Support system model for smallholder to accelerate the implementation of palm cattle integration

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Abstract. Palm cattle integration is plants and livestock integrated activities in a farming unit. This system is part of the government programs to meet national beef’s need at a macro level. It is also a strategy in optimizing land use to increase productivity and farmers’ income. However, its implementation has not been developing and running optimally. This condition is caused by various technical and institutional constraints faced by smallholders. In the long term, it may affect its sustainability because farmers cannot overcome it only by using their resources and capabilities. It can be overcome by providing a support system. This paper aims to analyze the constraints and develop a support system model for smallholders to accelerate the implementation of palm cattle integration. The constraints faced by farmers are related to working capital, raw material, technologies, skills, market, and tools and machinery. The strategies include strengthening farmer and farmer groups, optimizing production and productivity, and developing a market link. The support facilities consist of factors to increase farmers’ and farmer organizations’ capabilities and provide resources. Providing support facilities will involve local government, private sector, cooperative, financial service, production service, market and institutional service, certification service, and research agency.

1. Introduction

Palm cattle integration plays a strategic role in the national economy. The high demand for national beef has not been able to be met by domestic supply. Constraints in developing cattle are related to providing economically viable feed, effective livestock reproduction, efficiency scales, and market access. Livestock development has been concentrated in areas with low feed support, where there is not enough feed during the dry season. On the other hand, the massive expansion of oil palm plantations in Indonesia can integrate with cattle related to providing feed from biomass and land use under oil palm trees.

Relative to conventional agricultural production systems, palm cattle integration, as a bioindustry model, can lower reliance on external inputs, enhance nutrient cycling, and increase natural resource use efficiency. Implementing crop-livestock integration provides many benefits. From an agronomic perspective, it optimizes land use following the land’s productive capacity, and from an economic perspective, it increases yields at lower costs through product diversification [1]. The ecology aspect enhances ecological function [2], and from the social aspect, it creates jobs in rural areas [3].

Although palm cattle integration has several potential benefits, its implementation has not been developing and running optimally. It is related to the farmer’s condition with a lack of competencies, a restrictive mindset, and insufficient resources. In terms of farmer organizations, not all farmer groups have a solid structure and function to expand. In the long run, the constraints may affect its sustainability level and could be overcome by providing a support system. This paper aims to analyze the constraints and develop a support system model for smallholders to accelerate palm cattle integration.
2. Research approach
A support system model for smallholders to accelerate the implementation of palm cattle integration is developed using a literature study approach. This approach is enriched by selecting analytical tools that can be used to analyze and prioritize the strategies.

The support system model is constructed based on the bio-industry model, smallholder and farmers’ institutions, and the constraints in palm cattle integration implementation. After that, strategy analysis is discussed using pairwise comparisons as an analysis tool to prioritize strategies based on the value of importance between factors.

The analysis begins with compiling a pairwise comparison matrix. Two strategies or support facilities in the support system model are evaluated in terms of their relative importance. The analysis used the Saaty Scale (1-9). The number “1” means equally important, “3” means the level of importance is moderate, “5” means the level of interest is strong, “7” implies importance, and “9” means very important, while the number “2”, “4”, “6”, and “8” point between the judgments [4]. For “less important” relationships, reciprocal numbers are used. These values are entered row by row into the cross matrix. The diagonal of the matrix only contains the value 1. After that, the calculation is completed by normalizing the matrix. Each value in the matrix is divided by the sum of its column [5]. To get the weights of the individual criteria, the mean of each row of this second matrix is determined. These weights are already normalized, and their sum is 1.

3. Result and discussion

3.1. Bioindustry model based on palm cattle integration
Bioindustry is an effort to process living natural resources with support from industrial technology to produce various agricultural products with higher economic value [6]. The crop-livestock integration is a system shown by establishing a close relationship between the plant and livestock components in a farming business or within an area [7]. Palm cattle integration is a model where oil palm plantations and cattle farming are combined in the same place with a close relationship between plant and livestock components that use each other’s waste [8]. As one of the bioindustry models, palm cattle integration may increase an economy of scale and economy of scope. The economy of scale is business development that potential reduces production costs due to increased production volume. In contrast, the coverage economy is a business expansion that produces derivative products or by-products other than the main product. Economically, if adequately managed, palm cattle integration is financially viable [9].

Based on the livestock management model, palm cattle integration is intensive, semi-intensive, and extensive. The preference of livestock management is influenced by several factors, specifically the ability to prepare feed, the availability of feed, the area of oil palm plantations for grazing, farmers’ skills, and the benefits obtained [10]. The intensive model is carried out if no oil palm plantation area is allowed for grazing or necessary to collect livestock manure for organic fertilizer processing business. The semi-intensive model is chosen to consider oil palm plantations’ availability for grazing, but attention is still needed for livestock safety. The extensive model is selected when a large area of pasture allows the livestock to obtain adequate feed.

Oil palm plantations supply animal feed by providing forage from weeds and grass planted between oil palm stands, oil palm plantation waste, and oil palm processing [11]. Oil palm plants produce waste in the form of palm fronds and empty fruit bunches. Palm fronds can be utilized as an ingredient for feed or complete feed. Meanwhile, empty fruit bunches can be processed into liquid smoke, which can be used as a medicine for fleas and flies for livestock. Cattle will produce manure, which can be used as fertilizer, bio urine, and biogas (Figure 1). The use of organic fertilizers has the potential to reduce the use of chemical fertilizers. Besides that, cattle’s organic materials can be used to provide renewable energy [12].
Livestock management is carried out by applying recommended technology to select beef cattle calves, fattening systems, feeding, providing pens and controlling, and preventing disease. The livestock business is an individual business where the farmer provides all the cattle’s needs, such as feed, water, marriage, disease management, and hygiene. Livestock management must ensure adequate feed and not damage the oil palm plantations.

Livestock productivity is mainly determined by feed in addition to seed quality and disease control. Improving the quality of feed can be done by utilizing easy and adaptable technology so that feed can be obtained in sufficient quantity and quantity [13]. Animal nutrition plays an essential role in determining the sustainability of the livestock business [13]. The cost of feed is the most significant component in livestock production, which is around 60-70%, so increasing feed efficiency is a concern in developing livestock production technology.

Complete Feed Block (CFB) is a complete feed formula containing energy, protein, minerals, vitamins, and other additives that are functional to inhibit methane formation indigestion, form protein from N feed sources and increase rumen microbial activity [14]. Palm oil waste is a mixture of fronds (60%), oil palm sludge (18%), palm kernel meal (18%), bran (4%), urea (0.4%), and salt (0.1%), with only protein content 7.8% gives bulls a live weight gain of 0.58 kg/day and is more economical than other feeds [14].

The urine from cattle is separated and processed explicitly as the main ingredient for producing liquid organic fertilizer. Meanwhile, a mixture of faeces is used to produce organic fertilizers in solid or powder form. Visually, oil palm plants that are given manure show better growth. The larger plant stems indicate this, better stretch or fall of the palm fronds, leave’s color to be greener and brighter, the color of the fruit palms that appear brownish-yellow or more, and the fruit bunches of the palms are bigger [14].

The benefits of palm cattle integration include increasing resource use diversification, reducing business risks, increasing labor and input use efficiency, reducing chemical input dependence, being environmentally friendly, increasing production, and increasing sustainability [15] [16]. In the replanting phase, optimizing farmers’ income can be carried out by increasing the productivity of fresh fruit bunches (FFB), increasing FFB prices, and decreasing farm costs. Farmers can increase FFB productivity by using inputs that can increase production, including fertilizer [17], where livestock is one of the potential fertilizer sources.

3.2. Smallholder and farmers’ institution in palm cattle integration

The management of oil palm plantations is operated by large private companies, smallholder plantations, and large state-owned companies. By the total palm plantation area of 14,362,350 ha in 2018, the state plantation area is 4.29%, the private company is 55.09%, and smallholder plantations is 40.62% [18].

Figure 1. Bioindustry model based on palm cattle integration
Smallholder plantations are divided into plasma farmers and independent farmers. Plasma farmers are smallholder plantations which in their development are integrated into large private companies or large state plantations, which around 12.35%. Independent farmers were covering an area of 87.65%.

Several factors influence farmers’ success in optimizing value chains and building market linkages, such as location, infrastructure, agricultural services, water management technology, and production technology. Other factors are factors related to the community, such as skills, education, and organizational management. Meanwhile, individual characteristics are related to ambition, discipline, and the ability to plan and implement activities [19].

Regarding the transactional model of smallholder farming, there are five main types of models: (1) small-scale independent smallholders assisted by local agents to connect to the supply chain; (2) large-scale independent smallholders collaborating with local traders or mills to take a role in the supply chain, (3) farmer groups or cooperative partners who collaborate with palm oil mills and carry out direct transactions, (4) smallholders collaborating with companies with a nucleus-plasma scheme, and (5) smallholder plantations under company management [20]. Palm cattle integration institution formally organizes farmers to allow joint efforts to reduce transaction costs, increasing productivity, legalizing land ownership, increasing access to formal credit, and ensuring sustainable agricultural practices [20].

Farmer groups played a significant function in the development of palm cattle integration. As an institution that formally coordinates farmers, farmer groups can receive various assistance or programs on a group scale. Additional technical guidance and technology transfer are usually based on farmer groups. In a complete feed production activity, palm kernel meal buying must meet the minimum purchase quantity and continuous purchase. In fertilizer processing activities, the amount of raw material can be fulfilled by collecting in groups based. However, there is a lack of managerial and business management aspects. In expanding the business from the economy of scale and the economy of scope, this condition will interrupt business growth.

3.3. The constraints in palm cattle integration implementation

The palm cattle integration was initiated in 2003 by a private oil palm company to utilize cattle to transport fresh fruit bunches. The implementation of palm cattle integration then extends to farmers who have oil palm plantations. Government support is provided by allocating a budget to make livestock grazing areas under oil palm trees equipped with electric guardrails. The forage source obtained by cattle comes from forages and oil palm leaves around the oil palm plantations, while cattle waste is utilized as a source of nutrients for oil palm plants. This integration system is further expanded by using waste from palm oil processing factories such as oil palm sludge and palm kernel meal as raw material for feed.

The driving factors for the development of palm cattle integration at the farmer level are adequate breeder resources and experience, farmer groups’ existence, availability of cultivation facilities and infrastructure, forage between plants, manure as fertilizer, and the low sales productive female cows [21]. However, palm cattle integration is facing problems that resulted in the slow development of the system. The constraints faced by farmers in implementing palm cattle integration related to limited market knowledge, the limited functions of the association, low capital capacity, and the production system affect debt, information acquisition, and performance source of income [22]. Developing palm cattle integration as a business expansion requires financial support for activities from upstream to downstream [23]. Managing business and financial operation, develop a business plan, and viable diversification product are some issues that derive from the organizational aspect [24]. More specifically, the constraints faced by farmers in implementing palm cattle integration are:

1. Working Capital. Working capital is the main obstacle in palm cattle integration, where working capital is required to procure feeder cattle and make suitable cages. Palm cattle integration needs additional cost due to the enlarging scope of productive activities. It needs to be addressed to ensure palm cattle integration sustainability in the future [25].

2. Raw Materials. The processing of palm oil into crude palm oil and palm kernel oil produces by-products in palm kernel cake and palm sludge. Access to by-products from oil palm companies such as palm kernel meal, palm oil cake, and palm sludge as feed sources is still low [10].
Besides limited access, farmers also face problems related to skills and technology in processing [21].

3. Technology. Several technologies have increased the opportunity to develop successful palm cattle integration, including superior varieties, fertilization, cultivation techniques, soil management, weed control practices, livestock management, technology for feed, and disease control. The technology-related problem is the low adoption at the farm level.

4. Skills. Palm cattle integration requires skills other than what farmers have so far, considering the basis of their agricultural activities is oil palm plantations. Expansion of agricultural activities by adding livestock activities requires knowledge and skills that must be possessed by farmers. However, there is a lack of livestock skills and knowledge of palm cattle integration [10].

5. Market. It is necessary to develop market access to sell products from palm cattle integration [10]. In remote locations, transportation costs will be more expensive, making it difficult to compete with producers close to the market or consumers [21].

6. Tools and Machines. The tools and machines owned by farmer groups are not entirely adequate in quantity and quality [10]. Several tools and machines for processing palm fronds and organic fertilizers are available through government programs, but their use is not optimal [26].

Various issues also influence the implementation of palm cattle integration. The presence of livestock in oil palm plantations is supposed to spread Ganoderma disease and cause soil compaction. Basalt stem rot caused by *Ganoderma boninense* is a significant threat to sustainable palm oil production. It is one of the primary fungal pathogens in oil palm plantations. However, biological control is using bacteria to reduce infection [27]. Besides that, soil compaction is rising due to livestock activities in oil palm plantations [10]. However, the study showed that cattle in oil palm plantations do not negatively impact the soil structure, indirectly influencing plant growth and root penetration [28].

3.4. Support system model to sustainable palm cattle integration

There are three strategies to accelerate palm cattle integration implementation based on the farmer’s condition for value chain and market linkages. At the first level, the strategy aims at strengthening farmer and farmer groups. The accumulation of assets and farmers’ ability will be formed through social capital and knowledge transfer. At the second level, the strategy will concentrate on optimizing the production of the bio-industry system. This strategy will focus on skills training and working on specific types of innovation analysis with farmers. Besides, local-based production management is also built through strengthening organizational aspects. At the third level, when farmers are already selling the product to a market, the strategy to optimize product performance and build links with specific buyers. Service providers’ network is strengthened at this stage, especially from suppliers of inputs, extension services, and financial services, besides developing a market link.

The strategy can be implemented effectively if support facilities are provided adequately. The support facilities consist of: (1) support aspect for increasing capabilities of farmers and farmer organization include skill and knowledge, entrepreneurship skills, organizational development, networking, and market link; and (2) support aspect for providing resources such as production inputs working capital, raw material, technology, as well as tools and machinery (Figure 2).
Institutions involved in providing support facilities are not only single institutions but are more directed to a group of institutions that work together to provide these services. The collective organization includes government, private sector, community-based organization, NGO, and business-focused farmer organizations [19].

3.5. Support system model analysis
The selected strategy is possible as a combination of these three strategies. Hence the support system model is a combination of various support facilities that break down from the strategy. Variation and amount of each support facility depend on the farmer’s condition for value chain and market linkages and the constraints in palm cattle integration. The analysis is using the pairwise comparison.

If palm cattle integration is still in the initiation stage towards achieving economy of scale and economy of scope, the strategy aims to strengthen farmer and farmer groups (Figure 3). The strategy focuses on increasing production and productivity by using collective efficiency. It will consider skill and knowledge development, entrepreneurship skill development, and organizational development as the main support facilities (Figure 4).

Figure 2. Support system model to sustainable palm cattle integration

Figure 3. Strategies rank for initiating stage case.

Figure 4. Support facilities rank for initiating stage case.
In the palm cattle integration system, providing support facilities will involve local government, company, cooperative, financial service, production service, market and institutional service, certification service, and research agency. The sharing of roles and functions will be organized to support palm cattle integration sustainably through the synergy among institutions.

4. Conclusion

Palm cattle integration has not been implemented optimally. The constraints faced by farmers are related to working capital, raw material, technologies, skills, market, and tools and machinery. There are three strategies to accelerate palm cattle integration: strengthen farmer and farmer groups, optimize production and productivity, and develop a market link. It can be implemented effectively by providing support facilities that increase farmers and farmer groups’ capabilities and provide the resources to have a sustainable production system.

The support system model is a combination of various support facilities that break down from the strategies. The support facilities consist of: (1) support aspect for increasing capabilities of farmers and farmer organization include skill and knowledge, entrepreneurship skills, organizational development, networking, and market link; and (2) support aspect for providing resources such as production inputs working capital, raw material, technology, and tools and machinery. Each support facility’s combination and level depending on the farmer’s condition for value chain and market linkages and the constraints faced in palm cattle integration. Providing support facilities will involve local government, private sector, cooperative, financial service, production service, market and institutional service, certification service, and research agency.

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