

CONSERVATION AND COMMUNITY INSTITUTIONAL STRENGTHENING: A STUDY OF A NATIVE PAPUAN PLANT NURSERY PROGRAMME IN THE MALASIGI VILLAGE FOREST, SOUTHWEST PAPUA

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Abstract: Community-based nursery programmes are increasingly promoted as a bridge between plant conservation and Indigenous livelihoods, yet their evaluation rarely moves beyond counting seedlings. This study examines the nursery programme run by the Belempe Village Forest Management Institution (LPHD Belempe) in the Malasigi customary village, Sorong Regency, Southwest Papua, through three analytical lenses: ecological composition, the legitimacy of conservation claims, and institutional capacity. Using a descriptive-evaluative case study design, data were collected through a nursery inventory, structured observation, semi-structured interviews with 15 key informants, and document review, and were analysed through proportional analysis, a taxonomic and conservation-status audit, and SWOT-TOWS analysis. The programme produced 5,000 seedlings of 11 taxa: agroforestry (53.5%), multipurpose (30.0%), and Rare, Threatened and Endemic (RTE) species (16.5%). The audit, however, shows that about one third of the seedlings are introduced fruit species, and that the RTE label is only partly consistent with formal status, as *Intsia bijuga* is assessed as Near Threatened by the IUCN while *Aquilaria* spp. are listed in CITES Appendix

II. The central finding is a persistent gap between outputs (seedlings produced) and outcomes (seedlings surviving, planted and used), sustained by the absence of monitoring rules within the institution and by a high dependence on a single corporate partner. The study proposes species verification, seedling quality standards, a tiered monitoring framework, functional zoning of seedling distribution, a phased partnership exit strategy, and protocols for free, prior and informed consent over noken-related traditional knowledge.

Keywords: Community-Based Conservation; Corporate Social Responsibility; Institutional Strengthening; Papua; Social Forestry.

INTRODUCTION

New Guinea hosts the richest island flora in the world, with more than 13,000 vascular plant species and an endemism rate of about 68% (Cámara-Leret et al., 2020). This botanical wealth is not only of ecological value; it is embedded in the food systems, crafts and knowledge systems of Papuan Indigenous peoples. Although Papua's forest cover remains largely intact, pressure on it is rising: around 0.75 million hectares of forest were lost in Indonesian New Guinea between 2001 and 2019, and spatial modelling projects losses of up to 4.5 million hectares by 2036 if development follows the trajectory observed in Kalimantan (Gaveau et al., 2021). The second figure is a model scenario, not a forecast, and it is used here only to show the scale of the pressure that conservation planning must anticipate. Threat quantification work from Papua New Guinea, on the other side of the island, likewise shows that conservation responses must be prioritised against measured threats rather than assumed ones (White et al., 2021). Under these conditions, conservation can no longer rely solely on protecting areas; it also requires active efforts to supply planting material, restore vegetation and secure sustainable use (Chazdon, 2008; Holl and Aide, 2011).

Indonesia's social forestry policy, including the Village Forest (Hutan Desa) scheme, gives communities legal rights to manage state forest land (Ministry of Environment and Forestry, 2021). Evidence indicates that Village Forests can reduce deforestation, but performance varies with social context, climate and

land-use history (Santika et al., 2017), and the programme as a whole has delivered recognition more consistently than livelihood or conservation gains (Fisher et al., 2018). Studies of community forest management in Lampung confirm that forest cover effects are context-dependent rather than automatic (Putraditama et al., 2019), and work on village and community forests in Indonesia finds that legal recognition alone does not produce institutional strength: strength depends on the rules, skills and resources that operate inside the managing institution (Wahyu et al., 2024). Community-based ecosystem service management designed to reduce emissions from deforestation and degradation faces the same condition, in that its effects depend on how local institutions actually function (Muttaqin et al., 2019). In Papua, this question is further shaped by the Special Autonomy framework, which formally recognises the customary rights of Indigenous Papuans (Law No. 2 of 2021).

Tree nurseries are one such concrete activity. Beyond supplying seedlings, a nursery is an arena in which rules, divisions of labour and collective knowledge are put to the test (Ostrom, 1990; Lillesø et al., 2011). In many places in Indonesia, nurseries are also established through partnerships with companies as part of corporate social responsibility (CSR), which raises additional questions about ownership, dependency and accountability (Frynas, 2005). The Malasigi customary village in Klayili District, Sorong Regency, inhabited by the Moi Kelim Indigenous community, illustrates this configuration. The village has developed special-interest ecotourism based on birdwatching and noken weaving, while LPHD Belempe runs agroforestry and forest-based ecotourism units with support from an energy company partner (Detik Finance, 2025). That last claim rests on a single news item and is reported here as such, not as independently verified programme data. Through a greenhouse nursery, LPHD Belempe has produced 5,000 seedlings of 11 taxa intended to serve productive, cultural and conservation functions.

The restoration literature, however, warns that the number of seedlings produced or planted is a weak indicator of success; what matters is survival, species suitability, site selection and the benefits that actually reach communities (Brancalion and Holl, 2020; Di Sacco et al., 2021). Evaluations of

community forestry likewise tend to omit the data needed to judge outcomes (Hajjar et al., 2016). Two specific problems follow. First, nursery programmes in Papuan customary villages are rarely examined in the literature, and existing evaluations are largely narrative. Second, such evaluations seldom check whether the species produced are in fact native and of the conservation status claimed, nor do they link technical achievements to the institutional capacity of the managing organisation. Recent work on smallholder tree planting underlines the same point from the other side: providing seedlings and information changes planting and survival only when follow-up and survival are actually tracked (Rudolf et al., 2020).

This article addresses these gaps by evaluating the LPHD Belempe nursery programme through three lenses: ecological composition, the legitimacy of conservation claims, and institutional capacity. Its novelty lies in combining a conservation-status audit with an institutional reading of a community nursery, producing an evaluation tool that other village forest institutions in Papua can replicate. Four research questions guide the study. RQ1: What is the composition of the seedlings produced by the nursery, by functional group, taxon and biogeographic origin? RQ2: Are the taxonomic identities, biogeographic origins and conservation statuses of the species propagated consistent with the programme's own labels, in particular the labels native Papuan flora and Rare, Threatened and Endemic species? RQ3: What internal and external factors, identified through SWOT analysis, affect the sustainability of the programme? RQ4: What TOWS strategies, monitoring framework and policy recommendations follow from those findings for the institution and its partners? The article proceeds with a literature review, the research method, the results and discussion, and the conclusions, in which each question is answered in turn.

LITERATURE REVIEW

Social forestry and community-based conservation

Community-based conservation rests on the premise that local people who depend on resources have both the incentive and the knowledge to manage

them sustainably. Agrawal and Gibson (1999) criticise romantic notions of the community as a homogeneous entity and argue that conservation outcomes depend on internal power relations, institutions and interactions with external actors. In Indonesia, social forestry has expanded rapidly since 2016 under a national allocation target, yet assessments show that formal recognition has often outpaced improvements in livelihoods and forest condition (Fisher et al., 2018). Quantitative studies confirm that Village Forests can avoid deforestation, but that their effect is context-dependent (Santika et al., 2017; Putraditama et al., 2019). The shift from joint forest management towards more smallholder-based community forestry in Java shows the same lesson in institutional form: outcomes change when the locus of decision-making and benefit changes, not when the label of the scheme changes (Ota, 2019). Community preferences for how social forestry facilitation is programmed also matter, because a programme designed without attention to what communities themselves prioritise is less likely to be sustained once facilitation ends (Wulandari and Kurniasih, 2019). The common thread is that outcomes are shaped less by the legal status of a scheme than by the functioning of the institutions that implement it, a point developed for village and community forests through the concept of local institutional strength (Wahyu et al., 2024). Social forestry therefore cannot be judged by recognition alone; it must be judged by whether it leaves behind institutions capable of running concrete activities, and by whether customary-rights recognition endures over decades of decentralisation rather than in a single project cycle (Sopaheluwakan et al., 2023). The institutional dialectic identified in an Indonesian community case, in which deforestation and conservation pressures operate through the same institutions, is a useful caution here: the same body that conserves can also be the channel through which extraction is organised (Martin, 2025).

Nurseries as institutional arenas

Ostrom's (1990) design principles for long-enduring commons institutions, which include clearly defined rules, monitoring by accountable parties, graduated sanctions and conflict-resolution mechanisms, offer a useful lens for reading community nurseries. Her later social-ecological systems framework

further emphasises the interaction between resource units, users and governance systems (Ostrom, 2009). In smallholder agroforestry, Lillesø et al. (2011) show that seed and seedling supply systems often fail not because of propagation techniques but because of weak supply chains, unclear quality standards and limited institutional support. Co-management research adds that durable arrangements emerge through knowledge generation, bridging organisations and social learning over time (Berkes, 2009). Taken together, these studies suggest that a nursery should be evaluated both as a technical facility and as a site of institution-building. That reading must, however, be disciplined by evidence on how commons principles actually vary: conservation needs differ where common-pool governance principles are applied unevenly, so the presence of a principle on paper cannot be treated as proof of its operation in practice (McClanahan and Abunge, 2019). A nursery that keeps no records, applies no quality standard and enforces no rule about what is planted where is, on this reading, not merely technically weak; it is institutionally incomplete.

Participation, inclusion and corporate partnerships

Participation varies in depth, from tokenistic consultation to genuine delegated control (Arnstein, 1969; Pretty, 1995). Reed (2008) shows that participation improves environmental decisions only when it is institutionalised early, involves relevant stakeholders and is supported by skilled facilitation. Agarwal (2001) demonstrates that community forestry can produce participatory exclusions, particularly of women, when rules and meeting practices are not designed for inclusion. More recent evidence confirms that such exclusion persists in practice even where formal participation is claimed: in Nepal's community forestry, women's exclusion has persisted through meeting practice and rule design rather than through formal prohibition (Baral et al., 2024), and out-migration of men has reshaped, but not removed, the gendered division of forestry labour and decision-making (Prateek et al., 2019). When programmes are financed through CSR, a further risk arises: initiatives may be designed around corporate reporting cycles rather than community priorities, producing visible outputs but limited long-term development impact (Frynas, 2005). The

convergence and divergence of ecotourism, biodiversity conservation and livelihoods is relevant here, because a nursery linked to ecotourism can serve conservation and livelihoods at once only when the benefits and the decisions are shared rather than captured by one party (Samal and Dash, 2023). These insights imply that the sustainability of a community nursery depends on the quality of participation and on the governance of the partnership that funds it. Rural livelihoods and community-based conservation can reinforce each other, but the scope for synergy depends on how benefits are distributed and who bears the costs (Meyer and Börner, 2022).

Research gap and analytical framework

Existing studies of community forestry tend to focus on deforestation outcomes or livelihood indicators at the scheme level, and data on intermediate outcomes are often not collected (Hajjar et al., 2016). Few studies examine nursery programmes at the village level in Papua, and fewer still interrogate whether conservation labels are scientifically justified. This study therefore applies a results-chain logic (inputs, activities, outputs, outcomes, impacts) and reads the evidence through three lenses: ecological composition, the legitimacy of conservation claims, and institutional capacity. Each finding is placed explicitly at its level on the results chain to avoid inferring impact from output data.

The framework is defined here with its indicators and its limits stated plainly, because a framework that is only named cannot discipline an evaluation. For the ecological lens, the indicators are the composition of the seedling portfolio by functional group, taxon and biogeographic origin, expressed as counts and shares. For the legitimacy lens, the indicator is the match between the programme's labels and formal conservation status, assessed taxon by taxon against the IUCN Red List and CITES listings; legitimacy is operationalised only through that comparison, and no wider criterion for what counts as a legitimate claim is asserted beyond it. For the institutional lens, the indicators are the presence and operation of written rules on recording, monitoring, mother-tree protection and benefit-sharing, the continuity of labour, water, growing media and funding, and the diversity of funding sources. No thresholds were defined in advance for any lens, and the tiered monitoring framework proposed later in

this article is an output of the study, not a tool that was used to evaluate the programme. Of Ostrom's design principles, only the absence of monitoring rules is actually analysed in the evidence, because no data were reported on graduated sanctions or on conflict-resolution mechanisms for Belempe; those principles are therefore named as part of the framework but not claimed as findings. The participation question is treated the same way: whether community members decide species, planting sites and benefit-sharing, or whether external partners decide and locals implement, is posed as an open question, and the evidence collected does not answer it. That gap is stated as a finding about the evidence, not filled by assumption.

Two bodies of recent literature sharpen the monitoring part of the framework. A diagnostic for collaborative monitoring in forest landscape restoration shows that monitoring fails when roles, indicators and feedback into decisions are not agreed before data collection begins (Guariguata and Evans, 2019), and a review of restoration monitoring frameworks finds that many frameworks state principles they do not operationalise (Gutierrez et al., 2021). The monitoring framework proposed in this article is therefore deliberately simple: it specifies who records what, by what method and how often, and it leaves numerical targets unset so that they can be set together with managers to match local capacity, following the lesson that monitoring challenges in restoration are as much institutional as technical (Mansourian and Stephenson, 2023; Elias et al., 2024). On consent, an Indigenous-informed relational approach to free, prior and informed consent treats consent as an ongoing relationship rather than a single permission, which is the standard applied in this article to token-related traditional knowledge (Mitchell et al., 2019).

METHOD

Research design and site

The study used a descriptive-evaluative case study design with a mixed-methods approach. The unit of analysis was the nursery programme as a whole, covering seedlings, facilities and the managing institution. The research was conducted at the Belempe greenhouse nursery managed by LPHD Belempe in the Malasigi

customary village, Klayili District, Sorong Regency, Southwest Papua Province. The community is identified as the Moi Kelim Indigenous community. No fieldwork dates or period are reported in the original study, and none are supplied here: the timing of fieldwork is a stated gap in the evidence, and any claim about when the inventory or interviews took place would be invented.

Data collection

Four complementary techniques were used to allow triangulation. First, a nursery inventory, recording the taxa and number of seedlings in each functional group. Second, structured observation of the facility, including infrastructure, growing media, shading and watering systems, and maintenance practices. Third, semi-structured interviews with 15 key informants selected purposively (LPHD board members, daily nursery managers, customary leaders and noken weavers), covering the division of roles, operational constraints and plans for seedling use. Fourth, document review of activity records, seedling distribution records, the Village Forest Management Plan and field documentation. Three gaps in this account are stated rather than repaired. No breakdown of the 15 informants by group is reported, so it is not possible to say how many board members, managers, leaders or weavers were interviewed. No inventory method detail is reported: whether the count was a census or a sample, on what date it was taken, and by whom, are all unstated. No species-identification method is reported: how scientific names were assigned, whether from nursery records, local knowledge or visual identification, is unstated, and that gap matters because several species identities are provisional, as reported below.

One internal inconsistency in the original account is clarified here by wording, not by new data. The method describes seedling distribution records as part of the document review, while the results state that there are no data on actual planting. Both statements can stand only if they refer to different things, and they are therefore read as follows: the records reviewed were nursery activity and distribution records, including intended distribution, while field planting outcomes, meaning seedlings actually planted, surviving and used, were not

recorded. No planting figure is reported anywhere in this article, and none is implied by the clarification.

Data analysis

Composition analysis. The proportion of seedlings was calculated for each taxon and functional group. These proportions describe the structure of the seedling portfolio and are not intended as a measure of plant community diversity in the field.

Taxonomic and conservation-status audit. Each taxon was traced for its scientific name, biogeographic origin (native to the Malesia-Papua region or introduced), IUCN Red List status and CITES trade status. The audit results were then compared with the functional categories used by the programme. One element that the original method promised is not carried forward, and the reason is recorded here rather than hidden. The original method stated that national protection status under Minister of Environment and Forestry Regulation No. P.106/MENLHK/SETJEN/KUM.1/12/2018 would also be audited, but no such status was reported for any taxon in the original results, and the regulation's species list could not be verified from an accessible official source. No national protection status is therefore asserted for any taxon in this article. That omission is recorded as a limitation, and the regulation remains in the reference list because it is cited in the method discussion, not because a status finding is claimed from it.

SWOT-TOWS analysis. Internal factors (strengths and weaknesses) and external factors (opportunities and threats) were identified from the triangulated data and combined in a TOWS matrix (Wehrich, 1982) to generate SO, WO, ST and WT strategies. These strategies were then translated into a tiered monitoring framework and stakeholder-specific recommendations. No coding rule, factor-selection criterion or weighting for the SWOT factors is reported in the original study, and none is supplied here; the SWOT analysis is qualitative and unweighted, and its strategy priorities require validation through focus group discussions with managers and community members, as the limitations section states.

Research ethics

Informants took part voluntarily after receiving an explanation of the study's purpose and giving verbal informed consent. Personal identities are not reported. Information on traditional knowledge, particularly regarding noken fibre plants, is presented only in general terms, and ownership of that knowledge remains with the Moi Kelim community. No ethics approval body or approval reference is stated in the original study, and none is invented here.

RESULT AND DISCUSSION***Composition and structure of the seedling portfolio***

The Belempe nursery produced 5,000 seedlings of 11 taxa grouped into three functional categories (Table 1; Figure 1). The agroforestry group dominated with 2,675 seedlings (53.5%), followed by the multipurpose group with 1,500 seedlings (30.0%) and the RTE group with 825 seedlings (16.5%). At the taxon level, the distribution was fairly even: ten of the eleven taxa account for 325 to 550 seedlings each (6.5 to 11.0%). The one striking exception is red fruit (buah merah), with only 25 seedlings (0.5%). This answers RQ1 in descriptive terms: the portfolio is diversified across taxa and dominated, in share, by productive rather than conservation functions, a point developed below.

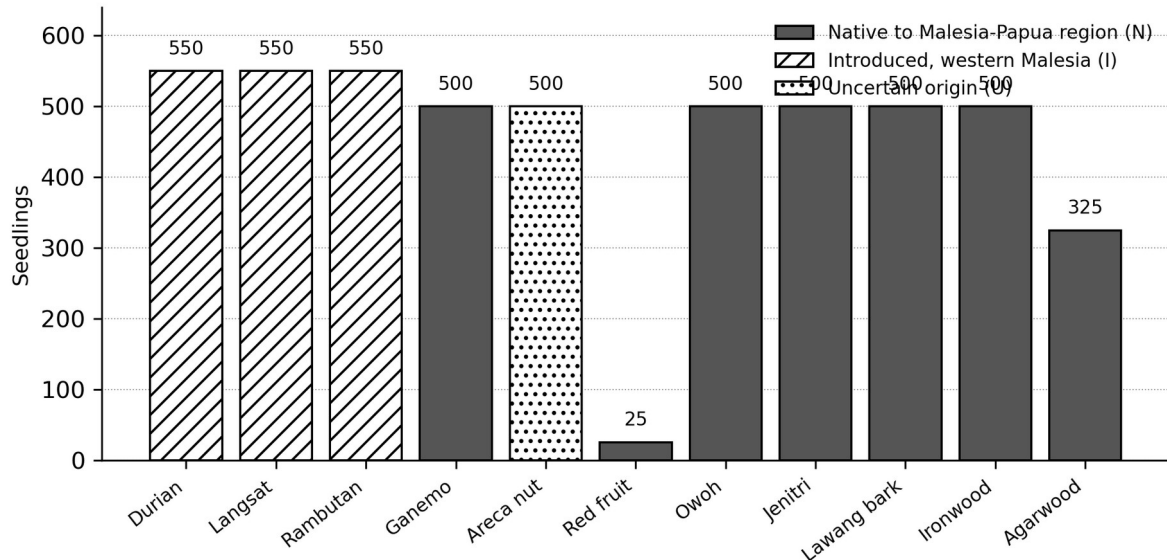
Table 1. Seedling composition by functional group and taxon at the Belempe nursery

Group	Taxon (local and scientific name)	Seedlings	Share (%)	Origin
Agroforestry	Durian (Durio sp., probably D. zibethinus)	550	11.0	I
	Langsat (Lansium parasiticum)	550	11.0	I
	Rambutan (Nephelium sp., probably N. lappaceum)	550	11.0	I
	Ganemo (Gnetum	500	10.0	N

	gnemon) (b)			
	Areca nut, pinang (Areca catechu)	500	10.0	U
	Red fruit, buah merah (Pandanus conoideus)	25	0.5	N
	Subtotal agroforestry	2,675	53.5	
Multipurpose	Owoh, noken fibre plant (Commersonia sp.) (b)	500	10.0	N
	Jenitri (Elaeocarpus ganitrus) (b)	500	10.0	N
	Lawang bark, kulit lawang (Cinnamomum sp.) (b)	500	10.0	N
	Subtotal multipurpose	1,500	30.0	
RTE	Ironwood, kayu besi (Intsia sp., probably I. bijuga)	500	10.0	N
	Agarwood, gaharu (Aquilaria sp.)	325	6.5	N
	Subtotal RTE	825	16.5	
Total	11 taxa	5,000	100.0	

Notes: N means native to the Malesia-Papua region; I means introduced (originating in western Malesia); U means uncertain origin, long cultivated in Papua. (b) means species identity requires verification against herbarium specimens; names given are provisional. All shares were rechecked from the counts and are arithmetically consistent.

Figure 1. Number of seedlings per taxon by functional group and biogeographic origin



Notes: Bars are ordered as in Table 1: agroforestry taxa first, then multipurpose taxa, then RTE taxa. Pattern codes origin: solid bars are native to the Malesia-Papua region, hatched bars are introduced from western Malesia, and the dotted bar is of uncertain origin. The published chart was checked visually against Table 1: every plotted value matches Table 1 exactly, so the chart is presented here in black and white from the same values rather than copied.

The even distribution shows that the programme does not rely on one or two commodities but spreads its propagation effort almost equally across taxa. From a risk perspective, this is a strength, since the failure of one species does not undermine the whole programme. The low number of red fruit seedlings, by contrast, warrants explanation. Whether it reflects limited vegetative propagation material, low propagation success or a deliberate priority choice, it is noteworthy because red fruit is a native species of high cultural and dietary value in Papua and therefore aligns closely with the programme's stated mission. Monitoring of a seedling planting restoration elsewhere shows why such a gap matters: without follow-up counts after planting, a nursery cannot tell whether a small initial stock is a deliberate choice or an early sign of propagation failure (Fiore et al., 2019).

Origin and conservation status: testing the legitimacy of claims

The audit produced two findings that are not visible in the programme's own framing, and they answer RQ2. First, not all seedlings are native Papuan flora.

Durian, langsung and rambutan are generally regarded as originating in western Malesia and introduced into Papua; together they account for 1,650 seedlings, or 33.0% of the total. Areca nut (10.0%) is of uncertain origin, although it has long been cultivated in Papua and holds strong cultural significance. Native taxa therefore account for 2,850 seedlings (57.0%). Second, the RTE label is not fully consistent with formal conservation status (Table 2). The distinction between native to the region and endemic to Papua matters throughout: native to the Malesia-Papua region is not the same as endemic to Papua, and the programme's title phrase about a native Papuan nursery programme must not be read as a verified claim that the stock is native Papuan flora.

Table 2. Programme categories compared with the formal conservation status of the RTE group

Taxon	Programme category	Formal status	Implication
Ironwood (<i>Intsia bijuga</i>) (a)	Rare, Threatened and Endemic	IUCN: Near Threatened (Barstow, 2020); distributed from East Africa to the Pacific, hence not endemic to Papua	Correctly described as a conservation-priority species under logging pressure, but not as threatened or endemic
Agarwood (<i>Aquilaria</i> sp.)	Rare, Threatened and Endemic	All <i>Aquilaria</i> spp. are listed in CITES Appendix II; IUCN status depends on the species	Species-level identification determines any threat claim; trade in seedlings and products is subject to regulation

Notes: (a) Subject to confirmation of species identity through herbarium verification. National protection status under Regulation No. P.106/MENLHK/SETJEN/KUM.1/12/2018 is not reported for either taxon, because the original audit did not report it and the regulation's species list could not be verified from an accessible official source; see the Method and Limitations sections.

These findings do not diminish the conservation value of either taxon, both of which face clear exploitation pressure because of the value of their timber and resin. Accurate terminology nonetheless matters for scientific accountability, particularly when results are reported to funding partners and government

agencies. A more defensible label for this group is conservation-priority species, accompanied by an explicit statement of each species' status. The discrepancy also has a political dimension: labels such as endangered or endemic carry symbolic weight in CSR and programme reporting, and their imprecise use can inflate perceived achievements while obscuring what remains to be done. Both status claims in Table 2 are conditional, and they are kept conditional here. The Near Threatened assessment for ironwood depends on the identification probably *I. bijuga*, and the threat claim for agarwood depends on species-level identification that the nursery stock, recorded only to genus, does not yet supply. Species identity is provisional for seven of the eleven taxa in total: three are marked probably a named species (durian, rambutan and ironwood) and four more are footnoted as requiring herbarium verification (ganemo, owoh, jenitri and lawang bark), while agarwood is given only to genus. Only langsung, areca nut and buah merah carry unqualified binomials. No provisional identity is upgraded to a confirmed species anywhere in this article.

Strategic factors (SWOT)

Triangulation of the data produced the internal and external factors summarised in Table 3. The programme's main strengths lie in its diversified portfolio and its legally recognised institutional base, whereas its main weaknesses are informational: there are no performance data beyond seedling counts. These factors answer the descriptive part of RQ3; their strategic consequences are taken up in the TOWS section that follows.

Table 3. Internal and external factors in the management of the Belempe nursery

Dimension	Code	Factor
Strength	S1	A portfolio of 11 taxa spread fairly evenly across productive, cultural and conservation functions
Strength	S2	LPHD holds legal management rights over the Village Forest
Strength	S3	Direct links to cultural identity (noken fibre) and to the ecotourism business unit

Strength	S4	The greenhouse allows control of shade, humidity and watering
Weakness	W1	No data on germination, survival, seedling quality or actual planting
Weakness	W2	Several species identities are unverified, and the RTE label does not match formal status
Weakness	W3	Technical requirements differ across taxa, but species-specific propagation protocols are lacking
Weakness	W4	Continuity of operational resources (labour, water, media, funding) is not assured
Opportunity	O1	Educational ecotourism: plant interpretation, nursery demonstrations and vegetation-wildlife links
Opportunity	O2	Noken's UNESCO (2012) intangible heritage status raises the value of its raw materials
Opportunity	O3	Collaboration with universities, herbaria, government and corporate partners
Opportunity	O4	Social forestry and Special Autonomy policies open access to assistance and funding
Threat	T1	Post-planting mortality due to water stress, light, wildlife damage and weed competition
Threat	T2	Pressure on forests and mother trees threatens seed sources
Threat	T3	Market uncertainty and long waiting periods before

Threat	T4	productive species yield Climate variability, pests and diseases
Threat	T5	Seedling numbers exceed maintenance capacity and planting land
Threat	T6	Dependence on a single corporate funder

TOWS strategy matrix

Combining these factors yields four groups of strategies (Table 4). The WO and WT strategies are prioritised for the short term because the informational weaknesses (W1 to W2) are preconditions for the success of all other strategies.

Table 4. TOWS matrix and strategy priorities

Strategy	Formulation	Priority
SO (S1, S3 x O1, O2)	Develop a from seed to noken interpretation trail combining nursery demonstrations, native plant interpretation and noken weaving as an ecotourism product	Medium (years 2 to 3)
WO (W1, W2 x O3)	Partner with a herbarium or university to verify species, draft species-specific propagation protocols and train community data recorders	High (year 1)
ST (S2 x T2, T6)	Adopt LPHD rules on mother-tree protection, seed collection and forest product use, backed by customary sanctions; diversify funding sources	High (year 1)
WT (W4 x T1, T5)	Match seedling production targets to maintenance capacity and available land; prioritise native species for forest enrichment and	High (year 1)

introduced species for
agroforestry gardens

The original matrix left five factors without an explicit strategy link, and that gap is closed here by mapping each of them onto the article's own material, without adding new evidence. W3, the lack of species-specific propagation protocols, is in substance already inside the WO formulation, which commits the herbarium or university partnership to drafting such protocols; it is therefore read as part of WO rather than as an unmapped weakness. S4, greenhouse control of shade, humidity and watering, extends the same WO partnership: the controlled environment is the place where verification trials and protocol development can be run under comparable conditions, and it also supports the WT strategy by allowing hardening of seedlings before they face field mortality risks under T1. O4, policy access to assistance and funding under social forestry and Special Autonomy, extends the ST strategy of funding diversification, and it is the policy channel through which the stakeholder recommendations on village and Special Autonomy funds operate. T3, market uncertainty and long waiting periods before productive species yield, is addressed through S1, the diversified portfolio itself: because early-yield multipurpose species and long-cycle conservation species sit in the same portfolio, income timing can be staggered rather than depending on a single species maturing, and that staggering is a direct consequence of the composition reported in Table 1. T4, climate variability, pests and diseases, is addressed through S4 together with the monitoring framework: the greenhouse buffers early-stage seedlings, and the survival monitoring in Table 5 is the mechanism by which pest and disease losses after planting would be detected. The WT pairing itself is loose in one respect that should be stated: W4, continuity of resources, is paired with T1, post-planting mortality, and T5, capacity and land limits, but mortality is driven by field conditions as much as by nursery resources, so the WT strategy is best read as a capacity-matching rule, not as a mortality control in itself. No factor is left unmapped, and no strategy in this paragraph introduces a finding, a figure or a partner that the article does not already contain.

The output-outcome gap as the core problem

The most fundamental finding of this study is that all verifiable achievements lie at the output level. Five thousand seedlings represent a real accomplishment, but they do not answer the central conservation question: how many survive, where they are planted and whether they grow. Global reviews of tree-planting initiatives show that post-planting mortality can be very high when species selection, seedling quality and maintenance are not planned (Brancalion and Holl, 2020). The programme's contribution to conservation should therefore be reported as potential rather than achievement until survival data become available. This distinction is not merely a matter of academic caution: it determines whether LPHD can learn from its own implementation and adapt the programme accordingly. It also echoes a broader pattern in community forestry, where the data needed to judge outcomes are frequently not collected at all (Hajjar et al., 2016). Evidence on seedling planting versus direct seeding over six years shows that survival, growth and cost must be tracked together before any planting method can be judged successful (Ferreira et al., 2022), and monitoring of a seedling planting restoration shows that early counts without follow-up survival data cannot support claims about restoration outcomes (Fiore et al., 2019). The diagnostic literature on collaborative monitoring makes the institutional point explicit: monitoring that does not feed back into decisions is decoration, not management (Guariguata and Evans, 2019), and frameworks that state principles without operationalising them leave programmes exactly where Belempe now stands, with outputs counted and outcomes unknown (Gutierrez et al., 2021). Accelerating restoration monitoring therefore depends on practical actions, including agreed indicators and regular feedback, rather than on more ambitious indicator lists (Elias et al., 2024).

Tension between conservation and livelihoods in the portfolio

The seedling composition reveals an implicit choice: 83.5% of the seedlings serve use functions (agroforestry and multipurpose), and only 16.5% serve conservation. This choice is rational from the community's perspective, since tangible economic incentives are a precondition for long-term participation (Agrawal and Gibson, 1999). However, the finding that about one third of the

seedlings are introduced species calls for clear zoning. Restoration principles hold that native species should be prioritised for ecosystem recovery, whereas productive exotic species belong in cultivated land (Di Sacco et al., 2021). For LPHD Belempe, this implies two distribution pathways: native species such as ironwood, agarwood, ganemo and jenitri for enrichment planting inside the Village Forest according to its management blocks, and durian, langsung and rambutan for agroforestry gardens on community land. Such separation also prevents vegetation enrichment from turning into a gradual conversion of natural forest into fruit orchards. The synergy between livelihoods and conservation is real but bounded: where benefits and costs are unevenly shared, livelihood gains can coexist with conservation losses, so zoning and benefit-sharing rules are not optional extras but the mechanism that keeps the two aims compatible (Meyer and Börner, 2022).

The nursery as an institutional arena

The institutional lens helps explain why the informational weaknesses arise. Ostrom (1990) shows that long-enduring commons management requires, among other things, clear rules and monitoring by parties accountable to the community. The absence of a recording system at the Belempe nursery can thus be read as the absence of monitoring rules, rather than merely a technical shortfall. Lillesø et al. (2011) similarly show that small-scale seed and seedling systems often fail because of weak supply chains and institutional support rather than propagation techniques. Strengthening LPHD therefore needs to be expressed in concrete terms: who records what, when, and to whom the data are reported. Without such rules, gains in technical capacity are unlikely to survive the end of external assistance. In co-management terms, the nursery can become a site of social learning only if the knowledge it generates is recorded, shared and used in decisions (Berkes, 2009). The Indonesian evidence on local institutional strength supports this reading directly: village and community forest institutions differ in strength precisely on these operational dimensions, not on their legal status (Wahyu et al., 2024). Variability in how common-pool governance principles operate is itself a conservation risk, because a principle that is present in a statute or a plan but absent in daily

practice offers no protection (McClanahan and Abunge, 2019). The institutional dialectic observed in an Indonesian community, where the same institutions channel both conservation and deforestation pressures, is a further reason to judge Belempe by its operating rules rather than by its legal recognition (Martin, 2025).

Partnership governance and programme dependency

The programme operates within a corporate-community partnership in which an energy company provides funding and technical support. Such partnerships bring resources that village institutions rarely mobilise on their own, but they also carry known risks: activities may be shaped by reporting cycles rather than community priorities, outputs may be emphasised over outcomes, and the programme may stall once corporate support ends (Frynas, 2005). The output-oriented evidence base identified in this study is consistent with this pattern. Three governance measures could reduce the risk. First, a jointly agreed results framework should commit both parties to outcome indicators, not only seedling targets. Second, a phased exit strategy should progressively transfer operational costs and decision-making to LPHD, supported by revenue from seedling sales and ecotourism. Third, funding should be diversified through village funds, Special Autonomy allocations and environmental funding mechanisms, so that the institution is not dependent on a single partner. Transparent disclosure of the funder's role in programme design and evaluation would further strengthen the credibility of reported results. That disclosure is made concrete in the Acknowledgements to this article, which state plainly that two authors are affiliated with the funding partner and one author with the managing institution, so that readers can weigh the analysis with that position in mind.

Quality of participation and inclusion

Interviews with 15 informants from the LPHD board, nursery staff, customary leaders and noken weavers indicate that the programme involves several community groups. Nevertheless, involvement in implementation is not the same as control over decisions. Using the participation typologies of Arnstein (1969) and Pretty (1995), the critical question is whether community members decide which species to propagate, where seedlings are planted and how

benefits are shared, or whether these decisions are made by external partners and then implemented locally. It is stated explicitly here that evidence on that decision-control question was not collected in this study, so the participation-depth question remains open and no answer is implied by the involvement reported above. Noken weaving in Papua is largely carried out by women, so their role in decisions on fibre plants deserves particular attention; community forestry can exclude women when rules and meeting practices are not designed for inclusion (Agarwal, 2001). That risk is not hypothetical: women's exclusion has persisted in community forestry practice through meeting practice and rule design even where participation is formally claimed (Baral et al., 2024), and shifts in household labour, including out-migration of men, reshape who participates without automatically giving women decision control (Prateek et al., 2019). The monitoring framework proposed below therefore includes sex-disaggregated indicators of participation, as proposed indicators, not as measured results.

The cultural dimension: noken and traditional knowledge

Propagating owoh as a noken fibre plant places the programme at the intersection of plant conservation and cultural heritage. UNESCO (2012) inscribed noken on the List of Intangible Cultural Heritage in Need of Urgent Safeguarding, and the availability of raw materials is one of the factors that determine the craft's continuity. Developing products from traditional knowledge, however, must respect free, prior and informed consent (FPIC) and fair and equitable benefit-sharing, as set out in the Nagoya Protocol and the United Nations Declaration on the Rights of Indigenous Peoples (Secretariat of the Convention on Biological Diversity, 2011; United Nations, 2007). An Indigenous-informed relational approach to FPIC treats consent as an ongoing relationship rather than a one-off permission, which fits a programme in which fibre plants, weaving knowledge and seedling production will interact over many seasons (Mitchell et al., 2019). Documentation of the relationship between the local name owoh, its botanical identity and its processing techniques should be carried out together with weavers, with data ownership remaining with the community. The link to ecotourism reinforces the same condition: where

ecotourism, conservation and livelihoods converge, the convergence holds only when communities retain control over the cultural products being displayed and sold (Samal and Dash, 2023).

Proposed monitoring framework

To close the output-outcome gap, a simple tiered monitoring framework that LPHD data recorders can operate is proposed (Table 5). Numerical targets are deliberately left to be set together with the managers so that they match local capacity, and no target is set anywhere in this article. The framework follows the diagnostic lesson that collaborative monitoring works only when indicators, methods, frequencies and feedback into decisions are agreed in advance (Guariguata and Evans, 2019), and it is kept principled in the sense used by the restoration monitoring literature: each level states what will be measured, how, and how often, and the levels are ordered along the results chain so that impact is never inferred from output counts alone (Gutierrez et al., 2021). Monitoring challenges in restoration are commonly institutional rather than technical, including unclear ownership of data and weak feedback loops, and the framework below addresses those challenges by assigning recording to named LPHD roles and reporting to LPHD meetings (Mansourian and Stephenson, 2023). Practical acceleration of monitoring depends on such tangible arrangements rather than on longer indicator lists (Elias et al., 2024).

Table 5. Tiered monitoring framework for the Belempe nursery programme

Level	Indicator	Method	Frequency
Output	Seedlings per taxon; percentage of healthy, plantable seedlings meeting quality standards (height, diameter, root-ball firmness)	Nursery census; standard record sheet	Monthly
Ecological outcome	Seedlings planted per georeferenced site; survival at 3, 6 and 12 months; height increment	Permanent monitoring plots; individual tagging	Quarterly in year 1
Social outcome	Active members by	Attendance lists;	Every six months

	sex; seedlings used by households; noken fibre harvested; participation in key decisions	short interviews; LPHD records	
Governance	Share of operating costs covered by LPHD's own revenue; number of funding sources; decisions taken in LPHD meetings	Financial records; meeting minutes	Annually
Impact	Change in vegetation cover in enrichment blocks; ecotourism visits and income linked to the nursery	Satellite imagery; visitor data; household survey	Annually

Notes: Numerical targets are deliberately left unset, to be set together with managers so that they match local capacity. The social outcome indicator on participation in key decisions measures the decision-control question prospectively; it does not retrospectively answer that question for the period studied.

Recommendations by stakeholder

The findings translate into differentiated recommendations, which are elaborations of the single aligned set stated in the Conclusion, not a separate set. For LPHD Belempe, the priorities are to adopt written rules on data recording, mother-tree protection and benefit-sharing; to appoint and train data recorders; and to separate distribution pathways for native and introduced species. These elaborate the core recommendations on monitoring, quality standards and zoning. For the corporate partner, the priorities are to shift reporting from seedling counts to outcome indicators, to agree on a phased exit strategy with LPHD, and to disclose its role in programme design and evaluation. These elaborate the core recommendations on monitoring and on the phased exit. For the local government and Forest Management Unit (KPH), the priorities are to integrate the nursery into the Village Forest Management Plan, to provide extension support, and to channel village and Special Autonomy funds to

support operating costs. These elaborate the core recommendation on funding diversification, by naming the policy channels through which diversification would operate. For universities and research institutions, the priorities are species verification, participatory ethnobotanical documentation of noken fibre plants, and longitudinal survival studies. These elaborate the core recommendations on species verification and on monitoring, by naming who would carry out the verification and the survival tracking and over what horizon.

Limitations

This study has limitations that condition every conclusion above. First, the quantitative data cover only seedling numbers at a single point in time, so technical performance could not be analysed. Second, the identity of several species remains provisional until verified against herbarium specimens. Third, the SWOT analysis is qualitative and unweighted, so strategy priorities need to be validated through focus group discussions with managers and community members. Further research should take the form of longitudinal studies of seedling survival in the field and participatory ethnobotanical studies of noken fibre plants. Fourth, national protection status under Regulation No. P.106/MENLHK/SETJEN/KUM.1/12/2018 (Ministry of Environment and Forestry, 2018) was promised in the original method but is not reported for any taxon, because the original results did not report it and the regulation's species list could not be verified from an accessible official source; no status is asserted, and the gap is recorded here rather than repaired by assumption. Fifth, evidence on participation decision-control, meaning who decides species, planting sites and benefit-sharing, was not collected, so the participation-depth question remains open. Sixth, fieldwork dates, the breakdown of the 15 informants by group, the inventory method and the species-identification method are not reported, so the timing and the counting and identification procedures behind the seedling data cannot be audited from this article. Seventh, Figure 1 in the published article is a chart whose values were checked visually against Table 1 and matched exactly; the chart is presented here in black and white from the same values rather than copied.

CONCLUSION

Each research question is now answered in turn. RQ1, on the composition of the seedlings produced: the nursery produced 5,000 seedlings of 11 taxa, with agroforestry at 2,675 seedlings (53.5%), multipurpose at 1,500 (30.0%) and RTE at 825 (16.5%). Ten taxa account for 325 to 550 seedlings each, and the exception is buah merah at 25 seedlings (0.5%), a native species of high cultural and dietary value whose low stock warrants explanation. By origin, 2,850 seedlings (57.0%) are native to the Malesia-Papua region, 1,650 (33.0%) are introduced from western Malesia, and 500 (10.0%) are of uncertain origin. RQ2, on whether identities, origins and statuses match the programme's labels: they do not, in two respects. About one third of the stock is introduced fruit species, so the label native Papuan flora must be narrowed and distribution must be zoned. The RTE label is only partly consistent with formal status: ironwood, probably *I. bijuga*, is assessed as Near Threatened (Barstow, 2020) rather than threatened or endemic, and agarwood, recorded only to genus, is listed in CITES Appendix II (CITES, n.d.) at genus level with species-level threat status undetermined. The defensible label for the group is conservation-priority species, with each taxon's status stated explicitly and conditionally on herbarium confirmation. National protection status is not answered, because it was not reported in the original audit and could not be verified from an accessible official source.

RQ3, on the internal and external factors affecting sustainability: the strengths are a diversified portfolio of 11 taxa, legal management rights over the Village Forest, direct links to noken cultural identity and ecotourism, and greenhouse control of shade, humidity and watering. The weaknesses are the absence of data on germination, survival, seedling quality and actual planting; unverified species identities and a mismatched RTE label; missing species-specific propagation protocols; and unassured continuity of labour, water, growing media and funding. The opportunities are educational ecotourism, noken's UNESCO heritage status, collaboration with universities, herbaria, government and corporate partners, and policy access to assistance and funding under social forestry and Special Autonomy. The threats are post-planting mortality, pressure on forests and mother trees, market uncertainty and long waits before

productive species yield, climate variability, pests and diseases, seedling numbers exceeding maintenance capacity and planting land, and dependence on a single corporate funder. The binding constraint across these factors is informational and institutional rather than technical: without monitoring rules, the programme cannot convert its strengths into demonstrated outcomes, and without diversified funding it cannot survive the end of a single partnership.

RQ4, on the strategies, monitoring framework and policy recommendations that follow: the TOWS strategies are set out in Table 4, with the WO and WT strategies prioritised for year 1 because the informational weaknesses are preconditions for all other strategies, and with all five previously unmapped factors now linked to strategies on the article's own material. The monitoring framework is Table 5, with targets deliberately left unset to be set with managers. The policy implication is that social forestry support should be judged by the institutional capacity it leaves behind, not by the quantity of inputs it delivers. That implication is sharpened by the Indonesian evidence cited in this article: recognition without institutional strength does not produce conservation or livelihood gains on its own.

Accordingly, LPHD Belempe and its partners are advised to pursue one aligned set of recommendations, elaborated by stakeholder in the preceding section. The core set is: (a) verify the identity of all taxa in collaboration with a herbarium or university; (b) establish seedling quality standards and species-specific propagation protocols; (c) operate the tiered monitoring framework in Table 5 through data recorders appointed under the institution's rules; (d) separate distribution pathways for native species (forest enrichment) and introduced species (agroforestry gardens); (e) agree on a phased exit strategy and diversify funding sources; and (f) develop FPIC and benefit-sharing protocols for products based on traditional knowledge, particularly noken raw materials. The stakeholder elaborations of that set are: integration of the nursery into the Village Forest Management Plan and extension support from local government and the Forest Management Unit, which elaborate (e) by naming the policy channel; channelling of village and Special Autonomy funds to operating costs, which also elaborates (e); and longitudinal survival studies

and participatory ethnobotanical documentation of noken fibre plants by universities and research institutions, which elaborate (a) and (c) by naming who carries out verification and survival tracking. No recommendation in this article goes beyond that aligned set, and no target, threshold or outcome figure is asserted that the evidence does not support.

For policy, the case suggests that social forestry support should be judged by the institutional capacity it leaves behind, not by the quantity of inputs it delivers. A nursery that counts 5,000 seedlings but cannot say how many survived, where they were planted or who decided what was planted has demonstrated output, not conservation. The Belempe programme's value lies in its role as an entry point for strengthening Village Forest institutions, and that value will only become an achievement when monitoring rules, verified identities, zoned distribution and diversified funding are in place.

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