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ORIGINAL RESEARCH PAPER

From demonstration to adoption: Participatory agroforestry transition in East Java, Indonesia

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Abstract: Agroforestry is frequently presented as an integrative land-use option for combining agricultural production, livelihood diversification, and ecological repair. In contrast, farmers in forest-dominated environments rarely use tree-based systems only according to the availability of technical knowledge. Adoption is shaped by cash-flow uncertainty, labor requirements, access legitimacy, institutional support, and the credibility of local evidence. This study examines an early-stage participatory agroforestry intervention in Purnogiri village, Batu City, Indonesia, where farmer groups, Forestry Institution Malang district, and university facilitators jointly introduced demonstration-based tree-crop learning. Using participatory action research and qualitative case-study analysis, the study draws on field observation, focus group discussion, stakeholder coordination records, and intervention documentation. The intervention engaged 48 informants, introduced 160 agroforestry seedlings, and documented a 41% increase in farmer knowledge after socialization and field demonstration. The documented informant profile indicates middle-aged smallholder actors, with age ranging from 45 to 65 years, Elementary School to Senior High School education, 5 to 25 years of farming experience, and 0.5 to 2.0 ha of managed farmland. The strengthened analysis further situates the case within Batu City's smallholder horticultural economy, farmer-group and extension networks, and circular organic-resource potential, including the use of crop residues, fruit and vegetable waste, manure, composting, mulching and eco-enzyme preparation as complementary soil-management practices. The findings show that local readiness did not emerge from training alone, but from the interaction of four mechanisms: livelihood-compatible tree-crop design, demonstration-based social learning, institutional mediation and circular resource use. Existing intercropping experience created an entry point for agroforestry, while Forestry Institution-university-farmer collaboration reduced uncertainty around legitimacy and facilitation. The paper contributes to agroforestry adoption studies by showing that early adoption in state forest margins is a negotiated social and institutional process rather than a one-off transfer of technology. Longitudinal monitoring is still needed to verify seedling survival, management continuity, income effects, residue utilization, and ecological outcomes.

Keywords: agroforestry adoption; demonstration plot; institutional mediation; participatory action research; social learning; organic waste utilization; eco-enzyme.

1. Introduction

Agroforestry has become increasingly relevant in agricultural landscapes where farmers must produce food

while maintaining ecological functions. By deliberately integrating perennial vegetation with crops and, where appropriate, livestock, agroforestry can support tree cover, diversify farm output, buffer climatic stress and improve soil-water functions. These benefits are widely recognized in recent reviews, but the same literature also warns that agroforestry is not a universally adopted solution because its benefits are mediated by local knowledge, labor, land tenure, market access and institutional support (Mukhlis et al., 2022; Bhandari et al., 2026).

In Indonesia, the issue is particularly important in forest-margin areas where farmers cultivate land under complex access arrangements. Social forestry policy aims to improve community access to forest resources and support more sustainable local management (Government of Indonesia, 2021; World Bank, 2020). National studies argue that social forestry implementation depends not only on formal access, but also on the capacity of farmer institutions, local leadership, coordination across actors and viable agroforestry-based livelihood strategies (Kurniasih et al., 2021; Octavia et al., 2022; Situmorang et al., 2026).

The empirical case analyzed in this paper is Purnogiri village, Batu city, East Java. The area is located in a mountainous landscape near Mount Arjuno and is characterized by horticultural crops, fruit trees, mixed farming, and smallholder livestock. Field documentation shows that farmers already practice polyculture and intercropping, including citrus intercropped with leek. Such practices indicate that agroforestry does not enter a completely unfamiliar agricultural system. Rather, it can be introduced as a structured improvement of local mixed-cropping experience.

The problem is that conventional seasonal production remains attractive because it provides faster returns. Farmers may support tree planting in principle, but they need proof that tree-crop combinations will not weaken their short-term livelihood. This gap between ecological rationale and livelihood practicality is a central adoption problem. Contemporary adoption research increasingly treats agroforestry as a system-level decision rather than a simple choice to plant trees (Amare and Darr, 2020). A recent global review further shows that adoption barriers commonly cluster around technical knowledge, socio-economic feasibility, labor/time demands, upfront investment, and policy or institutional uncertainty (Tranchina et al., 2024).

This study addresses a specific gap: the limited understanding of how agroforestry adoption begins through participatory learning and institutional mediation before long-term ecological or economic impacts can be measured. Previous agroforestry adoption research has usefully identified barriers such as knowledge deficits, labor demands, market limitations, upfront investment, and policy uncertainty, but it has less often explained how early adoption readiness is socially produced in forest-margin communities where access legitimacy matters. The novelty of this paper lies in treating institutional mediation not as a background condition, but as a central mechanism that links farmer knowledge acquisition to trust, legitimacy, and willingness to maintain tree-crop systems. The paper does not claim that the intervention has already increased income, productivity or biodiversity. Instead, it investigates whether a participatory demonstration process can create early enabling conditions for adoption. This framing is important because demonstration-based extension can facilitate peer learning and reduce uncertainty, but it must be interpreted as an intermediate mechanism rather than automatic evidence of sustained adoption (Sutherland and Marchand, 2021; Sseguya et al., 2021; Lujan Soto et al., 2021).

The objectives were to: (i) identify local farming and socio-ecological conditions that support agroforestry transition in Purnogiri village; (ii) analyze the role of farmer groups, Forestry Institution and university facilitators in initiating adoption; (iii) evaluate the demonstration plot as a social learning mechanism; and (iv) clarify the evidence still needed before long-term impact claims can be made.

2. Material and Methods

2.1. Study area and case selection

The study was conducted in Purnogiri village, Batu city, East Java, Indonesia. The village lies in a mountainous area at approximately 600-700 m above sea level and has a farming system dominated by vegetables, fruit crops, food crops, and smallholder livestock. The case was selected because the available field documentation consistently described Purnogiri as the main location of the agroforestry intervention, including the farmer-group setting, field survey, socialization and demonstration-plot establishment. Earlier drafting materials contained references to another village, but these were removed to preserve location consistency and analytical validity.

The village has several conditions that make it suitable for an early-stage agroforestry case. Farmers cultivate seasonal horticultural crops such as carrot, broccoli, tomato, chili, shallot, onion and corn, while perennial crops such as avocado, citrus, mango, guava, coffee and jackfruit are also present. Local livestock activities, including cattle, goats, poultry and rabbits, further indicate the possibility of integrated tree-crop-livestock development in later phases.

This local setting is consistent with the broader agricultural structure of Batu City, where smallholder horticulture, fruit production, livestock activity and farmer-group organization remain central to rural livelihoods. Public reporting of the 2023 Agricultural Census for Batu City indicates that smallholder farmers dominate the agricultural sector, with 89.1% or 18,109 farmers cultivating less than 1.5 ha; the smallholder share is also high in forestry, livestock and horticulture-based enterprises (BPS Kota Batu, 2023; MalangVoice, 2024). Batu City's horticultural statistics further show that vegetable and fruit production is documented in commodity-disaggregated form, confirming the importance of crop diversity for estimating potential residues and designing tree-crop systems (BPS Kota Batu, 2024). For this reason, agroforestry in Purnogiri should be understood not only as tree planting, but as a livelihood-compatible strategy that links seasonal horticulture, perennial crops, livestock manure, farmer institutions and circular organic-resource management.

2.2. Research design

The study used a participatory action research design combined with qualitative case-study analysis. This design was appropriate because the research object was an intervention process rather than a controlled agronomic experiment. Participatory action research is useful when farmers and facilitators jointly identify problems, test context-specific practices and learn from field-based implementation (Barbon et al., 2021; Mponela et al., 2023). In this study, the approach was used to observe how local actors interpreted agroforestry, how institutional coordination shaped feasibility, and how a demonstration plot functioned as a learning device.

The intervention unfolded in four stages: field survey and problem identification; coordination with the farmer group and Forestry Institution Malang; socialization on agroforestry benefits and management; and establishment of a demonstration plot. The intervention engaged 48 informants and introduced 160 seedlings of locally relevant tree and fruit species. The process also produced a documented 41% increase in farmer knowledge after the socialization and demonstration activities. Conceptually, the intervention was interpreted as an adoption-readiness pathway rather than as direct proof of adoption. Existing farming experience provided the initial entry point; demonstration activities translated agroforestry into observable practice; knowledge improvement indicated cognitive readiness; and institutional legitimacy and support reduced uncertainty in the state forest-margin setting.

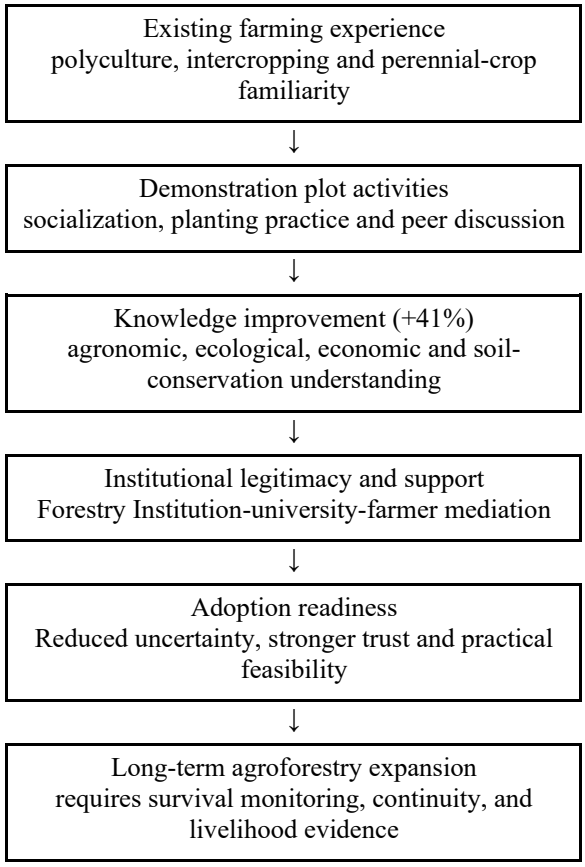

Figure 1. Conceptual framework of the participatory agroforestry adoption-readiness pathway.

2.3. Data sources and participants

The analysis used intervention documentation, field observation notes, focus group discussion records, stakeholder coordination records, demonstration-plot documentation, village-context information and supplementary secondary data on Batu City's agricultural and organic-waste context. The 48 informants included farmer-group participants, and local or institutional stakeholders involved in the socialization, coordination, and planting process. Informants were treated as knowledge holders rather than passive respondents, consistent with participatory research principles that value farmers' experiential knowledge alongside external facilitation (Lujan Soto et al., 2021; Mponela et al., 2023). The field records describe informants as predominantly middle-aged farming actors, with age ranging from 45 to 65 years, education from Elementary School to Senior High School, farming experience from 5 to 25 years, and managed land from 0.5 to 2.0 ha. These characteristics matter because agroforestry readiness depends on whether farmers possess sufficient practical experience, land-use autonomy, institutional access, and learning capacity to evaluate longer-term tree-crop investments.

The 41% knowledge increase is treated as an aggregate learning indicator from the intervention documentation. The indicator was calculated by comparing project-recorded pre-activity and post-activity knowledge scores after socialization and field demonstration. Based on the socialization materials, FGD records, and field-demonstration notes, the observed learning gains were interpreted across four domains: agronomic understanding of tree-crop compatibility, ecological understanding of tree cover and biodiversity functions, economic understanding of livelihood diversification and transition risks, and soil-water conservation understanding related to upland farming. Because item-level pre-test and post-test distributions were not available, the indicator is used as evidence of learning progress and triangulated with qualitative field evidence, rather than being treated as a validated psychometric measure.

Table 1. Evidence base and analytical use in the study.

Evidence source	Information extracted	Analytical use
Field observation	Land condition, crop diversity, existing mixed farming	Assessment of agroforestry entry points
FGD and coordination records	Farmer views, institutional issues, follow-up plans	Identification of social and institutional themes
Demonstration-plot records	160 seedlings, planting process, farmer participation	Analysis of demonstration-based learning
Knowledge-change record	41% increase after socialization and demonstration	Early evidence of learning effect
Stakeholder documentation	Forestry Institution-university-farmer collaboration	Assessment of institutional mediation

Note: Source: Authors, 2026.

Participant characterization was compiled from intervention records and strengthened with range-based descriptive information provided by the field team. Because individual respondent-level survey sheets were not available, age, farming experience, and farm size are presented as documented ranges with indicative midpoints rather than inferential sample means. This strategy improves contextual transparency while avoiding false precision. The profile suggests that the intervention involved experienced smallholders rather than first-time farmers, making demonstration-based learning especially relevant because participants could compare agroforestry with familiar horticultural, intercropping and mixed-farming practices.

Table 2. Documented characteristics of intervention participants.

Variable	Documented range or contextual value	Analytical relevance
Number of informants	48 farmer-group participants and local or institutional stakeholders	Shows the participatory scale of the intervention and provides a basis for qualitative case analysis
Age of informants	45-65 years; indicative midpoint approximately 55 years	Represents mature farming actors with accumulated land-use experience and local authority
Educational level	Elementary School to Senior High School	Indicates that learning materials and demonstrations need to be practical, visual, and locally grounded
Farming experience	5-25 years; indicative midpoint approximately 15 years	Supports experiential comparison between conventional seasonal production, intercropping and agroforestry
Farm size	0.5-2.0 ha; indicative midpoint approximately 1.25 ha	Suggests smallholder-scale agroforestry design must maintain short-term cash-flow crops while adding perennial value
Main farming orientation	Seasonal horticulture, fruit crops, mixed cropping, smallholder livestock and emerging tree-	Provides a livelihood-compatible entry point for agroforestry transition

	crop combinations	
Institutional network	Farmer group, local leadership, Forestry Institution Malang, university facilitators and village stakeholders	Links knowledge acquisition to legitimacy, facilitation, monitoring and collective learning
Circular-resource practices	Crop residues, fruit/vegetable waste and manure can be directed to mulching, composting, liquid organic inputs and eco-enzyme preparation	Connects agroforestry with soil fertility, waste reduction and low-cost ecological management

Note: Source: Field documentation and author-provided participant profile, 2026.

Table 3. Batu City agricultural and circular-resource context relevant to agroforestry adoption.

Contextual indicator	Available evidence	Relevance to agroforestry transition
Smallholder structure	Public reporting of ST2023 indicates 89.1% or 18,109 farmers in Batu City cultivate less than 1.5 ha; smallholder shares are high in forestry, livestock and horticulture (BPS Kota Batu, 2023; MalangVoice, 2024).	Agroforestry models must be designed for small plots and should not displace short-cycle crops that sustain household cash flow.
Local farmer profile comparator	A study of apple farmers in Tulungrejo, Bumiaji found an average age of 49 years, dominant Senior High School education and average farming experience of 25 years (Nabila et al., 2023).	The Purnogiri informant profile is consistent with an experienced farming population that can evaluate innovation through accumulated practice.
Farm size, production and income comparator	The same apple-farming study reported an average landholding of 0.38 ha, 625 apple trees, average annual output of 15,869.52 kg and average annual farm income of Rp 21,114,328 (Nabila et al., 2023).	Land, age and education shape income potential; agroforestry must therefore be framed as risk-managed diversification rather than immediate replacement of existing crops.
Horticultural capacity	Batu City horticultural statistics are available by commodity and district, documenting the importance of vegetable and fruit production in the local economy (BPS Kota Batu, 2024).	Crop diversity provides possible agroforestry combinations and also produces residues that can be recycled into soil amendments.
Farmer institutions and extension	Local apple-farming evidence notes 25 farmer groups in Tulungrejo and the role of farmer groups and extension in addressing farm problems (Nabila et al., 2023).	Farmer groups, extension services, universities, and forest institutions can become the organizational channel for demonstration, monitoring, and replication.
Organic-waste context	Batu City waste generation reportedly decreased to 44,178.87 tons/year in 2025; 21 TPS3R managed an average of 44.42 tons/day. A local AKSA sample in Oro-Oro Ombo recorded 757.15 kg of household waste from 50 households in eight days, 66.8% of which was organic, or approximately 505.8	Organic residues are a practical resource for composting, mulching and community-based waste reduction linked to agroforestry maintenance.

	kg (RRI, 2025; ECOTON, 2026).	
Eco-enzyme pathway	Wet fruit and vegetable waste can be fermented into eco-enzyme; training literature describes its use as a natural cleaner and as a way to reduce organic waste, while agricultural use should be treated as complementary and locally tested (Sasmita et al., 2025).	Eco-enzyme can become a low-cost learning activity in farmer groups, but its agronomic effect should be monitored before making strong productivity claims.

Note: Secondary data are used to contextualize adoption readiness.

2.4. Data analysis and trustworthiness

Data were analyzed using thematic analysis following Braun and Clarke's (2006) six-step approach: familiarization with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and reporting. First, field notes, FGD records, coordination notes, and demonstration-plot documentation were read repeatedly to identify evidence related to agroforestry transition. Second, initial codes were assigned to recurring issues, including mixed-cropping experience, farmer-group leadership, short-term income needs, institutional legitimacy, demonstration-based learning, seedling introduction, knowledge improvement, and follow-up monitoring. Third, related codes were grouped into candidate themes and compared across data sources. Fourth, themes were reviewed against the original evidence to avoid overgeneralization. The final themes were informed by adoption-as-system and agroforestry-barrier perspectives, but their interpretation remained grounded in the field evidence (Amare and Darr, 2020; Tranchina et al., 2024).

Trustworthiness was strengthened through triangulation, peer debriefing among the research team, and negative-case reasoning. Triangulation compared field observations, focus group records, stakeholder coordination notes, and demonstration-plot documentation. Peer debriefing was used to test whether the emerging themes were supported by the intervention records rather than by facilitator assumptions. Negative-case reasoning was also applied: claims were limited when the available data did not support them. For this reason, the paper avoids statements that agroforestry has already improved income, productivity, or ecological quality. Such claims require longitudinal evidence beyond the current dataset.

3. Results

3.1. Local agroecosystem capacity for agroforestry transition

Purnogiri village has latent agroforestry capacity because agricultural diversity and perennial-crop experience already exist in the local farming system. Seasonal horticultural crops provide short-term cash flow, while perennial crops such as avocado, citrus, mango, coffee, and jackfruit provide a basis for longer-term tree-crop integration. This matters because adoption is more likely when new practices can be built from familiar local repertoires rather than imposed as external prescriptions. In this case, agroforestry can be framed as a systematic upgrading of existing mixed farming, not as a replacement of farmers' livelihood logic (Amare; Darr, 2020; Mukhlis et al., 2022).

The case also shows that agroforestry is not a purely ecological agenda. For farmers, the acceptability of tree planting depends on whether trees can coexist with seasonal crops and whether the system protects household income during the transition period. The existing practice of citrus-leek intercropping is therefore analytically important. It demonstrates that farmers already use spatial and temporal complementarity between crops, even if the practice has not yet been formalized as a structured agroforestry model.

The strengthened participant and city-context data clarify why agroforestry must be designed as gradual diversification. Informants' age range of 45-65 years and farming experience of 5-25 years indicate that they already possess substantial practical knowledge, but their education range of Elementary School to Senior High School and smallholder land scale of 0.5-2.0 ha mean that new practices need direct demonstration rather than abstract instruction. Comparable Batu City evidence from apple farmers in Tulungrejo shows a mean age of 49 years, average farming experience of 25 years, dominant Senior High School education, average landholding of 0.38 ha, and average annual income of Rp 21,114,328, with age, education, and land size influencing income outcomes (Nabila et al., 2023). This comparison reinforces the article's argument that agroforestry adoption will be more credible when farmers see it as a way to stabilize livelihoods, improve soil management, and diversify farm value rather than as a conservation obligation detached from income needs.

Table 4. Local conditions and implications for agroforestry design.

Local condition	Observed evidence	Agroforestry implication
Mountainous landscape	Forest-margin and upland farming context	Need for tree cover and soil-water conservation
Seasonal horticulture	Vegetables, chili, shallot, onion and corn	Protects short-term income during transition
Perennial crops	Avocado, citrus, mango, coffee and jackfruit	Provides basis for tree-crop integration
Mixed cropping	Polyculture and citrus-leek intercropping	Reduces novelty barrier for adoption
Farmer groups	Multiple groups and local leadership	Supports collective learning and diffusion

Note: Source: Authors, 2026.

3.2. Farmer knowledge improvement and learning response

The intervention documented a 41% increase in farmer knowledge after the socialization and demonstration process. This finding suggests that farmers improved their understanding of agroforestry in several practical domains rather than merely recalling a general definition. Agronomically, learning centered on how tree species could be combined with seasonal crops without immediately displacing short-term production. Ecologically, farmers were introduced to the role of tree cover in landscape stability, biodiversity functions, and microclimate buffering. Economically, discussion focused on livelihood diversification, delayed returns from perennial crops, and the need to maintain seasonal crops during the transition period. In relation to soil and water conservation, farmers discussed why tree-crop systems are relevant in upland and forest-margin conditions. The result is meaningful because knowledge gaps are repeatedly identified as one of the major constraints to agroforestry adoption (Tranchina et al., 2024). However, the result should be read as evidence of cognitive readiness, not as proof of behavioral adoption or ecological impact.

The knowledge increase should nevertheless be interpreted with caution. The measurement was based on aggregate project documentation rather than a full psychometric instrument with item-level reliability testing. Its credibility therefore depends on triangulation with FGD responses, field observation, and the practical engagement observed during planting. The evidence shows that the intervention moved beyond passive attendance: farmers were exposed to the practical logic of agroforestry and participated in a setting where questions about crop compatibility, maintenance, delayed benefits and institutional legitimacy could be discussed. What remains unverified is whether this learning will be converted into sustained tree maintenance or expansion beyond the demonstration plot.

3.3. Demonstration plot as a social learning platform

The demonstration plot introduced 160 seedlings of tree and fruit crops into a farmer-managed learning site. Activities included land preparation, digging, planting, watering and early maintenance. The practical nature of the process matters because farmer adoption often depends on whether a proposed innovation can be observed, discussed and adjusted under real farm conditions. On-farm demonstrations are especially useful when they allow peer-to-peer learning and expose farmers to both the promise and the management burden of a new practice (Sutherland and Marchand, 2021; Sseguya et al., 2021).

In this sense, the demonstration plot worked as a social learning platform. It brought together farmers, university facilitators and institutional actors around a visible intervention. The plot made the proposed system open to discussion, correction and adaptation. It also created a potential living laboratory for further farmer training, student research and periodic monitoring.

Table 5. Participatory intervention components and learning functions.

Component	Field implementation	Learning function
Socialization	Explanation of economic, social and ecological roles of agroforestry	Introduced the logic of tree-crop integration
FGD/coordination	Discussion with farmer group and Forestry Institution actors	Clarified local needs and institutional expectations
Demo plot	160 seedlings introduced in a practical planting site	Made agroforestry observable

		and discussable
Farmer participation	Farmers joined discussion, planting and early care	Shifted learning from listening to doing
Monitoring plan	Follow-up through mentoring, evaluation and student involvement	Prepared the basis for longer-term evidence

Note: Source: Authors, 2026.

3.4. Institutional mediation in the Forestry Institution-university-farmer collaboration

Institutional mediation was central to the intervention. Because the agroforestry initiative was linked to a state forest-margin context, farmers could not treat tree planting simply as an individual agronomic choice. They needed a legitimate arrangement that connected farmer labor, university facilitation, and Forestry Institution authority. Coordination with the Forestry Institution branch in Malang and follow-up discussions toward formal collaboration helped create that legitimacy.

The actor configuration also shaped the type of knowledge produced. Farmers contributed practical experience and local land-use knowledge. Forestry Institution provided institutional legitimacy and access-related authority. The university team translated agroforestry ideas into training, facilitation and demonstration practice. The process therefore created a bridge between policy, local institutions and farming practice.

Table 6. Actor roles in the early-stage agroforestry transition.

Actor	Observed role	Contribution to adoption
Farmer group	Provided participation, land access and local management	Anchored agroforestry in daily farming practice
Local leadership	Mobilized participants and mediated local trust	Reduced social resistance to experimentation
Forestry Institution, Malang	Joined coordination and supported institutional pathway	Provided legitimacy in state forest-margin context
University team	Facilitated survey, socialization, FGD, and demo plot	Acted as knowledge broker and monitoring partner
Village stakeholders	Supported local development context	Linked agroforestry to broader rural sustainability

Note: Source: Authors, 2026.

3.5. Circular use of agricultural residues, organic waste and eco-enzyme potential

The agroforestry transition also has a circular-resource dimension. Although the intervention did not directly weigh agricultural residues in Purnogiri, the local farming system produces several residue streams that are relevant for agroforestry maintenance: rejected vegetables and fruits, citrus peels, crop leaves, pruning material, animal manure and household organic waste from farming families. These materials should not be treated as waste only. Coarser pruning residues and dry crop biomass can be returned as mulch; manure and mixed residues can be composted, and wet fruit or vegetable residues can be used for eco-enzyme fermentation. This is especially relevant in Batu City, where local waste-management reporting shows high organic-waste potential and community-based TPS3R and zero-waste initiatives are being strengthened (RRI, 2025; ECOTON, 2026).

For agroforestry adoption, residue utilization matters for three reasons. First, it reduces the perceived cost of tree maintenance by converting locally available materials into soil-cover and fertility resources. Second, it creates a practical learning activity that can be organized through farmer groups, universities, and extension services. Third, it links agroforestry to broader environmental governance, because tree planting, composting, mulching and eco-enzyme preparation can be presented as one integrated land-and-waste management package. Nevertheless, eco-enzyme should be positioned carefully. Training literature describes it as a fermented product made from wet organic residues and useful for reducing organic waste and replacing some household chemical uses, but its role as an agricultural input should be validated locally through simple field trials before being claimed as a productivity-enhancing technology (Sasmita et al., 2025).

4. Discussion

The findings show that agroforestry transition in Purnogiri village is best understood as a social and institutional process, not only a technical planting activity. This distinction is important because community-based agroforestry programs often overstate success when activities are completed smoothly, while the more difficult question is whether farmers can maintain trees, adapt crop combinations, and institutionalize management routines. Recent adoption literature supports this caution by showing that agroforestry decisions are embedded in interacting technical, economic, social and policy conditions (Amare and Darr, 2020; Tranchina et al., 2024).

The 41% increase in farmer knowledge strengthens the argument that the intervention generated learning. However, knowledge improvement is an intermediate outcome. It can help farmers understand agroforestry and reduce uncertainty, but it does not automatically guarantee adoption. This interpretation is consistent with participatory learning studies showing that farmers' learning is most likely to support practice change when it is linked to repeated observation, local experimentation and shared monitoring (Lujan Soto et al., 2021; Mponela et al., 2023).

The demonstration plot offers a practical response to this problem. Demonstration-based learning makes agroforestry visible and negotiable. Farmers can observe how trees and seasonal crops may be arranged, ask whether the system fits their land, and compare the expected benefits with their short-term income needs. The evidence from demonstration-plot research suggests that such sites work best when they are not treated as display plots only, but as arenas for interaction, questioning, and peer comparison (Sutherland; Marchand, 2021; Sseguya et al., 2021).

The state forest-margin setting adds another layer. Agroforestry requires institutional clarity because trees represent long-term investments. Without legitimate access and management rules, farmers may hesitate to plant or maintain perennial crops. This is why the Forestry Institution-university-farmer collaboration is not a peripheral administrative feature but a central explanatory mechanism. Evidence from Java and broader Indonesian social forestry indicates that community forestry evolves through institutional linkages and depends on coordination among local groups, government or state forest actors, and external facilitators (Kurniasih et al., 2021; Octavia et al., 2022; Situmorang et al., 2026).

Economically, the appropriate model for Purnogiri is not tree planting that displaces seasonal crops. The more realistic model is a mixed tree-crop system in which seasonal horticulture protects short-term income while perennial crops build medium- and long-term value. This design recognizes farmer rationality: adoption is more likely when ecological goals are translated into livelihood-compatible arrangements. Such a position is aligned with recent evidence that agroforestry can generate socio-economic and environmental benefits, but only when adoption barriers and local constraints are explicitly addressed (Wijayanto et al., 2022; Bhandari et al., 2026; Awazi et al., 2025).

The added participant and Batu City context further sharpens the mechanism behind adoption readiness. A farmer population with long experience but small landholdings is unlikely to accept agroforestry merely because it is ecologically desirable. Experienced farmers will test whether trees reduce seasonal income, compete for labor, complicate access rules, or increase management risk. This is why institutional mediation becomes the bridge between knowledge acquisition and adoption readiness: farmer groups translate new knowledge into shared practice, forestry actors clarify legitimacy in state forest margins, universities provide technical facilitation, and local waste-management institutions can support circular-resource practices. In this interpretation, organic-waste utilization and eco-enzyme training are not peripheral additions but complementary mechanisms that make agroforestry more affordable, observable, and socially embedded.

The study therefore contributes to the literature by clarifying both the mechanism and the boundary of early-stage agroforestry evidence. Its scientific novelty is not that demonstration plots or farmer training are useful in general, because that is already well established. Rather, the contribution lies in explaining how adoption readiness emerges when three conditions are connected: farmers already possess compatible mixed-cropping experience; demonstration activities translate the idea into observable practice; and institutional mediation connects farmer learning to legitimacy, trust, and follow-up support. In this pathway, institutional mediation functions as the critical bridge between knowledge acquisition and adoption readiness. It is legitimate to claim that the program engaged 48 informants, introduced 160 seedlings, increased farmer knowledge by 41%, and created a demonstration-based learning platform. It is not yet legitimate to claim long-term productivity, income, or ecological improvement. This restraint strengthens rather than weakens the article, because it places the case within a credible impact pathway: initial learning and legitimacy first, followed by monitoring of survival, management continuity, replication and livelihood outcomes.

4.1. Scalability and replicability implications

The intervention model has potential for replication in other Indonesian social forestry and Southeast Asian forest-margin settings, but scalability depends on institutional and material prerequisites. At minimum, replication requires: a legitimate land-access arrangement, an active farmer group or local learning platform, locally compatible tree and crop species, a visible demonstration site, periodic facilitation, and a monitoring protocol for seedling survival, labor allocation, income contribution, and residue use. The Batu City context suggests that replication can be strengthened when agroforestry is connected with existing farmer groups, extension services, university facilitation, TPS3R, bank-sampah initiatives and village-level organic-waste programs.

Resource requirements are also important. A scalable model would need seedling procurement, simple nursery or replacement arrangements, training materials, field facilitation, residue-management equipment, composting space and low-cost containers for eco-enzyme fermentation. The role of universities can be strategic because students and lecturers may support baseline assessment, farmer training, monitoring and documentation, while extension services and forestry institutions can ensure continuity beyond the project cycle. However, replication should avoid mechanical transfer. Each site needs a livelihood diagnosis, including crop calendars, land size, farmer income sources, education level, farmer-group capacity, residue availability and market access, before the agroforestry design is selected.

4.2. Limitations

This study has several limitations. First, the intervention was short and therefore cannot demonstrate sustained adoption. Second, the design did not include a control group, so the 41% knowledge increase cannot be interpreted as a causal treatment effect in the experimental sense. Third, the analysis relied on project-based documentation, field records, and qualitative materials, which are appropriate for process analysis but less suitable for estimating economic or ecological impact. Fourth, individual-level demographic data such as age, education and farm size were not fully documented, limiting comparison with survey-based adoption studies. Fifth, long-term outcomes such as seedling survival, maintenance behavior, household income, soil-water conservation, and biodiversity effects were not yet measured.

These limitations define the appropriate scope of inference. The study can explain how early adoption readiness was socially and institutionally produced, but it cannot yet estimate long-term adoption rates or biophysical impact. In addition, the newly added participant variables are based on documented ranges rather than individual-level survey data; therefore, average age, farming experience and farm size should be interpreted as indicative descriptive values. Income, farmer-capacity and farmer-institution information from Batu City are used as contextual comparators, not as primary measurements of the Purnogiri participants. Agricultural residues, household organic waste and eco-enzyme outputs were also not directly weighed in the intervention site. Future monitoring should therefore include residue quantification, compost and eco-enzyme batch records, cost savings, soil indicators and farmer-level adoption tracking.

5. Conclusion

The participatory agroforestry initiative in Purnogiri village established early enabling conditions for tree-crop adoption in a state forest-margin setting. The intervention engaged 48 informants, introduced 160 agroforestry seedlings and documented a 41% increase in farmer knowledge after socialization and demonstration activities. These results show that demonstration-based learning, farmer-group leadership and institutional mediation can help farmers move from abstract awareness toward practical understanding of agroforestry. The study further shows that institutional mediation is not merely an administrative complement, but a mechanism that links farmer learning to legitimacy, trust and adoption readiness.

The findings also show that agroforestry transition should not be assessed only by whether a training activity or planting event was completed. The more important question is whether the intervention creates learning, trust, legitimacy, residue-management routines and institutional partnerships that can support long-term adoption. Programs seeking to scale agroforestry adoption should therefore prioritize long-term demonstration plots, participatory learning processes, strong institutional partnerships and circular organic-resource practices rather than relying solely on conventional technical training or seedling distribution. In practical terms, agroforestry facilitation in Batu City and similar forest-margin areas should integrate tree-crop design with composting, mulching, manure use and carefully tested eco-enzyme preparation so that ecological restoration is connected with daily farm management and household cost reduction.

The study remains an early-stage case. Further monitoring is needed to measure seedling survival, maintenance behavior, adoption beyond the demonstration plot, household income effects, soil-water conservation and biodiversity outcomes. Until such

evidence is available, the strongest scientific conclusion is that the intervention created a credible foundation for agroforestry transition, not that it has already produced long-term socio-economic or ecological impact. For policymakers and practitioners, the practical implication is clear: agroforestry expansion in forest-margin communities requires not only seedlings and training, but also locally credible facilitation, institutional legitimacy and repeated evidence-building over time.

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Medea Rahmadhani Utomo: conceptualization and methodology. *Fitrotul Laili*: data collection and analysis. *Ajik Siswantoro:* data collection and analysis. *Fitrotul Laili*: writing - original draft, review, editing and supervision. *Ajik Siswantoro*. writing - original draft, review, editing and supervision. *Medea Rahmadhani Utomo*: writing - original draft, review, editing and supervision. *Asihing Kustanti*: writing - original draft, review, editing and supervision.

Ethics

The authors declare that this study was conducted in accordance with accepted ethical and scientific standards. The authors agree to address and resolve any ethical issues that may arise after the publication of this manuscript.