

Preliminary System Dynamics Model To Understand The Struggle Of Downstream Agro-Industry Development In Aceh, Indonesia

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Abstract

The successful agriculture industrialization in developing regions is a challenge which continues to be pursued globally. It is a dynamically complex system with many interplay stakeholders. Properly managing it, therefore, requires a root understanding of the underlying structures and feedback mechanisms that influence the system's behavior . This study explores the system dynamics modelling approach in Aceh Province, which has been envisioning a progressive downstream agro-industry development for decades after the Tsunami and conflict rehabilitation but with insignificant success, using data and information available from 2000-2015. The primary objective of this paper is to conceptualise and visualise the intricate challenges associated with the downstream industrial development of the agricultural sector within the province, followed by their incorporation into a simulation model. This model is intended to enhance comprehension and facilitate more effective policymaking. The findings indicate that the reinforcing loop of numerous efforts is slow and worsened by the strong balancing loop of pressure from rent-seeking activities in the system. It notably includes the massive investment promotion that has caused a shifting of the burden for Aceh due to the widespread extortion practice of being unaddressed, thus leading to temporary business establishments or inactive business plans. It is also evident that necessary law enforcement has been ignored. Results from the simulation model have replicated the historical behavior of stagnant agribusiness growth downstream. Three scenarios were simulated to recommend policy intervention by examining the doubled and halved extortion rate effect. The latter is projected to achieve a more favorable result for Aceh agro-industry development. In order to maintain the balance between economic growth, sustainable use of resources, and minimization of unintended environmental and social consequences, such intervention is subjected to other policies.

Keywords: agriculture, agro-industry, industrial development, system dynamics

JEL: C63, O13, Q13

A. INTRODUCTION

The agricultural industry has been widely acknowledged as a powerful engine to improve the economic growth of developing regions. According to da Silva (2009), there are clear indications that the modernization of agriculture in the form of processing agribusiness or agro-industry can have a significant impact on collective well-being development, which through improved employment opportunities, income generation, poverty reduction, better quality of skills

and knowledge, foreign exchange earnings, and many more positive benefits. The value-adding process to agricultural commodities will, in turn, result in higher regional competitiveness and help meet domestic demands and serve global markets.

Indonesia remains the world's fourth most populated country with abundant natural resources. However, there are severe problems of unmanaged potential within agricultural industries, mainly concentrated in Java (Holzhacker, 2016) and

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practiced mainly by informal smallholders in an unsustainable manner (Bamman, 2007). Indonesia seems to be trapped in a "resource curse" despite having an apparent comparative advantage for many agricultural commodities. The rich agricultural resources are spread throughout this archipelago country; as Jan and Chen (2005) have suggested, the interventions based on industrial development need to be region-specific. Systemic efforts to address issues related to industrial development need to be within a provincial context to improve undeveloped regions in developing countries like Indonesia, one of which is Aceh.

Aceh is a unique province of Indonesia, with a special autonomy status. It is in the country's most western and northern parts, with an area of 7.2 million Ha, or as big as a typical Scandinavian country, with a total population of more than 5 million people (Aceh Bureau of Statistics, 2016). It is close to India's Andaman and Nicobar Islands and is a potential region exporting products to South Asian countries, including India and Arab (Aceh Investment Coordinating Board, 2016). Due to having substantial natural resources, Aceh has a long history of political independence and fierce resistance to control by outsiders, including the former Dutch colonists and the Indonesian government itself. Some estimate that the oil and natural gas reserve in Aceh is the largest in the world, and the province also has abundant agricultural resources with flourishing land and good weather all year long (McCulloh, 2005).

The agriculture sector of this province has promising potential to improve the economic value through manufacturing industries. The local government has already embraced such a vision and is stated in the official government strategic plan for many years. However, the vision has yet to be reflected in a sound performance. For example, previous initiatives of the long-term central industrial zone and free trade area were launched to increase attention on industrial development in general and agro-industries in particular (Government of Aceh Province, 2014). Despite years of striving, Aceh

province has only the most minor agro-industry level of enterprises, particularly downstream ones (Sofyan, 2014). The current condition of Aceh agro-industry only reflects the resource potential of the province, not the ease of doing business for entrepreneurs, farmers, local people and global consumers at large. It indicates a gap between what the government tries to achieve and the people's willingness to do. The current situation can be defined as a 'policy resistance', reflecting what happens due to the intertwining interactions of many variables. Figure 1 illustrates the concept of policy resistance in the context of this research.

As a post-separatism conflict and post-Tsunami region, Aceh today has survived 18 years of peace and many valuable milestones and government cycles. The resolution of the conflict in 2005 ended Aceh's isolation and opened the door for development, investment, and economic reintegration with the rest of Indonesia and the world. Since the peace agreement, Aceh has been granted a special autonomy status that allows the provincial government to self-organize with less intervention from the central Indonesian government. Aceh received an additional budget amounted to 12.54 billion USD in total until 2027 (Ananta & Onn, 2007), making this province with one of the highest annual province budgets, but is the seventh poorest province in Indonesia (17.08% poverty) with 9.93% unemployment rate (Aceh Bureau of Statistics, 2016). Aceh today is still one of the most underdeveloped provinces of Indonesia, and agricultural resources would be one vital key to its future development. Therefore, in the interest of all stakeholders, these resources are managed well.

To accelerate the rate of poverty reduction, the government endeavors to address priority issues and strategic programs. Value-added agricultural products are one of the priorities. It is under the Long-Term Development Plan of Aceh 2005-2025 (Government of Aceh Province, 2014), which stated that the focus of the second stage (2013-2017) is "to increase production and value-added agriculture

and marine fisheries" and the third stage (2018-2022) focused on the development of "the processing and manufacturing industries". These facts prove that the leaders of Aceh have set a serious vision to transform their comparative advantage in the vast agricultural resources' potential towards a competitive advantage of value-added agriculture products and gradually leave dependency on oil, gas and mining. The effective value-added agriculture products should result from productive agro-industrial activities, particularly downstream ones. Unfortunately, 2022 has ended, but no significant progress towards such a vision is seen of a bright downstream agro-industry development in Aceh.

The government of Aceh has been focusing on developing investment in agro-industries and refining the value chain. However, downstream industries have had inadequate capacity. It has yet to be successfully sustained in Aceh among dozens of programs and attempts enabling the agro-processing industries.

From the general investment climate perspective, Aceh province is still relatively unstable. It is vulnerable and urgently requires policy reforms after the protracted conflict and political atmosphere that has directly affected the realization of development plans in Aceh (Crow, 2000). Like the rest of Indonesia and other developing countries, Aceh is struggling to reorganize a system of administration that has been convoluted for a very long time, with widespread corruption and weak law enforcement (Padiyar et al., 2012). Nevertheless, on the positive side, Aceh is committed to continuously improving the investment climate and boosting the economy's competitiveness. In addition to the breakthrough program of regional economic development, the government of Aceh is also working with national programs to accelerate the value-adding industries based on agricultural commodities.

The government of Aceh may not have adequate and necessary tools to analyze the performance of policies affecting the agricultural sectors. They are under increasing pressure to achieve many economic development targets through industrialization. In the

face of a continually changing political and socio-economic landscape of Aceh, these challenges, therefore, cannot be addressed and solved in isolation with the "silo mentality" of single-dimensional mindsets. A region like Aceh needs better-engineered planning to formulate effective action plans and a program roadmap to avoid making similar past efforts in vain or even worse, unintended consequences of the policies and programs.

Envisioning Aceh's future with sustainable downstream agro-industry requires a robust system thinking approach as the problematic issues are complex and involve multi-stakeholders and multi-disciplines of systems behavior. This paper presents the behavior assessment of Aceh's downstream agro-industry development "inertia" using a system dynamic modelling approach. Within a system thinking framework, a dynamic model is viewed as advantageous, serving as a valuable tool for decision-makers involved in development planning and as an educational tool to enhance understanding of different regional subsystems (Lektuers, 2015). The results and findings of the model could provide meaningful insights in a visual form of a working reusable model for the stakeholders to act immediately.

The main objective of this research is to systematically understand the interactions within downstream agro-industrial development systems of Aceh that have yet to be successful despite previous efforts. Three research aims have been established to achieve this objective.

Firstly, a qualitative approach seeks to construct a conceptual framework capable of elucidating the dynamic and interrelated nature of the downstream agro-industrial systems in Aceh province. Secondly, a quantitative endeavor entails the development of a modelling and simulation platform designed to uncover the underlying factors contributing to the inertia in the development of downstream agro-industries within Aceh province. Lastly, the research aims to pinpoint and prioritize critical leverage

points through scenario simulations, offering decision-makers valuable insights to enhance their efforts towards realizing downstream agro-industries in Aceh.

B. LITERATURE REVIEW

Agro-Industry Development and Aceh

Industrialization of the agriculture sector has been widely acknowledged as a powerful engine to improve the economic growth of developing regions. According to da Silva (2009), there are clear indications that the modernization of agriculture in the form of agribusiness or agro-industry can have a significant impact on the collective well-being development through improved employment opportunities, income generation, poverty reduction, better quality of skills and knowledge, foreign exchange earnings, and many more positive benefits. The value adding process to agricultural commodities will, in turn, result in higher competitiveness of a region and/or a country and help meet domestic demands and serve global markets.

Generally, there are two popular forms of agriculture industrialization: mechanization in maximizing the quantity of upstream raw agriculture commodities and manufacturing to produce value-added products for end customers (Alhilali, 2013). Agro-industry, which is sometimes referred to as agribusiness, is the branch of agriculture that is focused on value-added products of processed materials and commodities. There are four subsystems of agro-industry within agriculture value chain systems based on the Government of Aceh Province (2014). The first is the off-farm upstream agro-industries that consist of activities related to production and trade to produce pre-production facilities such as the nursery industry, animal feed industry, drug industry, hatchery technology industry and others. The second subsystem is on-farm upstream agro-industries, including industrial activities that utilize facilities to produce significant commodities such as fattened cattle as a source of meat, the production of crops, plantations, fisheries produce, and others. Third, downstream agro-

industries involve the processing and trade of major commodities in the forms of ready-to-use, ready-to-cook and ready-to-eat products because of industrial activities. Lastly is the agro-industry supporting subsystems related to banking, transportation, capacity building, education and research, government regulations and many others. Among these four subsystems, the downstream agro-industry has the most critical value as it could accelerate infrastructure development, province revenue, and distributed economic growth. Figure 1 illustrates the typical value chain of agro-industrial systems.

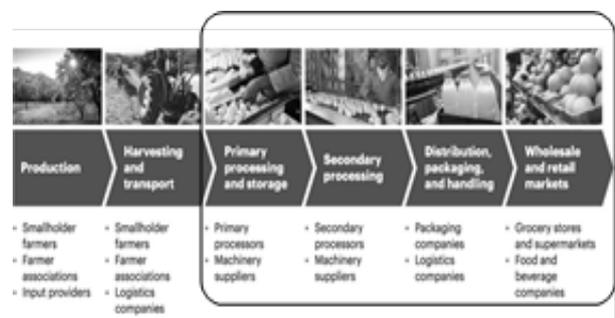


Figure 1. Agriculture Value Chain and its Downstream Part (UNIDO, 2009)

There are many advantages of having a developed downstream agro-industry. According to Hicks (2007), the three most beneficial effects of having downstream agro-industry in place are the grassroots direct impact, accelerated knowledge and technology transfer for local labor readiness and the sovereignty of agriculture products for local demands, such as food, personal care items, beverage, etc. Moreover, this downstream agribusiness could typically be approached by two different streams. One is the typical significant investment for mass manufacturing production, while the other is the knowledge-based creative economy, typically in the form of small and medium enterprises (SMEs) (Lee & Barret, 2001).

Aceh can improve its agricultural productivity with manufacturing-based activities, particularly downstream agro-industries. As of 2016, the cultivated area in Aceh's spatial planning is

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2,934,602 Ha available for production forest, community forest, agriculture, fisheries, mining, industry, tourism, and housing, and in total, still less than 1% of the land is used for industrial factories (Government of Aceh Province, 2014). This fact demonstrates that the province's potential is still very high to be utilized for the downstream agro-industry; otherwise, a significant level of hidden activities that exploit the natural resources within the province will continue to exist. The current condition of Aceh agro-industry only depicts the resource potential of the province, but not the ease of doing business for entrepreneurs, farmers, local people and global consumers at large. It indicates a big gap between what the government is trying to achieve and what the people are willing to do, a phenomenon of policy resistance, as illustrated in Figure 2.



Figure 2. Indication of Agro-Industry Policy Resistance

Historically, Aceh was a glorious region for international agriculture trading in the past kingdoms' era (Aceh Investment Coordinating Board, 2016), and the agriculture commodities still flourish well up to now. Aceh could be revolutionized towards a productive downstream agro-industry base in Indonesia. That is why Aceh has been envisioned to become competitively industrialized after the 2004 Tsunami reconstruction and peace memorandum in 2005. Since then, there have been many initiatives, mainly involving international NGOs, to increase agriculture productivity regarding value-adding

processes around Aceh (McCarthy, 2007). However, the efforts to develop downstream agro-industries have yet to result in any significant change for the local people and in terms of development. Even worse, the illegal and unsuitable small industries have developed, benefiting only small groups, and harming the environment (Phelps et al., 2011). Figure 3 summarizes several past attempts as part of downstream agro-industry development in Aceh.



Figure 3. Past Efforts of Aceh Agro-Industry Development

These efforts with insignificant success include taking for granted numerous more specific efforts from the special autonomy fund and donors' aid for physical infrastructure construction and the assistance program that aimed for a better business climate, particularly the agro-industry. It is such a pity that in a flourishing region like Aceh, fewer and fewer people want to be involved in agricultural activity or even think about having a job/business in agriculture. The increasing middle-class economy that leads to increasing consumerism and consumption habits could be the driver for producing local domestic products, but Aceh has yet to happen. Acehnese are still extremely stuck to the dependency on the neighboring region, North Sumatra, on supply and demand of value-added commodities produced in Aceh in the first place (Baihaqi & Hamid, 2015). While agricultural resources remain the primary source of livelihood in Aceh, a large proportion of rural communities are under the poverty line due to the incomes of agricultural communities remaining very low.

One of the derived policies applied in Aceh to achieve its vision is the enactment of massive

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investment promotion and incentives for investors. A vision, "Aceh as Indonesia's Leading Investment Destination by 2017", was set by the Investment Coordinating Board with many action plans and programs. In addition, the Department of Industry and Trade of Aceh also stated a similar vision for Aceh to have a competitive industry. The considerable potential for the development of agricultural processing industries in the whole province uses the upstream agriculture commodities that until 2016 recorded a total of 15 types of plants and 6 types of forestry products, together with other horticulture, food crops, livestock, and fisheries (Aceh Investment Coordinating Board, 2016). Among these vast upstream resources, 13 commodities are massively promoted through the province's investment promotion activities (see Figure 4).

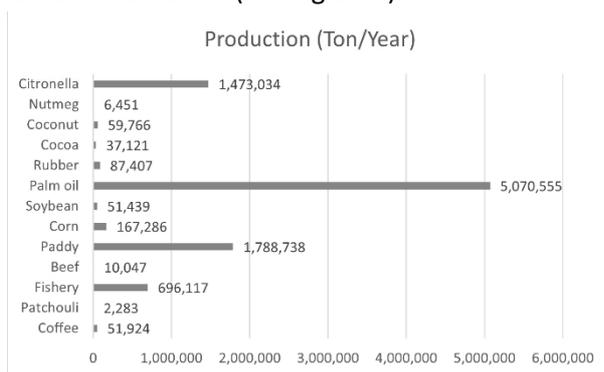


Figure 4. Major Agriculture Production in Aceh Investment Profile (2016) and Anshar & Karnasih (2014)

The above 13 commodities are projected to be industrialised or processed and produce added-value products, as described in Aceh Investment Profile (2016).

Arguably, the complex nature of agro-industry development must be causing the slow progress of the actor of a specific project of downstream agro-industry realization in handling the process. There is a need for a better view of the system to have a comprehensive understanding that could be better approached and visually perceived by stakeholders upon actions. Otherwise, there could be a tendency to wander around the problem structures repeatedly every time an action is underway. Such a pattern is

time-consuming and wastes money and effort in every stakeholder initiative and coordination.

Table 1. Potential Downstream Agro-Industry from Top Commodities in Aceh

Commodity	Potential Downstream Agro-Industry
Coffee	Instant coffee and packaging industry
Patchouli	Essential oil industries (i.e. perfume)
Fishery	Modern processing industry with a block ice factory
Beef	International Halal Beef Industry, Leather
Paddy	Modern rice milling plant
Corn	Poultry feed factory
Soybean	Poultry feed factory
Palm oil	Range of palm oil processing industries
Rubber	Range of rubber processing industries
Cocoa	Paste, butter, chocolate powder
Coconut	Virgin coconut oil industries
Nutmeg	Essential oil industries (i.e. perfume)
Citronella	Essential oil industries (i.e. perfume)

Systems Model for Agriculture Management and Regional Planning

Managing sustainable agriculture production and trading is dynamically very complex. Unfortunately, this has been approached conventionally by forecasting and observing the trend of the performance indicator individually. There are interplay behaviors that should be considered. Systems models in agriculture planning are primarily conducted within a supply chain or value chain structure, where stock and flows of the agriculture commodity are likely discrete and straightforward. However, many underlying qualitative measures has been ignored in modelling the real-world agriculture problem regionally in an aggregated perspective of commodities. Arguably, System Dynamics is the right tool to implement better systems modelling for agriculture problems, as conducted by Lektours (2015), Setianto (2014), and Wiranata (2003). Moreover, that includes the attempt presented in this research to investigate the root causes of the hardship in realizing agribusinesses for value-added agriculture products in Aceh.

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Making the case for change is challenging because we cannot know whether we will get the desired results. Systems thinking and system dynamics is one applicable methodology to approach the change expected from a policy. System dynamics was introduced explicitly at MIT in the 1970s within the discipline of computer science (Sterman, 2000). Over time, the method has been utilized in many fields of study, as change and policy are almost always multidisciplinary. From analyzing new business models to public health policies, system dynamics are becoming more popular as they can consider the feedback loops and delays to simulate change over time.

Systems thinking refers to the mental efforts to uncover system behavior, while system dynamics emphasizes the effort to understand that behavior that uses informal maps and formal models (Mai, 2012). Because acknowledging complex problems is multi-dimensional and must involve all stakeholders in the mental model, working as a collective effort is the most effective way to deal with complex issues. It requires cross-sectoral collaboration to resolve and deal with many uncertainties. Adaptive management approaches are required as more knowledge becomes available through iterative learning-by-doing. The systems thinking and system dynamics approach has impressively demonstrated how to deal with complex challenges in a multi-stakeholder environment. Thus, it is a unique 'methodology' in dealing with the problem of agro-industry development of regional planning and by local government.

In engineering, simulated model development as a tool for high-level decision-making and socio-economic problem solving still needs a lot of encouragement and mainstreaming. The domain of real-world problems that apply the 'systems thinking and system dynamics' approach is potent and practical for the stakeholder's learning process and formulating concrete actions. It is fair to expect that an engineering solution should not only focus on technical output but also provide opportunities for the broader application of complex socio-techno-

economy issues. The advancement of computational and simulation science through system dynamics is one of the most promising gateways to address this issue.

Systems model methodologies certainly have limitations. This method relies heavily on mapping causal relationships between variables without enough recourse to evidence-based scientific literature, resulting in the perception that it is a 'soft science' (Maan & Cavana, 2007). As such, there can be misconceptions that system dynamics rejects traditional scientific views. However, the reality of problems requires analyses of causation among system components. Conceptualization and simulation modelling in system dynamics integrate sound theoretical and empirical approaches to specify the most likely causal pathways and contribute to its credibility as a valuable systems model for agriculture management as an essential regional planning effort.

C. RESEARCH METHOD

This study used system dynamics methodology to understand downstream agro-industry issues in Aceh. System dynamics is a computer simulation modelling aimed at solving various problems in socio-technical systems. It includes understanding the endogenous feedback relationships that cause observed patterns of behavior in a system and knowledge of using simulation modelling for experimental analysis. It enables a mentality to look across disciplinary boundaries to holistically discern the impacts of well-intentioned policies and solutions. It will also prepare the understanding of the policy implementation process in various organizational settings and create confidence in the success of policy interventions.

In this research, five main steps are used as the methodology for systems thinking and system dynamics modelling. They are problem articulation, formulating a dynamic hypothesis, formulating a simulation model, testing the model, and scenario design as a nonlinear approach (see Figure 3).

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Figure 3. System Dynamics Methodology

This study used secondary data obtained through a systematic investigation. It involves the comprehensive review and analysis of existing literature, reports, and publicly available research data. The secondary data sources encompass various materials, such as academic publications, government reports, and industry-specific databases of pre-existing information providing valuable insights into the research context.

D. RESULTS AND DISCUSSION

Problem Articulation

Problem articulation is conducted from the extensive literature reviews. Articles and reports about Aceh's barriers and challenges in realizing the envisioned downstream agro-industry development also appear in the benchmarking to the typical effort in other regions of the world. The main problem in this study has been clearly expressed in the introduction: the persistent failure to sustain downstream agribusiness in the province. Figure 5 presents the system behavior over time that depicts a kind of oscillatory pattern of downstream agribusiness growth in Aceh, as the Aceh Bureau of Statistics reported in 2016. There are no statistics on downstream agribusinesses, and the below number of behaviors was approximated from the total number of all industries that existed in Aceh minus the industry in oil, gas, chemical, mineral and metal goods. The selected data were classified as 'big and medium manufacturer' by the statistics bureau according to

the International Standard Industrial Classification of All Economic Activities, which is any manufacturing business with more than 20 employees (da Silva, 2009).

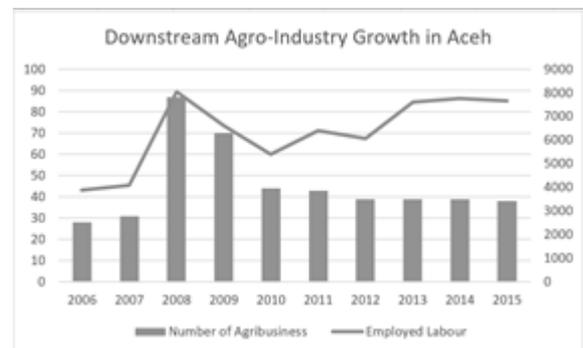


Figure 4. Behavior Over Time of the Problem

There was an extreme increasing trend in 2008. Most likely, it was the result of massive international aid for the post-tsunami communities at that time, as mentioned by Phelps [26] and Padiyar [33], that a significant amount of money was given in the form of business capital in an effort for locals rebuild their livelihood. Many of them tried to use the capital to establish agribusinesses, sometimes with the assistance of donors. However, as shown in the statistics, many businesses were falling. It indicated they could only be temporary businesses, and since 2010, there has been almost no increasing trend, if not decreasing. To answer why such stagnant behavior persists in Aceh, the findings from literature reviews reveal several issues that are believed as the main problems limiting the progress of sustaining downstream agribusiness in Aceh (see Table 3).

The identification of main problems are grouped into three to get the initial connection of the system components to each other: agricultural resource, law enforcement, and business and management. They are further analyzed in the next step to be modelled conceptually into the dynamic hypothesis of the system structure.

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Table 3. Identified Main Problems of Developing Downstream Agro-Industry in Aceh

Agricultural Resource	Insufficient supply from the upstream commodities
	Long dependency on commodities trading with Medan's middlemen
	Many illegal and/or informal exploitation claiming resources and land
Law Certainty	Back up by government and police officials in the agriculture mafia side
	Complex regulation and bureaucracy
	Illegal fees on new businesses by some locals (extortion)
Management & Governance	Investors' prejudice on Aceh (Islam and conflict vulnerability)
	Uncoordinated and overlapped government in different levels and departments
	No reliable supply of skilled workforce
	No reliable access to utilities (i.e. water, electricity, and other basic infrastructures)
	Insufficient infrastructure for transportation and logistics
	Poor access to market demand
	Locals' dependency on grants and privileges

Dynamic Hypothesis

To be systematic in understanding the core problem, we simplified the whole dynamics of the system in the form of a Causal Loop Diagram (CLD). It is essential at this stage to specify and structure the boundary of the system we want to focus on. It is done by mapping the causal relationship between the main

problems identified in step 2 that have caused the system's behavior over time in Fig 4.

We started with developing the preliminary CLD that produces the behavior pattern in Fig 4, which is the behavior mode of 'stasis' or 'equilibrium'. According to Sterman (2000), such behavior arises because the dynamics affecting the state of the system are so slow that change is imperceptible or because there is a balancing loop being so dominant and preventing the change. In Aceh's context, both conditions are likely present in the system. It is the slow effect of all the efforts in increasing the ease of doing downstream agribusiness, together with the dominant prevention of change by the agriculture mafia balancing loop. From the main problems identified in Table 2, we could apply systems thinking and map the generic structure. Then, by manipulating the wordings of pre-selected variables in Table 3, the complete CLD is constructed to understand the system better, as shown in Figure 5. There are 6 balancing loops and 4 reinforcing loops with 22 variables interacting in the conceptual model.

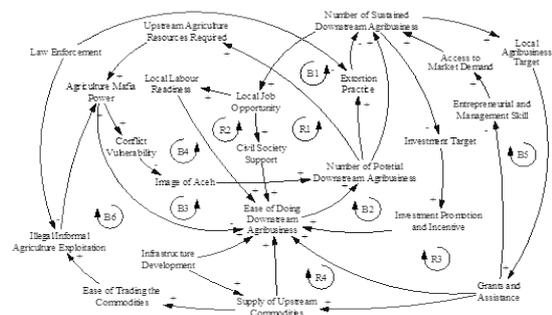


Figure 5. The Causal Loop Diagram (CLD)

This CLD contains several main loops that reveal key messages about how the system works. They are (1) Government intervention in loop B2, R3, and B5, (2) Civic engagement in loop R1, R2, and B1, and (3) Law certainty in loop B, B4, R4 and B6. The first government intervention (see Figure 6) mainly describes the current intervention by the government, which is around attracting external investors, encouraging local entrepreneurs and improving infrastructures. These loops show that

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these kinds of efforts are right and are a good mechanism that, in turn, will increase the number of sustained downstream agribusinesses in Aceh after delays. However, other forces are affecting these loops, as observed in the next main loops.

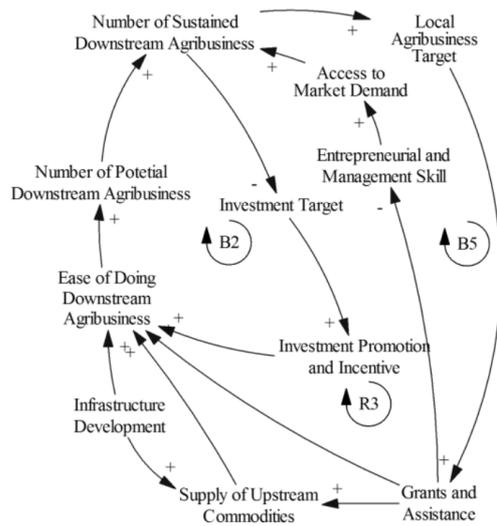


Figure 6. Government Intervention Loops

The second main loops are civic engagement as shown in Figure 7. It depicts that although the ease of doing downstream agribusiness is increased and thus creates more potential investors or new local SMEs, a big problem is triggering extortion practices and harming the new businesses.

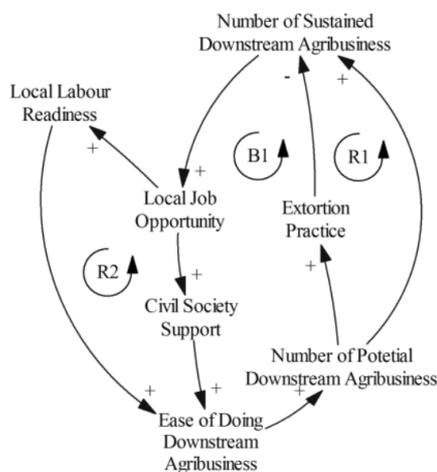


Figure 7. Civic Engagement Loops

Furthermore, the last main loops are law certainty as shown in Figure 8 below. It indicates that Aceh's law enforcement system is currently weak in facilitating and ensuring that new businesses survive and sustain. A significant concern in the agriculture mafia includes people from the government and even the police/military officials.

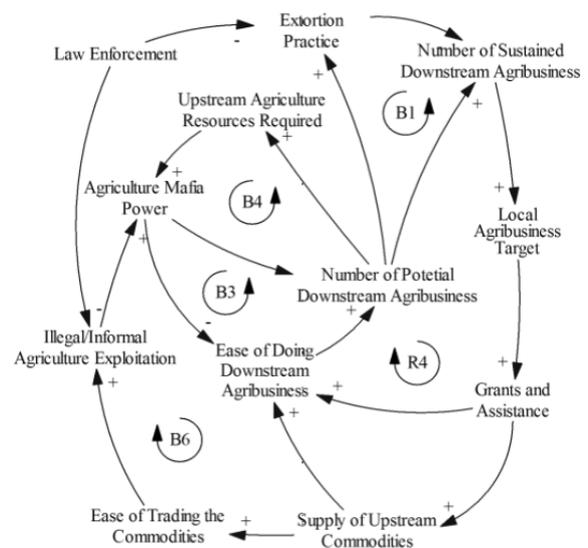


Figure 8. Law Certainty Loops

The extortion practice and the massive agricultural resource exploitation by illegal/informal businesses are unaddressed. It leads to the extreme difficulty of new businesses wanting to explore the full potential of performing downstream activities or the decreasing number of sustained downstream agro-industry.

System Archetypes

Using the developed dynamic hypothesis for the downstream agro-industry development system in Aceh, we identified groups of feedback loops that fit the structure of commonly called system archetypes. We applied these archetypes to explain the potential consequences of current policy affecting the system by a typical pattern of specified system archetypes (Braun, 2002). From each archetype, we learn its management principles to suggest key leverage points or interventions as the

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basis of designing our policy recommendation in the last step of system dynamics.

The first archetype is a successful to the successful, as shown in Figure 9, due to the long practice of upstream agricultural commodities these past 3-4 decades. Informal and illegal businesses dominate agriculture resources in Aceh and end up being traded through a long chain of middlemen. Thus, making the margins value of the commodities the lowest for Aceh's farmers and traders. Moreover, these people in the informal/illegal business are indicated to have a tied relationship with the agriculture mafia in Aceh. Making most of the resources in Aceh would only be accessible by those circles in play. It is challenging for conventional business players, like potential investors and new SMEs, to survive and sustain in such an environment. The agriculture mafia's persistent success and conventional businesses' persistent failure are due more to initial conditions rather than intrinsic merits. The possible managing principle that could be applied to this phenomenon is reviewing the current performance assessment systems to determine if they are set up to favor some parties. If the government keep leaving this obvious problem unaddressed, then the resource will always be on the mafia side, and so the vision of having downstream agro-industry will be really slow or even not happening at all.

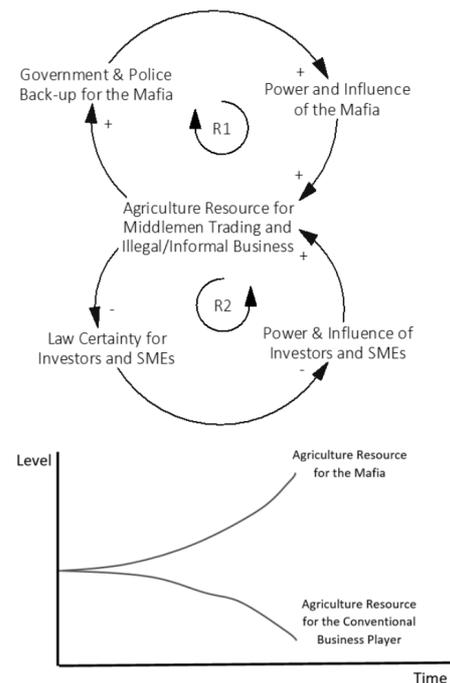


Figure 9. System Archetype “Successful to Successful”

The second one is the “fix that fails” in Figure 10. An unintended consequence of providing grants and funding to encourage SMEs in downstream agribusiness without proper scheme and monitoring. It worsens the mentality of the Aceh people, who have a high dependency and expectancy on easy money. It has been a problem in Aceh since the post-tsunami reconstruction, where donors and governments have provided aid and help in very significant amounts for many years after. As for the case of agribusiness, the grants cause less independent effort from the business to optimize their entrepreneurial and management skills to ensure that the business is profitable and sustainable. The managing principle for this archetype is to focus on the long-term goal of helping establish long-term SMEs that could innovate and grow independently. The grants and assistance from the government or donors are great. However, they should never be only short-term quick fixes because otherwise, they will be spoiled with privileges and never grow as competitive businesses.

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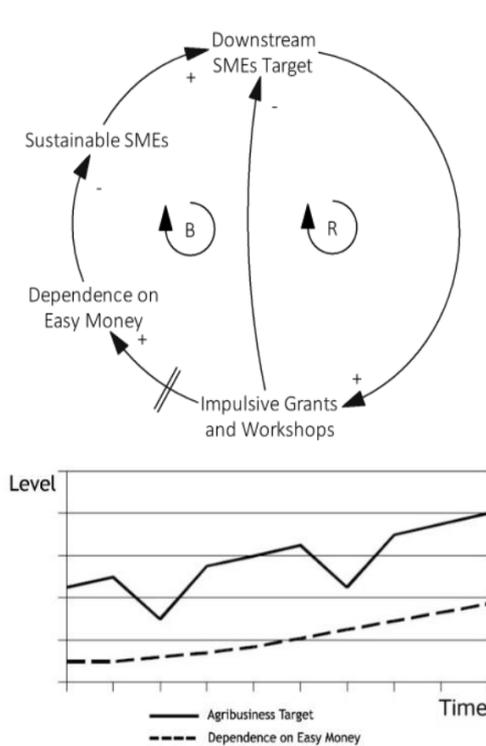


Figure 10. System Archetype “Fix that Fails”

The last one is a “shifting the burden” archetype. It arises as a side effect is present because the massive investment promotion and incentive could trigger even more extortion practices in Aceh towards potential investors that Acehnese received as wealthy people (see Figure 11). *The possible managing principle for such a condition is to focus on the fundamental solution: the ease of doing downstream agribusiness.* The quick fix of promoting investment opportunities is, of course, still necessary. However, it should not only be a matter of promoting and promoting without assisting the investors with the fundamental ease they are looking for in Aceh.

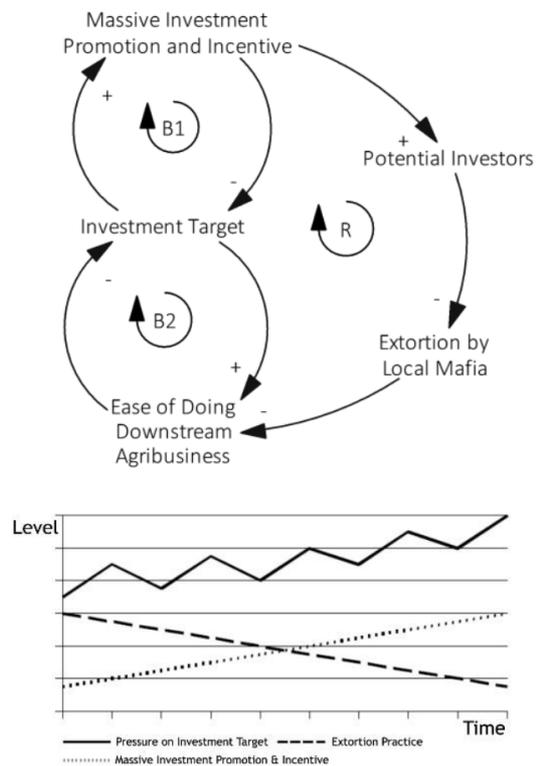


Figure 11. System Archetype “Shifting the Burden”

Simulation Model & Policy Scenario

The next step of system dynamics modelling for simulation is a Stock and Flow Diagram (SFD), which uses the Stella Architect software package. SFD and Stella equations will be provided with full explanations of the relationships between parameters and their units of measure.

Key characteristics of the produced model in this study focus on the dynamics of agro-economy, civic engagement, and law certainty sector, with inputs of high-level variables. It relies on calibration techniques for behavior shifting. The primary variable observed is the changes in the processing industry or several downstream agribusinesses, local job opportunities generated, and the impacts of investment promotion and funding given to or used to form local businesses. The stock and flow model are grouped into three model sectors, as presented in Figures 12,13 and 14.

Preliminary System Dynamics Model to Understand the Struggle of Downstream Agro-Industry Development in Aceh, Indonesia

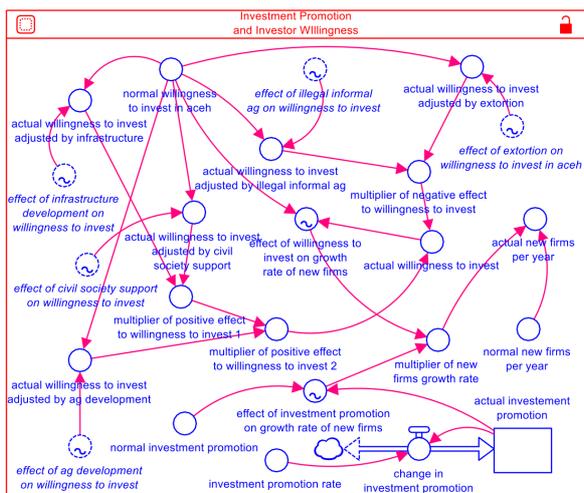


Figure 12. Model Sector of Investment Promotion and Investor Willingness

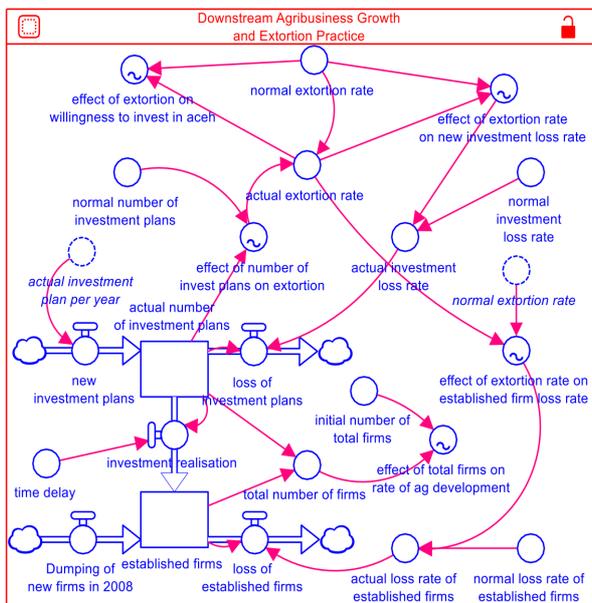


Figure 13. Model Sector of Downstream Agribusiness Growth and Extortion Practice

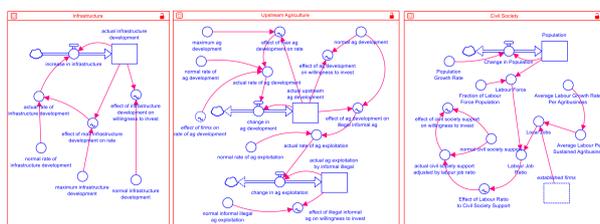


Figure 14. Model Sector of Infrastructure Development, Upstream Agriculture Production and Civil Society Support

This preliminary model is the baseline scenario of current problems and ongoing policies. It includes ongoing efforts to attract external investors and

establish government-owned enterprises, which are in line with Aceh's government policy and master plans. Some forecasts on policy-driven variables are set up by permitting the integration of various projections from experts, policymakers, activists, and other stakeholders found in the literature reviews. In many parts, however, they are subject to the estimation of behavior change, providing the closest fit to such projections.

After running the stock and flow diagram, the result of the simulated model for the total years until 2032 (aligned with Aceh's long-term development plan projection) is shown in the graph output in Figure 15. It indicates that downstream agribusiness growth is stagnant with the current condition, with a slight decrease over time until 2032 and most likely afterwards. The extreme rise of agribusiness firms in 2010 resulted from massive donor aid for Aceh in the post-tsunami and post-peace making since 2005. There is also an indication that many business regulations on logging and other forest activities are being loosened to support the physical reconstruction in Aceh. The key takeaway here is ultimate. There is now way Aceh could continue the efforts on ongoing policies and programs only as it will not positively affect the new outcome. Some fundamental solutions must be taken as a breakthrough by the government as a massive movement. Infrastructure development and investment promotion that are already in place with relatively good attention are not fast and effective enough to create the enabling environment of downstream agro-industry climate in Aceh. For model testing, the behavior pattern tests were applied and shown in Figure 15 to compare modelled trends with historical trends.

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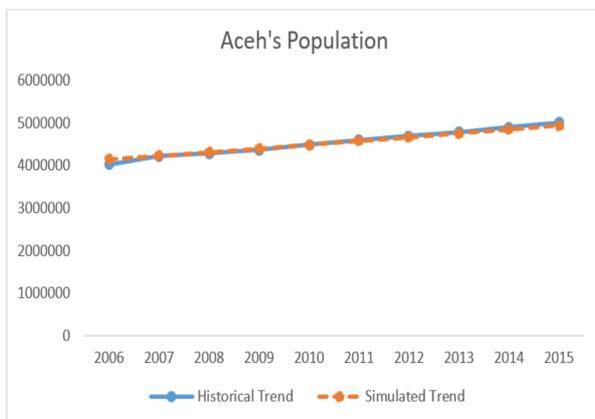
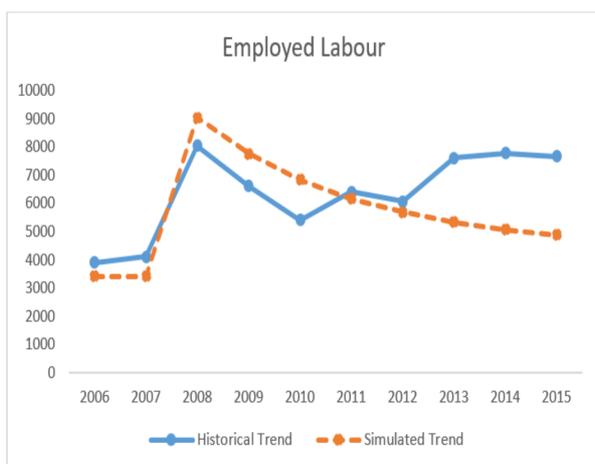
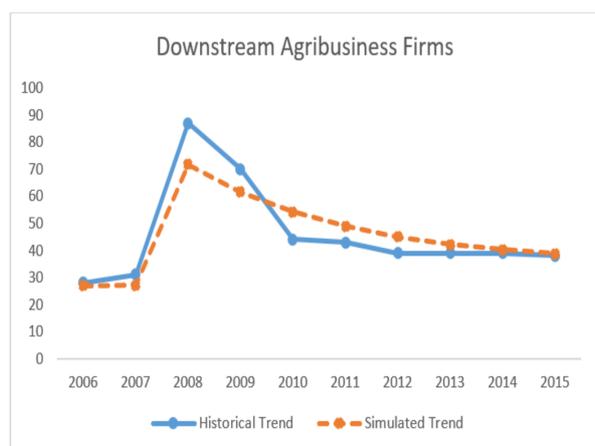


Figure 15. Simulated Trends and Historical Trends

Then, in the last bit of the paper results, policy intervention scenarios are applied simply to the extortion rate. Figure 16 summarizes the scenarios evaluated using the simulation model. The base case scenario represents the current situation, the optimistic scenario minimizes the extortion rate in half, and the pessimistic scenario doubles the extortion rate.

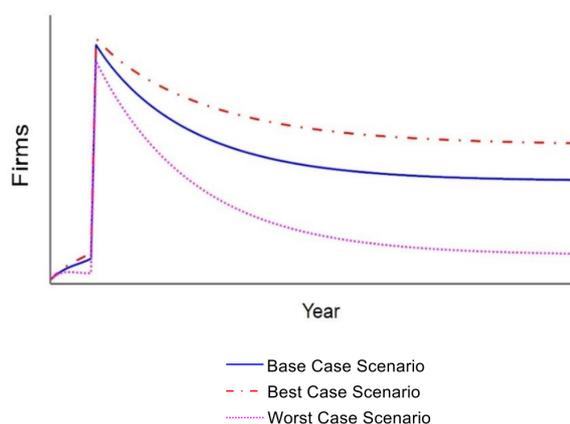


Figure 16. Simulated Trend Produced by Each Scenario between 2006 and 2032

The behavior over time produced by the pessimistic scenario is a significant reduction in the number of firms, and vice versa; the optimistic scenario, where it halves the extortion rate, could increase the number of the downstream agribusiness firms in Aceh. However, there is a substantial concern here that the growth is still in a stagnancy trend. In contrast, the desirable vision for Aceh's agro-industry is undoubtedly towards a positive trend. The strong balancing loops of negative effects on all the positive efforts persist. It is time for Aceh to remove all obvious barriers while optimizing sustainable and inclusive regional economic development efforts.

The developed model has excluded several details of variables within the agro-industry system in Aceh. It is because, according to the research aims, the researcher focused on the primary problem of not being able to sustain meaningful agribusiness for value-added agriculture products in Aceh. It is acknowledged that investigating a specific cause and impact in-depth, of environment and population, for example, is highly important. However, that effort will be very complex and is another level of problem layer for Aceh. Such effort will require primary data from the field and sufficient time to engage with stakeholders.

The main limitation of this research is that it relies only on secondary data. As a mini-thesis project with limited time, budget and flexibility, the

researcher had to build assumptions and mental models based on available literature and publications, including a few on data about agriculture practice in Aceh. It is also difficult to document all insights from the reviewed literature in a scientific manner. Reasonably, this might make the system dynamics modelling in this research even more vulnerable as a "soft science" approach due to possibly biased interpretation of literature on the author's own judgement. However, the attempt to map out the problem structures with correct justification has been achieved and, therefore, still could provide a meaningful conclusion about the problems happening in Aceh and its possible effective interventions.

E. CONCLUSION

In this paper, we used system dynamics to model the downstream agro-industry development in Aceh, Indonesia. The model has been able to represent the system's main components and produce a conceptual model that replicates the past behavior of the downstream agro-industry in Aceh. It showed that the current situation is unsustainable, with only temporary business establishments. The main problem is the presence of powerful rent-seeking practices such as extortion from an agriculture mafia, making it difficult for businesses to sustain in Aceh. We recommend that the government address the problem by providing more support to local businesses and cracking down on the law uncertainty.

The system dynamics model developed in this study is a valuable tool for understanding the complex dynamics to promote the downstream agro-industry in Aceh. The study utilized secondary data and assumptions for parameterization. Despite these constraints, the model effectively mapped out the problem structures and provided valuable insights into the challenges in Aceh, offering possible intervention strategies. The causal loop diagrams (CLD) development underwent three stages, aligning with systems thinking theory and prior knowledge. The simulation model excluded some variables and relationships, focusing on the current situation and

ongoing policies. Model testing compared simulated trends with historical data, demonstrating relatively similar system behavior over time. The study also presented intervention scenarios on model simulation, with the model showing the potential impacts of various strategies.

Along with the absence of fieldwork and direct stakeholder input, the study's limitation is also on model completeness and use of assumptions. The dynamic hypothesis has identified feedback loops that captured more variables of social issues and the influence of new downstream agribusiness. These were not transferred to our system dynamic model. Also, as with all systems, obtaining empirical data for all variables is impossible. It means that some degree of subjectivity is inevitable. Examples of this in our model are mostly the graphical functions used as dimensionless multipliers. While it was tested during model testing, they are not empirically derived. Given these limitations, our model is best suited for Initial behavior structure assessment only to assess the influence of current conditions and scenarios on future patterns rather than predicting the precise outcomes. This paper served as a preliminary system dynamics model to address complex agricultural challenges and offered a reusable learning platform.

Further research should be conducted with stakeholders' participation in the form of interviews and workshops. It should integrate the stakeholders so they could feel ownership of the model by directly translating their arguments. Thus, details for each sector could be modelled in-depth, such as the calculation of stock of upstream commodity itself and the market demand of downstream products and resources like land availability could be captured. It is also recommended that future system dynamics research for Aceh agro-industry is conducted as commodity-focused studies, starting with the most priority ones. All of them will develop both the conceptual and the simulation models that correspond to a better understanding and better choice of variables with quantitative value in more detailed and holistic dynamics.

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