




Review

Traditional Subsistence Farming of Smallholder Agroforestry Systems in Indonesia: A Review

Budiman Achmad ¹, Sanudin ², Mohamad Siarudin ^{3,4,*}, Ary Widiyanto ^{2,*}, Dian Diniyati ¹, Aris Sudomo ⁵, Aditya Hani ^{3,5}, Eva Fauziyah ^{2,3}, Endah Suhaendah ⁵, Tri Sulistyati Widyaningsih ^{6,7}, Wuri Handayani ⁴, Dewi Maharani ⁵, Suhartono ^{3,4}, Maria Palmolina ⁸, Dila Swestiani ⁵, Harry Budi Santoso Sulistiadi ⁵, Aji Winara ⁹, Yudha Hadian Nur ⁹, Muthya Diana ⁹, Dewi Gartika ⁹ and Agus Ruswandi ⁹

- ¹ Research Center for Social Welfare, Village and Connectivity, BRIN, Jakarta 10330, Indonesia; budi071@brin.go.id (B.A.); dian075@brin.go.id (D.D.)
 - ² Research Center for Population, BRIN, Jakarta 12710, Indonesia; sanu003@brin.go.id (S.); evaf001@brin.go.id (E.F.)
 - ³ Forest Science Graduate Program, Faculty of Forestry, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia; adit029@brin.go.id (A.H.); har436@gmail.com (S.)
 - ⁴ Research Center for Ecology and Ethnobiology, BRIN, Bogor 16911, Indonesia; wuri003@brin.go.id
 - ⁵ Research Center for Plant Conservation, Botanic Gardens, and Forestry, Bogor 16122, Indonesia; aris.sudomo@brin.go.id (A.S.); enda051@brin.go.id (E.S.); maharanid858@gmail.com (D.M.); dila001@brin.go.id (D.S.); harr014@brin.go.id (H.B.S.S.)
 - ⁶ Leadership and Policy Innovation Program, The Graduate School, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia; tri.sulistyati.widyaningsih@brin.go.id
 - ⁷ Bureau for Organization and Human Resources, BRIN, Gedung B.J. Habibie, Jl. M.H. Thamrin No. 8, Jakarta Pusat 10340, Indonesia
 - ⁸ Research Center for Society and Culture, BRIN, Jakarta 12710, Indonesia; mari039@brin.go.id
 - ⁹ Research and Development Agency of West Java Province, Jl. Kawalayaan Indah Raya No. 6, Kelurahan Jatisari, Kecamatan Buah Batu, Kota Bandung 40286, Indonesia; ajiwinara@jabarprov.go.id (A.W.); yudhahadian@jabarprov.go.id (Y.H.N.); muthyadiana@jabarprov.go.id (M.D.); dewigartika@jabarprov.go.id (D.G.); agusruswandi@jabarprov.go.id (A.R.)
- * Correspondence: mohamad.siarudin@brin.go.id (M.S.); aryw002@brin.go.id (A.W.)



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Abstract: Agroforestry has been practiced for decades and is undoubtedly an important source of income for Indonesian households living near forests. However, there are still many cases of poverty among farmers due to a lack of ability to adopt advanced technology. This literature review aims to identify the characteristics and factors causing the occurrence of agricultural subsistence and analyze its implications for the level of farmer welfare and the regional forestry industry. The literature analysis conducted reveals that small land tenure, low literacy rates, and lack of forest maintenance are the main causes of the subsistence of small agroforestry farmers. Another reason is that subsistence-oriented agroforestry practices are considered a strong form of smallholder resilience. All of these limitations have implications for low land productivity and high-sawn timber waste from community forests. To reduce the subsistence level of farmers, government intervention is needed, especially in providing managerial assistance packages, capital assistance, and the marketing of forest products. Various agroforestry technologies are available but have not been implemented consistently by farmers. Therefore, it is necessary to develop an integrated collaboration between researchers, farmers, and regionally owned enterprises (BUMD) to increase access to technology and markets. Although it is still difficult to realize, forest services, such as upstream–downstream compensation and carbon capture, have the potential to increase farmer income.

Keywords: agroforestry; collaboration; farmers; government intervention; subsistence

1. Introduction

Agroforestry has long been practiced in Indonesia. As a sustainable land-use practice [1], it increases overall agricultural productivity by combining woody perennial with

food crops, including livestock on the same land [2]. When the concept is practiced appropriately, it can provide economic, ecological, social, and cultural benefits. The crop diversity in intercropping can provide a good income on a daily, monthly, and yearly basis. However, it depends on the agroforestry pattern adopted, such as agrisilviculture (forestry–agriculture), silvopasture (forestry–animal husbandry), agrisilvopasture (forestry–agriculture–livestock), silvofishery (forestry–fisheries), bee-forestry, sericulture (silkworm forestry), or multipurpose forest tree production systems (fusion complex). Ecologically, agroforestry supports soil and water conservation. With multi-strata plants, of course, it can minimize the occurrence of erosion, reduce runoff, and increase the effectiveness of water absorption. The spatial pattern of agroforestry can also function as a windbreak [3,4].

Sustainable agroforestry is thought to be a future agricultural practice as an alternative to unsustainable conventional agriculture [5]. In conventional agriculture, maximum tillage accelerates the decomposition of organic matter, thereby reducing its presence in the soil, while in the agroforestry pattern, the rate of decomposition of organic matter is slower due to a minimum tillage balance with the input of organic matter from trees as a complementary strategy [6]. Maximum tillage has the potential to reduce mycorrhizal fungi and increase runoff so that soil organic matter is reduced, while conservation tillage, by minimizing soil damage, can increase the presence of mycorrhizal fungi, as well as the absorption of phosphorus and soil aggregates [6,7]. The conservation agriculture principle is to have minimum soil disturbance and crop rotation while maximizing cover crops to obtain increased yields (30–200%) and labor efficiency (60%) [6]. Conservation agriculture with trees (CAWT) avoids maximum tillage to prevent the negative effects of intensive tillage, such as from ploughing (barren soil, erosion, heating, decomposition of organic matter, and damage to structures and nature) [6]. The top layer of soil, which is responsible for supporting crop life but is also the most susceptible to erosion and degradation, must be protected with particular care [6]. Crop rotations should include legumes, deep-rooted crops, and high-residue crops that have fixed nitrogen in the soil, and their biomass should add nitrogen through decomposition [6]. The litter and roots of tree components continuously add plant nutrients to the soil [8].

The function of trees in CAWT is potentially positive for agricultural crop production [6] and contributes to soil nutrient enrichment and crop production [8]. The function of trees in agroforestry, such as in fertilizer trees, can optimize the supply of native soil N and increase land productivity. The advantage of using fertilizer trees (*Gliricidia* sp., *Calliandra* sp., *Leucaena* sp., etc.) in agroforestry is that they ensure a multifunctional farm that provides wood, fodder, shade, soil improvement, and watershed breeding [9]. As an integrated, tree-based farming system, agroforestry is a reliable system due to its potential to address land degradation with additional environmental and social benefits [10,11]. In addition, agroforestry supports biodiversity conservation [12] and has higher financial returns than conventional agriculture [13]. Agroforestry also contributes significantly to climate change mitigation by increasing carbon sequestration and storage in the biosphere [14]. Furthermore, in contrast to conventional systems, agroforestry systems can better maintain biodiversity and provide food security, land security, and financial security [15].

Fertilization technology increases food crop production and provides additional income for households through sources such as the selling of tree seeds and firewood [16]. The choice of technology is driven by the size of the landownership, and more benefits are associated with larger landholdings. The adoption of agroforestry in subsistence agriculture is often limited by local social conditions and natural endowments [17].

Economically, agroforestry practices are a part of the livelihood strategies of farmers. In some cases, smallholder forests are the main source of income and even cause land owners to occupy a higher social status. Land size can be one of the factors that affects the economic value obtained from agroforestry systems. The larger the land area, the greater the economic value generated [18]. In addition, the adoption of agroforestry can diversify farmers' livelihoods and increase their income [19]. Moreover, some agroforestry

practitioners adjust to an economic focus while keeping an ecologically sound development orientation. However, they occasionally sacrifice the sociocultural aspect [20].

Agroforestry has numerous advantageous effects on the environment, including on how land is used, which leads to ecological, economic, and social benefits [21]. As a result, its sustainability must be preserved. In the case of food security, smallholder farming with commercial agroforestry systems tends to focus on income production, whereas traditional systems concentrate on the benefits of nutritional diversity. Agroforestry benefits the environment and promotes stability [22]. The mixed garden, the most popular agroforestry pattern in Indonesia, also has the highest carbon stock compared to other tree-crops patterns [23].

In Indonesia, subsistence farmers are accustomed to going into debt to obtain the initial capital for farming, which will then be paid off at the time of harvest. When there is asymmetrical information between farmers and creditors about price knowledge and market access, a debt-bondage system to help farmers with financial capital does not appear to be a viable aid to the farmers [24]. Related to income, interactions in factor markets cause price shocks in these markets, which subsequently allow for essential products to reach subsistence producers. Additionally, this lowers wages and land rentals, boosting household subsistence production. As a result, subsistence households' real income decreases [25]. However, under certain circumstances, subsistence farming can operate as a stabilizer and benefit all agriculture [26]. From a macroeconomic perspective, an improvement in semi-subsistence agricultural production might boost economic growth overall, lower the trade deficit, enhance household incomes, and boost government revenue [27].

Despite all these advantages, the adoption of agroforestry systems is still low, and the adoption gap remains largely unexplained [17]. There are disincentives for planting trees among the understory, including a lack of knowledge, upfront costs, long periods of time before there is a return, and reduced short-to-medium-term cash flow and/or household food production [28]. For subsistence farmers, the existence of trees will be detrimental to agricultural crop production if soil tillage is carried out as in conventional agriculture. The ability to integrate trees on agricultural land is strongly influenced by the perception and knowledge of farmers [29], where farmer managerial skills in implementing agroforestry are still low [30]. In a limited treatment of trees, the presence of trees can reduce the growth of commercial food crops [31], while no-tillage can produce higher maize and cassava yields than tillage [32]. As a result, farmers who are unable to produce enough food for their livelihood, and who depend on cash income to meet many expenses, engage in irregular, nonagricultural commercial activities to generate income for the provision of food and other necessities [33].

Likewise, the adoption of such promising land-use practices has been slow in terms of achievement [1]. Agroforestry programs should not be considered a poverty alleviation strategy [1]. This is because smallholders may not be able to cope with the initial production losses resulting from the transition from conventional agriculture to agroforestry. Hence, policy interventions are essential in order to involve smallholders in the promotion of agroforestry. Attention and incentives should be given to traditional smallholder agroforestry farmers who have helped to balance between biodiversity conservation and economic growth [8].

Most agroforestry programs in Indonesia prioritize land rehabilitation and are focused on generating long-term economic benefits from a particular crop. Little is known about whether and how poor farmers behave differently from nonpoor farmers in adopting agroforestry practices. To reap the greatest benefits from agroforestry systems, a fundamental understanding of how and why farmers make long-term land-use decisions is required [34].

It is truly becoming a question of why the high potential advantages of the agroforestry system seem to have no impact on alleviating poverty for farmers in Indonesia. Various references to agroforestry practices indicate that, until recently, they were still at the subsistence level, e.g., Refs. [35–38], even though some are already at either the subsistence or commercial levels, e.g., Refs. [3,20,39]. Studies on subsistence farming in agroforestry

practices seem to be scattered in case studies that are probably site-specific to a region and only emphasize certain topics. Therefore, a comprehensive review is needed to understand the subsistence farming phenomenon and formulate possible solutions to obtain an alternative management practice. This paper aims to review the nature of subsistence farming, identify related factors, and offer alternative solutions. We overview the developmental phases of agroforestry in Indonesia, then we highlight subsistence farming and identify the internal and external contributing factors. We also discuss the alternative strategies needed to achieve sustainable farming based on the strengths, weaknesses, opportunities, and treatments of the smallholder farmer side of the equation.

2. Methods

This review was conducted based on agroforestry publications derived from various reputable sources through the thematic proximity approach to capture the nature of agroforestry in Indonesia, especially farming under subsistence conditions. Some keywords in English and Indonesian were used to find relevant issues by employing a search engine. An intensive search for online publications for 2000–2022 was carried out in February–March 2022. The stages of searching and screening the publications are shown in Figure 1. This process resulted in 123 articles, which were then deeply studied because they were relevant to the subdiscussions: (1) existing conditions of agroforestry practices, (2) factors influencing subsistence in agroforestry management (biophysical, social, and economic), and (3) subsistence agroforestry management strategies.

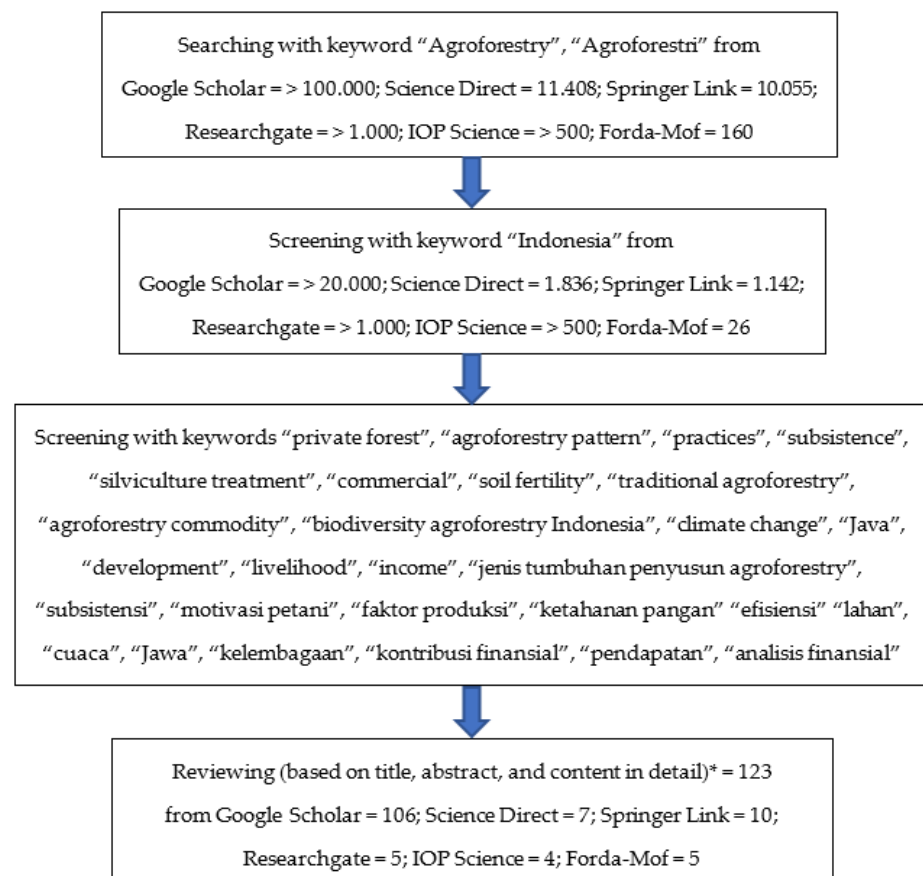


Figure 1. Stages of the literature selection. Note: * The same 14 articles were found in two different sites.

The review was carried out by reading the contents of the literature in detail. The selecting criteria for the literature reviewed in the subdiscussions (that is, of the existing conditions of agroforestry practices) were that they discussed issues related to (1) traditional agroforestry systems in Indonesia, including the types of plants and cropping patterns;

(2) the knowledge and motivation of farmers to develop traditional agroforestry; (3) the management, institutions, and problems of traditional agroforestry; and (4) the benefits of agroforestry, including social, economic, and environmental benefits. The selecting criteria for the literature reviewed in the subdiscussion on the factors influencing subsistence in agroforestry management were that the references discussed issues related to: (1) the explicit or implicit definition of subsistence agroforestry, farmer perceptions of privately owned forest management, agroforestry on limited land, traditional agroforestry, and dry land use; (2) the characteristics of subsistence agroforestry and the characteristics of farmers in subsistence agroforestry; (3) the motivations and factors that influence farmers to manage subsistence agroforestry, factors that influence farmers to adopt agroforestry patterns, and factors that influence the sustainability of agroforestry; and (4) the contribution of agroforestry to farmers, especially with respect to small-scale (household) needs and their problems. In the subdiscussions on subsistence agroforestry management strategies, the selected literature considered external and internal factors to fill in the SWOT framework analysis. To obtain internal factors (strengths and weaknesses), the selected literature focused on smallholder agroforestry management practices in Indonesia. Determination of external factors (opportunities and challenges) was identified from references to general conditions related to agroforestry businesses and agroforestry policies in Indonesia. After finding the external and internal factors, several agroforestry development strategies could be analyzed. Synchronization between the results of the SWOT analysis with the results of previous studies was carried out by searching for related literature.

After obtaining the existing conditions of agroforestry, the factors causing subsistence, and the development strategy, more technical and detailed steps were needed about smallholder agroforestry practices in Indonesia. This was achieved by synthesizing the literature on the selection of agroforestry species; multi-businesses with integrated farming; the intensification of agroforestry, soil, and water conservation on critical lands; and adaptation to climate change. Studies related to social policy and marketing dimensions were needed to support the intensification of agroforestry in order to help us improve agroforestry management practices and provide more welfare for smallholders. The articles reviewed were written in English and Indonesian, such as journal articles, proceedings, reports, and theses, as listed in Appendix A, Table A1.

The results of the literature search were used to present the development and existing conditions of agroforestry in Indonesia. The review then focused on factors causing subsistence in agroforestry practices in Indonesia, as well as the strategies required to develop sustainable agroforestry management for smallholder farmers. Cases that occurred in Indonesia were used as references to seek the causative factors of subsistence in Indonesia. However, given the limited publications regarding external factors, the references referred to were enriched from outside cases in various countries (e.g., Bangladesh, Brazil, India, Kenya) similar to those in Indonesia.

Our strategy to overcome the subsistence condition was analyzed using SWOT analysis, a mapping of external and internal factors that affect smallholder agroforestry businesses. The internal factors were the strengths (S) and weaknesses (W) of smallholder agroforestry businesses in Indonesia, while the external factors were opportunities (O) and threats (T) in developing smallholder agroforestry businesses. In this section, some points will inevitably be similar to the factors causing subsistence e.g., limited landownership, limited financial capital, low education level, and limited knowledge of agroforestry. However, the points in the SWOT analysis are more for smallholder agroforestry in general, in this case, subsistence, semi-commercial, and commercial.

3. Results and Discussion

3.1. Development Phase of Agroforestry Practices

Historically, there were three phases of agroforestry development, namely, classical, premodern, and modern agroforestry. Classical agroforestry was practiced in approximately 700 BC in the form of slash-and-burn, including shifting cultivation, which was a

transformation from a hunting lifestyle and food gathering into plant and animal domestication. Premodern agroforestry, recognized as Taungya, was mainly aimed at producing forest products, and in Indonesia, it was introduced by the colonial government in the form of teak forest development at the end of the 19th century. Attention to agricultural components, farmers, and crop production in the Taungya system was low, but it was designed more to benefit the government's agenda. This philosophy was intended to mobilize landless and jobless laborers in rural areas to work in state forests, with compensation granting them the right to utilize space among the trees to plant crops. Therefore, rural communities felt fewer benefits from such systems. Several international organizations were generated to provide policy and programs to improve food productivity and environmental conservation, such as Social Forestry (SF) by the World Bank, Forestry for Rural Development (FRD) by the FAO, and the agroforestry research institute ICRAF by the World Agroforestry Centre.

3.2. Existing Conditions of Agroforestry in Indonesia

The practice of agroforestry in private forests plays a pivotal role in cultivating trees outside the state forest areas, providing a farmer safety net in terms of economic value through production functions [40], and serving as the last bastion of biodiversity conservation for flora and fauna amid the accelerated deforestation rate in natural forests [41–44]. Agroforestry has contributed to strengthening smallholder farmers' resilience to climate change in Indonesia by offering 20% more food variety in the traditional pattern and a fivefold income increase in the commercial pattern [22]. Agroforestry systems also provide environmental service benefits, such as increasing soil organic content; improving soil health through nutrient repair and fertility processes; improving soil biological dynamics; improving soil carbon sequestration and climate change mitigation; and improving water quality, climate change mitigation, and adaptation [39,45,46].

Some of the benefits related to soil nutrients and fertility, as well as soil carbon sequestration, can be obtained from minimal or no-tillage practices, even without trees. However, the presence of trees in agroforestry systems can add more benefits. The presence of trees and perennial plants in agroforestry produces the highest aboveground carbon stocks, including belowground carbon stocks, thereby improving carbon sequestration and mitigating climate change [23,39]. Trees in agroforestry also enhance soil organic content, increase soil nutrients and fertility, and increase soil microbial dynamics, which have a positive effect on soil health [45]. Trees improve soil quality in agroforestry through three main processes, namely, increasing input with tree fertilizers (N₂-fixing), increasing soil nutrients from the production and decomposition of tree biomass (falling of leaves, branches, twigs), absorption, and the utilization of nutrients from deep tree roots, thus creating a nutrient cycle in the agroforestry system [46].

Traditional agroforestry systems have long been applied in different parts of Indonesia and have become local wisdom in each area with various vernacular names, as presented in Table 1. A distinctive feature of traditional agroforestry systems is the selection of diverse crops to sustain the resilience of farmer households in accessing sources of food, timber, firewood, and herbal medicines [3,4]. These agroforestry patterns are determined based on the skill of the local farmers and agroecological conditions [11]. The diversity of agroforestry constituents consists of two categories, namely, simple agroforestry and complex agroforestry. In general, simple agroforestry uses one species of commercial tree as the main plant intercropped with one commercial understory, resulting in low plant diversity [47]. Complex agroforestry involves growing two or more species as the main trees along with moderate plant diversity, and the practice is usually found in mixed gardens or home garden patterns [48–51]. However, the diversity of annual crop and tree species in agroforestry systems is higher than that of agricultural and forest crops [38].

Along with the socioeconomic, cultural, and policy development of rural communities, some agroforestry patterns have also improved from traditional subsistence management to business–commercial management with the selection of several types of commercial or

industrial crops, such as coffee [52] and porang [53], or integration with ecotourism [54]. The relative profitability of agroforestry business models can be measured based on the associated risks and timeframes [55]. However, the basis of the farmers' considerations in choosing the type of crop is influenced by economic, occupational, cultural, and educational background [56,57]. It is common to have a combination of commercial and noncommercial crops to optimize land use in order to fulfill household needs in terms of subsistence or as a source of daily, monthly, and annual financial income [3,4]. In general, farmer preferences are more biased toward economic benefits and mindfully maintaining the availability of a food supply, but they pay less attention to ecological aspects [19]. Crops that provide instant extra income are more desirable to farmers [58].

Generally, farmers in Java with narrow farmland ownerships tend to cultivate commercial timber trees (such as teak, sengon, mahogany, gmelina, manglid, African wood, and jabon) combined with understory crops that can support daily needs such as food, buildings, and traditional medicines, including coffee, chocolate, cardamom, and tea [59–62]. Some examples of simple agroforestry patterns on smallholder farmer land in Java are displayed in Table 1. Additionally, farmers on islands other than Java choose many types of nontimber trees or fruit trees as the main stand, as well as industrial crops as the understories, as presented in Table 1. Some examples of agroforestry patterns that are widely practiced by the community, especially on the island of Java Island, can be seen in Figure 2.

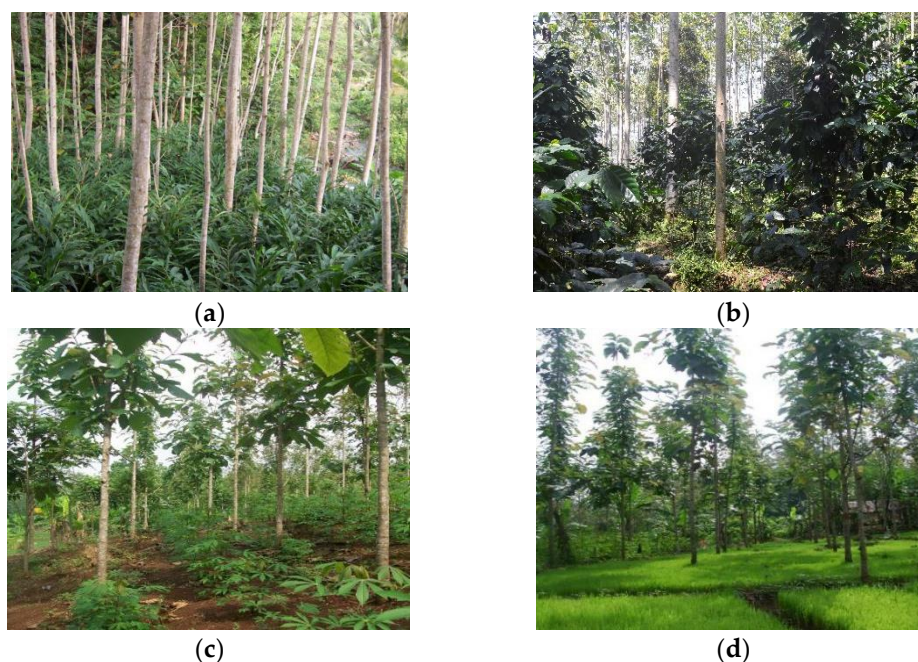


Figure 2. Agroforestry models in Indonesia: (a) *Paracarianthes moluccana* and *Amomum compactum* (picture by Achmad, 2012); (b) *Anthocephalus cadamba* Miq and coffee (picture by Achmad, 2020); (c) *Tectona grandis* and *Manihot utilissima* (picture by Widiyanto, 2016); (d) *Tectona grandis* and *Oryza sativa* L. (picture by Widiyanto, 2015).

The main objective of silviculture is to improve timber productivity by applying tree improvement, site manipulation, and plant protection [63]. With agroforestry, the science of silviculture is expected to encounter issues beyond timber production [64]. Moreover, silviculture treatment on timber-based versus nontimber-based forest products provides a different result for land productivity [22]. Traditional agroforestry practices are usually subsistence and are conducted in a small area of land with minimal silviculture treatments [65,66].

The recognition to apply agroforestry also arises when the benefits of ancient integrated agricultural systems survive after a series of land problems, such as deforestation, soil degradation, and biodiversity decline [46]. This implies that agroforestry contributes

to the environment by reducing erosion rates, restoring degraded land, reducing landslide risk, increasing carbon stock, and affecting microclimate and soil moisture [67–69]. The agroforestry systems developed in several locations in West Java are able to decrease soil erosion and restore land degradation, while the highest carbon stock is produced from mixed types with a larger number of trees [23]. Agroforestry, which dominates the foothills of volcanic mountains prone to landslides in Java, can reduce landslide reactivation by selecting species of trees and plants with certain ecological functions to reduce surface runoff, water absorption, and soil moisture without compromising the social and economic value of farms [70]. A mixture of deep-rooted tree species and grasses with smooth and dense rooting can maintain the stability of riverbanks and high hillsides [71]. The diversity of tree root distribution between species can reduce the landslide risk in productive coffee agroforestry systems [71]. The agroforestry system is an easy and affordable way to mitigate microclimate instability and soil moisture degradation, and it can be potentially employed as an adaptive strategy to counter extreme climate impacts through shade cover arrangements [72].

The transition from subsistence to semicommercial or commercial agroforestry is not a simple process. Problems regarding landownership and access, market opportunities, and farmer regeneration always arise from farmers. It is common knowledge that rural farmers are generally villagers over the age of 50 who need guidance on how to maintain their agricultural businesses, especially in regard to utilizing wireless networks. Currently, few among the young generations want to continue working as farmers. Ironically, most parents who work as rural farmers are also unwilling to pass down the profession [73]. The factors that hinder farmer regeneration are the low income generated by the agricultural sector, demanding and laborious work, the perception that farming is only suited to those from a poor background with limited education, and the type of work chosen as the last alternative [74]. This results in only 26.67% of farmers' children having high motivation to become farmers [75]. The education level of farmers, according to Statistics Indonesia (BPS), is still dominated by elementary and junior high school levels. Meanwhile, college graduates and diplomas only account for 0.57%. This low education level can affect farmers' managerial abilities in developing agroforestry. Farmers' managerial capacity in planning, implementing, and evaluating the application of agroforestry systems is a major factor that influences their motivation to apply technology [76]. The low quality of human resources is a drawback in the agricultural sector, which may lower agricultural productivity [77].

In Lampung, many smallholder farmers have the basic skills to turn their subsistence horticultural systems into semicommercial ventures. To facilitate this process, farmers obtain assistance to (1) identify appropriate horticultural species/cultivars that are suitable to the land's biophysical and their own socio-economic conditions; (2) adapt to vegetative propagation and other horticultural management practices; and (3) develop a permanent market relationship. In West Sumatra, 1–2 hectares of agroforestry provide 26–30% of total household income. This percentage range is due to differences in land size, crop selection, level of commercialization, and the intensity of agriculture [78].

The success of agroforestry development needs support from internal and external factors. However, the existing institutions have not yet optimally supported the development of agroforestry [79]. The institutional development of agroforestry can be guaranteed if: (1) incentives are provided for agroforestry farmers or organizations; (2) organizational reinforcement is provided; (3) equality in infrastructure and information asymmetry is guaranteed; (4) assurance about ownership and access to resources is obtained; (5) control over opportunistic behavior is established; and (6) some rules are enforced and obeyed [80]. The key factors of agroforestry development in Indonesia are farmer institutions [81], policy support, the availability of technology packages, the optimization of stakeholder involvement [79], and leadership [82]. Farmer groups are required to accommodate member activities; facilitate farmer-to-farmer relationships; and handle peer group mentoring concerning silvicultural techniques, such as pruning [83]. In addition, farmers gain better interaction and communication skills by joining the farming community [84]. Therefore,

the farmer group, as an institution, has benefits and roles to play in improving each member's economic wellbeing as well as sustaining the forest. The implementation of these activities should rely on the personal interests and motivations of smallholder farmers to improve their livelihoods rather than depend on the government's project financing. The improvement and expansion of smallholder horticultural systems can also serve public environmental purposes [85]. Unfortunately, the value of the environmental service of agroforestry is underappreciated and is unreliable as a cash source, at least with respect to today's conditions.

Table 1. Existing agroforestry patterns in Indonesia.

Planting Patterns	Location	Key Commodities	Plant Diversity	Source
Tea-based agroforestry	Tasikmalaya, West Java 850 msl	<i>Magnolia champaca</i> and <i>Camellia sinensis</i>	18 species Shannon–Wiener Diversity Index (H') = 0.37–0.66 (low)	[86]
Sengon + clove + spices	Magetan, Central Java	<i>Paraserianthes falcataria</i> , <i>Zingiber</i> sp. <i>Syzygium aromaticum</i> and <i>Curcuma longa</i>		[87]
Cocoa-based agroforestry	Bulukumba, South Sulawesi	<i>Theobroma cacao</i>	29 species $H' < 1$ (low)	
Coffee-based agroforestry	Bulukumba, South Sulawesi	<i>Coffea</i> spp.	17 species $H' < 1$ (low)	[88]
Coconut-based agroforestry	Bulukumba, South Sulawesi	<i>Cocos nucifera</i>	26 species $H' < 1$ (low)	
Cashews + guava	Bulukumba, South Sulawesi	<i>Anacardium occidentale</i>	8 species $H < 1$ (low)	
Mixed crop home garden	Tana Toraja, Bone & Bulukumba South Sulawesi	<i>Casuarina junghuhniana</i> , <i>Pinus merkusii</i> , <i>Elmerillia pubescens</i> , <i>Syzygium aromaticum</i> , <i>Tectona grandis</i> , <i>Aleurites moluccana</i> , <i>Artocarpus heterophyllum</i> , <i>Coffea arabica</i> , and <i>T. cacao</i>	47 species $H' = 1.25$ – 2.18 (moderate)	[56]
Damar-based agroforestry	Lampung	<i>Shorea javanica</i>	93 species	[51,89]
Dukuh agroforestry system, South Kalimantan	Banjar Regency, South Kalimantan	<i>Durio zebethinus</i> , <i>Artocarpus integer</i> , <i>Lansium parasiticum</i> , <i>Hevea brasiliensis</i> , <i>C. longa</i> , <i>Kaempferia galanga</i> , <i>Zingiber officinale</i> , <i>Alpinia galanga</i> , and <i>Mussa paradisiaca</i>	9 species	[90]
Sengon-based agroforestry	West Java	<i>P. falcataria</i> , <i>Swietenia macrophylla</i> , <i>Maesopsis eminii</i> , <i>Cocos nucifera</i> , and <i>Amonum cardamomum</i>	7 species	[58,91]
Bamboo-based agroforestry	Bandung Regency, West Java 700–900 masl	<i>Gigantochloa verticillate</i> , <i>Gigantochloa pseudoarundinacea</i> , <i>Gigantochloa apus</i> , and <i>Gigantochloa ater</i> , <i>Bamboosa vulgaris</i> , <i>M. eminii</i> , <i>P. falcataria</i> , <i>Hibiscus macrophyllus</i> , <i>Melia azedarach</i> , <i>Toona sureni</i> , <i>M. champaca</i> , <i>Lansium</i> spp., <i>Persea americana</i> , <i>Syzygium polycephalum</i> , <i>Mangifera odorata</i> , <i>Baccaurea racemose</i> , <i>Syzygium aromaticum</i> , and <i>C. arabica</i>	76 species	[48]
Mixed garden (home garden)	Central Bengkulu	<i>H. brasiliensis</i>	38 species	[92]
Traditional mixed garden (traditional agroforestry)–mixed garden	Central Sulawesi	<i>A. moluccana</i> , <i>Parkia speciosa</i> , <i>Artocarpus heterophyllum</i> , <i>T. grandis</i> , <i>C. nucifera</i> , and <i>T. cacao</i>	43 species in Ta'a Wana, 52 species in Javanese's village, 39 species in Balinese's village	[93]
Talun (mixed forest)	Bogor, West Java	Bamboo	94 species (44 families)	[49]
Mixed garden	Bogor City, West Java	Fruit trees	83 species (41 families)	[49]
Garden farming	Bogor City, West Java	Fruit trees	100 species (45 families)	[49]
Home garden agroforestry	Banyuwangi, East Java 600–800 masl	<i>C. nucifera</i> , <i>Garcinia mangostana</i> , <i>D. zibethinus</i> , <i>S. aromaticum</i> , <i>Coffea liberica</i> , <i>Coffea canephora</i> , and <i>Nephelium lappaceum</i>	Trees (39 species), Poles (9 species), Herbs (41 species), Liana (8 species)	[94]
Mindi + sengon + african wood + baros + palawija	Garut, West Java 750–1400 masl	<i>Melia dubia</i> Cavanilles, <i>P. falcataria</i> , <i>M. eminii</i> , and <i>Manglieta glauca</i>	14 species	[95]
Coffee-based agroforestry	Banjar, South Kalimantan	<i>H. brasiliensis</i> , <i>Coffea</i> sp, <i>Lansium parasiticum</i> , <i>Artocarpus champeden</i> , <i>C. nucifera</i> , and <i>Musa</i> sp.	5 species	[96]
Trees + rice + cassava	Bondowoso, East Java 500–900 masl	<i>Falcataria moluccana</i> , <i>T. grandis</i> , <i>Gmelina arborea</i> , <i>Oryza sativa</i> , <i>Manihot esculenta</i> , and <i>Zea mays</i>	35 species	[97]

3.3. Why Subsistence

3.3.1. Subsistence Outlook

Subsistence farming is defined as self-sufficient farming in which farmers focus on cultivating sufficient quantities of food for their families. In addition, subsistence agriculture is characterized by such things as having a wide variety of crops and livestock to eat, and sometimes fiber for clothing and building materials. The decision in determining the type of plant to use usually depends on the type of food that will be consumed in the coming year. It is also determined by market prices, where if the price of a commodity is considered too high, they choose to plant their own [98]. Although they are considered to prioritize self-sufficiency for their families, most subsistence farmers also trade a few of their agricultural products, especially for obtaining goods that cannot be produced from the land, such as salt and kitchen equipment. Most subsistence farmers currently live in developing countries. Numerous subsistence farmers grow alternative crops and have agricultural capabilities that are not found in advanced agricultural methods [99]. Subsistence refers to those who are periodically food insecure, relying on irregular cash income from diversification into a range of sources [100].

Some farmers apply agroforestry systems based on economic considerations rather than social and ecological considerations [30]. This is indicated by the selection of plant species that make up agroforestry with the main objective of utilizing the results to meet the needs of farmer households in the short, medium, and long term. Agroforestry is widely adopted by farmers because this system can increase income while also diversifying their livelihoods [19]. Agroforestry provides income to farmers in the form of weekly, monthly, and annual income [101]. Farmers in Wonogiri earn weekly income from cayenne pepper, monthly income from secondary crops, and annual income from timber plantations [101]. Farmers apply simple agroforestry by intercropping trees with one or more seasonal crop types. Sengon (*Paracrianthes moluccana*) is the main crop because it is considered to possess high economic value and is a form of family savings that can be used for certain urgent needs [102]. Sengon and salak (*Salacca zalacca*) agroforestry can meet the daily needs of families and can support a balanced work structure [103]. The traditional agroforestry system is carried out to meet daily needs, and some of the surpluses are sold to collectors and weekly village markets, such as palm sugar (*Arenga pinnata*), banana (*Musa paradisiaca*), sapodilla (*Manilkara* sp.), mango (*Mangifera indica*), avocado (*Persea americana*), petai (*Parkia speciosa*), and jengkol (*Archidendron pauciflorum*) [104].

Farmers also obtain animal feed from community forests so that they do not need to look for grass in places far from home [101]. Income from the agroforestry system can meet the needs of a family with four to five dependents. Household expenses can be reduced because some foodstuffs can be obtained from the forest, such as vegetables, cayenne pepper (*Capsicum frutescens*), cassava (*Manihot esculenta*), corn (*Zea mays*), turmeric (*Curcuma longa*), ginger (*Zingiber officinale*), and galangal (*Alpinia galanga*).

Benefits in the form of income obtained by farmers from plant cultivation activities have caused farmers to continue cultivating plants, including forest plants. More often than not, farmers' primary motivation to sell wood is to fulfill their urgent needs, for example, wanting to hold a celebration, going on a pilgrimage, paying for children's educational fees, or other needs, which are often referred to as the cutting-and-needed system. More than half of agroforestry income comes from selling sengon wood as the main crop [102]. Agroforestry has increased the security of farmer livelihoods as a safety net that helps households pass through periods of increased vulnerability, for example, due to crop failure and illness [105]. Agroforestry systems are used to support subsistence needs, increase income through the sale of surplus produce, and strengthen the ownership situation of farmers.

3.3.2. Factors Related to Subsistence in Agroforestry

The subsistence level of agroforestry can be seen from the perceived benefits of the agroforestry system, which are limited to meeting the needs of the family, not for com-

mercial purposes. Two factors influence the agroforestry farming system, namely, internal factors such as farmer experience, motivation, landownership area, number, and type of plants, as well as external factors in the form of support from agroforestry extension institutions and community leaders [106]. Likewise, the subsistence of farmers is also influenced by these two factors.

1. Internal factors

The internal factors that influence the subsistence of agroforestry farmers are presented in Table 2.

Table 2. Internal factors that lead to the subsistence of agroforestry farmers.

No	Internal Factor	Source
1.	Limited landownership	[18,107,108]
2.	The character of farmers who are less willing to take risks	[17]
3.	Low education level and poor agroforestry knowledge	[21,38,101]
4.	Limited financial capital	[109,110]
5.	Farmer preferences related to gender and cultural identity	[108,111]

- Limited landownership

Limited land is one of the factors causing farmers to grow only crops to meet family needs. Most farmers own less than 1 ha of land [112] with an average agroforestry area of 0.5 ha [102]. The dominant species are plants that can be consumed in the form of food crops. Farmers who have narrow lands prefer to grow various types of crops to meet subsistence needs and, at the same time, have savings [113], although some farmers replace traditional crops such as rice, corn, and vegetables with valuable commercial crops such as taro, pineapple, banana, papaya, and teak trees [105]. The area of land managed by farmers can come from their own land, a rental system, or profit-sharing. Land fragmentation increases when adult household members marry, create their own families, and manage land separately. Land expansion is difficult if the available land is limited, which results in crop yields that are not sufficient for family needs [105].

Limited landownership may push farmers to choose a management system, whether it is intensive agriculture or agroforestry. One consideration for farmers converting agricultural land into community forests is the management of agricultural land, which, in addition to requiring large capital support, also requires a large amount of labor [101].

- Not willing to take risks

Decisions regarding agroforestry adoption are carried out based on natural and social endowments such as preferences, incentives, and risk, as well as uncertainty assessments across three dimensions, that is, profitability, feasibility, and acceptability [114]. The majority of investments are designed to produce direct production for domestic use. However, any surplus can be sold on occasion. Households with minimal assets may find themselves with less, if any, assets for other occupations after allocating land, labor, cattle, time, and tools to one activity. Escaping food poverty demands investments, but because margins are tight, their willingness to invest in new technologies may give way to cost considerations, resulting in non-adoption if decisions are based as much on past and current conditions as on potential profits [17].

Production hazards in small-scale agriculture include animal and crop illness, drought, flood, climatic unpredictability and change, and/or market shocks, which can affect individuals or entire communities [100]. Even the most attractive investments might come with enormous risks if they fail. Even though they are sometimes used interchangeably, risk and uncertainty “convey different aspects” [115].

Risk minimization is consequently critical, not just profit maximization, especially for food-insecure farmers. While agroforestry adoption is a high-risk endeavor, other investments, such as raising animals, are frequently viewed as insurance [116]. External

risk reduction options, unrelated to agroforestry but rather to animal husbandry as a key part of subsistence farming, may include insurance programs or warranties, as well as the provision of animal health support services. In poor households, livestock investments are frequently a top priority for savings [117].

Small farmers tend to prefer continuous yields, even though they are small compared to large yields, which are intermittent. This is because smallholders mostly need certain short-term income rather than uncertain long-term income (both in terms of yield and price) and risk. The experience of tumor rust disease in sengon stands is an example of the risk of loss experienced by Ciamis farmers.

- Low education level and poor agroforestry knowledge

The knowledge and perceptions of farmers influence how they manage their land with agroforestry patterns. Their knowledge causes them to have low motivation in managing agroforestry optimally, so the results obtained are only sufficient to meet the needs of their families [76]. A farmer's economic orientation may not be for commercial purposes but rather to meet daily household food reserves, as well as to use the farm as a vegetable source [118]. In addition, farmers also use wood twigs as fuel [101]. Cultivators continue to carry out agroforestry cooperation programs because they can help meet daily needs and improve farmer welfare if the management is carried out optimally [119].

The knowledge and skills involved in cultivating timber and agriculture are obtained by farmers from their parents and other ancestors from childhood onward [101], and on average, farmers have to manage community forests for more than twenty years. Experience in agroforestry agriculture can support the process of increasing a farmer's capacity [113].

Formal education is significantly correlated with farmers' perceptions of community forest management at a significance level of 5%. The higher their level of formal education, the higher their perceptions of community forest management using agroforestry patterns [101]. They do not perform thinning and assume that the more trees they have, the more results they will obtain [101]. Understanding the perception and knowledge of smallholder farmers regarding the integration of trees on farms is essential for minimizing the barriers to integrating trees on farms [120]. Farmers' capacity to implement agroforestry systems is still categorized as low, especially in terms of farmer managerial capacity [30].

Farmers' knowledge of the types of plants that are resistant to shade is still limited. Some farmers still make decisions in choosing understory crops based on market demand [121]. Ultimately, the expected results are typically not obtained. For the crop types commonly grown on their land, farmers plant based on hereditary knowledge from their ancestors [122]. Some ecological aspects that affect the sustainability of agroforestry include the rate of plant pest and disease attacks and the farmers' level of understanding with respect to soil and water conservation, land conservation measures, the availability of organic fertilizer manufacturing technology, the availability of organic material sources, the productivity of produce, land fertilization, soil processing, and pesticide use [21].

- Limited financial capital

One factor has also become an obstacle for forest farmers is the lack of financial capital to procure seed and fertilizer production facilities [109]. This is very reasonable because, generally, seeds and fertilizers are important production factors in farming [123–126]. In addition, the area of land and the number of plant types cultivated are two production factors affecting the income of agroforestry farmers [127]. The selection of types and cropping patterns indirectly affects the success of agroforestry management. Cropping patterns are physical capital that can be adaptively used to overcome the crisis and determine farmer income; the higher the income of farmers, the higher the ability to save and manage land [128].

The level of farmer income is itself often interlinked with land size. The land factor significantly affects the income level of farmers [129]. The land is the main capital in producing goods/services in agriculture [130] and is closely related to the level of income obtained by forest farmers, so its limitations are often regarded to be an obstacle [107]. The

optimization of land production factors is very important so that agroforestry farming is more productive and efficient [131]. Several results from farming research state that the land factor affects productivity both technically and economically [132–136]. The low efficiency in the use of production factors is one of the causes of low farm productivity [137]. However, the production factor is an energy input in agricultural production that also determines the level of agricultural output produced [138].

Limited financial capital is also linked to the lack of alternative income sources for farmer livelihood. Educational qualifications and literacy skills are highly related [139]. Various factors cause the absence of other reliable sources of income, including the low level of education of farmers, which limits their ability to obtain jobs according to their skill competencies.

- Farmer preferences related to gender and cultural identity

Subsistence in agroforestry practices is often caused by the preferences of the farmers themselves. Some farmers actually have the basic skills required to shift from subsistence to semi-commercial enterprises [85]. However, farmers often continue to practice subsistence agroforestry as their economic orientation due to personal beliefs, which may be related to gender in selecting plant species. Gendered species preference is related to tree diversity in agroforestry systems [111]. Therefore, the extent to which this subsistence practice is applied will be influenced by the involvement of female farmers in making decisions about species selection. In addition, farmer preferences, as part of their cultural identity, can also cause agroforestry subsistence practices to persist. The Badui Luar, for instance, practice subsistence agroforestry on shifting land systems as part of their cultural identity [108].

2. External Factors

External factors that affect the subsistence of agroforestry farmers are presented in Table 3.

Table 3. External factors that lead to the subsistence of agroforestry farmers.

No	External Factors	Sources
1.	Government policies that are not responsive to household interests (increases in the price of seeds, fertilizers, and medicines).	[17]
2.	Bad weather/climate change.	[140–142]
3.	Labor shortage.	[101]
	Limited market access:	
	- Weak market linkages and poor access to market information;	[143–145]
	- Difficulties imposed related to costs, the management system, and local market constraints;	[146–148]
4.	- Price instability, poor market information, and poor market infrastructure for the tree products;	[143,149–151]
	- Long period of growth;	[152–154]
	- Preference for the near-term benefits.	[155]
5.	Food import.	[156–159]

- Government policies that are not responsive to household interests

Subsistence farmers need information and input support in developing agroforestry [17]. Therefore, government policies related to capital are necessary. The variables affecting the income of agroforestry farmers are age, plantation area, number of workers, ethnicity, religion, land slope, and credit assistance [160]. Agroforestry farmers develop their businesses by only relying on personal and family capital [113]. They do not rely on capital support from public, private, and/or cooperative financial institutions. Furthermore, they are not interested in obtaining business capital loans due to the high-interest rates and the complicated bureaucracy of financial institutions. Farmers think that agroforestry farming is a gamble. If they are lucky, they will earn large profits; otherwise, if they have bad luck, they will suffer losses. This is due to the uncertainty of product prices.

Four key factors determine the sustainability of agroforestry businesses: the role of extension workers, the availability of technology packages, the existence of farmer groups, and the role of the government [21].

- Bad weather/climate change

Subsistence farmers are most vulnerable to climate change [140]. Climate change increases the severity and frequency of extreme weather [142]. Extreme weather affects the sustainability of agroforestry farming. The forms of weather changes include hurricanes, continuous rain, long dry spells, peaks of pest and disease attacks, and crop failure [141]. Furthermore, in tree-based agroforestry, weather changes cause a decrease in the number of harvests or even crop failures in the given year [141].

- Social commitment to maintaining traditional agricultural practices

Rural communities in Indonesia, which generally live off agriculture, including agroforestry, have several characteristics, including close kinship relations with fellow citizens and still holding strong customs and traditions. Ignoring these traditions may lead to social sanctions that can take the form of social alienation. This situation requires them to dedicate quite a lot of time to meeting the social and cultural demands of their environment. As a result, farmers tend to look for easy cultivation techniques and do not have enough time to implement an intensive cultivation system [161]. Community forests, particularly in the form of agroforestry, are often underdeveloped and managed traditionally [162].

- Labor shortage

Indonesian farmers tend to prioritize agricultural activities other than tree-based farming. This is particularly because agricultural farming requires more intensive management and labor, besides being related to their food security. Smallholder farmers, therefore, prefer to grow trees using traditional agroforestry. The labor required to manage traditional agroforestry is only supplied by family members [101]. Hence, it is only natural that agroforestry only produces products to fulfill their personal and family needs.

- Limited market access

Among the problems faced by farmers is their lack of information about the marketing chain of community timber and an unawareness of the growing demand for community timber [101]. Nontimber agroforestry products, such as fruits, also have fluctuating prices [105]. These situations certainly do not motivate the community to cultivate trees intensively in agroforestry practices. Market access can affect price certainty, which will impact the sustainability of agroforestry businesses. Market certainty is an aspect that affects farmer motivation. Points of access to the market from agroforestry areas may also be considered by farmers [113]. Although agroforestry has various benefits for smallholders, local governments usually prefer oil palm plantations over agroforestry because they possess higher potential income [163].

- Limited access to capital/credit

Limited access to capital causes farmers not to optimally manage their land. Due to a lack of institutional support for agroforestry in agriculture policy, borrowers frequently lack information regarding financing availability [154].

- Food import

The agricultural sector still plays an important role in spurring the national economy through labor absorption in agriculture in order to create food security and foreign exchange earnings through exports and imports [156,157]. In the era of liberalization, the marketing of agricultural products in the agricultural system and the fate of farmers depend entirely on the free market mechanism [158].

The challenges of developing food crop agriculture in the globalization era are getting bigger, so this requires Indonesia to improve production efficiency and product competitiveness to reduce opportunities for import flows [157]. The increasing number of imported

food products entering Indonesia indicates that the comparative advantage of domestic food products is lower than that of other countries [159].

In addition to adding new sources of income and livelihoods for communities around forests, agroforestry also represents the government's efforts to improve national food security by adding food sources from forest areas [164]. The impact of food import policies are also felt by agroforestry farmers, whose livelihoods depend on food products from the forest. A policy of import duties on food commodities as a form of social policy sometimes creates a dilemma. It benefits farmers, but on the other hand, also places a burden on the poor [156]. The negative impact will be felt more by small and poor farmers who are unable to compete directly with imported products without assistance and protection from the government [158].

3.4. Sustainable Agroforestry Management Strategies for Smallholder Farmers

Agroforestry has become a common practice for farmers in Indonesia. The contribution of agroforestry to the household economy of farmers is one of the determining factors for the sustainability of the agroforestry system. Improving agroforestry governance from subsistence to commercial ones requires a comprehensive strategy and involves many stakeholders. Internal and external factors from the farmers' side are presented in Table 4.

Table 4. SWOT analysis of smallholder agroforestry in Indonesia.

Strength (S)		Weakness (W)	
1.	Availability of existing managerial and technical capacity: <ul style="list-style-type: none"> • Smallholder agroforestry has over 10 years of experience [165]; • Traditional agroforestry practices [166], silviculture practices [65], and soil and water conservation technologies are available to smallholders [167,168]. 	1.	Limited landownership: <ul style="list-style-type: none"> • The average farm size ranges from less than 0.1 ha to 1 ha [18,165,177,178].
2.	Recognized social, economic, and ecological benefits of agroforestry practices: <ul style="list-style-type: none"> • Potentially enhancing the resilience of smallholders in disaster-prone areas [165]; • Strengthening social cohesion when sharing with neighbors [48,169]; • Contributing positively to productivity and smallholder livelihoods in agroforestry and home garden systems [170–173]; • Significantly assisting smallholders with climate change adaptation, improved soil fertility and conservation, pest and disease control, income diversification, and offsetting fuelwood [174–176]; • Agroforests contribute to maintaining on-farm diversity [48]. 	2.	Low education level and poor agroforestry knowledge: <ul style="list-style-type: none"> • Smallholder farmers have low education [18,165] • Farmers' knowledge about agroforestry is still lacking [101]; • Farmers are reluctant to implement agroforestry due to culture and capacity [178].
3.	Availability of institutions at the farmers' level: <ul style="list-style-type: none"> • The existence of community groups that participate in agroforestry practices, such as farmer groups and soil and water conservation groups. 	3.	Limited financial capital: <ul style="list-style-type: none"> • Limited capital for the provision of seed and fertilizer production facilities [109]; • Low access to credit/financial assistance [179–181].
		4.	Poor management practices: <ul style="list-style-type: none"> • A lack of awareness regarding the positive influence of proper silvicultural management and limited technical capacity [182]; • Agroforestry is regarded as the second livelihood for some farmers [18,165]; • Some farmers do not fertilize trees or only do so during the intensive maintenance of crops [165]. <i>Kebun campuran</i> (mixed garden) is not intensively managed [18].
		5.	Poor perception of agroforestry benefits: <ul style="list-style-type: none"> • Farmers' understanding of the benefits of agroforestry (income, food, and conservation) is still low [165]; • Farmers' perceptions of the benefit of agroforestry practices show varying results (high in Central Java [101] and East Java [183,184] but low in Lampung [185] and Ciamis West Java [76]); • Smallholders regard trees as competitors for annual crops/smallholders consider trees to make gardens difficult to be cleared periodically [48].
		6.	Limited market linkage and farmer bargaining: <ul style="list-style-type: none"> • Low volume of trade, limited access to information, and weak market linkage information [182]; • Low bargaining position of smallholder farmers [186,187].

Table 4. Cont.

Opportunity (O)		Threat (T)	
1.	Increasing global interest in local agroforestry practices: <ul style="list-style-type: none"> Local practices in various parts of the world, especially in the tropics, have become a global interest that is increasingly relevant because of their sustainability on a local-to-global scale [188]. 	1.	Decreasing tree-based land availability: <ul style="list-style-type: none"> Population growth and economic pressure lead to increased demand for food production, conventional agricultural land [189], housing, and other land uses [18,189]; on the other hand, it decreases agroforestry land [189,197]; Volcano eruption reduces land area [165].
2.	Increasing global demand for agroforestry products and services: <ul style="list-style-type: none"> Adaptation to high population growth and a rise in the market economy [48]; Globalization of food and increases in demand for food security [189]; Mixed gardens have become international tourist destinations and sources of fresh organic produce for traditional food [18]; An important measure to obtain multidimensional benefits as pointed out in the Sustainable Development Goals [190] and biodiversity conservation strategy [18]. 	2.	Forest and land degradation: <ul style="list-style-type: none"> Forest and land degradation or conventional farming practices that are not environmentally friendly [198–200].
3.	Availability of financial support schemes: <ul style="list-style-type: none"> Financial support from central and local governments. Central and regional agencies whose main tasks are related to the management of forestry, agriculture, and environmental resources (RHL program with agroforestry and community development [191] and social forestry) [192,193]; Finding alternatives to swidden agriculture [178,194]; CDM/carbon trade becomes part of rural development and the availability of incentives that allow for small land and direct payments [195]. 	3.	Climate change: <ul style="list-style-type: none"> Climate change affects agroforestry to keep food production [140,156].
4.	Legal support: <ul style="list-style-type: none"> The availability of regulations on food security [196], the sustainable land protection of food agriculture, conservation, environmental, community empowerment, etc. 	4.	Labor shortage: <ul style="list-style-type: none"> A lack of laborers or family members to do the work and a rise in the wages of agricultural workers [48].
		5.	Market uncertainty: <ul style="list-style-type: none"> Market uncertainty and low-profit margins of agroforestry products [186,187]; The increasing price of seeds, fertilizers, and medicines; high social burden; high land rent; rising wages for agricultural workers; and imported agricultural products [156]; The increasing number of imported food products entering Indonesia [156,159].
		6.	Poor coordination and technical assistance from the government: <ul style="list-style-type: none"> Weak coordination between central and local agencies, as well as between regional and cross-regional governments [201]; Limited extension services [105].

The mapping of strengths, weaknesses, opportunities, and challenges above was used as the basis for designing an agroforestry business development strategy. The strategy was prepared based on the interaction between internal and external factors (SO, ST, WO, and WT). It takes into account the importance of agroforestry business development (Table 5).

Table 5. Strategies of agroforestry business development in Indonesia.

SO Strategy	ST Strategy
<ul style="list-style-type: none"> Improving the performance of existing stakeholders (GO, NGO, local community) for supporting the agroforestry business using the community development/RHL program [202,203]; Utilizing the existing social capital and labor support effectively and efficiently in maintaining agroforestry practices [204]; Transferring agroforestry silviculture and soil conservation technology through smallholder farmer groups, environmental groups, communities, and so forth [65,203]; Fulfilling food needs due to population growth through increased agroforestry practices [22,164] Strengthening of farmer groups (institutional and capacity, skill and capital) [202]. 	<ul style="list-style-type: none"> Increasing the success of agroforestry business practices for addressing livelihood, smallholder income, food security, land conservation, population growth pressure, lands rehabilitations; and obtaining benefits from climate change resilience [22,205,206] Controlling land-use change in maintaining and increasing agroforestry areas for SDGs [206,207] Improving agroforestry silviculture techniques, improving soil and water conservation practices for improving land productivity, and reducing land degradation [208]

Table 5. Cont.

WO Strategy	WT Strategy
<ul style="list-style-type: none"> Improving the effectiveness of community development to improve agroforestry practices [164,191]; Improving land availability for farmers with social forestry programs/RHL program [192]; Improving market access for agroforestry products; Financial support from regional governments and NGOs for smallholder farmer groups with respect to agroforestry practices [194,209]; Capital and production tools form incentives that allow for small land and direct payments from CDM/carbon trading [195], developing integrated agroforestry management policy with respect to the SDGs [210]. 	<ul style="list-style-type: none"> Maintaining local knowledge in agroforestry practices [166]; Keeping traditional practices/tree diversity from conventional agriculture [37]; Enhancing community awareness in food security, land degradation, climate change, and environmental services [211]; Improving synergy between stakeholder/cross-sectoral institutions at both the central and regional levels [202,203,209].

3.5. Enabling Smallholder of Agroforestry Practices in Indonesia

3.5.1. Selection of Agroforestry Plant Species

The existence of agroforestry outside the state forest area (private forest) is proven to provide great benefits for landowners. Cultivated tree species provide yields for building wood, firewood, animal feed, species, and medicinal plants [212]. The use of native species with multiple benefits needs to be encouraged with research and policy interventions because native trees can maintain biodiversity [213]. The greater the plant diversity in agroforestry, the greater the value of the forest from the yield variety and the environmental benefits. In rubber plantations, more shrubs will increase soil C and N as well as the infiltration rate from soil pores [214].

3.5.2. Integrated Farming (Agrosilvopasture/Livestock and Plants)

Product diversification from agriculture–livestock–forestry (agrosilvopasture), with market access and management efficiency, will result in income stability [215,216]. In agrosilvopasture, the use of livestock manure (fertilizer) and crop waste (animal feed) residues is an efficiency that can reduce tradeoffs between agriculture and the environment [217]. The integration of livestock and crops can increase economic efficiency by 38.4% [218,219]. The existence of plants for forage can supply animal feed needs during the dry season [220]. This system can also maintain the N content in the soil, the bacterial community cycle, and the N cycle process [221].

3.5.3. Soil and Water Conservation

The use of trees, especially legume trees, plays a pivotal role in maintaining soil fertility. Tree roots increase the rate of soil infiltration and the availability of water as a reserve during the dry season, thereby reducing plant stress [222]. The management of agroforestry plant biomass is a key factor in maintaining soil fertility. Cocoa leaf waste can be decomposed quickly when mixed with gliricidia leaves so that it can maintain soil nutrient input [208]. Farmers in mountainous areas need to apply alley cropping as a soil conservation technique. The productivity of annual crops in the tree aisles hanging 48 m and 96 m is still quite high even despite tree canopy cover; however, it still possesses high environmental value [223].

3.5.4. Improved Access to Land and Markets

Population growth and economic pressures have caused the availability of agricultural land to be increasingly limited. This has become an obstacle in the development of the agroforestry business in Java, Indonesia. Governments can provide access to forest land, community participation-based planning, and agricultural diversification [105]. The Indonesian government has made efforts to distribute access to land resources for

the community by granting state forest land management permits through the social forestry program.

One of the factors affecting the level of commodity prices produced by private forests is land access to markets. The price of wood in private forests can be influenced by the location's accessibility to transportation. Good roads increase the efficiency of transport to market, thereby promoting more commercial agricultural cultivation [224]. The existence of village funds can be allocated to improve road access to private forest land. The government can also provide information on market access through extension workers [225]. In general, private forest harvests are sold to local middlemen and then to larger middlemen; thus, to increase farmer incomes, partnerships between industry and farmers are needed and incentives are provided to empower private forest farmers [226].

3.5.5. Climate Change Adaptation

Adaptation to climate change is required to reduce the risk of failure in crop cultivation. Farmers adapting to climate change will be influenced by farmer institutions, access to finance, information on climate, and extension [211]. Farmer adaptation practices to increase land productivity include the application of soil and water conservation techniques, the use of varieties that are resistant to high temperatures/shade, and the use of mulch [227]. The use of shade trees in agroforestry patterns is needed to deal with climate change that causes an increase in temperature [228]. Agroforestry has proven to be a technique that is suitable for farmers to apply in the era of climate change.

3.5.6. Intensification of Smallholder Agroforestry

Previous research shows that intensive agroforestry practices (with environmental manipulations) result in higher productivity than traditional practices [229–231]. Meanwhile, the agroforestry patterns in smallholder forests vary, including border trees, alley cropping, mix patterns, and alternate rows [232]. Yard agroforestry and complex agroforestry forms are still focused on experimental forms of intensive silvicultural applications such as fertilization, spacing, and pruning [233,234]. Both agroforestry forms are associated with the development of private forests with various characteristics on a household scale with limited lands, such as in Indonesia today. As a matter of course, many findings are not necessarily suitable for general application and produce trial/experimental results that are either not suitable or error-prone. Discretion in selecting research recommendations to suit the specific characteristics of private forest development is the key to success.

In agroforestry development, there are two main activities: (1) species selection and (2) management [235]. Species selection is determined by land conditions [236], latitude [237], light intensity [237,238], the social culture of the community [239], and the market [187]. Treatment in agroforestry will regulate the availability of growth resources [240,241], such as light intensity [237], water [242], and nutrients [214]. This is achieved by sharing growth resources [232] or minimizing competition among species [243] and additional growth factor inputs [244,245]. The components of the treatment carried out are spacing or density [239,246,247], thinning [248] and pruning [249], rotation [250], and fertilization [244]. The factors for implementing agroforestry technology are influenced by the feasibility of financial analysis [22,251], policy support [252], market networks [187], collective action to solve limited landownership [253], adoption power [114,216], and extension [254,255]. The picture below tries to illustrate how the implementation of agroforestry works (Figure 3).

So far, the implementation of agroforestry has relied more on knowledge passed down from ancestors and the use of subsistence (fulfillment of daily needs) or market demand from cultivated plant commodities. The types of seasonal food crops, which are usually understory and perennial fruit trees, are timber plants that have been developed for a long time and have contributed to the local food supply. The forms of environmental manipulation or land management that can be carried out based on studies so far are (1) the use of tolerant varieties that have been created; (2) the implementation of thinning/pruning/tree-spacing to make room for incoming light; (3) fertilization, manure being relatively safe for

environmental sustainability, as is the use of inorganic fertilizers, especially N types; and (4) optimizing the benefits of current trees in the system. In this effort, policies established by the government and other stakeholders collaborate to empower the community to achieve food security, such as in (1) the creation of new shade-resistant varieties; (2) converging research results that produce agroforestry models that adapt to the characteristics of private forests (biophysical variations, household scale/areas of 0.25 ha), and management collective action in farmer groups to achieve commercial areas; (3) the extension of intensive silvicultural concepts in multifunctional agroforestry entry for farmers; and (4) the provision of production facilities and infrastructure (subsidized seeds and fertilizers).

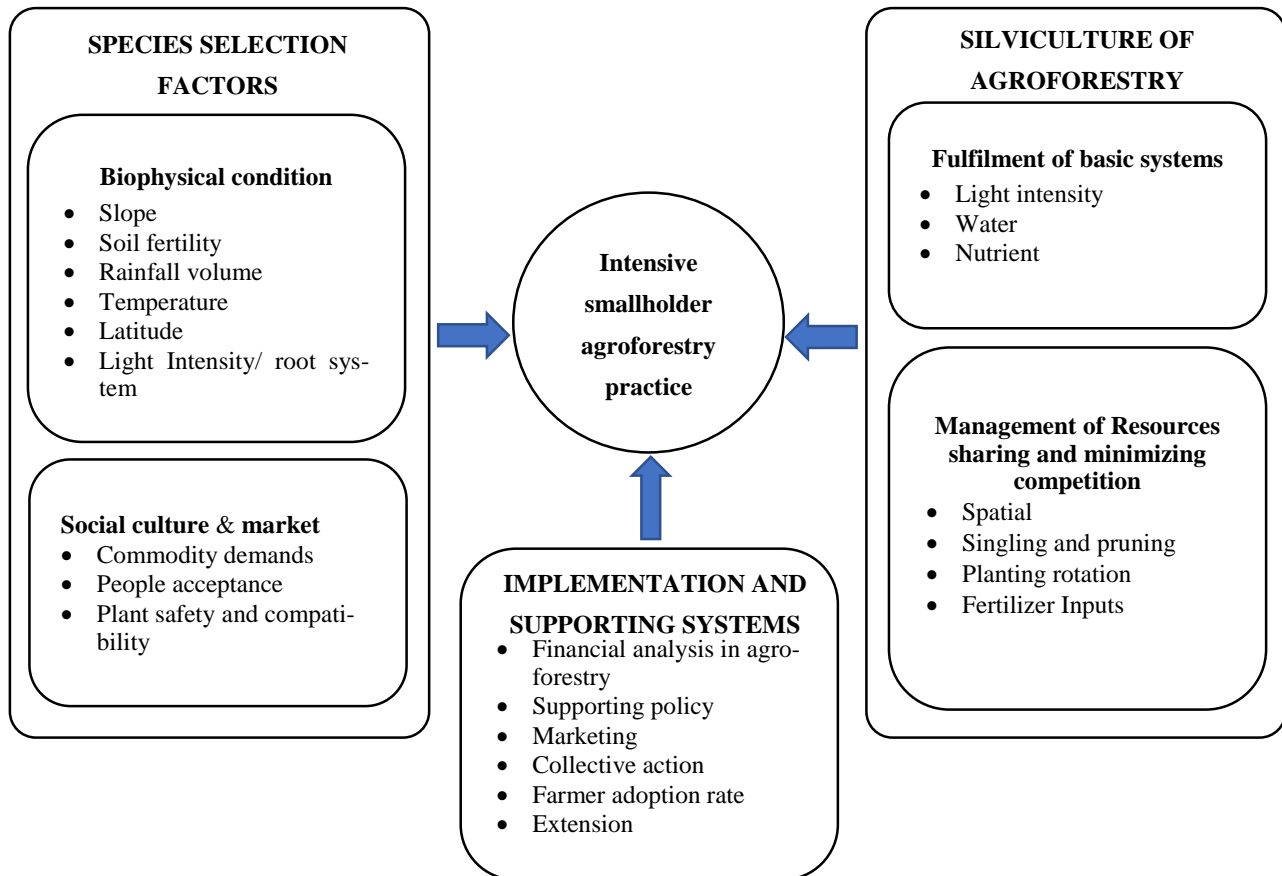


Figure 3. Framework for enabling intensification of smallholder agroforestry practices. Source: compiled from [22,114,187,214,216,232,236–246,248–255].

Agroforestry development during the private forest cycle is not a static environment; agroforestry development for any kind of seasonal crop cannot be separated from other dimensions, such as social policies and marketing dimensions. If agroforestry in Indonesia is assessed according to the characteristics of success required by [256], namely, productivity, yield sustainability, and adoption, then it only fulfills the productivity aspects, while the latter two are still challenging to achieve [257]. There are several obstacles in agroforestry development that are especially faced by farmers: technical, financial, market, and social doubts [203]. In addition, there is no binding legal provision and less (half-hearted) partisanship in supporting agroforestry development from relevant parties.

The support and synergy of all parties for the development of agroforestry can include various factors [202,203]: (1) support from government policies and programs that are pro-agroforestry (technical, financial, legality); (2) capacity building from the community, assistants, governments, and related institutions; (3) support from science and technology packages and community facilitation; and (4) market support. Furthermore, synergy and support from all parties for the development of agroforestry, with respect to optimizing

land use in order to support food security and farmer investment, are expected to increase Indonesian farmer welfare and purchasing power. Agroforestry is a solution to many problems, and it has the potential to become the future of agriculture by achieving the environmental benefits and services it promises [5].

4. Conclusions and Recommendations

Based on this review, it can be concluded that the combination of limited landownership, low average literacy, and limited financial capital are the main factors causing smallholders to be unable to increase their income from agroforestry practices. A feasible strategic effort is to intensify forest management using agroforestry patterns by optimizing the use of growing space and maintaining plants by applying cultivation technology. However, in reality, the technology has failed to be adopted by farmers because of limited capital and low knowledge due to low average literacy levels. This means that assistance in the form of technology alone has not been able to touch the subsistence problem of small farmers. Given this situation, government policies that are oriented toward providing other incentives aimed at encouraging an increase in the number and diversity of income sources need to be stimulated. Until recently, forest services have not been utilized as a source of income for farmers, although the government often calls for the importance of maintaining the ecological function of forests. Therefore, the upstream–downstream compensation model should be employed as an entry point for initiating the appreciation of other forest services, such as the carbon sequestration capacity of agroforestry and the control of soil erosion or landslides. This upstream–downstream compensation mechanism is expected to have positive implications for the reforestation of bare hills, which are widespread in several areas.

In the end, we need to consider that each region has different characteristics related to biophysical and socioeconomic statuses of farmers. The proposed strategies to improve the sustainability of farming are not necessarily applicable to all local and regional conditions. Further research is needed to review successful cases of intensive farming and commercially oriented agroforestry practices, as well as to evaluate how these cases can be applied to other areas. On the other hand, it is too early to assume that subsistence farming is tantamount to failure. We realize some potential benefits may be obtained from subsistence farming, such as conservative farming due to non-tillage practices, high biodiversity spots due to the cultivation of noncommercial tree species, and higher potential carbon sequestration due to the longer harvesting cycle of the trees. Sustainability seems to be the key to further agroforestry development for smallholder farmers as an alternative to other intensive, modern, and commercial practices. Therefore, a more comprehensive study is needed to compare the productivity, socioeconomic, and environmental aspects between traditional and modern agroforestry, subsistence and commercial agroforestry, and non-intensive and intensive agroforestry.

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Appendix A

Table A1. Full list of reviewed studies.

No.	Bibliography	Search Site	Sub-Discussions
International Literature			
1.	[202]	GS	3
2.	[191]	GS	3
3.	[55]	GS, SP	1
4.	[152]	SD	3
5.	[39]	GS	1
6.	[11]	GS	1
7.	[57]	GS	1
8.	[22]	GS, SP	1
9.	[71]	GS	1
10.	[94]	GS	1
11.	[54]	GS	1
12.	[42]	GS, FM	1
13.	[53]	GS	1
14.	[52]	GS, RG	1
15.	[44]	GS	1
16.	[108]	GS	2
17.	[104]	GS	1, 2
18.	[37]	GS	3
19.	[90]	GS	1
20.	[153]	GS	2
21.	[60]	GS, IS	1
22.	[61]	GS, SP	1
23.	[177]	GS, SD	3
24.	[186]	GS	3
25.	[204]	GS	3
26.	[162]	GS	2
27.	[254]	SP	3
28.	[66]	GS	1
29.	[114]	SP	2
30.	[19]	GS	1
31.	[207]	GS	3
32.	[201]	GS	3
33.	[48]	GS	1, 3
34.	[56]	GS, IS	1
35.	[50]	RG	1
36.	[18]	GS	3

Table A1. Cont.

No.	Bibliography	Search Site	Sub-Discussions
37.	[205]	GS	3
38.	[93]	GS	1
39.	[49]	GS	1
40.	[70]	GS	1
41.	[251]	GS	3
42.	[253]	GS	3
43.	[178]	SP	3
44.	[194]	GS	3
45.	[105]	SD	2, 3
46.	[193]	SD	3
47.	[95]	GS, IS	1
48.	[83]	GS, SP	1
49.	[241]	GS	3
50.	[187]	GS	3
51.	[151]	RG	2
52.	[85]	IS	1
53.	[180]	GS, SD	2, 3
54.	[62]	GS	1, 3
55.	[182]	GS	2, 3
56.	[165]	GS	3
57.	[65]	GS, SP	1
58.	[163]	SD	2
59.	[111]	GS	2
60.	[59]	GS	1, 3
61.	[23]	GS	1
62.	[67]	GS	1
63.	[112]	SD	2
64.	[97]	GS	1
65.	[78]	GS	1
66.	[38]	GS, SP	1, 2, 3
67.	[113]	GS	2
68.	[103]	SD	2
69.	[181]	GS	3
70.	[110]	GS	2
71.	[92]	GS	1
72.	[43]	GS	1
73.	[3]	GS	1, 3
74.	[4]	GS	1
75.	[209]	SP	3

Table A1. Cont.

No.	Bibliography	Search Site	Sub-Discussions
Local Literature			
76.	[189]	GS	3
77.	[107]	GS	2
78.	[109]	GS	2, 3
79.	[225]	GS	3
80.	[128]	GS	2
81.	[134]	GS	2
82.	[58]	GS	1
83.	[82]	FM	1
84.	[255]	GS	3
85.	[89]	GS	1
86.	[87]	RG	1
87.	[130]	GS	2
88.	[5]	GS	3
89.	[47]	GS	1
90.	[125]	GS	2
91.	[184]	GS	3
92.	[244]	GS	3
93.	[101]	GS	2, 3
94.	[91]	GS	1
95.	[119]	GS	2
96.	[96]	GS	1
97.	[122]	GS	2
98.	[102]	GS	2
99.	[161]	GS	2
100.	[141]	GS	2
101.	[164]	GS	2
102.	[84]	RG	1
103.	[129]	GS	2
104.	[74]	GS	1
105.	[160]	GS	2
106.	[183]	GS	3
107.	[21]	GS	2
108.	[76]	GS	1, 2, 3
109.	[79]	GS, FM	1
110.	[30]	GS, FM	2
111.	[106]	GS	2
112.	[88]	GS	1
113.	[131]	GS	2

Table A1. Cont.

No.	Bibliography	Search Site	Sub-Discussions
114.	[226]	GS	3
115.	[232]	GS	3
116.	[185]	GS	3
117.	[118]	GS	2
118.	[121]	GS	2
119.	[81]	FM	1
120.	[51]	GS	1, 3
121.	[86]	GS	1
122.	[41]	GS	1
123.	[127]	GS	2

Note—Search sites: GS (Google Scholar), SD (Science Direct), SP (Springer), RG (Researchgate), IS (IOP Science), FM (Forda-Mof). Subdiscussions: 1 (existing agroforestry), 2 (subsistence factor of agroforestry), 3 (strategy of agroforestry).

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