



Agrosilvopastura as a Planned Agricultural form System Towards Sustainable Agriculture in Southeast Aceh District

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Abstract. Agroforestry is also a form of sustainable agriculture model. Agroforestry systems are formed of three main components, namely forestry, agriculture, and livestock. The agrosilvopastura system is the combination of woody components (forestry) with agriculture (annuals) as well as livestock on the same land management unit. The priority order of the most important alternative options for sustainable agriculture includes strengthening farmer institutions, developing a cadre of farmers/farmer groups aware of sustainable agriculture, and increasing demonstration activities for sustainable agricultural technology. Financial analysis shows that all agroforestry systems are economically viable, and agrosilvopastura provides the most inputs compared to agrosilnikultur and silvopastura. Erosion that occurs on agroforestry land agroforestry, especially agrosilvoculture in the buffer zone of Southeast Aceh District is not harmful because it is smaller than the allowable erosion (<30.6 tons/ha/yr). The total biomass and carbon of stands in agroforestry systems with agrosilvopastura type of 103.17 and 46.74 tons per hectare, respectively, are similar to the total biomass and carbon of stands in mangrove forests. carbon in *Rhizophora apiculata* mangrove forest with a density of 463 trees per hectare, which were 169.46 (biomass) and 47.08 (carbon) tons per hectare, respectively. Agrosilvopastura systems can play a role in mitigating floods compared to monoculture farming systems for each hectare of land for every 1 hour of work.

Key word: agrosilvopastura sustainable, agricultural technology, economic viability, soil erosion, biomass.

1. INTRODUCTION

The World Bank translates the sustainable development paradigm in the form of the environmentally sustainable development triangle framework. Sustainable development rests on economic, ecological, and social sustainability. social. Economically sustainable means that a development activity must be able to generate economic growth, maintenance of capital, and social sustainability. economic growth, capital maintenance, resource use, and efficient investment. resources, and investment efficiently. Ecologically sustainable means that the activity is capable of maintain ecosystem integrity, maintain the carrying capacity of the environment, and conserve natural resources including biodiversity. natural resources including biodiversity. Social sustainability means that the development can create equitable distribution of development results, social mobility, social cohesion, community participation, community empowerment, social identity, and institutional development (Serrano et al., 2014). and institutional development (Serageldin, 1996 in Dahuri 1998).

Sustainable agriculture has several principles, namely: (a) using effective, productive, cheap external input systems, and discarding production methods that use input systems from industry, (b) understanding and appreciating local wisdom and more involving the role of farmers in natural resource management and agriculture, (c) implementing conservation of natural resources used in the production system (Shepherd, 1998 in Budiasa, 2011). The

problem often faced in realizing sustainable agriculture is the tug-of-war between various development interests. Some factors that influence the success of sustainable agriculture include social, economic, and institutional factors (Purwanto and Cahyono, 2012); the choice of appropriate conservation techniques, in accordance with the social, economic, and cultural background of the community (Sabiham in Arsyad, S. and E. Rustiadi, 2008); individual, economic, and institutional factors (Illkpitiya and Gopalakrishnan, 2003); institutional factors, government policies, and technological changes (Ananda and Herath, 2003). Efforts to harmonize various aspects of interests while maintaining environmental sustainability are a challenge in realizing sustainable agricultural development.

According to Salikin (2003), sustainable agricultural systems can be implemented using various models including organic farming systems, integrated farming, integrated pest control, and LEISA (Low External Input Sustainable Agriculture). Organic farming system is an agricultural production system that makes organic material the main factor in the farm production process. LEISA (low-external-input and sustainable agriculture) is agriculture that optimizes the use of local natural and human resources, is economically viable, ecologically sound, culturally appropriate, socially just, and external inputs are only a complement (Reijntjes et al. 1999). Integrated pest management is a pest control technology that aims to maximize the effectiveness of biological and cultural control. Chemical control is done by minimizing disturbance to the environment (Luna and House, 1990 in Budiasa, 2011). Meanwhile, agroforestry is also a model of sustainable agriculture. The agroforestry system is formed of three main components, namely forestry, agriculture, livestock. The combination of these components results in agrisilviculture (forestry + agriculture), silvopastura (forestry + livestock), and agrosilvopastura (forestry + agriculture + livestock) (Budiasa, 2011). An overview showing the scope of the agroforestry land use system can be seen in Figure 1. The conservation farming system is an integration of farming activities and conservation activities carried out on sloping land (Idjudin, 2011).

Soil erosion control, water conservation, increased soil productivity, and stability of hillsides are the principles of conservation farming (Idjudin et al. 2003). The multiple cropping system aims to minimize the risk of farming while functioning in integrated pest management, and maintenance of soil fertility (Budiasa, 2011). Meanwhile, the non-visible service-producing functions of agroforestry systems include balancing environmental quality such as mitigating floods, controlling soil erosion, maintaining groundwater supply, carbon sequestration, cooling and freshening the air, and maintaining biodiversity), as well as creating

panoramas (beauty) and rural attractiveness (Nair, 1989c; Chundawat and Gautam, 1993; Lal, 1995).

2. METHOD

This study utilizes a **descriptive qualitative method** by reviewing secondary data derived from literature, government publications, previous research, and field observations in Southeast Aceh District. The approach focuses on evaluating the agrosilvopastura system as a sustainable agricultural practice by analyzing its ecological, social, institutional, and economic dimensions.

Data collection includes documentation techniques, supported by analysis of erosion rates, biomass and carbon sequestration, land suitability, and economic feasibility (NPV, B/C Ratio, IRR) of agroforestry systems. The study also involves stakeholder interviews and literature-based triangulation to determine alternative priorities in implementing sustainable agriculture through farmer empowerment, development of farmer cadres, and demonstration of sustainable technologies. The analysis is intended to explore the viability and potential of agrosilvopastura in enhancing rural livelihoods while conserving natural resources.

3. LITERATURE REVIEW

Sustainable agriculture is a development model that integrates economic productivity, ecological integrity, and social equity (Serrano et al., 2014; Serageldin in Dahuri, 1998). One of the key approaches in achieving sustainability is through **agroforestry systems**, including agrosilvopastura, which integrates forestry (trees), agriculture (annual crops), and livestock (Budiasa, 2011).

According to Reijntjes et al. (1999), sustainable agriculture such as LEISA (Low External Input Sustainable Agriculture) prioritizes local resources, minimizes external inputs, and promotes ecological and social balance. Salikin (2003) and Luna & House (1990) emphasize models such as integrated farming and integrated pest management as effective for sustainable practices.

Agrosilvopastura systems are structured land-use practices where **woody perennials, crops, and livestock** coexist in a planned manner to provide both productive and ecological services (Dariah et al., 2016). These systems improve soil fertility, control erosion, increase water infiltration, and contribute to carbon sequestration (Hairiah et al., 2018; Abdul-Rauf, 2004; 2007). Research by Setyorini et al. (2019) indicates that agrosilvopastura enhances land productivity and farmer welfare, especially on marginal or degraded land.

Institutional aspects are critical to sustainable agriculture. Sasongko et al. (2013) and Purwanto & Cahyono (2012) highlight the role of **farmer groups, local knowledge, and empowerment** in adopting sustainable agricultural practices. Demonstration plots and exemplary farmer cadres help in the practical dissemination of knowledge, creating peer-based learning environments (FAO, 2020).

Economically, agrosilvopastura is feasible when evaluated using financial indicators such as **Net Present Value (NPV), Benefit-Cost Ratio (B/C), and Internal Rate of Return (IRR)** (Bukhari & Indra; Setyorini et al., 2019). Land suitability studies further support the effectiveness of these systems on moderately to marginally suitable land when assisted with inputs like organic fertilizers (Utomo et al., 2015).

In summary, the agrosilvopastura model presents a promising approach for sustainable agriculture in ecologically fragile areas by combining ecological benefits, economic viability, and institutional support.

Agrosilvopastura (Agrosilvopastural systems)

Agrosilvopastura systems are combinations of woody components (forestry) with agriculture (annuals) and at the same time livestock / animals on the same land management unit. Natural forest stands are not an agrosilvopastura system, although the three supporting components can also be found in the ecosystem in question. The combination in agrosilvopastura is carried out in a planned manner to optimize production and service functions (especially woody/forestry components) to humans/communities (to serve people). It is possible that the combination is also supported by natural regeneration and wildlife. The interaction of agroforestry components is naturally easy to identify. The simplest interaction, for example, is the role of vegetation as a provider of wildlife food (e.g. fruits for various types of birds), and vice versa, for example the function of wildlife can help the process of pollination or regeneration of stands, as well as a source of animal protein for farmers (Anonymous).

4. RESULT AND DISCUSSION

Criteria and Alternatives for Tracing the Social Aspects of Sustainable Agriculture For parameters regarding social aspects, there is data on the search for sustainable agriculture carried out in Lawe Bulan District, Southeast Aceh Regency based on the results of literature searches it can be seen that several criteria that affect the success of sustainable agriculture include: socio-cultural, economic, agricultural technology, institutions, and government policies.

Furthermore, based on the combined opinions of respondents on institutional criteria, it is known that the alternative of strengthening farmers' institutions is the most important priority in sustainable agricultural planning in Lawe Bulan sub-district. Farmer group empowerment is the key to strengthening farmer institutions. Empowerment means that farmer groups position themselves as subjects of agricultural development. Farmer groups are able to identify themselves, realize the problems they face, can help themselves to solve their problems, know what they need to do, and know how to solve their problems this is actually a group need, and ultimately increases the role of farmer groups independently. The tendency of some existing farmer groups has not optimized their function and management. This is because some farmer groups position themselves more as objects of agricultural development programs/activities, i.e. recipients of assistance from both the government and other funders. Farmer institutions are more likely to be dependent where the active or not the role and function of the institution depends on whether or not there is assistance provided.

Through farmer institutional empowerment programs/activities, farmers are expected to be able to take the initiative independently to solve the problems they face, especially those related to the implementation of sustainable agriculture. Assistance from various parties provided is really felt as a group need and part of their planning to overcome the problems faced. This will ensure the sustainability of the assistance/activities provided because it is needed and there is a sense of ownership by the farmers. In addition, it is important for farmer institutions to increase their role in establishing mutually beneficial cooperation with various parties in order to overcome the problems faced, for example, low prices when overproduction occurs are overcome by a partnership system (Sasongko et al. 2013).

The next alternative priority is to develop a cadre of farmer groups/farmers aware of sustainable agriculture as pioneers/examples/exemplars. These programs/activities are quite important and strategic because farmers need figures, figures, examples, role models who have successfully implemented sustainable agriculture models. Through this process farmers will see firsthand, learn, analyze, consider, and finally decide. The introduction of forms of sustainable agriculture application through real examples will be more easily accepted than the theory in the room. cadres of farmers/farmer groups need to continue to be initiated by various parties, so that the perpetrators of sustainable agriculture models are increasingly flourishing so that other farmers have no difficulty in imitating, emulating, agricultural practices that apply the principles of sustainable agriculture around them (Sasongko et al. 2013).

The next alternative priority is to increase demonstration plots of sustainable agricultural technology. Demonstration plots are important for introducing existing sustainable

agricultural technologies, how they are operationalized, the results/profits, and then farmers become aware of, believe in, and trust the agricultural technology being introduced. The hope is that there will be a process of change/increase in farmers' knowledge, attitudes, and behavior in the application of sustainable agriculture (Sasongko et al. 2013).

Land Suitability and Economic Aspects of Agrosilvopastura In this paper review, a financial analysis of the agroforestry system was carried out in Indrapuri District with a 20-year concession period and an interest rate of 8%, obtained, NPV value > 0 (positive), and B / C Ratio ≥ 1 and IRR value \geq the interest rate (i) for all forms of land use, can be seen in table 2. From these data, it shows that all agroforestry systems in the form of agrisilviculture, silvopastura and agrisilvopastura are feasible to implement.

Financial analysis of agroforestry per hectare in Indrapuri District the silvopastura system obtained the results of the level of suitability of teak and mahogany woody plants classified as moderately suitable (S2). Annual crops, namely bananas, the level of land suitability is classified as moderately suitable (S2) and for fodder plants such as elephant grass has a level of marginal suitability (S3). The results of the evaluation of land suitability for plant species whose land use is in the form of agrosilvopastura obtained results for the woody plant component teak (*Tectona grandis*), mahogany (*Swietenia* sp), candlenut (*Aleuritas moluccana*), has a land suitability level classified as moderately suitable (S2); while mango (*Mangifera indica*), jackfruit (*Artocarpus integra*), rambutan (*Nephelium lappaceum*), areca nut (*Areca catechu*). has a land suitability level classified as marginally suitable (S3). Furthermore, annual crops of banana (*Musa puleuca*) and cacao (*Theobroma cacao* L) and fodder elephant grass (*Pennisetum purpureum*), have a land suitability level classified as marginally suitable (S3).

Based on the level of land suitability, it is also necessary to design agroforestry on critical land. To adopt technology for farming activities, it is necessary to know the specific constraints that exist in the location. The constraining factors themselves, there are those that can be manipulated or improved with technology, but there are also constraining factors that are difficult to fix because it will require high costs and difficult to repair by farmers. Based on the results of the evaluation of land suitability, it is recommended that the types of Non MPTs woody plants are teak and mahogany because they are classified as quite suitable (S2), for MPTs plants such as rambutan, jackfruit, mango, areca nut and candlenut in certain areas classified as marginally suitable (S3), but with the provision of fertilizers can be improved to be quite suitable (S2). Likewise, for annual crops such as bananas and cacao with the application of fertilizers, their suitability can be increased to moderately suitable (S2). For

annual crops such as chili, eggplant and corn, classified as (S3) or marginally suitable, this of course requires a fairly high fertilizer input in cultivating it.

Based on observations and interviews, a profile of the components that make up the agroforestry system on critical land was obtained according to the landscape. Woody plants such as teak and mahogany will be better planted on the ridge area, because they are more adaptive to extreme land conditions. MPTs, annual crops and fodder are better planted on the slopes and valleys, assuming that the fertility level is better than on the ridges. The success of tree-based agroforestry is based on species selection. The principle of tree species selection in agroforestry is the accuracy between the location of establishment with the characteristics of the selected species and its use value (Suryanto et al, 2005).

Ecological Aspects of Agrosilvopastura in the ecological aspect, the parameters presented in this review research journal are erosion rate (table 4), total biomass and carbon sequestration (table 5), and infiltration capacity (table 6). Data were taken from a study conducted by Abdul-rauf (2004) on agroforestry farmland in the buffer zone of Southeast Aceh District, Aceh.

Erosion that occurs in agroforestry land are all below the allowable erosion, still in a harmless level. While erosion that occurs in monoculture farmland (intensive) is a dangerous erosion (much greater than the allowable erosion).

Furthermore, in the same field, the total biomass and carbon of stands in several agroforestry subtypes in the Buffer Zone were calculated. Accompanied by the percentage of total soil carbon per hectare at a depth of 20 cm.

Erosion on agroforestry and agricultural land in the buffer zone of Southeast Aceh District on slopes of 15-25% it can be seen that the highest biomass and total standing carbon were found in the natural forest system. While the highest biomass and total carbon from land that has been cleared (utilized) by humans, was found in the agrosilvopastura subtype with a structure or main constituent component consisting of sweet bark, petai papan and grass vegetation under the tree stands, amounting to 88.87 tons per hectare. The lowest total standing carbon was found in the land use system for monoculture agriculture (upland rice, and chili) of only 2.17 tons per hectare or about 10.3 times less than the average total standing carbon in the agroforestry system.

Biomass and total carbon (C) of stands and soils in several agroforestry subtypes in the buffer zone of Southeast Aceh District it also shows that higher total soil carbon is always followed by lower total bioamass and standing carbon (vegetation). Higher total soil carbon was generally found in the agrosilvicultural sub-type than in the agrosilvopastura sub-type.

While total biomass was generally higher in the agrosilvopastura type, except for the natural forest system. Compared to the potential biomass and total carbon in primary forests, the potential biomass and total carbon in the agrosilvopastura and agrosilvicultural types in this buffer zone are about 3-6 and 6-12 times less than the potential biomass and carbon in the natural forest system, respectively total carbon in the primary forest. The potential biomass of primary forest from Istomo (2002) was 329.18 tons per hectare, while that of this study was 616.4 tons per hectare. However, the potential biomass and total carbon of stands in the agrosilvopastura and agrosilviculture types in this buffer zone are about 16.4 and 7.3 times greater, respectively, when compared to the potential biomass and carbon of stands found in monoculture farming systems, which means that the agrosilvopastura type is closer to natural forest systems, while the agrosilviculture type is closer to monoculture farming systems when viewed from the potential biomass and total carbon of its stands.

The next parameter, soil infiltration capacity in agroforestry systems is generally 1.3-2.0 times greater than in monoculture farming systems. This means that the soil's ability to absorb water in agroforestry systems is greater than in monoculture farming systems. As a result of the smaller soil absorption capacity in monoculture agricultural systems causes greater surface runoff, and vice versa, surface runoff in agroforestry systems is smaller because the soil absorption of water is greater.

Infiltration capacity and surface runoff in agroforestry and agricultural land types in the buffer zone of Southeast Aceh District high soil infiltration capacity allows the soil in the agroforestry system to retain more water, which means that this agroforestry system has a greater role in mitigating floods. With the difference between the infiltration capacity in the agrosilviculture type and the infiltration capacity in monoculture agriculture of 32.01 cm/hour, it means that this type can absorb 3,201,000,000 cm³ or 3201 m³ or 3,201,000 liters more water than in the monoculture agricultural system for every 1 hectare of land for every 1 hour of rainfall events. Similarly, the agrosilvopastural type can absorb 970 m³ more water than the monoculture farming system for every hectare of land for every 1 hour of rainfall.

5. CONCLUSIONS

The priority order of the most important alternative options for building sustainable agriculture includes strengthening farmer institutions, developing a cadre of farmers / farmer groups aware of sustainable agriculture, and increasing the activities of technology demonstration plots sustainable agriculture. Based on the constituent components, there are three agroforestry systems carried out by the community on critical lands, namely in the form

of agrisilviculture, silvopastura and agrosilvopastura, where the existing agroforestry system is a traditional agroforestry system managed according to local conditions and wisdom. Financial analysis shows that the three agroforestry systems in the research location are economically feasible to implement. Agroforestry systems that are more suitable and sustainable (income reaches decent living needs, land is not degraded and feasible agrotechnology) to be applied in the buffer zone of Southeast Aceh District, Aceh is the type of Agrosilvopastura which is the type of agroforestry system that is more suitable and sustainable combination of forest trees/crops, agricultural crops, and fodder grasses, because the land is generally steep to very steep, the soil solum is shallow and the soil structure is loose. Erosion that occurs on agroforestry land, especially agrosilvopastura in the buffer zone of Southeast Aceh District, Aceh is not dangerous because it is smaller than the allowable erosion (<31.6 tons / ha / year), while erosion that occurs on intensive agricultural land (monoculture) about 136.79 tons / ha / year or 4.4 times greater than the allowable erosion. Total biomass and standing carbon in the agroforestry system with agrosilvopastura type of 104.17 and 46.74 tons per hectare, respectively, are almost the same as the total biomass and total standing carbon in *Rhizophora apiculata* mangrove forest with a density of 463 trees per hectare, which are 169.46 (biomass) and 47.08 (carbon) tons per hectare, respectively.

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