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SUPPLY CHAIN CONCEPTUAL MODEL TO OPTIMIZE A LOCAL FOOD AGROINDUSTRY FROM THE COCONUT MILK PROCESSING

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ABSTRACT
This study uses a soft system methodology to examine the coconut milk supply chain, which supports the local food agro-industry, particularly for rendang products. It aims to develop a fundamental concept to optimize this supply chain. The proposed method is effective for addressing complex, multi-stakeholder problems. Using systems thinking, real-world system behaviour is converted into a conceptual model, facilitating decision-making through customer, actor, transformation, worldview, owner, and environment components. The findings include a conceptual model translated into a causal loop diagram, part of a dynamic systems approach, which shows the interconnections and feedbacks among variables in the supply chain, such as raw material supply, logistics costs, production volume, and distribution costs. This stage identifies stakeholders and systematically illustrates the relationships in managing the flow of goods. It provides a basis for designing a supply chain network aligned with local government policies for developing the coconut milk agro-industry. It aims to optimize the local food industry, particularly rendang, in West Sumatra province. After creating the conceptual model, gap analysis and validation were conducted, comparing the model with real-world insights from stakeholders, including coconut farmers, producers, rendang manufacturers, academic institutions, and local governments. Validation focused on efficiency, efficacy, and effectiveness. The results demonstrate the foundational idea for designing the coconut milk agro-industry supply chain network to support local food products, as depicted in the causal loop diagram.
Keywords: *Coconut Milk, Conceptual Model, Local Food, Soft System Methodology, Supply Chain.*

1. Introduction

The future of agroindustry in supporting local food supply focuses on sustainability, innovation, and meeting consumer demands. There is a trend towards shorter food supply chains, localized farming practices, and environmentally friendly methods of food production. The Coconut Milk utilization sector strengthens the local food agroindustry in West Sumatra, Indonesia. Indigenous delicacies are cultivated using local resources, technology, and regional heritage (Utami, 2021). The coconut-based gastronomic industry has potential to enhance agricultural goods (Tulashie et al., 2022; Wardah et al., 2020).

Among the various commodities derived from the coconut, one of significant importance is coconut milk, which is acquired by squeezing shredded coconut either with the inclusion of water or not, resulting in a lustrous white liquid (Yunita et al., 2022). Coconut milk is an oil-in-water emulsion (Roni et al., 2022; Yunita et al., 2022), is a culinary product that is susceptible to rapid degradation and acquires a rancid taste within a short period (Citraresmi & Jusuf, 2019; Hamad, 2011; Onsaard et al., 2005). This can be attributed to the considerable water, fat, and protein content of coconut milk (Srihari, 2010). A number of research on the processing of coconut milk have been conducted, including (Tulashie et al., 2022), who explored coconut milk production as a substitute for dairy milk, (Gea, 2016) focused on technology transfer and management enhancement to augment coconut milk productivity, (Ariningsih et al., 2021; Novarianto, 2023) conducted an analysis of coconut milk products to establish national standards for Indonesian coconut milk products, food additives and pasteurization processes as approaches to prolong the lifespan of coconut milk products have been investigated by (Wulandari et al., 2017), and (Patil & Benjakul, 2018) examined coconut milk processing for

VCO while considering protein functionality. (Abdullah et al., 2021) investigated the physical characteristics of coconut milk supplemented with chestnut emulsifiers.

Rendang, a popular dish in Sumatera Barat, uses coconut milk. It is considered the world's most delicious cuisine. Rendang enterprises are thriving due to high demand (Gusnita & Mariana, 2020). Coconut milk is used to enhance the flavor of Rendang (Wulandari et al., 2017). Environmental fluctuations affect coconut milk production (Alfian et al., 2023). Consistent supply of high-quality coconut milk is important for smooth Rendang production (Prastika & Gusnita, 2022; Zelly et al., 2017). However, the data from the District Agriculture Department of Padang Pariaman shows that the coconut percentage sold out of West Sumatera is quite high, about 68.43%. Consequently, fluctuating prices and a limited supply of coconuts for the local agroindustry have contributed to unstable prices. In West Sumatra, the small-scale coconut milk processing industry still uses simple technology, producing low-quality coconut milk that still needs to be optimal in product marketing.

Small-scale domestic coconut milk processing industries use traditional techniques and lack technological expertise, leading to substandard production (Moreno et al., 2020; Pestaño & Jose, 2016). Limited market information hinders adaptability to fluctuating production volumes (Sairam & Jayasekhar, 2019; Zainol et al., 2023). Farmers sell whole coconuts due to abundant supply, resulting in underutilization of coconut commodities. These limitations affect capacity, quality, and distribution of coconut milk production. High demand for Rendang agroindustry processes requires a significant supply of coconut milk.

Therefore, it is crucial to establish a model for coconut milk supply chain to enhance local agroindustry in Rendang. The SSM approach is highly effective at identifying and resolving complex problems involving multiple stakeholders (Hildbrand & Bodhanya, 2017). The SSM framework consists of two perspectives: real-world and systems thinking. Real-world perspective is used to identify problems and validate data analysis, while systems thinking is important for formulating structured solutions based on real-world observations (Berrutti et al., 2023; Devi et al., 2023). Complex problems can be effectively tackled by examining the organization of the problem and devising conceptual solutions for system transformation according to the SSM approach (Checkland, 2000; Damenu & Beaumont, 2017; Seki et al., 2020).

Research employing the SSM approach has been widely implemented in various fields, encompassing the sugar agroindustry (Asrol et al., 2017; Hildbrand & Bodhanya, 2017), natural fiber industries (Nurhasanah et al., 2020), fisheries (Nurani et al., 2018), batik industry (Novani et al., 2014), digital service information systems (Aryee & Hansen, 2022; Devi et al., 2023), construction (Seki et al., 2020), bank information security (Damenu & Beaumont, 2017), solar system (Fathi et al., 2020), halal cosmetics (Masood & Zaidi, 2023), building maintenance (Ebekozien & Samsurijan, 2022), product development (Shankar et al., 2009), governance (Díaz-Pérez et al., 2022), performance management (Liu et al., 2012; Sgourou et al., 2012; Zlatanović & Mulej, 2015), human resources (Antunes et al., 2016; Óskarsdóttir et al., 2021), and education (Soemartono, 2014).

The Soft Systems Methodology (SSM) used in designing the coconut milk supply chain is a comprehensive approach based on interconnected stakeholders to increase value and profitability. Implementing the SSM approach through focus group discussions is essential for addressing complex problems. This will create a comprehensive database of the coconut milk supply chain, involving various stakeholders such as farmers, processing industries, transportation services, distributors, and consumers. The objective of this research is to use SSM to develop a conceptual model of the coconut milk supply chain to support the local food industry, which anticipates the threat of the unavailability supply of coconut milk.

This study provides important contributions to coconut-related industries by emphasizing the importance of sustaining coconut fields and optimizing cultivation practices. It also ensures a consistent and stable supply of coconut milk within the Rendang industry. The model identifies crucial factors for the successful establishment of the coconut milk agroindustry, such as factory locations, production capacity, and supply and demand dynamics. The growth of the small-scale coconut milk agroindustry is designed to coexist with small-scale coconut-milk

businesses. This framework offers insights and investment opportunities for coconut-related industries.

2. Literature Review for Conceptual Model of Local Food Supply Chain System

Prior studies have utilized the SSM approach to investigate the local food supply chain systems listed in Table 1. The authors contributed to the enhancement of a conceptual model of supply chain systems in various local food areas. The results of the conceptual model can provide guidelines and enable structured decision-making (Tavella & Hjortsø, 2012). Enhanced system operations and coordination approach to provide a simpler and more effective supply chain (Anggraeni et al., 2022). Develop a circular economy to prevent a lack of interaction in the supply chain (Nattassha et al., 2019). Improve collaboration, coordination, and communication in supply chains (Tavella & Hjortsø, 2011). Improving food security strategies (Sriwana et al., 2017).

Table 1 - SSM application of the local food supply chain systems conceptual model.

Authors	Topic	Object	Objectives	Contribution	Benefit	Result
Tavella, (2012)	The SSM is employed to improve the planning and administration of local organic food supply chain (LOFSC)	local organic food	- Suggest SSM as a new approach - Reduce uncertainties and improve coordination in LOFSC.	- Suggesting new approach for designing and managing LOFSC. - Providing a guideline for LOFSC partners to intervene and act in problem situations.	- SSM extracts valuable tacit knowledge from stakeholders. - SSM enhances motivation and engagement for improvement.	- SSM can be applied to lower LOFSC uncertainty. - SSM enables structured decision making and meaningful actions.
Anggraeni, 2022	Coordinate work to improve the local food system.	vegetables and fruits	- Constructing a conceptual model to realise a local food system. - Suggestions for coordinated efforts and actions to change the supply chain structure.	- Sustainable development in the economy, society, and the environment. - Building relationships between farmers and customers.	- Increased competitiveness for small-scale farmers. - Increased availability of nutritious and fresh food items.	- Local food system operation and coordination procedures. - Structured and simple supply chain with intermediary and wholesalers.
Nattassha, 2020	The implementation of a circular economy in the agri-food supply chain.	organic fertiliser producer	- Produce a conceptual model for an organic fertilizer producer. - Identify issues and lack of interaction in the supply chain	- Produce a conceptual model for an organic fertilizer producer - Identification of problems in the communication between the corporation and farmers.	- Circular economy implementation benefits agri-food industry economically and environmentally. - It has the potential to produce biomass, biofuel, and organic fertilizers, decrease greenhouse gas emissions, and enrich soil fertility.	- Circular economy can prevent economic value loss - Better communication with farmers is needed
Tavella, (2011)	Benefits of using SSM	local organic food	- Suggest the SSM as a new approach - Reduce uncertainties within LOFSC.	- proposed for designing and managing LOFSC. - Improves collaboration, coordination, and communication in supply chains.	- SSM provides organization and structure to problem-solving processes. - SSM promotes collaboration, coordination, and communication among stakeholders.	- SSM enables stakeholders to work towards improving problem situations. - SSM supports coordination and enhances efficiency in LOFSCs.
Sriwana,	Strategic	non-rice food	- Altering people's	- Proposed	- Improved food	- Continuous

2019	planning of sources food diversificatio n in West Java.		mindset on staple foods - Providing information of individuals' food needs	strategies for food diversification in West Java - Aimed to improve food security in the region	security in West Java - Increased consumption of non-rice food sources	organization of activities to alter people's mindset on consumption of staple foods - Provision of information on required nutrients available in non-rice food sources

Previous studies on the conceptual model of the supply chain system in the agroindustry field have been devised using the SSM approach, as listed in Table 2. The conceptual model offers enhancements to the quality management system (Fadhil et al., 2018), facilitated identification and action on problematic aspects (Proches & Bodhanya, 2015), enhanced management systems (Zulfiandri, 2017), and improved institutional strengthening (Raharja et al., 2020).

Table 2 - SSM implementation on the conceptual model of the agroindustry.

Author	Topic	Object	Objectives	Contribution	Benefit	Result
Fadhil, 2018	The approach to improving the coffee agroindustry's quality management system.	Coffee	- Improve the quality of Gayo coffee products - Establish a comprehensive quality management system	- SSM approach used to improve quality management system - Conceptual modeling used as reference for improvement	- Fair benefit sharing between traders and farmers. - Farmer financial institutions facilitate access to capital.	- SSM approach provides solutions for unstructured problems. - Improvement efforts needed at every level for quality improvement.
Proches, 2015	Application of SSM in the Sugar Industry	Sugar	- SSM aims to improve problematic situations. - The research aims to identify and address multiple perspectives and objectives in the sugar industry.	- SSM facilitated identification and addressing of multiple perspectives. - SSM enabled collaboration and joint creation of desired future.	- SSM facilitated identification of multiple perspectives and objectives. - SSM enabled collaboration and joint decision-making among stakeholders.	- SSM facilitated identification and action on problematic aspects - Importance of involving all relevant stakeholders in the process
Zulfiandri, 2017	The study investigates the establishment and growth of a cocoa-focused agroindustry group.	Cocoa	The goals include forming a cocoa agroindustry group, analyzing growth and institutional patterns, assessing internal factors' impact, developing a conceptual model, and establishing a rating standard for cocoa agroindustry.	- Comprehensive research on institutional capability and internal issues. - Technological incentives provided by the government.	- Farmers and traders benefit collectively from the utilization of cocoa beans. -The government seeks to achieve benefits for the enhancement of welfare.	- Three parties (government, technopreneur, farmers) involved in transformation. - Three systems of intentional human behaviour have been found.
Raharja, 2020	Reinforcement model for the institution of oil palm farmers.	Oil palm	- Recognize roles and barriers of stakeholders - Determine a proper plan to improve farming	- Constructing an adaptive institutional model - Finding proper strategies for strengthening smallholder	- Strengthening institutions benefit oil palm smallholders - Institutional models provide legal certainty and	- Established a new model of institutional to support palm oil farmers - Determined the essential

	institutions.	institutions	positive impact	components of the institutional enhancement process.

The supply chain conceptual model for the local food industry can be developed by utilizing the SSM to facilitate sustainable procedures and guarantee food availability, which are significant tasks the regional food agroindustry performs. This model should prioritize the principles of food sovereignty, which advocate for small farmers' autonomy and the preservation of cultural diversity in food crops. This approach will help address the challenges posed by corporate-controlled global food systems and promote local practices such as organic farming, preservation of small-scale farmland, and direct connections between food producers and consumers through farmers' markets

3. Research Methods

Soft System Methodology (SSM)

SSM is a methodology that uses a systems approach to explain and solve complex problems. The working principle of SSM involves finding solutions and continuously improving the system (Rodriguez-Ulloa & Paucar-Caceres, 2005). SSM has been widely used in various domains because it can address difficult problems and provide practical solutions (Hanafizadeh & Aliehyaei, 2011).The core idea of SSM is to view a system as a series of activities with ongoing changes. These activities are carried out by stakeholders and can affect the system's relationship with its environment (Liu et al., 2012). Transformations resulting from activities are expected to improve system performance, with prompt improvements for deviations. SSM involves continuous analysis and improvement, assuming that each activity has benefits and impacts that must be controlled.

The basic framework of SSM involves examining situations and problems from two perspectives: the real world and system. A real-world perspective is necessary to identify problems and verify the results of the analysis, whereas a system perspective is used to formulate structured solutions based on real-world observations. SSM's strength lies in its ability to structure problems and determine recommendations for system improvement (Liu et al., 2012). The SSM framework can depict real-world problems and conceptual system issues, understand unstructured problems, and provide recommendations for actions to improve real-world systems. The SSM framework for determining system solutions is shown in Figure 1.

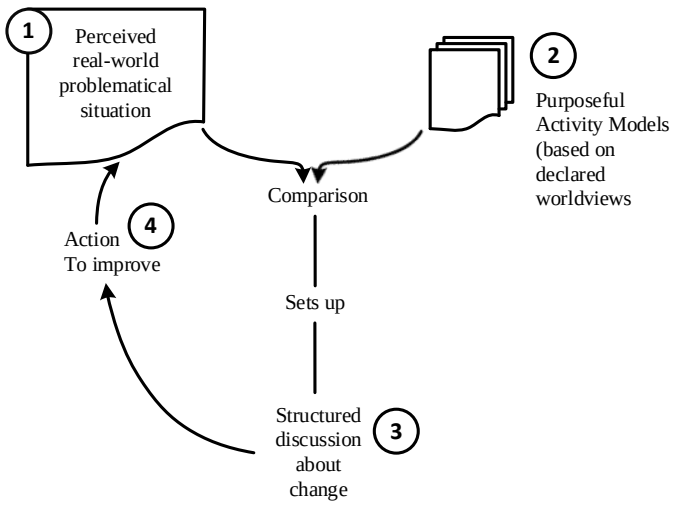

Fig. 1. Soft-System Methodology Framework.

Research Framework

This study uses the SSM approach and Causal Loop Diagram (CLD) to create a conceptual model of the coconut supply chain and the coconut milk production system.

Different perspectives and methods are necessary to address the problem in detail. The combination of SSM and CLD is new in the context of the coconut milk supply chain. CLD models stakeholder involvement in the agro-industrial supply chain. This research used primary and secondary data. Primary data was collected through interviews with coconut farmers and industry participants, as well as Padang Pariaman District Agriculture Department and academics. Secondary data came from literature reviews, including reference books, research reports, and scholarly journals. Field observations were done to observe issues in the coconut milk supply chain and among farmers.

Stages of Research

Figure 2 illustrates the research process using the SSM framework, which consists of six stages as described below:

Step 1. Described an unstructured problem.

This is an important initial step that can be applied to describing, gathering information, and establishing assumptions related to the system under discussion. The field observation is carried out by interviewing 30 participants in five stakeholders: 1. Five people of coconut farmers, 2. Ten people from the coconut milk agroindustry, 3. Five people from agroindustry rendang, 4. Five people from the local government. 5. Five people are scientists in the field of agroindustry. The existence of ties and interactions between stakeholders is the reason for the criteria for selecting participants to be interviewed. Where, the interview discussion structure includes the following: 1. productivity, 2. level of technology used, 3. supply of raw materials, 4. quality, 5. price, 6. market, 7. labour, 8. investment and income, 9. production waste, 10. transportation, 11. regulation.

Step 2. Express the problem with a rich picture.

To express a problem from various perspectives in a more structured manner, it can be depicted in a rich picture. Problem expression through a rich picture can be achieved by representing each problem object with unique and consistent symbols, thereby allowing a comprehensive depiction of the entire problem of the system.

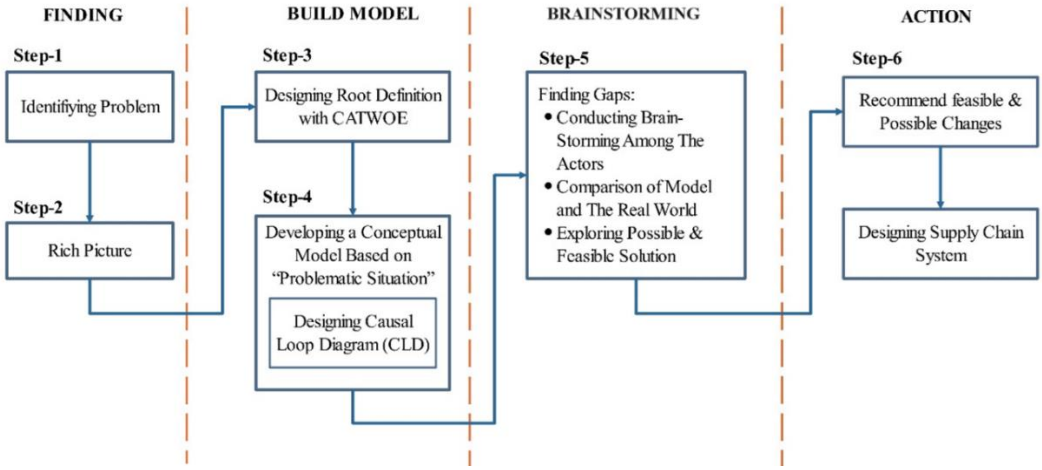

Fig. 2. The stages of research

Step 3. Formulating the root definition.

In order to pinpoint the core problems with the system and communicate them in succinct and understandable terms, a rich picture was used to create the root definition. This phase is the initial step in the system-thinking perspective conducted by the researcher. Some important considerations for the root definition statement include the following:

a. A transformative statement appears in every root definition.
b. There is just one statement that expresses a transformation in the root definition.
c. Using CATWOE (customer, actor, transformation, worldview, owner, and environment), the root concept was broken down into its component parts. An identification technique called

CATWOE is used to identify the crucial elements that must be included in the root definition.

d. In accordance with the system's goals, transformation (T) and worldview (W) statements must be correctly and clearly specified. There was just one transformation statement in the root definition statement.
e. Though they aren't stated in CATWOE elements, further assertions could be added to improve the root description.

Step 4. Designing and formulating the conceptual model.

The primary output of the SSM process is the conceptual model, which is developed from the root definition with a more detailed description. In the conceptual model, the activities and functions of the system are analyzed, and their relationships are determined to achieve the system's objectives. The conceptual model is adaptable to changes in the system problem and serves as a solution that includes all CATWOE elements. Proposed solutions align with the system's identified needs in the initial analysis phase. Dynamic systems such as CLD are incorporated into the conceptual model for this study. Dynamic systems are used to address dynamic issues and provide a specific description of a system's state. Applying this concept involves identifying system variables and parameters, and designing CLD.

The diagram of a causal loop is a graphical representation that depicts the relationships of cause and effect among variables within a system. The basic elements of a CLD are the variables, factors, and arrows. The variables stand for circumstances, events, choices, or acts that are susceptible to variation from other factors. The CLD concept has the benefit of allowing qualitative variables to be included in a system-thinking approach. The concept of a CLD is useful for explaining the interconnections in various situations.

Step 5. Analyzing the gaps between conceptual models and real-world systems.

This phase is necessary to identify several possible improvements in the real world if the formulated conceptual model is further reviewed by stakeholders, experts, and relevant parties within the system. This review examines the activities within the conceptual model and compares them with real-world situations. The results of this comparison were then reformulated through activities that could be performed as transformation recommendations within the system.

Step 6. Required Action Recommendations.

The actions for system improvement are derived from the previous stage, which is necessary to enhance system performance according to the desired outcomes. These actions encompass desired changes within the system in a better and more suitable direction. Formulating actions for system improvement should consider the culture and norms previously applied within the system, ensuring that the recommended actions align with the environmental characteristics of the system.

4. Results and Discussions

Unstructured Problem in the Coconut Milk Supply Chain

Field visits and observations aim to delve deeper into the complex, problematic, and unstructured issues. The first visit and interviews were conducted with the Department of Agriculture and Food Security of Padang Pariaman regarding the potential for coconut cultivation and development. The second observation took place in the Padang Sago and V Koto Kampuang Dalam districts, where the coconuts were produced. The third visit occurred in the Lubuk Alung district, which is known for coconut milk production and marketing. The fourth visit was to Padang City, a hub for the production and marketing of local food products, including Rendang. The assessment was carried out by outlining the roles of stakeholders and aspects along the coconut milk supply chain that support the rendang agro-industry. Five actors are involved: coconut farmers, the coconut milk agroindustry, the rendang agroindustry, transportation services, and consumers.

According to statistical data from the Department of Agriculture and Food Security of Padang Pariaman, only 31.57% of coconut production in the region is used for consumption and

agro-industries. The remaining 68.43% is sold as whole coconuts outside of West Sumatra, resulting in a lack of added value. Coconut milk is derived from grated coconuts and is typically produced using traditional methods. This can lead to quality control issues and fluctuating production volume. Farmers often sell whole coconuts when there is no demand.

The Rendang agroindustry relies on biological sources for raw materials. Coconut milk, a vital component of rendang, is vulnerable to environmental change. The quality of the coconut milk produced is uncertain. Coconut milk has a notable impact on the overall production process. A consistent stream of coconut milk raw materials is imperative for rendang production. Cooperation among stakeholders is required to manage risks in the supply chain. Efficiency in production cost is important for company profit and competitiveness. Perishable product cost and distribution are challenging.

Rich Picture Design

The issues occurring in the coconut milk agro-industrial supply chain are depicted in a rich picture. This rich picture expresses the problem situation in the supply chain, referring to business processes that occur along the supply chain network. Several stakeholders are involved in the supply chain network, including coconut farmers, the coconut milk agroindustry, the rendang agroindustry, the Department of Agriculture and Food Security of the Padang Pariaman Regency, the Integrated Investment and Industrial Service Office of the Padang Pariaman Regency, coconut transportation services from farms to coconut milk processing facilities, coconut milk delivery services to rendang processing facilities, and banking institutions.

In Figure 3, several actors also utilize coconut milk to process it into different products, including the VCO agro-industry, CCO agro-industry, restaurants, and households. However, the study discussed in this research focuses only on the coconut milk agro-industry that can support the rendang agro-industry. Coconut farmers act as sources in the supply chain business process. The coconut milk agroindustry and rendang agroindustry function as makers. Coconut transportation and milk delivery services serve as deliverers. The problems begin with the source, that is, coconut farmers. In some coconut-producing areas, farmers tend to sell their harvested coconuts without considering their age. Consequently, young and old coconuts are often indistinguishable, and transactions occur when the coconuts are still on the trees. This led to fluctuating coconut prices and low productivity.

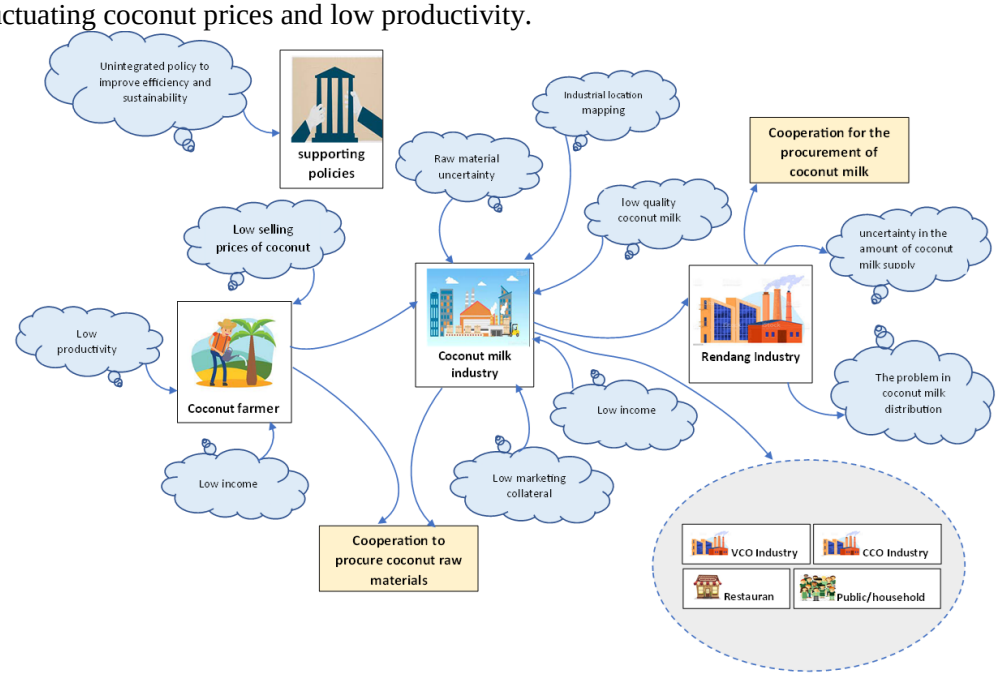

Fig. 3. Rich picture conceptual model of the coconut milk supply chain.

The issues faced by manufacturers include the inability of the coconut milk agroindustry to maintain the quality of coconut milk owing to equipment limitations, the absence of product testing and certification for the coconut milk produced, insufficient communication and promotion resources, and limited market networks, resulting in low sales. Meanwhile, the

rendang agro-industry faces uncertainties in the supply of coconut milk, which matches the production capacity and low quality of the received coconut milk.

Issues related to the delivery aspect pertain to economic and value-added aspects. The proximity of coconut farms to coconut milk-processing locations results in unavoidable transportation costs. Transportation costs lead to high production expenses and reduced added value of coconuts. Furthermore, the coconut milk agroindustry does not have its own fleet and must rent transportation services every time it delivers coconut milk to the rendang agroindustry. Figure 3 provides an overview of the problems associated with the coconut milk agroindustry supply chain in the Padang Pariaman Regency.

Formulated Root Definition of Relevant System Activities in Supply Chain Design

The root definition development phase is at the core of the problem situation, based on the relevant system. The root definition is presented succinctly and comprehensively and portrays detailed human activity within the designed system. A well-performing formulation explicitly yields the CATWOE elements.

In the client description, the actor is affected by the system. The transformation description is a process performed by the system by defining the initial and final conditions to be achieved. The worldview (weltanschauung) description is the impact of system implementation in a worldview that makes transformation meaningful in context. The owner's description is the entity with the power to determine the usefulness of the system or to halt the transformation. The environmental description is the factor that influences the transformation but cannot control the system. Table 3 presents the CATWOE elements in the coconut milk supply chain.

The root definition formulation based on the CATWOE elements is as follows: "A coconut milk agroindustry system; Operated by coconut farmers, farmer groups, and coconut milk agroindustry; Through the coconut milk processing process, coconut raw material supply planning, economies of scale, and marketing; To meet the needs of the rendang agroindustry; In order to increase added value and efficiency; Under conditions of uncertain raw materials, low coconut milk quality, low marketing guarantees among the presence of VCO agro-industry, CCO agro-industry, restaurants and households, and suboptimal government policies in promoting the competitive potential of coconut milk to support the rendang agroindustry as one of the local food products."

Table 3 - CATWOE Elements in the Coconut Milk Supply Chain.

CATWOE elements	Description
Client	- Rendang agroindustry.
Actor	- Coconut farmers. - Coconut milk agroindustry.
Transformation	- Designing a coconut milk supply chain system that can support the rendang agroindustry.
Weltanschauung	- Increasing the added value of coconuts will enhance the well-being of coconut farmers and the coconut milk agroindustry. - Improving productivity and a rapid response to the needs of the rendang industry by ensuring the availability of coconut milk in the supply chain network. - Enhancing supply chain efficiency by implementing a sustainable coconut milk supply chain system design.
Owner	- Coconut milk agroindustry
Environment	- Low coconut productivity. - Low marketing guarantees. - Low product quality assurance for coconut milk products. - VCO Agroindustry - Coconut Oil Agroindustry - Restaurant - Public / Household

The root definition formulation based on the CATWOE elements is as follows: "A coconut milk agroindustry system; Operated by coconut farmers, farmer groups, and coconut milk agroindustry; Through the coconut milk processing process, coconut raw material supply planning, economies of scale, and marketing; To meet the needs of the rendang agroindustry; In

order to increase added value and efficiency; Under conditions of uncertain raw materials, low coconut milk quality, low marketing guarantees among the presence of VCO agro-industry, CCO agro-industry, restaurants and households, and suboptimal government policies in promoting the competitive potential of coconut milk to support the rendang agroindustry as one of the local food products."

Conceptual Model of the Coconut Milk Agroindustry Supply Chain

Based on the root definition, a conceptual model was created, leading to crucial tasks in the design of a model for the coconut milk supply chain that can sustain the rendang agroindustry. At this stage, a CLD is used as the basis for constructing the conceptual model, as explained in Figure 4. The behavior of a system or model depends on its structure. Structure refers to existing components and their interconnections. The parameters associated with each component also played a significant role. The interrelationships between system players are depicted in a CLD. The CLD illustrates the interconnections between elements in the coconut milk agro-industrial supply chain system.

There are four variables in the CLD: dependent, independent, policy, and decision. The independent variables are those that are independent of the other variables and cannot be controlled. The independent variables included truck payload capacity, number of trucks, and distance for distributing coconuts from farmers to the coconut milk factory. The dependent variables are those whose values depend on the independent variables. The dependent variables included truck allocation, daily coconut production, truck speed, coconut arrival rate, storage capacity, coconut yield to coconut milk, time used in the coconut distribution process from farmers to the coconut milk factory, and coconut milk sales to the rendang industry. Policy or control variables are fully controlled by government policies. The policy variables include coconut milk prices and the quality of the coconut milk purchased by the coconut milk industry. The decision variables were the expected model outputs from the simulations. These variables included the amount of coconut collected, transportation and truck usage costs, coconut milk production, and coconut milk distribution costs.

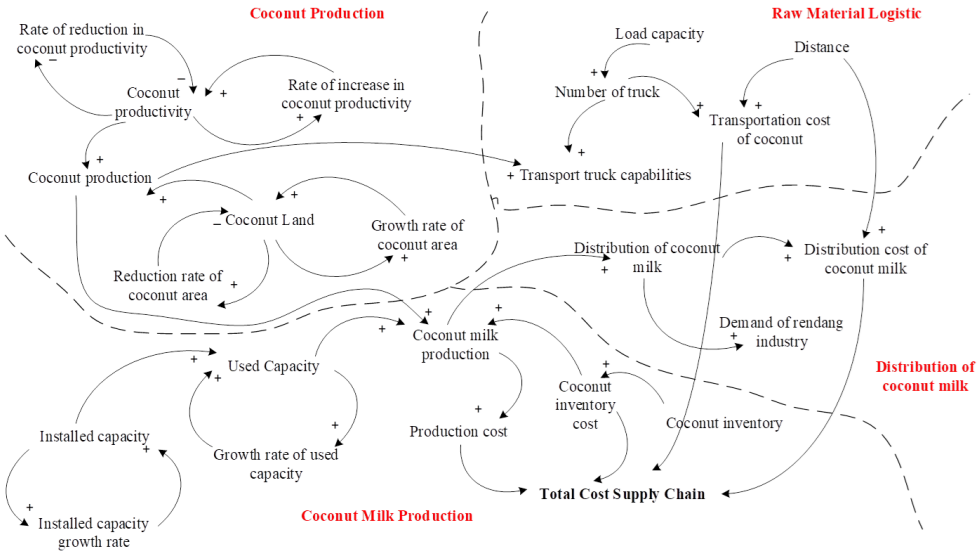

Fig. 4. Causal Loop Diagram.

The conceptual model of raw material supply is built on the partnership between the coconut milk agroindustry and coconut farmers. Coconut farmers provide coconuts as raw material for milk production. Raw materials are a critical aspect of the production process because it cannot proceed without raw materials. In the raw-material supply model, the extent of coconut plantations has a positive impact on coconut milk production. The extent of coconut plantations, measured in hectares (ha), correlates positively with coconut production. Coconut productivity, calculated in tons per hectare (ton/ha), also had a positive influence on coconut production. A higher coconut productivity results in an increase in coconut production. This heightened coconut production in turn affects the increase in coconut milk production.

The availability of coconuts depends on the quantity of coconuts supplied by farmers. The quantity of coconuts delivered is also influenced by the capacity of trucks transporting coconuts to the coconut-milk factory and the number of allocated trucks. Transportation costs to the coconut milk factory will increase as the distance covered increases and vice versa. The quantity of coconut milk produced increased when the availability of coconuts at the factory was high. This will affect production costs, and if the quantity of coconut milk production leads to greater fulfillment of the demand in the Rendang industry.

The production capacity is a factor that influences coconut milk production. Installed capacity or exclusive capacity is a machine's ability in a coconut milk factory to process coconuts daily without considering downtime, such as machine breakdowns or coconut supply shortages. The capacity is the machine's ability in the coconut milk factory to process coconuts while considering the downtime in its processes. The larger the capacity of coconut milk-processing machines, the greater their ability to produce coconut milk per day.

The results of the conceptual model design are considered valid because they meet the criteria of the 3Es as listed in Table 4. *Efficacy* is fulfilled when the coconut milk agroindustry supply chain model can achieve supply chain efficiency by increasing the income of coconut farmers and the agroindustry through value addition. *Efficiency* is attainable because it involves all stakeholders contributing to the supply chain, and can identify the needs of all stakeholders. Therefore, when the supply of raw materials to the coconut milk agroindustry is fulfilled, which enhances the productivity and ensures the availability of coconut milk for the Rendang industry is called *Effectiveness*.

Table 4 - Conceptual model assessment criteria of the coconut milk agro-industry supply chain based on 3Es

Conceptual model activity	Efficiency	Efficacy	Effectiveness
Identifying the needs of farmers and agro-industry.	Understanding the needs of farmers and agro-industry.	Optimal utilization of resources according to needs.	Performance improvement based on needs.
Identifying the potential produced by farmers.	Understanding the potential that is owned.	Optimal utilization of resources based on potential.	increased potential influences enhancement of supply chain performance.
Understanding the role and relationship between farmers and agro-industry.	Understanding the role and relationship will increase partnerships.	Improving supply chain performance.	partnerships realization leads to the success of supply chain performance.
Local government provides Good Agricultural Practices (GAP) training to farmers to increase coconut productivity and quality.	Understanding GAP will increase coconut productivity and quality.	Improving coconut productivity and quality.	A successful percentage of GAP implementation will improve supply chain performance.
Local government provides Good Manufacturing Practices (GMP) training to coconut milk agro-industry to increase coconut milk productivity and quality.	Understanding GMP will increase coconut milk productivity and quality.	Improving coconut milk productivity and quality.	A successful percentage of GMP implementation will improve supply chain performance.
Setting the selling price of coconut at the farmer level.	Sale price stability will increase productivity and income.	Improving farmer income and motivation.	Realization of stable price indicates the success of supply chain performance.
Increasing added value.	Production time efficiency will increase productivity and income.	Improving income, farmers, agro-industry and supply chain performance.	Product value-added indicates the values of successful supply chain performance.
Increasing supply chain efficiency.	Time efficiency will increase supply chain performance.	Improving supply chain performance.	The high value of efficiency indicates the successful value of supply chain performance.

Analyzing the gaps between conceptual models and real-world systems

A gap analysis was conducted after designing the conceptual model. A gap analysis was performed to compare the conceptual model with a real-world system. The method used in this

stage involves discussions with stakeholders, including coconut farmers, coconut milk processing industries, rendang processing industries, academics, and industrial and agricultural departments. Table 5 presents an analysis of the gap between the conceptual model and the real world.

Table 5 - Gap Analysis of the Conceptual Model and the Real World.

Activities of the Conceptual Model	Real World			Reflection with Objectives
	Conditions	Device	Action	
Identifying the needs of farmers and the agroindustry	Being part of a supply chain network	All stakeholders are part of the coconut milk supply chain.	Engaging in discussions and conveying the needs of each stakeholder	Being able to understand the needs of each stakeholder
Identifying the potential generated by farmers	Having coconut plantations	Knowledge about coconut processing.	Providing training to farmers	Developing insights and knowledge among farmers
Understanding the roles and relationships between farmers and the agroindustry	Understanding the activities and roles of each stakeholder	Harvesting and post-harvest activities of all stakeholders.	Identifying the inputs and outputs of all stakeholders	Establishing strong cooperation/partnerships among stakeholders
The local government provides Good Agricultural Practices (GAP) training to farmers to enhance coconut productivity and quality.	Farmers are part of a supply chain network.	Government regulations	Making agreements between farmers and the government regarding the quality of the coconuts produced.	Farmers are capable of providing appropriate quality and productivity.
The local government provides Good Manufacturing Practices (GMP) training to the coconut milk agroindustry to improve productivity and quality.	Agroindustry is part of a supply chain network.	Government regulations	Making agreements between the agroindustry and the government regarding the quality of the produced coconut milk.	Agroindustry is capable of providing appropriate quality and productivity.
Setting the selling price of coconuts at the farmer level.	Knowing the basic selling price of coconuts.	Local government	Formulating policies for determining coconut prices at the farmer level.	Increasing farmer motivation due to price guarantees.
Increasing added value.	Supply chain situational analysis and supply chain network mapping.	Value-added input-output analysis	Optimally increasing added value.	Capable of enhancing added value and competitiveness.
Improving supply chain efficiency.	Supply chain situational analysis and supply chain network mapping.	Gap analysis and problem root cause analysis, along with providing recommendations for efficiency improvement efforts.	Conducting efficiency evaluations along the supply chain network.	Providing solutions to improve efficiency.

Required Action Recommendations

The formulation of improvement actions for the development of the coconut milk agroindustry based on the SSM stages included (i) enhancing the added value and competitiveness of coconut milk and (ii) developing and implementing partnership models related to demand information and raw material supply, enhancing the development of a raw material supply chain planning model.

Discussions

This research presents the development of a methodology by integrating SSM and CLD, which aims to analyze the potential for improving the coconut supply system and coconut milk production to support local food products. SSM implementation successfully mapped the supply chain network for coconut milk through a series of situational analysis stages aligned with the actual conditions at the research site.

The supply chain conceptual model is divided into four research stages: finding, building a model, brainstorming, and taking action. Initially in the finding stage, four areas are observed to assess by outlining the roles of stakeholders and aspects of the coconut milk supply chain that support the rendang agro-industry. The cooperation among stakeholders is required to manage risks in the supply chain. Then, the rich picture conceptual model is implemented to achieve cooperation in procuring coconut raw material between coconut farmers and the coconut industry, and cooperation in procurement of coconut milk for the local food agroindustry.

To build a model, detailed human activity is portrayed by root definition to obtain the CATWOE elements of the designed system. Root definition results with the CLD are used to build the conceptual model. Four considered processes, such as coconut production, coconut milk production, raw material logistics, and distribution of coconut milk become essential parameters to define the total cost supply chain. Where, the conceptual model results are compared to the real-world system to analyze the gap. Brainstorming among stakeholders, coconut farmers, coconut milk processing industries, rendang processing industries, academics, and industrial agricultural departments are defined in Table 4. Actor activities in the coconut milk agroindustry are identified based on their condition, device, and action in the real world to achieve the supply chain recommendation.

Findings from the enhanced supply chain conceptual model by integrated SSM and CLD can be used to facilitate improvements in supply and production systems to support sustainable coconut supply chains. CLD implementation helps to define the total cost supply chain of the coconut milk agroindustry. Then the SSM analyze the situation and problem between the real world and the designed system to determine recommendations for an enhanced system. However, the recommendation has not yet been implemented during this research.

Compared to the prior research with SSM implementation in local food supply chains are listed in Table 1. It can be stated that the SSM outcomes can suggest new approaches and guidelines (Tavella & Hjortsø, 2012), work coordination (Anggraeni et al., 2022), conceptual model (Nattassha et al., 2019), and a new approach to support coordination (Tavella & Hjortsø, 2011). Where, (Nattassha et al., 2019) have integrated the SSM and interpretive structural modelling (ISM). The prior research in Table 2 also implements the SSM for several agroindustry such as coffee, sugar, cocoa, and palm oil. The SSM contributed to develop the strategy for a quality management system (Fadhil et al., 2018), facilitates collaborative discussions to achieve organized process (Proches & Bodhanya, 2015), facilitates the development of a conceptual model and the establishment of rating standards (Zulfiandri, 2017). The combination of SSM and ISM contributes to developing a conceptual model to enhance their welfare and institutional effectiveness (Raharja et al., 2020).

Furthermore, the proposed research integrated SSM and CLD to ensure the availability of coconut and develop a conceptual model. It can be a novelty compared to previous research on the rendang agroindustry in Table 6. Marketing margin analysis was used to develop a strategic marketing approach for the rendang industry, focusing on the beef supply chain (Winda Sartika et al., 2024). Exploratory factor analysis (EFA) is used to analyze coconut production in the rendang industry by improving the knowledge of smallholders through field visits and training (Omar et al., 2023). The responses-priority index (RPI) addresses the coconut price fluctuation in the coconut value chain (Kalidas et al., 2020a). Then, the dynamic model analysis, CLD, flow diagram, and mean absolute percentage error (MAPE) have been integrated into predicting future trends in beef availability (Sartika et al., 2021). In addition, the proposed model integrated SSM and CLD to maintain coconut milk availability for the rendang industry while improving profitability.

Table 6 – Comparison study of rendang industry in different problems.

Authors	object	Issue	Stakeholders	method	achievement	Finding
(Winda Sartika et al., 2024)	Beef rendang industry supply chain	Inefficiency in Product Flow, High Marketing Margins.	breeders, traders, collectors, wholesalers, retailers, and manufacturers.	Marketing margin analysis	- Identified the marketing margin values - assessing marketing efficiency	strategic marketing approaches
(Omar et al.,	marketing	lack of	Rendang	-exploratory	Factor	- EFA can analyze

2023)	margin values and farmer's share percentages of Rendang Industry	technology and marketing information, and instability of coconut prices.	Producers, Marketing Institutions, Consumers, Government Agencies	factor analysis (EFA) -Kaiser-Meyer-Olkin (KMO) Test -Bartlett's Test of Sphericity	Identification, Reliability Assessment, Significance of Agronomic Practices, and Recommendations for Improvement.	the key factor for coconut production. - Field visits and training can enhance smallholders knowledge.
(Kalidas et al., 2020b)	Coconut Value Chain	Coconut price fluctuation	Coconut farmers, Coconut Processors, Market Intermediaries, Government, Research Institutions	Responses-priority index (RPI)	developing new coconut varieties and establishing institutional support	Improved market information, institutional support, and systematic production practices
(Sartika et al., 2021)	Beef Availability for Rendang Industry	Insufficient beef Local Supply	Farmers, Producers, Importers, Government, Retailers, Consumers, Researchers.	Dynamic Model Analysis, Causal Loop Diagram, Flow Diagram, Mean Absolute Percentage Error (MAPE)	Develop a dynamic model to improve policy for beef availability in the rendang industry	predicting future trends in beef availability
Proposed paper	Coconut milk availability for rendang industry	Uncertainty raw material, low interaction between stakeholder.	Farmer, government, coconut-milk industry, rendang industry.	CLD, SSM	- Raw material supply chain planning (coconut availability) - Relationship between stakeholder	Improve profitability, and coconut availability.

5. Conclusion

The successful conceptual design of the coconut milk supply chain system to support the rendang agroindustry involves seven key activities. These activities include analyzing needs and identifying supply chain mechanisms, understanding the roles and relationships among supply chain stakeholders, calculating the added value of supply chain stakeholders, developing a raw material supply chain planning model, analyzing influencing factors, improving supply chain efficiency, and enhancing supply chain productivity. This conceptual model was validated using efficiency, efficacy, and effectiveness criteria involving a gap analysis that compared the model with a real-world system. The formulation of improvement actions for the coconut milk agroindustry development encompassed enhancing added value and competitiveness, developing and implementing partnership models related to demand information and raw material supply, and creating a raw material supply chain planning model. The application of Soft Systems Methodology (SSM) in this research successfully mapped the coconut milk supply chain network through a series of situational analysis stages that aligned with the actual conditions at the research site. Furthermore, regional policy strategy development is suggested as future research based on the proposed conceptual model framework to complement the continuity of small-scale local food agro-industry rendang.

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