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Model-based Decision Support System Using a System Dynamics Approach to Increase Corn Productivity

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Abstract

Background: As the population increases, the need for corn products also increases. Corn is needed for various purposes, such as food consumption, industry, and animal feed. Therefore, increasing corn production is crucial to support food availability and the food industry.
Objective: The objective of this project is to create a model to increase corn farming productivity using scenarios from drip irrigation systems and farmer field school programs.
Methods: A system dynamics approach is utilized to model the complexity and nonlinear behaviour of the corn farming system. In addition, several scenarios are formulated to achieve the objective of increasing corn productivity.
Results: Simulation results showed that adopting a drip irrigation system and operating a farmer field school program would increase corn productivity.
Conclusion: The corn farming system model was successfully developed in this research. The scenario of implementing a drip irrigation system and the farmer field school program allowed farmers to increase corn productivity. Through the scenario of implementing a drip irrigation system, farmers can save water use, thereby reducing the impact of drought. Meanwhile, the scenario of the farmer field school program enables farmers to manage agriculture effectively. This study suggests that further research could consider the byproducts of corn production to increase the profits of corn farmers.

Keywords: Corn Farming, Decision Support System, Modeling, Simulation, System Dynamics

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I. Introduction

Corn, as a carbohydrates producer, is a strategic agricultural commodity. Currently, the demand for corn is rising along with the increase of the population. In addition to human consumption, corn commodity is used as a food ingredient for animals. Corn yields fluctuate depending on the season [1]. Fig. 1 displays the national corn production trend line for 2010-2020. According to reference [2], the major cause of the decline in the overall amount of corn production is the frequent conversion of agricultural land and the decline in land productivity per hectare. On the other hand, the demand pattern for corn tends to increase throughout the year. According to the Ministry of Agriculture of the Republic of Indonesia, more than 58% of the nation's corn demand is utilized for feed, with the remaining percentage going toward food and other industrial uses [3]. Therefore, corn production as a strategic commodity needs to be increased in line with increasing demand and population. Low productivity and ineffective production are some of the problems facing corn farming [4]. Some of the issues in corn growing that lead to low output, as in [5], include critical land status, inappropriate fertilization techniques, problems with food crop seeds, and problems with marketing agricultural products.

Based on the issues listed above, strategies are needed to boost the harvesting of corn. Various studies related to corn farming have been conducted. An artificial neural network model was used in reference [6] to estimate the production of corn for the next few years. Meanwhile, the SALTMED model was used to analyse the effect of fertigation applications on increasing corn productivity [7]. The possible effects of climate change on corn cultivation were evaluated as in reference [8], using the Root Zone Water Quality Model (RZWQM) with the Decision Support Systems for Agrotechnology Transfer (DSSAT) crop module. An investigation into the effect of water systems on corn farming was conducted as in reference [9]. It was discovered that reducing moisture and making a few minor adjustments to the way irrigation is currently done can boost corn yields. Meanwhile, the development of a conceptual model for corn farming was carried out by reference [10] using a system thinking approach. The authors developed a

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conceptual model that has some important information regarding internal and external factors that influence corn productivity and production. Table 1 illustrates a comparison of previous research.

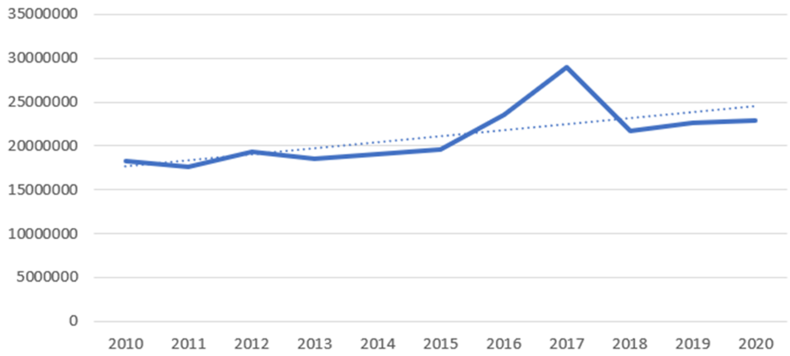

Fig. 1 National Corn Production (tons) in Indonesia 2010-2020 [1]

Several previous studies have conducted in-depth analysis of corn farming systems. However, the aspects of causality and behavioral changes in the system over time are not considered. The corn farming system is far more intricate due to a growing variety of individuals and their interactions [11]. Studying corn farming systems in detail and depth can help in understanding the circle of interaction between actors and factors universally. Therefore, this study intends to develop a model that supports the linkages between factors and capture the dynamics in the corn farming system. System dynamics approach is a model-based decision support method that has been widely applied to analyse nonlinear systems, with various interactions between elements in complex systems. A system dynamics approach is quite effective in studying the elements of complex systems [12], [13]. This study aims to analyse the behaviour and dynamics in corn farming to increase its productivity. A system dynamics approach was used in this study because of its ability to generate insights into the complexity of structures and behaviours in corn farming, and understanding how various factors influence each other. To facilitate the analysis of information flow in the model, the model was broken down into three sub-models: corn demand, corn productivity, and farmer profit. After that, the model was subjected to behavioral validity testing to validate the model. Then, multiple scenarios that might boost corn productivity were created.

TABLE 1
RESEARCH COMPARISON

	Purpose
Reference [6]	Increase corn productivity to maintain consistency to supply demand and reduce corn imports to a minimum
Reference [7]	Optimize their utilization for corn production by examining the impact of various fertility levels on the yield of the crop based on three irrigation frequencies
Reference [8]	Examining how water use and the output of maize under both full and deficit irrigation are affected by climate change
Reference [9]	Optimizing irrigation methods and agronomic systems
Reference [10]	Developing a conceptual model (Causal Loop Diagram) to increase environmentally friendly corn production
This Study	Explore the causal relationship and behavior of elements in corn farming systems to increase productivity

In this study, we simulated two scenarios: the adoption of a drip irrigation system and the Farmer Field School (FFS) program. In the first scenario, the use of drip irrigation system technology was proposed because it considers the fact that this system is able to overcome the problem of prolonged drought [14]. In these situations, using a drip irrigation system was a suitable option as corn farmers could increase water efficiency and conservation by implementing drip irrigation technology. In the second scenario, the Farmer Field School program was proposed because through this program, farmers will have improved knowledge on corn production. About 59% of farmers were small farmers with land holdings of less than 0.5 ha. Because these farmers were often poorly educated, they were not able to adopt advanced agricultural technologies [15]. Through the farmer field school program, farmers would be equipped with the knowledge to make better input modifications, including dosage and application time

[16]. By implementing these two scenarios, corn production was hoped to increase not only in terms of quantity but also in terms of quality.

II. METHODS

This research applied a system dynamics approach to analyse the behaviour of complex systems in corn farming. System Dynamics (SD) model was introduced by Jay W. Forrester in 1956 [12]. SD is an effective method to recognize the connections and interactions between variables within a particular system. SD is a simulation technique for evaluating decision-making. This research consists of several basic stages in the creation of a model of system dynamics, namely: in-depth understanding of the corn farming system, determination of key variables and data collection, conceptual model development, simulation model development, model testing, and policy scenario formulation.

A. System Understanding

At this stage, we defined the problem along with the variables that have an important impact on the system. System understanding is the stage where the modeler needs to properly understand the system to be modelled, including all its constituent parts, their interrelationships, and its long-term operation. The system understanding stage in system dynamics modeling is very important because it is a fundamental first step in designing and analysing a system. This understanding helps modelers to understand system behavior and identify relationships between interrelated variables. System understanding was done by exploring various related literature on corn farming. The literature can be in the form of journals, books, theses, or online references related to both corn cultivation and system dynamics modeling.

Corn is a type of food crop that belongs to the grass family which is classified as a grain crop. Corn is widely recognized by the population in Indonesia as it is the second staple food after rice. Apart from food, corn is also in high demand as animal feed. Over 50% of Indonesia's total corn demand is used for animal feed [17]. The weather, illnesses, pests, cultivation technology and management, agricultural regulations, innovations, and many other factors can affect the final output of corn production in corn farming [18]. Meanwhile, corn productivity is strongly influenced by land area, fertilizer, labour, pesticides, climate, and seeds [19]. In addition, handling during harvest and afterward has an impact on both production quantity and quality. Large losses might result from harvesting and post-harvest handling errors. Picking is the first step in the harvesting process, and this is referred to as harvesting. Post-harvest handling refers to the processes involved in processing agricultural goods following harvesting [20].

B. Determination of Key Variables and Data Collection

At this stage, key variables are determined to make it easier to interpret the corn farming system. The determination of key variables requires the SD model to be divided into three sub-models: Corn Demand, Corn Productivity, and Farmer Profit. This division was done to help understand the system better. Focusing on small parts of the system allows for better understanding of the dynamics and interactions between these components. In addition, splitting the model into sub-models is a common practice in the development of system dynamics models to improve efficiency, understanding, and overall project manageability. Then, through a comprehensive literature review, key variables in corn farming were assembled. The literature used as references to capture key variables related to corn farming were [3], [6], [10], [19], [21], [22].

The variables collected were classified into endogenous variables and exogenous variables (see Table 2). Endogenous variables are those that represent internal characteristics of the system under study. Exogenous variables, on the other hand, represent outside factors outside the system's control. Furthermore, data collection was carried out on historical data which were used as input values and validation instruments in the model with the actual system. Data collection as a validation instrument was performed based on data availability. Historical data was acquired from the online websites of the Central Bureau of Statistics (BPS) and the East Java Agriculture Office. The data employed as instruments to validate the model were Population, Corn Harvest Area, Corn Productivity, and Corn Production.

C. Conceptual Model Development

Conceptual model development was developed through Causal Loop Diagram (CLD). CLD is developed to properly recognize the system's variables' causal relationships. It is a crucial tool for replicating the system's feedback mechanism [13]. CLD draws a system structure that describes the variables in the system, the nature of the causal relationships between the variables, and the behavior of the loop interactions formed [23]. Each causal relationship across variables is linked with an arrow and its polarity. Positive loops marked with the symbol "+" indicate the behavioral qualities of the loop as reinforcing, while negative loops marked with the symbol "-" indicate the behavioral properties of the balancing loop. Vensim PLE x64 software was used to construct the system dynamics model in this study. Fig. 2 illustrates the CLD of corn farming in this study.

TABLE 2
ENDOGENOUS AND EXOGENOUS VARIABLES

Sub-model	Endogenous Variables	Exogenous Variables	References
Corn Demand	-	Animal feed demand Corn consumption per capita Total population Birth rate Death rate Immigration rate Emigration rate	References [6], [10], [22]
Corn Productivity	Harvest land area Corn productivity Corn seed effect Irrigation effect Fertilizer effect Pesticide effect Corn fulfillment ratio Corn production	Rainfall effect Pest and disease effect	References [19], [21], [10]
Farmer Profit	Farmer's gross income Farmer's net income Cultivation cost	Corn market price	References [3], [21], [10], [22]

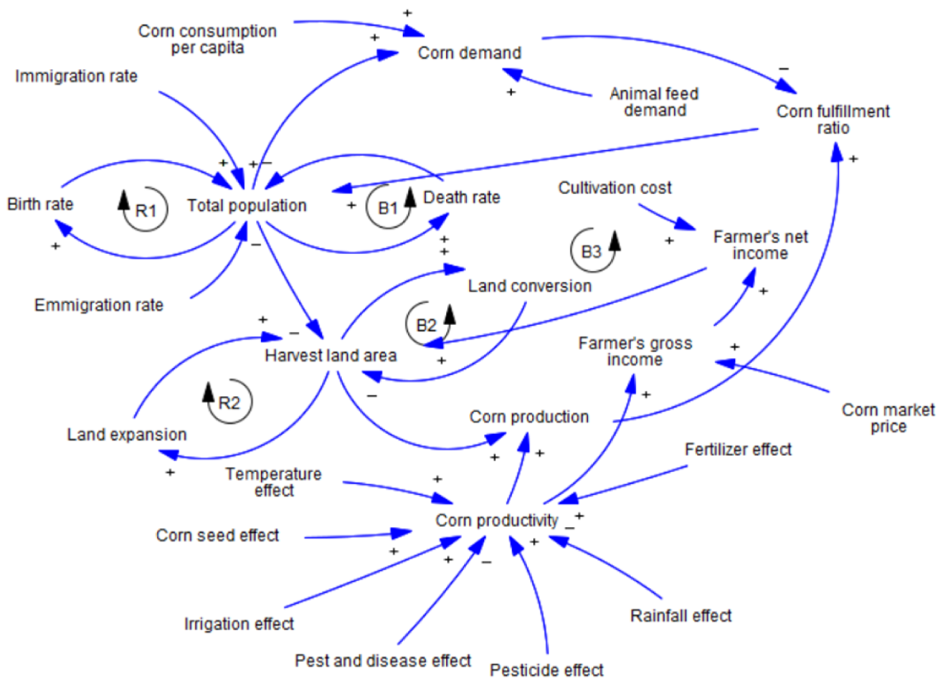

Fig. 2 Causal Loop Diagram of Corn Farming

Overall, this CLD has five loops, including three balancing loops (B1), (B2), (B3) and two reinforcing loops (R1), (R2). In loop B1, an increase in the total population will result in an increase in the death rate. In contrast, an increase in the death rate will result in a decrease in the total population. In loop R1, an increase in the total population will cause an increase in the birth rate. Likewise, an increase in the birth rate will upsurge the total population. In loop B2, increasing harvest land area increases land conversion. However, increasing land conversion will reduce the harvest land area. In loop R2, increasing the harvest land area will increase total land expansion. Likewise, increasing land expansion will increase the harvest land area. In loop B3, an increase in harvest land area will result in an increase in corn production. An increase in corn production can increase the corn fulfillment ratio. Increasing the corn fulfillment ratio will increase the total population. However, an increase in the total population will reduce the harvest land area because an increase in population will increase the demand for land for residence.

D. Simulation Model Development

Stock and Flow Diagram (SFD) serves as the basis for simulation modeling. SFD depicts a more detailed system structure than CLD. In SFD, information and material flows are distinguished and the importance of consistency of units and dimensions throughout the diagram is emphasized [24]. Building SFD is based on the structure of CLD, but in the SFD new components and information flows can be added, without changing the big picture of the system in the CLD structure [23]. SFD can also display a timeline model, which refers to how the development of events in a system is depicted on a timeline and how the time model is used to simulate system dynamics. Simulation of the corn farming system was executed with a simulation time period of 15 years, ranging from 2006 to 2021. Historical data and information used are based on the condition of the corn farming system in East Java Province, Indonesia. The East Java Agriculture and Food Security Office and Central Bureau of Statistics (BPS) websites were used to get the statistics and information. Fig. 3 describes the SFD of the corn demand sub-model. In this sub-model, the population and corn consumption need variables influence corn demand. The population variable is a cumulative variable that describes the total population. The population increase and population decrease variables are called inflow and outflow variables which represent the increase and decrease in total population. Population increase is influenced by several variables, namely birth rate, immigration rate, corn fulfillment ratio, and total population. Meanwhile, population decrease is influenced by the death rate, emigration rate and total population variables.

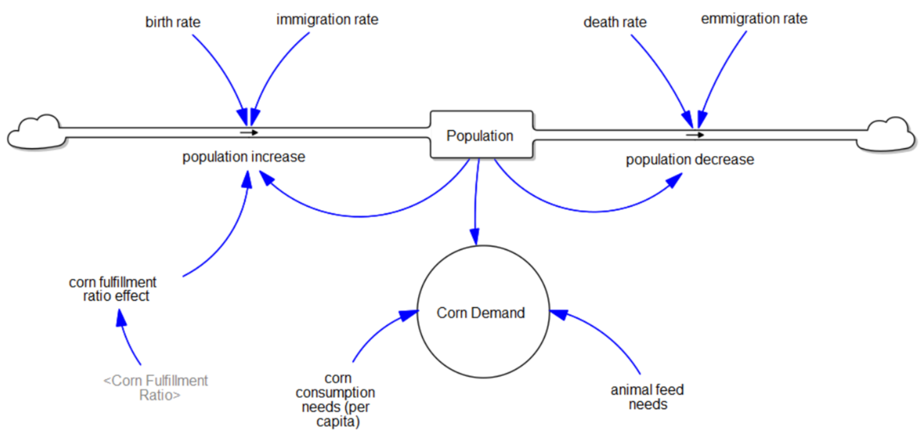

Fig. 3 Corn Demand Sub-model

Furthermore, in the SFD of the corn productivity sub-model, corn production is influenced by corn productivity and harvest area. The corn harvest area is the portion of a crop that has been lifted after it has matured. Meanwhile, corn productivity is a value that shows the average yield of corn production per unit area of corn plants in a certain period. Corn production is a result of the influence of agriculture input factors such seeds, fertilizers, the availability of irrigation, pesticides, and others. Fig. 4 shows the SFD for the corn productivity sub-model. The corn fulfillment ratio variable is obtained from the division between the amount of corn production and corn demand. This is the relationship between corn demand and corn productivity.

Switching to the farmer profit sub-model, the farmer's gross income is the result of multiplying productivity per hectare for corn by the price of corn in the market. The greater the yield of corn produced per hectare, the greater the farmer's gross income. Furthermore, based on gross income, farmers get a net profit based on the amount of cultivation costs incurred. Corn production costs are determined by fertilizer costs, labor costs, land rental costs, equipment rental costs, fuel costs, and seed costs [25]. Fig. 5 illustrates the SFD of the farmer profit sub-model.

E. Model Testing

After the simulation was carried out, verification and validation were also necessary to determine the model's viability. Model verification needs to be carried out to ensure whether the model structure is correct both in terms of dimensions and units. Verification in this study was carried out using features in the Vensim PLE x64 simulation software. A model structure that is correct will display the result "Model is OK.", while "Units are OK." indicates that the units used are appropriate. Once verified, the model structure proceeded to the model validation stage. The aim of model validation was to compare the model's simulated behavior to the real system's actual behavior. It is crucial to compare the output values generated by the simulation using the model with the output values obtained from the actual system in this stage. As in [26], if the error rate (E1) and error variance (E2) are less than 5% and 30%, respectively, the model is considered valid. Testing was applied to several variables with a significant effect on corn farming and based on the availability of data. Validation is performed using a formulation that considers error rate and error variance as in [26]. Equations (1) and (2) are the testing equations for error rate and error variance.

$$E1 = \left|\frac{S-A}{A}\right| x\ 100\% \qquad (1)$$

Where, S = the mean of the simulation data, A = the mean of the historical data.

$$E2 = \left|\frac{Ss-Sa}{Sa}\right| x\ 100\% \qquad (2)$$

Where, Ss = the results of the simulation's standard deviation, Sa = the results of the historical data's standard deviation.

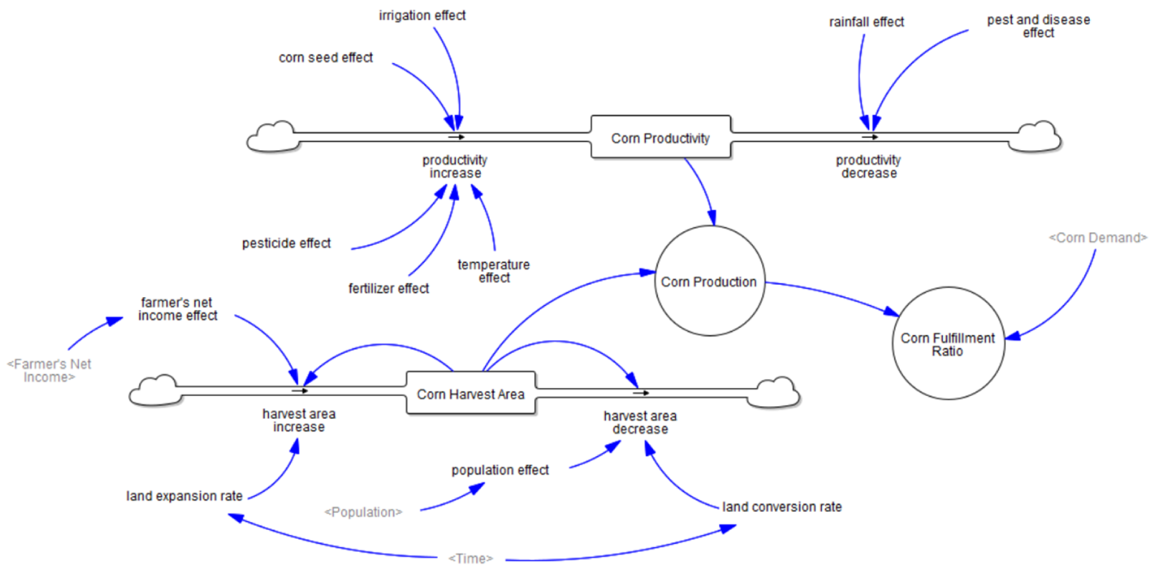

Fig. 4 Corn Productivity Sub-model

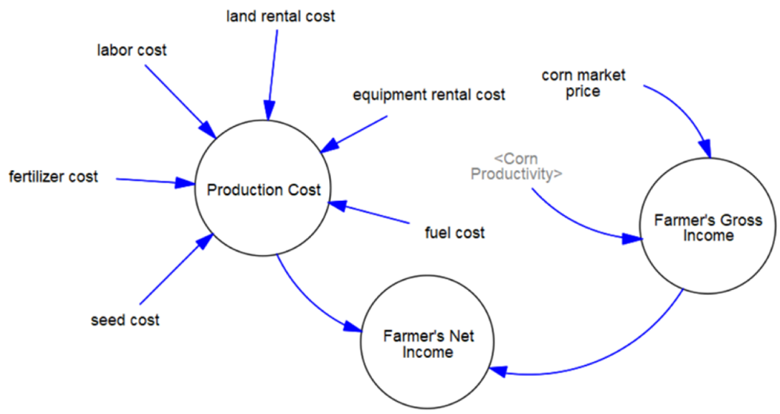

Fig. 5 Farmer Profit Sub-model

F. *Model Scenario Formulation*

Scenario formulation is a planning strategy effort that reflects the future behavior of the system [27]. The process of creating a scenario involves updating or adding feedback loops or model parameters, as well as introducing new parameters and feedback loops [28]. This stage can also be called the time forecast model which involves predicting or forecasting the future state or behavior of the system dynamics. The process of utilizing historical data or known parameters to project how a system will develop over time. To achieve the objective of increasing corn productivity, two scenarios were formulated, namely: (1) a drip irrigation system implementation scenario; and (2) a farmer field school program scenario.

III. RESULTS

A. Baseline Model

In this part, the simulation results of the basic SFD model of corn farming are presented. During the period from 2006 to 2021, corn productivity experienced a good upward trend. On aggregate, corn productivity increased by an average of 3.06% per year. Based on the simulation results, the highest peak of productivity occurred in 2021 with a productivity rate of 5.70 tons/hectare. Fig. 6 shows the simulation results of corn productivity in East Java. Increased corn productivity is influenced by various variables such as the availability of irrigation systems, corn seeds, temperature, fertilization, and pesticides. Meanwhile, the effects of rainfall, and the influence of corn pests and diseases affect the accumulation of corn productivity.

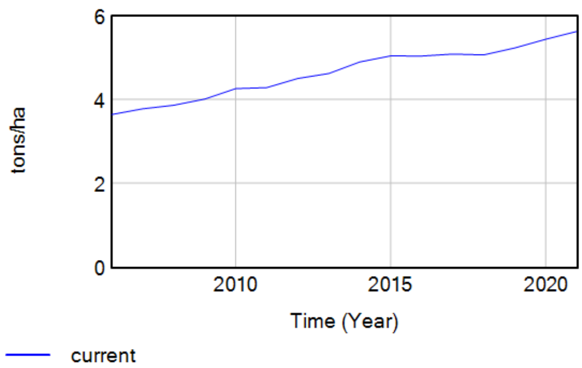

Fig. 6 Simulation Results of Corn Productivity Base Model

B. Model Testing Results

Model verification, also known as model structure testing, is the initial test performed on the model. Fig. 7 depicts the results of the model verification. In this verification, the Vensim software displayed the results “Model is OK.” and “Units are OK.” indicating that the model structure was appropriate. After the model structure was verified, it was then validated. Model validation was executed during the simulation period from 2006 to 2021. As mentioned in the Methods section, historical data was acquired from the online websites of the Central Bureau of Statistics (BPS) and the East Java Agriculture Office. The population, corn harvest area, corn productivity, and corn production were the variables in this study that have been validated. Table 3 shows the results of model testing by considering the evaluation of error variance and error rate. The validation results shows that the Population variable had an E1 value of 0.21 and an E2 value of 4.41. Then the Corn Harvest Area variable had an E1 value of 3.61 and an E2 value of 29.14. Corn Productivity variable had an E1 value of 2.89 and an E2 value of 1.27. Finally, the Corn Production variable had an E1 value and an E2 value of 0.04 and of 8.09 respectively. These results show that the error rate (E1) and error variance (E2) values for the validated variables are below 5% and 30%. This proves that the model developed can be said to be valid and has represented the real system.

C. Scenario Formulation Results

In this research, scenario simulations were run until 2035 to study the future behavior of the system. As previously planned, the scenarios were formulated to increase corn productivity include the implementation of a drip irrigation system and a farmer field school program.

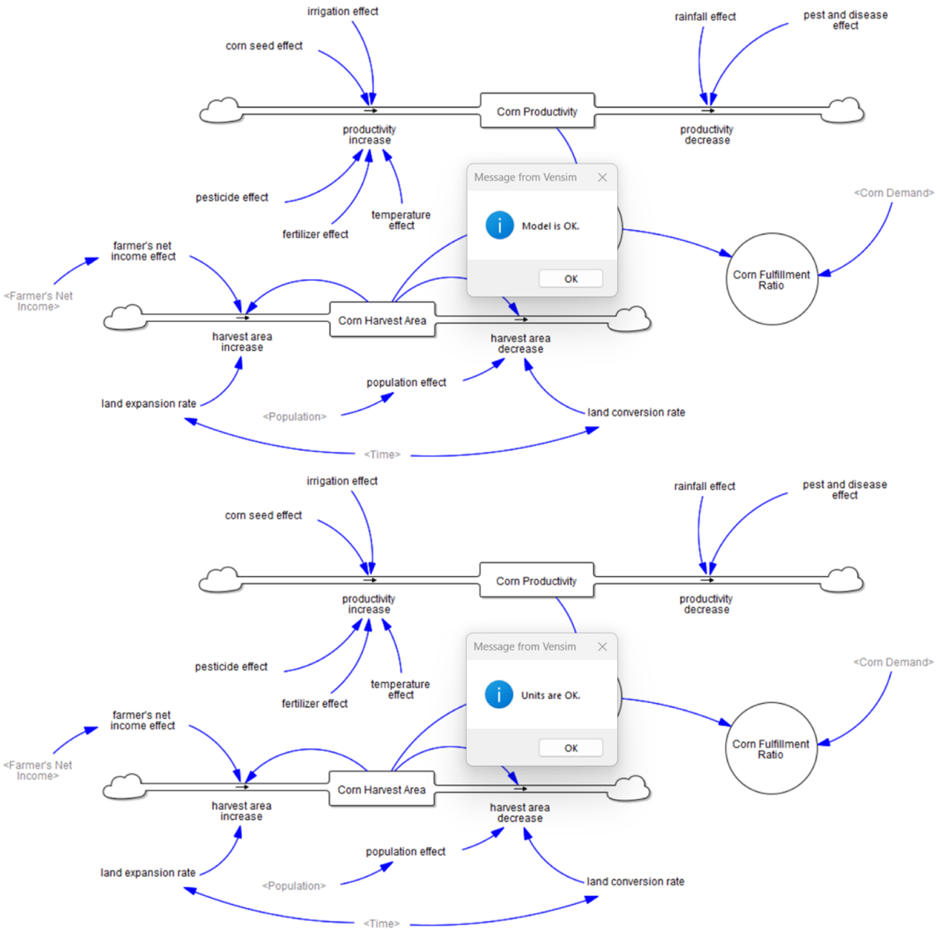

Fig. 7 Model Verification Results

1) Drip Irrigation System Scenario

In 2019, 34006 hectares of agricultural land experienced drought in East Java, Indonesia - the largest compared to other provinces such as Central Java (32809 hectares) and West Java (25416 hectares). This was due to the fact that there was an extreme drought until the middle of the year [14]. This is also what disrupts the supply of corn production. The use of a drip irrigation system is a very suitable solution for such conditions. Drip irrigation technology can help corn farmers conserve water and improve utilizing water efficiently. Fig. 8 illustrates the drip irrigation scenario.

This scenario changes the irrigation effect variable in the corn productivity sub-model to a drip irrigation effect. This will minimize water waste by distributing the water equally and straight to the root zone of the plant. When plants receive the right amount of water based on their demands, their growth and productivity are enhanced [29]. The goal of drip irrigation, which applies water in small amounts and continuously, is to keep soil moisture levels high enough to meet plant water requirements. The results of the drip irrigation system implementation scenario can be seen in Fig. 9.

Based on the simulation results of the drip irrigation scenario, corn productivity, which initially had an average productivity of 5.51 tons/hectare per year until 2035, increased to 6.07 tons/hectare per year until 2035. The increase demonstrates that a 10.09% annual improvement in corn yield is projected under the drip irrigation scenario. Meanwhile, the average corn production also increases to 7902769 tons per year. Meanwhile, in the no scenario condition, the average corn production is 6987397 tons per year. This suggests an average 13.10% increase in corn production under a drip irrigation system scenario.

TABLE 3
MODEL TESTING RESULTS

	Population		Corn Harvest Area		Corn Productivity		Corn Production	
Year	Historical Population Data	Simulated Population Data	Historical Harvest Area Data	Simulated Harvest Area Data	Historical Productivity Data	Simulated Productivity Data	Historical Production Data	Simulated Production Data
2006	36408960	36409000	1099184	1099180	3.64	3.64	4011182	4001020
2007	36693404	36703100	1153496	1175570	3.68	3.74	4252182	4397680
2008	36981001	36923100	1235933	1249920	4.08	3.79	5053107	4742030
2009	37271775	37229700	1295070	1324480	4.06	4.07	5266720	5397920
2010	37565706	37597000	1257721	1394300	4.44	4.32	5587318	6027590
2011	37840657	37957800	1204063	1343550	4.52	4.46	5443705	6001600
2012	38106590	38163200	1232523	1300080	5.10	4.50	6295301	5853400
2013	38363195	38354900	1199544	1286150	4.80	4.64	5760959	5970130
2014	38610202	38571700	1202300	1295700	4.77	4.64	5737382	6012370
2015	38847561	38885800	1213654	1291640	5.05	4.65	6131163	6010350
2016	39075152	39246900	1238616	1288200	5.07	4.87	6278264	6273660
2017	39292971	39551400	1257111	1273640	5.04	4.91	6335252	6259860
2018	39500851	39897600	1261453	1258670	5.35	5.12	6753563	6444690
2019	39698631	40131700	1301904	1243720	5.57	5.37	7251484	6680250
2020	40665696	40554800	1258567	1239360	5.52	5.57	6946552	6911040
2021	40878789	40887200	1274526	1243900	5.50	5.70	7014870	7096330
E1 (%)	**0.21**		**3.61**		**2.89**		**0.04**	
E2 (%)	**4.41**		**29.14**		**1.27**		**8.09**	

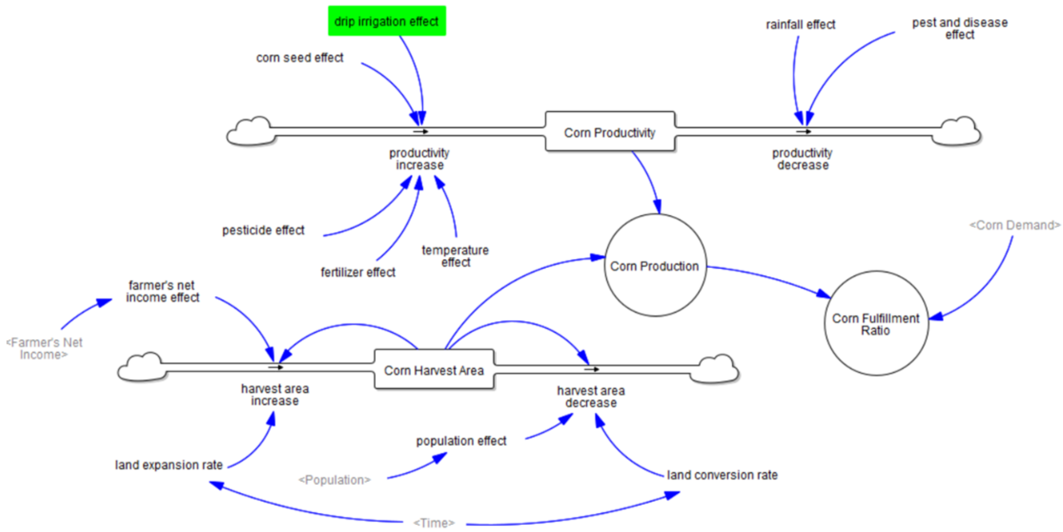

Fig. 8 Scenario Model of Drip Irrigation Use

2) Farmer Field School Program Scenario - Integrated Crop Management

This scenario refers to the strategy implemented in Indonesia to meet corn demand. Through this initiative, farmers can observe and learn firsthand how new technologies are applied both in terms of technology management and input use [16], [30]. Over the past ten years, Farmer Field Schools (FFS) have been employed as an intensive training method to promote awareness and the usage of ecologically friendly farming practices in many developing nations [31]. Fig. 10 below is a scenario model from the Farmer Field School (FFS) program. In this scenario, we add a new variable, namely the farmer field school effect. By implementing the FFS program, farmers will have sufficient knowledge regarding how to use agricultural inputs efficiently and effectively, which will influence the use of fertilizers and pesticides. Through this initiative, farmers receive training in the efficient management of corn farms and the correct use of inputs. Fig. 11 is the result of the FFS program scenario.

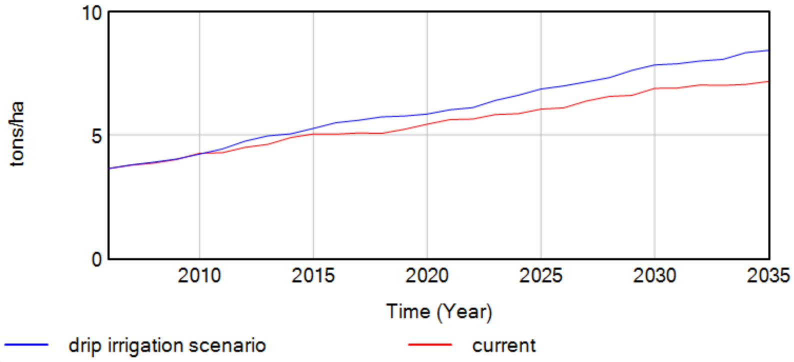

Fig. 9 Scenario Result of Drip Irrigation System Implementation

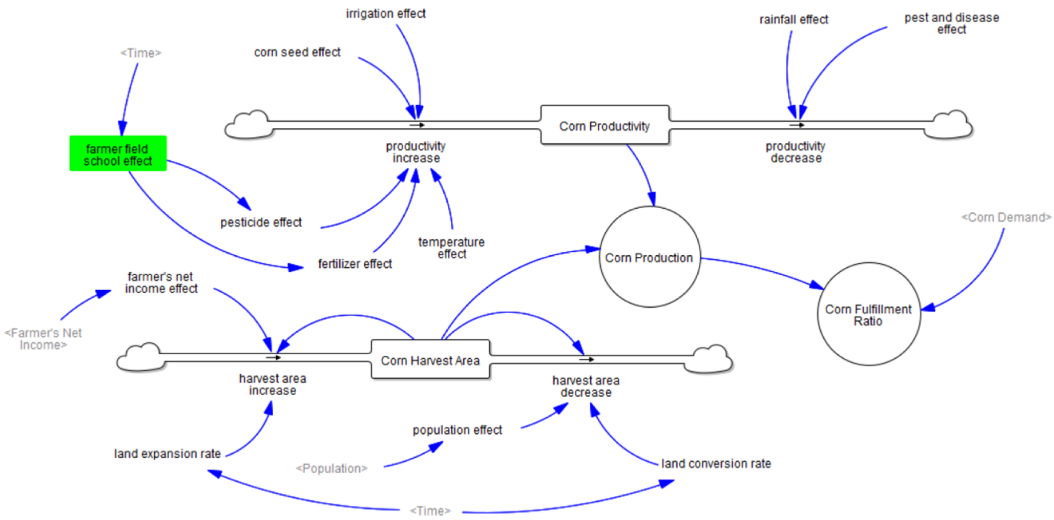

Fig. 10 Scenario Model of Farmer Field School Program

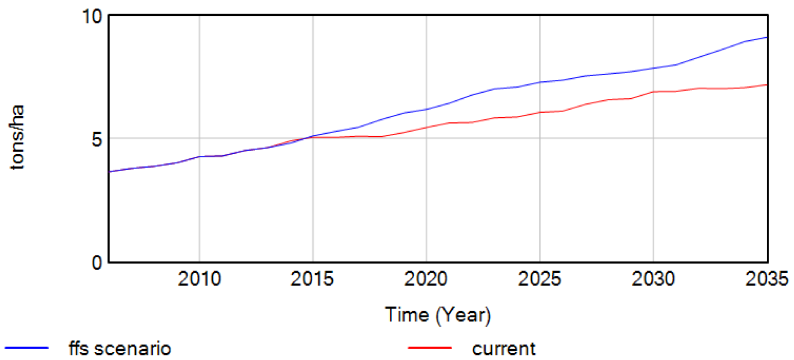

Fig. 11 Scenario Result of Farmer Field School Program (FFS)

The average corn productivity after the second scenario, namely the farmer field school, is projected to be 6.23 tons/ha, whereas before the farmer field school the average corn productivity is 5.51 tons/ha. This means that by conducting farmer field schools, corn productivity can increase by 13% on average - not much different from the level of corn production, after the field school farmers were able to increase slowly. Before the farmer field school, the average corn production was 6987397 tons. After the farmer field school, the average corn production increased slowly in 2013 to 8085923 tons. This indicates that a 16% average increase in corn production can be achieved by holding farmer field schools.

IV. DISCUSSION

A technique called System Dynamics (SD), which is ideal for dealing with complicated dynamical systems and nonlinear interactions, was used in the simulation of this study. Farming system is a complex system that has a structure with predominant feedback complexity. The two presented scenarios in this study focus on increasing productivity in corn farming. While the drip irrigation scenario focuses directly on productivity, the farmer field school scenario focuses more on improving farmers' understanding of better corn crop management to manage crop productivity.

Drip irrigation scenario refers to the technique of applying water to plants formed from pipe lines that are usually small in diameter. It sends the filtered water directly to the ground near the plants. An "emitter" transmitter, which is the name of the water-transmitting mechanism on the pipe, releases many liters of water every hour [32]. By leveraging this technology, farmers can maintain corn productivity [33], [34].

Meanwhile, farmer field schools, integrating crop management, allows farmers to better customize inputs both in terms of dosage and timing of application. Productivity gains are largely determined by differences in input use. To ensure that farmers may buy agricultural inputs at a lower cost and can use the inputs as advised, the government must establish a competitive input market. At the farm level, inadequate funding and low farmer education are key issues. Therefore, both central and local governments should frequently provide technical help to farmers to encourage them to grow their agricultural output. Such support could take the shape of increased access to tenable credit programs, successful marketing techniques, instruction, extension, and a deeper comprehension of farmers [16].

According to our findings, maintaining stable corn production involves maintaining corn productivity per hectare, which is often influenced by many variables. Not only does a growing population raise the demand for corn, but it also results in a reduction in harvested area since more people need more land to live on. Apart from that, the use of plant inputs such as fertilizers and pesticides are also no less important. Fertilizers and pesticides that are used excessively or do not match the required portions can cause water and soil pollution, which can disrupt corn productivity. Therefore, several relevant stakeholders can consider the scenario that has been implemented, namely by conducting training and counselling on the importance of the farmer field school program. This program is necessary, because through the program, farmers are provided with technical knowledge related to crop management such as the use of fertilizers and pesticides according to the required portions. Furthermore, it is crucial to adopt agricultural technology, such as drip irrigation systems, so plants receive water and nutrients optimally, even during the dry season.

V. CONCLUSIONS

In this article, corn farming systems were analysed with the aim of increasing corn productivity. Corn productivity is a complex system where various variables are interrelated within it. The amount of water available for irrigation, as well as the amount of fertilizer, pesticide, and seed used, can all affect corn output. To achieve this goal, an SD model of corn farming system was established. Furthermore, SD models were used to project future corn farming systems. Data and information from the Indonesian Central Bureau of Statistics (BPS) website and the East Java Provincial Agriculture and Food Security Office were used as the basis for analysis and input for model validation. SD model development was carried out starting from conceptual model development (CLD), simulation model (SFD), to scenario formulation.

It was known that the variables that influence corn production include the harvest area and the level of corn productivity. Different inputs including seeds, fertilizer, pesticides, the availability of irrigation, and weather conditions like rainfall have an impact on corn productivity. Furthermore, scenarios were formulated for the objective of increasing corn productivity. The first scenario was the application of drip irrigation to increase and maintain land productivity even during the dry season. The average corn productivity and production might increase by 10.09% and 13.10% annually under the drip irrigation scenario. The second scenario was the implementation of farmer field schools - integrated crop management. This scenario has a higher yield increase because it emphasizes increasing farmers' knowledge in corn crop management. With the farmer field school scenario, the average corn productivity can increase by 13% and the average corn production by 16% per year. Future research could expand the analysis by considering the factor of corn products for food diversification strategies, animal feed needs, and bioethanol.

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