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REVIEW OF LOGISTICS SYSTEM FOR DEVELOPMENT OF LEADING COMMODITY AGROINDUSTRY TO SUPPORT SPECIAL ECONOMIC ZONES (SEZS) IN ACEH PROVINCE

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Abstract

Agro-industry development is one of the priorities of Aceh's economic development which is based on increasing agricultural sector production as a source of raw materials for industry. The Aceh government has established the development of special economic zones as one of the strategic steps for economic development. This study aims to analyze the logistics system to support the development of the Aceh Special Economic Zone agroindustry in Lhokseumawe and its surroundings. This study uses a survey method by collecting data from various sources that will play a role in the development of agro-industry in this area. The input-output analysis model is used to see the role of each subsector in supporting agro-industry in the region. The research results show that the plantation sector is one of the providers of agro-industrial raw materials that still has the greatest opportunities with a raw material availability coefficient of between 111 and 239 percent. The main plantation commodities as raw materials are coconut, palm oil, coffee, and cocoa. The logistics index of raw material availability is 28 percent. Therefore, the Aceh Government prioritizes agro-industry based on the potential availability of agro-industry raw materials.

Keywords: ***Agro-industry Development, Input-Output Analysis, Logistics System, Plantation Commodities, Special Economic Zone (SEZ).***

INTRODUCTION

Aceh Province has abundant natural resources, especially in the agricultural, plantation and fisheries sectors. Mainstay commodities such as palm oil, rubber, cocoa, coffee and marine products have strategic value in driving regional economic growth. Data from the Aceh Central Statistics Agency (BPS) (2024) shows that the agricultural sector contributes around 24.5% to the formation of Aceh's Gross Regional Domestic Product (GRDP), making it one of the backbones of the province's economy. However, this large contribution has not been balanced by the optimization of added value through the development of downstream-based agro-industry. At the global level, demand for agro-industrial products continues to increase, especially from the Asian and Middle Eastern markets. However, Aceh still faces challenges in terms of export competitiveness, where exported commodities are often still in raw form with low added value. In fact, further processing can increase profit margins while creating jobs (World Bank, 2022). Therefore, strengthening the value chain through agro-industry development is a must.

The Aceh government has established a development plan of a Special Economic Zone (SEZ) on the northeast coast as one of the main strategies to accelerate economic development. The SEZ is expected to become a growth center that drives industrialization, including agro-industry based on superior commodities. One of the main supporting infrastructures for the Special Economic Zone is Krueng Geukueh Port, which functions as a gateway for exports and imports of Acehnese products. Notteboom & Rodrigue's (2005) research states that port development has a positive correlation with regional economic growth, especially in supporting commodity export logistics. However, port effectiveness is highly dependent on the efficiency of the integrated logistics system, from upstream (production) to downstream (distribution to global markets). Currently Aceh still faces obstacles such as:

1) Limited logistics infrastructure (warehouses, cold storage, transportation networks).
2) High logistics costs due to long and unintegrated distribution chain.
3) Fluctuations in agro-industrial production (Figure 1), which are influenced by climate, market, and supply chain inefficiencies.

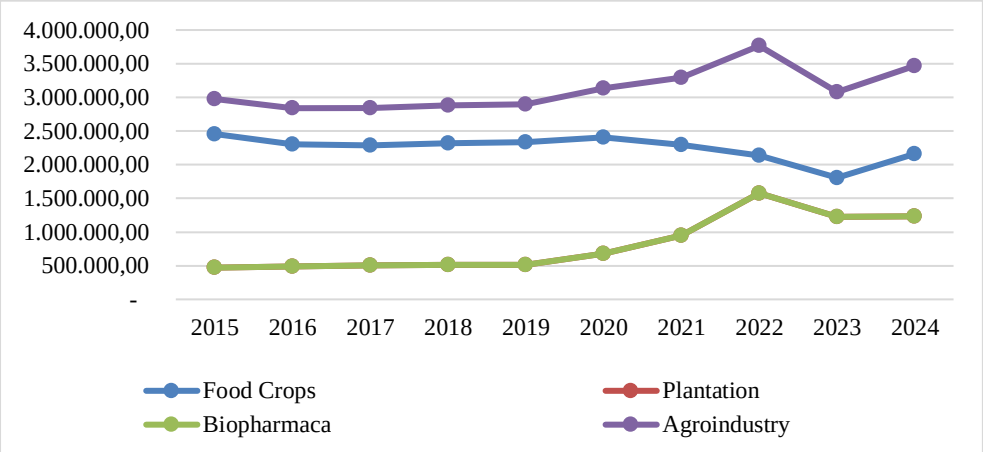

Figure 1: Development of Agroindustry in Aceh Province 2015-2024

Logistics systems play an important role in agro-industrial development, with three main components: (1) supply chain management to ensure the availability of raw materials, (2) efficient transportation and distribution infrastructure, and (3) the application of logistics information technology (e-logistics) to improve tracking and distribution efficiency. However, the report of the Indonesian Ministry of Trade (2023) revealed that the logistics system in Aceh is still not optimal. The main challenges include low connectivity between logistics nodes (such as ports, warehouses, and production centers), minimal cold storage facilities for perishable commodities such as fishery products, and complicated regulations and bureaucracy that hamper the export process. The phenomenon of a sharp decline in Aceh's agro-industrial production in 2023 (Figure 1) shows the vulnerability of the existing system. Initial analysis indicates three contributing factors: (1) post-pandemic supply chain disruptions and global conflict, (2) climate anomalies that impact agricultural productivity, and (3) over-reliance on unstable traditional markets. These conditions highlight the urgent need for logistics system resilience. As stated by Rushton et al. (2022), logistics resilience requires three approaches: (1) diversification of distribution channels to reduce risk, (2) integration of digital technologies such as blockchain and Internet of Things (IoT) to increase supply chain transparency, and (3) strengthening strategic partnerships between stakeholders (government, industry, and farmers) to create sustainable synergies.

LITERATURE REVIEW

The logistics system plays an important role in supporting agro-industrial development, especially in terms of efficient distribution, storage and processing of commodities. According to Rushton et al. (2022), a good logistics system must include supply chain management, transportation infrastructure, and information technology to minimize losses and increase product added value. In the context of agro-industry, punctuality of delivery and quality of storage (cold chain logistics) determine the competitiveness of commodities, especially for perishable agricultural and fishery products (Bowersox et al., 2020). In Aceh, the development of agro-industrial logistics systems still faces obstacles such as limited warehouse and cold storage infrastructure, as well as high distribution costs due to fragmented geographical conditions (BPS Aceh, 2024). Research conducted by Simatupang & Sridharan (2008) emphasized the importance of collaboration between stakeholders to create an integrated logistics system, especially in special economic zones such as the Aceh Special Economic Zone. SEZs are designed as areas with special economic facilities to attract investment and increase exports. According to Government Regulation No. 12/2020, SEZs must be supported by adequate logistics infrastructure, including ports, industrial areas, and distribution networks connected to the global markets. Krueng Geukuh Port in North Aceh is expected to become a major logistics center for agro-industrial commodities given its strategic position in the Malacca Strait (Coordinating Ministry for Economic Affairs, 2023). Research by Notteboom & Rodrigue (2005) shows that the success of SEZs relies heavily on the integration of an efficient logistics system, including: 1) availability of supporting infrastructure (warehousing, cold chain); 2) Regulations that support ease of export-import; 3) Partnerships between the private

sector and government in logistics management. However, implementation in Aceh still faces challenges, such as the low quality of supporting infrastructure and suboptimal coordination between agencies (ADB, 2023). Some countries have successfully integrated logistics systems with agro –industry development in special economic zones. For example, Thailand through the Songkhla SEZ succeeded in increasing exports of agricultural products by building integrated logistics parks connected to seaports and airports (World Bank, 2022). Meanwhile, Malaysia developed the Penang SEZ as a halal logistics center, supported by blockchain technology for agro -industry product traceability (MITI Malaysia, 2023). The development of agro-industrial logistics in Special Economic Zones (SEZs) in various countries shows several key success factors. First, large investments are needed in the development of modern technology-based logistics infrastructure to support efficient distribution and storage of commodities. Second, incentive policies for the processing industry are an important driving factor in increasing the added value of agro-industrial products. Third, strengthening the synergistic relationship between farmers as raw material producers, the processing industry, and export markets is a crucial element in creating a sustainable supply chain (FAO, 2021). These three aspects are interrelated and form a comprehensive agro-industrial logistics ecosystem, the successful implementation of which determines the competitiveness of products in the global market. Aceh has great potential in agro-industry, especially commodities such as palm oil, cocoa, coffee, and marine products. However, according to Bappenas (2023), some of the main challenges of the logistics system in Aceh SEZ include: 1) Inadequate infrastructure, especially cold storage and land transportation networks, 2) High logistics costs due to long distribution chains, 3) Complex regulations, hampering the export process.

METHOD

The method used is a survey and case study, namely conducting an in-depth study on the topic of agro-industry development of Aceh's agricultural mainstay commodities and stringing it with the development of Kuala Langsa port as an export port. The in-depth study of Aceh's mainstay agricultural commodities, especially from the eastern coastal region, was conducted through a hierarchy of production centers, industrial capacity and development possibilities. The study instruments prepared were a checklist and an in-depth interview guide with key informants containing: (1) Key Informant Identity, (2) Institution/Company, (3) Views on Aceh's leading commodity agro-industry, (4) Optimism for Agro-industry development in East Aceh, (5) Actual agro-industry capacity and (6) Development prediction mechanisms and feasibility of agro- industry locations. To complement the results of in-depth interviews, secondary data were collected from the East Aceh Bappeda and BPS Aceh reports on the main superior commodities, especially those that support Aceh's exports. The data required for the agro-industry survey and case studies consisted of primary and secondary data. Primary data on the hierarchy of agricultural mainstay commodities and the possibility of agro-industry development were collected through in-depth interviews with key informants. Key informants to be interviewed in-depth include:

1) Head of Dinas/Ka.Subdin of Food Crop Agricultural Production,
2) Head of Service Office/Subdin of Plantation and Forestry Production,
3) Head of Service Office/Subdin of Fisheries and Marine Production;
4) Head of the Office/Subdin of Data and Programs of Trade and Industry.
5) Association of produce exporters
6) Agro-industry players in the North-East Coastal Region of Aceh

Secondary data on actual production, potential production for the development of mainstay commodities, actual agroindustry capacity and potential capacity for development were collected through SKPK reports and agroindustry actors in East Aceh District (around Krueng Geukuh Port). Secondary data were also collected from BPS Aceh and SKPK reports to complement the potential for agroindustry development in this area. The analysis model used is input output mode with the objective variable is the support of agro-industry capacity to the development of Kuala Langsa Port as an export port. The independent variables are, actual production and potential production of agricultural mainstay commodities, product yields and agroindustry raw materials. With a steady state model and a continuous model, a simulation of agro-industry support for Kuala Langsa export growth is made.

The proposed formula is as follows:

$(X11+ X12+.....+ X1n)\ I1 \leq C1$ and $(X21+ X22+.....+ X2n)I2 \leq C(2)$

With :

X11 : Commodity Production Agricultural mainstay (1) actual
X12 : Commodity Production Agricultural mainstay commodity (2) actual
X21 : Potential Product of Agricultural Mainstay Commodity (1)

X22 : Potential Products of Agricultural Mainstay Commodities (2)
I1 : Actual agroindustry technology index
I2 : Potential agro-industry technology index
C1 : Actual port capacity
C2 : Potential port capacity

RESULTS AND DISCUSSION

To support agro-industry in the north-east coast of Aceh, of course, raw materials are needed that are continuously available in sufficient quantities to meet installed capacity. Potential agri-industry raw materials can be sourced from food crop agricultural products, and smallholder plantations. Food crop agriculture in Aceh Province that has the potential to provide agro- industry raw materials are rice, corn, soybeans, peanuts, green beans, cassava and sweet potatoes. Plantation crop products that are the mainstay of this region include: oil palm, coffee, cocoa, coconut and biopharmaca plants. From BPS Aceh data from 2019 to 2024, the production potential is very large. Most of the mainstay commodity production is agricultural products and smallholder plantations. The production of plantation mainstay commodities in six districts that support the Aceh North-East Coast Agroindustry in 2024 amounted to 306,920 tons consisting of five national mainstay commodities and ten regional mainstays. Most of these plantation products 61.4 percent can be processed at east coast agro-industrial sites, which have the potential as agro- industrial raw materials in the North-East Coast Region of Aceh. To see the growth and development trend of plantation production in the previous period. The mainstay plantation production centers that have the best access to the Kuala Langsa port include: Pidie, Pidie Jaya, Biruen, North Aceh, East Aceh, and Aceh Tamiang. These six districts are plantation centers in Aceh Province. During the previous four years, the production development of Aceh's mainstay plantation commodities.

Table 2. Production Development of Aceh's Mainstay Plantation Commodities from 2015 to 2024.

	Production in Year (tons)				
Commodity	2020	2021	2022	2023	2024
Food Crops					
Rice	1,972,000	1,873,400	1,723,528	1,404,235	1,659,966
Corn	287,702	280,510	273,497	266,660	333,324
Soybeans	75,830	73,935	72,086	70,284	87,855
Groundnut	5,769	5,625	5,484	5,347	6,684
Green Mung Beans	2,175	2,121	2,067	2,016	2,520
Cassava	41,469	40,432	39,421	38,435	48,044
Sweet Potato	21,098	20,571	20,056	19,555	24,444
Total Food Production	2,406,043	2,296,592	2,136,140	1,806,532	2,162,837
Plantation Park					
Oil Palm	444,436	705,240	966,044	979,649	971,812
Coffee	73,000	73,419	70,744	75,300	101,020
Rubber	66,671	67,920	69,169	63,854	63,900
Cocoa	34,794	39,296	407,000	38,300	36,600
Coconut	62,832	63,316	63,800	66,400	63,100
Total Plantation Production	681,733	949,191	1,576,757	1,223,503	1,236,432
Biopharmaca					
Ginger	1,506	2,138	2,453	2,769	3,101
Kencur	27,036	26,797	27,275	33,594	21,422
Turmeric	20,056	16,837	23,275	10,398	45,556
Total Biopharmaceutical					
Total	3,136,374	3,291,554	3,765,900	3,076,796	3,469,348

Key informants' views on agro-industry development based on the supporting potential around the Kuala Langsa port. Agro-industries that have developed in the North-East Coast Region of Aceh are mostly plantation and

forestry products. The total raw material from the plantation subsector is approximately 971,812 tons. Palm oil products that are widely produced consist of CPO, Kernel and palm kernel shells. These three types of palm oil products have dominated Aceh's agro-industry products. Coconut products consist of copra, coir and coconut shell charcoal. Exported rubber products consist of latex, lump and crum rubber. Agricultural products of food crops and horticulture consist of rice, corn, soybeans, chili, and tomatoes. Tomatoes are widely produced in the central region of Aceh with good access to East Aceh. So far, grain production in the coastal region of Aceh's tumor, most of which is sent outside Aceh through Medan. It is estimated that Aceh's grain surplus in two harvest seasons ranges from 37 to 42 percent (Aceh Food Crop Agriculture Office, 2025). Thus the supply of grain outside Aceh is approximately 600,000 tons per year. Through grain traders in each production center, ranging from Aceh Besar District to the North-East Coast of Aceh. Likewise, the production of foodstuffs in this region every year is approximately 2,162,837 tons sent outside Aceh. Likewise with horticultural products, some are marketed outside Aceh. The mainstay of horticultural commodities shipped through the east coast of Aceh is almost 800,000 tons per year. The most horticultural products sent outside Aceh include: Chili, Banana Barangan, Potatoes and several types of vegetables. (Aceh Food Crop Agriculture Office, 2025).

These products are shipped outside Aceh in fresh form and it is possible to develop agro- industry in this strategic position. The food crop agro-industry that has developed on the east coast is rice processing, but the operating technology index is still very small (<0.7). This means that there are many other agro-industries that can be developed to generate greater added value. The FGD results illustrate that there are several constraints to the development of agro-industry in food crops and horticulture, including: (a) seasonal products and chaotic production arrangements (b) low quality of human resources, (c) investment security conditions that have not supported the growth of agro-industry. In general, the agro-industrial potential for processing rice flour, animal feed, and sauce factories is very large in the North-East Coast of Aceh. The supply intensity of raw materials for these agro-industries is quite high. Raw materials from potential mainstay commodities from the fisheries subsector, namely: fresh fish products caught from the sea consisting of: tuna, skipjack, grouper and shrimp. All of these types of fish can be developed processing industry. The raw materials for the livestock by- product industry are also quite good, such as the cattle leather industry, bone meal and so on. The people of Aceh in general, and the people of the east coast in particular, have a high consumption of mutton and beef. Thus by-products such as leather and bone can be developed in this livestock- based agro-industrial system.

Potential products are calculated based on average productivity and potential land development. On the basis of average productivity, the calculation of potential products is multiplied by the crop area assuming the utilization of better cultivation technology. Oil palm plants in Aceh still have an average productivity of 4.877 tons per hectare, whereas ideally with better cultivation techniques it can reach 12 tons per hectare per year. This means that the potential product can reach 240 percent of the actual condition. Likewise, the actual cocoa still has an average productivity of 0.444 tons per hectare per year. While the ideal with better cultivation techniques can reach three t i m e s the actual productivity. Especially for plantation crops that are also considered industrial crops, the availability of raw materials to support the development of agro-industry has great potential. If we add to this the potential of the area that can be developed in accordance with the agro-climatic conditions in Aceh, the potential product can reach three times the actual conditions that exist today. With the above assumptions, the FGD results concluded that the potential products of agro-industry raw materials are as described in Table 3 below.

Table 3. Potential Plantation Production of Six Districts Supporting Agroindustry in the North- East Coast of Aceh in 2025.

Plantation	Plantation Area	Actual	Potential Crop	Potential
Cocoa	74,800	33,177	112,200	99,531
Areca nut	36,200	41,220	43,440	82,440
Cloves	22,400	4,189	26,880	8,378
Coffee	121;226	101,020	154,800	128,998
Coconut	9,120	87,311	10,944	174,622

By calculating the increase in crop area and intensification of crop management, the potential production of plantations as agro-industrial raw materials can increase between 185 percent and 225%. This increase is too optimistic, but according to stakeholders this can be achieved if all stakeholders can play their role. If potential plantation products can reach 2,295,209 tons per year, then agroindustry capacity will increase from C1= 0.42 to C2= 0.84. In general, agro- industry operating conditions above 0.75 are very feasible to develop. Some commodities

that are not feasible are pepper, tobacco and cloves. These three commodities experience very large fluctuations caused by several factors, among others:

1) Climate change which greatly affects production
2) Farmer interest is starting to decline, due to substitution with other commodities.
3) Government regulations that do not prioritize these three commodities.

Based on the trend of the last five years and the prediction of potential products, the coefficient of agroindustry development of several mainstay commodities is shown in Table 4 below.

Table 4. Agroindustry Capacity Based on Actual Raw Materials and Potential Raw Materials in the North-East Coast Region of Aceh.

Agroindustry	C1	Actual Production (tons)	C2	Potential Production (tons)
Cocoa	111	36.600	332	109.800
Coffee	137	101.020	275	303.060
Coconut	291	63.100	582	189.300
AI Index	0,28		0,62	

The calculation results show that the development of agro-industry of agricultural mainstay commodities in the north-east coast of Aceh is very feasible to develop with an installed capacity between 0.28 to 0.62 of the availability of raw materials. The greater the index, the sma ller the production round in the industrial process. If the agro-industry index is less than 0.5, it means that raw materials are available as much as 200 percent of the installed industrial capacity. Some commodities that are somewhat sensitive to changes in production are coffee and cocoa. The latex factory that has been installed in East Aceh district has been very sensitive to the decline in rubber productivity in this area. The same applies to the growth of the cocoa industry. Downstreaming of cocoa products has begun in the districts of East Aceh, North Aceh and Pidie Jaya. The growth of this agro-industry is a pull factor for cocoa agribusiness development in this region. Based on the output coefficient for each commodity, the largest is : animal feed made from copra, kernel, and palm oil by-products. While the industry, cocoa, rubber, areca nut, turmeric, and ginger are relatively small, but still greater than one. The complete coefficient results are shown in Table 5 below.

Table 5. Industry Index of Each Agroindustry Capacity in the East Coast Region of Aceh.

Agroindustry	**C1**	**I1**	**C2**	**I2**
Palm Oil	413	1.73	5,239	44.01
Rubber	593	2.49	593	4.98
Cocoa	332	1.39	332	2.79
Coffee	137	1.15	275	2.31
Coconut	582	2.44	582	4.89

Table 5 explains that agro-industrial capacity in the east coast region can reach 13,234 to 18,080 tons per year; the largest industrial capacity required is the animal feed industry. The CPO industry and its by-products (cooking oil, activated charcoal, compost) also strongly support the port of Kuala Langsa and several other locations on the east coast of Aceh. The prospects for agro-industry development in the east coast region of Aceh are examined from various angles, namely: (a) prospects for raw materials, (b) access to development centers, (c) investment feasibility. These three aspects can answer about the agroindustry prospects of superior commodities in this region (Gonzaga et al., 2019; Kain & Verma, 2018). From the angle of availability of raw materials, the prospect of agroindustry is indicated by the index of technology and raw materials. From the index above, the biggest agroindustry prospect is the animal feed industry with an attraction of 22 times the availability of raw materials (corn, soybean, coconut meal, and palm pulp). Likewise, the foodstuff industry from spices with an index of 7; which means that the availability of raw materials is seven times the capacity of agro-industry above 1,600 tons per year. Likewise, access to palm oil FFB raw materials is spread from Biruen District, East Aceh, East Aceh and Aceh Tamiang. Agro-industry locations are also placed with consideration of travel time and road conditions to development centers.

Based on the feasibility of investment, some agro-industry can be analyzed with the criteria Net Present Valu (NPV), Net Benefit Cost Ratio (Net B/C); Internal Rate of Return (IRR) and Pay Back Period (PBP) then seven commodities are very feasible as shown in Table 6.

Table 6. Criteria for Agroindustry Feasibility Investment in the Eastern Region of Aceh.

Agroindustry	Investment Criteria			
	NPV	Net B/C	IRR	PBP (Years)
Oil Palm	1,613,938	1.39	19.39	14
Spices	3,904,801	1.39	21.11	12
Coconut	2,180,304	1.37	20.98	12
Coffee	38,916,889	2.82	34.07	8

CONCLUSION

This study concludes that the development of a special economic zone in the North-East Coast of Aceh is feasible with the priority development of the plantation subsector. The development of this special economic zone is based on the agricultural sector, especially the plantation agro-industry. Therefore, the development of agro-industry in this area will be a leverage factor for economic development and the trade system. The Krueng Geukuh port will be utilized when supported by agro-industrial development in the North-East Coast region of Aceh. Thus agro-industry for the development of export ports has good prospects, both in terms of the availability of raw materials, access to the location of development centers, supporting infrastructure and investment feasibility. The priority of agro-industry development based on its greatest prospects is the plantation industry, spice products, coconut, palm oil and several other regional superior commodities.

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