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DYNAMIC MODEL SIMULATION OF SAGO RICE AVAILABILITY TO SUPPORT RESILIANCE CASE STUDY IN MERANTI ISLANDS DISTRICT

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ABSTRACT

Sago is a typical Southeast Asian plant that is often found in water areas such as Meranti Regency. Even though Meranti Islands Regency in Sumatra is the largest center for sago growth, public consumption of sago is not yet in line with the high potential of this plant as a source of carbohydrates. In facing population growth and increasing food needs, sago has become a strategic commodity to maintain food security. This research uses dynamic modeling with Powersim Studio 7 to simulate planning scenarios to ensure the availability of sago in the future. Simulations show that Meranti Islands Regency can achieve the target of sago plantation area in 2032 with an accelerated growth policy, producing 3,915,168.71 tons of sago rice in 2040 and 499,182.72 tons in 2022.

Keywords: *food security, Meranti Islands, population growth, sago*

BACKGROUND

Meeting food needs is a challenge for Indonesia, which is an archipelagic country. The higher the population growth, the higher the need for food. Research conducted by Prasada et al. (2020) told that land area also has a significant effect on the portion of food expenditure. The increasing agricultural area causes a decrease in the share of food expenditure, which shows the increasing food security of the population. This can happen because the more agricultural land available in a region, the higher the potential that region has to produce the food needed by the population, so that food availability can be guaranteed and the population's food security can be increased. The decrease in land area, one of which is caused by the sale of land for conversion, will result in a decrease in food supplies which will then impact food security (Janah & Eddy, 2017).

The concept of food security is related to several derivative concepts, namely food independence and food sovereignty. Where the meanings of the three are often interchanged in their use (Dharmawan & Kinseng, 2006). Food independence shows the capacity of a region (national) to meet its food needs in a self-sufficient manner. The greater the proportion of food and foodstuffs that are supplied from outside the regional community system, the less independent they will be in providing food and vice versa. Research related to the availability of food supplies has been widely carried out in recent years, such as Kumar & Nigmatullin (2011) stated that the availability of food supplies includes food quality, entity integrity, safety and health, sustainable production, product diversification, and information services related to foodstuffs.

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The geographical location and area of Indonesia is the cause of differences in soil conditions and suitability for plant types, including sources of food produced. Differences in farming culture and staple foods between regions also influence people's choices in choosing food commodities to consume. The potential of Indonesian food sources as a choice for public consumption is quite large, namely 77 types of carbohydrates, 26 types of nuts, 389 types of fruit, 228 types of vegetables, 110 types of spices, as many as 40 types and beverage ingredients and 1,260 types of medicinal plants (Nugrayasa, 2015).

Sago is a plant that found in the area Indonesia such as Papua, Maluku, Central Sulawesi, South Sulawesi, Southeast Sulawesi, South Kalimantan, West Kalimantan, Jambi and Riau. Judging from its productivity, sago trees have higher productivity than other carbohydrate-producing plants, such as sweet potatoes, corn, rice and cassava (Sakiynah et al., 2013) . This can be used as another option for consuming carbohydrates besides rice. However, despite the advantages of sago such as high productivity and the gluten-free nature of sago, people do not consume much sago. The high productivity of sago and its nutritional value do not make people want to consume sago.

Riau is the largest sago producing province in Indonesia with a contribution of 80.99% of the total sago production in Indonesia (Direktorat Jenderal Perkebunan, 2019). Sago is processed into various foods such as sepolet, gedegob, roti jala, lontong and sago cendol. Sago starch is very flexible and can be reprocessed into various types of food such as sago noodles, sago biscuits and typical Riau sago rendang. One of the largest sago producing districts in Riau province is Meranti Islands Regency. The area of people's sago plantations in Meranti Islands Regency is around 41,151 Ha (Dinas Ketahanan Pangan dan Pertanian Kabupaten Kepulauan Meranti, 2021) which is spread across nine sub-districts in the Meranti Islands Regency and has 97 sago processing refinery units with a dry sago flour production of 247,013.8 tons/year.

Table 1. Number of Farmers and Sago Commodity Production in Meranti Islands Regency 2022.

No	District	TBM (Ha)	TM (Ha)	Jmlh (Ha)	Fabrique (Unit)	Farmer (KK)	Prod (Ton/Th)	Productivity (Kg/Ha)
1	Tebing Tinggi	-	381	381	3	296	3,296.7	8,653
2	T. Tinggi Barat	1,486	7,535	9,021	36	2,511	67,799.9	8,998
3	Rangsang	136	387	523	3	749	3,482.2	8,998
4	Rangsang Barat	-	255	255	-	246	1,979.5	7,763
5	Merbau	2,647	2,724	5,371	7	1,903	24,513.2	8,999
6	T. Tinggi Timur	7,286	9,398	16,684	33	5,548	86,236.0	9,176
7	Pulau Merbau	849	1,298	2,147	5	1,322	11,527.5	8,881
8	Rangsang Pesisir	386	1,969	2,355	5	1,227	17,908.0	9,095
9	Tasik Putri Puyu	375	3,174	3,549	5	2,267	30,270.4	9,537
	Total	13,165	27,121	40,286	97	16,069	247,013.8	9,108

Sources: Plantation Crop Statistics for the Meranti Islands Regency Food Crops and Agriculture Service 2022.
Information:
TBM : Immature plants
TM : Produce plants
TTR : Damaged plants

The sago plant in Meranti Islands Regency is a garden business that has been carried out for generations. Since 2009 there have been private plantations PT. National Sago Prima which has developed sago plants in Meranti Islands Regency with a land area of ± 14,000 hectares from an area of 21,620 hectares from the concession permit he obtained (Dinas Ketahanan Pangan dan Pertanian

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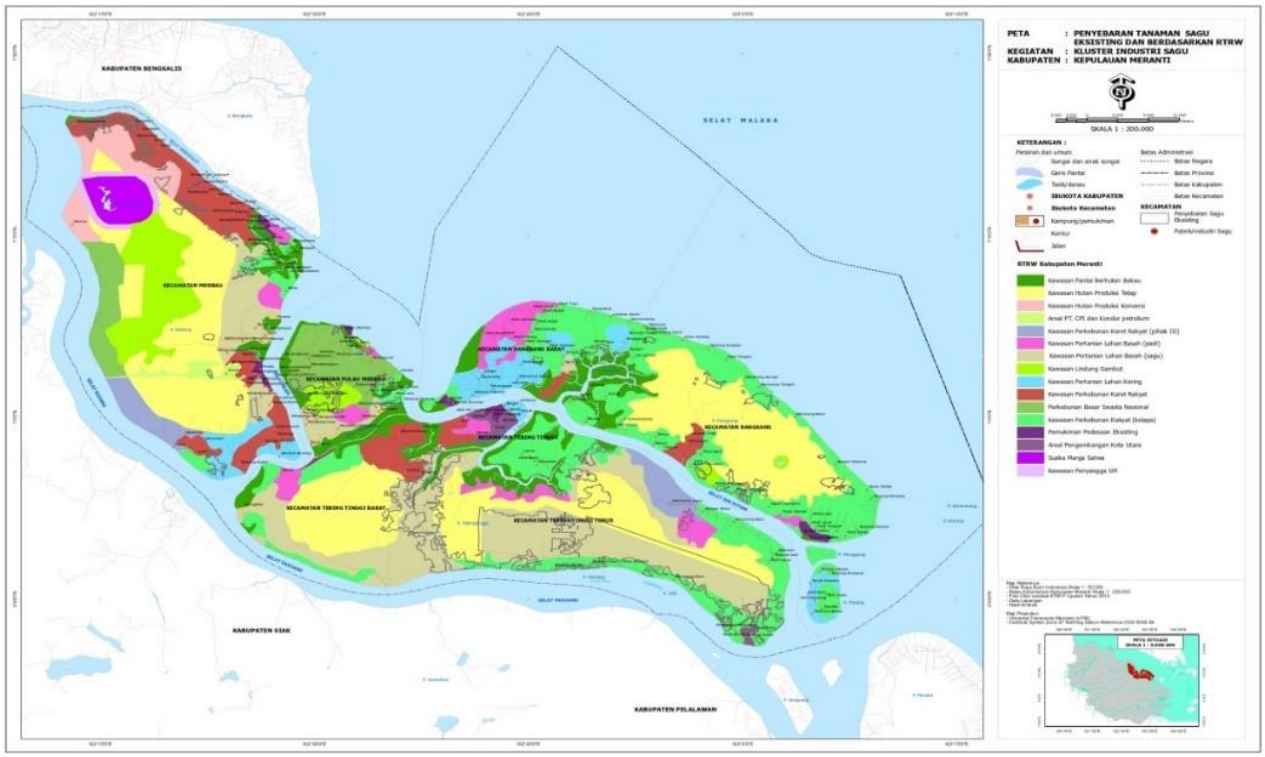
Kabupaten Kepulauan Meranti, 2021). Meranti Islands Regency processes sago into wet sago flour and dry sago flour. The wet sago flour is processed to make sago noodles and other processed food products, such as cakes, while the dried sago flour is exported to Malaysia Batu Pahat. Total exports



of dry sago flour to Malaysia were 4,322 tons/year (Dinas Perdagangan, Perindustrian, Koperasi dan UKKM Kabupaten Kepulauan Meranti Tahun 2021).

Figure 1. Map of Sago Distribution in Meranti Islands Regency

Sago is a strategic commodity, it is very important to know the behavior of the sago supply system for planning purposes. The method used is dynamic modeling and then carrying out simulations on the model to find out various possibilities or planning scenarios in order to guarantee the availability of sago and make sago as sago rice for food security. Research by Dwi (2016) shows that developing a rice supply model is needed as a tool to support decision makers in developing policies to ensure rice availability. Based on the tests and analyzes that have been carried out, the variables of productivity and availability of rice fields are two important variables that can have a significant impact on the rice production system as a whole. These two variables can be used as a reference as a basis for studying the development of policy models within the framework of ensuring rice availability. Therefore, to overcome the problem of rice availability, what needs to be done is to improve the rice availability system, so that the availability of rice for the community is always available to meet their needs. This fact is what prompted researchers to conduct research on the availability of sago rice using a dynamic systems approach in Meranti Islands Regency.

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RESEARCH METHODS

Research Design

This research is a combination of explanatory research and causal research, namely a combination of secondary data analysis and experimentation. Exploratory research using secondary data analysis to determine the situation and problems of sago in Meranti Islands Regency, while causal research using experiments to determine the relationship between phenomena. This research was carried out by applying dynamic system simulations to determine the sago supply chain over the next 10 years and is oriented towards social, economic and environmental aspects. The data used in this research is secondary data in the form of 5 years time series data on sago production, sago plantation area, harvest area, sago production, sago productivity, land conversion, extensification, sago consumption, population of the Meranti Islands Regency.

The data sources for this research are related agencies, including the Central Statistics Agency and the Ministry of Agriculture. Modeling uses a dynamic systems approach with the PowerSim Studio 7 program. Outline the stages of solving problems using a dynamic systems approach; 1) Problem Formulation and Definition, 2) Conceptual System Preparation, 3) Model Formulation, 4) Model Simulation and Validation, and 5) Policy or Decision Analysis and Improvement. Validation test using mape with the Microsoft Excel program, this test can be used to determine the suitability of forecast data with actual data.

Verification and Validation

Model verification is carried out by checking dimensionally (units of measurement) of the model variables. Model validation is an attempt to evaluate the model created, conclude whether the model built is an accurate representation of the reality being studied so that it can produce convincing conclusions (Eriyanto, 1999). Generally, model validation is carried out according to modeling objectives, namely by comparing dynamic behavior with real conditions. If it is considered valid, then the model can be used as a representative of the real system.

There are many statistical tests that can be used to measure deviations between simulation output and actual data, including: Mean Absolute Deviasion (MAD), Mean Square Error (MSE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Percentage Error (RMSPE) where each statistical test above measures the accuracy of the simulation output. In this research, the MAPE test was used to determine the suitability of forecast (simulation) data with actual data. According to (Soematri in Saputra et al., 2019) The criteria for model accuracy using the MAPE test are: MAPE < 5%: Very precise, 5% < MAPE < 10%: Accurate, MAPE > 10%: Not precise. The data used for model verification is actual data and simulation results for 2017-2022, while the data used for model validation is data existing and simulation results for 2022-2032 with the following mathematical formula:

$$MAPE = \frac{1}{\frac{n\sum(Xm - Xd)}{Xd}} \; x \; 100\%$$

Information:
Xs : The simulation data
Xe : The existing data
n : Period/amont of data

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RESULT AND DISCUSSION

Flow Diagram Simulation (Stock and Flow Diagram) of Availability of Sago and Sago Rice Land in Meranti Islands Regency

The flow diagram simulation (stock and flow diagram) of the availability of sago and sago rice land in Meranti Islands Regency is a translation of a causal loop diagram which can be simulated based on data quantification and the data assumptions above. To understand the stock and flow diagram simulation of the availability of sago and sago rice land in Kepualaun Meranti Regency, see Figure 2.

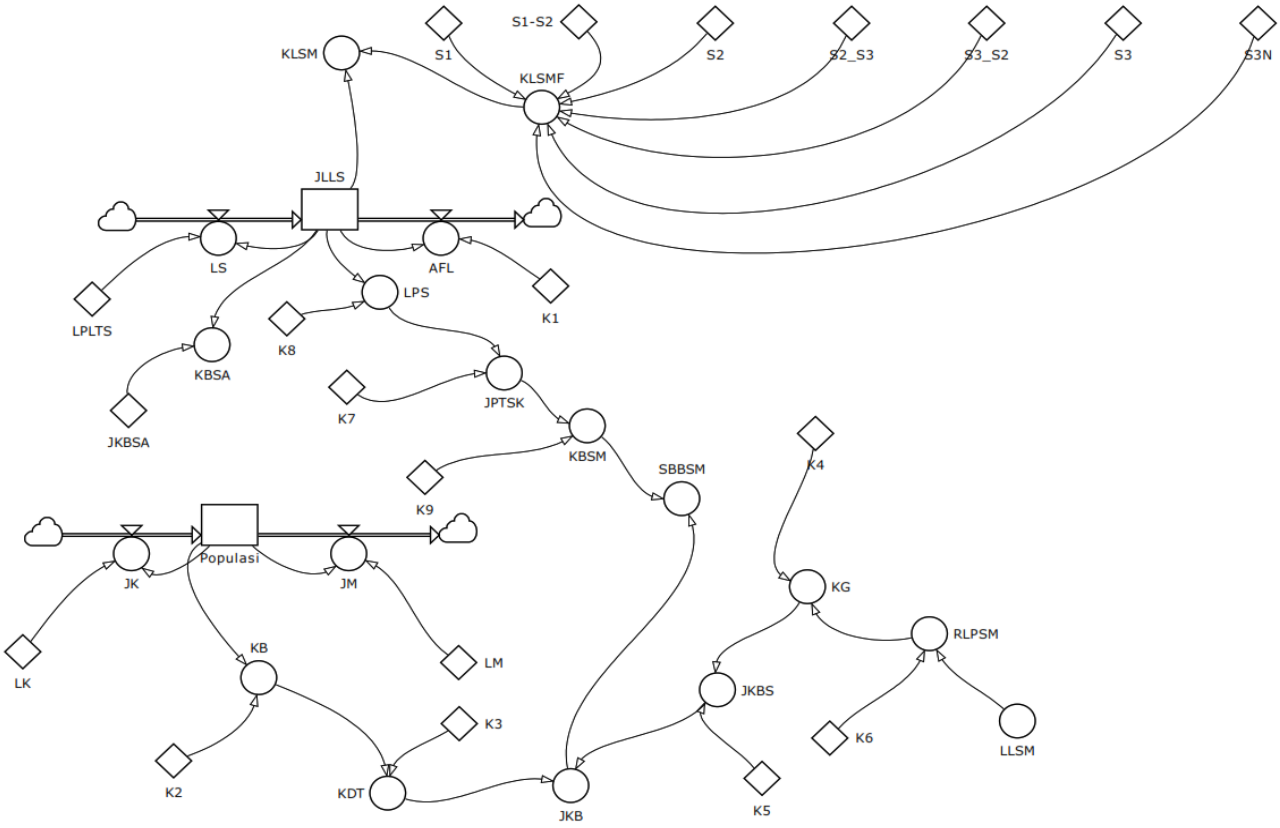

Figure 2. Flow Diagram Simulation (Stock and Flow Diagram) Availability of Sago and Sago Rice Land in Kab. Meranti Island.

The variables used in this simulation are:

KLSMF	: Suitability of sago land according to function (ha)
KLSM	: Availability of meranti sago land (ha)
JLLS	: Total area of sago land (ha)
LS	: Sago land (ha/year)
LPLTS	: Rate of increase in sago planting area (ha/year)
AFL	: Land conversion (ha/year)
K1	: Land conversion (ha/year)
KBSA	: Need for sago seeds (stems/ha)
JKBSA	: Number of sago seed bets (stems/ha)
JK	: Number of births (persons/year)

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LK : Birth rate (persons/year)
JM : Number of deaths (people/year)
LM : Death rate (persons/year)
Population : Total population of Meranti (people)
KB : Rice consumption (kg)
K2 : Rice consumption per capita (kg/year)
KDT : Consumption in tons (tons)
K3 : Conversion of kg to tons (tons)
JKB : Amount of rice needed (tons)
K4 : Grain production (tons/ha)
JKBS : Amount of rice available (tons)
K5 : Conversion of grain to rice (%)
KG : Availability of grain (tons)
LLSM : Area of Meranti rice fields (ha)
RLPSM : Average harvested area of Meranti rice fields (ha)
K6 : Percentage of harvested area (%)
LPS : Sago harvest area (ha)
JPTSK : Amount of dry sago flour production (tons)
K7 : Conversion of dry sago flour (ton/ha)
K8 : Harvest percentage (%)
K9 : Conversion of dry sago flour to sago rice (%)
KBSM : Availability of meranti rice (tons)
SBSM : Stock of meranti sago flavor (tons)

Verification and Validation of the Simulation Model for Meranti Sago and Sago Rice Land Availability in Meranti Islands Regency

Based on the model that has been built and developed, a simulation trial is then carried out. Validation aims to determine whether the model that has been built or the simulation model is acceptable and represents the real system or not by comparing the structure of the behavior of the model developed with the structure and behavior of the system in real situations. Procedures in computer form need to be validated before being used in simulations. Validation of simulation programs can be carried out based on the results of checking the similarity between simulation results and real operational results using data input the same one. If this test shows that the simulation results do not match the results of real system operations, the simulation program used is considered invalid and cannot be used in the simulation. Research conducted by (Saputra et al., 2019) with the title Analysis of Rice Availability Using a Dynamic System Approach in Punggaluku Village, Laeya District, South Konawe Regency, the results of the Verification and Validation test using MAPE showed that the results of the population simulation model showed a very high level of accuracy (very exact) with a MAPE value of 0.192%, and for paddy field area and rice production it shows high accuracy (very precise) with MAPE values of 2.17% and 3.07% respectively. To find out whether the system is real or not real in this research, see the following table.

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Table 2. Simulation Model Validation Test

Year	Resident		Sago Land Area		Rice Production	
	Data	Sumulation	Data	Simulation	Data	Simulation
2020	206,116	206,116	39,951	39,951	2,806.91	2,219.36
2021	209,460	221,502	40,186	40,352	3,949.83	2,971.32
2022	213,532	238,036	40,286	40,756	3,950.00	2,470.33
MAPE	5.74%		0.53%		5.73%	

Source: Processing Data

Table 2 validation test of the sago area simulation model shows a very high level of accuracy (very precise) with a MAPE value of 0.53%, for population and rice production it shows high accuracy (exact) with a MAPE value of 5, respectively 74% and 5.73%. Based on this, the model formed is able to describe the actual conditions.

Simulation Scenario of Sago Land Area Without Policy in Meranti Islands Regency

Availability of Sago Land Area in Meranti Islands Regency

The availability of sago land area will influence the production and productivity of dry sago flour which will later be processed into sago rice. This needs to be known, so that areas with sago production potential can be better developed and areas that do not have the potential to develop sago can develop other suitable food potential. The aim is to increase the availability of sago rice. The balance between the availability and demand for rice consumption is greatly influenced by population. If the availability of rice is greater than the need for rice consumption, then the region is said to have a rice surplus, whereas if the availability of rice is lower than the need for rice consumption then the region is said to have a rice deficit. To find out the extent of utilization of sago land area in sago development, see Figure 3.

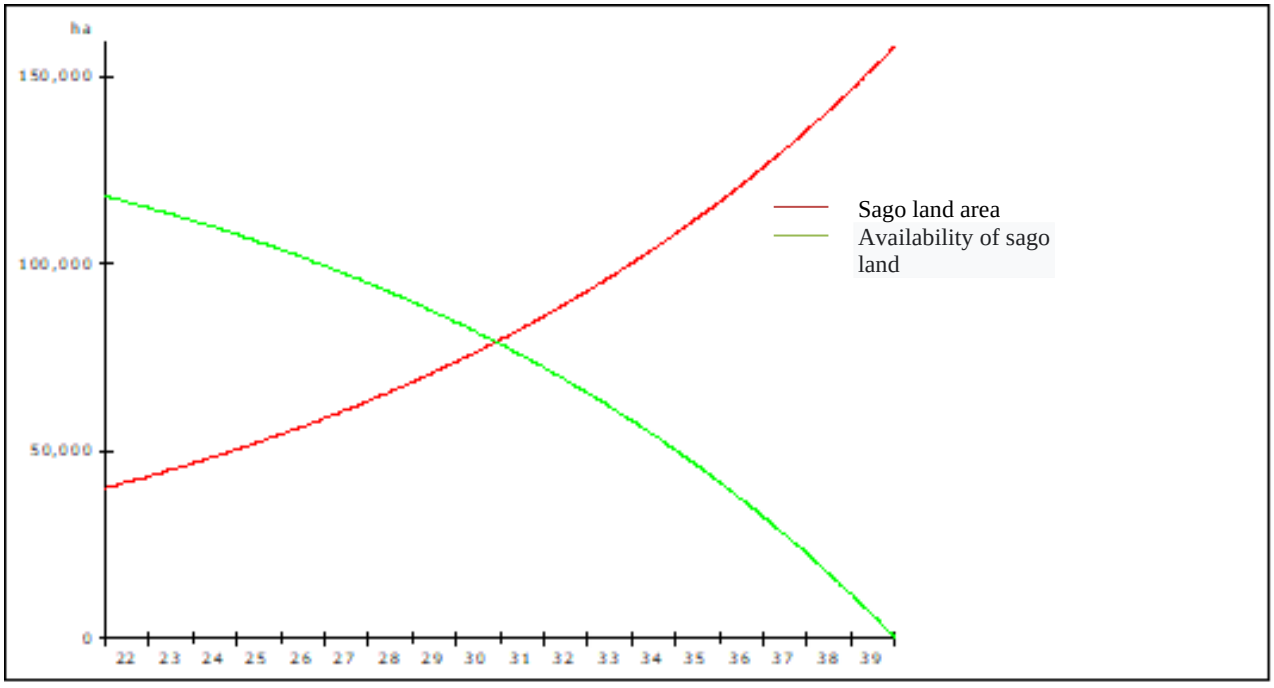

Figure 3. Graph of Simulation Results of Sago Land Availability in Meranti Islands Regency

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Based on Figure 3, it shows that the amount of land area continues to increase every year, while the amount of land availability continues to decrease every year. So, it can be explained that the availability of sago land based on land suitability in Meranti Islands Regency could reach as much as 158,571 Ha by 2040. This means that in 2040 the availability of sago land will be limited.

Availability of Rice in Meranti Islands Regency

It is important to know the availability of rice and the need for rice consumption, so that areas that have rice production can develop further and areas that do not have the potential to develop rice can develop other suitable food potential. The aim is to increase the availability of rice. The balance between availability and demand for rice consumption is greatly influenced by population. Data obtained from the Meranti Islands Regency Food Crops and Livestock Food Security Service shows that Meranti Islands Regency only has a potential land area of 4,379 ha and a productive land area of 2,472 ha. More details about the potential area of rice fields based on sub-districts in Meranti Islands Regency can be seen in the following table.

Table 3. Land potential and productive land for paddy fields in Meranti Islands Regency (2022).

No	District	Potential land area (Ha)	Productive area (Ha)
1	Rangsang Barat	1,774	1,477
	- Desa Anak Setatah	135	-
	- Desa Sei Cina	575	425
	- Desa Bina Maju	454	538
	- Desa Melai	510	514
	- Desa Segomeng	100	-
2	Rangsang Pesisir	810	675
	- Desa Sendaur	590	580
	- Desa Kedaburapat	220	95
3	Rangsang	350	
	- Desa Topang	200	-
	- Desa Penyagun	150	-
4	Tebing Tinggi Timur	220	
	- Desa Tj. Gadai	70	300
	- Desa Teluk Buntal	1,000	20
	- Desa Lukun	50	-
5	Pulau Merbau	1,225	-
	- Desa Kuala Merbau	350	
	- Desa Centai	125	
	- Desa Tj. Bunga	100	
	- Desa Renak Dungun	650	
	Total	4,379	2,472

Source: Food Security and Agriculture Service of Meranti Islands Regency (2022)

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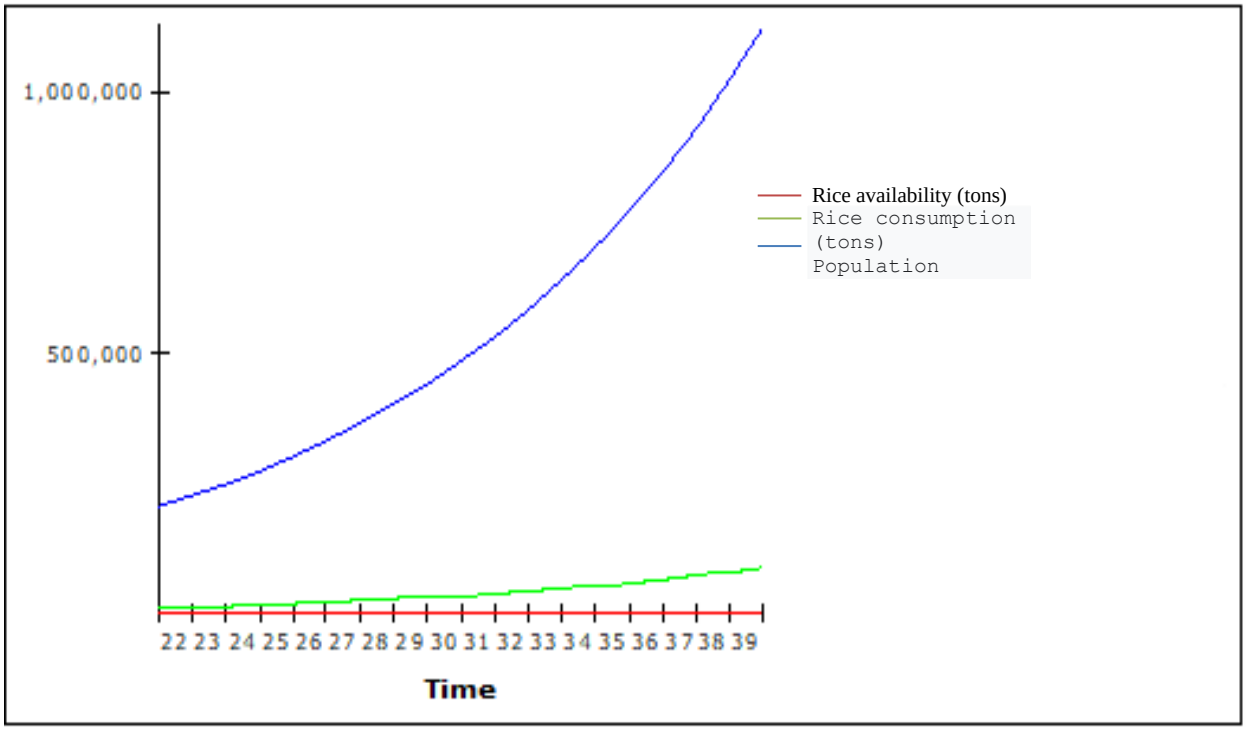

Figure 4. Graph of Simulation Results of Populations, Consumption Levels and Rice Availability in Meranti Islands Regency.

Based on the table and figure above, to find out the availability of rice in Meranti Islands Regency according to regional potential, it can be seen in Figure 4 which shows that the population in Meranti Islands Regency continues to increase every year, so that the level of rice availability in Meranti Islands Regency continues to increase. Rice consumption also continues to increase. The graph comparing consumption levels with rice availability shows that there will be a fairly high rice deficit every year until 2040. This comparison can be seen in Table 4**.**

Table 4. Simulation Results of Population Number, Consumption Level and Rice Deficit in Meranti Islands Regency.

No	Year	Population	Consume Rise (ton)	Rice Deficit (ton)
1	2022	210,407.00	17,436.43	11,883.27
2	2023	230,913.63	19,135.81	13,582.65
3	2024	235,418.87	21,000.82	15,447.66
4	2025	278,117.52	23,047.60	17,494.44
5	2026	305,223.33	25,293.86	19,740.70
6	2027	334,970.93	27,759.04	22,205.88
7	2028	367,627.78	30,464.40	24,911.32
8	2029	403,446.44	33,433.61	27,880.44
9	2030	442,767.03	36,692.10	31,138.94
10	2031	485,919.88	40,268.18	34,715.02
11	2032	533,278.47	44,192.79	38,639.62
12	2033	585,252.72	48,499.89	42,946.73
13	2034	642,292.46	53,226.78	47,673.61
14	2035	704,891.40	58,414.35	52,861.19
15	2036	773,591.34	64,107.51	58,554.35
16	2037	848,986.89	70,455.54	64,802.38

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No	Year	Population	Consume Rise (ton)	Rice Deficit (ton)
17	2038	931,730.63	77,212.52	71,659.36
18	2039	1,022,538.71	84,737.78	79,184.62
19	2040	1,122,197.11	92,996.47	87,443.31

Source: Processing Data

Based on table 4 above, the simulation results show that an increase in population will increase the level of rice consumption. In 2022 the population will be 210,407 people with a consumption level of 17,436.43 tonnes, the population increase will continue to increase until 2040 the population will be 1,122,197.11 people with a consumption rate of 92,996.47 tonnes. However, the increase in consumption levels which is increasing every year in Meranti Islands Regency is inversely proportional to the availability of rice in 2022. Meranti Islands Regency's rice field area is 4,379 ha, only producing a harvested land area of 2,434.7 ha, where the harvested land area only produces 8,716.31 tons. grain and produced 5,553.16 tons of rice. This means that in the same year Meranti Islands Regency experienced a rice deficit of 11,883.27 tons or was only able to meet local rice needs of 31.85% for 2022 and every year Meranti Islands Regency continues to have a rice deficit due to limited potential areas for development. To meet the availability of rice which is always available in Meranti Islands Regency, it is necessary to carry out a simulation policy scenario to see a picture of future rice availability as well as policy recommendations. Based on the simulation above, policy determination needs to be carried out by simulation. For consideration, a simulation study was carried out to obtain the right policy.

Policy Scenario for Increasing Sago to Sago Rice in Meranti Islands Regency

This scenario was carried out to see the potential for sago production, namely dry sago flour into sago rice, where so far the sago produced from sago processing has only been in the form of dry sago flour and then processed into various typical sago foods except sago rice. To see the potential of sago flour to become sago rice, see Figure 5.

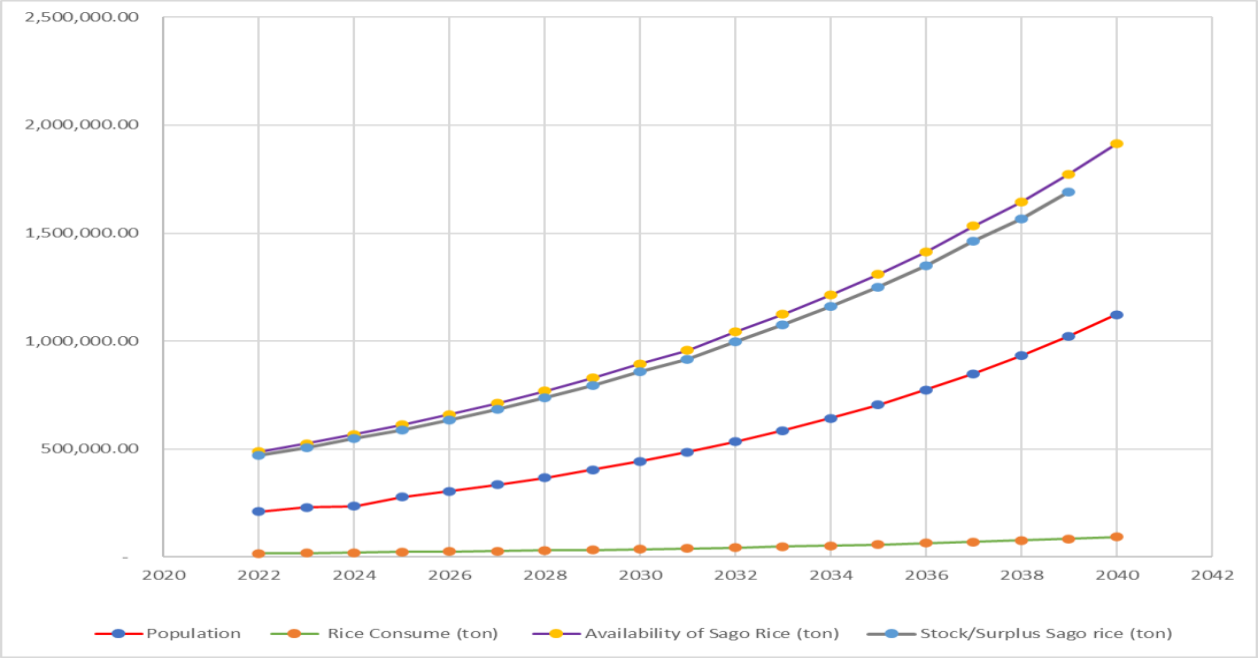

Figure 51. Policy Scenario for Drying Sago Flour into Sago Rice

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Based on figure 5 above, the increase in population every year is increasing which results in an increase in consumption. The comparison graph shows that if dry sago flour is processed into sago rice then the availability of sago rice is sufficient and even surplus to meet consumption needs. This comparison can be seen in table 5.

Table 5. Simulation of the Results of Dry Sago Flour Becoming Sago Rice

Year	Population	Rice Consume (ton)	Availability of Sago Rice (ton)	Stock/Surplus Sago rice (ton)
2022	210,407.00	17,436.43	487,299.46	469,863.03
2023	230,913.63	19,135.81	525,777.88	506,642.07
2024	235,418.87	19,509.16	567,294.65	547,785.49
2025	278,117.52	23,047.60	612,089.70	589,042.10
2026	305,223.33	25,293.86	660,421.87	635,128.01
2027	334,970.93	27,759.04	712,570.48	684,811.44
2028	367,627.78	30,465.31	768,836.88	738,371.57
2029	403,446.44	33,433.61	829,546.22	796,112.61
2030	442,767.03	36,692.10	895,049.33	858,357.23
2031	485,919.88	40,268.18	956,724.73	916,456.55
2032	533,278.47	44,192.79	1,041,980.84	997,788.05
2033	585,252.72	48,499.89	1,124,258.33	1,075,758.44
2034	642,292.46	53,226.78	1,213,032.66	1,159,805.88
2035	704,891.40	58,414.35	1,308,816.84	1,250,402.49
2036	773,591.34	64,107.51	1,412,164.39	1,348,056.88
2037	848,986.89	70,355.54	1,532,672.52	1,462,316.98
2038	931,730.63	77,212.52	1,643,985.63	1,566,773.11
2039	1,022,538.71	84,737.78	1,773,798.97	1,689,061.19
2040	1,122,197.11	92,996.47	1,913,862.70	1,820,866.23

Source: Processing Data

Based on table 9 above, if dry sago flour is produced into sago rice, Meranti Islands Regency can produce 487,299.46 tons of rice in 2022. This means that the demand for rice in Meranti Islands Regency is met and there is even a surplus. Based on population size and consumption levels, the demand for rice in 2022 in Meranti Islands Regency will be 17,436.43 tons, so that Meranti Islands Regency will have a rice surplus of 469,863.03 tons in the same year. In 2023 Meranti Islands Regency can produce 525,777.88 tons of sago rice and in 2040 with Meranti Islands Regency it can produce as much sago rice as the available sago rice stock land or rice surplus of 499,182.72 tons in 2022 and in 2040 Meranti Islands Regency can produce rice sago was 1,913,862.70 tons and there was still a surplus if the population growth simulation in the same year in Meranti Islands Regency was 1,122,197.11 people, namely 1,820,866.23 tons. According to BPS data from Riau Province 2023. Riau Province's rice needs in 2022 are as much as 122,560 tons, so the capacity produced for sago rice in Meranti Islands Regency in the same year was as much as 487,299.46 tons, meaning that rice needs at the provincial level can be met by sago rice from Meranti Islands Regency and there is still a surplus of 364,739.46 tons.

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CONCLUSION AND SUGGESTION

This research produced 3 (three) sub models, namely the sub model of availability of sago land area, availability of rice and upgrading of sago (dried sago flour) to sago rice. The sago land area availability model designed shows that the sago land area based on land suitability is 158,571 ha which can be met until 2040. Then the rice availability model which aims to see the projected availability of rice in the Meranti Islands Regency shows that every year the Meranti Islands Regency must import rice from outside the Regency, this is due to the limited rice land owned by the Regency. In 2023, the total rice deficit in Meranti Islands Regency will be 14,966.10 tonnes with rice availability only amounting to 2,470.33 tonnes. The model for increasing sago (dried sago flour) into sago rice where with the area of sago land owned by the Meranti Islands Regency, the results obtained are that if sago (dried sago flour) is processed into sago rice, the Meranti Islands Regency will become a food self-sufficient area and has the potential to maintain food security where the availability of sago and to make sago rice is quite promising. In 2023, the simulation results can produce 525,777.88 tonnes of sago rice, while local demand is only 19,135.81 tonnes and the need for rice at the provincial level in the same year is 122,560 tonnes, meaning that Riau Province's rice needs can be met by Meranti Islands Regency.

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