Planning model of raw materials for seaweed agroindustry in Southeast Sulawesi Province, Indonesia

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Abstract. This study aims to propose a planning model of raw material for seaweed agro-industry in Southeast Sulawesi Province. The analytical methods used are the analysis of raw material and land area requirements, Economic Order Quantity (EOQ) and Reorder Point (ROP) analyses and Exponential Comparison (MPE) analysis. The results showed that seaweed agro-industry in Southeast Sulawesi Province can be developed, because the amount of seaweed produced as agro-industrial raw material for carragenan is higher than the need for agro-industrial raw materials, but it is mainly exported, causing some problems for domestic industries. An Alkali treated cottonii (ATC) production of 14.4 tons per month, or 172.8 tons per year, requires 557424 tons of raw material per year, smaller than the production of seaweed by the Landmark Sulawesi Province, which is 865320 tons per year. Moreover, an economical agro-industrial inventory system is 65693 tons per order, and the reorder point in the procurement of raw materials is when the amount of raw materials in the agro-industrial warehouse amounts to 168.4 tons. The raw material needs for seaweed agro-industry considers continuity and accuracy of supply, followed by quality of raw materials and quantity of raw materials with the model of raw material procurement is the pattern of partnership with farmers as the first priority followed by the pattern of cooperation with cooperatives.
Key Words: inventory system, model, planning, procurement system, raw material.

Introduction. Indonesia, as an archipelagic country with 17504 islands and 81000 km of coastline, has enormous potential and opportunities in the development of marine culture. The strong potential of marine culture is due to large sea areas, estimated at 24.5 million ha, out of which 1.11 million ha are potential areas for seaweed cultivation. The practical water area for the development of seaweed cultivation is estimated at 222180 ha (20% of the potential area), where *Euchema cottonii* is in high demand. *E. cottonii* is one of the most cultivated seaweed species. It has economic benefits because it contains a high amount of polysaccharides, which are a source of carrageenan (Thirumaran & Anantharaman 2009).

Suryaningrum et al (1991) state that, generally, the composition and chemical content of seaweed is influenced by species, life phase, growth rate, and age at harvest. The best quality of carrageenan seaweed *E. cottonii* is when the harvest age is 45 days (Widyastuti 2010), but other authors suggest a longer period, of 52 days (Masthora & Abdiani 2016), or 50 days (Wenno et al 2012; Basmal & Ikasari 2014). The highest yield and viscosity of carrageenan were obtained from *E. cottonii* harvested at 45 days, while the highest gel strength was obtained from yields that were 60 days old. Similarly, Harun et al (2013) states that the best carrageenan produced by *Kappachicus alvareezii* was at 30 day-age of harvest and above. *K. alvarezii* is one of the main commodities in the international market, and Indonesia is an exporter (Kasim et al 2016).

The process of raw material production for seaweed agro-industry at the cultivation level is continuously carried out by coastal communities in most regencies in Southeast Sulawesi Province, Indonesia. The cultivation development program sponsored by the Ministry of Maritime Affairs and Fisheries of Indonesia has been in line with the

Poverty Alleviation Program in coastal areas and small islands carried out by the Department of Fisheries and Maritime Affairs of Southeast Sulawesi Province, Indonesia. Moreover, the procurement of seaweed seeds for certified cultivation has been carried out since 2016. All these activities require integrated efforts, especially in the processing of an agro-industry. Processing seaweed in an agro-industry to produce advanced seaweed products in the form of carrageenan can be a leveraging point for the economic development of coastal communities. Muthalib et al (2017) state that the development of the seaweed business, in addition to increasing the production and productivity of seaweed, is also very important in increasing the income and standard of living of the people.

Seaweed agroindustry that processes dried seaweed into carrageenan products, such as alkali treated cottonii (ATC), semi refined carrageenan (SRC) and refined carrageenan (RC) requires sufficient raw materials in quality, quantity and continuity. The raw materials needed for seaweed agro-industry are largely determined by the production capacity of an agro-industry. The production capacity is the ability of a business to obtain results within a certain period of time and with certain technologies. The production capacity for small, medium and large scale agro-industries is influenced by their ability to process raw materials and the level of technology used (Mustam 2005). In determining a production capacity, it is important to conduct a production chain analysis, so that the number of products needed by the market can be adjusted to the amount of production, processing, cultivation methods and area of cultivation and to determine the sustainability of raw material supplies and the sustainability of the agro-industrial production process (Mustam 2005; Citraresmi & Azizah 2019).

One of the problems of seaweed agro-industry is that there is no guarantee of raw material (seaweed) in quantity, time or price. Currently, there is a struggle for traders, exporters and processing agro-industries. This condition causes fluctuations and uncertainty regarding the price of seaweed, a factor on which cultivators rely. In addition, the supply of raw materials for industrial needs is not guaranteed, so there is often a lack of supply of agro-industrial raw materials (Rahman 1999). The domestic seaweed processing industry is currently producing with an average idle capacity of 26% for *E. cottonii*, 20% for *Gracillaria*, and 40% for *Spinosum*. One of the causes of idle capacity is the competition for seaweed raw materials with export traders (Trade Policy Research and Development Agency Ministry of Trade 2014).

Based on these problems, the domestic seaweed processing agro-industry, especially in Southeast Sulawesi Province, must have a good plan in the procurement of raw materials, so that the agro-industry can have a planned production. Based on this, the goal of this study is to analyze the planning model for seaweed agro-industrial raw materials in Southeast Sulawesi Province.

Material and Method. This research was conducted in 2019 in Southeast Sulawesi Province with a focus on 4 regencies as seaweed centers, namely North Konawe Regency, South Konawe Regency, Bombana Regency and Muna Regency.

Data in this study were obtained through field surveys and interviews with experts. The field surveys were carried out through observation of cultivation activities. Observation activities were conducted by visiting the processing and trading units to determine the pattern of seaweed marketing transactions. Interviews were conducted in depth with experts (local government, research institutions/universities representatives and practitioners who were considered aware of the problems related to seaweed development).

The raw material planning model includes the procurement of raw materials, the area of cultivated land, and the raw material inventory system. The data analysis process was carried out using DSS-A (Decission Support System-Agroindustry) software.

The system of raw material requirements (KBB) and land area requirements (KLL) were analyzed using the following formulas:

$$KBB = KP/(R\text{-}ATC)$$

KLL = (PRB-NK/PRB)/PB

Where: KBB - raw material requirements; KP - production capacity; R-ATC - ATC yield (the percentage value comparison between the ATC values - output - to dry seaweed - input); KLL - land requirement; NK - conversion value (wet seaweed to dried seaweed).

The raw material inventory system was analyzed using the Economic Order Quantity (EOQ) and the Reorder Point (ROP), as follows:

EOQ = √(2xDxS/H)

ROP = (dxL)xSS

Where: D - order fees per order; S - cost of storage per year; H - total save cost per unit; d - use of raw materials per day; L - order waiting time; SS - safety stock.

The raw material procurement system was analyzed using the Exponential Comparison Method (MPE). The formulation of the score calculation for each alternative in the exponential comparison method was as follows:

$$TN_i = \sum_{n=1}^{m} (RK_{ij})^{TKK_j}$$

Where: TNi - total alternative value i; RKij - degree of importance of the j^{th} relative criteria in the choice of decision i; TKKj - degree of importance of the j^{th} relative criteria, TKKj>0; n - number of decision choices; m - number of decision criteria.

The steps in making a decision are: (1) alternative decision-making; (2) the preparation of the decision criteria to be studied; (3) the determination of the relative importance of each decision criterion by using a particular conversion scale as per the decision-making requirement; (4) determining the degree of relative importance of each alternative decision; and (5) rating the value derived from each alternative decision.

Results and Discussion. The agro-industry raw material planning model was divided in 3 systems, namely: the determination of raw material requirements and the area of cultivated land, the raw material inventory system, and the procurement of raw materials.

System for raw material requirements and cultivation area. The main problem faced by the carrageenan agro-industry is the lack of availability of seaweed raw materials for the domestic industry. The scarcity of seaweed raw materials for domestic industries is thought to be caused by high exports in the form of dried seaweed (raw material) (Ministry of Industry 2019). Anggadireja et al (2011) stated that 80% of *E. cottonii* seaweed production is exported in dried form as raw material for the carrageenan industry abroad.

The system of raw material requirements was built to overcome the problem of uncertainty about the amount of raw seaweed available, and to create a balance between the availability of raw materials and the existing agro-industrial production capacity. This is because the guarantee of supply of raw materials is one of the factors driving the development of seaweed agro-industry. The determination of raw material requirements is also carried out to determine the sustainability of raw material supplies and the sustainability of the agro-industrial production process. Citraresmi & Azizah (2019) state that in order to avoid problems in the procurement of raw materials that can affect company profits, the company must maintain the availability of raw materials in accordance with the quantity and quality required by the company. Based on the survey results, the marketing chain of seaweed produced in Southeast Sulawesi Province is presented in Figure 1.

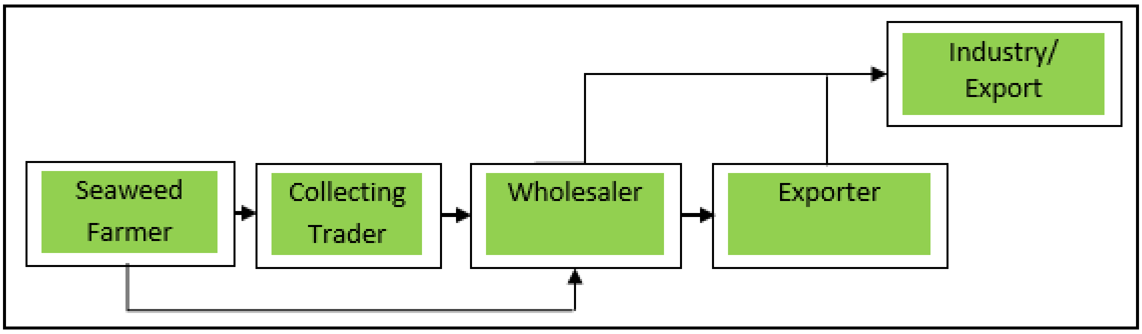

Figure 1. Seaweed marketing chain in Southeast Sulawesi Province.

The raw material supply system was studied to determine the sustainability of raw material supplies and the sustainability of the agro-industrial production process. For agro-industry sustainability related to the supply of raw materials, seaweed production at the level of farmers must also receive attention, so that the farmer production capacity can be stable. The calculation in determining the raw material needs for seaweed agro-industry was carried out based on data from respondents who are the managers of the seaweed agro-industry. The ATC production produced by the agro-industry according to its production capacity is 14.4 tons per month and the yield of seaweed processed into ATC is at an average of 31%. This 31% yield is similar to the number of the Indonesian Ministry of Marine and Fishery's Directorate of Fishery (2016), which states that the yield of dry seaweed to ATC is 31.5%. The results of the analysis using the need for raw materials showed that in producing 14.4 tons of ATC per month, the need for raw materials for agro-industry in the form of dry seaweed was 46.452 tons per month or 1.935 tons per day. If the seaweed farmers use the method of cultivation with longline or long ropes with wet seaweed productivity of 8720 kg per ha in a production cycle, or 34880 tons per year with 4 harvests per year, the area of land that must be cultivated is 128 ha.

The area of seaweed cultivation in Southeast Sulawesi Province and in each of the regency seaweed centers experienced changes that will affect the amount of seaweed production in general. The data shows that the proportion of land use for seaweed cultivation is dominated by longline seaweed cultivation with *E. cottonii*. The average area of seaweed cultivation by the community is 1 to 2 ha. The production of agro-industrial raw materials (seaweed) by farmers generally experiences problems in the form of reduced production during the peak of the rainy season and the peak of the dry season. Therefore, agro-industries are required to have adequate or minimum storage of raw materials capable of meeting production needs for 3 months.

Raw material inventory system. Designing a model of raw material inventory for seaweed processing agro-industry was carried out to ensure the minimum necessary raw material supply at a low cost. Raw material planning using the EOQ method will help prevent the situation in which there is no stock, so that it does not interfere with the processes of agro-industry, and minimize storage costs and storage warehouse space. The results of the seaweed processing agro-industry EOQ show that the amount of economic agro-industry raw material purchases is 65693 tons per order, assuming that the agro-industry raw material needs are 38710 kg per month, ordering costs are 138.9 USD per order or 3.59 USD per ton of raw materials, and storage costs are 333.5 USD per package of the number of raw materials or 10.77 USD per ton of raw material.

After the determination of the economic quantity of raw material purchases was carried out, a ROP analysis was conducted to determine the reorder point. The results of the analysis show that the reorder point that agro-industries must carry out in the procurement of raw materials should take place when the amount of raw materials in the agro-industrial warehouse amounts to 168.387 tons. This result was obtained with the assumption that the need for raw materials per day is 1935 kg, based on the calculation of the need for agro-industrial raw materials, the waiting time for ordering raw materials is 15 days, obtained from the estimated time needed in the process of shipping dry seaweed as agro-industrial raw materials from the cultivator or trader location to the agro-industry after ordering, and stock safety is 139.355 tons, the amount of agro-industrial raw materials for the production process for 3 months. According to respondents who are owners of the agro-industry, the seaweed processing agro-industry must have a minimum supply of raw materials to meet the production process for 3 months, to anticipate the failure of the seaweed harvest at the cultivation level, which will impact the inhibition of material supply of agro-industrial raw material. This result also illustrates that the agro-industry must reorder raw materials when the remaining raw materials are 29032 tons outside the safety stock. The ROP for the seaweed processing agro-industry is presented in Figure 2.

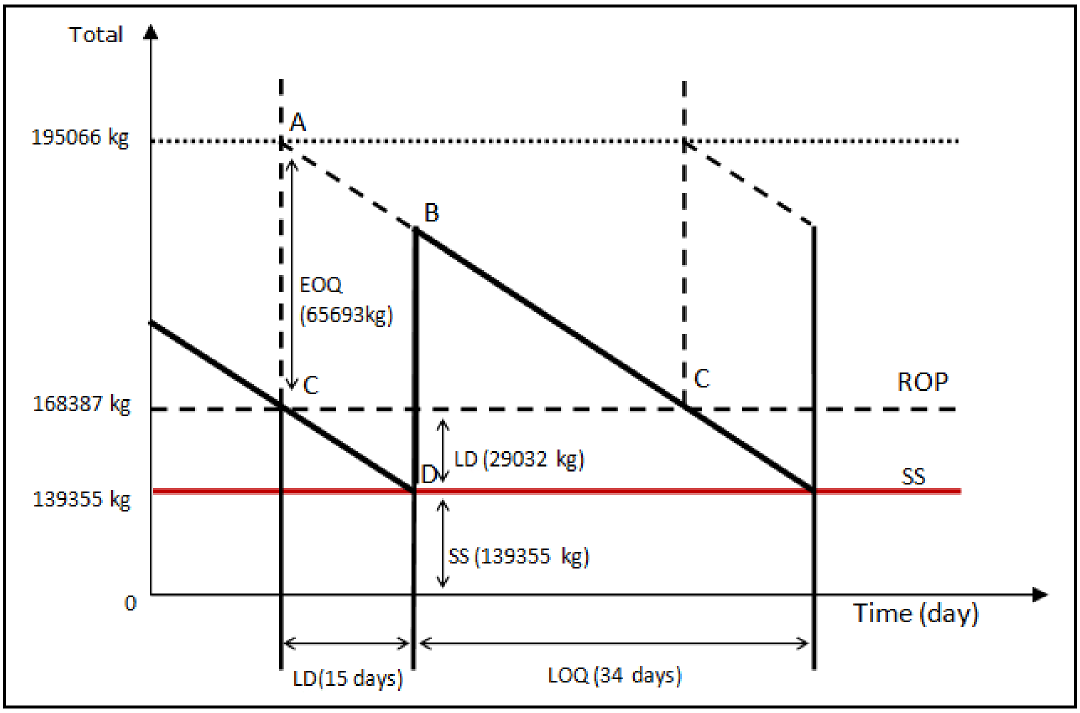

Figure 2. Points of reordering raw materials for seaweed agro-industry. A-C - number of orders requested; B-D - number of orders that have arrived; LD - lead time demand (number of uses while waiting for an order); SS - safety stock; LOQ - life of the order quantity (the time a material is ordered); ROP - reorder point; EOQ - economic order quantity.

Raw material procurement system. The raw material procurement system for seaweed agro-industry was analyzed using 5 criteria. Based on the results of the weighting analysis of these criteria, the alternative priority of raw material procurement was calculated using 5 alternatives (Tables 1 and 2). Table 1 shows the results of the priority analysis of criteria in the agro-industry raw material procurement system in Southeast Sulawesi Province.

Table 1

Priority analysis of criteria for the agro-industry raw material procurement system

No	*Criteria*	*Weight*	*Priority*
1	Continuity and accuracy of supply	0.3451	1
2	Quality of raw materials	0.3274	2
3	Raw material quantity	0.1947	3
4	Price of raw materials	0.0796	4
5	Ease of acquisition	0.0531	5

Table 2 shows that the main consideration in meeting the needs of raw materials for seaweed agro-industry should be given to continuity and accuracy of the supply of raw materials with a weight of 0.3274, followed by the quality of raw materials with 0.3274 and the quantity of raw materials with 0.1947. Suprapto (1997) states that the sustainability of agro-industry is closely related to the sustainability of the raw material supply. The lack of supply also affects the loss of opportunities in adding value from agro-industry.

The sustainability of seaweed processing agro-industries and investment decisions are determined by the quality assurance, quantity and continuity, patterns of distribution of raw materials, production processes, markets, business capital, and guarantees for businesses (regulation). Its development strategy can be pursued through mapping and structuring cultivation areas, developing business systems within the area, institutional strengthening and empowerment of farmers (Foster & Burt 1992).

The results of the MPE analysis of raw material procurement priorities of the seaweed agro-industry show that the main priority is a partnership pattern with a value of 6.3471, followed by a pattern of cooperation with cooperatives and the purchase of raw materials from traders/suppliers, with values of 6.7960 and 6.7701, respectively (Table 2).

Table 2

Alternative priorities for the raw material procurement system in seaweed agroindustry

No	*Alternative*	*Value*	*Priorities*
1	Business partnership	6.9862	1
2	Cooperation with cooperatives	6.7960	2
3	Purchases from the suppliers/traders	6.7701	3
4	Buy directly from the cultivator	6.3539	4
5	Free purchase	6.3471	5

The partnership pattern chosen in the procurement of raw materials suggests that seaweed farmers can form cooperatives or form joint business groups, which can then partner with the agro-industry. Neish (2007) states that for the empowering of seaweed cultivators, farmers can create a joint business group (KUB) that could play a role in trading, including marketing, and could even act as an exporter.

Partnership and cooperation are a necessity for agro-industries based on fishery commodities because fishery products are generally seasonal, so that the sustainability of fishery agro-industries is closely related to the sustainability of raw material supply (DEFRA 2006; Setthasakko 2007). Van der Vorst (2004) stated that each company is positioned in a network and involved in at least one supply chain, so that at one time a parallel process can occur. With the certainty of price and certainty of the seaweed market, farmers can be more protected from losses.

Institutional formation at the level of seaweed farmers in terms of providing raw materials for agro-industry, as well as in the form of cooperatives, is certainly not easy. This is caused by the close relationship between farmers and local collectors with a high level of trust. Nuryadi et al (2017) illustrate the close relationship between seaweed traders and cultivators and the inter-institutional linkages in the seaweed agribusiness system (Figure 3).

Azis (2011) and Neish (2007) state that 60-70% of seaweed cultivators in Indonesia have a binding relationship with inter-island traders. Seaweed cultivators find it easy to obtain capital from collectors and inter-island traders for the cost of seeds, production facilities and for other needs such as education for children and medical problems. Therefore, the pattern of partnerships in the procurement of agro-industrial raw materials can be done through partnerships with local collecting traders (Table 2), which places the procurement of raw materials at traders/suppliers as the 3rd priority.

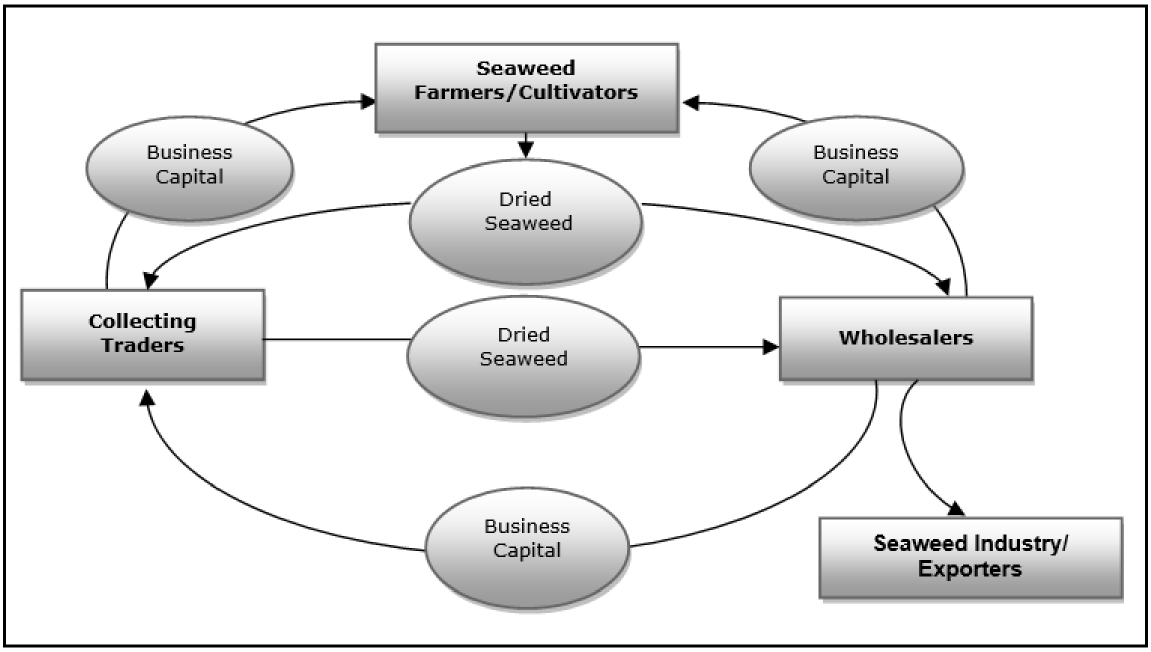

Figure 3. The seaweed agribusiness system (Nuryadi et al 2017).

The partnership pattern can be maximized by entering into cooperation agreements and providing education or improving the quality of human resources for each party that cooperates with farmers, cooperatives, traders and agro-industries. Limi et al (2018) and Nuryadi et al (2019) state that in the development of seaweed agribusiness, it is necessary to strengthen the position of seaweed cultivation actors through the establishment of agro-industry, simplifying marketing chains, providing capital from cooperatives and banks, as well as training and coaching from universities and the government. In addition, the training and development of human resources are needed in increasing skills and expertise in the process of seaweed cultivation in an agroindustry, because the expertise acquired by labor is a capital for workers (van den Brink & van der Woerd 2004; Bhattacharya et al 2005). Labor skills emerge as important indicators on social aspects, having a real influence on business or industry performance (Andrew 1999; DEFRA 2006; Ashton et al 2008).

The education of collectors or cooperatives is also one of the strategic steps, because traders and cooperatives have close relationships and often interact with farmers as the main parties in providing agro-industrial raw materials. These traders can ensure the quality of seaweed as an agro-industrial raw material. Mulyati & Geldermann (2017) state that educating and training the suitable seaweed farmers is an important job for traders and cooperatives. If the quality of human resources for each component related to the provision of agro-industrial raw materials would function properly, seaweed agro-industry could have a better production in terms of quantity, quality and continuity. Then the agro-industry would be competitive.

Porter (1998), Waits (2000) and the World Bank (2002) state that industrial organizations are very useful in responding to the challenges of globalization, technological development, demands for decentralization. They also encourage the formation of a network of production and distribution activities and increase the competitive advantage of an industry. To improve competitiveness, efforts should be made to increase promotion of products produced by agro-industries, both domestically and abroad, improve product quality, encourage banks to facilitate access to capital, and improve infrastructure development (Natalia & Nurozy 2012).

Conclusions. The seaweed agro-industry in Southeast Sulawesi Province has the potential to be developed. The seaweed agro-industry produces alkali treated cottonii with a production capacity of 14.4 tons per month or 172.8 tons per year, requiring

557424 tons of raw material per year, less than the production of seaweed produced by the Landmark Sulawesi Province (865320 tons per year). The economical agro-industrial raw material inventory system amounts to 65693 tons per order, and the reorder point in the procurement of raw materials is when the amount of raw materials in the agro-industrial warehouse is 168.387 tons. The fulfillment of seaweed agro-industry raw material needs depends on continuity and accuracy of supply, followed by quality and quantity of raw materials. The model of raw material procurement shows the pattern of partnerships with farmers as the first priority, followed by the pattern of cooperation with cooperatives.

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