour planting and perennial vegetation reduce runoff. The PCRWR 2023 Study shows even more striking results for drought resilience, where CBATGs maintained a 78% crop survival rate compared to 53% in conventional systems due to better soil organic matter (3.1% vs. 1.7%) and water efficient practices. Most importantly, PMD Climate Bulletin data shows that CBATGs reduced yields losses due to heat by 17 percentage points (12% vs. 29%) illustrating the microclimate control advantages of heightened yield dips due to diversified canopy layers. All together these results prove that CBATGs' ecological design mitigates multiple climate shocks at once, with flood and drought resilience metrics surpassing Pakistani national agricultural averages by 25–30%. The uniformity across all three-risk metrics shows CBATGs provide systemic rather than hazard-specific adaptation solutions, which is increasingly important for a climate variable future for Pakistan.

Table 4: Policy Implementation Challenges

Barrier	Frequency (%)	Severity (1-5)	Stakeholder Consensus	Source
Land Tenure Issues	67%	4.2	High	Our FGDs
Lack of Technical Training	58%	3.8	Medium	Agri. Extension Dept.
Insufficient Funding	82%	4.7	Very High	State Bank of Pakistan
Policy	73%	4.1	High	PIDE

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Inconsistencies	Policy Review

Table 4 described that This evidence points out important systemic issues in scaling CBATGs, with funding gaps having the most negative impact (82% frequency, 4.7 severity). This highlights Pakistan's underfunding of sustainable agriculture, where only 1.2% of agricultural credit focuses on eco-drives initiatives (State Bank of Pakistan). Leasehold insecurity (67%, 4.2 severity) disproportionately impacts women farmers as 73% of participants in our FGDs suggest do not have formal ownership to the land which limits long term investments into agroecology.

Although technical training shortages (58%) may seem less frequent, the severity score of 3.8 indicates the extension services' lack of poly culture management and eco-tourism knowledge mitigation is a critical failing gap. This finding is troubling, given 89% of farmers surveyed had no agro-ecology training. More troubling is the policy inconsistency (73%, 4.1 severity) such as conflicting subsidies for chemical fertilizers and organic inputs (PIDE Policy Review) that erodes CBATG adoption. The "Very High" consensus on funding issues from government, NGOs, and farmers indicates an immediate need for blended finance models, while the "Medium" training consensus suggests easier, localized approaches would be adequate. These barriers are interrelated multiplications… for example, tenure insecurity constrains access to credit, worsening funding difficulties – requiring holistic policy solutions instead of fragmented ones

Conclusion and Recommendations

These findings suggest that Pakistan can achieve sustainable development while addressing the multi-faceted issues of climate change, biodiversity loss, and rural poverty through Climate-Smart Biodiversity Agroecological Tourism Gardens (CBATGs). These findings further suggest that CBATGs strengthen ecosystem resilience through increased biodiversity and carbon sequestration while providing eco-tourism and diversified livelihoods. However, policy barriers, climate risks, and funding constraints are the factors that impede fully leveraging their potential.

In order to increase the effectiveness of CBATGs, we suggest the following three steps: First, a tailored national CBATG policy framework aligned with the existing Climate Change Act and One-Window Agricultural Policy needs to be crafted by policymakers. Second, community stakeholders should be trained in agroecology and sustainable tourism management through targeted micro-level capacity-building initiatives. Third, public-private partnership models and green finance initiatives need to be developed to promote funding for the establishment of CBATG.

Further studies need to assess primary long-term performance indicators of CBATGs in relation to economic sustainability and gender equity across various agro-climatic zones of Pakistan. It would also be beneficial to conduct similar studies in South Asia to provide greater perspective on regional adaptation strategies. Moreover, these studies also need to address the innovative financing strategies and digital technologies that would help eliminate barriers to the implementation of proposed CBATGs, thus ensuring their adaptability to Pakistan's varying ecological regions.

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