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NATIVE TREE SPECIES IN PHILIPPINE TREE-BASED LANDSCAPES: A REVIEW OF MANAGEMENT, RESTORATION, AND CONSERVATION PERSPECTIVES

Vincent Vermudo[1]* and Ejay Karl Verdin Vermudo[2]

[1]Central Bicol State University of Agriculture – Sipocot Campus, Sipocot, Camarines Sur, Philippines

[2]De La Salle University, 2401 Taft Avenue, Manila 1004, Philippines

*Corresponding author: vincent.vermudo@cbsua.edu.ph

ABSTRACT – Native tree species play a vital role in biodiversity conservation, ecological restoration, and sustainable landscape management in the Philippines. However, information on their utilization, management, and ecological contributions remains fragmented across different disciplines and management contexts. This review synthesizes existing literature on native tree species in Philippine tree-based landscapes using a narrative review approach. The reviewed studies were organized into five thematic areas: (1) agroforestry and forestry systems, (2) reforestation, restoration, and rainforestation systems, (3) species selection, propagation, and plantation management, (4) ecological functions and ecosystem services, and (5) socioeconomic, governance, and indigenous knowledge dimensions. Findings indicate that native tree species contribute significantly to biodiversity conservation, ecological restoration, carbon storage and sequestration, watershed protection, and livelihood enhancement. Native-tree-based systems support ecological succession, forest recovery, and the conservation of native, endemic, and threatened species. Restoration approaches such as Rainforestation demonstrate considerable potential for accelerating ecosystem rehabilitation and strengthening community participation. Nevertheless, challenges persist, including limited planting materials, inconsistent nursery standards, governance constraints, market limitations, and the continued dominance of exotic species in large-scale restoration programs. Overall, native tree species represent an important resource for achieving sustainable landscape management and biodiversity conservation in the Philippines. Strengthening restoration planning, nursery systems, research initiatives, and community-based approaches will further enhance their contribution to ecological resilience and sustainable rural development.

Keywords: agroforestry, biodiversity conservation, ecosystem services, forest restoration, native tree species, sustainable landscape management

INTRODUCTION

Forests play a critical role in maintaining ecological stability through biodiversity conservation, carbon sequestration, watershed protection, soil conservation, and climate regulation. Among the most

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important components of these ecosystems are native tree species, which have evolved under local environmental conditions and support complex ecological interactions within natural landscapes. Compared with many introduced species, native trees provide habitat and food resources for indigenous wildlife, contribute to ecological resilience, and support the maintenance of ecosystem processes. Consequently, the use of native tree species has increasingly been promoted as a key strategy for forest restoration, biodiversity conservation, and sustainable landscape management in tropical countries (CBD 2024).

The Philippines is widely recognized as one of the world's megadiverse countries, possessing exceptionally high levels of species richness and endemism despite its relatively small land area. The country contains a substantial proportion of global biodiversity and is considered one of the world's biodiversity hotspots due to its large number of endemic and threatened species (Convention on Biological Diversity [CBD] 2024). However, decades of deforestation, land-use conversion, agricultural expansion, infrastructure development, and other anthropogenic disturbances have resulted in extensive forest degradation and habitat loss. These pressures continue to threaten biodiversity and compromise the ecological functions and ecosystem services provided by forest ecosystems throughout the country (CBD 2024; Climate Change Commission 2024).

Recognizing the need to rehabilitate degraded forestlands, the Philippine government has implemented several large-scale restoration programs, most notably the National Greening Program (NGP). Established through Executive Order No. 26 in 2011 and expanded through Executive Order No. 193 in 2015, the NGP aims to promote sustainable forest management, biodiversity conservation, climate change mitigation and adaptation, poverty reduction, and food security. Since its implementation, the program has facilitated the planting of billions of seedlings across millions of hectares of forestlands, making it one of the largest restoration initiatives in the country (DENR 2024; Engay-Gutierrez et al. 2023). Despite these achievements, several assessments have reported that restoration activities remain heavily dominated by a limited number of fast-growing exotic species, while native tree species continue to comprise only a relatively small proportion of the overall planting mix (Engay-Gutierrez et al. 2023). Furthermore, concerns regarding seedling survival, species selection, nursery quality, and long-term sustainability continue to influence restoration outcomes.

Beyond government-led reforestation efforts, native tree species have become increasingly important in agroforestry systems, rainforestation farming, community-based forest management initiatives, biodiversity-friendly farming systems, and forest landscape restoration programs. Numerous studies have documented their contributions to biodiversity conservation, ecological restoration, carbon storage, watershed protection, environmental education, and rural livelihoods. Research has also highlighted the importance of species-site matching, plantation design, propagation techniques, governance arrangements, community participation, and local ecological knowledge in determining the success of native-tree-based systems. These findings suggest that native tree species contribute not only to ecological recovery but also to broader social and economic development objectives.

Although research on native tree species in the Philippines has expanded considerably over the past two decades, available information remains dispersed across multiple disciplines and thematic areas. Existing studies vary in their focus, ranging from species performance and plantation management to ecosystem services, restoration effectiveness, governance, and community participation. Consequently, a comprehensive synthesis of current knowledge is needed to better understand the multifunctional roles of native tree species and identify key opportunities and challenges associated with their conservation, management, and utilization.

This review paper therefore synthesizes available literature on native tree species in Philippine tree-based landscapes. Specifically, it examines their roles in agroforestry and forestry systems, reforestation and restoration initiatives, plantation management and species performance, ecosystem service provision, and socioeconomic and governance dimensions. By integrating findings from diverse studies, the review seeks to provide a comprehensive understanding of how native tree species contribute to biodiversity conservation, forest restoration, and sustainable landscape management in the Philippines.

METHODOLOGY

Literature Search and Selection

This study employed a narrative review approach to synthesize and critically examine existing literature on native tree species in the Philippines. For the purposes of this review, native tree species are operationally defined as species naturally occurring in the Philippines prior to significant human-mediated introductions, consistent with definitions adopted in biodiversity and conservation literature (CBD 2024). The review aimed to consolidate current knowledge on the utilization, management, conservation, restoration, and ecological significance of native tree species across various tree-based landscapes and management contexts, identify emerging research gaps, and highlight future directions for research, policy, and practice. Because the objective of the study was to synthesize and interpret existing knowledge rather than quantify effect sizes or statistically compare findings, a narrative review approach was deemed appropriate.

Relevant literature was retrieved from Scopus, Web of Science, ScienceDirect, and Google Scholar. Google Scholar was used primarily as a supplementary source to identify potentially relevant studies and publications that may not have been indexed in the other databases. To improve the comprehensiveness of the search, backward citation tracking (reviewing references cited in selected studies) and forward citation tracking (identifying studies that subsequently cited key publications) were also conducted. The search covered studies published between 2000 and 2026. This period was selected to capture both foundational and contemporary developments in Philippine native-tree research, including the growing interest in rainforestation, biodiversity conservation, forest and landscape restoration, reforestation, native-species domestication, smallholder forestry, and sustainable landscape management initiatives. Only publications written in English were considered. Search terms were developed around three core concepts: native tree species, tree-based landscapes and management interventions, and the Philippine context. Representative search strings included: ("native tree species" OR "native trees" OR "indigenous tree species" OR "native woody species") AND ("rainforestation" OR agroforestry OR reforestation OR restoration OR "tree plantation" OR "forest landscape restoration" OR "smallholder forestry" OR "tree-based system") AND (Philippines OR Philippine)

Additional keyword combinations were incorporated when new concepts emerged during the review process. Studies were included if they met all of the following criteria: (1) conducted within the Philippine context; (2) examined tree-based systems, landscape restoration initiatives, rainforestation approaches, reforestation programs, agroforestry systems, smallholder forestry, tree plantations, or other management interventions involving native tree species; (3) discussed the utilization, management, conservation, domestication, restoration, ecological functions, or socio-economic significance of native tree species; and (4) were published in peer-reviewed journals, or in technical reports and publications produced by recognized research and development institutions, such as the Department of Environment and Natural Resources (DENR), the University of the Philippines Los Baños (UPLB), the World Agroforestry Centre (ICRAF), and similar organizations. Studies were excluded if they: (1) focused

exclusively on exotic or introduced tree species; (2) examined natural forest ecosystems, biodiversity inventories, or ecological assessments without a clear tree-based management, restoration, production, or utilization context involving native tree species; (3) focused on urban forestry systems unrelated to native-tree management objectives; (4) were duplicate publications; or (5) lacked sufficient information relevant to the objectives of the review.

Literature selection followed a three-stage screening process. First, titles were reviewed to determine relevance to the topic. Second, abstracts were assessed against the inclusion and exclusion criteria. Finally, potentially relevant studies were evaluated through full-text review. A total of 80 records were screened for eligibility. Following the application of the inclusion and exclusion criteria, 47 studies were retained for qualitative synthesis, while 33 studies were excluded.

Data Extraction and Thematic Synthesis

Relevant information from the selected studies was systematically extracted and organized using a structured literature review matrix. Information recorded included the author(s), year of publication, study location, landscape or management context, native tree species reported, purpose of species utilization or integration, documented ecological and socio-economic benefits, reported constraints, and key findings relevant to the review objectives. The selected literature was analyzed using an inductive thematic synthesis approach. Rather than imposing predetermined categories, thematic patterns were allowed to emerge from recurring concepts, observations, and findings reported across the reviewed studies. This approach was adopted to minimize researcher-imposed categorization and to ensure that the synthesis remained grounded directly in the available evidence. Emerging themes were refined iteratively throughout the review process as additional studies were examined and compared.

The analysis involved repeated reading and comparison of the selected studies to identify common patterns and recurring concepts. Similar findings were subsequently grouped into broader thematic categories, which formed the framework for structuring the results and discussion of the review. Particular attention was given to understanding how native tree species are utilized and managed across Philippine tree-based landscapes, their ecological and socio-economic contributions, constraints affecting their wider adoption, and opportunities for promoting native-tree-based approaches in support of biodiversity conservation, ecological restoration, climate resilience, and sustainable landscape management.

RESULTS AND DISCUSSION

Native Trees in Agroforestry and Forestry Systems

Native tree species are increasingly integrated into diverse Philippine agroforestry and forestry systems—encompassing farmer-managed timber agroforestry, coffee-based systems, rainforestation farms, community-based forest management (CBFM) initiatives, and Conservation Agriculture with Trees (CAT)—contributing simultaneously to agricultural production, biodiversity conservation, and ecosystem services. Despite shared objectives, these production landscapes exhibit considerable variation in species composition, management approaches, and goals, suggesting that agroforestry development in the Philippines is highly context-specific rather than standardized (Harrison et al. 2007; Macanes et al. 2010; Dacumos et al. 2025).

Several studies highlight the growth potential of native trees under agroforestry conditions and the necessity of matching species to site characteristics. Santos Martin, Lusiana, and van Noordwijk (2010)

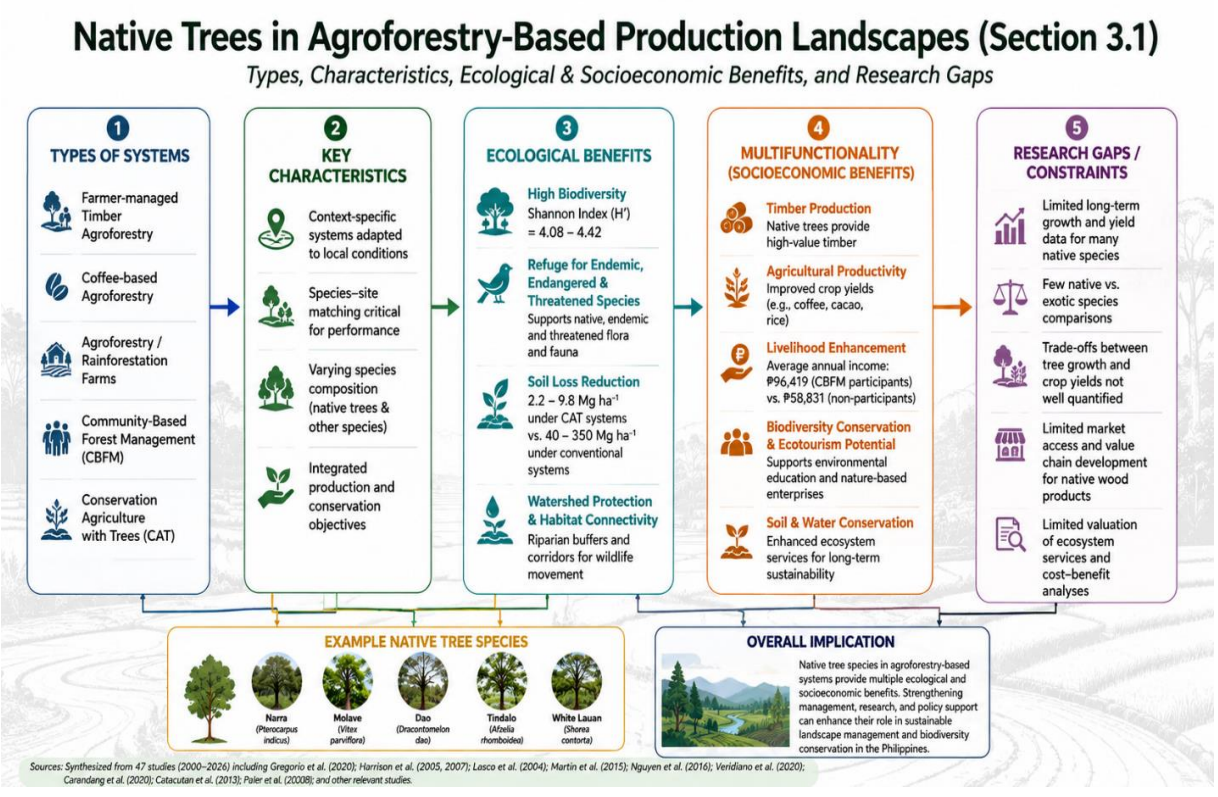

Figure 1. Overview of Native Tree Utilization in Agroforestry-Based Production Landscapes in the Philippines: Systems, Characteristics, Benefits, Species, and Research Gaps.

successfully modeled the growth performance of six native timber species (white lauan, molave, narra, nangka, dao, and tindalo) at an initial density of ~5,000 trees ha^{-1} using exponential functions ($R^2 = 0.789$ for *Vitex parviflora* and $R^2 = 0.854$ for *Pterocarpus indicus*), demonstrating that incorporating Growth Retardation Factors improves predictive accuracy. Similarly, Santos Martín (2007) identified species-site matching, farmer adoption, and economic profitability as critical factors for sustainability; integrated social, biophysical, and economic assessments via Water, Nutrient, and Light Capture in Agroforestry Systems (WaNuLCAS) simulations and Policy Analysis Matrix evaluations showed that native tree agroforestry remains productive despite trade-offs between tree growth and crop yields. Consistent with this, Goeltenboth and Goeltenboth (2000) reported that altitude, geology, and soil properties significantly influenced tree performance across rainforestation farms, with nutrient availability varying distinctly between limestone- and volcanic-derived soils.

Beyond production, these systems consistently provide extensive ecological benefits, serving as vital refuges for native, endemic, and threatened flora and fauna within human-modified environments. For plant communities, Daipan and Bao-idang (2025) recorded 118 species from 95 genera and 54 families in Tuba, Benguet, exhibiting high Shannon diversity (H' = 4.42) and Margalef richness (R = 117.84), with native and endemic species comprising 69% and 11% of the flora, respectively. In an agroforest adjacent to a protected area in Mindanao, Philippines, Achondo et al. (2026) documented 165 species across 65 families, including nine endemic and nine threatened species, yielding a Shannon diversity of 4.08 and evenness of 0.80. Coffee-based agroforests likewise support high biological diversity: Cacactin et al. (2025) documented 93 trees representing 21 native species in Abra, Philippines, including threatened taxa like *Agathis philippinensis* and *Shorea* species, while Barrientos et al. (2025) recorded 108 individuals across 26 trees, 38 saplings, and 44 non-tree flora in La Union, Philippines (H' = 2.65 for trees, 1.79 for saplings, and 2.15 for non-tree flora; tree evenness J = 0.96).

For faunal conservation, Achondo, Ibañez, and Espaldon (2025) documented 49 bird species (42 genera, 32 families) within biodiversity-friendly farms, where 49% were endemic—including the Vulnerable *Gorsachius goisagi* and Critically Endangered *Loriculus philippensis*—with a Shannon diversity of 3.17 and seasonal variations (44 species during migration and 41 during off-migration). The presence of forest-dependent birds and mixed-species flocks suggests these systems function as habitat corridors and supplementary refuges contributing to landscape-level conservation.

Furthermore, native tree integration yields substantial ecosystem services and socioeconomic advantages. Bugayong (2003) reported that CBFM agroforestry initiatives facilitated soil erosion control, improved fertility, slope stabilization, and microclimate regulation while increasing annual household earnings to ₱96,419 compared with ₱58,831 among non-participants. Mercado Jr. and Reyes (2013) demonstrated the effectiveness of CAT in mitigating land degradation under ~3,000 mm annual rainfall; soil losses were restricted to 2.2 Mg ha^{-1} (grass hedgerows), 9.8 Mg ha^{-1} (forage-legume hedgerows), 5.7 Mg ha^{-1} (shrub hedgerows), and 6.5 Mg ha^{-1} (tree hedgerows), contrasting sharply against 40 Mg ha^{-1} under contour cultivation and 350 Mg ha^{-1} under conventional up-and-down-slope farming.

Structural configurations and management objectives vary dynamically across landscapes. Surveys by Harrison et al. (2007) across 81 smallholders and 252 farm parcels revealed that coconut-based systems were most prevalent (44%), with timber species like gmelina and mahogany adapted dynamically to local livelihood needs rather than following a uniform model. Macanes et al. (2010) documented four major configurations across 13 municipalities and 95 practitioners—agrisilvicultural, agrisilvipastoral, silvipastoral, and agrisilviculture-sericulture systems—with agrisilvicultural setups being the most

dominant. More recently, Dacumos et al. (2025) demonstrated structural diversity in coffee-based agroforestry across six plantations, mapping 17 tree species, seven shrubs/palms, and nine grasses/ferns arranged in intercropping, multicropping, and monocropping configurations that successfully optimized soil quality, biodiversity support, and overall system productivity.

Agroforestry and forestry systems provide important opportunities for integrating native tree species into productive landscapes. These systems simultaneously support timber production, agricultural productivity, biodiversity conservation, habitat provision, soil and water conservation, and livelihood enhancement. However, important knowledge gaps remain. Long-term assessments of native tree growth and productivity are still limited, particularly across different agroecological zones. Comparative studies evaluating native and exotic species under similar management conditions remain scarce, while economic analyses often focus on short-term profitability and rarely incorporate ecosystem service valuation. Additional research is also needed to identify optimal species combinations and management strategies suitable for different environmental conditions and farming contexts. Addressing these gaps would strengthen the evidence base for promoting native-tree-based agroforestry as a sustainable land-use strategy in the Philippines.

Native Trees in Reforestation, Restoration, and Rainforestation Systems

Native tree species constitute the foundation of Philippine reforestation, rainforestation, and forest restoration initiatives, driving biodiversity conservation, ecological rehabilitation, long-term forest recovery, and the preservation of genetic resources through diverse assemblages, mother-tree selection, mixed-species planting, and participatory approaches. Illustrating this diversity, Lillo et al. (2021) documented extensive native tree diversity and identified 241 healthy mother trees across secondary forests in Cebu, emphasizing their importance as seed sources for restoration programs. Among restoration strategies, Rainforestation—developed under the Philippine-German Applied Tropical Ecology Project and adopted by the DENR in 2004—has emerged as one of the most widely studied approaches, utilizing more than 100 native species to mimic natural forest structure while supporting biodiversity conservation and local livelihoods (Asio 2017).

Long-term monitoring confirms that native-tree-based restoration systems contribute significantly to ecological succession and biodiversity recovery. Nguyen et al. (2014) documented shifts in stand composition toward shade-tolerant species over time, while Hernandez et al. (2022) reported substantial increases in species richness and native species representation in restored landscapes. Likewise, Tulod et al. (2017) found that plantations of teak, mangium, and mahogany supported native woody regeneration, including threatened species. Calope et al. (2025) further demonstrated that native species such as *Polyscias nodosa* and *Syzygium simile* successfully recruited beneath *Acacia mangium* canopies, highlighting the role of plantations as facilitators of forest recovery.

Despite these positive outcomes, restored forests do not immediately replicate the structural and functional characteristics of natural forests. Veridiano et al. (2020) reported that mixed-species Rainforestation plantations exhibited lower carbon stocks and timber volumes than logged natural forests, although growth trajectories suggested that ecological parity may be achieved over longer timeframes. Collectively, these findings indicate that native-tree-based restoration contributes to ecosystem recovery but requires sustained management and long-term monitoring.

Restoration success depends heavily on species-site compatibility, spatial planning, and governance arrangements. Using Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP), Onte et al. (2026) identified priority reforestation areas within the Angat Watershed and

highlighted the suitability of native species such as guijo, dao, and kalumpit for restoration efforts. Socially, Fernandez et al. (2021), Fernandez and Bande (2018), and Fernandez (2018) described Rainforestation as a "learning by doing" platform that promotes environmental education, biodiversity conservation, and community engagement. Moreover, Fernandez et al. (2024) and Fernandez and Fernandez Jr. (2020) demonstrated that restoration initiatives can enhance women's participation in nursery management, planting, and decision-making processes.

Ultimately, institutional sustainability remains central to restoration success. Gregorio, Herbohn, Tripoli, and Pasa (2023) emphasized that secure tenure arrangements, equitable benefit-sharing mechanisms, effective leadership, and high-quality planting materials are essential for sustaining community participation, whereas weak governance and inadequate social preparation consistently undermine restoration outcomes. Overall, the reviewed literature demonstrates that native tree species play a critical role in restoring degraded landscapes while simultaneously supporting biodiversity conservation, ecological resilience, and community development in the Philippines.

Species Selection, Propagation, and Plantation Management of Native Trees

Species selection, propagation, and plantation management are critical components of successful native tree restoration, as species differ substantially in survival, growth, and ecological requirements. Consequently, restoration success depends on appropriate species-site matching, high-quality planting materials, and silvicultural practices tailored to local environmental conditions, nursery standards, and stakeholder preferences.

Substantial variation in growth and survival has been documented across native tree species. Aguilos et al. (2020) reported considerable differences in survival and growth among 33 native species, with fast-growing species consistently outperforming slow-growing dipterocarps under plantation conditions. Similarly, Marquez et al. (2021) observed marked differences in species performance, identifying *Acacia mangium*, *Alstonia scholaris*, *Casuarina equisetifolia*, and *Pterocymbium javanicum* among the best-performing species, while climatic variables such as rainfall and temperature significantly influenced survival and growth patterns.

Effective restoration planning depends on species-site compatibility rather than species origin alone. Parlucha et al. (2017) demonstrated that while *Pterocarpus indicus* was the highest-performing native species and *Gmelina arborea* the best-performing exotic species, no significant differences existed between native and exotic groups overall. Complementing this, Chechina and Hamann (2015) developed a framework integrating ecological suitability and social preferences, revealing that species considered ecologically desirable are not always preferred by local stakeholders.

Plantation design and stand management strongly influence competition, survival, and long-term stand development. Vanclay, Gregorio, and Herbohn (2023) demonstrated that species exhibit varying competitive behaviors, with *Shorea palosapis* functioning as a benign competitor and *Paraserianthes falcataria* exhibiting strong sensitivity to crowding. Likewise, Nguyen et al. (2016) identified tree size as the strongest predictor of growth and survival, whereas Gregorio, Herbohn, and Vanclay (2012) emphasized the importance of spacing, shade, and nurse trees in enhancing establishment and reducing mortality among native species.

The production of high-quality planting stock remains a major operational challenge despite advances in propagation science. Magno, Peque, and Oclarit (2025) found that although native species dominated nursery production, many facilities exhibited seedling quality issues that may compromise field

performance. In contrast, Gutierrez et al. (2020) developed a science-based propagation program for *Litsea leytensis* that combined plus-tree selection, DNA barcoding, clonal propagation, and mycorrhizal inoculation, demonstrating the potential of modern propagation techniques to support native tree conservation and large-scale restoration efforts.

Farmer preferences likewise influence the adoption of native tree species in rural landscapes. Polinar (2009) found that economic utility remains the primary determinant of species selection, although land availability, tenure insecurity, and restrictive harvesting policies continue to constrain native tree adoption. These findings reinforce the observations of Chechina and Hamann (2015) that ecological suitability and socioeconomic considerations do not always align seamlessly. Overall, the reviewed literature highlights that successful native tree restoration depends not only on biological performance but also on effective nursery management, appropriate plantation design, and the integration of social and institutional considerations.

Ecological Functions and Ecosystem Services of Native Trees

Tree-based restoration and forest management systems provide a wide range of ecological functions and ecosystem services—including biodiversity conservation, carbon storage, ecological succession, watershed protection, and sustainable forest management—which are shaped by species characteristics, restoration design, and institutional arrangements.

Several studies underscore the direct contribution of native tree species to biodiversity conservation and carbon storage. Reyes Jr. and Sarnowski (2020) documented substantial variation in species abundance and carbon storage within a restoration site, identifying *Chisocheton cumingianus* and *Intsia bijuga* among the highest contributors to carbon sequestration. Complementing these findings, Matheson (2018) described *Acacia* species as fast-growing, nitrogen-fixing trees that facilitate ecological succession through soil enrichment, litter deposition, and microclimate regulation. However, the study also highlighted the invasive potential of certain *Acacia* species when introduced outside their native range, emphasizing the importance of appropriate species selection.

The translation of ecological objectives into successful restoration outcomes is strongly influenced by governance and institutional arrangements. Von Kleist (2020) found that biodiversity outcomes within Forest Landscape Restoration (FLR) initiatives under the National Greening Program (NGP) were constrained by target-driven implementation and limited community participation, underscoring the need for improved governance and nursery systems. Similarly, Lopez et al. (2010) documented the long-term ecological benefits of community-based forest management (CBFM) systems across approximately 10,000 ha, demonstrating substantial carbon sequestration while maintaining forest regeneration, watershed protection, and livelihood benefits through the application of Forest Improvement Technology (FIT).

Overall, tree-based restoration and forest management systems generate multiple ecological benefits, including biodiversity conservation, ecological succession, carbon storage, carbon sequestration, watershed protection, and regeneration support. Nevertheless, important knowledge gaps remain. Few studies simultaneously quantify biodiversity and multiple ecosystem services within the same systems, limiting understanding of potential trade-offs and synergies among ecological objectives. Furthermore, long-term evaluations of how species composition, restoration design, and governance arrangements influence ecological outcomes remain limited. Addressing these gaps would strengthen the evidence base needed to design restoration initiatives that maximize both biodiversity conservation and ecosystem service provision. The major ecological functions, ecosystem services, and governance considerations associated with native tree species identified in this review are summarized in Figure 2.

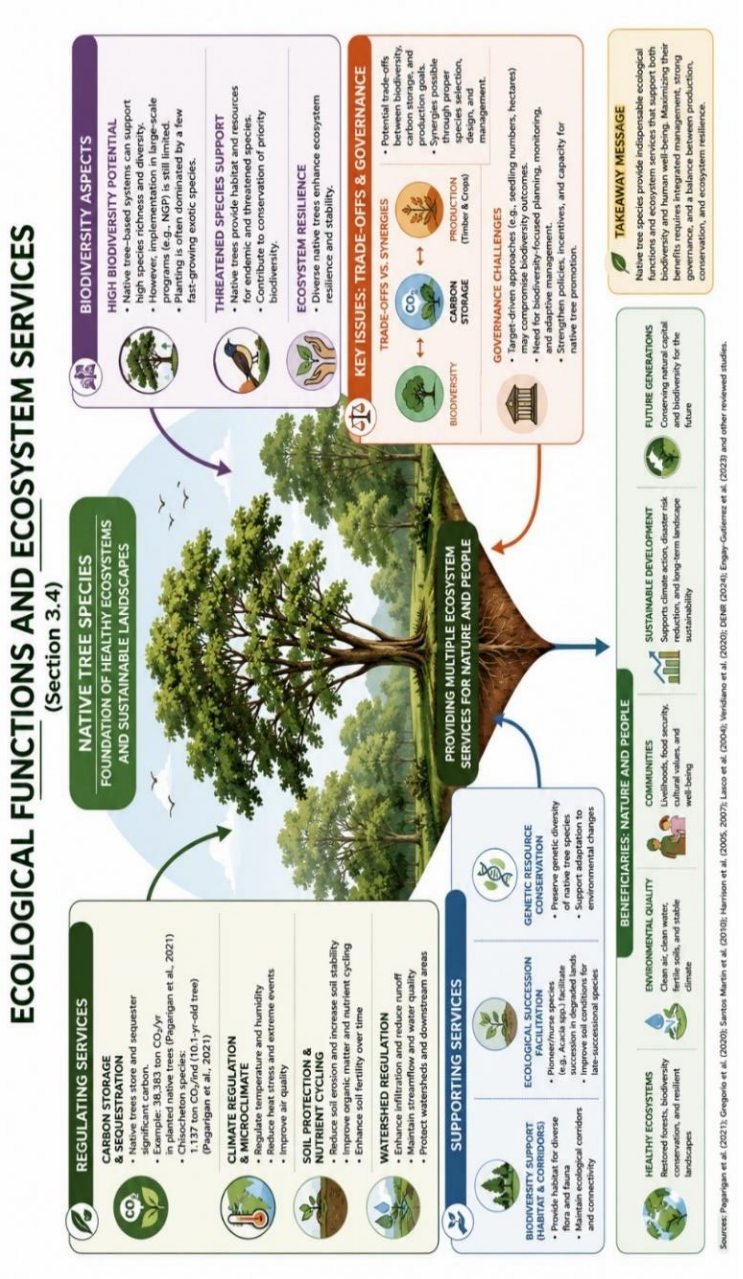

Figure 2. Ecological Functions and Ecosystem Services of Native Tree Species: Regulating, Supporting, and Biodiversity Benefits, Trade-offs, and Governance Considerations.

Socioeconomic, Governance, and Indigenous Knowledge Dimensions

The adoption, management, and promotion of native tree species in the Philippines are heavily dictated by socioeconomic conditions, policy environments, institutional support, and local ecological knowledge (LEK). While their ecological and economic potentials are recognized, wider adoption is severely bottlenecked by limited planting stocks, long production cycles, weak market incentives, and governance constraints, balanced against the crucial role of farmer preferences and community participation. At the national level, Engay-Gutierrez et al. (2023) evaluated the National Greening Program (NGP), noting that while it planted ~1.67 billion seedlings across >2 million hectares (~25.8 million seedlings across 21,925 ha in 2019 alone), native species accounted for a meager 11.9–14% of the planting mix (~235,000 ha from 2011–2016), leaving exotics to dominate 85% of the landscapes. Furthermore, survival rates fell below the 85% target—logging just 58.18% in Balangue (2016) and 65.33–74.46% in Luna (2016)—despite a combined annual institutional production of ~5.7 million seedlings (3.7 million from DENR nurseries in 2012), raising serious concerns regarding long-term national biodiversity outcomes. Livelihood preferences, economic parameters, and market volatilities heavily influence smallholder species adoption. Mangaoang and Pasa (2003) reported that farmers pragmatically classify trees by utility (construction, furniture, firewood, poles, boat building, tool handles), generally preferring native trees for durability but opting for exotics due to propagation ease and seedling availability. Financially, Harrison et al. (2005) utilized Net Present Value (NPV) and Internal Rate of Return (IRR) analyses to demonstrate that smallholder forestry remains only marginally profitable, with native species generating lower financial returns than exotics due to long rotations, scarce growth data, and weak pricing mechanisms. Correspondingly, Harrison et al. (ACIAR Leyte forestry research group) highlighted that while smallholders value indigenous timber quality, expansion is gridlocked by weak propagation infrastructure, inadequate market pathways, and insufficient institutional support despite high farmer interest. This structural reliance on exotics (*Gmelina arborea*, *Paraserianthes falcataria*, *Acacia* spp., *Eucalyptus deglupta*) was initially driven by their promotion as rapid-yield "million-peso trees"; however, Santos et al. (2007) observed that crashing timber prices and unstable markets caused farmers to abandon tree farming post-harvest, arguing that top-down selection frameworks focus blindly on growth rates while ignoring socioeconomic, cultural, and market vulnerabilities. Consequently, indigenous knowledge systems and community-based frameworks serve as crucial underutilized safety nets for landscape sustainability. Landicho et al. (2021) documented local practices—including on-farm tree integration, communal forest management, and soil-water conservation—noting that despite low measured floral diversity in farm lots ($H' = 0.9718$) and communal forests ($H' = 0.437$), soil organic matter remained exceptionally high at 5.86% and 6.49%, respectively, verifying the ecological efficacy of LEK. Santos et al. (2007) further emphasized that integrating LEK and farmer preferences into formal selection programs is vital to successfully diversifying farm forestry and achieving long-term landscape resilience. Successful promotion of native tree species depends on the complex interaction of ecological, socioeconomic, institutional, and cultural factors. While native species are widely recognized for their timber quality, durability, and multiple uses, adoption remains constrained by limited planting materials, weak market incentives, long production cycles, and insufficient institutional support. The reviewed studies indicate that local ecological knowledge, farmer preferences, and community participation remain important yet underutilized resources for restoration and forestry development. Future research must bridge these socio-ecological dimensions by integrating economic valuation, smallholder decision-making dynamics, policy impact assessments, and long-term institutional arrangements to develop realistic, market-viable, and community-owned strategies for native tree management in the Philippines.

CONCEPTUAL FRAMEWORK OF NATIVE TREE DEVELOPMENT AND UTILIZATION IN THE PHILIPPINES

Conceptual Framework

The conceptual framework below illustrates the role of native tree species in promoting sustainable landscape management and biodiversity conservation in the Philippines. The framework was developed from the major themes identified in the reviewed literature, namely agroforestry and forestry systems, reforestation and restoration initiatives, species selection and plantation management, ecological functions and ecosystem services, and socioeconomic, governance, and indigenous knowledge dimensions. The framework positions native tree species as the central component of various management systems and restoration strategies. Through their integration in agroforestry, forestry, and restoration programs, native tree species contribute to ecological outcomes such as biodiversity conservation, ecological restoration, carbon storage and sequestration, forest recovery, and watershed protection. At the same time, they generate socioeconomic benefits, including livelihood opportunities, environmental education, community participation, and sustainable resource use. These ecological and socioeconomic outcomes collectively contribute to the broader goal of sustainable landscape management and biodiversity conservation. The framework further emphasizes that successful native tree promotion depends not only on biological and ecological factors but also on governance, institutional support, and local ecological knowledge. The conceptual framework developed from the major themes identified in the reviewed literature is presented in Figure 3.

Description of the Conceptual Framework

The conceptual framework is organized into four major components: (1) native tree species, (2) management contexts, (3) ecological and socioeconomic outcomes, and (4) sustainable landscape management and biodiversity conservation.

The first component, native tree species, represents the central focus of this review. These species provide ecological functions, economic opportunities, and restoration potential that support a wide range of landscape management objectives. The reviewed studies demonstrate considerable variation in species performance, ecological requirements, and utilization patterns, highlighting the importance of species selection and site suitability in achieving desired outcomes.

The second component, management contexts, encompasses the various systems in which native tree species are utilized. These include agroforestry and forestry systems, reforestation and restoration initiatives, rainforestation approaches, and plantation management strategies. The literature further indicates that these management systems are influenced by socioeconomic conditions, governance structures, institutional support mechanisms, and local ecological knowledge, all of which affect species adoption, management practices, and restoration success.

The third component consists of ecological and socioeconomic outcomes. Ecological outcomes include biodiversity conservation, ecological restoration, forest recovery, carbon storage and sequestration, and watershed protection. These outcomes emerge through the establishment, management, and conservation of native tree species within different landscape contexts. Simultaneously, native-tree-based systems generate socioeconomic outcomes such as livelihood enhancement, environmental education, community participation, women empowerment, and sustainable resource use. The reviewed studies suggest that ecological and socioeconomic outcomes are closely interconnected, with improvements in one dimension often supporting gains in the other.

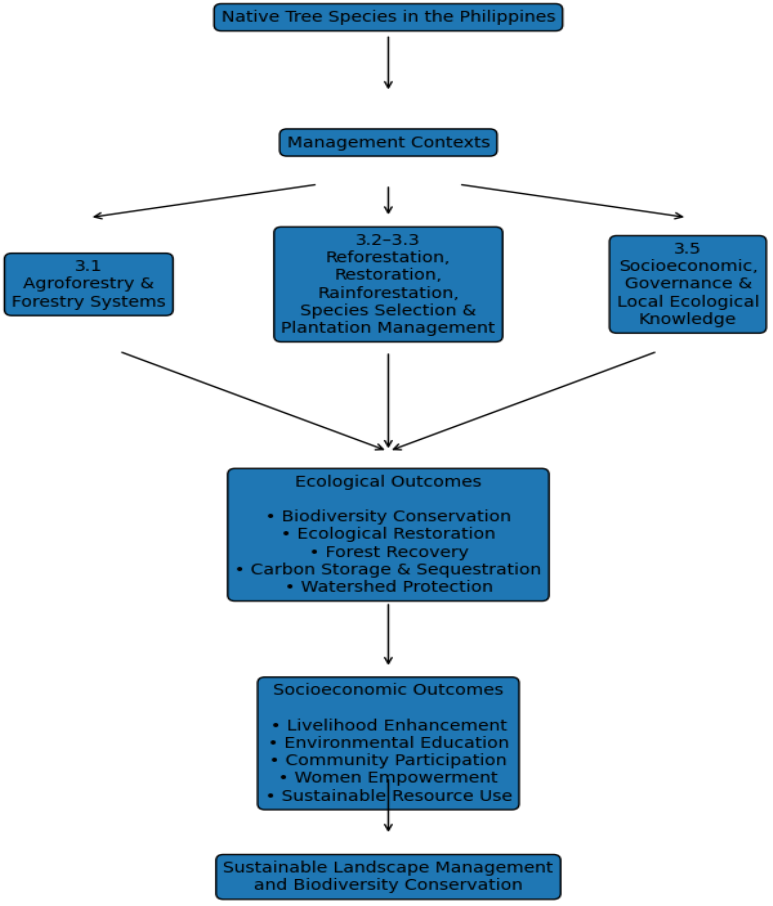

Figure 3. *Conceptual Framework of Native Tree Development and Utilization in the Philippines*

The final component, sustainable landscape management and biodiversity conservation, represents the ultimate outcome of the framework. This reflects the overarching conclusion of the review that native tree species can contribute significantly to the restoration, conservation, and sustainable management of Philippine landscapes when supported by appropriate species selection, effective management practices, community participation, and enabling institutional environments.

More importantly, the framework highlights the dynamic and reciprocal relationships among its four major components. Native tree species influence management decisions through their varying ecological characteristics, growth performance, and socioeconomic value. In turn, management contexts determine how these species are established, managed, and integrated across different landscape systems. The interaction between species characteristics and management practices subsequently shapes ecological and socioeconomic outcomes, which are mutually reinforcing and collectively contribute to sustainable

landscape management and biodiversity conservation. These outcomes, in turn, inform future restoration priorities, species selection, and governance interventions, illustrating a continuous and adaptive process rather than a strictly linear sequence of events.

The framework therefore emphasizes that achieving long-term restoration success and biodiversity conservation requires an integrated approach that simultaneously considers ecological processes, socioeconomic benefits, governance arrangements, and local knowledge systems. Unlike previous studies that have examined these dimensions independently, this review synthesizes them into a unified conceptual framework that demonstrates how native tree species, management contexts, and ecological and socioeconomic outcomes interact to support sustainable landscape management in the Philippines. As such, the framework represents a unique contribution of this review and provides a holistic perspective that may guide future research, policy development, and restoration initiatives involving native tree species across diverse Philippine landscapes.

IMPLICATIONS FOR POLICY AND PRACTICE

The findings of this review demonstrate that native tree species play an important role in biodiversity conservation, ecological restoration, carbon sequestration, watershed protection, and livelihood enhancement in the Philippines. Across agroforestry systems, reforestation initiatives, rainforestation programs, and community-based forest management projects, native tree species consistently contributed to both ecological and socioeconomic objectives. However, their wider adoption remains constrained by limited planting materials, inadequate species-site matching, weak market incentives, governance challenges, and the continued dominance of exotic species in many restoration programs.

The review highlights the need for policies that strengthen the use of native tree species in restoration and reforestation initiatives. Restoration programs should prioritize species-diverse approaches that consider ecological suitability, local environmental conditions, and long-term ecosystem functionality. Greater investment in nursery development, seed-source conservation, propagation technologies, and quality planting material production is also necessary to improve restoration success and plantation performance. The findings further emphasize the importance of community participation, local ecological knowledge, and institutional support in achieving successful restoration outcomes. Restoration efforts are more likely to succeed when local stakeholders are actively involved in planning, implementation, and management activities and when restoration strategies are aligned with local livelihood needs and environmental conditions.

Finally, the review underscores the need for long-term monitoring and continued research on native tree species performance, ecosystem services, socioeconomic benefits, and restoration effectiveness. Strengthening the integration of ecological science, governance, community participation, and local knowledge can support the broader goal of sustainable landscape management and biodiversity conservation in the Philippines.

CONCLUSION

This review synthesized evidence from 47 studies on the utilization, management, restoration, and conservation of native tree species in the Philippines. The findings demonstrate that native tree species

contribute significantly to biodiversity conservation, ecological restoration, carbon sequestration, watershed protection, and sustainable rural livelihoods across diverse tree-based landscapes.

The reviewed literature further highlights the importance of species-site matching, quality planting materials, effective management practices, governance support, and community participation in determining restoration success. Despite their recognized ecological and socioeconomic benefits, the wider adoption of native tree species remains constrained by limited planting materials, institutional and governance challenges, and the continued dominance of exotic species in large-scale restoration programs.

More importantly, this review provides a holistic synthesis of current knowledge on native tree species in the Philippines by integrating ecological, socioeconomic, governance, and management dimensions within a single framework. The findings underscore the potential of native tree species to support sustainable landscape management and biodiversity conservation while informing future research, policy development, and restoration initiatives. Strengthening restoration planning, nursery systems, long-term research, and community-based approaches will be essential to maximizing their contribution to ecological resilience and sustainable development.

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STATEMENT OF AUTHORSHIP

V. Vermudo conducted the literature search and screening, synthesized the literature, identified the thematic areas, developed the conceptual framework, formulated the implications and recommendations, and drafted the manuscript; E.K.V. Vermudo contributed to the conceptualization, formulation of implications and recommendations, and review and revision of the manuscript. Both authors discussed the findings and approved the final manuscript.

DECLARATION OF ORIGINALITY AND ETHICAL COMPLIANCE

The authors declare that this manuscript is an original review work and that the literature search, screening, data extraction, and synthesis presented herein were conducted by the authors. All sources of information used in the review have been appropriately acknowledged and cited. The authors further declare that the manuscript is free from ethical issues. As this study is based exclusively on previously published literature and publicly available sources and did not involve human participants, animals, or primary data collection, ethical clearance was not required

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