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Drivers and barriers to agroforestry adoption among forest farmers: A systematic review

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ABSTRACT

Background: Agroforestry is widely promoted as a sustainable land-use system that addresses poverty, environmental degradation, and climate change. Despite its strategic role, adoption among forest farmer groups remains limited, indicating a gap between policy ambition and field-level implementation. Identifying the determinants influencing adoption decisions is therefore essential to improve intervention strategies. **Methods:** This study applies a systematic literature review of empirical publications from 2020–2025. Selected studies were synthesized to identify key determinants of agroforestry adoption, organized into four analytical pillars: economic, socio-cultural, institutional, and ecological factors. **Findings:** Agroforestry adoption emerges as a multifaceted decision shaped by interacting structural and contextual factors. Economically, income diversification and market access act as major incentives, though high initial costs and delayed returns constrain uptake. Socio-cultural factors, particularly farmer group participation, education, and social capital, significantly increase adoption likelihood. Institutional support—especially secure land tenure under Social Forestry programs and access to extension services—plays a decisive enabling role. Ecological pressures, including land degradation and soil erosion, frequently trigger transitions toward agroforestry as a resilience strategy. These determinants operate interdependently rather than independently. **Conclusion:** Effective agroforestry promotion requires integrated policies that simultaneously address economic viability, social capacity, institutional support, and ecological conditions. A holistic support ecosystem is needed to position farmers as active agents of sustainable land transformation. **Novelty/Originality of this article:** This review synthesizes recent empirical evidence into a four-pillar analytical framework, conceptualizing agroforestry adoption as a dynamic and systemic process, and providing a structured basis for more coherent, evidence-based policy design.

KEYWORDS: agroforestry adoption; adoption determinants; forest farmer.

1. Introduction

Indonesia, an archipelagic nation with a large rural population, faces pressing dual challenges. The high rate of land degradation, deforestation, and the increasingly tangible impacts of climate change necessitate immediate conservation efforts. However, millions of smallholder farmers depend on this same land to meet their food and economic household needs. Communities living on the forest frontier, particularly forest farmers, are at the center of this dynamic. Large-scale monoculture farming practices, despite increasing short-term production, often lead to declines in soil quality, erosion, and biodiversity loss. Nutrient-poor soil conditions eventually push farmers to clear new forest land, creating a relentless cycle of degradation. This situation creates an urgent need for land-use systems

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that can harmonize agricultural productivity goals with ecological conservation imperatives.

Amidst the search for solutions, agroforestry has emerged as one of the most promising nature-based solutions (Muthee et al., 2024). The advantage of agroforestry systems, which integrate trees, food crops, and/or livestock within the same land management unit, offers a solution for restoring lands degraded by unsustainable agricultural practices and deforestation (Achmad et al., 2022). The benefits of agroforestry systems are multidimensional and well-documented. By mimicking the structure of native forests, agroforestry systems provide a range of ecosystem services. Specifically, agroforestry plays a vital ecological role, including land conservation (maintaining soil fertility and water reserves), carbon sequestration, and supporting crop production (Budiastuti et al., 2022). The application of agroforestry systems can improve soil structure, thereby prevent soil erosion and enhance water retention (Fahad et al., 2022). Furthermore, agroforestry has significant potential for climate change mitigation by sequestering carbon and greenhouse gas emissions (Mukhlis et al., 2022).

In addition to ecological benefits, agroforestry also intrinsically provides positive impacts on the economy of communities surrounding forests. For millions of households living around forests, this system can sustain and diversify farmer incomes through timber (e.g., firewood, poles) and non-timber products (e.g., fruits, nuts, fodder, medicinal plants). The product diversification generated by agroforestry reduces the risk of single-crop failure. Besides commercial purposes, the diversification of agroforestry products is also used to meet household subsistence needs. Ultimately, agroforestry contributes to the food security and economic stability of forest farmers (Duffy et al., 2021).

Agroforestry systems have long been practiced in developing countries, including Indonesia. Various forms of traditional agroforestry systems, ranging from the simplest, such as home gardens, to more commercially-oriented systems like rubber or coffee agroforestry (Mukhlis et al., 2022), are evident. This demonstrates that agroforestry practices in Indonesia have strong historical and contemporary foundations. These established practices provide a solid foundation for modern, science-based agroforestry models. Thus, agroforestry can become a land-use system that is not only environmentally friendly but also culturally resonant and aligned with global Sustainable Development Goals (SDGs) (Harahap & Santiago., 2024).

In the Indonesian context, the implementation of agroforestry has been embedded in the social forestry program as a primary policy instrument promoting community-based forest management. Through this program, the government grants local communities access to manage forests by combining native forest trees with agricultural crops (Widiyanto et al., 2025). By providing access to manage forests, it is expected to improve the welfare of communities around the forest, resolve land conflicts, and ensure sustainable forest management (Widiyanto et al., 2025). Thus, the social forestry program signifies a paradigm shift in Indonesia's forest governance, moving from state-centered to community-based empowerment in forest management (Octavia et al., 2022). Furthermore, social forestry also serves as the Indonesian government's institutional mechanism to expand agroforestry implementation in Indonesia, transforming traditional agroforestry practices into a national strategy for sustainable development.

Despite being supported by a strong policy framework, the adoption of agroforestry systems by farmers remains inconsistent and faces significant challenges (Achmad et al., 2022). Therefore, it is crucial to understand the complex factors behind farmers' decisions to adopt agroforestry systems, which can serve as a reference for future policy planning and forest management programs in Indonesia. This article presents a comprehensive review of scientific literature from 2020-2025 to identify and analyze the dynamic interactions between economic, institutional, socio-cultural, and ecological factors influencing the adoption of agroforestry systems by Indonesian forest farmers.

2. Methods

2.1 Research design

This research was conducted using a systematic literature review approach. This method encompasses the systematic collection, identification, selection, and synthesis of data from relevant literature (Smela et al., 2023). The study commenced by defining keywords, digital data sources, and inclusion criteria as benchmarks for literature collection (Carrera-Rivera et al., 2022).

2.2 Data sources and search strategy

The literature search was conducted online using Google Scholar, Mendeley Web, and the Directory of Open Access Journals (DOAJ), which serve as freely accessible academic digital data sources. Keywords were determined based on the research objectives, followed by the establishment of Boolean search strings. To maximize relevance, the primary search string used was: ("agroforestry adoption") AND ("forest farmers" OR "smallholders") AND ("Indonesia"). Search results were collected using the Mendeley Reference Manager application. Duplicate records and redundant search outputs were removed during iterative search refinement.

2.3 Inclusion criteria

The literature utilized comprised scientific publications in the form of journal articles, proceedings, or books that met predefined inclusion criteria to minimize bias (Carrera-Rivera et al., 2022). These criteria were systematically developed to ensure the relevance, quality, and consistency of the selected studies. In addition, they served as a guideline for filtering out studies that did not align with the research objectives. The criteria are summarized in Table 1 below.

Table 1. Inclusion criteria for the systematic review

Category	Inclusion Detail
Type of literature	Peer-reviewed and open-access scientific publications
Publication date	Scientific publications published within the last five years (2020-2025)
Language	Scientific publications written in English
Data types	Studies presenting primary data
Region	Studies conducted in the territory of Indonesia
Subject	Studies with research subjects including forest farmers, or forest farmer groups
Research Topic	Studies with research topics related to the implementation of agroforestry systems by forest farmers or forest farmer groups, especially studies that explicitly analyze the factors, determinants, and/or drivers and barriers to agroforestry implementation in Indonesia.

2.4 Study selection process

After removing duplicates, a screening process was conducted by reviewing titles and abstracts to identify relevant studies. Publications that did not meet the inclusion criteria were excluded, while eligible studies were selected for full-text review. Additionally, backward reference searching was conducted by examining bibliographies of selected studies to identify other relevant sources. The overall process of literature search and selection is illustrated in Fig. 1.

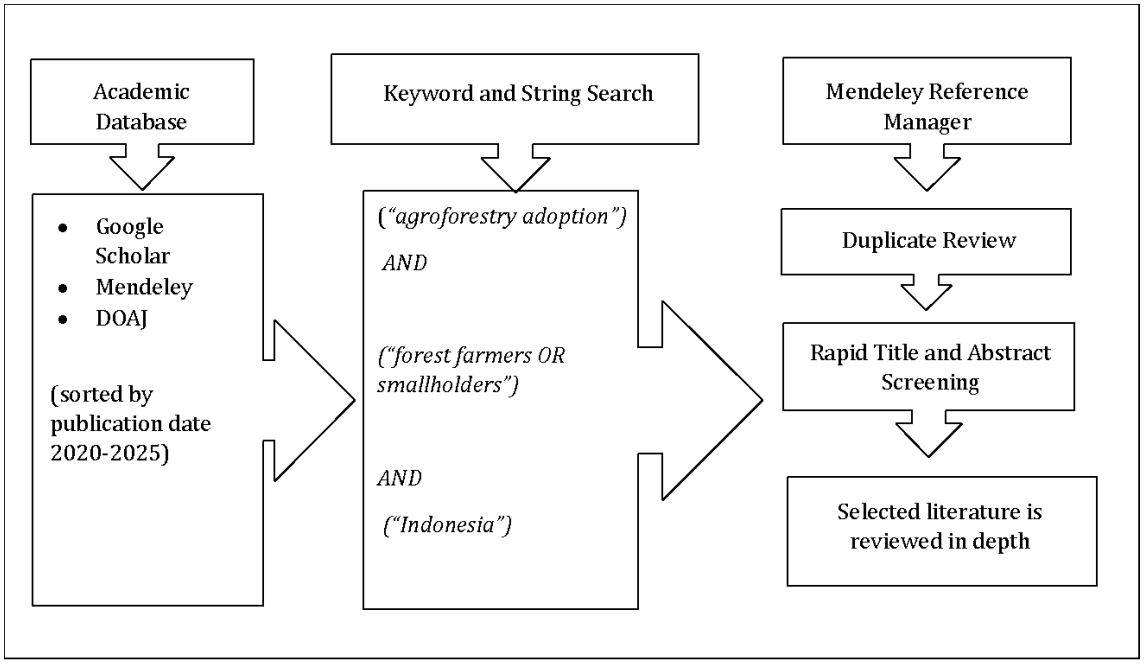

Fig. 1. Stages of literature search and selection

2.5 Data extraction

Data extraction was performed systematically by collecting key information from the selected studies. The extracted data included bibliographic details, study location, research methodology, and identified determinants of agroforestry adoption. Each determinant was categorized based on its direction of influence (positive, negative, or insignificant), along with relevant qualitative findings.

2.6 Data analysis

The extracted data were analyzed using a thematic analysis approach, which enables the identification and interpretation of patterns or themes within qualitative data (Kiger et al., 2020). The identified factors were grouped into four main thematic categories: (1) economic factors, (2) socio-cultural factors, (3) scological factors, (4) institutional and policy factors. The synthesis results were further elaborated to generate conclusions and policy recommendations supporting agroforestry adoption among forest farmers in Indonesia.

3. Results and Discussion

3.1 Synthesis of factors influencing agroforestry adoption

Through the systematic literature review process, 21 relevant studies were compiled that explicitly discuss the determinants of forest farmers' decisions in adopting agroforestry systems. Farmers are generally motivated to adopt agroforestry systems when they perceive greater benefits compared to their previous agricultural systems (Madjid et al., 2023). Broadly, the findings reveal that all factors influencing adoption are the result of a dynamic interplay among economic calculations, socio-cultural contexts, institutional support, and ecological conditions. (Table 2) below presents a summary of the primary determinants identified in this review, followed by an in-depth analysis of each category.

Table 2. Main determinants of agroforestry adoption

Factors	Category	Direction of Influence	Mechanism	Literature
Income Diversification	Economy	Positive (+)	Reduces risk of dependency on a single commodity and increases total household income	(Nöldeke et al., 2021); (Roslinda et al., 2023)
Food Security	Economy	Positive (+)	Creating food security for farming families and reducing dependence on markets to meet food needs	(Mukhlis et al., 2022)
Market Access and Stable Prices	Economy	Positive (+)	The perception of a reliable market for agroforestry products encourages investment.	(Susanti et al., 2020); (Pujiwinarko et al., 2024)
Long-Term Profitability	Economy	Positive (+)	Maintaining the economic stability of farmers in the future	(Tropenbos., 2023); (Nöldeke et al., 2021); (Wijayanto & Lo., 2023)
High Initial Costs	Economy	Negative (-)	Capital constraints and limited access to credit hinder initial investment in seedlings and labor.	(Deli et al., 2022); (Nöldeke et al., 2021);
Farmer Age and Experience	Socio-cultural	Positive (+)	Older farmers have a higher awareness of long-term environmental degradation.	(Wijayanto., 2022)
Farmer Education Level	Socio-cultural	Positive (+)	Education improves the ability to process new information and understand the benefits of innovation	(Kheynad., 2025)
Local Knowledge	Socio-cultural	Positive (+)	Alignment with local cultural values fosters a sense of ownership and pride.	(Harahap & Santiago., 2024); (Mardiani et al., 2022); (Lestari & Winarno., 2023)
Positive Perceptions and Attitudes	Socio-cultural	Positive (+)	The belief that the practice is beneficial and valuable	(Mukhlis et al., 2022); (Denashurya., 2023); (Madjid et al., 2023)
Social Capital	Socio-cultural	Positive (+)	Facilitates knowledge sharing, reduces individual risk, and improves access to resources	(Yusriadi., 2025); (Wijayanto; 2022)
Government Policy on Agroforestry	Institutional	Positive (+)	Promotion programs, technical assistance, and incentives from the government encourage adoption	Octavia et al., 2022); (Widiyanto et al., 2025)
		Negative (-)	Policy inconsistencies between agencies result in agroforestry lacking the harmonized support needed to thrive.	(Tropenbos, 2023)
Land Tenure	Institutional	Positive (+)	Granting local farmers rights to manage forest land long-term (35 years)	(Octavia et al., 2022); (Widiyanto et al., 2025)

Factors	Category	Direction of Influence	Mechanism	Literature
Access to Agricultural Extension Services	Institutional	Positive (+)	Extension agents and field experts are important sources of technical information for farmers	(Wibisono et al., 2025); (Jaya et al., 2022)
		Negative (-)	Access to extension services remains limited	(Wibisono et al.,2025); (Jaya et al., 2022)
Land Degradation & Erosion	Ecology	Positive (+)	Poor land conditions become a trigger for farmers to seek restorative practices like agroforestry	(Mukhlis et al., 2022); (Wijayanto et al., 2022); (Fahad et al., 2022)
Natural Disaster Mitigation	Ecology	Positive (+)	Farmers are trying to mitigate the possibility of natural disasters that threaten their harvests.	(Rozaki et al., 2021); (Fahad et al; 2022); (Yusriadi et al., 2024); (Anhar et al., 2025)

3.1.1 Economic and livelihood factors

Analysis of economic factors indicates that farmers' decisions to adopt agroforestry systems are strongly influenced by the perception of financial benefits. For forest farmers who depend on uncertain natural conditions, agroforestry offers a strategic pathway to mitigate risk and maintain future economic stability. Income diversification and enhancement are the most consistently cited drivers in the literature. A simulation study of agroforestry systems by Nöldeke et al. (2021) in West Kalimantan revealed that farmers who adopted a mixed agroforestry system of Tengkawang (Shorea stenoptera) and rubber (Hevea brasiliensis) successfully diversified their livelihood portfolios while significantly increasing their income. This finding aligns with a study on agrosilvopastoral systems in West Kalimantan, which found that diverse agricultural products contributed to 82.74% of total community income, indicating their central role in the local economy (Roslinda et al., 2023). Both studies affirm the function of agroforestry as a "living savings account," which serves as a strong incentive for farmers facing economic uncertainty.

Agroforestry contributes to farmer household food security both directly and indirectly. Directly, agroforestry systems yield a diverse array of food crops, fruit trees, and occasionally, livestock. This diversity of agroforestry products provides a sustainable supply of nutritious food for household consumption (Mukhlis et al., 2022). The fulfillment of household food supplies via agroforestry reduces farmer dependency on market food purchases, particularly for farmers in remote areas with limited market access. Indirectly, agroforestry also contributes to food security through income diversification and the creation of economic stability for forest farmers. Income derived from the sale of agroforestry commodities enables farmers to purchase adequate food necessities, particularly during the non-harvest season.

Furthermore, market access and favorable prices play a crucial role. Farmers who rely on monoculture plantations are highly susceptible to commodity price fluctuations and extreme climatic events, such as prolonged drought (Susanti et al., 2020). In contrast, a study in the Dieng Plateau found that farmers' perceptions of stable market prices for agroforestry products significantly influenced their decision to adopt agroforestry systems (Pujiwinarko et al., 2024). This affirms that adoption is not merely a production decision at the farm level but is also heavily influenced by value chain dynamics and broader market conditions.

Agroforestry systems demonstrate the potential for greater long-term profitability compared to other farming systems. A study by Tropenbos (2023) in Sumatra found that coffee agroforestry systems contributed over 50% of farmer household income, whereas conventional farming systems contributed only about 12%. Furthermore, this study's comparative analysis indicated that agroforestry systems have a net present value (NPV) 65% to 98% greater than corn or rice monoculture, or shifting cultivation, over a 30-year timeframe. Similar findings emerged from an agroforestry simulation study in West Kalimantan. Combining rubber and tengkawang in an agroforestry system was predicted to significantly increase future household income, thereby holding the potential to alleviate poverty and enhance welfare (Nöldeke et al., 2021). A study by Wijayanto & Lo (2023) in East Java likewise confirmed this. Through propensity score matching analysis, it was found that farmers who adopted agroforestry systems had significantly better incomes than their conventional counterparts.

Despite its potential for long-term profitability, agroforestry adoption confronts significant economic barriers in the short term. High initial costs and capital constraints are primary obstacles. The initial investment required to purchase quality tree seedlings, prepare the land, and finance additional labor is often beyond the reach of smallholder farmers. Findings from a study on potato farmer groups revealed that smallholders struggle to purchase superior seeds due to capital limitations (Deli et al., 2022). This is closely intertwined with the issue of a prolonged initial capital turnover period. Trees require many years to begin yielding significant economic benefits. The time preference of farmers, who require immediate income to meet household daily needs, makes them tend to be risk-averse toward this type of long-term investment (Nöldeke et al., 2021).

In-depth, these economic factors reveal a dynamic that can be termed the "risk versus resilience" paradox. On one hand, the literature cites risk aversion as an inhibitor, implying that farmers prefer familiar practices (Nöldeke et al., 2021). However, on the other hand, strong evidence indicates that farmers adopt agroforestry precisely as a strategy to reduce long-term risk through income diversification and increased resilience to climate shocks. This means the adoption decision is not a simple rejection of risk, but rather a complex calculation. Farmers may be reluctant to take the short-term financial risks associated with the initial investment, but they are highly motivated by the desire to mitigate long-term ecological and market risks. Thus, the policy challenge is not merely "overcoming risk aversion," but rather "bridging the short-term financial gap to unlock long-term resilience benefits".

3.1.2 Socio-cultural factors: The human dimension

Individual and household characteristics of farmers play a significant role in shaping the propensity to innovate. Farmer age and experience show a positive correlation with adoption. A study in East Java found that older farmers were more likely to adopt agroforestry (Wijayanto et al., 2022). This is presumably because they have a greater awareness of long-term environmental changes, such as soil erosion and land degradation, which they have observed over many years. Their experience in vegetative activities also serves as a significant driving factor. Education level is also consistently found to positively influence adoption decisions. Higher education tends to increase farmers' ability to seek, understand, and evaluate new information regarding the benefits and techniques of agroforestry (Kheynad et al., 2025).

Adoption decisions are also strongly influenced by non-material factors, such as farmers' positive perceptions and attitudes toward the success of agroforestry. A positive attitude toward agroforestry—the belief that the practice is beneficial and valuable—is a fundamental prerequisite (Mukhlis et al., 2022; Denashurya et al., 2023). This positive attitude is shaped by the perceived relative advantage of agroforestry compared to existing practices. Farmers are motivated when they believe the new system will offer clear economic, environmental, or social benefits (Madjid et al., 2023). When farmers observe their peers successfully implementing agroforestry, their perception of risk decreases, and

it provides a tangible example to emulate. A study conducted on Oil Palm agroforestry in Jambi Province revealed a positive relationship between adoption decisions and farmers' perceptions of the agroforestry system. This implies that an agroforestry system that is easy to implement and observe will increase farmers' willingness to adopt it (Madjid et al., 2023).

In many parts of Indonesia, agroforestry is not a novel concept but an evolution of traditional land-use systems that are deeply integrated into the local culture. The adoption of modern or formalized agroforestry is often motivated by its alignment with this local wisdom and cultural identity (Harahap & Santiago, 2024). Local wisdom and farmers' traditional insights in managing agricultural land are considered holistic and inherently adaptive (Mardiani et al., 2022). This insight is gathered from generation to generation, accumulated gradually, tested through trial and error, and transmitted to future generations orally or through shared practical experience.

Traditional agroforestry practices, passed down through generations, contain profound knowledge regarding local ecosystems, species compatibility, and sustainable resource management. When modern agroforestry initiatives can be integrated with the local wisdom of the region, the initiatives are more likely to be accepted by the community. This is due to an alignment with local cultural values, which fosters a sense of ownership and pride. This cultural suitability strengthens individual and collective identity among farmers and enhances the social sustainability of the agroforestry system. A study conducted in the provinces of South Sumatra, Bengkulu, and Jambi revealed that local communities near forests successfully harmonized local insights and wisdom in the implementation of cinnamon and coffee agroforestry (Lestari & Winarno., 2023).

However, the most prominent social factor is social capital, measured through participation in social activities, farmer groups, and cooperatives. The role of cooperatives as institutions that provide information and training is positively associated with the adoption rate of agroforestry systems by farmers (Wijayanto et al., 2022). Close relationships with neighbors, friends, or forest farmer groups form social networks for sharing insights, resources, and labor (Yusriadi., 2025). Trust within these networks facilitates cooperation and collective action, such as establishing nurseries, marketing products, or managing shared resources. Involvement in these social networks is one of the strongest predictors of adoption (Wijayanto et al., 2022).

Further analysis indicates that social capital can function as a substitute for weak formal support. The strong influence of farmer groups and social networks suggests an important causal relationship. In contexts where formal institutional support, such as extension services, is ineffective, gender-biased, or inaccessible, informal social networks become the primary mechanism for knowledge transfer and risk mitigation. Information is often more easily accessed and perceived as more trustworthy when it comes from fellow farmers. This indicates that farmer-to-farmer learning is not merely a complementary channel, but rather a resilient social infrastructure that functions even in the absence of formal support. Therefore, policy interventions should not focus solely on "providing" top-down extension, but also on "empowering and resourcing" existing farmer networks.

3.1.3 Institutional factors: The enabling environment

A conducive institutional environment is a prerequisite for the large-scale adoption of agroforestry. The presence of supportive government policies is explicitly mentioned as a significant factor. This includes programs promoting agroforestry, provision of technical assistance, and regulatory support from relevant ministries such as the Ministry of Agriculture and the Ministry of Environment and Forestry. The legal foundation for promoting agroforestry has been strengthened through a series of regulations, notably the Regulation of the Ministry of Environment and Forestry (KLHK) No. 9 of 2021 concerning Social Forestry Management (Octavia et al., 2022; Widiyanto et al., 2025). This policy framework outlines several schemes accessible to communities, including Village Forests (*Hutan Desa*), Community Forests (*Hutan Kemasyarakatan*), and Forestry Partnerships (*Kemitraan Kehutanan*). Under these schemes, communities are typically granted

management permits for 35 years, which can be extended, providing long-term tenure security aimed at encouraging sustainable land-use investments (Octavia et al., 2022).

Although the Social Forestry program is considered to have provided support for promoting agroforestry, it has not been sufficient to overcome policy inconsistencies. A study by Tropenbos Indonesia (2023) highlights the problem of a lack of policy coherence and coordination among government agencies. For example, the Ministry of Environment and Forestry promotes agroforestry, while at the same time, the Ministry of Agriculture or local governments provide subsidies and incentives for high-production monoculture crops. This institutional fragmentation results in a system where agroforestry is less recognized within the bureaucracy and lacks the harmonized support needed to thrive.

Land tenure issues represent the most profound and fundamental barrier to the adoption of agroforestry systems. In agroforestry, tree planting is a long-term investment; consequently, farmers are hesitant to adopt the system if they lack tenurial certainty to manage the land over a long period (Susanti et al., 2020). Although the social forestry program is designed to address this problem by granting 35-year management permits, its on-the-ground implementation can be more complex. The bureaucratic implementation of social forestry often hinges on local political dynamics and does not always provide genuine long-term security for farmers (Widiyanto et al., 2025). When farmers feel confident that they will reap the benefits of their tree investments in the future, they are more willing to switch to agroforestry systems.

Beyond macro-policies, the availability of support services at the local level is critical. The transition from simple monoculture to more complex agroforestry requires new knowledge and skills. However, access to effective agricultural and forestry extension services is a primary constraint for many smallholder farmers in Indonesia. A frequently cited issue is the low government budget allocation for Social Forestry development, which impacts the limited resources available for technical assistance and extension (Tropenbos, 2023). Technical assistance, such as seedlings and fertilizer, is greatly needed by farmers, especially during the initial transition period to agroforestry systems. To encourage farmer participation in agroforestry implementation, the government is expected to provide incentives in the form of easier farmer access to seedlings, fertilizer, and other agricultural equipment (Jaya et al., 2022).

In addition to technical assistance, farmer access to agricultural extension services or training is also a crucial factor. Extension agents are needed as the vanguard of program implementation, serving functions for both knowledge transfer and mentoring. This was reported in a study of agroforestry farmer groups in Central Kalimantan by Jaya et al. (2022). The farmers required assistance in selecting seedlings and crop types for harvesting and marketing. Although field extension officers in the forestry sector are available from the Forest Management Units / *Kesatuan Pengelolaan Hutan* (KPH), their numbers and distribution are limited. This finding aligns with a study on agroforestry coffee plantations in Riau, which reported that extension services were limited and insufficient. This leaves farmers without the necessary technical guidance on crucial aspects of agroforestry management, such as species selection, planting design, pest control, and post-harvest processing (Wibisono et al., 2025). This lack of institutional support for knowledge transfer directly contributes to knowledge gaps and constrains the capacity of farmers to adopt agroforestry systems.

3.1.4 Ecological factors: The biophysical context

Ecological factors often act as the initial trigger that prompts farmers to consider transitioning to innovative agricultural systems. The data strongly suggest that the decision to adopt often does not originate from a proactive search for economic opportunities but is instead triggered by a reactive response to ecological crises. Land degradation and erosion are found to be strong drivers of adoption. The multi-layered canopy of trees and shrubs in agroforestry systems can intercept heavy rainfall, thereby reducing the soil's erosive power. Meanwhile, the extensive root systems in agroforestry bind the soil, thus significantly

reducing soil loss, particularly on sloping land (Mukhlis et al., 2022). Agroforestry adoption was found to be higher on lands that were already degraded and on terraced lands vulnerable to soil erosion, as farmers utilize it as a tangible mitigation strategy (Wijayanto et al., 2022). Furthermore, the need to restore soil fertility is another key biophysical driver. The continuous leaf litter from trees in agroforestry systems enriches the soil with organic matter, thereby increasing the availability of essential nutrients for surrounding crops (Fahad et al., 2022). This soil fertility improvement process can reduce the dependency on expensive chemical fertilizers, lowering production costs and enhancing land health for long-term production. Therefore, the motivation to adopt agroforestry systems is often a direct response by farmers to declining yields resulting from land degradation (Mukhlis et al., 2022).

In addition to addressing soil degradation, agroforestry systems also function to mitigate potential natural disasters that threaten crop yields. A study conducted in the region surrounding Mount Merapi revealed that agroforestry was proven capable of protecting crops from various disasters, such as erosion, landslides, and materials ejected by volcanic eruptions (Rozaki et al., 2021). Agroforestry also mitigates the impacts of drought on crop yields by enhancing infiltration and water retention in the soil profile, thus helping to reduce drought effects and ensuring water reserves for crops during the dry season (Fahad et al., 2022). Other studies have found a significant correlation between rainfall patterns and agroforestry canopy cover. In this context, farmers perceive the greening landscape as a catalyst for attracting greater rainfall, providing protection during extended dry periods. Extensive canopy cover not only reduces the risk of desertification but also enhances the soil's capacity to retain water, ensuring more resilient farmland (Yusriadi et al., 2024). Furthermore, agroforestry can increase carbon sequestration as a climate change mitigation measure. Preserving old, mature trees, particularly in coffee agroforestry systems located in forested areas, can maximize carbon storage potential equivalent to that of secondary tropical forests (Anhar et al., 2025). The desire to mitigate the possibility of disasters that threaten crop yields motivates farmers to switch to agroforestry systems. Forest farmers are motivated by these tangible benefits, as they directly influence more stable and reliable crop yields.

3.2 The interplay of factors in farmer decision-making (case studies)

The decision to adopt agroforestry is not a uniform process but a highly context-specific calculation of trade-offs, risks, and opportunities. The interplay of the economic, institutional, and socio-cultural factors discussed in previous sections varies dramatically depending on the specific agricultural system and geographical location. By examining case studies from the literature, it becomes clear that a "one-size-fits-all" approach to promoting agroforestry is destined to fail. Interventions must be tailored to the unique realities of different commodity landscapes.

3.2.1 Case study: Oil Palm Agroforestry (OPAF)

The case of oil palm agroforestry (OPAF) provides a compelling example of the challenges of introducing diversification into a landscape dominated by a highly profitable and well-established monoculture. Oil palm is a major export commodity for Indonesia, and its cultivation as a monoculture has been widely supported by government programs and driven by strong market demand, enabling many smallholders to achieve significant financial gains. Despite the well-documented negative environmental and social impacts of this expansion, and the potential for OPAF to mitigate these issues, its adoption by smallholders remains extremely limited (Susanti et al., 2020).

The analysis of a study conducted by Susanti et al (2020) reveals a powerful confluence of barriers. The primary obstacle is a critical knowledge gap regarding the management and, crucially, the yields of OPAF systems. Farmers are accustomed to the predictable inputs and outputs of monoculture oil palm and are uncertain about how intercropping other species

will affect the productivity of their main cash crop. This uncertainty creates a high perception of risk.

This knowledge barrier interacts powerfully with economic factors. The existing monoculture system is not just familiar; it is highly lucrative and has a well-understood pathway to market. OPAF, as a new system, must compete directly with this powerful incumbent. The perceived risk of lower oil palm yields or the lack of a market for the intercropped species makes the economic trade-off seem unfavorable for many farmers. The decision is further influenced by socio-demographic factors. Studies show that farmers with higher levels of education and those with off-farm income (a side job) are significantly more likely to adopt OPAF. This suggests that farmers who have a greater capacity to process new information (education) and those who have an alternative source of capital and income security (off-farm work) are more willing and able to bear the risks of experimentation. For the majority of farmers who lack these advantages, the rational choice is to stick with the proven, profitable monoculture system. Therefore, promoting OPAF requires not just providing information, but also creating significant financial de-risking mechanisms to make it a competitive alternative to the status quo.

3.2.2 Case study: Coffee agroforestry in the Gayo Highlands

In contrast to the OPAF case, the coffee agroforestry systems of the Gayo Highlands in Aceh, Sumatra, represent a context where agroforestry is a more traditional and established practice (Anhar, 2025). Here, shade-grown coffee is the norm, valued for producing high-quality beans and being well-suited to the mountainous terrain. The challenges in this landscape are not primarily about convincing farmers to adopt agroforestry in the first place, but rather about ensuring that the existing systems are managed sustainably and can adapt to new pressures, particularly climate change.

A study conducted by Anhar et al (2025) showed the interplay of factors presents a different dynamic. A key ecological driver is the impact of climate change, which is compelling some farmers to expand their coffee cultivation into higher elevations, often encroaching on protected forest areas. This creates a potential conflict between livelihoods and conservation. The primary institutional enabler is the Social Forestry (SF) program, which provides a legal pathway for these farmers to manage their coffee plantations within these forest zones, thereby resolving tenure conflicts and legitimizing their land use.

However, this case also perfectly illustrates the "implementation deficit" of the SF program. While the program grants legal access, it often fails to provide the necessary follow-up support. The research highlights a critical knowledge and support gap: farmers operating under the SF scheme require targeted assistance to implement sustainable coffee cultivation practices that can maximize both their income and the ecological benefits of the system, particularly its potential for carbon storage. Without this support, there is a risk that the systems will be managed in ways that degrade the forest ecosystem.

Comparing these two cases reveals a crucial lesson: the nature of the adoption challenge is fundamentally different depending on the context. In the oil palm landscape, the core challenge is overcoming the inertia of a powerful monoculture incumbent by demonstrating and de-risking a viable alternative. In the coffee landscape, the challenge is to support and enhance an existing agroforestry tradition, ensuring it is ecologically sustainable and resilient in the face of new pressures like climate change, using the SF program as a framework for improved governance. This demonstrates that effective policy and programmatic interventions must be highly nuanced and deeply tailored to the specific economic, ecological, and cultural realities of the farming system they seek to influence.

Agroforestry adoption often creates strong synergies, resulting in a "triple-win" scenario where economic, ecological, and social benefits are achieved simultaneously. This synergy is the main appeal of agroforestry as a sustainable development tool. However, it is also important to acknowledge the potential for trade-offs. One of the most common trade-offs is between commercial objectives and food security objectives. A system focused on a single high-value commercial commodity (e.g., coffee or rubber) may generate higher cash

income but might sacrifice the food and nutritional diversity offered by traditional mixed-garden systems. Another trade-off is between short-term income needs and long-term investment. Farmers may have to sacrifice a portion of current income to allocate land and labor for planting trees that will only provide returns in the future (Nöldeke et al., 2021). Managing these trade-offs is key to designing agroforestry systems that fit the needs and preferences of farmers.

3.3 Strategic recommendations for scaling agroforestry in Indonesia

The comprehensive analysis of the drivers and barriers influencing agroforestry adoption provides a clear basis for formulating strategic recommendations. To effectively scale up agroforestry in Indonesia, interventions must move beyond isolated projects and adopt a systemic approach that addresses the interconnected challenges in policy, finance, and knowledge. The following recommendations are designed to create a more enabling ecosystem for smallholder farmers to transition towards more sustainable and resilient land-use systems. The subsequent table provides a summary of these levers for change, linking specific problems to actionable solutions.

3.3.1 Policy and governance reform

Effective and coherent governance is the bedrock upon which successful agroforestry scaling can be built. Reforms are needed to ensure that the policy environment genuinely supports and incentivizes long-term, sustainable land management. This includes improving institutional coordination, clarifying land tenure systems, and ensuring consistent policy implementation across administrative levels.

3.3.1.1 Strengthen land tenure security within the social forestry program

The government must move beyond the administrative act of issuing SF permits to ensuring that these permits translate into genuine, long-term tenure security that is perceived as stable and defensible by farmers. This requires simplifying bureaucratic processes, providing clear and participatory demarcation of boundaries, and offering legal support to communities to help them navigate the system and defend their rights. This is essential to unlock the long-term private investment of farmers in their land.

3.3.1.2 Ensure policy coherence across sectors

A high-level, cross-ministerial task force, potentially coordinated by the National Development Planning Agency (BAPPENAS), should be established to harmonize agricultural, forestry, trade, and land-use planning policies. The objective is to eliminate the contradictory incentives that currently undermine agroforestry, such as the simultaneous promotion of monoculture expansion and forest conservation. This body would be responsible for aligning subsidies, regulations, and development goals to create a consistent and supportive policy signal for integrated, diversified land use.

3.3.1.3 Increase and target social forestry budgets

The national and regional governments must increase the budget allocations for the SF program. Crucially, these funds should be strategically targeted towards on-the-ground implementation support—such as capacity building, technical assistance, and post-permit mentoring—rather than being primarily consumed by administrative licensing processes. This will help to close the critical "implementation deficit" that currently plagues the program.

3.3.2 Financial innovation and market development

Overcoming the significant economic and financial hurdles requires innovative thinking that goes beyond traditional agricultural finance and market development. This includes the development of alternative financing mechanisms, such as blended finance, microcredit schemes, and payment for ecosystem services, to support farmers' initial investment and long-term sustainability. Furthermore, strengthening market linkages and value chains can enhance the economic viability of agroforestry products, thereby increasing farmers' incentives to adopt and maintain such systems.

3.3.2.1 Develop tailored financial products

Financial institutions, in collaboration with the government and international development partners, should design and pilot financial products specifically tailored to the unique cash flow of agroforestry systems. This could include long-term loans with grace periods that align with the maturation of tree crops, low-interest "green" credit lines, and blended finance models where public or philanthropic funds are used to de-risk private investment. Such products would address the critical lack of capital that currently prevents many farmers from adopting agroforestry.

3.3.2.2 Build value chains for diverse agroforestry products

Public and private sector investment is needed to build robust and equitable value chains for the diverse products of agroforestry. This includes supporting the formation and strengthening of farmer cooperatives to improve collective bargaining power, investing in local post-harvest processing facilities to add value, and facilitating direct linkages between farmer groups and buyers who are seeking certified, sustainably produced goods. Efforts should also focus on market development and promotion to create demand and establish price premiums for these products.

3.3.3 Strengthening knowledge and capacity ecosystems

Closing the knowledge gap is fundamental to empowering farmers to successfully manage complex agroforestry systems. This requires a shift towards more participatory and accessible knowledge-sharing models. Such approaches facilitate the exchange of knowledge between researchers, extension agents, and farmers, ensuring that innovations are grounded in local contexts. Furthermore, strengthening institutional support and continuous training programs can enhance farmers' adaptive capacity and promote the sustained adoption of agroforestry practices.

3.3.3.1 Re-design extension services for a farmer-centric approach

Government extension services need to be reformed, moving away from a top-down, one-size-fits-all information delivery model. The new model should be participatory and farmer-centric, utilizing methods like farmer field schools and demonstration plots. Crucially, it must actively integrate local and indigenous ecological knowledge with modern scientific insights, recognizing farmers as co-creators of knowledge rather than passive recipients of information. Leveraging existing social networks and farmer-to-farmer learning platforms can significantly increase the reach and effectiveness of these services.

3.3.3.2 Invest in accessible, applied research and data

Continued support for research institutions is vital for developing practical, location-specific agroforestry models that are optimized for both profitability and ecological benefits. However, there must be a stronger emphasis on ensuring that the outputs of this

research—such as data on species compatibility, expected yields, and market potential—are translated into accessible formats and disseminated effectively to extension agents and farmers. This will help to reduce the uncertainty and perceived risk associated with adopting new systems.

4. Conclusions

The decision of an Indonesian forest farmer to adopt an agroforestry system is a multifaceted calculation of risk and reward, profoundly shaped by the surrounding economic, institutional, social, and ecological landscape. This systematic review of contemporary scientific literature reveals that while the potential of agroforestry to deliver resilient livelihoods, restore degraded environments, and contribute to national development goals is immense, the realization of this potential is far from guaranteed. The pathway to adoption is paved with clear and compelling drivers but obstructed by significant and deeply interconnected barriers.

Farmers are primarily motivated by the promise of economic stability through income diversification and enhanced long-term profitability, coupled with the tangible ecological benefits that underpin the sustainability of their land. However, these powerful motivations are often neutralized by the immediate and pressing realities of insecure land tenure, a chronic lack of access to capital, and weak connections to viable markets. Furthermore, the inherent complexity of agroforestry systems, combined with significant knowledge gaps and inadequate institutional support, creates a high perception of risk that many resource-constrained smallholders are unable or unwilling to bear.

The Indonesian government's Social Forestry program represents a critical and well-intentioned policy framework to address some of these challenges, particularly land tenure. Yet, a persistent gap between policy design and on-the-ground implementation limits its effectiveness. The success of agroforestry at scale cannot be achieved through piecemeal projects or top-down decrees alone. It requires a systemic shift towards building a truly supportive ecosystem for smallholders—one that aligns policy across sectors, innovates in finance and market development, and fosters knowledge systems that are participatory, accessible, and respectful of local wisdom. Ultimately, empowering farmers to choose sustainability requires making that choice not only ecologically sound but also economically viable and socially supported.

This comprehensive review also highlights several critical gaps in the existing literature, pointing towards important directions for future research that can better inform policy and practice. First, much of the current research on the benefits of agroforestry is based on cross-sectional data, case studies, or simulation models. There is a pressing need for more long-term, longitudinal studies that track cohorts of farmers over time. Furthermore, there is a lack of deeper socio-psychological research. While some studies have addressed psychological factors, more in-depth investigation of the socio-psychological dimensions of farmer decision-making is needed. Addressing these research gaps will be crucial for developing the next generation of policies and programs that can effectively and equitably scale agroforestry across the diverse landscapes of Indonesia.

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