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SIMULATION MODEL OF CASSAVA AVAILABILITY FOR MOCAF (MODIFIED CASSAVA FLOUR) BY CONSIDERING SUSTAINABILITY

Dessy Srikandi*)[1], Muhammad Hisjam), Eko Pujiyanto**)**

*) Master Program of Industrial Engineering Department, Faculty of Engineering, Universitas Sebelas Maret
Jl. Ir. Sutami No.36A, Jebres, Surakarta, Central Java 57126, Indonesia
**) Department of Industrial Engineering, Faculty of Engineering, Universitas Sebelas Maret
Jl. Ir. Sutami No.36A, Jebres, Surakarta, Central Java 57126, Indonesia

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Abstract

Background: There is a high demand for wheat flour, but the supply of it is reduced due to high prices and world oats availability because of climate change and conflicts. Cassava is processed through a fermentation process into mocaf flour and can be used as an alternative substitute for wheat flour. However, the availability of cassava has decreased in the last five years.
Purpose: This research aims to determine the factors that influence the availability of cassava by considering sustainability.
Design/methodology/approach: This research uses primary data from the Mocaf agro-industry and secondary data from the Central Bureau of Statistics website, as well as previous research. Supply chain management is used in this study with a model simulation of a dynamic system. The simulation model begins by creating a Causal Loop Diagram (CLD), building a mathematical model to formulate relationships between related entities, developing a Stock Flow Diagram (SFD), and drawing the model with Stella Software.
Findings/Result: The results show that the factors that influence the availability of cassava as raw material for mocaf are harvest growth and an increase in the purchasing price of cassava at the farmer level. The simulation results show a substitution policy of 30% and cassava harvest growth of 1% every year, with the total availability of cassava being 17 million tons. The sustainability factor which refers to the simulation results, namely from the environmental dimension, can reduce CO2 emissions. The social dimension is the absorption of rural labor and home industry labor, utilization of marginal land, increasing income, and realizing food security. The economic dimension is the added value and durability of the mocaf.
Conclusion: The factors that influence the availability of cassava as raw material for mocaf are harvest growth and an increase in the purchasing price of cassava at the farmer level. Implementation of the development scenario the availability of cassava can be fulfilled.
Originality/value (State of the art): Substitution policy for mocaf and cassava harvest growth can increase the availability of cassava and implementation of the development scenario (substitution policy of 30% mocaf and cassava harvest growth of 1%) the availability of cassava can be fulfilled.

Keywords: mocaf, model simulation, cassava, supply chain management, dynamic system

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[1] Corresponding author:
Email: srikandi0401@student.uns.ac.id

INTRODUCTION

Wheat can be processed into wheat flour, and processed wheat products are very popular in Indonesia. Wheat consumption for the national flour industry reached 8.9 million tons, or equivalent to 6.9 million tons of wheat flour (KlikLegal.com, 2022). Domestic demand for wheat and wheat flour is expected to continue to increase along with population growth and the level of food demand. World wheat prices in February 2023 fluctuate between US$787.60 – US$792.00 per bushel (Sadya, 2023). These price fluctuations become domestic opportunities to cultivate local plants into industrial harvests that can be processed into flour that can function as flour.

Food availability is a global issue that becomes an evaluation of domestic food security. Law No. 18 of 2012 concerning food security, one of which contains the availability of sufficient food, diversification of staple foods with potential resources, and local wisdom. Cassava has special potential because it is easy to cultivate and does not require specific land. Cassava has been developed into a substitute for flour and rice. The total supply of cassava in 2018 amounted to 17,426,000 tons, with domestic production of 16,119,000 tons, imports of 1,341,000 tons, and the number of exports in that year amounted to 34,000 tons (satudata.pertanian.go.id, 2020).

The marginal land area in Indonesia reaches 157,246,565 hectares, and the potential land utilized is around 58.4% (Sahabatpetani.com, 2018). The potential for domestic cassava production is still open by utilizing this marginal land because it is suitable for cassava plants that can grow and produce well on dry land, the availability of nutrients is less than optimal and has low acidity, and has a positive impact on efforts to improve the environment so that the soil is fertile again (Watemin et al. 2016).

The national cassava consumption rate in 2019 was 4.363kg/cap/year, and in 2020 it increased to 4.827kg/cap/year (satudata.pertanian.go.id, 2020). The increase in tuber consumption can be indicated by increasing public awareness of living healthy with low sugar and gluten-free consumption patterns. This is in line with WHO recommendations for a healthy lifestyle, one of which is to consume nutritious foods derived from non-animal plants such as vegetables, fruits, low fat, sugar, and salt (WHO, 2010). In the last year, public interest in mocaf products has reached an average of 62%, this is also strengthened by the increase in healthy lifestyles, with a percentage of 53% (trends.google.co.id, 2023).

The increasing consumption of tubers is a great opportunity for local farmers and entrepreneurs. One promising form of business is the mocaf agro-industry. However, the price of mocaf flour, which is priced at IDR15,000 – IDR25,000/kg, is still a consideration for consumers. Recently the Minister of Trade will provide a price subsidy of IDR3,000/kg so that the selling price becomes IDR12,000/kg (Aini, 2022). This is an opportunity for mocaf producers and consumers who choose to use healthier flour.

Several previous studies have produced policies with a dynamic system, namely the policy of stopping or tightening the conversion of wetland agricultural land for infrastructure development, the study of rice (Mahbubi, 2013). Scenario without policy changes and scenario of increasing potato productivity by implementing sustainability aspects (social, economic, and environmental) (Aminudin et al. 2014). A partnership scenario with a policy of expanding planting areas and increasing cassava productivity for the cassava tape industry is needed (Purnomo et al. 2015). Prediction of rice availability in East Java in 2014 but not yet ready to contribute 60% of the surplus of 10 million tons of rice (Garside & Asjari, 2015). Policy on the percentage of rice production (Budiawan et al. 2017). Policy to expand planting area to increase land productivity for corn (Panikkai et al. 2017). Corn self-sufficiency policy will continue until 2019, with the expansion of planting area (Kusuma & Rachbini, 2019). The policy supports national corn self-sufficiency for industrial and consumption markets through zero corn imports using 80% superior hybrid seeds and a proportion of corn sales to industrial markets of 85% (Maftuhah et al. 2020). The design of a dynamic system model for rice availability in Bandung Regency that can support sustainable food security with an optimistic scenario, namely planting productivity of 7.5 tons/ha with a planting intensity of 2.7 times can reach a surplus of 1,028 tons in 2028 (Setiadi et al. 2022). Alternative rice food security from the perspective of the Indonesian state is to increase the amount of exported rice, and increase the amount of government rice reserves followed by increasing rice production which has proven to have the highest average value in the next 10 years (Sintiya, 2023).

Previous research on food includes rice, corn, potatoes, and cassava for the tape industry. Studies on the availability of cassava for making mocaf as a substitute for wheat have never been carried out. In general, the cassava supply chain consists of farmers who cultivate and produce cassava, cassava collectors, industries that produce processed cassava, distributors, and consumers (Tama et al. 2019). This research is about the factors that influence the availability of cassava supply by predicting up to 30 years, a dynamic system model of the cassava supply chain in the mocaf industry by considering elements of sustainability, and policies in the availability of mocaf as a substitute for wheat flour.

METHODS

This research is a model for the cassava supply chain as the main raw material for making mocaf nationally. The research was conducted using the websites of the National Food Agency, the Central Bureau of Statistics, and the Ministry of Agriculture of the Republic of Indonesia. Direct research was also conducted with mocaf agro-industry business actors, namely PT. Tepung Mocaf Solusindo and KWT Makmur. The study was conducted from March 2022 to June 2023.

This research uses primary data from the mocaf agro-industry which is used as a conversion coefficient in the model creation process. Apart from that, it uses secondary data from the Central Bureau of Statistics website and previous research. Data collection is carried out through the website of the Central Bureau of Statistics, Ministry of Agriculture, Food Security, Ministry of Trade, and supporting websites related to the object of study. The data needed, include population, wheat per capita consumption, cassava production, cassava import, cassava export, agricultural production cost, and cassava price. For data that is not available on the website above, researchers use previous research data sourced from the Scopus website and Google Scholar. Mocaf production cost data is obtained from information from the mocaf agro-industry.

Figure 1 is a framework for this research. Starting with observing the situation regarding mocaf as a substitute for wheat, then continuing with the problem of the object of study, how mocaf as a local food can be used as a substitute for wheat and is able to support domestic food security. Next, determine the assumptions and approach in building the model, simplify the cassava supply chain model for mocaf raw materials with the entities involved. Making models using Stella software, the results are then analyzed in the form of decisions and implementing policies that lead to possible solutions to problems.

System identification and analysis is the identification of aspects involved in the system, simulation models begin with making an initial design of causal loop diagrams, building mathematical models to formulate relationships between related entities, developing stock-flow diagrams, and drawing models with Stella software. The simulation logic diagram explains the sequence of steps in creating a simulation which is the conceptual basis for building a model with Stella software. The initial step is to determine the target time, namely 30 years of simulation with annual time intervals. Continue by creating a Stock Flow Diagram (SFD) for each subsystem (demand, production, and supply). Running simulations can be performed if the model built is verified and valid which can be run with Stella software, which produces output based on the mathematical logic built into the model. If needed, you can improvement scenarios by building new model. The steps of simulation models can be seen in Figure 2.

Problem situation	Input	Process	Output
• High imports of wheat • The world supply of wheat is decreasing • The need for flour substitution • Availability of cassava supplies is decreasing • Local food for food security • Considering the sustainability of the cassava supply chain	• Population • National Wheat Consumption • National Cassava Production • Cassava Production Costs • Mocaf Production Costs and Price Subsidies	• Assumptions, simplifications and approaches in building models • Causal Loop Diagram (CLD) • Stock Flow Diagrams (SFD) using Stella software • Policy analysis and implementation	• Factors influencing the availability of cassava for making mocaf • Wheat import reduction policy • Mocaf policy as a flour substitute to support local food-based food security • Implementation of sustainability in the cassava supply chain

Figure 1. Framework research

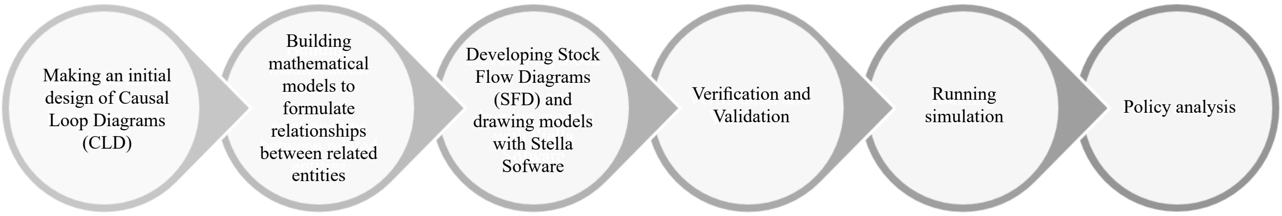

Figure 2. The step of simulation models

The hypotheses of this study are factors that affect the availability of cassava can be known, cassava availability can be known by developing a cassava supply chain model and policy options using local potential, namely mocaf flour in efforts to substitute flour. This hypothesis was taken based on an initial description of the cassava supply chain with its influencing factors which can be developed and built with CLD to obtain factors that influence the availability of cassava, the amount available, and the potential that might be achieved in efforts to substitute wheat flour.

RESULTS

Causal Loop Diagrams (CLD)

Causal Loop Diagrams (CLDs) developed in the early 1960s, are used in dynamical systems to map the dynamic behavior of complex systems by creating flow diagrams that have cause-and-effect relationships between various aspects, entities, or variables (Daellenbach & McNickle, 2005).

The design of the Causal Loop Diagram (CLD) in this study consists of the demand subsystem, production subsystem, and supply subsystem. The demand subsystem model is designed to illustrate simulated national mocaf demand. The demand for mocaf is taken based on national flour demand, this is because mocaf will be used as a substitute for flour. The production subsystem model is designed to describe the availability of mocaf in meeting demand as well as the availability of cassava chips as semi-finished raw materials in mocaf production. The supply subsystem model is designed to describe the main raw material supply system, namely the availability of cassava in meeting mocaf production which is influenced by harvest growth. This study was only conducted for cassava commodities, consumption patterns, and cassava distribution patterns nationally, the period used is annual not a harvest period, and sustainability factors are adjusted to related commodities and entities. CLD availability of cassava in making mocaf can be seen in Figure 3.

Mathematical Models

A model is a representation of the system, it can be iconic, analog, and symbolic (Daellenbach & McNickle, 2005). Simulation is one of the imitation techniques in a process that occurs in the system with the help of computer devices and is based on certain assumptions so that it can be studied scientifically (Suryani et al. 2021). Although the model to be formulated is very complex, the basic structure is quite simple, illustrated in the following Equation 1 (Suryani et al. 2020):

$$E = f(X_i, Y_j) \quad \text{.....} \quad (1)$$

E is the effect of system performance (the results to be obtained). Xi, controllable variables and parameters. Yj, uncontrollable variables and parameters. While f is the relationship that occurs between Xi and Yj which results in E.

The amount of mocaf substitution is influenced by policy variables, the percentage of substitution and products that use 100% mocaf raw materials. The percentage of flour substitution in this study refers to previous research of 20% (Ruriani et al. 2013), 25% (Ramadhan & Sari, 2015), and 30% as the percentage of new policies. There are four products made from pure mocaf from 26 products that have been studied (Ruriani et al. 2013) which is 15.38%. The mathematically constructed formulation of the CLD demand subsystem can be seen in Table 1.

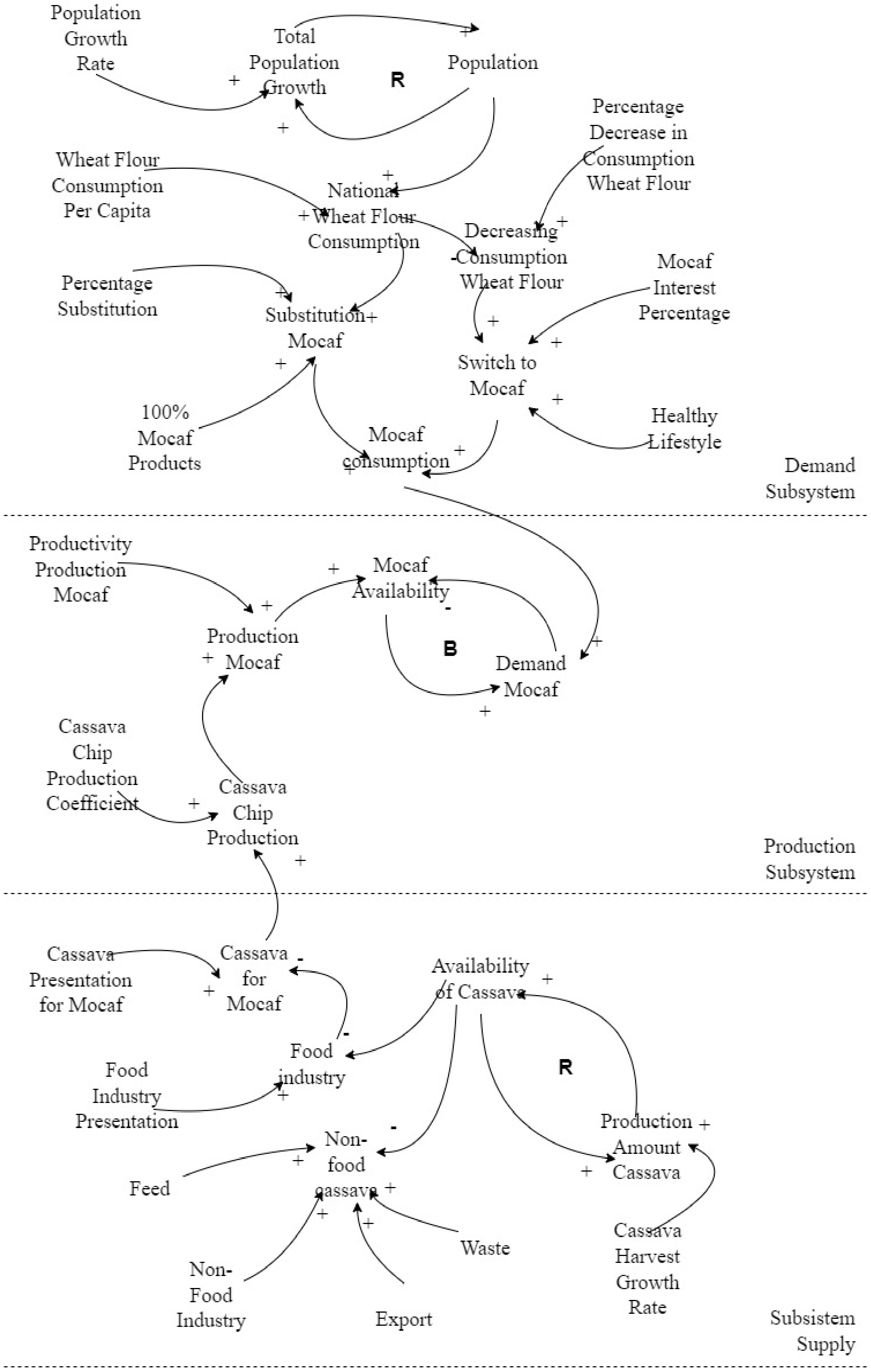

Figure 3. Causal Loop Diagram cassava availability for mocaf

The availability of mocaf is influenced by the demand of mocaf and mocaf production. In this research, mocaf production was influenced by the availability of cassava chips, which are semi-finished raw material. Production is not influenced by demand because there is no integrated system that regulates the amount of mocaf production relative to national demand. Policies that might be implemented if the amount of mocaf available is excessive, namely for exports and domestic food reserves that can be utilized when a disaster occurs. The relationship that occurs between mocaf availability and mocaf demand is balancing, which indicates that increasing demand will reduce the amount of availability, and availability decreases due to the increasing demand. The mathematical formulation for running the model can be seen in Table 2.

The availability of cassava itself is mostly used for the food industry, 85.09%. It is assumed that around 2% -5% of this amount is used as raw material for making mocaf. The mathematical formulation in modelling the supply subsystem can be seen in Table 3.

Stock Flow Diagrams (SFD)

In this study, Stella software was used to build a simulation model design with Stock Flow Diagrams (SFD). The simulation model is designed using a CLD that has been created previously with parameters that will be described in a system using Stella software. The entire system simulation model with Stella software can be seen in Figure 4.

Table 1. Mathematical models for demand subsystem

Variable	Symbol	Formulation
Population Growth Rate	PGR	1,08%
Total Population Growth	TPG	P*PGR
Population	P	264.225.880
Wheat Flour Consumption per capita	WFC	Forecast(data history,5,30)
National Wheat Flour Consumption	NWFC	WFC*P
Percentage Decrease in Consumption Wheat Flour	a	1,30%
Decreasing Consumption Wheat Flour	DWFC	NWFC*a
Mocaf Interest Percentage	b	62%
Healthy Lifestyle	C	53%
Switch to Mocaf	SM	b*c*DWFC
Percentage Substitution	PS(n)	20%; 25%; 30%
100% Mocaf Product	d	15,38%
Substitution Mocaf	MS(n)	PS(n)*c*NFWC
Mocaf Consumption	MC(n)	MS+SM
Number of substitution	n	-

Table 2. Mathematical formulation of production subsystems

Variable	Symbol	Formula
Mocaf Demand	DM	CA
Mocaf Production	MP	e*CCP
Mocaf Production Productivity	e	80%
Cassava Chip Production	CCP	f*CM
Cassava Chip Production Coefficient	f	1/5
Mocaf Availability	MA	MP

Table 3. Mathematical formulation of supply subsystems

Variable	Symbol	Formula
Cassava Percentage for Mocaf	g	RANDOM (2-5%)
Cassava for Mocaf	CM	g*FI
Food Industry Percentage	FIP	85.09%
Food Industry	FI	85.09%*CA
Cassava Non Food	CNF	F+NFI+Ex+W
Feed	F	2%
Non Food Industry	NFI	8.94%
Export	Ex	0.20%
Waste	W	3.77%
Cassava Availability	CA	TCP
Total Cassava Production	TCP	CA+(CA*h)
Cassava Harvest Growth Rate	h	-1.35%

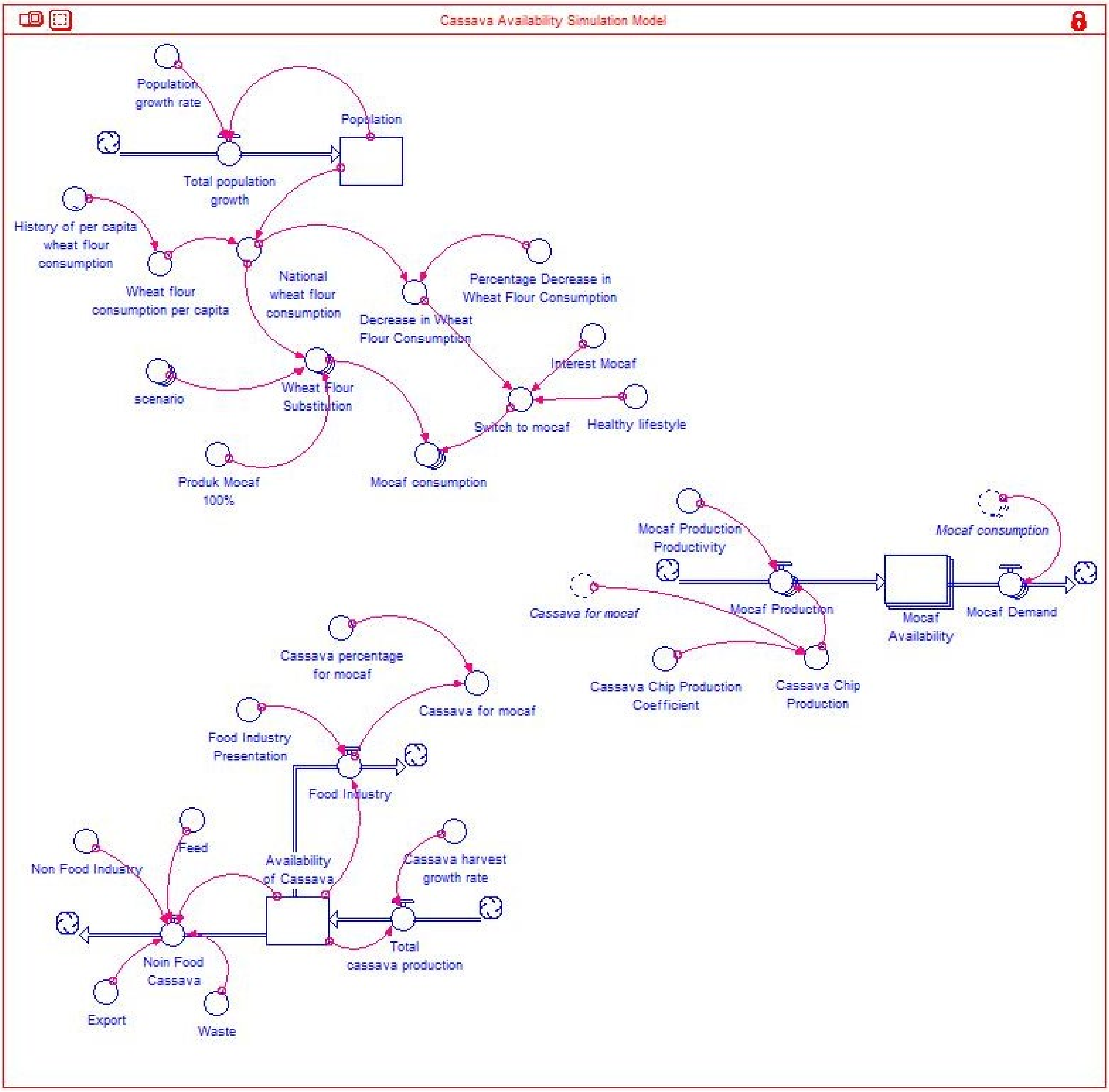

Figure 4. Model simulation of cassava availability as raw material for making mocaf

The demand subsystem illustrates that mocaf demand begins with the amount of national flour consumption which has decreased consumption by 1.30%, assuming the decrease in flour consumption switches to mocaf. Consumers who switch to mocaf are also influenced by 62% of those interested in mocaf and 53% of those who have a healthy lifestyle. Mocaf consumption is influenced by wheat consumers who switch to mocaf and the amount of wheat substitution. Flour substitution with three substitution policies run on the model are 20%, 25%, and 30% substitution. The amount of demand is influenced by the population. The population at the beginning of the simulation is a five-year average population of 264,225,880 people affected by a percentage of population growth of 1.08%.

The production subsystem model is designed to describe the availability of mocaf in meeting demand as well as the availability of cassava chips as semi-finished raw materials in mocaf production. The value of mocaf availability at the beginning of the simulation is the amount of mocaf production. Mocaf production itself has a productivity percentage of 80% of cassava chips. Cassava chips are produced from wet cassava with a ratio of 1kg of cassava chips produced from 5kg of fresh cassava.

The supply subsystem model is designed to describe the main raw material supply system, namely the availability of cassava in fulfilling mocaf production. The availability of cassava as the main raw material for making mocaf comes from the amount of cassava production which is influenced by the growth rate of harvest yields. The percentage of cassava in the food industry is 85.09%, of which the percentage processed into mocaf is assumed to be 2-5%.

Verification and Validation

The simulation model built must be credible by verification and validation of the model. Verification is a way to check that conceptual simulation models (flowcharts and assumptions) are correctly translated into computer language (Law & Kelton, 1991). Verification is performed before running the model. Verification as a first step for monitoring the built model is by the flowchart logic. If there is an error in making a model, connecting between stock, flow, and converter, as well as data input errors, Stella's software automatically refuses to run. Verification can also be done by clicking Run-Check Unit on the Stella software. Which serves to check the consistency of units in the model.

Validation is the process of determining whether the simulation model can accurately represent the real system by the research objectives (Law, 2008). Mean Absolute Percentage Error (MAPE) is one of the validity test methods used to determine the result data with actual data (Purnomo et al. 2015), which can be seen in Equation 2.

$$\mathrm{MAPE} = \frac{1}{n} \sum \frac{|Xm - Xd|}{Xd} \times 100\% \qquad (2)$$

Where, Xm= Simulation result data, Xd= actual data, and n = period/ amount of data. MAPE test accuracy criteria are, MAPE < 5% = the model results very accurately describe real conditions, MAPE between 5%-10% = the model results adequately describe real conditions and MAPE > 10% = the model results are not accurate in describing real conditions.

The MAPE calculation result of cassava availability of 5.86%, indicating that the model results are quite accurate in describing real conditions. The MAPE result of the population is 2.18%, so the model results are very precise in describing the real conditions.

Policy Scenarios

An overview of the scenario in this research can be seen in Figure 5. The initial scenario set wheat substitution at 20%, 25% and 30%. Scenario development is a combination of initial scenarios with harvest growth of 1% every year. Additional scenario development can be done as needed.

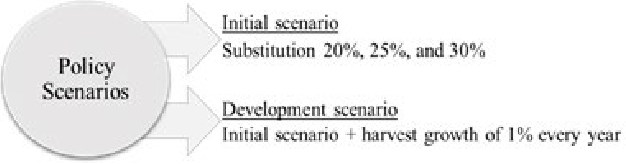

Figure 5. Policy scenario

The selected scenario is 30% substitution with 1% harvest growth every year. The results can be seen in Figure 6. This illustrates that the addition of 1% harvest growth every year affects the level of cassava availability.

The increase of cassava harvests also increases the amount of cassava used for mocaf production, so the availability of mocaf increases. A comparison of the results of the two simulations for the availability of mocaf at the end of the simulation year can be seen in Figure 7. The availability of mocaf in the development of the third substitution is smaller than in the other two, this is because the magnitude of demand influences availability, and the demand itself is influenced by the magnitude of substitution.

The amount of cassava for mocaf production can be seen in Figure 8. The amount of cassava for mocaf production is not known with certainty, at the beginning of this study the assumption of determining the percentage of cassava needed for mocaf was carried out randomly at 2-5% as a result of the amount of cassava for mocaf fluctuating. Until this study ended, no significant cassava percentage data had been obtained, so additional simulations were carried out assuming the percentage of cassava for mocaf was 2%. Additional simulations will be carried out in selected scenarios assuming the percentage of cassava for mocaf is 2%.

From the results of data processing, a policy was selected with the highest average value of mocaf demand of 39,980 tons. The two selected policies were compared to see the availability of cassava raw materials that were close to the value at the beginning of the simulation year, which was 18,930,400 tons. The results can be seen in Table 4. This shows that using a policy of increasing harvest growth by 1% every year, allows the availability of cassava to be achieved every year. Yield growth can be done by increasing planting area and reducing land conversion to concrete.

Sensitivity analysis was carried out on the selected scenario, namely the development scenario. The results show that 30% substitution and 1% harvest growth every year results in a more significant availability of cassava and mocaf compared to the initial scenario. The higher the percentage of harvest growth, the amount of cassava and mocaf availability will increase. The results of the sensitivity analysis of changes in harvest growth to the availability of cassava and the availability of mocaf can be seen in Table 5.

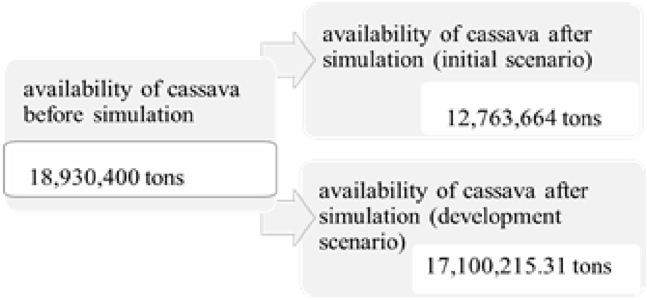

Figure 6. Cassava availability

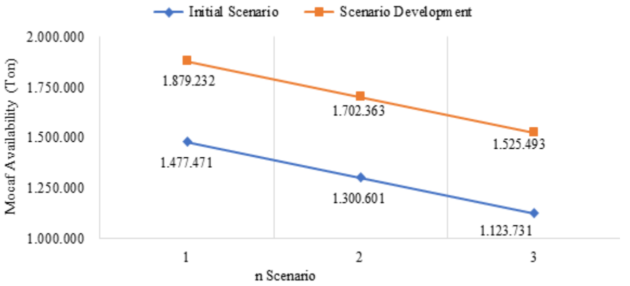

Figure 7. Mocaf availability at the end of the year simulation

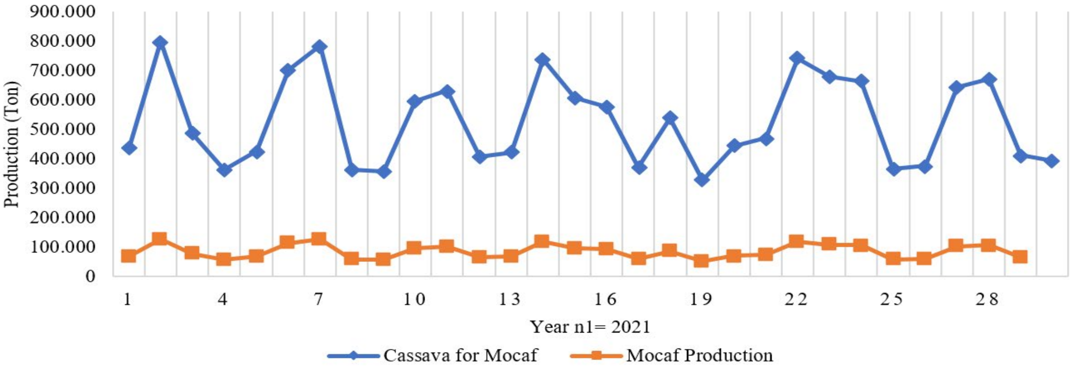

Figure 8. Cassava for mocaf and mocaf production

Additional Simulation of The Percentage Of Mocaf Needs

This additional simulation is made to identify the percentage of cassava for mocaf production which is close to the amount of demand, so that production is not excessive or lacking. The model is formulated with existing data and previous research related to carbohydrate commodities. According to research on rice production, a 15% increase in purchase prices can increase production by 0.282% (Kusumaningrum et al. 2010). Assuming cassava for mocaf is 2%, it can be known the amount of cassava supply and the amount of cassava for mocaf. Increasing the purchase price of cassava can increase farmers' cassava production. The availability of cassava in the scenario development simulation amounted to 17,100,215.31 tons, increasing to 18,560,625 tons after additional simulations with an increase in purchase prices at the farmer level by 15%. Mocaf production has decreased, along with the availability of cassava. On the other hand, the demand for mocaf increases over time accompanied by an increase in the availability of mocaf that is enough to meet demand. The demand for mocaf at the end of the simulation year was 44,185 tons with a total production of 50,573 tons, and the availability of mocaf at the end of the simulation year of 372,773 tons could be used as food reserves, as well as exports. Additional simulations show that the percentage of cassava for mocaf of 2% is sufficient for mocaf production to meet demand. A comparison of the production, demand, and availability of mocaf can be seen in Figure 9. PM is the amount of mocaf production, DM is the number of mocaf demand, and AM is the number of mocaf available.

Cost Calculation

Price and cost analysis refers to 30% substitution and 1% harvest growth. From the simulation results of the development scenario, the average availability of mocaf is 875,496.19 tons/year which is equivalent to 1,129,263 tons of wheat or 30,718 bushels of wheat at $ 792 per bushel, US exchange rate of IDR15,500 then we can save IDR377,090,600,527 or IDR377 billion.

Market structures that are not perfectly competitive lead to cassava market failure. Efforts to address this issue include eliminating market failures and reducing high transaction costs (Abriani et al. 2023). Downstreaming cassava into cassava chips as a semi-finished material for mocaf flour can be an alternative to increasing the cassava market. The income of each entity involved increases, as can be seen in Table 6.

Table 4. The comparison results of two selected policies

Scenario	30% (initial scenario)	30% & 1% (development scenario)
Population	360,800,488.75	360,800,488.75
Cassava Availability	15,651,962.26	18,000,337.51
Mocaf Availability	713,133.98	875,496.19

Table 5. Sensitivity analysis of the development scenario

30% Substitution and 1% harvest growth (Development Scenario)						
Harvest Growth (%)	1	1.02	1.08	1.09	1.11	1.13
Mocaf Availability (Ton)	875,496	904,909	912,094	913,297	915,708	918,125
Cassava Availability (Ton)	18,000,338	18,051,869	18,207,616	18,233,743	18,286,143	18,338,738

Table 6. Results of simulated earnings of each entity

Description	Cassava Farmer	MSMEs & Home Industry	Mocaf agro-industry
Production (Ton)	5,252,977	1,050,595	875,496
Cost Production per Ton (IDR)	284,139	1,200,000	11,000,000
Subsidies per Ton (IDR)	-	-	3,000,000
Selling price per Ton (IDR)	750,000	10,000,000	12,000,000
Income (IDR)	2,447,157,183,418	4,202,381,712,000	3,501,984,760,000
Income (%)	164%	67%	50%
Earnings per Ton (IDR)	465,861	4,000,000	4,000,000

In addition to domestic consumption, export opportunities are still open (exports of 45 tons of mocaf to Turkey in 2022 worth 1.2M) (Yulianto, 2022), mocaf exports have a higher price of around IDR26,700/kg. With an average availability of 875,496 tons of mocaf, domestic mocaf demand can be met. The existing Mocaf can be allocated as non-rice food reserves, and exports assuming 2% mocaf exports, with a revenue value of IDR1.1 Trilliun. The results are summarized in Table 7.

Sustainable Supply Chain Management (SSCM)

SSCM is described by adopting the sustainable metric with three dimensions, namely environmental, social, and economical (Lsaputri et al. 2020). Qualitatively research has been carried out on the implementation of SSCM for the agro-industry mocaf namely, sieve residue for animal feed, indoor flouring process minimizes air pollution, uses electricity-based technology, and minimizes use of fossil fuels (Srikandi et al. 2022). With many limitations, this study will illustrate the benefits of sustainability value based on simulation results calculated by referring to previous research and field studies. The flow of sustainability elaboration can be seen in Figure 10 and the results of the continuation value can be seen in Table 8.

Table 7. Mocaf export simulation results

Description	Value	Remark
Average Availability of Mocaf	875,496 ton	Results of the development scenario
Average Mocaf Demand	44,663 ton	Average request during simulation
National Mocaf Stock	830,834 ton	Availability minus demand
Mocaf Food Reserve	16,617 ton	Assumption of non-rice food reserves 2%
Mocaf Export	41,542 ton	Assumption export mocaf 2%
Mocaf Export Earnings	IDR1,109,162,806,993	Export results 41,542 ton
Mocaf stock	772,675 ton	Mocaf available

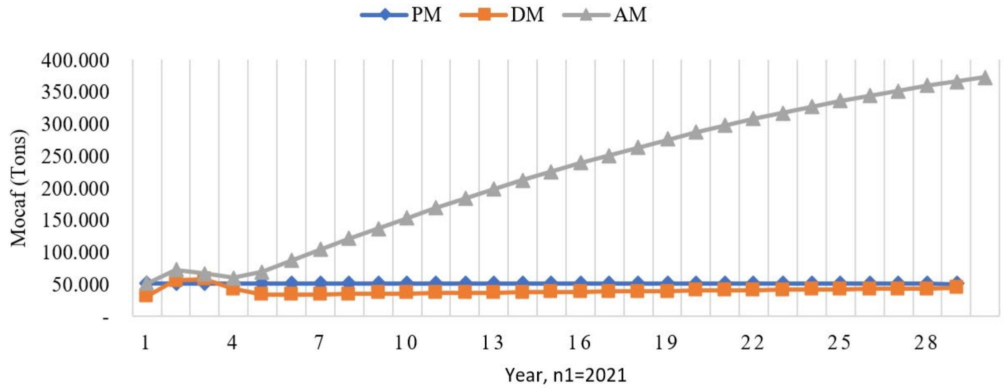

Figure 9. Mocaf production quantity, demand, and availability

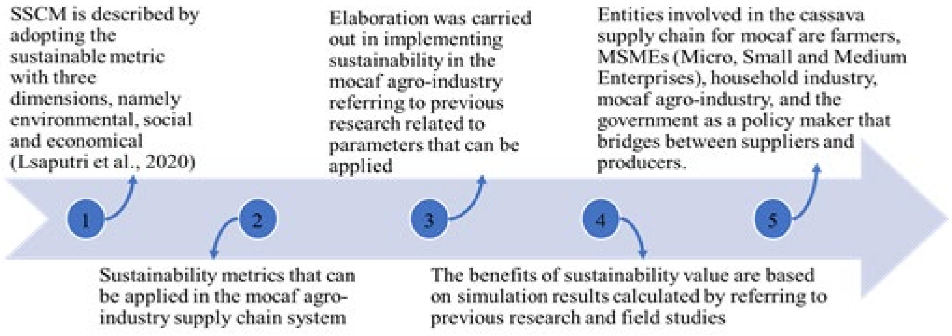

Figure 10. The sustainability elaboration for agro-industry mocaf

Table 8. Research results of sustainability application

Dimensions and Parameters	Research Results	Previous research and related references	The value of sustainability	Entity
Dimension: Environment Parameter: Air emissions	Mocaf production averages 875,496 tons/ year	Transport emissions from agrifood systems of 0.5 Gt CO2eq (FAO, 2021)	0.5 Gt CO2eq is equal to 499,999,999 metric tons. By producing 875,496 tons of mocaf, it can reduce wheat imports by 1,129,263 tons, thereby reducing CO2 emissions due to transportation by 0.002259 Gt CO2eq.	Mocaf agro-industry, Ministry of Industry, Ministry of Trade
Dimension: Social Parameter: Employment	The amount of cassava production increases with the development of a 1% harvest growth scenario, which can be done by adding planting areas that have an impact on increasing the workforce in rural areas	The marginal land area in Indonesia reaches 157,246,565 hectares, and the potential land utilized is around 58.4% (Sahabatpetani.com, 2018).	41.6% of untouched land amounts to 65,414,571 hectares. If 1% of this land is managed by cassava farmers, each with 1 hectare, it can support 654,146 farmers. This increase in planting area would significantly impact the rural workforce by providing more employment opportunities.	Farmer, Ministry of Agriculture
	Mocaf production averages 875,496 tons/ year	1-ton mocaf got 100kw supply from home industry (KWT Makmur)	1 ton of mocaf can absorb the labor of 10 home industries. If it produces 875,496.19 tons of mocaf per year, it can absorb 8,755 home industries	Mocaf agro-industry, Ministry of Industry
Dimension: Social Parameter: Earnings	To produce mocaf of 875,496.19 tons, 1,050,595.43 tons of cassava chips are needed with cassava raw material needs of 5,252,977.13 tons.	Increased production increases rural incomes (Mahbubi, 2013)	- Increased production along the supply chain can increase income. - The income obtained by farmers is 164% with a waiting time of 10-12 months, MSMEs 67%, and mocaf agro-industry business actors 50%.	Farmers, MSMEs, Mocaf agro-industry, Ministry of Agriculture, Ministry of Industry, Ministry of Trade
Dimension: Social Parameter: Productivity	The average availability of cassava in the development scenario is 18,000,337.51 tons	Harvest productivity, 30 tons of cassava per hectare (Widowati, 2009)	By utilizing 654,146 hectares of marginal land by cassava farmers, a harvest of 19,624,371 tons was obtained	Farmer, Ministry of Agriculture
Dimension: Social Parameter: Food security	Production equipment subsidies for MSMEs producing mocaf	16 million smallholder farming households (farming households with less than 0.5ha land tenure) (bps.go.id, 2023)	Mocaf can be used as self-consumption from its yard by 16 million agricultural households to create food independence	Farmers, MSMEs, Ministry of Agriculture and BPN
Dimension: Economy Parameter: Added value	The selling price of mocaf after subsidies is IDR 12,000	price of raw cassava IDR 750,000/ ton at farmer level (KWT Makmur)	Added value based on price, the results of processing cassava into mocaf reached 93.75%, with the price of raw cassava IDR 750,000 / ton at the farmer level, which was processed into mocaf produced IDR 12,000,000 / ton.	Farmers, MSMEs, Mocaf agro-industry, Ministry of Trade

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The factors affecting the availability of cassava in the supply chain for mocaf raw materials are harvest growth and the increasing purchase price of cassava at the farmer level. The results showed that dynamic system simulations can describe the availability of cassava raw materials using a 30% substitution policy and 1% harvest growth every year (development scenario). With the implementation of this policy, the availability of cassava can be fulfilled until the end of the simulation year of 17,100,215.31 tons. Additional simulations show that the percentage of cassava for mocaf of 2% is sufficient for mocaf production to meet demand. The sustainability factor which refers to the simulation results, namely from the environmental dimension, can reduce CO_2 emissions. The social dimension is the absorption of rural labor and home industry labor, utilization of marginal land, increasing income, and realizing food security. The economic dimension is the added value and durability of the mocaf.

Recommendations

Research on the availability of cassava for mocaf nationally has several obstacles, namely, the availability of cassava demand data used for making mocaf and mocaf demand data. With these constraints, further research should be carried out in-depth for each subsystem and entity so that the results can be more accurate.

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