



## DYNAMIC SYSTEM MODEL OF RICE COMMODITY AVAILABILITY FOR INCREASING THE NEEDS OF THE SOCIETY OF BALIKPAPAN CITY

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### ABSTRACT

The availability of rice is a matter of considerable concern; this is related to food needs in an area, one of which is the City of Balikpapan. The city of Balikpapan is a city that has the potential to experience an increase in population due to increased birth rates and immigration and is supported by the discourse on the isolation of the National Capital. In one year, humans are able to spend 0.1146 tons/year. With an increase in population, it has the potential to increase rice consumption in the City of Balikpapan. Therefore, a rice availability simulation is carried out by considering the availability factors by using a Causal Loop Diagram and calculating factor values by using a Stock and Flow Diagram to see what conditions will be in the future after modeling. From the simulation, two scenarios were obtained to overcome the problem of rice availability in Balikpapan City, which resulted in an increase in the procurement and procurement of rice from Bulog and distributors, and the scenario chosen was scenario 2, namely an increase in rice procurement and distribution.

Keywords: Availability of rice, Consumption of rice, Policy for Increasing Community Needs, Procurement, Distribution.

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## 1. INTRODUCTION

Presidential Regulation (Perpres) Number 125 of 2022 concerning the administration of government food reserves, one of the foodstuffs that must be fulfilled in funds is rice. The food problems discussed in Presidential Decree Number 125 of 2022 are conditions of shortage or excess and/or the inability of individuals or households to meet food and security needs. One of the efforts made in maintaining the availability of rice is to carry out rice production, which is held in every region that is capable of producing rice. According to the theory (Mathus, 1998), the increase in human population affects the availability of rice in an area. This is because by increasing the human population, it will affect the level of consumption or food needs in an area, which also applies to the city of Balikpapan. The problem faced by the City of Balikpapan is that it is very dependent on the availability of rice from other regions, such as Sulawesi and East Java. This is because production is caused by a minimal amount of agricultural land, which is only 32 hectares, coupled with a rain-fed system, and harvests only occur once or twice a year. Meanwhile, the land produces 398 tons of rice, or only 0.7 percent is sufficient not up to 1 percent. Rice in Balikpapan City is classified as low and unable to meet the needs of the large population of Balikpapan City (Kaltim Pos, 2022). This dependence makes it a problem in fulfilling the need for rice in the City of Balikpapan. This really indicates an imbalance between rice stocks and consumption which is fluctuating. Therefore, it is necessary to review the factors of rice availability so that imbalances do not occur and result in food problems.

The previous study (Pradnyana et., 2021) provided an explanation of the dynamic system model of food security with the availability of rice in the Province of Bali, whereas in this study, it was explained that food security in the Province of Bali was still insufficient because rice production in the Province of Bali experienced a deficit or decreased with the dynamic system model. Meanwhile, in the previous study (Adi, et. 2021), researchers conducted research on the balance in the availability of rice as a candidate for the new National Capital with a dynamic system approach. This research looks at the activities that influence the implementation of dynamic systems. Thus, in the end, it will provide

solutions for policies that can be implemented for the availability of rice in East Kalimantan.

Based on previous research and conducting a survey of problems in the City of Balikpapan, this research will be carried out with a dynamic approach to provide a realistic picture of changes in the rice supply system over time and unforeseen events. By making Causal Loop Diagrams and Stock and Flow Diagrams with a dynamic system approach, it can be a reference in policy-making, especially the Balikpapan City government, which has the authority to plan and manage rice supplies to be able to minimize imbalances between demand and supply and avoid shortages of rice supplies when certain circumstances.

## 2. METHODS

Following the initial stages of research in developing a dynamic system model, the steps taken were a survey regarding actual problems and system conceptualization using a Causal Loop Diagram. The Causal Loop diagram was made to describe the interaction between factors of rice availability in Balikpapan City. This interaction will have the possibility of positive or negative interactions. This relationship can be positive if the addition of one variable causes the addition of another variable. Meanwhile, if the addition of variables will cause a decrease, then the relationship is negative.

The next stage is a model formulation which is visualized using Stock and Flow Diagrams. In making stock and flow, it is divided into several Sub-Models. This Sub-Model is a variable that becomes the input formulation in the Stock and Flow Diagram in the actual condition of rice availability in Balikpapan City. The three sub-models are the consumption, stock, and production sub-models. The Consumption Sub-Model consists of the Population, which is influenced by the Birth Rate, Immigrants, Foreign Workers, Emigrants, and Mortality Rates.

Furthermore, the Stock Sub-Model consists of Bulog Stock, Procurement and Distribution of Bulog Rice, Market Rice Stock, Distributor Rice Stock, and Procurement and Distribution of Distributor Rice. The last sub-model is the production sub-model, which consists of rice production, paddy field area, cultivated land area, dry paddy productivity, lowland rice productivity,

and the rate of decline in cultivated land. After that, the formulation is carried out, and the model is verified and validated.

**Verification** The model verification process is a process in which to ensure that the model built meets operational logic standards or is by the logic of the flowchart (Prabandewa, 2019). In this verification process, the STELLA 9.1.3 software tool is used, which is helpful for checking errors in the model created or the system model's consistency. The model can be verified or run well according to the concept representation in actual conditions. After making the model and confirming it, model validation is a way to check whether the conceptual simulation model accurately represents the existing model system being modeled (Shalihah, 2017). Validation aims to determine whether the simulation model is acceptable or the simulation model is not permitted and represents the actual system or not. (Garside, 2015). Model validation used the statistical test method (Black Box Validation) by comparing the average output of the existing system and the average output of the simulation results using the statistical test method, namely the Paired Sample T-Test assisted by using SPSS software.

After the model has been verified and valid, it can be continued with model simulation, which will be analyzed and developed using STELLA 9.3.1 software. This simulation was created to protect the availability of rice in Balikpapan City by incorporating factors from the actual availability of rice. The initial initiation of the year is 2019 and is projected for the next 20 years, namely 2039 things, because you want to see the visualization of data that will be predicted in simulation.

### 3. FINDINGS AND DISCUSSION

#### 3.1. Findings

##### Models

##### Formation of a Dynamic System Model

The dynamic system model is built based on a causal diagram that describes the relationship of each factor to the actual conditions in Balikpapan City by entering input data, namely the elements of rice availability in Balikpapan City in actual situations. In forming a dynamic system, it is necessary to have Causal Loop Diagrams and Stock and Flow Diagrams to see the dynamic system model obtained after the simulation

process is carried out. After carrying out identification and surveys, and interviews, a description of the rice supply system was obtained, which can be observed as shown below. In Figure 1, it can be explained that the flow of the rice supply system in Balikpapan City starts from distributors from outside the area who, in the survey, come from Jakarta, Sidoarjo, Makassar, and Surabaya. Furthermore, the goods will be sent by ship, which will be given to distributors. Meanwhile, Bulog has a different rice supply from distributors, where Bulog gets rice from the Rice Grain Milling Unit (UPGB). This is also because Bulog is a government unit tasked with maintaining food availability throughout Indonesia. After *getting an overview of the rice supply system* in the City of Balikpapan, it is possible to make Causal Loop Diagrams and Stock and Flow Diagrams.

##### Causa-Loops Diagram

Making a Causal Loop Diagram is done by compiling an initial model of the availability of



Figure 1. Flow of the Balikpapan City Rice Supply System

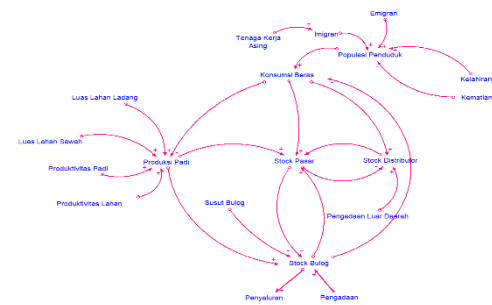


Figure 2. Causal Loop Diagram Actual

rice in the City of Balikpapan, which is built based on the factors or influencing variables observed in the aforementioned actual conditions. This variable is divided into three sub-models grouped into several, namely the consumption sub-model,

decrease. Meanwhile, if a variable has a negative relationship, then these variable experiences the opposite change; for example, if the number or value of one of the variables increases, then the affected variable experiences the opposite amount or value, that is, it experiences a decrease in the amount or value.

$H_0 = \mu_{aktual} - \mu_{simulasi} = 0$  then, there is no significant difference between the actual system output and the simulated system output.

$H_1 = \mu_{aktual} - \mu_{simulasi} \neq 0$  then, there is a significant difference between the actual system output and the simulation system output.

Significance of 2 tailed  $< \alpha$  then  $H_0$  is rejected.

Significance of 2 tailed  $\geq \alpha$  then  $H_0$  is accepted.

As for decision-making using a significance level of 5% or 0.05 and information is shown in the table below

Table 1. Validation Test Results

| Variable         | Year | Actual  | Simulation Result | P value | Conclusion     |
|------------------|------|---------|-------------------|---------|----------------|
| Population       | 2019 | 484,041 | 484,041           | 0.313   | $H_0$ accepted |
|                  | 2020 | 487,392 | 488,544           |         |                |
|                  | 2021 | 494,718 | 495,957           |         |                |
|                  | 2022 | 519,666 | 505,391           |         |                |
| Paddy Farm       | 2019 | 7       | 7                 | 0       | $H_0$ accepted |
|                  | 2020 | 0       | 0                 |         |                |
|                  | 2021 | 0       | 0                 |         |                |
|                  | 2022 | 0       | 0                 |         |                |
| Paddy Field Area | 2019 | 57      | 57                | 0.193   | $H_0$ accepted |
|                  | 2020 | 67      | 56.8              |         |                |
|                  | 2021 | 46      | 56.34             |         |                |
|                  | 2022 | 30      | 55.70             |         |                |

The statistical test results found that if the value of the P value  $\geq \alpha$  or P value  $\geq 0.05$  value, then  $H_0$  is accepted, or it can be stated that the model is valid.

#### Analysis of the Results of the Actual Model Output

Meanwhile, when the verification and validation process is carried out on the model, an analysis of the results of the running Stock and Flow Diagram results for each Sub-Model inputted in the model's system is carried out. In running this Sub-Model from 2019-2039 or the next 20 years. As an initial initiation, the value model input into the system is 2019, which plays

a role as a reference. Then the results from the following year will be a reference in comparing simulated and actual values. The following is an analysis of the results of the actual model output based on the results.

The consumption sub-model is a sub-model that is closely related to the availability of rice; this is because the population influences consumption. As for Figure 5, the input value of the population variable is the Stock 484,041 population. This population is population data in the adult category, namely residents starting at the age of 17 years. The consumption level assumption is 0.1146 tons/year. The value of 0.024 for the birth rate variable is the average birth rate increase, and 0.009 is the average death rate increase in Balikpapan City. Then the number of immigrants was 19,044 people in 2019, and the number of foreign workers in this model, the input value is 711 people in one year.

Meanwhile, figure 5 is what becomes the

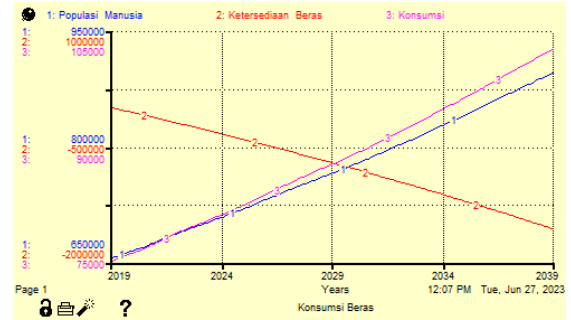


Figure 5. Consumption Sub Model Comparison Results

outflow in the population stock is the rate of population decline, where the influencing variable is the number of emigrants who have an input value of 18,360 people, the same as immigrants; emigrants also have fluctuating or unpredictable values that can experience a decrease or increase. The Consumption Sub-Model strongly identifies that the City of Balikpapan is still lacking in meeting the availability of rice in the City of Balikpapan with population segmentation. This parameter refers to a population value higher than the rice availability value. In this case, it is necessary to improve the rice availability system to maintain the rice demand by the people in Balikpapan City.

The stock model is divided into 2: the Government or bulk with the private sector. The difference between government procurement or Bulog and private procurement is that government procurement does not depend on distributors.

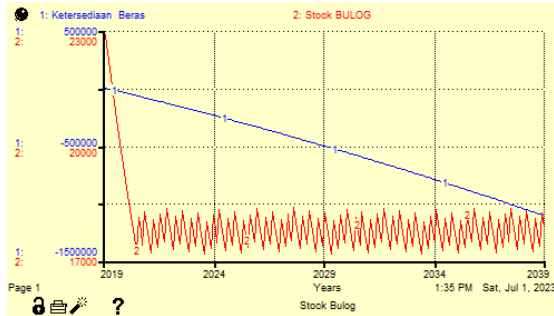


Figure 6. BULOG Simulation Output Results

The following are the results of figures 6 the Stock Sub-Model for actual conditions. The Bulog stock is influenced by a variable factor, namely procurement that becomes an inflow where the value input in the model is 0.7 or equal to 70%, where this figure is the value of the average level of the initial stock of rice divided by the amount of rice imported to Bulog. Meanwhile, the outflow is the procurement of rice, where the input value is 0.2 or equal to 20%. This value is the average number of ending stocks after the initial stock reduces income in the following year. From this explanation, the distribution of rice from Bulog is from the government segmentation, which is still considered insufficient due to the large number of procurements. If this is continued, it will affect the increase in depreciation and stockpiling of Bulldog's warehouse stock. So, it is necessary to improve the system in the government segmentation Stock and Flow Diagram, namely Bulog.

Figure 7 shows that there is an indication of graphical instability from the distributor's stock with the availability of rice. The reason for this problem is that the distribution and procurement of each distributor are different, and this is also related to other distributions between each distributor. The input value for procurement and distribution from each distributor is divided by city/district area, namely Jakarta, Makassar, Sidoarjo, and Surabaya, with a stock capacity of each distributor with a stock value of 1,128 tons

for Jakarta, 3,660 tons for Makassar, 3,576 tons for Sidoarjo and Surabaya. 20,556 Tons. The distribution value for each region, namely Surabaya, is 0.42, then the distribution from Jakarta and Sidoarjo is 0.23, and Makassar has 0.21 with a procurement of 0.4. From the data, the distribution of rice from distributors is still relatively small compared to procurement; this will have an impact on the lack of effectiveness in distributing rice to market needs, namely the community.

In the production sub-model, a graph like figure 8 above is related to the rice availability rate where this availability rate is influenced by the average productivity level of rice fields and fields where in this input productivity is the result of the amount of production from each rice field and field measured with regression from paddy fields of 0.357. Furthermore, one of the factors in the rate of availability of rice is the area of paddy fields and the area of paddy fields. Where the value of paddy fields in 2019 is 57 hectares, and the area of paddy fields is 7 hectares. In this model, the outflow stock is obtained, namely the rate of decline of paddy field area and paddy field area as a factor of paddy field area and paddy field area. The input value is used in the rate of decrease in the paddy field area, namely by using a probability with a Standard Deviation value of 16.65 and a Mean value of 9 because the input value in the formulation uses random syntax, so a maximum and minimum value is required where in this model the input value a minimum of 0.4 and a maximum of 0.7. Following are the graphical results of the input for the actual condition simulation of the Paddy Field Area and Paddy Land Area.

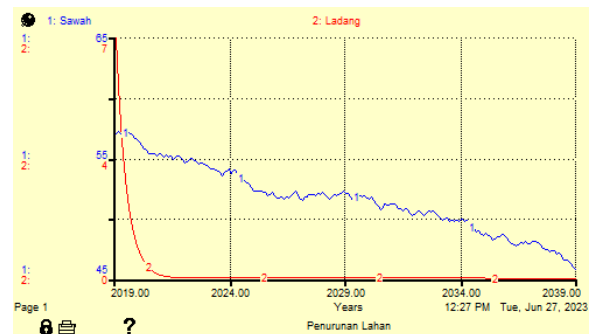


Figure 8. Land Depreciation Graph

### 3.2. Discussion

After the system model in the actual model has been verified and validated, the next step is developing a scenario. This scenario is used to become a proposed improvement of the system that is adjusted to the initial goal of making a dynamic system model of rice availability in Balikpapan City. Several policies were created to fulfil this research in developing this scenario, shown in the following table 2.

Table 2 Scenario Design

| No | Scenario                                                                          | Goal                                                                                                          |
|----|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| 1. | Increase the Distribution of 50% and Procurement of Rice 10% Bulog                | Increasing segmentation distribution from the government so that Bulog's rice distribution is more effective. |
| 2. | Increase Procurement by 30% and Distribution of Rice by 20-30% from Distributors. | Increasing the availability of rice through distributor stock affects the amount of increased consumption.    |

This scenario was made based on existing problems where actual data analysis found that the availability of rice still needed to be improved compared to the existing population. This problem arises because the distribution value in the actual model is relatively small, so it is necessary to develop the system in this actual model.

#### Scenario 1 Increasing Bulog Rice Distribution

In a systematic calculation, if the rice supply becomes more significant, it will affect Bulog's stock, which will be greater. Therefore, if the stock has increased from the actual initial condition of 0.7 or 70%, the procurement of the number of Bulog warehouse stocks will be 0.8 or 80%. Furthermore, the distribution of rice also increased from 0.20 or 20% to 0.80 or 80%. The results of the input can be seen in the graph below.

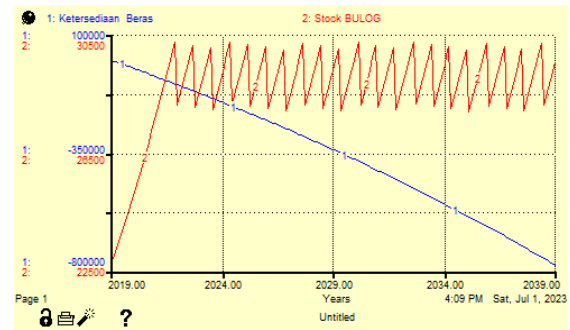


Figure 9. Scenario Bulog Stock Chart

Figure 9 shows that by increasing the procurement of rice so that there is no accumulation of rice, it is also necessary to increase the capacity of the warehouse. This is necessary to increase rice storage prior to distribution. The increase made in this study amounted to 30,000 tons from the previous 17,500 tons in actual conditions.

#### Scenario 2 Increasing Distributor Procurement

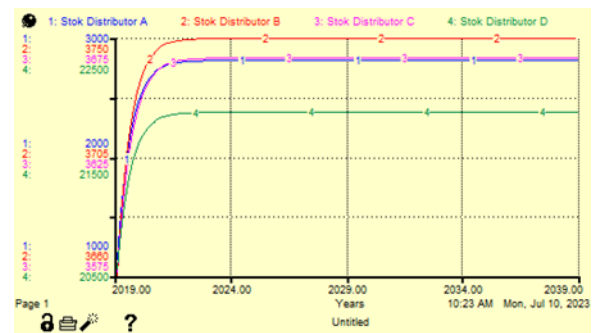


Figure 10. Scenario Distributor Stock Chart

In scenario 2 as shown in figure 10, what is being done is increasing the procurement of distributors with the actual condition of the distribution of an average of only 20% and, at most, only 40%, not reaching 50%. The distribution value of each distributor also has a small matter of 40%. If this system continues to be implemented, it will cause problems, namely the shrinkage of rice caused by a storage time that is too long, so it has the potential to damage rice. Compared to the simulation, which has a procurement value of 0.7 or 70% and distribution of 0.5 or 50% and 0.6 or 60%. This comparison indicates that increasing procurement and distribution and increasing the capacity of the warehouses of each distributor will affect the

amount of stock value in a distributor. The following is after the scenario treatment is carried out.

#### 4.CONCLUSION AND SUGGESTION

From the results of this study, it was found that the availability of rice can be visualized with a dynamic system approach using Causal Loop Diagrams and Stock and Flow Diagrams. As for the results of the actual model, the availability of rice has quite significant causalities with the factors that affect rice's availability, which are visualized using a Causal Loop Diagram. This is also supported by when forecasting from the Stock and Flow Diagram that the availability of rice in the City of Balikpapan still needs to be increased to meet the demand for rice by the population. The rice availability factors are divided into 3 sub-models, namely the consumption sub-model, which is influenced by people; the production sub-model, which is controlled by rice productivity from paddy fields and fields and the stock sub-model, which is influenced by the procurement and distribution of rice.

The scenario chosen is scenario 2, namely by increasing procurement to 70% of rice stocks from each distributor and increasing distribution to 60% and 50%, which was initially only 20%. This scenario was chosen with the aim that rice distribution would go directly to the community so that it would be easier to control the availability of rice in the market. However, with the implementation of this system, it is necessary to carry out specific policies from the relevant agencies regarding the control system for the availability of rice. This is useful for preventing fraud. Implementing this system can become a reference for the City of Balikpapan in maintaining the availability of rice in the City of Balikpapan, which is accompanied by an increasing population in the City of Balikpapan.

#### References

- Adi, Aswan; Rachmania, Dwi; Krina Murti, Bayu. 2021. Neraca Ketersediaan Beras di Kalimantan Timur Sebagai Calon Ibukota Baru Indonesia Dengan Pendekatan Sistem Dinamis. Jurnal BETA (Bioekosistem dan Teknik Pertanian., Vol 9. No 1.
- Arvianto, A., & Hadi, N. H.. 2017. Analisis Kebijakan Persediaan Beras Provinsi Jawa Tengah. Teknik Industri. Semarang: Universitas Diponegoro.
- Agregat Data Kependudukan, Dinas Kependudukan dan Catatan Sipil Kalimantan Timur. 2023. Accessed on 17 Mei 2023 from Web Resmi online: <https://dkp3a.kaltimprov.go.id/e-infoduk/>
- Bala, B. K. 2022. Energy Systems Modeling. United State: CRC Press.
- Bala, Bilash Kanti; Arshad, Fatimah Mohammed; Noh, Kusairi Mohd. 2017. System Dynamics Modelling and Simulation. Singapore: Springer Nature.
- Badan Pusat Statistik Kota Balikpapan. 2019. Balikpapan dalam Angka 2019. Accessed on 13 Maret 2023 from Web Resmi online: <https://balikpapankota.bps.go.id/publication/2019/08/16/0fa8702a31af652b5aabeeb4/kota-balikpapan-dalam-angka-2019.html>
- Badan Pusat Statistik Kota Balikpapan. 2020. Balikpapan dalam Angka 2020. Accessed on 13 Maret 2023 from Web Resmi online: <https://balikpapankota.bps.go.id/publication/2020/04/27/9527d161a8abb3b602ea6a0f/kota-balikpapan-dalam-angka-2020.html>
- Badan Pusat Statistik Kota Balikpapan. 2021. Balikpapan dalam Angka 2021. Accessed on 13 Maret 2023 from Web Resmi online: <https://balikpapankota.bps.go.id/publication/2021/02/26/995ad56da7168d041f2cbbd8/kota-balikpapan-dalam-angka-2021.html>
- Badan Pusat Statistik Kota Balikpapan. 2022. Balikpapan dalam Angka 2022. Accessed on 13 Maret 2023 from Web Resmi online: <https://balikpapankota.bps.go.id/publication/2022/02/25/e78628bde521d84e52633df5/kota-balikpapan-dalam-angka-2022.html>
- Balikpapan Tergantung Daerah Lain, Genjot Produksi Petani Balikpapan. Kaltim Pos. 2022. Accessed on 12 Maret 2023 from online newspaper: <https://kaltimpost.jawapos.com/pro-bisnis/25/03/2022/balikpapan-tergantung-daerah-lain-genjot-produksi-petani-balikpapan>
- Dampak IKN, Jumlah Penduduk Balikpapan Kian Bertambah. Ini Balikpapan. 2022. Accessed on 12 Maret 2023 dari berita online: <https://www.inibalikpapan.com/dampak-ikn-jumlah-penduduk-balikpapan-kian-bertambah/>
- Dinas Pangan, Pertanian dan Perikanan Kota Balikpapan. 2023. Data Aktual Produksi

- Beras, Luas lahan Sawah dan Ladang, Luas Tanam Tanaman Sawah dan Ladang Kota Balikpapan.
- Eunike, A., Setyanto, N. W., Yuniarti, R., Hamdala, I., & Lukodono, R. P.. 2021. *Perencanaan Produksi dan Pengendalian Persediaan*. Malang: Universitas Brawijaya Press.
- Goenadhi, Ec Lydia; Nobaiti. 2017. *Pengantar Ekonomi Mikro*. Banjar Baru: Scripta Cendekia.
- Hertadi, C., D. P. 2020. *Pengaruh Faktor Demografi Dan Lingkungan Kerja Terhadap Dinamika Pola Perkembangan Kepribadian Masyarakat Industri Pengolahan*. Thesis, Institut Teknologi Sepuluh Nopember.
- Hanifah, Ashma., & Suryani, Erma. 2017. Model Sistem Dinamik Untuk Meningkatkan Rasio Penuhan dan Efisiensi Pada Manajemen Rantai Pasok Biodiesel Nasional. *Jurnal Teknik ITS*, Vol 6 No. 2.
- Karlingger, F.N. 2006. *Asas-Asas Penelitian Behavioral*. Yogyakarta: UGM Press
- Manetsch TJ, Park GL. 1982. *Systems analysis and simulation with applications to economic and social systems*. Department of Electrical Engineering and System Science, Michigan State University, USA
- Pradnyana, I. G., Widia, I. W., & Sumiyati. 2021. Model Sistem Dinamik Stok Beras untuk Mendukung Ketahanan Pangan Provinsi Bali. *Jurnal Beta(Biosistem Dan Teknik Pertanian)*, Vol 9 No 1.
- Riset Padi untuk Tingkatkan Produksi Beras Nasional. 2022. Accessed on 12 Maret 2023 from online newspapers: <https://www.brin.go.id/news/109616/riset-padi-untuk-tingkatkan-produksi-beras-nasional>
- Saputra, H. E., Karimuna, L., & Herdhiansyah, D. 2019. Analisis Ketersediaan Beras Dengan Pendekatan Sistem Dinamik. *Jurnal Sains Dan Teknologi Pangan*. Vol.4, No.4. Kendari: Universitas Halu Oleo.
- Setiadi, H., Mubassiran, & Hatmani, R. D. 2022. Perancangan Model Sistem Dinamik Ketersediaan Beras Dalam. *Jurnal Logistik Bisnis*. Vol 12 No 01. Bandung: Politeknik Pos Indonesia
- Siyoto, Sandu; Ali, M Sodik (2015). *Dasar Metodologi Penelitian*. Yogyakarta: Literasi Media.
- Suparmoko, M.A. 2017. *Ekonomi*. Jakarta: Yudhistira.