Analysis of specific agricultural commodity supply chain modelling in Indonesia

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Chapter 1

ANALYSIS OF SPECIFIC AGRICULTURAL COMMODITY SUPPLY CHAIN MODELLING IN INDONESIA

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ABSTRACT

This paper offers an analysis of Supply Chain Modelling studies for three specific agricultural commodities in Indonesia, palm oil, cacao and kenaf. The three commodities have similar and different characteristics.

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The aim of this paper is to discuss how researchers, working on the three different commodities, attempted to develop models using different environments and goals. Next researchers delved into the nature of research techniques and methods used to identify what aspects can be learned from each so that in future studies they can either collaborate or make use of the techniques/methods to conduct researches with better results. Initially each researcher discussed the nature of the industry, goals and approaches, comparing methods and outcomes of the simulation. After all, modelling always follows similar if not the same steps. While there is no perfect generic model of the supply chain, especially in the agricultural business, there is always an opportunity to improve the quality of models in terms of their usability by the supply chain actors. The first two models made use of the combined agent-based fuzzy-AHP approach while the third made use of the soft system methodology and sought to develop an intelligent decision making tool to assist the farmers in order to optimize their added value and measure performances. Readers of this paper will find that interaction and collaboration between the three studies will reveal ways to fine tune their research techniques and methods that will benefit future endeavours.

Keywords: research collaboration, soft system methodology, agent-based modelling, intelligent decision making, agricultural supply chain, fuzzy-AHP

1. INTRODUCTION

Management goals in organizations everywhere are to improve overall performance. In order to achieve this goal, management considers Supply Chain Management (SCM) as one of the important areas that can be improved upon. SCM has been considered an important and popular area of research by experts and academicians. Supply Chains (SC) include raw materials, semi-finished or finished products and transfer of products to warehouses, covering the entire lifecycle of product (Pasi, Mahajan, & Rane, 2020). A Supply Chain is a group of interdependent companies operating in sequence that cooperate in handling, improving and controlling the flow of goods, money and information beginning with suppliers in the upstream all the way downstream to the consumer

(Preckel, Gray, Boehlje, & Kim, 2004); (Van Der Vorst, 2006). Principal roles of the Supply Chains are to add value to products by moving them from one location to another, or to perform modification processes (Janvier, 2008). Value adding changes to the process are applied to quality, costs, delivery activities, flexibilities in shipping products, and innovations (Trienekens, 2011) to improve profitability.

This paper offers an analysis of Supply Chain Modelling studies for three specific agricultural commodities in Indonesia, palm oil, cacao and kenaf. The three commodities have similar and different characteristics. The aim of this paper is to discuss how researchers, working on the three different commodities, attempted to develop models using different environments and goals. Next researchers delved into the nature of research techniques and methods used to identify what aspects can be learned from each so that in future studies they can either collaborate or make use of the techniques/methods to conduct researches with better results.

Initially each researcher discussed the nature of the industry, goals and approaches, comparing methods and outcomes of the simulation. After all, modelling always follows similar if not the same steps. While there is no perfect or generic model for a supply chain, especially in the agricultural business, there is always an opportunity to improve the quality of models in terms of their usability by the supply chain actors. However business model developments are considered to be lagging behind in practice, due to a lack of formalization and structure. The question arises, what are business models made of?

We contend that business models are composed of two different sets of elements: (a) concrete choices made by management about how an organization must operate, and (b) what are the consequences of those choices including but not limited to compensation practices, procurement contracts, location of facilities, assets employed, extent of vertical integration, and sales and marketing initiatives. Every choice has some consequences: for example, offering high level incentives (a choice) has implications regarding the willingness of employees to exert effort or to cooperate with co-workers (consequences) (Casadesus-Masanell & Ricart, 2010).

The first two models made use of the combined agent based fuzzy-AHP method while the third made use of the soft system methodology and sought to develop an intelligent decision making tool to assist farmers in optimizing their added value and measure performances.

2. Nature of the Industry

2.1. Palm Oil

One of the most important supply chains in Indonesia is for palm oil. Palm oil is not a native plant to Indonesia. Palm trees were imported to Indonesia from West Africa in 1848. The first commercial palm oil plantation was set up in Sumatra with operations starting in 1911. Since that time, Indonesian palm oil estates have grown to become the largest producer of crude palm oil (CPO) in the world. Three main products produced from palm oil are frying oil, margarine, and soap with several other by-products.

Table 1. Palm Oil Products Exported from Indonesia 2010 - 2019

Year	CPO		Palm Kernel	
	Volume	Value	Volume	Value
	Tons	US$ 000	Tons	US$ 000
2010	16,291,856	13,468,966	1,572,286	1,727,693
2011	16,436,202	17,261,248	1,442,666	2,113,877
2012	18,845,020	17,602,168	1,460,374	1,510,486
2013	20,577,976	15,838,850	1,644,532	1,301,596
2014	22,892,224	17,464,754	1,479,833	1,540,690
2015	26,467,564	15,385,275	1,819,307	1,565,685
2016	22,761,814	14,366,754	1,576,490	1,910,524
2017	27,353,337	14,366,754	1,717,595	2,211,339
2018	27,898,875	16,530,212	1,772,904	1,701,531
2019	28,279,350	14,716,275	1,937,238	1,268,634

Table 1 and 2 illustrates how important palm oil is to Indonesia (BPS Statistics Indonesia, 2019). Export of palm oil and palm kernels have increased yearly. In 2019 the CPO export volume was 28.2 million tons, an increase of 5% and palm kernel oil export was 1.94 million tons, an increase of 9.3% compared to 2018. Biodiesel product does not offer an attractive profit. Government policies requires the biodiesel to be produced from palm kernals as an alternative to meeting fuel demands for use in public and private vehicles. This is necessary due to dwindling oil reserves which are not renewable, potentially causing an energy crisis in the near future (Rahmawati, Noor, & Zakir, 2016).

Table 2. Indonesian Biodiesel Oil Production and Uses (M-tonnes)

Year	Production	Domestic	Export	Domestic Growth	Blending Rate
2014	3.32	1.55	1.37	0.67	B10
2015	1.39	0.77	0.28	-0.78	B10
2016	3.07	2.52	0.4	1.76	B10
2017	2.87	2.16	0.16	-0.37	B10
2018	5.17	3.15	1.51	0.99	B20
2019	7.04	5.36	1.11	2.22	B20
2020	8.47	8.05	0.42	-2.69	B30

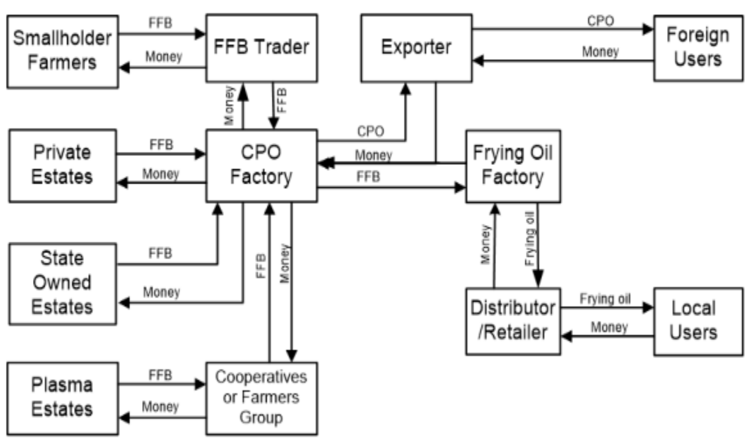

Figure 1. Typical palm oil supply chain in Indonesia (Hidayat, Marimin, Suryani, Sukardi, & Yani, 2012).

Figure 1 shows a typical palm oil supply chain (POSC) in Indonesia. Each multiple actor is represented by a single group. Smallholder farmers, plasma estates and core estates are represented by farmers. Exporters, distributors and retailers are represented by distributors.

Due to monopsonistic conditions, palm oil farmers' bargaining power was low. CAO in 2009 reported difficult conditions for small farmers resulting in low productivity and profit per hectare compared to very high profits per hectare for large estates. Small farmers lack of opportunities to access financial and technical support, and minimum representation in the supply chain decision making processes contributed to this condition.

2.2. Cacao

Indonesia is the third largest cacao producer and exporter in the world after Ghana and Ivory Coast (BPS, 2020). Cacao was first introduced in Indonesia by the Spanish in 1560, in Minahasa, Celebes (now Sulawesi). Cacao pods ripen and are ready for harvest after 5 - 6 months (Wahyudi, Panggabean, & Pujiyanto, 2009). Foreign buyers preference for Indonesian cacao is largely because it does not melt easily at room temperature, making cacao more suitable for blending (Suprapti, Dase, Lopies, Djamaluddin, & Masuri, 2013).

Supply chain for the cacao agro-industry is fairly long. Cacao is produced by farmers, the most common upstream industrial group, who process cacao pods into dry beans. Main consumers of cacao beans are the intermediate cacao industry or grinding industry. The Grinding Industry Group (GIG) converts cacao beans into intermediate products such as cacao liquor, cacao butter and cacao powder.

Dried cacao beans are processed into cacao powder and cacao butter. Rosniati, Yunus, & Duma, 2013 states that to manufacture 3920 kg of chocolate candy, 1170 kg of cacao liquor and 741 kg of cacao butter is required. Based on results of the conversion, it takes 1519.5 kg of cacao to produce 1170 kg of cacao liquor and to make 741 kg of cacao butter, 2359.10 kg cacao liquor or 3063.81 kg cacao are required. It can be further simplified that from 10.13 kg of dry cacao beans, 7.8 cacao liquor can be produced which can then be processed into 2.45 kg cacao butter and 4.77 kg cacao powder as shown in Figure 2.

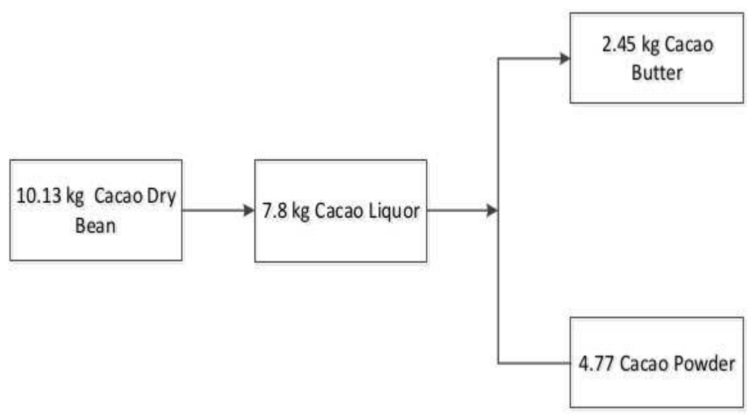

Figure 2. The cacao conversion process (Mulato et al., 2004).

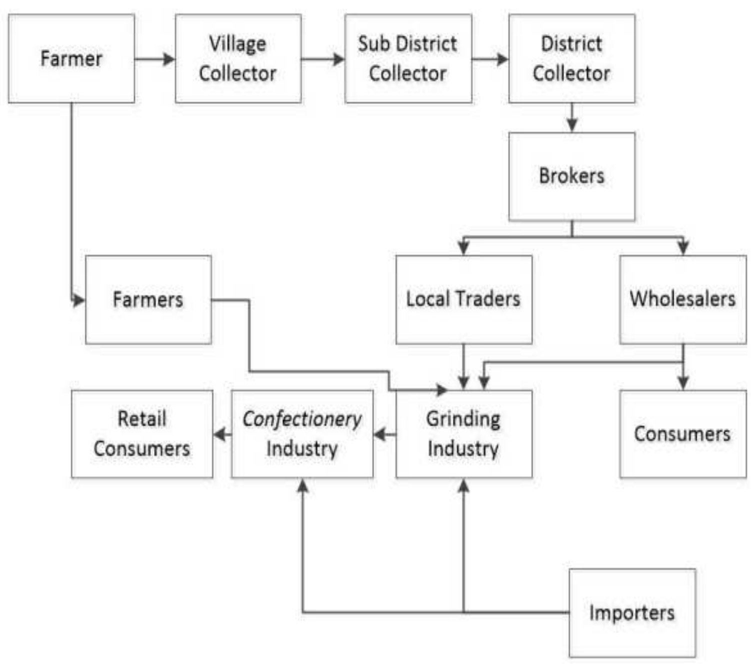

Figure 3. Cacao supply chain in Larompong, Sulawesi.

Products from the grinding industry are sent downstream to be processed into food and beverages such as chocolate candy bars, chocolate powder milk, dry bread, ice cream, biscuits and so on. Cacao intermediate products are also used as raw material in the pharmaceutical and cosmetic industries, including soap, lipstick, skin moisturizer and so on.

The cacao agro-industry supply chain in each region has different paths. Figure 3 illustrates the cacao agro-industry supply chain in Larompong Village, South Sulawesi. It shows that the distribution line from farmers to the grinding industry is very long, resulting in high distribution costs reducing farmers profits.

Most of Indonesia's cacao production is exported with the remaining products marketed domestically. Indonesia's cacao exports span five geographical areas, Asia, America, Europe, Africa and Australia with a major share exported throughout Asia. In 2019, the top five importing countries for Indonesian cacao were Malaysia, America, India, China and The Netherlands. Volume of exports to Malaysia reached 80.59 thousand tons or 22.48 percent of the total export volume. The second largest volume was exported to the United States, shipping 61.77 thousand tons or 17.23 percent, a value of USD 285.68 million. India was the third largest importer buying 28.85 thousand tons.

2.3. Kenaf

Growth of the natural fibre processing industries in the world is perceived to be the most important of the three (Jose, Salim, & Ammayappan, 2016). This is believed to be the case because natural fibre, as a renewable raw material, is abundantly available in nature and exhibits a high toughness (Dunne, Desai, Sadiku, & Jayaramudu, 2016) potentially reducing a product's weight resulting in energy savings, reduced production costs, and improved appearance of the product's surface (Global Materials Teams, 2011). Moreover, people's awareness of environmental sustainability has grown globally.

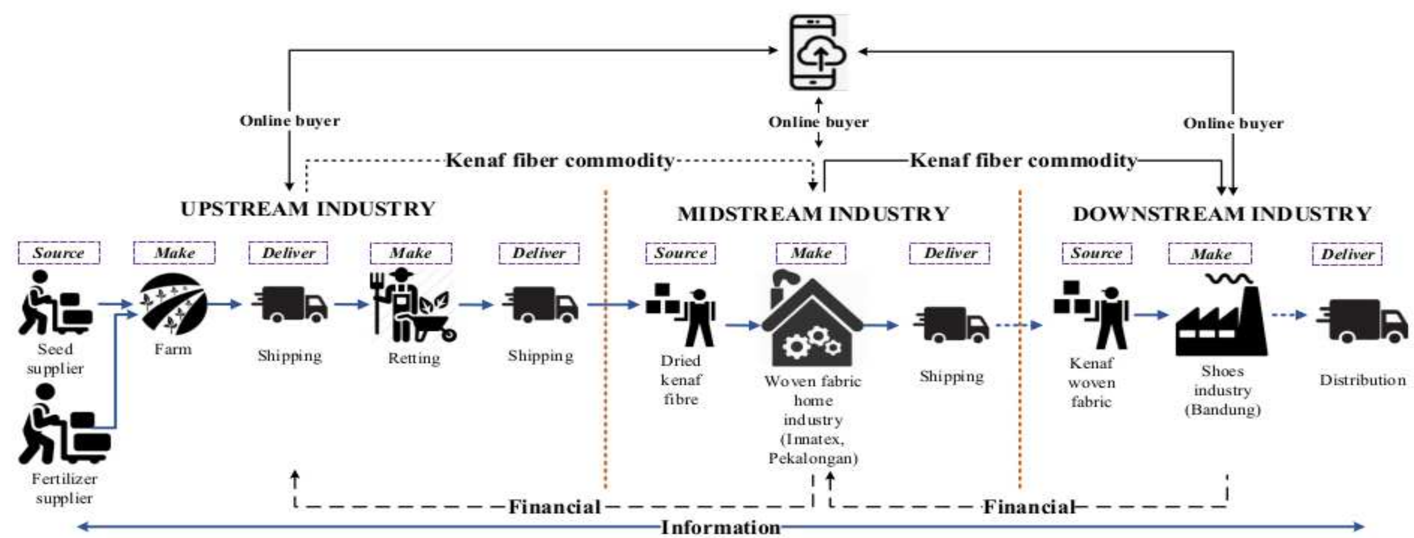

Figure 4. Kenaf fibre supply chain in Indonesia.

Comparison between consumption and production levels of natural fibre in Indonesia resulted in a gap between supply and demand by 90.38% (Global Materials Teams, 2011). Only 9.62% of the kenaf fibre demand in Indonesia is produced domestically while exporting 90.38%. Kenaf, sisal, jute, coir, flax, abaca, and cotton are types of natural fibre documented by Food and Agriculture Organization ([FAO] Food and Agriculture Organization, 2019). FAO recorded the amount of natural fibre imported to Indonesia from 2010 to 2015 ([FAO] Food and Agriculture Organization, 2019). The largest import of kenaf was cotton fibre 648.09 thousand tonnes/year (Gossypium irsutum L.), followed by kenaf fibre (Hibiscus cannabinus L.) averaging 31.12 thousand tonnes/year. Other fibres were imported but in small quantities.

Figure 4 illustrates a typical kenaf supply chain in Indonesia from upstream to downstream with product sales conducted online (Nurhasanah, Machfud, Mangunwidjaja, & Romli, 2020). Stakeholders in upstream companies are owners, company general managers in the middle industries and online buyers at the market place. Level of demand for kenaf dried fibre, from uncertain online buyers is predicted by the artificial intelligence network, while the level of demand from intermediate industries is predicted by a fuzzy approach. This is the importance of the upstream industry in becoming users of the Intelligent Decision Support System (IDSS) platform. Midstream industries use this platform to share information on their inventory levels, so that upstream industries will be alerted if the midstream industries inventory levels have reached the reorder point. This information flow can be received quickly and sent back in a timely manner to be used by the upstream and midstream industries to plan their operations more efficiently. However this can only be of benefit to all users if there is a system that supports the decision-making process. On the basis of this needs analysis, the midstream industry is assigned to be the user in this IDSS blueprint.

2.4. Similarities and Differences between All Three Commodities in Terms of Product Characteristics

- All three commodities are agricultural products. Palm oil and cacao are found in food products people use on a daily basis. Palm oil is used to produce products like frying oil and margarine, and in products used daily such as cleaning soaps and detergents. Palm oil is also the main ingredient used to produce bio diesel and some pharmaceutical products.
- All three products are not processed by a single actor, but require sequential processing to produce the end products to be consumed or used.
- Although kenaf belongs to the agricultural group, it's not a food type but is used to make furnishing components and car interior parts.
- Demand for palm oil and cacao has been increasing every year as the population and the requirement for food increases.
- Differences between all three:
    - Cacao and palm oil plants are grown in large multiyear estates, harvested multiple times a year and does not require replanting oevery time.
    - Kenaf is a seasonal crop which is harvested less than a year after planted. Once harvested the ground is replanted with new seedlings in order for the next crop cycle to grow.

3. Goals and Approaches

3.1. Palm Oil

The business scale of each POSC actor is different from each other. Risks faced by each actor are different in type and level.

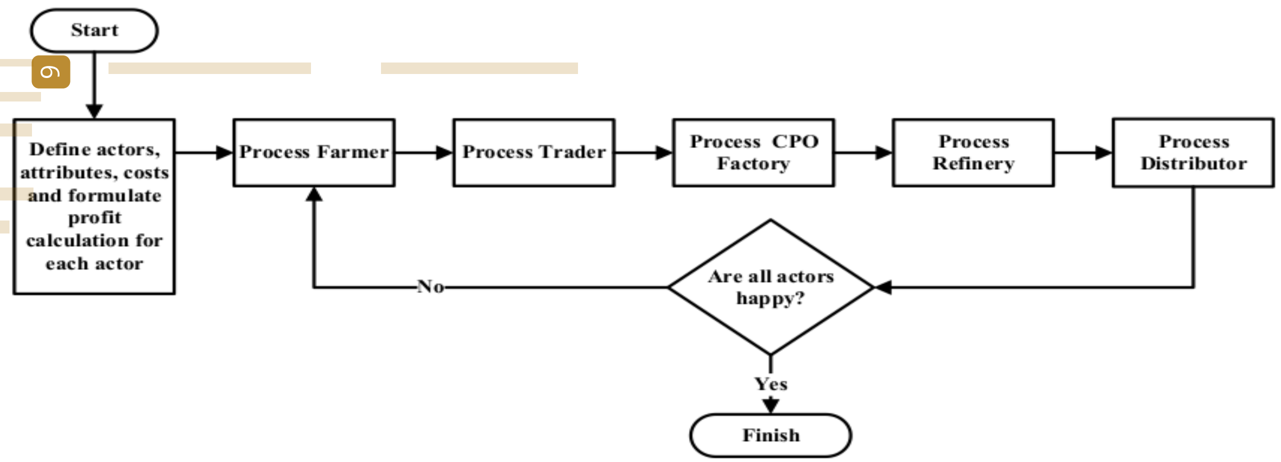

Figure 5. Overall negotiation process in the POSC.

Investment and technology employed by each actor is also at different levels. These three factors influence the opportunity to create added value for each actor. The added value created by each actor helps increase the total added value for the overall supply chain.

Objective of the study on POSC is to design a model to simulate the interactive and negotiation behaviour of POSC actors, and to facilitate optimum fair distribution of the added value for each actor, while considering successive investment, risk, and technology levels. To achieve this objective, implementation of a stakeholder dialogue negotiation procedure was conducted as shown in Figure 5. It starts by ensuring each actor has a fair added value. Afterwards the process is conducted for all actors simultaneously to ensure everyone in the group is happy and onboard.

Agent-based approach was selected as it provides the best means to study supply chain actors (or agents) behaviour and their interaction. This study design is a utility added value model based on the level and weight of risks, investment, and technology faced or employed by the POSC actors.

3.2. Cacao

The cacao supply chain study was conducted over a four year period from 2014 to 2017. Updates were included and new methods were inserted into this report where appropriate. The general objective of cacao research is to design a sustainable cacao agro-industrial supply chain model using a smart system. The specific objectives of this research are:

a. Designing supply chain institutions for the cacao agro-industry in Larompong District, Luwu Regency, South Sulawesi.
b. Designing proposed strategies to increase the sustainability of the environmental dimension.
c. Design a fair profit distribution model.

3.3. Kenaf

The study on kenaf was conducted from 2019 – 2021. The main objective of this study is to design an intelligent supply chain model for the natural fibre agro-industry. In order to achieve the goal, 3 sub models were developed that addressed research questions, i.e., (1) Developing a sub model of collaboration among actors in the supply chain of natural fibre agro-industry, (2) Designing a sub-model of integrated production and inventory planning in supply chain of natural fibre agro-industry, and (3) Developing a sub model for improvement in supply chain performance of natural fibre agro-industry.

4. Modelling Methods

4.1. Palm Oil

Fuzzy AHP and Agent-based methods were selected as they provide the best means to study the supply chain actors (agents) behaviour and their interaction. Scope of this chapter is to focus on the POSC beginning with farmer groups, traders, crude palm oil (CPO) factories, frying oil factories (refineries), and frying oil distributors. To achieve this objective some theories, methodologies, and models are utilized.

Figure 6 shows the framework of the palm oil supply chain model. Preparation and literature study starts the supply chain process. Questionnaires were developed to collect data from the field. Data for this model was obtained from POSC actors in palm oil estates, factories and traders in some parts of Sumatera and Java. Validation was conducted by interviews with relevant decision makers and academicians, while verification was done by running the simulation model with an expert Netlogo analyst/programmer.

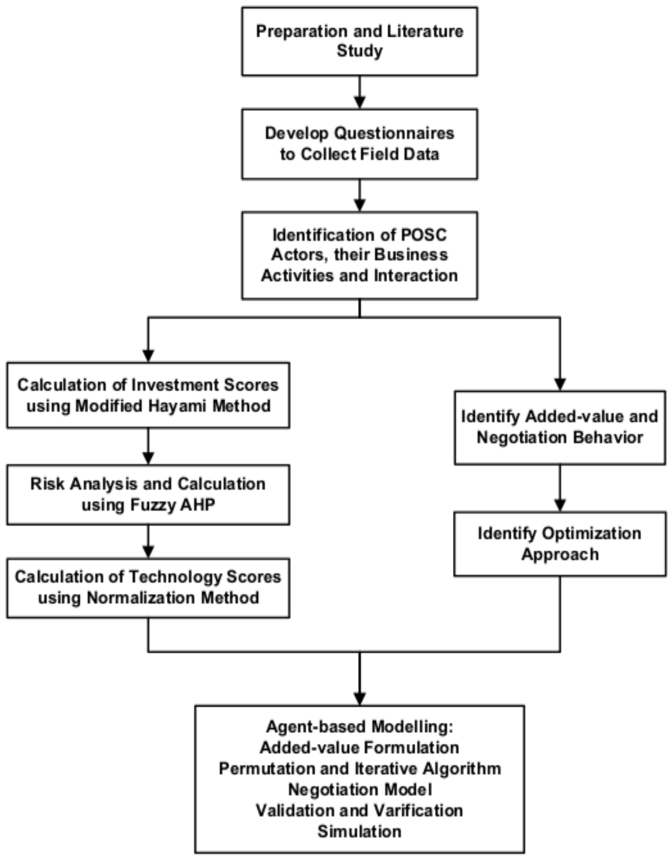

Figure 6. Framework of the POSC Agent-based modelling.

4.2. Cacao

Low productivity of cacao is the initial problem used as a basis for research. Low productivity of cacao has resulted in land conversion for other use. Land conversion can result in a decrease in the amount of production, disrupting the sustainability of the cacao agro-industrial supply chain. This problem must be corrected immediately because cocoa is one of the mainstay commodities of plantations which plays an important role in the Indonesian economy as a source of foreign exchange, a source of income and employment. The problem of low productivity was al conveyed by Iphov Kumala Sriwana one of the authors in 2021 (Iphov Kumala Sriwana, Arkeman, Marimin, & Assa, 2021).

In 2015, cacao plantations in Indonesia totaled 1.71 million hectares. In 2018, plantations covered 1.61 million hectares, a decrease of 5.74 percent. In 2019, it is estimated cacao plantations will decrease by 1.14 percent to 1.59 million hectares in just one year.

In 2015, production of cacao beans was 593.3 thousand tons and increased to 767.28 thousand tons in 2018 an increase of 29.32 percent in 3 years. In 2019, it is estimated that cacao bean production will increase to 774.20 thousand tons or an increase of 0.90 percent. Research stages, can be seen in Figure 7. This increase each year is significant as each year the productive acreage is decreasing.

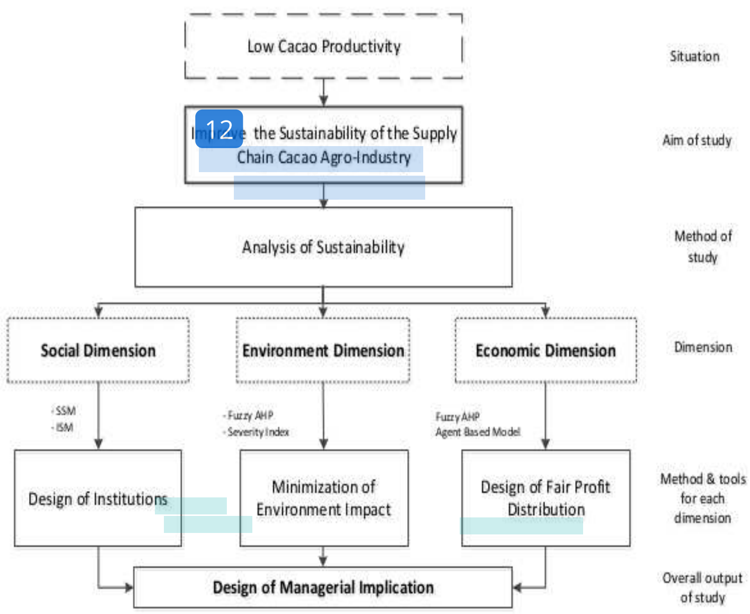

Figure 7. Research stages of cacao supply chain agro-industry.

Fair profit distribution is one of the important criteria in the economic model. This was conveyed in a paper by (Iphov Kumala Sriwana, Menanno, Arkeman, & Shafiq, 2018). Minimizing the environ-mental impact of using pesticides can provide a high added value of up to 12 times compared to when pesticides were used (I.K. Sriwana, Arkeman, Syah, & Marimin, 2017).

4.3. Kenaf

This research framework is based on developing the kenaf fibre agro-industry (KFA). KFA is part of the upstream supply chain network playing a major role in the sustainability of kenaf fibre downstream. The main focus of the SCM study is to ensure a continuous supply of raw kenaf fibre for industrial users from the midstrem to downstream industries.

Availability of kenaf fibre is very much influenced by results of its production. In order to maintain production levels, KFA must be able to maintain demand for kenaf fibre and establish responsive relationships with industrial users and consumers (online buyers).

In the Volatility Uncertainty Complexity and Ambiguity (VUCA) era, KFA faced difficulties fulfilling demands due to uncertain and unsustainable requests for kenaf. This was due to volatile and complex global conditions, which raises the ambiguity of KFA in making decisions. Therefore, in addressing demand fulfilment and supporting decision making, this study designed a smart supply chain model for use by KFA. Design of the model is supported by a collaborative inventory sub model in the supply chain network. This sub model is supported by a demand prediction sub model for industrial Supply Chain Network users (horizontal relationship) and online buyers (vertical relationship).

The demand prediction sub model is supported by a prototype facility in the form of a Decision Support System (DSS based digital platform), which is adaptive in dealing with VUCA conditions experienced by KFA. Fulfilment of responsive demand, must be a priority, comes from online buyers who are found on the free market in global networks with unlimited access. The system cannot limit access of online shoppers to transact in volatile conditions of time and demand levels. Therefore, with an adequate IDSS, the system will read data in real time in order to fulfil demands.

Adaptive IDSS includes a supply collaboration sub-model to safeguard fulfilment of volatile, uncertain, and dubious demands. In this sub-model, SPKC facilitates KFA to make decisions in determining the level of safety stocks and customer satisfaction so that demand fulfilment is always maintained in order to ensure good relations are maintained.

An inventory collaboration sub model was developed through a multipurpose metaheuristic optimization model, Particle Swarm Optimization (PSO), based on calculation of Economic Order Quantity (EOQ). Determination of the safety stock value is supported by an expert opinion that identifies service levels based on the Mamdani Fuzzy Inference System (FIS).

The demand prediction sub model, which becomes an input for the inventory collaboration sub model, uses artificial intelligence and fuzzy systems. Artificial intelligence based on neural networks is used to predict volatile and uncertain demands of online shoppers. Fuzzy system based on Fuzzy time series and Fuzzy relationships is used to predict industrial demand for kenaf fibre users in the horizontal supply chain network. This sub model will be aligned with the prototype of the IDSS digital platform that can adapt and respond to consumer demands through accountable strategic and tactical decision making.

Global developments related to demand for kenaf fibre products, apart from bark, have forced KFA to make a decision to increase the added value of kenaf fibre products. Kenaf fibre products are starting to appear on the free market. They are derived from the core of kenaf stems, namely kenaf core chip and kenaf core powder. This added value will increase the competitiveness of Indonesian kenaf globally, especially with regards to the quality (grade) of kenaf fibre produced.

Continuously increasing added value will improve performance of the KFA supply chain. KFA's performance will be monitored properly through the adaptive IDSS. The digital platform prototype will support KFA in making decisions to continuously maintain and improve its performance. Monitored performances will make it easier for KFA to be globally competitive. The research framework is presented in Figure 8.

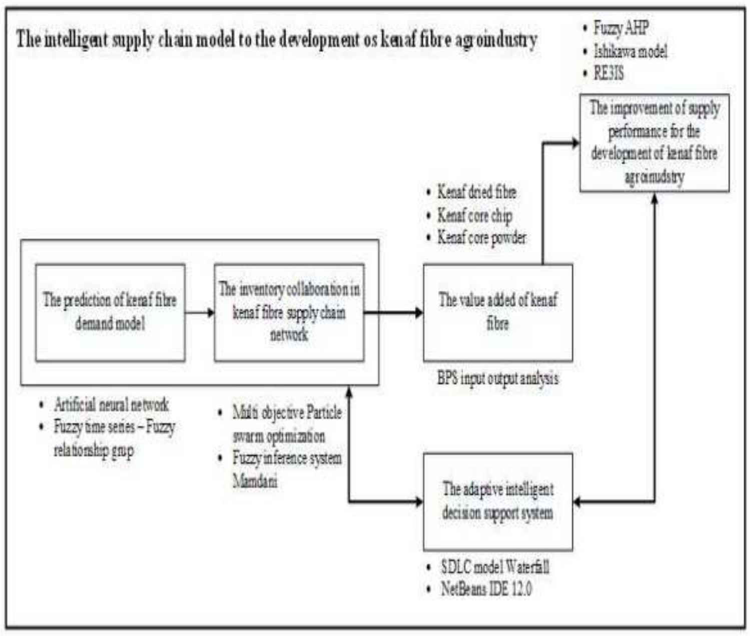

Figure 8. Research stages of kenaf fibre supply agroindustry.

5. Interaction and Collaboration

There are three types of industry interaction (modes) among researchers: 1. educational interaction, consisting of conferences or seminars, corporate training programs, or supervising thesis work; 2. research interaction, consisting of shared publications, research-related consulting, public research programs and contract research; 3. integrated interaction, consisting of joint research in shared premises and employment contracts with companies (Kotirantaa, Antti Tahvanainen, Kovalainen, & Poutanen, 2020). The educational and research interaction modes (1 and 2) are motivated by the possibility of individual academic advancement. Integrated interaction mode (3) is rare and significantly correlates with only one of the three types of industry cooperation motivations, commercialization of research findings.

Table 3. Interaction between the three models

	Palm Oil	**Cacao**	**Kenaf**
Modelling techniques - methods	Agent-based	Agent-based	Fuzzy AHP
	Fuzzy AHP	Fuzzy AHP	SCOR v.12
	Utility equation	Soft system methodology	Web mining
		Interpretive structural modelling	Artificial neural network
			Fuzzy time series-fuzzy logical relationship
			Fuzzy inference system Mamdani
		Multi dimensional scaling	Multi objective particle warm optimization
			Fuzzy TOPSIS
			System development life cycle
Software uses	Netlogo based on Java	Netlogo based on Java	Matlab R2014a
			Net Beans IDEA 12.0 based on Java
Nature of market	Global	Global	Local and Global
	Increasing demand	Increasing value added	
	Conflicting of interests between stakeholders		
Major problems in the chain	Unfair profitability spread between agents	Unfair profitability spread between agents	Scarcity of local product
	Resistance from importing countries		
	Opposition based on global warming	Good Mfg practices	
	RSPO issues		
Goals / objectives	Balancing the added value between agents	Sustainability	Improved availability of kenaf stock
Theme	Added-value gain	Added-value gain	Added-value gain
	Access to better price for smallholder farmers	Environmental risk analysis	Supply-chain performance measurement
		Institutional aspects	Inventory collaboration in supply chain network
		Access to better prices for smallholder farmers	Prototype of IDSS

Table 4. Expected collaboration activities

Issues	Detail descriptions
Collaboration opportunities	Develop business intelligence in terms of sharing useful data, information or resources amongst all three models. Thus collaboration is a mutually beneficial arrangement.
	Collaboration provides the opportunity to learn about other disciplines, which leads to development of innovative solutions because discussion can stimulate new ideas.
	Collaboration uses the division of labor to complete tasks in a timely fashion by dividing workload according to collaborator skills. As a result, work becomes more manageable. Each assigned activity targets members with the appropriate experience or expertise.
	Collaboration provides the opportunity to lend credibility and validity to research projects.
	Collaboration with many experienced researchers facilitates ongoing research efforts as well as future collaboration.
	To integrate the supply chain sustainability of the three agro-industry products.
Future ideas	Develop smart farming projects – using IOT based tools in the farm and distribution of products.
	Data mining opportunities on various aspects (seed, market, distribution, etc)
	Use of boiler ash fertilizer from oil palm bunches on the growth of cacao seedlings.
	Apply the concept of intelligent supply chain for POSC and cacao supply chain businesses.
	Use of boiler ash fertilizer from oil palm bunches on the growth of cacao seedlings.

Later we illustrate in Table 4 what we expect to achieve in our research interaction and collaboration. We conclude by identifying future research needs, opportunities for methodological improvement and policy interventions will increase overall productivity.

(Katz & Martin, 1997) explains the enthusiasm for research collaboration: (1) understanding the concept of research collaboration; (2) researchers are dealing with essentially the same phenomenon, whether concerned with collaboration between individuals, groups, institutions, sectors or nations; (3) researchers can in some way measure the level of collaboration; (4) that more collaboration is actually better, whether for the advancement of knowledge or for exploiting the results of scientific endeavours more effectively.

The expected focus of our collaboration in conducting our research is to address mutual expectations for all parties. Each of us may have different expectations about how each person will contribute and how we will be credited. By discussing these expectations openly, it's easier for each of us to contribute to the research project effectively.

The main benefits of conducting research in collaboration with others are promoting shared scientific credits and may lead to publication in high profile research journals. It could also reduce time needed to conduct experiments quickly (through sharing of resources and information).

Table 3 shows interaction between the three models in terms of what research and modelling activities are reasonably expected to achieve. Table 4 describes expected activities and collaboration avenues that we expect to gain.

Since 2007, cooperation between 7 Industrial Engineering Departments (IED) from private Indonesian universities has resulted in yearly annual international seminars on Industrial Engineering and Management (ISIEM). This seminar has attracted hundreds of papers written by industrial engineering researchers from private, state and foreign universities. Every year the number of papers submitted, presented and discussed have increased. This increase has resulted in papers more focused within fields of research and improved quality of papers from an increasing number of countries each year. There are obviously several opportunities for cooperation and collaboration amongst all researchers in the same field of interest, be it the products or commodities, tools, methodologies or organisations.

CONCLUSION

There exist many opportunities to develop cooperation and coordination on research and studies that would benefit the palm oil, cacao and kenaf industries. Collaboration provides the opportunity to lend credibility and validity to research projects, with many experienced researchers gaining access to data and research methods to facilitate ongoing research efforts as well as advancing further future collaborations. While not everybody has access to all data, some projects exchange data only among those involved while others share everything, data, methods/technology and results.

There always exists the opportunity to invite fellow researchers to collaborate because of the large extent of interest, facilities and available funding. Definitely the personality preferences and timing of research will determine the realization and extent of collaboration or cooperation. Internet and Zoom facilities have removed the distance problem between researchers. What's left behind is perhaps the sources of information or focus of the research open to us.

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