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Simulation Model and Scenario to Increase Corn Farmers' Profitability Erma Suryani1*, Rully Agus Hendrawan1, Lukman Junaedi2, Lily Puspa Dewi3 1 Department

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@gmail.com Abstract.

Corn demand in Indonesia is quite high, this commodity is useful as food, animal feed ingredients, and as industrial raw materials. The main problem in corn farming is not enough production to meet the demand as staple foods and industry. It is necessary to increase the amount of corn production to meet de- mand as well as to increase farmers' income and profits. Therefore, in this re- search we propose to develop a simulation model and scenario to increase farm- ers' income through land productivity improvement. As a method use for

model development, we utilize **system dynamics** framework **based on consideration** 2
that system dynamics

is a scientific framework for addressing complex and nonlinear feedback systems. System dynamics can use both qualitative and quantitative techniques such as computer simulations. It also facilitates the adoption of non- linear mental models so that they can search and describe the feedback process of problem dynamics. In

particular, system dynamics has proven useful in over- coming agricultural problems. Simulation results show that increasing farmers' income can be done through increasing land productivity. With the increase in land productivity, corn production will increase, so that the income of corn farm- ers will also increase. Increased productivity can be done by carrying out struc- tural and non-structural approaches. Structural approach can be carried out through rehabilitation of watersheds and irrigation networks. Meanwhile non- structural approach can be carried out through the application of new technolo- gies, strict land conversion rules, dynamic planting calendars, dissemination of climate information, and the development of climate field schools. Keywords: Simulation, Model, System Dynamics, Corn, Farmers' Profitability 1 Introduction For

Indonesia, corn is the second food crop **after rice.** 12

Even in some places, corn adfa, p. 415, 2019. © Springer Nature Singapore Pte Ltd. 2019 is the main staple food as a substitute for rice or as a mixture of rice. Corn demand in Indonesia is currently quite large reaching more than 10 million tons of dry shelled per year (Khalik, 2010). One of the development of the agricul- tural sector besides rice is corn. This commodity is an important food ingredient because it is the second source of carbohydrates after rice. Besides that, corn is also used as animal feed ingredients and industrial raw materials (Purwono and Hartono, 2005). From the market side, the marketing potential of corn continues to experience enhancement. This can be seen from increasingly the development of the live- stock industry that will eventually increase the corn demand as a mixture of animal feed. Currently, the problem of corn farmers is the amount of imported corn which has caused a fall in the price of local corn so that it can cause losses on farmers. The price of imported corn is often cheaper than local corn. The imported corn price is often cheaper than local corn. This is because the demand for animal feed entrepreneurs who lack local corn supply, so the government must import corn. Corn imports should not be done when farmers are harvesting, and must also be stopped during post-harvest especially in July-September and January- March. 2 Literature Review In this section, a literature review will be discussed about the structure of farm costs, prices, and farm income. 2.1 Farming Cost Structure Farming is the science that studies how to cultivate and coordinate production factors in the form of land and natural surroundings capital so as to provide benefits as well as possible (Suratiyah, 2006). Farming cost structure is influ- enced by two factors: fix cost and variable cost. Farming costs can be calculated using the formula as seen in Eq (1) (Rahmi et al., 2012).

TC=VC+FC (1) **where: TC = Total Cost ; VC = Variable Cost; FC = Fixed Cost** 4

2.2 Price Price is generally applied by buyers and sellers who mutually negotiate. The seller asks for

a price higher than the **production costs**	4

that must be paid. So that through this bargaining will reach the price that will be received. Prices act as a major determinant of buyer choice, especially in developing countries (Syukur, 2007). Although non-price factors have become increasingly important in buyer behavior over the past few decades, prices are still one of the most important elements that determine market share and probability of a company. 2.3 Farming Income Farming income

is the difference **between total revenue and total cost.**	3

Farm- ing income can be calculated using the formula as seen in Eq (2) (Rahmi et al., 2012).

I=TR-TC (2) where: **I = Income ; TR =Total Revenue; TC =Total Cost**	3

Farmers as producers of agricultural products, not only aim to achieve high production results but also aim to obtain high income as well (Gratitude, 2007). 3 Model Development This section demonstrates the model development which consists

causal loop diagram development, stock and flow diagram, model	6

formulation, as well as model validation.

3.1 Causal Loop Diagram Development. **The**	6

price of corn is influenced by the total cost of corn production, which con- sists of fixed costs and variable costs. Fixed costs are the cost of using tools used for corn farming such as land rent, and fuel costs. While variable costs are costs incurred for the purchase of seeds, fertilizers, pesticides and labor wages for land

processing, planting and refining, maintenance, fertilization, control of pest (Plant Disturbing Organisms), harvesting, threshing, transportation, as well as other agricultural services [Central Statistics Agency, 2015]. Most of the costs of corn farming are spent on labor costs (39.51%), then fertilizer (26.01%), fixed costs (24.81%) and finally the cost of seeds (9.67%) [Nizar, Siswati, Putri, 2016]. Factors

that significantly influence the total cost of corn production is the 10

rate of inflation. Based on the above researches, we develop a causal loop diagram of farmers' profit as seen in Fig. 1.

As we can see from Fig. 1, farmers' profit depends on land productivity, total 2 cost of

corn farming production, and producer price. tools and farming services equipments rent other cost land rent irigation cost costs of harvesting, threshing and freight plant disturbing Cropping Intensity Productivity + corn seed costs + + organisms control + -+ fertilizer costs ++ Total Cost of Corn ++ + + Pr+od+uction Per Ha Total Cost of + pesticides cost + + + Production + + fertilization - cost of land process costs + Total Cost of Corn + processing Production Per Ha Per Year -Farmers' Profit - cost of planting and maintenance cost + Inflation + embroidery + I+mpact of inflation P+roducer Price consumer price index (CPI) Fig. 1. Causal Loop Diagram of Corn Farmers' Profitability 3.2

Stock Flow Diagram and Model Formulation From the causal loop diagram 11

(CLD) that has been developed at the beginning of the model development, this CLD is converted into a stock flow diagram (SFD). SFD is a technique that represents a precise quantitative specification of all systems components and their interrelation (Transentis Consulting, 2018). Stock flow diagram of corn farmer profitability can be seen in Fig. 2. As we can see from Fig. 2, farmers' profitability is influenced by land productivity, total cost of corn farming production, and producer price. Cropping intensity and productivity will influence the corn production per year. The cost of corn seeds is one of the factors that influence the production costs of farming. The use of corn seeds on 1 hectare of land, is about 20-25 kg. It depends on the type of seed used (Sidabutar, Yusmini, Yusri, 2014). The average corn seed in 1 kg contains 2,200 seeds, and the other seeds contain 3,000

seeds (Asrofi, 2018). The average seed price that apply in the area is about Rp28,000/kg, so that the average cost of purchasing corn seeds is about Rp700,000/ha / (Central Statistics Agency, 2015). In corn farming, it is necessary to cultivate corn cultivation such as weeding and refining. The process of fertilizing corn plants using NPK fertilizer with a uniform composition. Fertilization process then requires third fertiliza- tion after corn is 30-40 days after planting with the composition of Urea 200Kg/Ha [bijibersemi, 2018]. Costs incurred for the purchase of fertilizer both Urea fertilizer and NPK fertilizer for corn production per hectare amounted to Rp1,213,500/ha/planting season. The cost of corn fertilization has grown around 3.4% per year as a result of inflation. rate of inflation consumer price index (CPI) inflation impact of inflation <Productivity in unit conversion 2 <Time> corn seed Tuban> rate in corn seed costs Productivity in Tuban costs farmer profit per <Cropping Kg/Ha per year year intensity> farmer fertilizer profit per rate in fertilizer costs total cost of mounth costs total cost of corn production per Kg profit per Kg production per year <total cost of corn growth producer pesticides production per Ha> rate in growth price rate in pesticides cost rate in reduction <impact of cost <irigation cost> inflation> <impact of unit conversion reduction total cost inflation> <per year> other cost cost of land of corn <other cost> <impact of rate in other cost rate in land processing production inflation> processing per Ha <tools and equipments rent> irigation cost rate in irigation tools and cost of planting <land rent> cost rate in tools and equirpemntents rate in cost of planting and embroidery equipments rent and embroidery land rent distributor profit farming rate in farm services rate in land rent <impact of margin ratio maintenance worker services <impact of inflation> collectors price rate in cost fees inflation> maintenance cost Average of profit and distributor price Transport Margin <impact of fertilization costs of harvesting, transport margin inflation> rate in fertilization process costs rate incosts of threshing and freight <producer price> ratio process costs harvesting, threshing and retailers profit margin ratio plant disturbing freight rate in control comllaercgtoinrrpartioofit collectors transport wholesaler price organisms control margin ratio retailers price <Time> wholesaler profit <impact of margin ratio <transport margin inflation> ratio> Fig. 2. Stock Flow Diagram of Corn Farmers' Profitability Pesticides used by corn farmers to prevent severe diseases and pests vary in type. To prevent disease attacks, fungicides / fungi chemical compounds such as manzate, DIthane, Antracol, Cobox, and Vitigran Blue are used. For pest control, insecticides / insecticides, which are sprayed liquid such as Diazinon 60 EC, Baycard 500 EC, Hopcin 50 EC, Clitop 50 EC, Mipcin 50 WP, Azodrin 15 WSC, are used. While insecticides in the form of granules include 3G and Dharmafur and Curater [Ihsan, 2018]. The costs incurred by corn farmers to purchase pesticides in 2017 averaged Rp110,300/ha/planting season with a growth rate. 3.2% per year as a result of inflation. Costs for payment of labor wages include costs for land processing activities, planting and refining, maintenance, fertilization, control of plant disturbing or- ganisms, harvesting, threshing, and transportation, as well as other agricultural services in the amount of Rp3,800,000 in 2014 /ha/planting season. With the growth rate of pesticide purchase costs due to inflation of 3.0% per year, the cost of purchasing pesticides in 2017 is Rp4.150.200/ha planting season. Other major expenses incurred arise from fixed costs such as irrigation costs, agricul- tural service costs, land rental costs, rental costs of business equipment or

other facilities, and other costs which are accumulated on average Rp3,600,000/ha/planting season in 2014. In 2017 the fixed cost reached around Rp3,971,300/ha/planting season as a result of inflation. The total cost of corn production in 2014 is estimated to be an average of Rp9.300.000/ha/planting season and in 2017 the fixed costs incurred by corn farmers were Rp10,217,500/ha/planting season because of inflation. Model formulation of several variables that have significant impact on farmers' profitability can be seen in Eq. (3) - (9). Productivity = Initial Productivity + ∫(Increase Productivity − Decrease Productivity) (3) Total cost of corn production per Ha = corn seed costs + farming services + fertilizer costs + irrigation cost + land rent +other cost+ pesticides cost +tools and equipment rent +worker fees (4) Worker fees = cost of land processing +cost of planting and embroidery +costs of harvesting, threshing and freight +fertilization process costs + maintenance cost +plant disturbing organisms control (5) Costs of harvest, threshing and freight = Initial Cost + ∫ rate incosts of harves, threshing, & freight (6) Rate in costs of harvesting, threshing and freight = costs of harvesting, threshing and freight *impact of inflation (7) Impact of inflation = IF THEN ELSE (consumer price index (CPI), inflation , 0) (8) Consumer price index (CPI) = Initial CPI + ∫(rate of inflation) (9) Simulation result of corn farmers' profitability can be seen in Fig. 3. As we can see from Fig. 3 farmers' profitability is influenced by productivity and profit/kg. Farmers' profitability in 2017 was around Rp26.37 Million as the impact of productivity which was around 10,143 kg/ha and profit/kg that was around Rp2600/kg. Fig. 3. Farmers' Profitability 4 Model Validation

Model validation constitutes a very important step in system dynamics frame- work. 8
According **to**

Barlas (1996),

a model will be valid if the error rate is ≤ **5% and** the **error variance** is ≤ **30%.** 5
We

validate the model by checking

the error rate and error variance. The formulations **of** error rate **and** 2

error variance are demonstrated in Eq. 10-11. Error Rate = ⌈S−$\bar{A}$⌉$\bar{A}$(10) Error Variance = ⌈Ss−Sa⌉ (11) Sa Where:
$S=\bar{}$

the average rate of simulation $\bar{A}=$ the average rate of data 1

A= Data at time t S = Simulation Result at time t $Ss=$

the standard deviation of simulation $Sa=$ the standard deviation of data 1

Error rate and error variance of 2

some variables that have significant impact to the corn farmers' profit

can be seen in Table 1: Table 1 13

Error Rate and Error Varia nce Variable Error Rate Error Variance Consumer Price 0.000025 0.0029 Total Production Cost 0.0467 0.0725 Producer Price 0.000052 0.00016

Based on the above calculation, all the error rates are less than 5% and error of variances are less than 30% which means that our model is valid. 5 Scenario Development Scenario is a method to 1

predict some possible future outcomes by changing the model structure and parameters. Scenario development consist of three dimen- sions, those are information acquisition, knowledge dissemination, and strate- gic choices (Bouhalleb and Smida , 2018). Several potential alternative scenar- ios

can be obtained from a valid model by changing the model structure or by changing the 7

model parameters (Suryani, 2012). In this research, we develop scenario to increase farmers' profitability through increasing land productivity. Increased productivity can be done by carrying out structural and non-structural approaches as shown in Fig. 4. Fig. 4. Scenario Result of Corn Farmers' Profitability As we can see from Fig. 4, corn farmers' profitability is projected could be increased to be around Rp. 38.67 Million in 2019 and would become Rp131.4 Million in 2030 as the impact of productivity improvement that would be around 13,100 kg/ha in 2019 and would be around 15, 133 kg/ha in 2030. 6 Conclusion and Further Research This paper discusses the corn farmers' profitability as the impact of productiv- ity, total farming production cost, and corn price. Several main factors impact- ing the total cost of corn production, those are fixed costs and variable costs. Fixed costs consist of the fee of using tools used for corn farming such as land rent, and fuel costs. While variable costs are costs incurred for the purchase of seeds, fertilizers, pesticides and labor wages for land processing, planting and refining, maintenance, fertilization, control of pest (Plant Disturbing Organ- isms), harvesting, threshing, transportation, as well as other agricultural ser- vices. Most of the costs of corn farming are spent on labor cost, fertilizer cost, fixed costs, seed cost, and inflation. Simulation result shows that farmers' profitability is influenced by productivity and profit/kg. Farmers' profitability in 2017 was around Rp26.37 Million as the impact of productivity which was around 10,143 kg/ha and profit/kg that was around Rp2600/kg. To increase farmers' profitability, we can conduct land productivity improvement. Land productivity improvement can be conducted by carrying out structural and non-structural approaches. The structural ap- proach can be done through rehabilitation of watersheds and irrigation net- works. Meanwhile the non-structural approach can be conducted through the application of new technologies, strict land conversion rules, dynamic planting calendars, dissemination of climate information, and the development of cli- mate field schools. Further research is required to explore other strategies to improve the corn supply chain profitability. Aknowledgments. This research is supported by Directorate of Research and Community Service – RistekDikti, ITS (Institut Teknologi Sepuluh Nopember) Research Center, Enterprise Systems Laboratory in Information Systems Department, Depart- ment of Agriculture in East Java, as well as Faculty of Information and Com- munication Technology of ITS. References 1. Asrofi. (2018, September 18). Corn Seeds Demand Per Ha (Kebutuhan Benih Jagung Per Hektar). Retrieved from KampusTani.Com: https://www.kampustani.com/kebutuhan- benih-jagung-per-hektar/ 2. Badan Pusat Statistik . (2015, September 25). Production Value and Production Costs per Planting Season per Hectare Cultivation of Paddy Rice Fields, Field Rice, Corn, and Soybeans (Nilai Produksi dan Biaya Produksi per Musim Tanam per Hektar Budidaya Tanaman Padi Sawah, Padi Ladang, Jagung, dan Kedelai, 2014). Retrieved from Tanaman Pangan: https://www.bps.go.id/statictable/2015/09/25/1855/nilai-produksi-dan- biaya-produksi-per-musim-tanam-per-hektar-budidaya-tanaman-padi-sawah-padi-ladang- jagung-dan-kedelai-2014.html 3. Bouhalleb A and Smida A 2018 Scenario planning: An investigation of the construct and its measurement J. of Forecasting (37) 419-517 4. Bijibersemi. (2018). Abundant Corn Harvest, This Is What Farmers Must Do (Panen Jagung Melimpah, Ini Yang Harus Dilakukan Petani). Retrieved from Pioneer: https://www.pioneer.com/web/site/indonesia/Panen-Jagung-Melimpah-Ini-Yang-Harus- Dilakukan-Petani 5.

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