



The potential of silvopasture as a solution for food security

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ABSTRACT

Background: Indonesia's animal food sub-sector remains highly dependent on imports. Beef consumption rose by 21% over the past five years without a matching increase in domestic production, and imports of feeder cattle and frozen meat reached 38% of national demand in 2024. Limited feed land and natural resource degradation further constrain livestock growth. Silvopasture, which integrates forestry and livestock systems, offers a sustainable solution to improve economic productivity, food security, and ecological balance. **Methods:** This study applies a literature review and policy analysis of scientific publications, national policies (Ministry of Environment and Forestry, Ministry of Agriculture, and Ministry of National Development Planning), and quantitative data from the Food and Agriculture Organization (FAO), Statistics Indonesia (BPS), and the World Bank (2020–2025). **Findings:** Silvopasture can increase land productivity by up to 40%, feed cost efficiency by 25%, and farmer income by 30%. If implemented nationally across 1 million hectares, it could reduce beef imports by 600,000 tons and create 250,000 green jobs by 2030. This paper recommends a National Silvopasture Policy Framework built on cross-sectoral policy integration, fiscal incentives, green financing, and capacity building for farmer-rancher institutions. **Conclusion:** Economically, silvopasture raises farmer income, lowers feed costs, and helps reduce beef imports. Ecologically, it improves soil structure, increases organic matter, and sequesters carbon. Socially, it strengthens the rural economy and creates jobs based on sustainable natural resources. **Novelty/Originality of this article:** To date, no national policy framework explicitly regulates silvopasture management. Social Forestry and Cattle Self-Sufficiency policies run separately, without institutional integration. A comprehensive, evidence-based approach is therefore needed to make silvopasture an integral part of national food security strategy.

KEYWORDS: agricultural policy, agroforestry, food security, green economy, silvopasture

1. Introduction

Food security is the main foundation of national development that determines economic, social, and environmental stability. In the context of Indonesia, with a population of more than 280 million, the challenges of food supply are increasingly complex. Population growth and increased community income have driven a surge in demand for animal products, particularly beef. Data from the Central Statistics Agency/*Badan Pusat Statistik* (BPS) (2024) shows that national beef consumption reached 3.1 kg per capita per year, an increase of 21% compared to 2020. However, domestic production is only able to meet around 60-65% of national demand, resulting in a high dependence on imports of feeder cattle and frozen beef, which accounts for around 38% of total demand (Food and Agriculture Organization (FAO), 2023).

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This gap between demand and production is exacerbated by limited feedland. The conversion of agricultural land to industrial and residential areas has reduced grazing areas, while intensive farming practices are often inefficient and have a negative impact on the environment. The livestock sector contributes about 7% of national greenhouse gas (GHG) emissions (FAO, 2022), while also putting pressure on water and land resources. On the other hand, most national food security policies are still oriented towards plant commodities such as rice, corn, and soybeans. Animal food security, which plays an important role in improving nutrition and human resource quality, remains a marginalized sector.

In this situation, silvopasture, an integrated system combining forestry and livestock farming, emerges as an innovative approach that combines economic productivity and ecological sustainability. This system integrates trees, grasslands, and livestock into a single land unit, thereby increasing space efficiency, improving soil fertility, and providing natural feed. Various studies have demonstrated the effectiveness of this system. For example, Idajati et al. (2023) in Mojokerto found that the implementation of silvopasture increased farmers' income by up to 35%, while Mursyid et al. (2024) on the slopes of Mount Merapi reported a 25% increase in feed availability and an improvement in the microclimate of the land. In addition to economic and ecological benefits, silvopasture also has the potential to strengthen rural social resilience. By diversifying production (livestock, timber, and intercropping), this system can reduce the risk of crop failure, increase household income resilience, and create new jobs in the green sector. If implemented on a large scale, for example on 1 million hectares of production forest, Indonesia has the potential to increase beef production by up to 300,000 tons per year and save USD 600 million in foreign exchange from reduced imports (National Development Planning Agency/*Badan Perencanaan Pembangunan Nasional* (Bappenas), 2024). However, to date there has been no national policy framework that explicitly regulates silvopasture management. Social Forestry and Cattle Self-Sufficiency policies are still running separately, without institutional integration that supports cross-sectoral land management. Therefore, a more comprehensive and evidence-based policy approach is needed to make silvopasture an integral part of the national food security strategy.

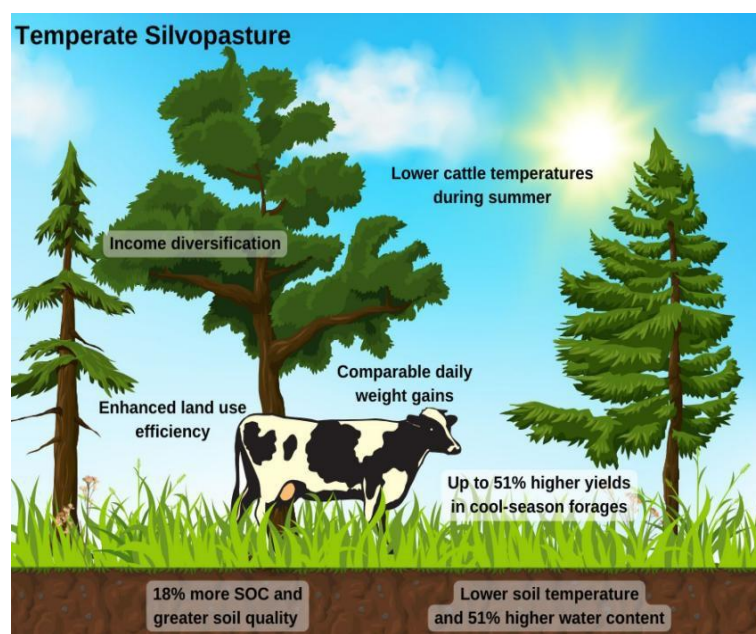


Fig. 1. Ecosystem services in temperate silvopastoral systems (Amorim et al., 2023)

Thus, the development of silvopasture policies not only addresses the challenges of animal food production, but also strengthens the foundations of the national green economy. This approach is capable of changing the paradigm of agricultural development

in Indonesia from resource exploitation to an integrative system that is productive, efficient, and sustainable.

1.1 Literature review

1.1.1 Basic concepts of silvopasture

Silvopasture is a form of integrated agroforestry system that combines trees, grasslands, and livestock on a single plot of land to achieve a balance between economic productivity and ecological conservation. According to Jose et al. (2019) in *Agroforestry Systems*, silvopasture can increase resource use efficiency by 30–40% through land function diversification, nutrient cycle management, and reduced environmental pressure. This system enables positive interactions between vegetative components (trees and grass) and biotic components (livestock), thereby creating ecological synergies that improve soil quality, microclimate, and ecosystem stability.

From an ecological perspective, the main principle of silvopasture is complementary symbiosis between biological elements. Trees provide shade and organic matter that maintains soil moisture, while livestock help distribute natural fertilizer through their manure. According to Nair et al. (2020) in *Forest Policy and Economics*, the presence of tree vegetation slows the rate of surface runoff, reduces erosion, and increases groundwater infiltration. In addition, tree root systems strengthen soil structure, making the land more resistant to degradation.

In the long term, these ecological interactions result in sustainable land productivity, in contrast to monoculture livestock farming, which tends to reduce soil fertility. Therefore, silvopasture is considered a concrete application of the principle of low external input sustainable agriculture (LEISA).

1.1.2 Economic dimensions of silvopasture

In addition to its ecological aspects, silvopasture has significant economic value. The FAO (2022) notes that this system can generate 20–50% higher income than conventional livestock systems, as it produces a variety of commodities: timber, forage, livestock, and other non-timber products. In Latin America, each hectare of silvopasture generates an economic value of between USD 800–1,200 per year, while monoculture livestock systems only generate around USD 600 (FAO, 2022).

A study by Wigena (2011) in West Nusa Tenggara showed that the application of silvopasture increased the carrying capacity of pastures by up to 30%, which had a direct impact on increasing livestock productivity. Research by Putri et al. (2023) in Bangkalan showed a 25% increase in the live weight of beef cattle and a 27% increase in farmer profits after two seasons of maintenance.

In addition, this system provides indirect economic effects in the form of increased income security for farmers. Diversification of production reduces economic risks due to price fluctuations or crop failure. In the context of rural development, this is important because around 70% of poor households in Indonesia depend on the agriculture and livestock sectors (World Bank, 2023). Thus, silvopasture has the potential to strengthen microeconomic resilience while stimulating local economic growth.

Beyond income and land productivity, silvopasture also generates measurable co-benefits for livestock welfare and productivity that are rarely captured in conventional cost-benefit analyses of Indonesian livestock policy. Recent physiological studies on tropical dairy and beef cattle show that tree shade in silvopastoral systems significantly lowers rectal and surface temperatures, respiration rates, and panting scores compared to cattle kept in full-sun pasture, with the difference most pronounced once the Temperature-Humidity Index exceeds the threshold associated with heat stress (McManus et al., 2026). Because heat stress is known to depress feed intake, weight gain, and reproductive performance in tropical cattle, the thermal buffering provided by tree cover represents an

additional, non-trivial productivity pathway through which silvopasture can support Indonesia's beef self-sufficiency target, alongside the feed-cost and land-productivity mechanisms already discussed above. Given that Indonesia's main cattle-producing regions, including parts of West Nusa Tenggara and East Java, experience high ambient temperatures and humidity for most of the year, this thermal-comfort effect is likely to be particularly relevant to the pilot areas proposed in Section 3.4.

1.1.3 Social dimensions and food security

In the FAO (2021) food security paradigm, there are four main pillars: availability, access, stability, and utilization. Silvopasture contributes directly to all four.

1. Food availability: This system provides sustainable natural feed and increases livestock production capacity, thereby increasing the availability of beef.
2. Access to food: Increased income for farmers and ranchers through crop diversification increases their purchasing power for food and other necessities.
3. Food stability: Due to its multi-productive nature, silvopasture is able to maintain production stability despite seasonal changes or feed supply crises.
4. Food utilization: The animal products produced are generally of higher quality because livestock obtain natural feed and a healthy growing environment, supporting improved nutrition for the community.

In addition, silvopasture strengthens rural social resilience. This system encourages community participation in forest land management (community-based forest management), creates social solidarity, and improves technical skills in animal husbandry and conservation. Research by Zainuddin & Sribianti (2018) in Gowa shows that the implementation of silvopasture has a positive effect on community welfare indices, with an average increase in household income of 30%.

Social resilience gains from silvopasture are not automatically distributed evenly within farming households, however. A global review of women's participation in agroforestry systems finds that although women frequently perform a substantial share of day-to-day labor in tree and livestock management, their formal participation in decision-making, and their share of the economic benefits, remain systematically lower than men's, particularly in enterprises involving higher-value products such as timber (Kiptot & Franzel, 2012). Constraints identified include unequal access to land titles, credit, and extension services, which mirror the land-tenure and green-financing barriers discussed for Indonesian farmers more broadly in Section 3.4. This suggests that the design of Indonesia's proposed Silvopasture Field Schools and cooperative institutions (Table 3) should explicitly include gender-responsive targeting, both to ensure equitable distribution of the projected 250 thousand green jobs and to avoid reproducing existing disparities in resource access within rural households.

1.1.4 Environmental dimensions and climate change

One of the main advantages of silvopasture is its contribution to climate change mitigation. The combination of tree vegetation and livestock creates an effective carbon sequestration system. The FAO (2022) estimates that silvopasture systems can sequester up to 5.3 tons of CO₂ per hectare per year through increased tree biomass and improved soil organic matter.

Research by Mursyid et al. (2024) on the slopes of Mount Merapi shows that *Acacia decurrens*-based silvopasture can increase soil carbon availability by 18% compared to non-integrative systems. In addition, this system also plays a role in biodiversity conservation by providing a natural habitat for various species of flora and fauna that were previously threatened by intensive livestock practices.

These national findings are consistent with independent evidence from tropical grazing systems elsewhere. A recent comparative study across dispersed-tree pastures, live fences, and silvopastoral forest plantations in southeastern Mexico found that silvopastoral

systems reduced soil CO₂ emissions by 12–32% and increased soil organic carbon content by 12–29% relative to full-sun open pastureland, with total carbon stocks 50–53% higher in silvopasture (Morales-Ruiz et al., 2025). The authors attribute this effect primarily to tree-driven regulation of soil temperature and moisture, which slows microbial decomposition of organic matter. This cross-regional consistency strengthens the evidentiary basis for treating silvopasture as a credible climate mitigation instrument in the Indonesian context, rather than a locally specific finding limited to the Merapi case.

From a global perspective, silvopasture is recognized as one of the Nature-Based Solutions strategies to address land degradation and climate change. As stated in the Intergovernmental Panel on Climate Change (IPCC, 2022) report, agroforestry systems such as silvopasture have great potential in achieving the Net Zero Emission target because they combine production and conservation functions.

1.1.5 Policy framework and implementation challenges

In terms of policy, silvopasture in Indonesia lies at the intersection of two main sectors: forestry and livestock. The Ministry of Environment and Forestry, through its Social Forestry program, has opened up opportunities for communities to manage production forest land on a limited basis, while the Ministry of Agriculture focuses on strengthening livestock production through its Beef Self-Sufficiency program. However, these two policies are still running independently without adequate institutional integration mechanisms (Idajati et al., 2023).

As a result, many silvopasture initiatives are local and experimental in nature, and are not yet coordinated at the national level. In fact, National Research and Innovation Agency/*Badan Riset dan Inovasi Nasional* (BRIN) (2024) research shows that Indonesia has more than 4 million hectares of potential silvopasture land in underutilized limited production forest areas. Other obstacles include a lack of economic incentives, limited access to green credit, and the absence of national technical standards for sustainable silvopasture practices.

The global policy context also shows high relevance to the sustainable development agenda. In the United Nations Strategic Plan for Forests 2030 (United Nations Department of Economic and Social Affairs (UN DESA), 2021), the integration of forests and agriculture is one of the main strategies for improving global food security. Therefore, national policies on silvopasture can be an important part of the implementation of the Sustainable Development Goals (SDGs) and the Paris Agreement.

1.1.6 Theoretical synthesis

Silvopasture is an integrated agricultural system that not only provides economic benefits, but also supports environmental conservation and social welfare. The theoretical framework for the development of silvopasture in Indonesia can be summarized as follows:

Table 1. Theoretical framework for the development of silvopasture in Indonesia

Dimensions	Mechanism	Main Impact	Reference
Ecology	Integration of tree vegetation and livestock	Improved soil fertility, carbon sequestration	Nair et al. (2020), Mursyid et al. (2024)
Economy	Diversification of production output	Increase in farmers' income by 25–35%	FAO (2022), Idajati et al. (2023)
Social	Community involvement in land management	Strengthening the resilience of rural communities	Zainuddin & Sribianti (2018)
Policy	Cross-sector integration Ministry of Environment and Forestry–Ministry of Agriculture	Institutional efficiency, program synchronization	Bappenas (2024), BRIN (2024)

Overall, the results of the literature review show that the successful implementation of silvopasture in Indonesia is highly dependent on institutional integration, fiscal policy support, applied research, and public awareness of the importance of sustainable natural resource management.

1.1.7 International policy lessons and comparative experience

Comparative international experience shows that the success of silvopasture policy is closely linked to the design of economic incentive mechanisms rather than to ecological potential alone. The Regional Integrated Silvopastoral Ecosystem Management Project, implemented in Colombia, Costa Rica, and Nicaragua between 2002 and 2008 with financing from the Global Environment Facility and the World Bank, was among the first large-scale initiatives to test a direct payment-for-environmental-services (PES) mechanism to encourage smallholder ranchers to convert degraded monoculture pastures into silvopastoral systems (Pagiola et al., 2004). The pilot demonstrated that even modest per-hectare payments, when combined with technical assistance, were sufficient to trigger significant land-use change among cattle ranchers who would otherwise lack the capital to establish trees, live fences, and improved forage on their land.

Building on these lessons, the Colombia Mainstreaming Sustainable Cattle Ranching Project scaled the approach nationally between 2010 and 2020, combining Global Environment Facility (GEF) grants with a dedicated green-credit line administered through the national agricultural financing fund, the Fondo para el Financiamiento del Sector Agropecuario (FINAGRO) (World Bank, 2021). Programme results indicate that pairing fiscal incentives with extension services and producer associations substantially increased adoption rates, while also improving biodiversity indicators and carbon- and water-related ecosystem services on participating farms (World Bank, 2021). This experience is highly relevant to Indonesia's institutional context, in which the Ministry of Environment and Forestry's Social Forestry programme and the Ministry of Agriculture's Cattle Self-Sufficiency programme currently operate as parallel, disconnected instruments. The Colombian model suggests that a single cross-sectoral financing vehicle, rather than two separately administered programmes, is a precondition for translating pilot-scale silvopasture success into national policy outcomes.

A systematic review of more than fifty studies on the adoption of silvopastoral systems across Latin America similarly finds that adoption is driven less by ecological knowledge than by access to credit, the security of land tenure, and the strength of farmer-to-farmer extension networks (Chamorro-Vargas et al., 2025). These findings reinforce the argument that Indonesian silvopasture policy cannot rely on ecological and economic potential alone; it requires a deliberate architecture of green financing, land-tenure clarity, and farmer institutions capable of absorbing and disseminating new practices, mirroring the institutional-integration strategy already outlined in Table 1.

2. Methods

This study uses a qualitative descriptive approach with a literature review and policy analysis method. This approach was chosen because the issue of silvopasture as a solution to food security is complex and multidimensional, covering ecological, economic, social, and institutional aspects. Through a literature review, this study seeks to identify the relationship between silvopasture practices and increased food security in Indonesia, while also examining the policy gaps that still exist at the national implementation level.

The literature search strategy followed a structured, keyword-based approach broadly consistent with systematic review practices used in comparable agroforestry adoption studies (Tranchina et al., 2024). Search terms combined the core concept of silvopasture and its synonyms (silvopasture, silvopastoral, agrosilvopastoral, agroforestry-livestock integration) with terms relevant to each analytical dimension of this study, namely food security, farmer income, carbon sequestration, soil health, animal welfare, and policy

adoption barriers. Sources were drawn from peer-reviewed journals indexed in international databases, institutional reports from Indonesian ministries and agencies (Ministry of Environment and Forestry/*Kementerian Lingkungan Hidup dan Kehutanan*, (KLHK), Ministry of Agriculture/*Kementerian Pertanian* (Kementan), Ministry of National Development Planning/*Badan Perencanaan Pembangunan Nasional* (Bappenas), BRIN, Statistics Indonesia/*Badan Pusat Statistik* (BPS)), and technical documents from international organizations (FAO, World Bank, Intergovernmental Panel on Climate Change (IPCC), United Nations Department of Economic and Social Affairs (UN DESA). Priority was given to publications from 2019 onward to ensure relevance to current national policy conditions, while foundational conceptual references on agroforestry theory were retained regardless of publication date. This approach allowed the study to triangulate global evidence on silvopasture performance with Indonesia-specific data on beef production, land availability, and institutional arrangements.

All data used was sourced from secondary data obtained through national and international scientific publications, official government reports, and statistical databases. The literature used included accredited journals and policy documents. In addition, quantitative data on beef production, consumption, imports, and feedland area was obtained from the FAO and the Ministry of Agriculture (2020–2025).

The analysis was conducted by reviewing the literature to gain an in-depth understanding of the effectiveness and benefits of the silvopasture system on national food security. Findings from various studies were compared and synthesized to identify patterns, similarities, and differences in relevant research results. A policy analysis was then conducted to assess the extent to which Indonesian government policies, both in the forestry and livestock sectors, have supported the integration of the silvopasture system in the context of national food security development.

3. Results and Discussion

3.1 Animal food challenges in Indonesia

Demand for beef in Indonesia is increasing significantly every year, in line with economic growth and urbanization. Based on data from BPS (2024), national beef consumption reached 3.1 kg/capita/year, up 21% compared to 2020. However, domestic production only reached 450,000 tons, while national demand is estimated at 720,000 tons (FAO, 2023). As a result, around 38% of beef demand still depends on imports of feeder cattle and frozen beef from Australia and India.

Limited feed land is also a serious problem. According to Greenhouse Gas Inventory and Monitoring, Reporting, and Verification (MRV) Report (2023), Grazing land in Indonesia only accounts for about 12% of total agricultural land, while most of it has been degraded due to logging and conversion (KLHK, 2023). On the other hand, intensive livestock systems that rely on concentrated feed increase greenhouse gas emissions and reduce soil quality. Therefore, an environmentally friendly and productive land integration model is needed, and silvopasture is one of the main alternatives.

This gap has become even more salient in light of Indonesia's recent food self-sufficiency milestones. In January 2026, the Indonesian government publicly declared that the country had achieved national food self-sufficiency (*swasembada pangan*) for 2025, driven primarily by a sharp increase in rice production (Antara News Jambi, 2026). However, this declaration masks significant commodity-level variation: government projections for 2026 estimate that Indonesia will still need to import approximately 321,660 tons of beef and buffalo meat, alongside large volumes of soybeans and garlic, indicating that the self-sufficiency narrative applies unevenly across the national food basket (Antara News Jambi, 2026). Beef therefore remains one of the few strategic commodities where the gap between the political narrative of food independence and the underlying production reality is most pronounced, reinforcing the argument that a

structural, land-based solution such as silvopasture, rather than incremental adjustments to import quotas, is required to close this gap in a way that is consistent with the broader self-sufficiency agenda.

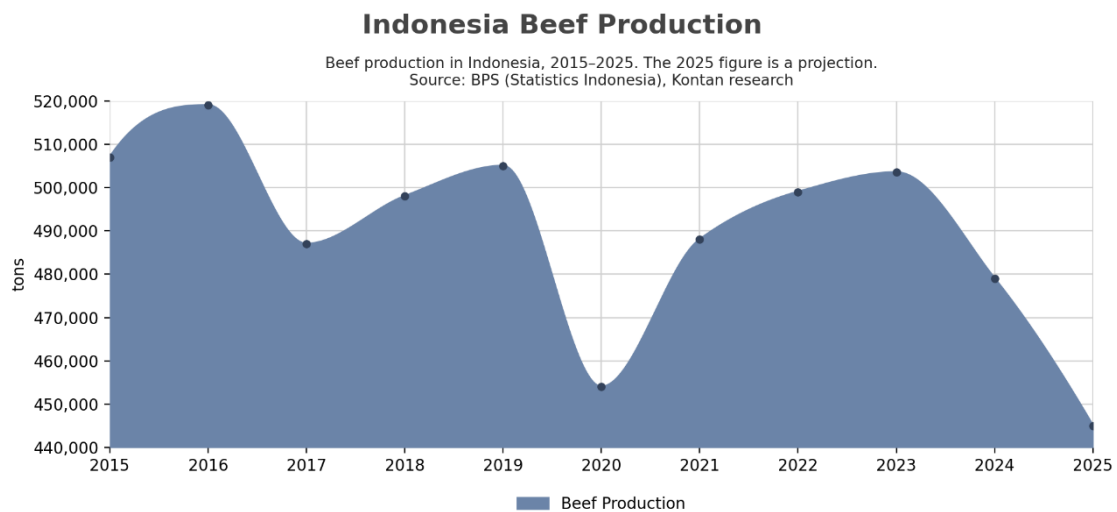


Fig. 2. Indonesian beef production
(Balai Veteriner Subang, 2025)

The graph of Indonesian beef production for the period 2015–2025 shows a fluctuating pattern, indicating that national production capacity is not yet stable. After peaking at around 510,000 tons in 2017–2018, production declined sharply in 2019–2020 due to feed shortages, culling of productive females, and supply chain disruptions during the pandemic. Production recovered in 2022, but BPS projections estimate that it will decline again to around 450,000 tons in 2025. This trend indicates that the conventional livestock system remains vulnerable to climate change, feed availability, and economic dynamics. These fluctuations underscore the urgency of developing alternative production systems such as silvopasture, which can enhance land efficiency, provide sustainable natural feed, and stabilize national beef production.

3.2 The concept and potential of silvopasture

Silvopasture is a system that integrates trees, grasslands, and livestock on a single plot of land. Trees serve to maintain moisture and enrich the soil, grass provides natural feed, while livestock distribute natural fertilizer through their manure. This system balances economic productivity and environmental sustainability. Economically, silvopasture can increase farmers' income by 25–35% compared to conventional livestock systems (Idajati et al., 2023). Feed costs can be reduced by up to 30% due to the availability of natural forage under the tree canopy. Ecologically, this system increases carbon sequestration by 5.3 tons of CO₂/ha/year and reduces soil erosion by up to 40% (Mursyid et al., 2024).

The image comprehensively illustrates the benefits of the silvopasture system in terms of food security, economy, and ecology. From a food perspective, this system provides a diverse range of nutrients such as milk, meat, eggs, fruit, and sustainable natural feed from grasslands and trees. Economically, silvopasture supports increased income through the sale of livestock, tree products, and savings in production costs thanks to the efficiency of natural inputs. Ecologically, this system provides dual benefits both above and below ground. Above ground, silvopasture acts as a windbreak, air filter, microclimate regulator, and carbon sink that supports biodiversity. Meanwhile, below ground, tree root systems improve soil health, increase water infiltration, reduce erosion, and provide habitats for soil

organisms that maintain ecosystem fertility. Thus, silvopasture is not only a food production system but also a sustainable development strategy that integrates economic, social, and environmental functions into a single integrated agricultural landscape.

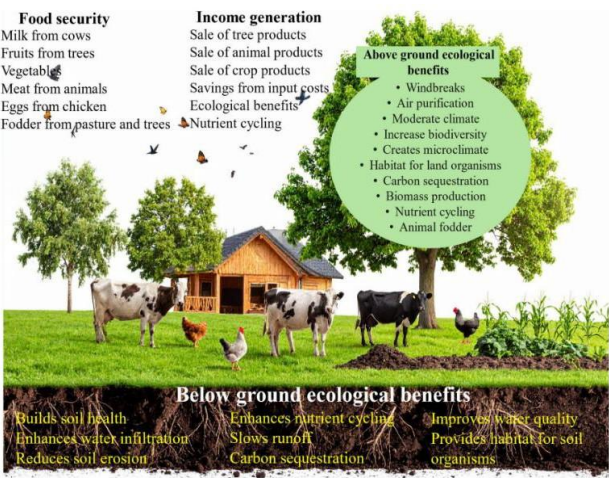


Fig. 3. Explanation of the benefits of agroforestry systems (Manono & Gichana, 2025)

An additional productivity pathway, distinct from feed cost and land efficiency, concerns the microclimatic buffering that tree cover provides to livestock under Indonesia's hot and humid tropical conditions. Experimental evidence from tropical cattle production systems shows that shaded animals in silvopasture consistently record lower body temperatures, lower respiration rates, and reduced panting compared to animals in open pasture, with the gap widening sharply once heat-stress thresholds are crossed (McManus et al., 2026). Chronic heat stress is associated with reduced feed intake, slower weight gain, and impaired fertility in cattle, all of which directly affect the beef production and import-substitution targets discussed in Section 3.1. Integrating this welfare dimension into Indonesia's silvopasture planning would strengthen the technical justification for tree-density and species-selection standards under the proposed National Silvopasture Research Center (Table 3), since shade architecture, not only forage availability, materially affects herd productivity.

3.3 Current policies

Institutionally, Indonesia already has two major policies related to silvopasture, namely the Social Forestry program in Regulation of the Minister of Environment and Forestry Number 9 of 2022 and Cattle Self-Sufficiency in Annual Report on Beef Cattle Self-Sufficiency 2024. However, both are still being implemented sectorally without strong integration. KLHK focuses on community forest management, while Kementan emphasizes increasing livestock populations. There are no specific regulations that explicitly govern silvopasture management. This has resulted in many initiatives in the regions remaining local and experimental in nature. BRIN (2024) estimates the potential for silvopasture land to reach 4 million hectares in limited production forest areas, a significant potential that has not been optimally utilized.

Table 2. Silvopasture policy conditions and reform recommendations

Aspect	Current Situation	Challenges	New Policy Direction
Institutional	The Ministry of Environment and Forestry and the Ministry of Agriculture are not yet integrated.	Weak coordination, overlapping authority	Establish a National Silvopasture Coordination Agency

Aspect	Current Situation	Challenges	New Policy Direction
Spatial Planning	Silvopasture has not been included in the Spatial Plan (RTRW).	Limited land use	Integrate silvopasture into spatial planning and social forestry
Economic Incentives	There are no subsidies or green credits.	Limited farmer access	Green credit and payment for ecosystem services schemes
Research and Technology	Research has not been standardized.	Slow technology transfer	National Silvopasture Research Center (BRIN– <i>Institut Pertanian Bogor (IPB)–Universitas Gadjah Mada (UGM)</i>)
Financing	There is no green financing.	Farmers struggle with capital	Establish a National

3.4 Barriers and enabling conditions for silvopasture adoption in Indonesia

Despite its demonstrated ecological and economic potential, the adoption of silvopasture and agroforestry practices more broadly remains globally limited. A systematic literature review covering 90 studies worldwide identified 31 distinct barriers to agroforestry adoption, the five most frequent being: insufficient technical and agronomic knowledge among farmers; weak market access and supply chains for agroforestry products; the additional labor and time required to manage a multi-component system; the upfront capital needed to establish trees, fencing, and forage; and limited availability of technical extension support (Tranchina et al., 2024). These barriers are structurally similar to the obstacles already identified in the Indonesian silvopasture context, where BRIN (2024) estimates over 4 million hectares of potential land remain underutilized precisely because of the absence of economic incentives, limited access to green credit, and the lack of national technical standards noted in Section 1.1.5.

A particularly relevant obstacle is the delayed financial return characteristic of tree-based systems: unlike annual crops, trees typically require several years to mature before generating income, which discourages adoption among farmers operating with thin cash reserves and limited access to formal credit (Tranchina et al., 2024). In the Indonesian case, this constraint is compounded by land-tenure ambiguity: Social Forestry licenses under KLHK grant farmers time-limited utilization rights rather than full land ownership, which reduces farmers' incentive to make long-term investments such as planting trees whose economic benefits may only be realized after the license period, and simultaneously weakens their ability to use the land as loan collateral.

Evidence from Latin America's more mature silvopasture policy landscape indicates that these barriers can be systematically addressed. Chamorro-Vargas et al. (2025) find that the strongest enablers of adoption are, in order of importance, access to targeted credit or payment-for-ecosystem-services schemes, security of land tenure, and the presence of strong farmer-to-farmer or cooperative extension networks capable of transmitting technical knowledge at low cost. Notably, the review also finds that adoption accelerates when incentive schemes are differentiated according to farm size and profitability, rather than applying a uniform subsidy across all farmers, a lesson consistent with the tiered strategy proposed in Table 3 of this article.

Applied to Indonesia, three enabling conditions therefore appear necessary before the potential outlined in Sections 3.1–3.3 can be realized at scale. First, a dedicated green-financing instrument, comparable to FINAGRO's silvopasture credit line in Colombia, is needed to bridge the multi-year gap between tree establishment and productive return; this would operationalize the fiscal-incentive component already identified in Table 2. Second, land-tenure arrangements under the Social Forestry scheme would need to be extended or made bankable, so that farmers can treat silvopasture as a long-term asset rather than a time-limited concession. Third, farmer cooperatives and extension networks, rather than

top-down government dissemination alone, should be positioned as the primary channel for technical knowledge transfer, consistent with both the Latin American evidence and the community-based forest management principle already discussed in Section 1.1.3. Addressing these three conditions in parallel, rather than sequentially, is consistent with the cross-sectoral integration strategy recommended in the following section.

3.5 Recommendations and implications

The combination of the above policy options can strengthen the role of silvopasture as part of the national food security strategy. The government can start with pilot projects in areas such as West Nusa Tenggara, South Sulawesi, and East Java, which have different land characteristics and high levels of community participation. The medium-term impact until 2030 is estimated to include an increase in beef production of 300 thousand tons per year, a reduction in imports of up to 40%, an increase in farmer income of IDR 10-12 million per hectare per year, the absorption of around 250 thousand green jobs, and additional carbon sequestration of 10 million tons of CO₂ per year.

Table 3. National silvopasture implementation strategy 2030

Strategy	Implementing actors	Policy direction	Key outputs
National institutional integration	Ministry of Environment and Forestry, Ministry of Agriculture, Ministry of National Development Planning	Establishment of the National Silvopasture Coordination Agency	Cross-sector regulation and coordination
Economic incentives and green financing	Ministry of Finance, Green Bank Indonesia, National Development Planning Agency	Green Credit Scheme and Payment for Ecosystem Services (PES)	Capital support for farmers and silvopasture cooperatives
Integration in spatial planning and social forestry	Ministry of Environment and Forestry, Local Government	Revision of the Spatial Plan to Include the category of silvopasture	Legality of forest use for livestock
Research and technological innovation	BRIN, IPB, UGM	Establishment of a National Silvopasture Research Center	National standards and technical implementation guidelines
Community education and training	Ministry of Agriculture, Ministry of Environment and Forestry, NGOs, Universities	Silvopasture Field Schools and agroforestry training	Capacity building for livestock breeders and farmers
Pilot projects and national expansion	Local governments, CSR, donor agencies	Pilot projects in West Nusa Tenggara, South Sulawesi, and East Java (2025–2030)	Operational model ready for national replication

Thus, silvopasture is not only a technical approach to sustainable livestock farming, but also a cross-sectoral development strategy that combines the green economy, food security, and natural resource conservation. This system is in line with the Sustainable Development Goals and can strengthen Indonesia's position as a pioneer of the green economy in Southeast Asia.

3.6 Alignment with the national food self-sufficiency agenda

The recommendations outlined above should be read against the backdrop of Indonesia's broader 2025–2026 food self-sufficiency agenda. While the government's January 2026 declaration of national food self-sufficiency was substantially driven by

record rice harvests, the persistence of a structural beef import requirement of over 300 thousand tons projected for 2026 demonstrates that self-sufficiency in staple grains has not translated into self-sufficiency in animal protein (Antara News Jambi, 2026). This asymmetry creates a policy window in which silvopasture can be positioned not as a marginal environmental initiative, but as a direct instrument for closing the specific commodity gap that remains after the government's primary food security targets have otherwise been met. Framing the National Silvopasture Policy Framework proposed in this article as a contribution to an already-prioritized national agenda, rather than as a competing or entirely new policy domain, may improve its prospects for cross-ministerial adoption, particularly given that the institutional integration challenge between the Ministry of Environment and Forestry and the Ministry of Agriculture identified throughout this article mirrors the coordination gaps that have historically slowed progress toward beef self-sufficiency since the program was first initiated in the 1970s.

4. Conclusions

Silvopasture is an integrated system of trees, grasslands, and livestock that has been proven to increase land productivity, economic efficiency, and maintain environmental balance. This system is a strategic alternative to address the challenges of animal food security in Indonesia, especially amid limited feed land and high dependence on beef imports. From an economic perspective, silvopasture can increase farmers' income by up to 30%, reduce feed costs by up to 25%, and contribute to a reduction in national meat imports. Ecologically, this system improves soil structure, increases organic matter content, and absorbs significant amounts of carbon. Socially, silvopasture strengthens the rural economy and creates new jobs based on sustainable natural resources. However, the successful implementation of silvopasture requires cross-sectoral policy support, institutional integration between forestry and livestock sectors, and inclusive green financing schemes. With these measures, silvopasture can become part of the national food security strategy and a key pillar of green economic development toward a self-reliant, productive, and sustainable Indonesia by 2030.

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