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System Dynamic Approach to Analyzing the Watermelon Supply Chain in Sidoarjo, East Java

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A B S T R A C T

The supply chain system will greatly affect the distribution channel that will be targeted, thereby affecting the availability of products and also the fulfillment of needs for the community. Sidoarjo Regency has the potential to produce watermelons independently; this is supported because Sidoarjo Regency is included in the Gerbangkartasusila region, with Surabaya City as one of the main supporting districts. Watermelon fruit has a very abundant amount of production in Sidoarjo Regency, but watermelon fruit is a seasonal fruit with erratic public consumption and tends to decrease, causing an excess supply of watermelon. Therefore, this research was conducted to determine supply chain behavior, then model and simulate it, as well as design a model for improving the watermelon supply chain in Sidoarjo Regency. Through a system dynamics simulation approach using Vensim software, the results show that the amount of watermelon stock in Sidoarjo is affected by production, consumption, and depreciation values. Then, the current total production of watermelons will be 1110 quintals in 2021. Through a simulation of the improvement model design with the addition of other regional distributions and the assumption of a distribution of 350 tons/year for the next 5 years, the supply of watermelons is still able to meet the needs of the people of Sidoarjo Regency. The improvement model reduces excess inventory in Sidoarjo Regency.

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1. INTRODUCTION

The horticulture sector is an agricultural sub-sector that plays an important role in enhancing Indonesia's economic development. This is because the agricultural sector is the main source of livelihood for most Indonesians. In the agricultural sector, this commodity has great potential to increase the income of Indonesian farming communities (Direktorat Jenderal Hortikultura, 2019). On the other hand, a commodity requires a structured distribution channel, which is called a supply chain. Supply chain management is a practice or discipline or knowledge commonly used by the

manufacturing industry in the business sector (private or corporate) to manage business processes, including production systems (Arif, 2022). The development of horticulture has made a significant contribution to the agricultural sector and the national economy, as can be seen from the Gross Domestic Product (GDP), the number of households that rely on sources of income from the horticulture sub-sector, employment, and an increase in people's income. One commodity with high potential is fruit. The climate that supports the diversity of existing varieties is suitable for tropical fruits, producing a variety of very varied fruits (Enni et al, 2022). The Central Bureau of Statistics (BPS) noted that East Java produces the most watermelons. The amount reached 138,245 tons, or the equivalent of 33.37% of the total national watermelon production (Widi, 2022). Sidoarjo Regency is one of the main supporting districts of Surabaya City. Sidoarjo Regency is included in the Gerbangkartasusila area. Sidoarjo Regency has an agricultural area of 17,205 Ha out of a total area of 63,440 Ha in Sidoarjo Regency in 2014, with agricultural food production reaching 2,041,380 quintals in 2014. The main commodities of Sidoarjo Regency are horticultural crops such as fruits (watermelon, melon, golden cucumber) and others in the form of green beans, soybeans, sugarcane, eggplant, bitter melon, and pickled cucumbers (Dhiaul, 2019). Sidoarjo Regency is one of the largest watermelon producers in Indonesia. With watermelon production in Sidoarjo, East Java, in 2018 it reached 523 quintals, then in 2019 it rose to 2161 quintals, while in 2020 it was only 331 quintals, and in 2021 it rose to 1110 quintals. 0.067 kg, in 2019 0.103 kg, and in 2018 0.068 kg (BPS, 2022).

Sidoarjo district has a total agricultural production of 2,041,380 with one of the highest productions, namely watermelons, with an average production amount of 1,031.25, while per capita consumption per week is 0.073 kg. Sidoarjo Regency has land for producing watermelons in several areas, including Lebo Village, Tulangan District, Wonoayu, Prambon, Jabon District, Krian, Tanggulangin, and Sawohan Village. District residents live in Sidoarjo, which now numbers 2,064,168 people (BPS, 2021). The consumption of watermelons in Sidoarjo tends to decrease starting from 2019 and above, while the existing production is very abundant, so that it is at an average rate of 1,031.25 quintals, which has an impact on the abundance of watermelons on the market. Therefore, in this study, the authors chose the dynamic system simulation method. This method was chosen because it is to analyze the behavior of the supply chain of watermelons, and it is hoped that the abundance of existing production in Sidoarjo can be distributed to other regions in order to balance production output with consumers in Sidoarjo. This method is considered more suitable because it can represent precisely and accurately important aspects of the system so as to produce better predictions in short, medium, and long-term trends. In addition, dynamic systems also provide a means of identifying influential variables in systems that involve complex dynamics (Arbian, 2018). The dynamic system approach can be carried out with several software packages that help with simulations, including Power Simulation (Powersim), Ventana Simulation (Vensim), Dynamo, and Stella (Ithink) software (Dutormasilabs, 2020). However, this study only uses Vensim because it can simplify problems without mathematical equations.

2. LITERATURE REVIEW

He, S., & Li, J. (2019), in their research, stated that dynamic systems theory (SD) was founded by Jay W. Forrester at the Massachusetts Institute of Technology and is a synthesis of systems science and computer simulation. Dynamic systems theory is a model based on causal relationships and a method that emphasizes the modeling of a system, integration, connection, development, and dynamics. Dynamic system modeling needs to be used to avoid making unqualified policies. The supply chain effect is the most fundamental for companies to maintain a continued competitive advantage. In solving this, the measurement of supply chain performance needs to be carried out as a whole (Murniati et al., 2019). supply chain management is integrating competent business resources into the distribution of goods (Hidayati et al., 2023)

Previous research about supply chain system has been carried out by Apurwanti et al., (2020) regarding Supply Chain Flow Shallots in Bantul

Regency. In the shallot supply chain in Bantul Regency, there are several actors who have different goals and advantages, therefore it needs integration in increasing efficiency. Several studies on supply chains also underlie it.This research is a supply chain analysis of watermelon in Sidoarjo Regency using a dynamic system approach to identifyThe relationship between the supply chain network and its structure The dynamic system model has a changing behavior, and it is possible that the feedback scheme will provide a more complex flow of information (Andhika, 2019). According to Kim et al. (2018), system dynamics is a system approach that is achieved through interrelationships between variables, analyzing changes in the system to estimate future trends, and is a nonlinear method that uses quantitative and qualitative data, which makes it possible to analyze complex system dynamics with feedback characteristics.

The definition of simulation is the application process of building a model of a real or proposed system, conducting experiments with this model to explain system behavior, studying system performance, or building a new system according to the desired performance. The use of simulation will provide management with a broader perspective when solving a problem. Therefore, the benefits obtained by using the simulation method are as a tool for system designers or decision makers, in this case managers, to create systems with certain performance both in the system design stage (for systems that are still in the form of proposals) and operational stages (for running systems) (Amaliah, 2019).

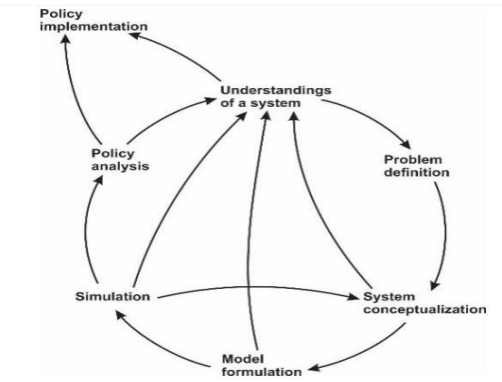


Figure 1. Richardson and Pugh's system dynamic diagram
Source : Richardson & Pugh (1981)

The formulation of the dynamic system simulation model during the modeling process begins simulation verification and validation Simulation verification and validation are carried out by carrying out tests, including testing through a model that is used as a reference, sensitivity test analysis, and analyzing the impact on scenarios that influence each other between variables, using the help of software facilities (Yuni, 2022).

3. RESEARCH METHOD

This study uses a system-dynamic method with the initial stage of collecting data on production and harvested areas. This data is obtained from the central statistics agency from 2018 to 2021. Then the reduction solution uses Vensim software. The method is based on the literature. Studies obtained from data obtained indirectly from previous research. References or documents that have been compiled The following problem-solving flowchart can be seen in Figure 2.

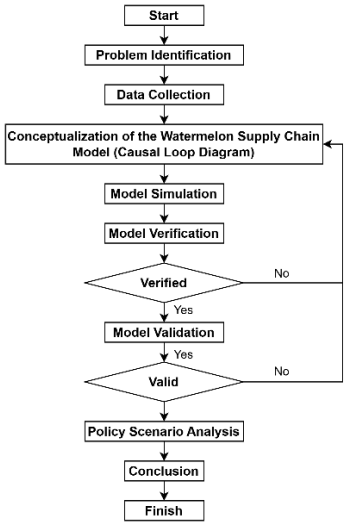


Figure 2. Flow chart of study

4. RESULT AND DISCUSSION

4.1 Define

In the supply chain, an analysis of the behavior of the system is carried out, which aims to evaluate the distribution of supplies related to watermelon fruit products. In behavioral analysis, there are several techniques that can be used. In this study, we used a system dynamics

model simulation approach. Through this method, supply chain behavior can be clearly shown because it can model the behavior of the system through a feedback loop and its impact (a causal loop diagram) on each of the variables involved. Making a conceptual model in this study using a Causal Loop Diagram (CLD), CLD can show patterns of relationships between variables that are the object of research. The variables used were obtained through supply chain analysis of watermelons in Sidoarjo Regency. After doing the conceptual model, the next step is to design a conceptual model that will be used. The following Figure 3 and 4 is the manufacture of CLD and SFD using Vensim Software.

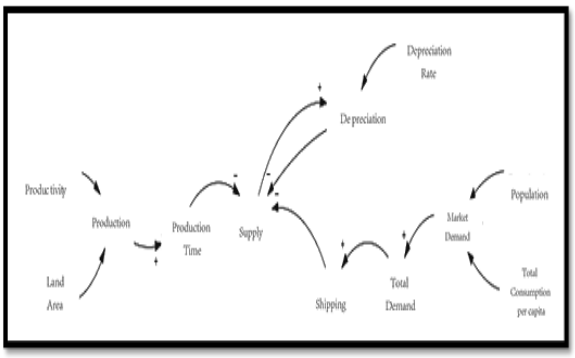


Figure 3. Causal loop diagram

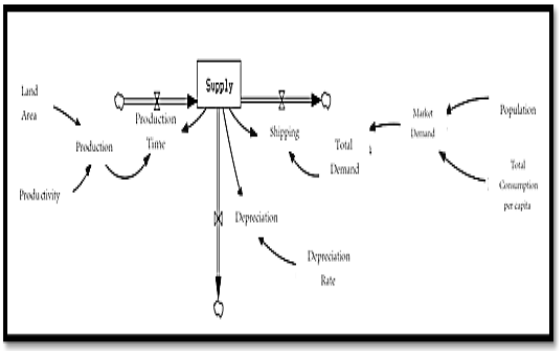


Figure 4. Stock flow diagram

4.2 Verification Of Models

Model verification is carried out to check again whether there is a model error or not. To verify the model, there are two stages: the first is to check the logic of the model, and the next is to check whether the units in the variable are appropriate or not. The following Figure 5 and 6 is verifivation of models.

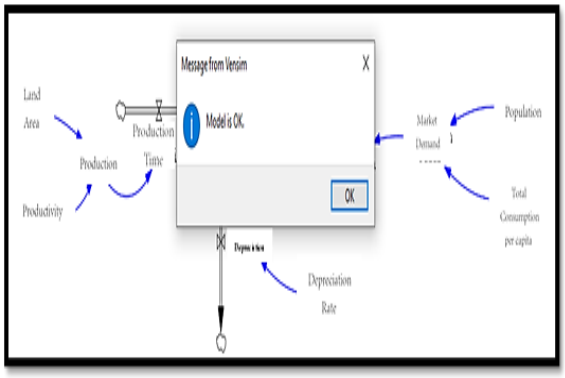


Figure 5. Model validation

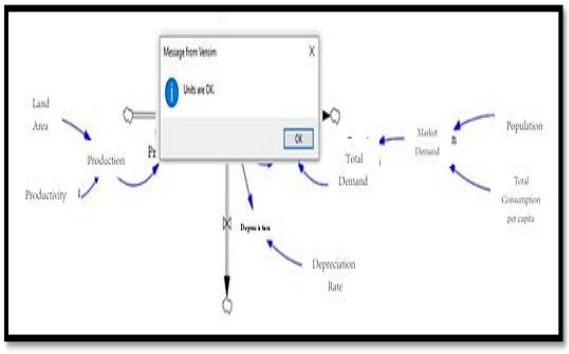


Figure 6. Unit validation

4.3 Model Simulation Result

After all the variables match the logic of the real system, the model is run to display the simulation results. Through the model in Figure 7, researchers can find out the behavior of the watermelon supply chain in Sidoarjo Regency, which can be seen from the supply and total demand variables.

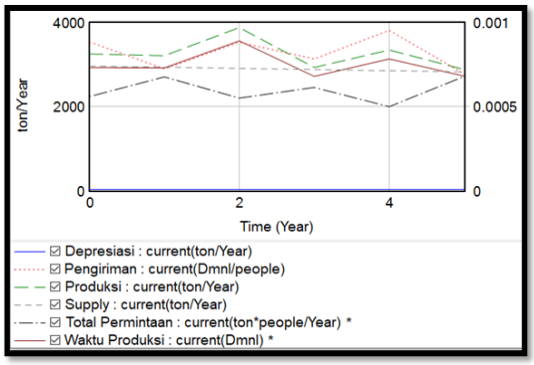
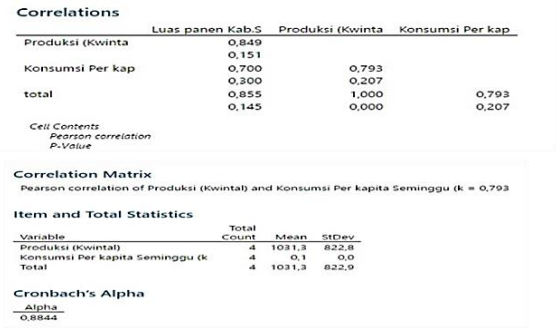


Figure 7. Model Simulation result

4.4 Model Validation

Model validation is carried out to ensure that the

model that has been created accurately represents the real system. In this study, validation was carried out using Minitab. The following Figure 8 shows the model validation that has been done.



Correlations

	Luas panen Kab.S	Produksi (Kwinta	Konsumsi Per kap
Produksi (Kwinta	0,849		
	0,151		
Konsumsi Per kap	0,700	0,793	
	0,300	0,207	
total	0,855	1,000	0,793
	0,145	0,000	0,207

Cell Contents
Pearson correlation
P-Value

Correlation Matrix
Pearson correlation of Produksi (Kwintal) and Konsumsi Per kapita Seminggu (k = 0,793

Item and Total Statistics

Variable	Total Count	Mean	StDev
Produksi (Kwintal)	4	1031,3	822,8
Konsumsi Per kapita Seminggu (k	4	0,1	0,0
Total	4	1031,3	822,9

Cronbach's Alpha

Alpha
0,8844

Figure 8. Model validation

4.5 Design of the Watermelon Supply Chain Improvement Model

The simulation model that has been created is used to analyze and determine the behavior of the watermelon supply chain in Sidoarjo Regency so that recommendations for improvement can be given to overcome problems. It is known that the supply of watermelon fluctuates according to the amount of demand, production, and depreciation. Therefore, it is necessary to improve the system so that existing supplies can be distributed to other areas so that existing supplies are not excessive because watermelons can depreciate with time or rot. The following Figure 9 is a design improvement model.

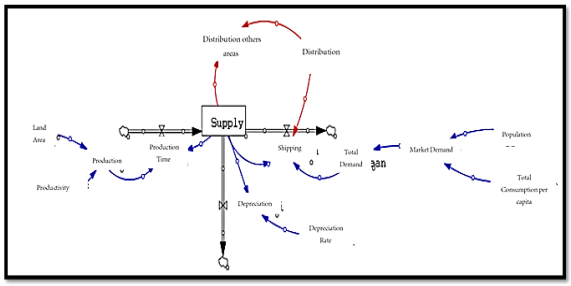


Figure 9. Addition of other area distribution variables

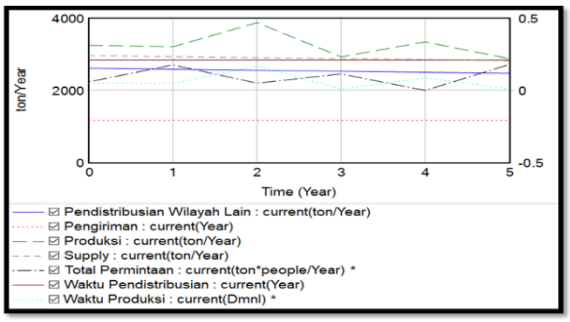


Figure 10. Simulation result improvement

5. CONCLUSION

The design of an improvement model with a dynamic system for 5 years shows that this design can increase the supply of watermelons in Sidoarjo. That is, the number of offers will also increase as long as the amount of production also increases. From the design improvement model with distribution to other areas assuming a distribution of 350 tons/year to reduce the amount of supply that is too much compared to the amount of demand, the result is that the existing supply is still sufficient for market demand for the next 5 years. Therefore, the design of the improvement model can be used as the best improvement alternative. However, this research can be developed in more detail so that future researchers are expected to be able to collect as much data and information as necessary and relevant, both primary and secondary, to reduce the use of research assumptions.

REFERENCES

Andhika, L. R. (2019). Model sistem dinamis: Simulasi formulasi kebijakan publik. Jurnal Ekonomi dan Kebijakan Publik, 10(1), 73–86. https://doi.org/10.22212/jekp.v10i1.1242

Badan Pusat Statistik. (2021). Rata-rata konsumsi per kapita seminggu beberapa macam bahan makanan penting, 2007–2021. Retrieved from https://www.bps.go.id/statictable/2014/09/08/950/rata-rata-konsumsi-per-kapita-seminggu-beberapa-macam-bahan-makanan-penting-2007-2021.html

BPS. (2022). Produk domestik regional bruto Kabupaten Sidoarjo menurut pengeluaran. Jakarta: Badan Pusat Statistik.

Direktorat Jenderal Hortikultura Kementerian Pertanian. (2019). Rencana strategis Direktorat Jenderal Hortikultura tahun 2020–2024.

Faradibah, A., & Erma, S. (2019). Development of a dynamic system simulation model to

improve the efficiency of transportation operating systems. ILKOM Scientific Journal, 11(1), 67–76. https://doi.org/10.33096/ilkom.v11i1.413.67-76

He, S.-k., & Li, J. (2019). A study of urban city traffic congestion governance effectiveness based on system dynamics simulation. International Refereed Journal of Engineering and Science (IRJES), 37–47. https://doi.org/10.1006/jema.2000.0369

Hidayati, A., & Pulansari, F. (2023). Performance measurement supply chain management (SCM) using the supply chain operation reference (SCOR) method at PT X. Indonesian Journal of Industrial Engineering & Management, 4(2). https://doi.org/10.22441/ijiem.v4i2.20506

Kim, H., Jeon, J., & Yeo, G. (2018). Forecasting a model of air passenger demand using system dynamics. Journal of Digital Convergence, 16(5), 137–143. https://doi.org/10.14400/JDC.2018.16.5.137

Murniati, W., Kurnia, W. I., Handayani, S., & Ishak, S. (2019). Pengukuran kinerja supply chain pada industri UKM kerajinan (Studi kasus: Industri kerajinan Ketak Lombok Tengah, Nusa Tenggara Barat, Indonesia). Journal of Industrial Engineering Management, 4(1), 1. https://doi.org/10.33536/jiem.v4i1.262

Muhammad, D. H. (2019). Perancangan fasilitas pelatihan pengolahan hasil pertanian di Kabupaten Sidoarjo. Jurnal Perancangan Teknik Arsitektur.

Richardson, G. P., & Pugh, A. L. (1981). Introduction to system dynamics modeling with Dynamo. Massachusetts: The Massachusetts Institute of Technology.

Rachma, E. A. (2020). Optimization of production planning using dynamic system models at PT X. Journal of Industrial Engineering Optimization (JOTI), 2(1), 36. https://doi.org/10.1109/AICI.2009.111

Yuni, K. S. (2022). System dynamic simulation modeling to predict the effect of main criteria for increasing the number of visitors to small and medium enterprises of the Kenjeran Bulak Fish Center (SIB). APTEK Journal, 14(2), 137–143. https://doi.org/10.30606/aptek.v14i2.1387

Arif, A. (2022). Pengantar manajemen rantai pasok. Modul pelatihan kompetensi pengadaan barang atau jasa pemerintah level 1.

Asista, E., Mulyasari, G., & Sumantri, B. (2019). Analisis pemasaran semangka (Citrullus vulgaris) di Kabupaten Pesisir Barat Provinsi Lampung.