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Modeling the Rice Self-Sufficiency in the Philippines: A System Dynamics Approach

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ABSTRACT

We study the interactions between the production and consumption of rice along with the several factors which involve a number of changes to the production and consumption through system dynamics modeling. We focus on three scenarios on the system dynamics model, which entails the possible effect on rice self-sufficiency and import dependency ratio by simulating the realistic values on rice production and rice consumption based on the PSA data. Historical data from 1995 was utilized and analyzed to build the model to have meaningful information regarding how the system behaves with the various factors in the system. After the model has been validated, several scenarios are simulated and their impact analyzed on the different sustainability dimensions, specifically the Philippines' Agricultural Indicator System. Results showed that production and consumption interventions are crucial to improving the Philippines' self-sufficiency and import-dependency ratio.

Keywords: Rice; Self Sufficiency; System dynamics modelling

1. Introduction

Worldwide, rice is one of the essential and staple foods. Furthermore, rice farming is the most prominent single land use for producing food [1], and many countries worldwide have an increasing trend of rice consumption, including the Philippines. To cater to the needs of every Filipino for rice, the country has been heavily dependent on imported rice, and recently, it has become one of the top rice importers in the world. The Philippines was once abundant in rice during the 1980s; however, its rice self-sufficiency ratio has declined. To date, rice self-sufficiency is still an elusive dream, and thus it would

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keep needing rice from neighboring countries to feed its population. Several policies were imposed to increase its production; however, supply-centered policies were not enough to solve this problem [2]. A deep understanding of the food system is vital to adequately address the problem and explore some potential policies that can be implemented.

The food system has currently been used to map the interactions between variables within the system. Interactions between food production and consumption should be adequately understood. Food production and consumption embody and are affected by essential natural and metabolic processes that have historically been difficult for industry and broader market and state development forms to control [3]. There has been no study done in mapping the rice-food system in the country; thus, this study attempts to fill the gap. Its objectives are to; a) Understand the rice-food system in the country and determine the current rice production and consumption in the country; b) To model the current rice self-sufficiency ratio of the Philippines; c) To forecast the rice self-sufficiency ratio of the Philippines.

1.1 Rice studies and rice self-sufficiency in the Philippines

The Philippines was rice-sufficient in the 1980s and achieved self-sufficiency in rice at that time. Maintaining self-sufficiency is challenging, and the Philippines plunged from self-sufficient to being reliant on rice importation. To date, the Philippines is one of the top importers in the world. Several factors have reportedly influenced the self-sufficiency in the country, and these are i. rice production, ii. consumption, and iii. importation.

Present studies in the literature about rice in the Philippines are abundant, mostly about promoting and investigating different rice varieties that can increase yields [4-7]. Also, rice studies in the Philippines are fragments of the different areas in the rice food system. The literature identifies different research outcomes in rice studies, including rice pest control [8-10], soil science on rice production [11, 12], strategies on reducing water input [13], land ownership [14], seed quality [15], and technology learning [16]. These mentioned researches focus mainly on rice production, and their dynamic behavior in the system is not fully understood throughout the food system components like rice production and consumption

Recently, the Philippines has been dependent on the neighboring ASEAN countries to fulfill rice needs. The Philippines imports rice mainly from Vietnam, which contributes 73% to the total imports in the country. Additionally, the Philippines even imports from Myanmar, which is not listed or included on the list of top countries producing rice globally. The growing demand for rice in the country should be fully addressed to achieve its goal to be self-sufficient in terms of rice. Rice importation in the country means that local production is inadequate for the demand. Satisfying its demand and being self-sufficient in food (i.e., rice) is one of the country's major problems that should be prioritized to look into. Understanding the food problem is one of the first steps to solve the insufficiency of rice in the country.

Other research efforts attempt to model the rice food system in the Philippines; however, they often lack a sustainability perspective. Most existing models are economically based, such as those using Computable General Equilibrium [17], partial equilibrium [18], and agent-based modeling [19]. In contrast, system dynamics offers unique advantages [20]. Systems thinking and modeling tools, such as causal loop diagrams and system dynamics simulations, provide effective means to conceptualize complex phenomena and communicate model-based insights

[21]. Additionally, system dynamics modeling can present a holistic view of the rice food system, helping to understand the interactions between different aspects of sustainability.

There is no present study about modeling rice production and rice consumption, specifically in the Philippines. Several factors can affect the production and consumption of rice in the Philippines. These factors involving rice production and consumption have dynamic and complex behavior in the rice production system. There are currently several studies about the rice status in the Philippines; however, none of them tackles the rice-food system in the country.

1.2 System dynamics to food system

System Dynamics Modelling is a modeling approach that adopts a top-down information feedback method [22-24]. It is used to analyze the system's complexity and as a way to understand and map its dynamic behavior. Applications of system dynamics have a wide range from health care [25] to supply chains [26, 27]. System dynamics takes a deep interest in determining the problem and evaluating possible policies to be implemented. Thus, system dynamics is suitable for the study of the interdependencies and dynamics of the rice-food system.

One of the benefits of system dynamics is to see a holistic view of the system which can be used to identify possible areas in the system that have a significant impact. In the Philippines, there are no recent studies in the literature that concern the interdependencies within the system. Thus, this study will adopt the system dynamics model to study and project the self-sufficiency ratio and the Philippines' import dependency ratio based on Rice Production and Consumption.

1.3 Food systems and agricultural system modelling

One of the world's biggest challenges today is food security. We are now entering a period of realization that there are growing interdependencies of drivers and actors in the food system. A food system comprises a complex set of activities and a wide range of actors, with interlinked processes involving the production, processing, consumption, and disposal of food products (Food and Agriculture Organization of the United Nations [28]. Understanding sustainable resource use is one of the advantages of adopting food system approaches [29]. Moreover, food system frameworks have been commonly employed in recent policy analysis studies.

According to Prosperi & Peri (2016), food systems face intersecting economic, environmental, and social challenges [30]. Integrating these aspects necessitates multidisciplinary approaches and integrated assessments to guide decision-making. A better understanding of the food system and the interrelations of these aspects is crucial for comprehending the complex dynamics involved in the interactions between human and natural components. Ericksen et al. (2008) further discuss that sophisticated analytical models of food systems help us understand how food moves from "farm to plate" and the need to frame policies to address the negative social and environmental outcomes of food system activities [31]. Food system outcomes result from the processes and activities within the system that feedback into environmental, social, and economic drivers, potentially leading to unintended consequences [32]. Therefore, modeling the food system is essential for a holistic understanding of the system and the internal interactions of its components. Additionally, food system models can help policymakers better understand and develop policies based on the behavior of complex systems [33-35].

System modeling in agriculture has evolved significantly over the years. According to Jones et al. (2016), seven key events have marked the development of agricultural systems from the 1950s to the 2010s: 1) Development of foundational science (1950s), 2) Policy needs in ecology (1960s), 3) Enhancement of satellite and communication (1970s), 4) Revolution of personal computing and the internet (1980s), 5) Broadening applications of system models (1990s), 6) Initiation of the sustainable agriculture movement (2000s), and 7) Increasing emphasis on food security (2010s).

Emphasis on food security and sustainability is an emerging topic in the research community today [30, 36, 37]. Food security is a fundamental goal for every country and a challenging task for any government. Achieving food security has led to the development of various methodologies and approaches over the years.

Agricultural food system models are proliferating in the literature. Agricultural models can be divided into two categories (38): 1) Agricultural Modeling (AM) and 2) Agricultural Complex System Modeling (ACSM). Agricultural Modeling is based on classical assumptions to comprehensively represent food systems. Popular methods include Computational General Equilibrium Models (CGE) [17, 39, 40] and Partial Equilibrium Models (PEM) [18, 41]. These methods estimate interdependencies between actors, assuming linear growth and exogenously driven changes in average behavior. However, they cannot represent the dynamics of complex systems characterized by causal feedbacks, non-linearity, and non-rational elements [38]. Agricultural Modeling was not designed to represent policy path dependency essential for sustainable development.

To address these limitations, Agricultural System Complex Modeling (ASCM) has been developed. ASCM can model non-linear events resulting from positive/negative feedback, show simultaneous accumulations of time delays and their effects in the system, and display dynamically interplayed feedback loops present in non-linear behavior. Two modeling approaches fall under ASCM: 1) Agent-Based Modeling [42, 43] and 2) System Dynamics Modeling [34, 37, 44, 45]. System Dynamics Modeling has been applied to various sectors such as global dynamics (World3 by The Club of Rome; Threshold 21 by the Millennium Institute), energy [46], business, economics, and product-service sustainable business models [47].

Recent literature reviews underscore the distinctions between System Dynamics Modeling and Agent-Based Modeling [48]. These paradigms differ primarily in their level of aggregation. System Dynamics Modeling excels at handling and modeling large systems due to its capacity to work with highly aggregated data, whereas Agent-Based Modeling focuses on heterogeneous systems with a narrower scope. Additionally, System Dynamics Modeling is generally easier to interpret, supported by well-established tools for model construction and simulation analysis. Consequently, the researcher chose to utilize System Dynamics Modeling for this study.

2. Materials and Methods

2.1 System dynamics approach

The food system modeling comprises production, consumption, and complex interactions and relationships between these food system components. The nature of these interactions and interdependencies needs to have systematic approaches to understand its complexities. Characteristics of this food system are helpful to government organizations if modeled correctly. The system dynamic model is essential to set policies, help decision-making, and understand the system holistically. A causal loop diagram is necessary to view the interactions between variables and drivers within the system to model it correctly. Simulating and analyzing the system behavior using system dynamics methodology provides appropriate feedback within the system.

2.2 Formulating the dynamic hypothesis

A dynamic hypothesis is necessary to solve the problem by the system dynamic method. The dynamic nature of the problem can form feedback loops; that is why it is called dynamic. The modeler states the facts and the reason for formulating the problem behavior as a specific behavior [2].

Self-sufficiency is a complex system that involves the interaction of food system components, mainly production and consumption. In the Philippines' rice production, various factors are involved, such as the rice yield in irrigated and non-irrigated rice, growth/shrinkage of production per year, harvested area (there are only available data on the PSA). On the other hand, factors like population growth and consumption per capita play a vital role in rice consumption. These identified factors are considered in making the dynamic hypothesis of this research. Fig. 1 shows the model structure framework of the study.

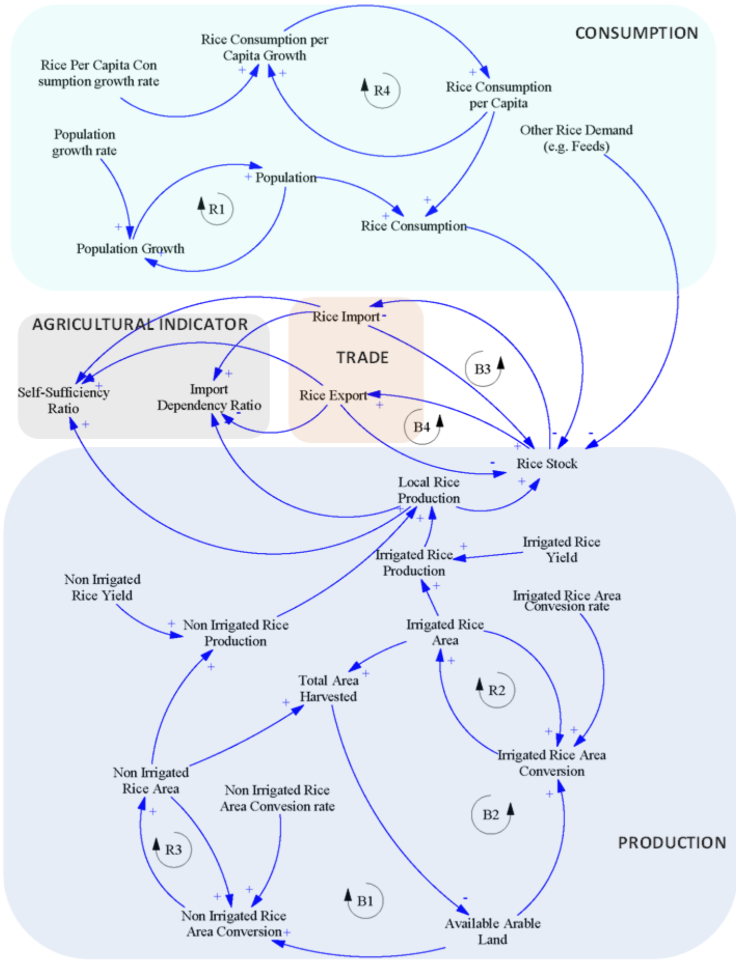

Fig. 1. Model Structure Framework of the Study in Causal Loop Diagram.

2.3 Verification of the variables

2.3.1 Harvest area

Fig. 2 shows that there is a significant increase in the area harvested for the irrigated rice. The harvested area has increased from 1.2 million hectares to almost 1.9 hectares in the past two decades. On the other hand, the harvested area for the non-irrigated rice is the same, from 1.002 million hectares to 1.05 million hectares. Fig. 3 reflects the rice productions between the irrigated rice productions compared to the non-irrigated rice production. More than 100% increase in the irrigated rice production and 66% increase in non-irrigated rice production. An increase in irrigated and non-irrigated rice production is also attributed to increased yield per hectare. There is an increase of 31.93% of yield in the irrigated rice and a 50% increase in non-irrigated rice from 1991 to 2023.

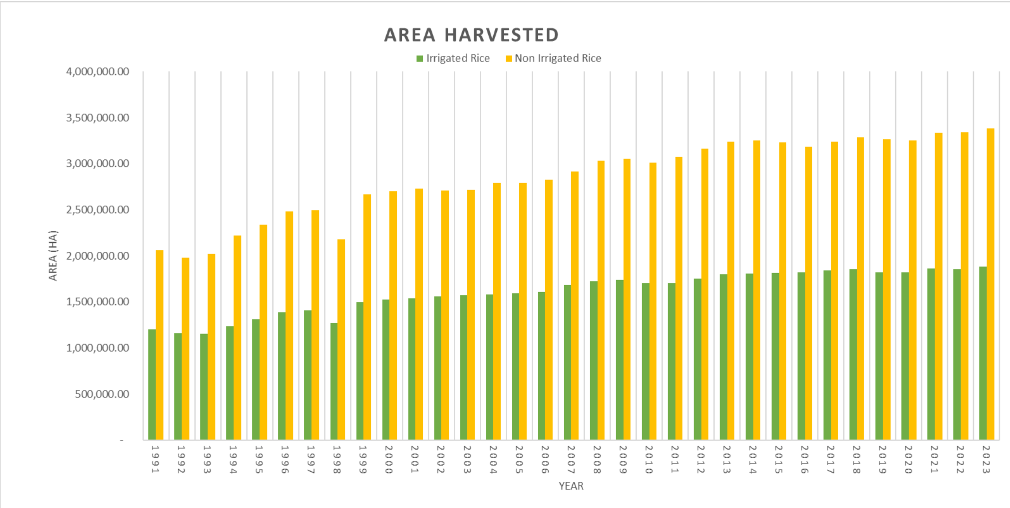

Fig. 2. Total Area Harvested.

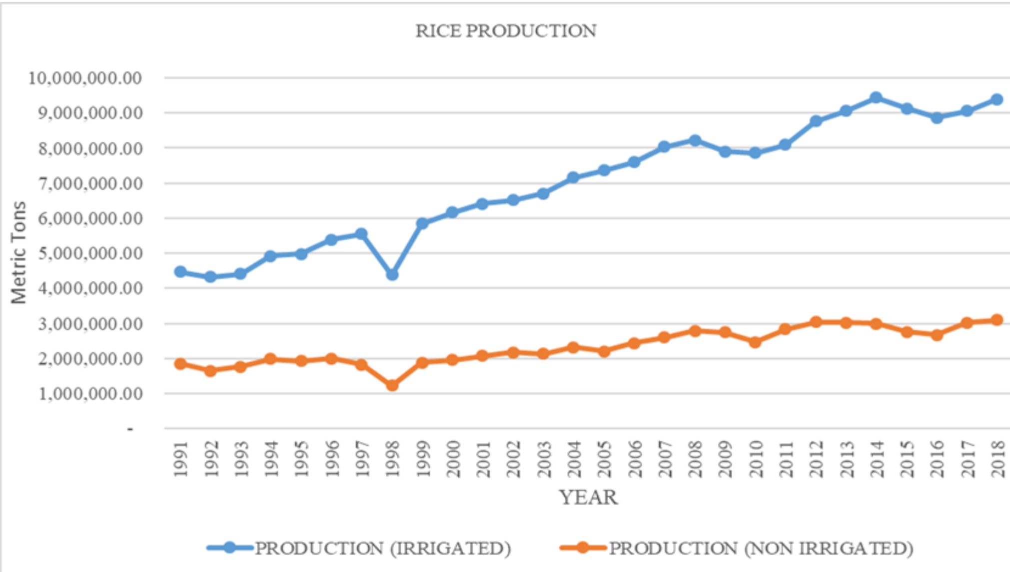

Fig. 3. Rice Production.

2.4 Stock-flow modeling

The specifications of the flow model presented in the figure are defined as follows.

2.4.1 Rice production function

The rice production function shows the rice production volume for each year. It is simulated using the area of the irrigated and non-irrigated land used for rice production. Considering the rice production history from 1993 to 2023, the yield for irrigated and non-irrigated rice is added to the model. Moreover, the milling recovery rate is further input to come up with the local production of rice.

2.4.2 Rice consumption function

Rice consumption is derived from the per capita consumption and the population in the country. Historical data shows that an increasing trend of rice consumption per capita of rice is remarkably the same trend with its population growth.

2.4.3 Rice stock function

The rice stock is derived by the addition of local production and imports, then deducted by the rice consumption. Other factors like the "Other usage of rice" are also added in the model to obtain the "rice available for consumption.

2.5 Model validation

To ensure the correctness of the system dynamics model, model validation should be done. The model should also be validated to be used as an effective tool to represent the system. To validate our model, we used two tests: the behavior-reproduction test and the extreme condition tests.

2.5.1 Behavior-reproduction test

Historical data has been used to carry out this test. The simulated behavior of the model is compared to the behavior of the historical data. Fig. 4 shows the actual and simulated data of the local production of rice. To compare these two sets of data, the error analysis in statistical methods has been used. Particularly to this model, MAPE (Mean Absolute Percentage Error) is further utilized to evaluate the model behavior. Results show that the MAPE is at 4.95% (see Table 1), which means highly accurate forecasting based on typical interpretation of MAPE values [49]. To further prove the model's validity, an F-test of equality of variance is conducted to prove that there is no statistical difference between the two populations. Then, the two populations' means were compared using the t-test for two populations with equal variance. Results showed that the variance and the two populations' means are equal at a 0.01 significance level.

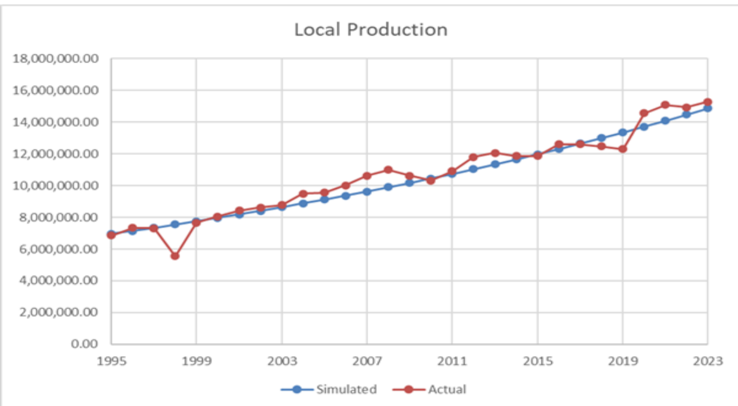

Fig. 4. Local Production (Simulated vs. Actual).

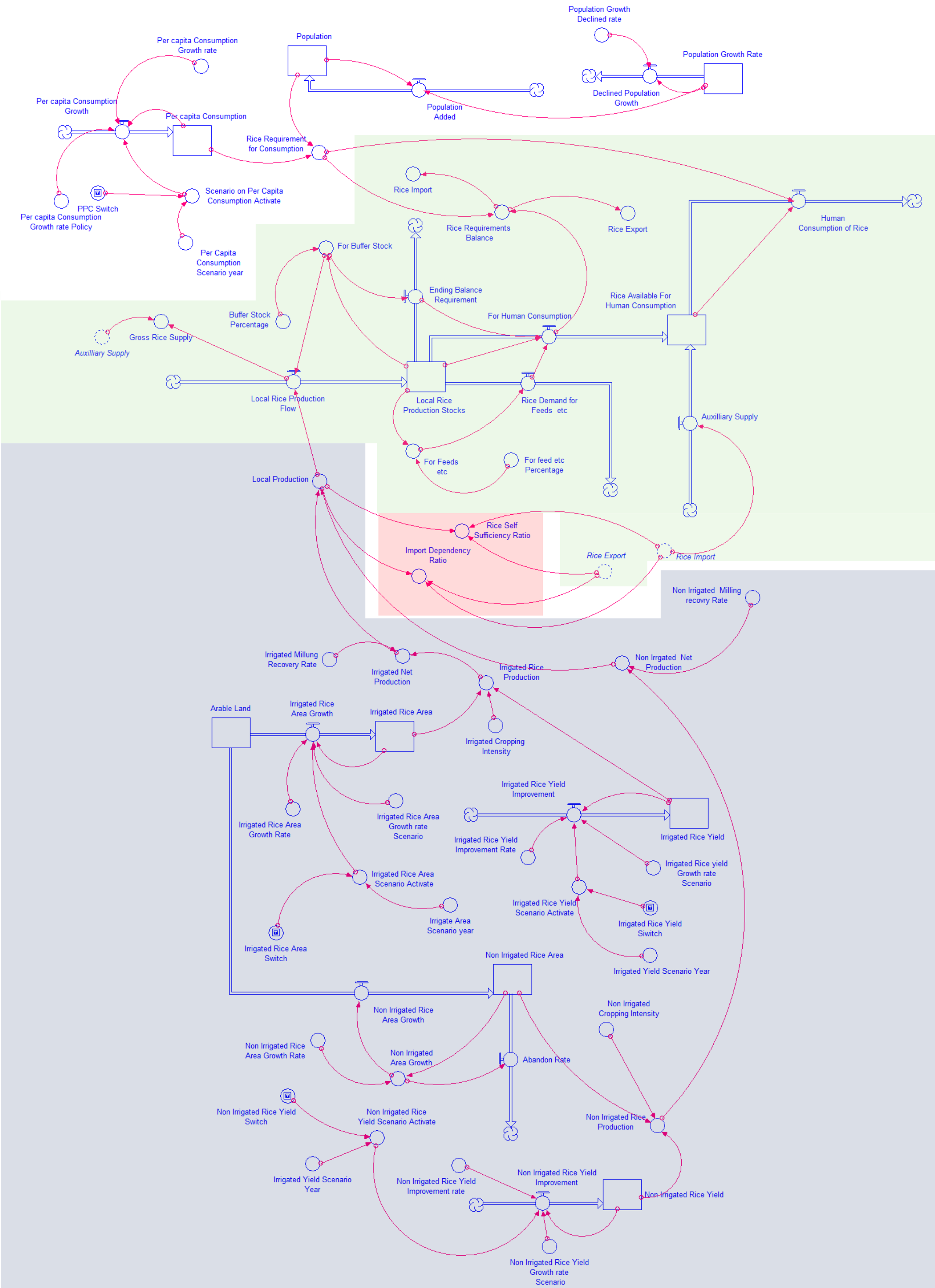

Fig. 5. Stock-Flow Diagram of the Rice Production and Consumption in the Philippines.

Table 1. Mean Absolute Percentage Error (MAPE).

	MAPE
Local Production (Simulated vs. Actual	4.95%

After validating the model, Fig. 6 illustrates the simulation of rice requirements in the Philippines up to 2040. The data reveals that rice requirements for consumption exhibit a consistent upward trend, with the most significant increase occurring from 2023 to 2024 (3.46%). This sharp rise indicates a substantial surge in demand. Although the rate of increase moderates slightly over the subsequent years, it reflects a growing but gradually stabilizing demand for rice within the country.

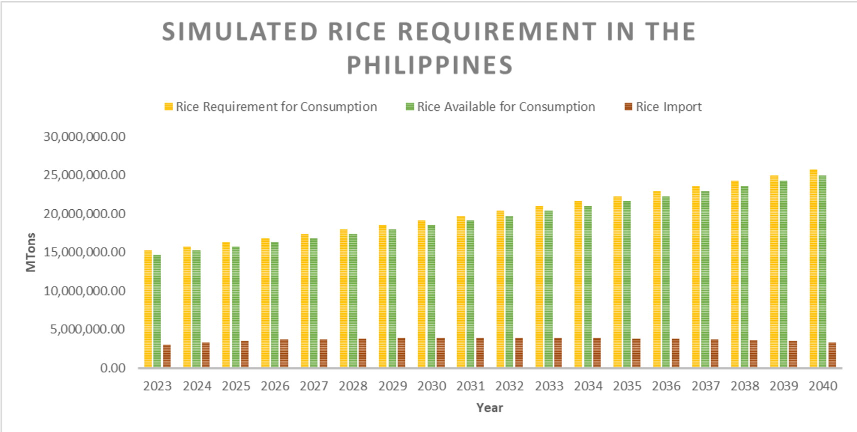

Fig. 6. Simulated Rice Requirement in the Philippines.

Similarly, the rice available for consumption shows a steady increase. The most substantial growth is observed from 2023 to 2024 (3.51%). This consistent rise in available rice suggests that production is effectively keeping pace with the escalating demand. The trend likely results from improvements in agricultural practices, technological advancements, or the expansion of the cultivated area.

In contrast, the simulations for rice imports reveal a different trend. Initially, there is a notable increase from 2023 to 2024 (6.50%), underscoring a high dependency on imports to meet the rice demand. However, the rate of increase steadily declines, eventually turning negative from 2032 onwards. This shift indicates that domestic production is gradually becoming sufficient to satisfy the growing demand, thereby reducing the reliance on imported rice. The declining import trend suggests significant progress toward achieving self-sufficiency in rice production, driven by enhanced local agricultural productivity and efficiency

2.5.2 Extreme Condition test

The model should remain meaningful when exposing to extreme conditions. The extreme condition test evaluated the validity of the equations used in the model by assessing the value of the results against the knowledge of what would happen under similar conditions in real life [24]. Fig. 7 shows an example in which the rice harvest and rice production are both set to zero.

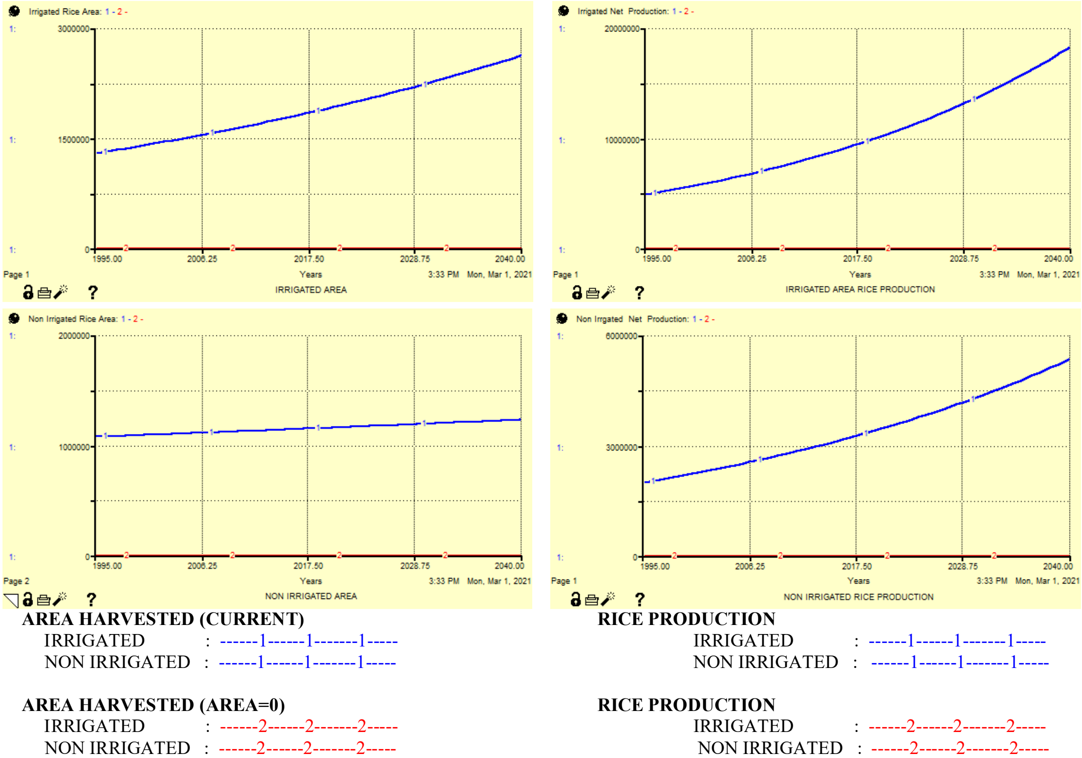

Fig. 7. Extreme Condition Test.

3. Results and Discussion

3.1 Scenario making

After the model has been validated, it can now be used for making different possible scenarios. Scenarios are made through the criteria of the factors affecting production and consumption. These factors can widely affect the rice-self-sufficiency ratio and the import dependency ratio of the country. Rice production, area harvested, rice yield, and the milling recovery rate are considered. On the other hand, rice consumption per capita is being considered for rice consumption.

The baseline condition is based on the historical data from 1995 to 2023 and simulated for 2024 to 2040 (16 years). In this baseline condition, rice self-sufficiency ratio is influenced by:

- Increasing the harvested area specifically for the irrigated rice by 1.58% per year and the shrinking of harvested area of the non-irrigated by 0.30% per year
- Increasing rice yield in both irrigated and non-irrigated rice by 1.36% and 1.9%, respectively.
- Increasing of per capita consumption by 1.35% per year.
- Decreasing population growth by 2.17% per year.
- The average milling recovery rate of 65.4%

3.2 Scenarios for the rice-food system model

Scenarios were developed to represent the potential solutions to achieve the rice self-sustainability ratio in the Philippines. The scenarios developed are:

➢ Scenario 1: Expanding Irrigated Rice Harvest Area

Scenario 1 gradually increases the harvested area for the irrigated rice by 3.5 million hectares from 2025 to 2040. According to the Philippine Department of Agriculture, the maximum area that is ideal for rice production is 5.4 million hectares, and two-thirds (2/3) of the total area is for irrigated rice production (3.5) million hectares. Currently, the physical area used for the irrigated rice production is 1.86 million hectares.

➢ Scenario 2: Enhancing Rice Yield

Scenario 2 targets a rice yield of at least 6.2 tons/ha for the irrigated rice and 5 tons/ha for the non-irrigated rice from 2025 to 2040. This makes the average rice yield 5.6 tons/ha. Currently, the Philippines is 4th in rice yield in the South Asia region [25]. Vietnam has one of the highest rice yields, which has a yield of 5.84 tons/ hectare (2015), and it has an increasing trend. The Philippines has a yield of 4.38 tons/ha; the goal of scenario 2 is to simulate rice yield in the rice self-sufficiency ratio in the Philippines.

➢ Scenario 3: Reducing Per Capita Rice Consumption

Scenario 3 is to gradually decrease rice consumption per capita by 10% in the year 2040. Presently, rice consumption per capita of Filipino is 128.43 kg/ year. Baseline condition shows that Filipinos will be consuming 160kg/year in 2040. Reducing 10% by 2040 means 16kg/year/person will be reduced. Therefore, 144kg/person/year is the target for rice consumption per capita by 2040.

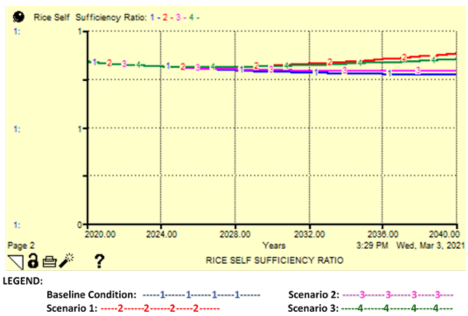

Fig. 9. Import Dependency Ratio.

3.3 Investigation of Sustainability Dimensions

Sustainable dimensions should be investigated to achieve a sustainable system. Here, we consider the rice self-sustainability ratio and import dependency ratio as standard measurements. The Philippine Statistics Authority emphasizes these two sustainability dimensions through the Agricultural Indicator System: Food Sufficiency and Security (28,50).

3.3.1 Rice Self-Sustainability Ratio (SSR)

Sufficiency ratio translates to the magnitude of the local production with the country's domestic utilization. The self-sustainability ratio is the local rice production divided by the local consumption (sum of local production and rice imports, subtracted from the rice exports), as presented in Eq. (3.1).

Rice SSR = (Local Production) / (Local Production + imports – exports) × 100%. (3.1)

A ratio closer to 1 is more desirable for the country's self-sufficiency. According to Fig. 7, the rice self-sufficiency ratio is highly susceptible to the different scenarios. Scenario 1 (Increasing the rice harvest area) has the most significant effect on the self-sufficiency ratio, increasing it from 0.78 in the baseline condition to 0.89 by 2040. Conversely, Scenario 2 (Increase in the rice yield) results in a lower self-sufficiency ratio of 0.80 by 2040. Increasing the rice harvest area appears to be the most effective strategy for enhancing the self-sufficiency ratio, as it significantly boosts local rice production. Additionally, decreasing rice per capita consumption (Scenario 3) also has a notable impact on rice self-sufficiency, improving the ratio to 0.87 by 2040 by reducing overall rice consumption in the country.

These findings align strongly with the previous results on the self-sufficiency ratio. Increasing the rice harvested area (Scenario 1) effectively boosts local rice production, thereby decreasing the need for rice imports.

Moreover, decreasing rice per capita consumption (Scenario 3) helps improve the Import Dependency Ratio (IDR) by reducing overall rice consumption, thus lowering the rice requirement for the country. Consequently, this minimizes the need for rice imports, further supporting the country's move towards greater self-sufficiency.

3.3.2 Rice Import dependency ratio (IDR)

The import dependency ratio indicates the extent to which a country's supply of commodities came from imports. The import dependency ratio is the import of rice divided by the local consumption, as presented in Eq. (3.2).

$$\text{Rice IDR} = \text{Import} / (\text{Local production} + \text{imports} - \text{exports}) \times 100\%. \quad (3.2)$$

The import dependency ratio (IDR) is a crucial indicator reflecting the extent of rice importation in the country (Fig. 8). The simulation results align closely with the self-sufficiency ratio findings presented earlier. Scenario 1, which involves increasing the rice harvested area, is particularly effective in enhancing local rice production. This scenario leads to a substantial reduction in rice imports, improving the IDR from 0.22 in the baseline condition to 0.11 by 2040. This improvement underscores the significant impact of expanding irrigated and non-irrigated rice cultivation on reducing the country's dependency on imported rice.

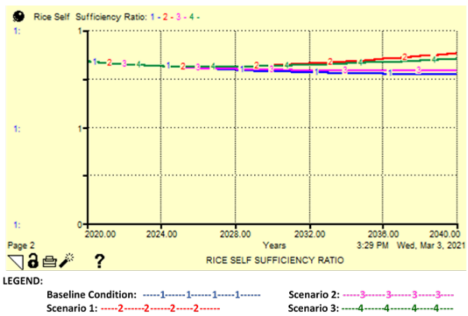

Fig. 8. Self-Sufficiency Ratio.

Furthermore, Scenario 3, which focuses on decreasing rice per capita consumption, also demonstrates a notable improvement in the IDR, reducing it to 0.13 by 2040. This scenario emphasizes the importance of public awareness campaigns and educational programs to promote diversified diets and reduce overall rice consumption. By lowering the rice consumption per capita, the demand for rice decreases, subsequently reducing the need for imports and enhancing the country's self-sufficiency.

In contrast, Scenario 2, which aims to increase rice yield, shows the least impact on the IDR. The IDR improves only marginally, from 0.22 in the baseline condition to 0.20 by 2040. While increasing rice yield contributes to higher local production, its effect on reducing import dependency is less pronounced compared to the other scenarios.

3.3.3 Policy recommendations

Based on the analysis of Scenario 1 (Increasing the rice harvest area), Scenario 2 (Increasing rice yield), and Scenario 3 (Decreasing rice per capita consumption), the following policy recommendations have been formulated to enhance rice self-sufficiency and reduce import dependency in the Philippines:

- **Expansion of Irrigated Rice Harvest Area**

The expansion of irrigated rice harvest areas should be a top priority. The government must allocate substantial funds towards developing irrigation infrastructure, which includes constructing new irrigation systems, rehabilitating existing ones, and ensuring efficient water management practices. Support programs should be established to provide financial incentives, subsidies, and technical assistance to farmers for expanding irrigated land. This may involve grants for purchasing irrigation equipment, low-interest loans for land development, and technical assistance for implementing irrigation techniques. Additionally, policies that facilitate the conversion of rainfed agricultural land to irrigated land should be implemented, incorporating land-use planning, zoning regulations, and incentives for adopting irrigation technologies. Sustainable water management practices must also be developed and enforced to ensure the efficient and effective use of water resources, preventing overuse and degradation of water bodies.

- **Promotion of Efficient Agricultural Practices**

Promoting efficient agricultural practices is crucial. Comprehensive training programs for farmers on modern agricultural techniques should be established, focusing on best practices for rice cultivation, soil health, pest management, and water-efficient practices. Subsidies and incentives for adopting high-yield, disease-resistant rice varieties are essential to boost productivity. Encouraging the use of advanced farming technologies, such as precision agriculture, remote sensing, and drone technology, can optimize input use and monitor crop health. Investing in agricultural research to develop new rice varieties, improve farming practices, and create innovative solutions for challenges faced by rice farmers is also vital. Collaborating with agricultural universities and research institutions can enhance these efforts.

- **Reduction of Per Capita Rice Consumption**

Reducing per capita rice consumption through public awareness campaigns and education programs is necessary. Launching nationwide campaigns to educate the public on the benefits of a diversified diet, highlighting the nutritional advantages of incorporating other grains, vegetables, and proteins into daily meals, is critical. Nutrition education should be integrated into school curricula and community health programs, teaching children and adults about balanced diets, the health benefits of reducing rice consumption, and how to prepare meals using alternative grains. Encouraging the production and consumption of alternative grains, such as quinoa, millet, and sorghum, and supporting local farmers in growing these grains through subsidies, technical assistance, and market development initiatives, is important. Providing incentives for consumers to choose healthier dietary options, such as subsidies for purchasing alternative grains, tax benefits for food manufacturers that produce healthier products, and discounts on healthy food items in grocery stores, can further promote dietary diversification. Engaging community leaders and local organizations in promoting diverse eating habits through community-based initiatives, cooking classes, and local food festivals can also raise awareness and encourage the adoption of these habits.

4. Conclusion

As the population continues to grow, rice consumption intensifies correspondingly. Currently, the model suggests that the self-sufficiency ratio and import dependency ratio in the country are at 84% and 16%, respectively. However, by 2040, these figures are projected to change to 78% and 22%, indicating that people will have less access to rice and the market supply will be insufficient. Consequently, there will be a significant increase in rice imports to meet the demand in the Philippines.

This paper presents three policy scenarios and simulates their impact using system dynamics modeling. The scenarios include increasing and maximizing the harvested area, improving rice yield, and reducing per capita rice consumption. The simulation results indicate that these policies have favorable impacts on rice self-sufficiency.

The first policy recommendation is to expand the irrigated rice harvest area. This approach is the most effective strategy for improving the rice self-sufficiency ratio. Therefore, the government should prioritize policies that support the expansion of irrigated rice harvest areas. Investments in irrigation infrastructure and support for farmers to cultivate additional land can significantly enhance local rice production and move the country closer to self-sufficiency. Appropriate investment and planning for better use of available arable land for rice farming are crucial, along with instructing the agricultural community on optimizing land usage to boost rice production.

The second policy focuses on promoting efficient agricultural practices to improve rice yields. Implementing and promoting modern, efficient agricultural practices can help increase rice yields. Training programs and subsidies for high-yield rice varieties and advanced farming techniques can contribute to achieving higher productivity. This policy underscores the need for continuous development and dissemination of better farming practices and technologies to maximize output from the existing cultivated areas.

The third policy aims to reduce per capita rice consumption. Public awareness campaigns and education programs on the benefits of diversified diets can help reduce per capita rice consumption. Encouraging the consumption of alternative grains and promoting balanced nutrition can decrease the overall demand for rice. In 2017, one Philippine policymaker suggested a study on policy in reducing rice consumption per capita in the country. This policy urged Filipinos to eat rice substitutes such as bread, cassava, and banana; however, no recent study or policy implementation occurred. This research can serve as a purpose in studying potential rice substitutes to achieve rice sufficiency since reducing rice consumption per capita has a significant effect on the rice self-sufficiency ratio in the country. By educating and instructing people on responsible rice consumption behaviors and avoiding excess, the country can effectively manage its rice demand and work towards achieving self-sufficiency.

In conclusion, increasing and maximizing the harvested area, improving rice yield through efficient agricultural practices, and reducing per capita rice consumption are pivotal strategies for enhancing rice self-sufficiency in the Philippines. These integrated policies, supported by system dynamics modeling, can significantly contribute to stabilizing rice supply and reducing dependency on imports, ultimately ensuring food security for the growing population. As a whole, this study can evaluate and demonstrate the application of various possible scenarios. This can be a helpful decision support tool as the Philippines moves toward achieving rice self-sufficiency in the future.

Acknowledgements

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