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Systems dynamic modeling on sustainable apples agriculture

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Abstract. *History shows the long process of apple plants originating from subtropical regions adapting to Indonesia's tropical climate until its popularity is increasingly marginalized and replaced with other commodities, especially in Batu City, Indonesia. To understand problems and find solutions, we can use Systems dynamics. This study aims to obtain a policy scenario that encourages sustainable apple farming. Data is collected from the local government and BPS City or Province so that the selected variables follow the specific location. The system approach is used to identify needs, problem formulation, preparation of input-output diagrams, cause-effect diagrams, and stock-flow diagrams. A series of scenarios are created and tested through simulation to understand the system's dynamic behavior better and obtain the desired output. The best scenario was chosen, namely by replanting 15% of old plants each year, using integrated agriculture with 13 sheep brooders, reducing land change by farmers keep the land if the annual income Rp 200 million and construction of special settlement starting in 2029, LED by integrating tourist ticket and hotels with 1 kg apple fruits also increasing health support for students.*

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INTRODUCTION

Agriculture plays a significant role in the economy and is the livelihood of 32 million Indonesians. The contribution shows the high role of the agricultural sector to the Gross Domestic Product (GDP) in 2016 of 8.39% (BPS, 2017). In addition, environmental changes due to agriculture can affect the sustainability of other dimensions, such as social and economic. Thoughts on the dimensions of development also continue to develop. Still, the most prominent ideas carry three dimensions: economic, environmental, and social (Bosc *et al.*, 2015).

Sustainable development has a multidisciplinary and multi-interpretation concept (Fauzi, 2019) and cannot be separated from agriculture (Pigford *et al*., 2018). The challenge of modelling is to bring together parts such as social and economic without losing their essence. Systems dynamics (SD) is an exciting approach (Hammond and Dube, 2012) and has been used to analyze questions related to food and agriculture (Nicholson and Stephenson, 2014). These studies implicitly apply quantitative assumptions and mathematical relationships to modeling food systems and agricultural processes. System dynamic simulation solves complex problems due to various variables' causal tendencies (Forrester, 1971).

Apples have been identified as an icon of Batu City. Still, various obstacles to cultivation and marketing have become a challenge for farmers to make the current apple crop less profitable economically because the land rent is relatively low compared with other commodities (Samudra *et al*., 2021). On the other hand, the shift of Batu City to becoming a tourist city has pushed the land-use conversion higher. The decreasing area of apple plants evidences this. If in 2003, the apple land in the Batu city area reached 2 179.72 ha, in 2020, it became 1 675.05 ha (Batu, 2020). From various studies, this research tries to combine all components of cultivation, income, and the growth of micro, small, and medium enterprises (MSMEs) for processed apple products using dynamic system modeling to produce a policy scenario that supports the sustainability of apple farming.

METHOD AND MODEL DESCRIPTION

System Dynamics Method

We used the system dynamics method to build this model following the objectives. System dynamics is an effective method for analyzing systems by simulation. Help reveal dynamic changes, feedback, delays, and other system processes characterized by quantification and control. Therefore, it has distinct advantages in analyzing, improving, and managing systems characterized by long development cycles and complex feedback effects (Eriyatno, 2012).

Logical Framework of Modeling

Apple farming in Batu City consists of three subsystems: biophysical, social, and economical. The biophysical subsystem is the most important because it already becomes residents' livelihood. Optimizing productivity will return the community's economy to farmers who are directly involved in the cultivation process and trade, product processing, and even tourism, positively impacting the social and economic subsystems. While the negative impact of the city's growth and population cannot be controlled, it will increase the need for housing and buildings, reducing the area of agricultural land, including apple land.

Data sources

The data used in this model mainly come from the first-hand information from field investigation, the results of the face-to-face interviews with stakeholders in local areas, and "2015–2020 Statistical Yearbook in Batu District City".

The Model Process

Causal Loop Diagram

A causal loop diagram (CLD) is drawn based on the logical framework, interconnected between the biophysical, social, and economic dimensions. The arrows show the positive (or self-reinforcing) (+) and negative (or self-correcting) (-) loops (Figure 1).

Stock-flow Diagram

The Stock-flow diagram is the core of the model used quantitation data of the causal loop diagram. Based on the actual data about apple farming from 2016 to 2020 and the differential equations built by the stock-flow diagram, the entire system in the sub-model is evaluated and simulated qualitatively and dynamically using Powersim Studio 10.

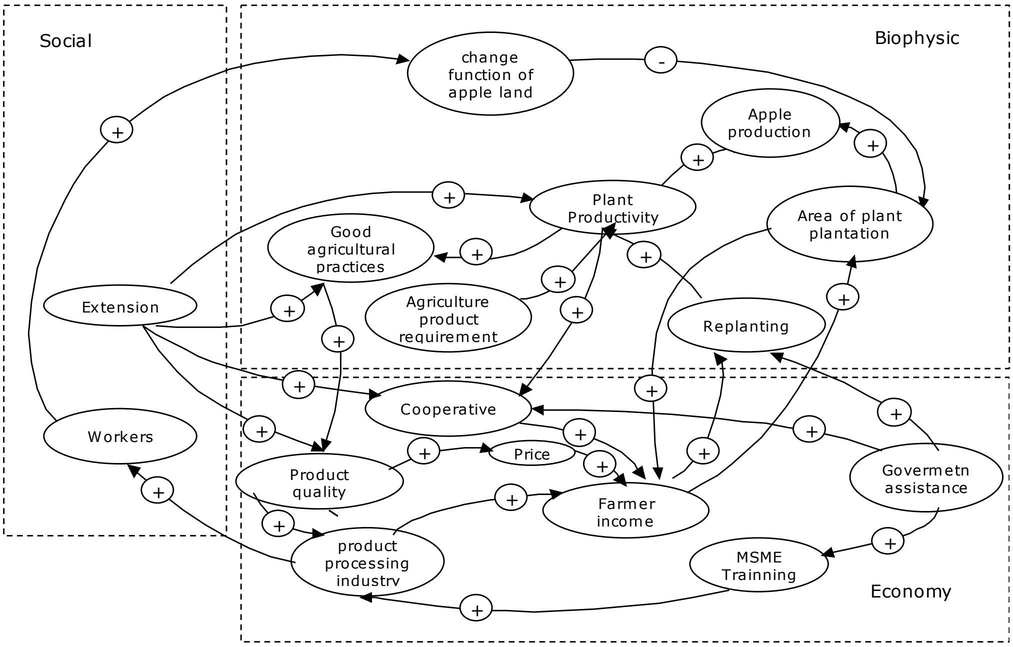

Figure 1 Causal loop diagram

Bio-physic sub-model

When viewed from the structure of the biophysical sub-model, the most decisive variable besides the area of apple land, which tends to change land use, is the apple plant's age because older plants the plant productivity will decrease. The age of apple plants is classified into three: young plants (0-4) years; productive plants aged 4-30 years; and old plants >30 years. Decreasing the productivity of old plants is encouraged to do plant replanting so that the quality and productivity of plants are maintained. Other variables such as fertilizers, pesticides, and herbicides will facilitate optimal maintenance. In detail, the relationship between social variables is shown in the SFD in Figure 2.

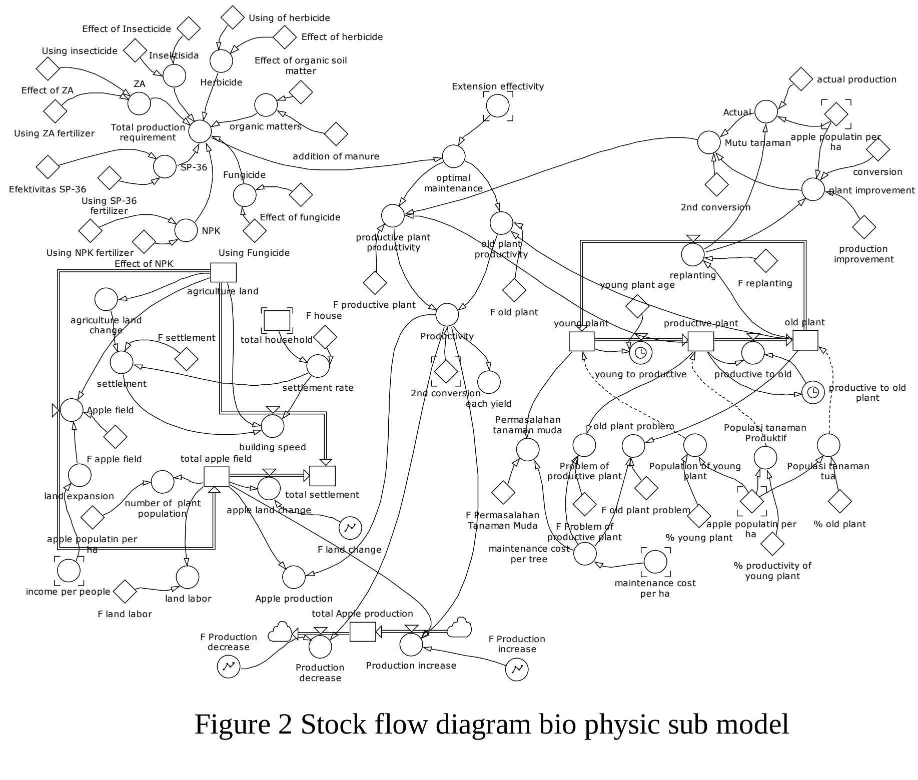

Figure 2 Stock flow diagram bio physic sub model

Social Sub-model

In the social sub-model (Figure 3), the variables used are the population in Batu City, the workforce, and households, which affect the agricultural sector, especially the agricultural labor. Based on various existing variables, the most decisive variable is the number of workers who get a job because the success of apple farming influences it and also the MSME in Batu City. Expected to know the need for agricultural labor so that variables can be analyzed that can encourage its increase. It is inseparable from other business activities, both in MSMEs processing apples and agricultural tourism, all of which in the model structure have been integrated with apple cultivation so that it is expected to absorb more workers.

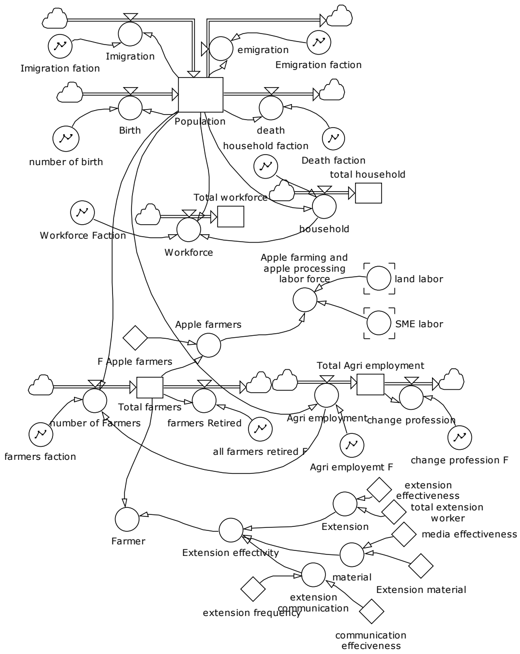

Figure 3 Stock flow diagram social submodel

Economic Sub-model

In the sub-economic model (Figure 4), the model structure consists of variables that have a role in describing the economic dimension. Variables that play a role in this dimension include agricultural input variables, costs incurred by farmers, MSME variables, agricultural tourism variables, and the quality and price of apples at the farm level. So far, sorting/grading is not done by farmers but by collectors who know the market's tastes. In addition to the price of fruit, quality will also affect farmers' income. Fulfilling the MSME industry's needs that utilize apples into processed forms, this model takes the most in-demand products by consumers.

Model test and validation

Performance validation tests are carried out to ensure that the model's performance is following the actual system performance and is declared to have met the criteria as a scientific model with correct model output behavior following the behaviors of the empirical data. They tested the validity of the data using Absolute Mean Error (AME) and Absolute Variant Error (AVE). In this study, the variables that validated the model's performance were the number of the working workforce, the area of apple land and the production of apples, and the number of MSMEs processing apple products in Batu City. The validation results show that the AME and AVE values are lower than 10%, indicating that the model has performed well and is scientifically acceptable. The results of the calculation of the AME and AVE values are presented as follows.

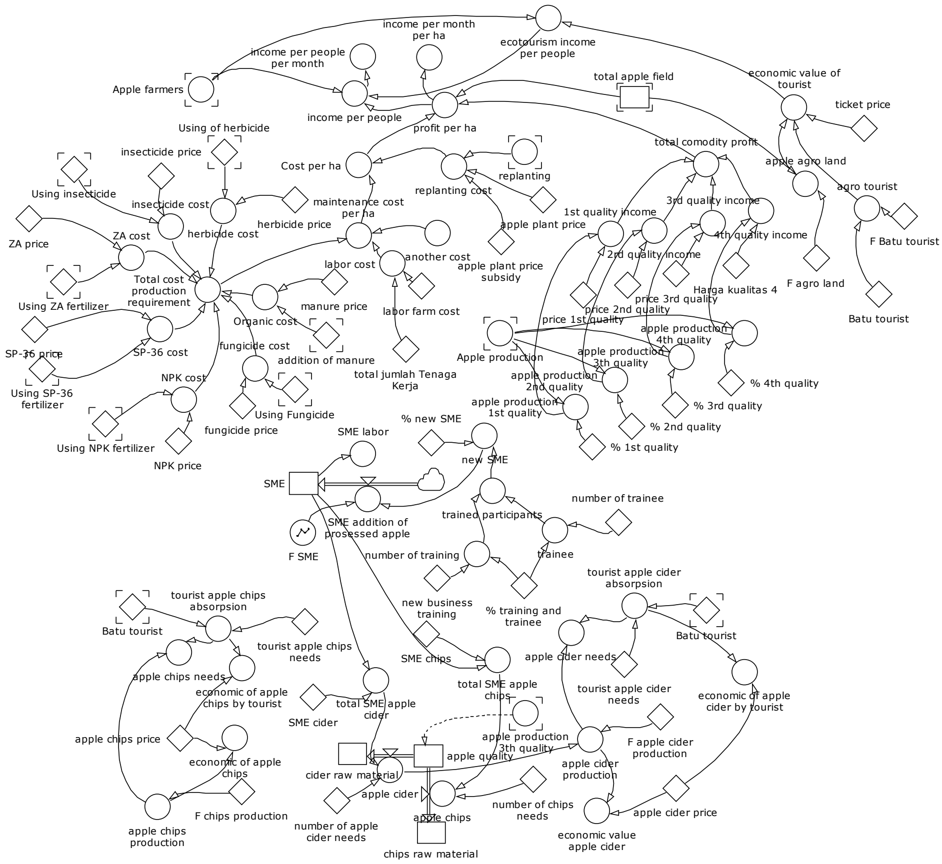

Figure 4 Stock flow diagram economic submodel

RESULT AND DISCUSSION

Scenario Comparison

Furthermore, the model is used to develop policy alternatives, besides that, various alternatives are analyzed to determine the best policy alternative. The scenario is designed with a combination of several factors that are simulated from the controlled input to answer the goal or the controlled output (Table 1). The scenario that will be applied is the result of expert discussion by considering the ability to use it in the future.

Plant and Land Improvement

Plant Rejuvenation

The main problem in apple farming today is that the age of the plant is old (Ruminta, 2015) past the productive period. But in reality, farmers are reluctant to do plant rejuvenation. In fact, according to Nurkhoiry *et al.* (2006), consideration of garden rejuvenation is one of them by considering plant productivity which includes plant density per hectare and plant pests and diseases. One of the reasons is the fear of declining income. Like most farmers, they are worried about the ability to meet their daily needs when replanting plants (Jenahar and Hildayanti, 2017) or even a lack of income while the plants are still young (Listyati and Ferry, 2014). Therefore, rejuvenation technology is needed that can be carried out by farmers independently according to their abilities and does not eliminate income, and does not rely on government assistance. One of the solutions is replanting with an underplanting model, which is more profitable than intercropping rejuvenation. Rejuvenating underplanting by cutting down old plants gradually or not in their entirety to allow the company not to lose income as long as the replanted plants are immature because income is still available from the remaining old plants (Wibowo and Junaedi, 2017).

Table 1 Scenarios applied to the model

No	Variable	Scenario		
		Pessimistic	Moderate	Optimistic
1	2	3	4	5
1	Improvement of crops and land			
	Replanting	5% of the plant population	10% of the plant population	15% of the plant population
	Adding manure	1 ton/ha	Integrated farming and goat farming with 6 female and 1 male brooders	Integrated farming and goat farming with 12 female and 1 male brooders
	Cover Crop	Using *Arachis pintoi* plants as much as 20% of the land area	Using *Arachis pintoi* plants as much as 40% of the land area	Using *Arachis pintoi* plants as much as 60% of the land area
2	Reduction of land use	Farmers keep the land if the annual income Rp 200 million and construction of special settlements starting in 2029	Farmers keep the land if the annual income Rp. 200 million and construction of special settlements starting in 2026	Farmers keep the land if the annual income Rp. 200 million and construction of special settlements starting in 2023
3	Local Economic Development	Sales of apples in: - Tourist entrance ticket (0.5 kg/tourist) - Tourist hotel fee (0.5 kg/hotel guest)	Sales of apples in: - Tourist entrance ticket (0.75 kg/tourist) - Tourist hotel fee (0.75 kg/hotel guest) - Health support for school students as much as 1 fruit/ month/student.	Sales of apples in: - Tourist entrance ticket (1 kg/tourist) - Tourist hotel fee (1 kg/hotel guest) - Health support for school students as much as 1 fruit/ month/student.
4	MSME Training	The increase in the number of entrepreneurship growth training (MSMEs) is only 10%.	The increase in the number of entrepreneurship growth training (MSMEs) is only 20%.	The increase in the number of entrepreneurship growth training (MSMEs) is only 50%.

Addition of Organic Matter and Use of Cover Crops

Apple farmers have applied intensive cultivation systems with high use of chemical fertilizers and pesticides for a long time (Indahwati et al., 2012). The loss of soil organic matter due to organic farming has contributed to climate change by releasing carbon stored in the soil due to anthropogenic behavior (Lal, 2018), decreasing soil fertility (Mahon *et al.*, 2018). The decline in soil quality is also caused by the lack of attention to land conservation which causes high soil erosion so that a lot of organic matter content is lost. At the same time, organic matter decreases, which is harmful to fertility and productivity (Boone *et al.*, 2018; Zhu *et al.*, 2018). Therefore, it is recommended to use cover crops (Hussain *et al.*, 2018; Rasyid, 2016; Munawir *et al.*, 2019; Merten and Minella, 2013) which have long been used in India by using legumes in annual crops (Usha *et al.*, 2015), to minimize loss of topsoil soil through erosion (Mozumdar, 2012; Wang *et al.*, 2019).

Soil organic matter is closely related to the physical, chemical, and biological properties of the soil and improves soil quality and productivity. Soil organic matter also plays an essential role in increasing water availability in the soil, maintaining soil fertility, as the leading supplier of N and other nutrients for plant growth (Asbur and Ariyanti, 2017). The research of Machado *et al.*, (2019) states that the accumulation and transformation of organic matter in the soil is significant in improving the soil's chemical, physical, and biological properties. The increase in soil organic matter will increase the growth of cultivated plants due to increased available water capacity, nutrient supply, soil structure and other physical properties (Asbur and Ariyanti, 2017). However, biomass procurement as a source of soil organic matter in situ is very limited (Subowo, 2010). Therefore, composting technology in agricultural land with low investment has been developed to re-integrate organic matter and minimize the impact on the environment because livestock manure has the potential as pollution in the form of leachate (Pergola *et al*., 2018). As with the integration of agriculture and goat farming, besides the benefits, the nutrient content is relatively high where goat dung mixes with urine (urine) which also contains nutrients (Trivana and Pradhana, 2017).

Reducing of Land Change

The development of the tourism sector is the most dominant sector as a cause of threat to the agricultural sector caused by the increased need for built-up land to support tourism sector activities (Uchyani and Ani, 2012). In 2003 the number of farmers in Batu City was 19 326 households, while in 2013, it fell to 17 358 households (BPS, 2019). The conversion of agricultural land because of the economic needs of farmers (Jin *et al.*, 2015), no more agriculture jobs that need to be maintained (Siciliano, 2012), the reduction in apple land since 2016-2020 was 5.12%, even according to Subagiyo *et al.* (2020) land conversion in Batu City reached 6.19% in 10 years. Other factors that encourage the emergence of land conversion are the need for land to construct buildings, the increase in land selling prices, and the decreased motivation of farmers (Santoso *et al*., 2017), in line with (Garrard *et al.*, 2016) that the complexity of land change is caused by factors environmental, social and economic.

MSME Growth and Strengthening Training

Micro and small businesses have fixed capital or have a certain number of workers (Bhattacharya and Londhe, 2014). This form of business is lauded as an essential tool in reducing poverty (Vial and Hanoteau, 2015) and spurring economic growth (United Nations, 2004); Word Bank, 2015). Generally, small businesses face various problems such as funding (Bhuiyan and Ivlevs, 2019), unskilled staff, and poor management, so skills and knowledge are needed (Mayuran, 2016).

There is a positive relationship between entrepreneurial development and small business performance. Training programs encourage them to gain better managerial skills in recording and accounting for financial transactions, inventory management, product marketing, competitive aggressiveness, and recognizing marketing opportunities. A well-trained entrepreneur will describe most of the entrepreneurial traits, and these traits will then translate into business growth with results: satisfied customers demonstrated by repeat purchases, customer royalties and increased sales volume, well-maintained business records, employees satisfied, ultimately increased capital investment and job creation (Kithae *et al*., 2013). According to Alarape (2017), small businesses whose owner-managers have experience participating in entrepreneurship programs. The training provided to entrepreneurs is felt to be very useful. However, after training, follow-up in monitoring is needed.

Local Economic Development

Local economic development is needed to maximize local potential or strengthen local economic competitiveness to improve the welfare of the local community (Munir and Fitanto, 2008). This requires collaboration from the community, private sector, government, and NGOs (Mandisvika, 2015). Local economic development requires the role of the government, one of which is informing business group clusters (Wijayanti and Darwanto, 2016). Even the efforts to accelerate local economic growth through agricultural commodities that have been carried out by Suhada (2017) in his research require: (a) integration of integrated agribusiness partnerships with institutional consolidation at the farmer level into independent farmer groups with legal entities; (b) Since agricultural commodities tend to be easily damaged, their production is seasonal, requiring quick handling. It is necessary to create added value through agro-industrial processes into marketable products; and (c) One of the efforts to reduce or minimize the risk of farming is to introduce an agricultural insurance program.

Scenario Results

Crop Productivity Per Hectare

In the existing condition, the productivity of apple crops per year is only 24 217.63 kg/ha from 2021 to 2035. Meanwhile, in the pessimistic scenario, productivity is 37 379.22 kg/ha in 2021, and in 2035 it will be 37 296.72 kg/ha. The moderate scenario of crop productivity in 2021 will increase to 44 557.86 kg/ha. In 2035 it will be 42 775.21 kg/ha. The optimistic scenario for productivity in 2021 is 50 340.31 kg/ha, while in 2035, it will be 47 887.12 kg/ha.

Income Per Hectare Per Year

Economically, the income of apple farmers per hectare in the existing conditions in 2021 is Rp 136 081 785.90, and in 2035 it will increase to Rp 133 127 129.98. The pessimistic scenario in 2021 is Rp 214 306 914.00 and increased by Rp 219 432 415.00 in 2035. A moderate scenario of income received by farmers in 2021 is Rp 254 625 472.00 and became Rp 250 937 343.99 in 2035, and the optimistic scenario the farmers' income in 2021 is Rp 289 601 892.41. In 2035, as much as Rp 280 444 154.72. Fourty percent (40%) contribute income from Local Economic Development (LED) and goat sales. Local economic development is needed to maximize local potential or strengthen local economic competitiveness so that it impacts improving the welfare of the local community (Munir dan Fitanto, 2008). This requires collaboration from the community, private sector, government, and NGOs working together (Mandisvika, 2015).

Micro, Small and Medium Enterprises (MSMEs)

The number of MSMEs in the existing scenario in 2021 is 124. In 2035, 142 MSMEs, pessimistic scenario number MSMEs in 2021 is 120 to 141 in 2035, the moderate scenario of MSMEs is 121 in 2021 and becomes 146 in 2035. The optimistic scenario is the number of MSMEs. MSMEs are 122 in 2021 and will be 161 in 2035.

Apple Farming and Apple Processing Labor Force

The number of workers there is no special treatment for pessimistic or others, because it is the output of on-farm apple farming activities (tourism, apple-goat integration, and apple processing MSMEs) in existing conditions is 35 085 people in 2021, and in 2035 the number of people working is 17 727. The pessimistic scenario is that the absorption of labor for apple farming and MSMEs is 37 117 people in 2021 and in 2035, as many as 21 620 people. In the moderate scenario, the number of workers working is 37 982 in 2021, and in 2035 it will be 42 540, and in the optimistic scenario, it will be 67 669 in 2021 and will be 54 414 people in 2035. Meanwhile, MSME training was conducted for three population categories for this labor force.

CONCLUSION

Using optimistic scenario, by replanting 15% of old plant each year, using integrated agriculture with 12 female and one male brooder, reducing land change by farmers keeps the land if the annual income Rp 200 million and construction of special settlements starting in 2029, Local economic development by integrating tourist ticket and hotels with 1 kg apple fruits also increasing health support for students. The desired output from apple productivity per hectare increases 49.42%, income per hectare increases 51.62%, number of MSME 7.42%, and number of labor from on and off-farm will increase 96.82%.

REFERENCES

[BPS] Badan Pusat Statistik. 2017. *Statistik Tanaman Buah-Buahan dan Sayuran Tahunan 2017*. Jakarta (ID): BPS.

[BPS] Badan Pusat Statistik. 2019. *Produk Domestik Regional Bruto Menurut Lapangan Usaha 2014-2018*. Batu (ID): BPS Batu.

Alarape AA. 2007. Entrepreneurship programs, operational efficiency and growth of small businesses. *J Enterprising Communities People Places Econ.* 1(3): 222-239.

Asbur Y, Ariyanti M. 2017. Peran konservasi tanah terhadap cadangan karbon tanah, bahan organik, dan pertumbuhan kelapa sawit (*Elaeis guineensis* jacq.) The role of soil conservation to soil carbon stocks, organic matter, and oil palm (*Elaeis guineensis* jacq.) Growth. *J Kultiv.* 16(3): 402-411.

Bhattacharya S, Londhe BR. 2014. Micro entrepreneurship: Sources of finance & related constraints. *Procedia Econ. Financ.* 11: 775-783.

Bhuiyan MF, Ivlevs A. 2019. Micro-entrepreneurship and subjective well-being: Evidence from rural Bangladesh. *J Bus Ventur.* 34(4): 625-645. doi: 10.1016/j.jbusvent.2018.09.005.

Boone L, Van V, Roldán-ruiz I, Sierra CA, Vandecasteele B, Sleutel S, Meester S De, Muylle H, Dewulf J. 2018. Introduction of a natural resource balance indicator to assess soil organic carbon management: Agricultural biomass productivity benefit. *J Environ Manage.* 224: 202-214.

Bosc PM, Marzin J, Belieres JF, Sourisseau JM, Bonnal P, Losch B, Pedelahore P, Parrot L. 2015. *Family Farming and the Worlds to Come: Defining, Characterizing and Measuring Family Farming Models*. Netherlands (NL): Springer.

Eriyatno. 2012. *Ilmu Sistem: Meningkatkan Integrasi Mutu dan Efektivitas Manajemen*. Ed ke-4. Larasati L, editor. Surabaya (ID): Guna Widya.

Fauzi A. 2019. *Teknik Analisis Keberlanjutan*. Jakarta (ID): Gramedia.

Forrester JW. 1971. *World Dynamics*. Cambridge (GB): Wright-Allen Press Inc.

Garrard R, Kohler T, Price MF, Byers AC, Sherpa AR, Maharjan GR. 2016. Land use and land cover change in Sagarmatha National Park, a world heritage site in the Himalayas of Eastern Nepal. *Mt Res Dev.* 36(3): 299-310.

Hammond RA, Dube L. 2012. A systems science perspective and transdisciplinary models for food and nutrition security. *PNAS*. 109(31): 12356-12363.

Hussain S, Sharma MK, Bashir D, Tundup P. 2018. Effect of orchard floor management practices on nutrient status in apple CV. Royal Delicious. *Int J Curr Microbiol Applies Sci.* 7(02): 2771-2792.

Indahwati R, Hendrarto B, Izzati M. 2012. Keanekaragaman arthropoda tanah di lahan apel Desa Tulungrejo Kecamatan Bumiaji Kota Batu. *Pros Semin Nas Pengelolaan Sumberd Alam Dan Lingkung.* Vol(No): 31-34.

Jenahar TJ, Hildayanti SK. 2017. Analisis kemampuan tabungan petani untuk menanggung biaya peremajaan kebun karetnya di Musi Banyuasin Sumatera Selatan. *J Ecoment Glob.* 2(1): 51-58.

Jin G, Zhaohua L, Wang Z, Chu X, Zhihui L. 2015. Impact of land-use induced changes on agricultural productivity in the Huang-Huai-Hai River Basin. *Phys Chem Earth*. 79-82: 86-92.

Kithae PP, Maganjo R, Kavinda L. 2013. Impact of entrepreneurship training on performance of Micro and Small Enterpricses (MSES) in Kenya: A case study of embu municipality. *Int J Bus Manag Rev.* 1(2): 1-17.

Lal R. 2018. Sustainable intensification of China's agroecosystems by conservation agriculture. *Int Soil Water Conserv Res.* 6(1): 1-12.

Listyati D, Ferry Y. 2014. Analisis pendapatan petani karet pada sistem peremajaan bertahap. *J TIDP*. 1(3): 157-166.

Machado DL, Pereira MG, Lopes L, Santos DOS. 2019. Organic matter and soil fertility in different successional stages of seasonal semidecidual forest. *Rev Caatinga, Mossoró*. 32(1): 179-188.

Mahon N, Crute I, Bonito MD, Simmons EA, Islam MM. 2018. Land use policy towards a broad-based and holistic framework of sustainable intensification indicators. *Land Use Policy*. 77: 576-597.

Mandisvika G. 2015. The role and Importance of local economic development in urban development: A case of harare. *J Advocacy Res Deveopment*. 4(3): 198-209.

Merten GH, Minella JPG. 2013. The expansion of brazilian agriculture: Soil erosion scenarios. *International Soil and Water Conservation Research*. 1(3): 37-48.

Mayuran L. 2016. Impact of entrepreneurship training on performance of small enterprises in jaffna district problem statement and research questions entrepreneurship training financial management performance of small enterprises. *Glob J Commer Manag Perspect.* 5(2): 1-6.

Mozumdar L. 2012. Agricultural productivity and food security in to progress agricultural production and increased agricultural productivity is requisite to ensure self-sufficiency in food, which is the first constituent of food security. *Bangladesh J Agric Econ.* 35(1/2): 53-69.

Munawir A, June T, Kusmana C, Setiawan Y. 2019. Dynamic factor that affect the land use change in the Lore Lindu National Park, Indonesia. *The Sixth International Symposium on LAPAN-IPB Satellite*; 2019 Sep 17-18; Bogor, Indonesia. Bogor (ID): SPIE.

Munir R, Fitanto B. 2008. *Pengembangan Ekonomi Lokal Partisipatif: Masalah, Kebijakan dan Panduan Pelaksanaan Kegiatan. Jakarta: Local Governance Support Program (LGSP)*. Jakarta (ID): LGSP-USAID.

Nicholson CF, Stephenson MW. 2014. Dynamic market impacts of the dairy margin protection program. *J Agribus.* 32(2): 101-128.

Nurkhoiry R, Agustira MA, Wahyono T, Moechtar D, Kurniawan A, Harahap IY, Koedadri AD. 2006. *Pedoman Norma Kerja Perkebunan Kelapa Sawit pada Lahan Mineral*. Medan (ID): Pusat Penelitian Kelapa Sawit, Medan.

Pergola M, Persiani A, Palese AM, Di Meo V, Pastore V, D'Adamo C, Celano G. 2018. Composting: The way for a sustainable agriculture. *Appl Soil Ecol.* 123: 744-750.

Pigford AAE, Hickey GM, Klerkx L. 2018. Beyond agricultural innovation systems? Exploring an agricultural innovation ecosistems approach for niche design and development in sustainability transition. *Agric Syst.* 164(1): 116-121.

Rasyid H. 2016. Pertumbuhan dan hasil tanaman apel (*Malus sylvestris* L.) varietas lokal sebagai akibat pemberian macam pupuk kandangdan dosis pupuk hijau *Arachis pintoii*. *Semin Nas dan Gelar Prod.* 2016: 325-333.

Ruminta. 2015. Dampak perubahan iklim pada produksi apel di Batu Malang Impacts of climate change on production of apple in Batu Malang. *J Kultiv.* 14(2): 45-48.

Samudra FS, Sitorus SRP, Santosa E, Machfud. 2021. Sustainable of appel production in the tropics using land rent. *Plant Arch.* 21(2): 221-229.

Santoso PBK, Widiatmaka, Sabiham S, Machfud, Rusastra IW. 2017. Analisis pola konversi lahan sawah dan struktur hubungan penyebab dan pencegahannya (studi kasus Kabupaten Subang, Provinsi Jawa Barat). *J Pengelolaan Sumberd Alam dan Lingkung.* 7(2): 184-194.

Siciliano G. 2012. Urbanization strategies, rural development and land use changes in China: A multiple-level integrated assessment. *Land use policy*. 29(1): 165-178.

Subagiyo A, Prayitno G, Kusriyanto RL. 2020. Alih fungsi lahan pertanian ke non pertanian di Kota Batu Indonesia. *J Kajian, Penelit dan Pengemb Pendidik.* 8(2): 135-150.

Subowo G. 2010. Strategi efisiensi penggunaan bahan organik untuk kesuburan dan produktivitas tanah melalui pemberdayaan sumberdaya hayati tanah. *J Sumberd Lahan*. 4(1): 355-372.

Suhada B. 2017. Strategi pengembangan ekonomi lokal Kabupaten Lampung Timur. *J Deriv.* 11(1): 1-7.

Trivana L, Pradhana A. 2017. Optimalisasi waktu pengomposan dan kualitas pupuk kandang dari kotoran kambing dan debu sabut kelapa dengan bioaktivator PROMI dan orgadec time optimization of the composting and quality of organic fertilizer based on goat manure and coconut coir dust usi. *Sain Vet.* 35(1): 136-144.

Uchyani R, Ani SW. 2012. Tren alih fungsi lahan pertanian di Kabupaten Klaten. *SEPA*. 8(2): 51-58.

United Nation. 2004. *Unleashing Entrepreneurship: Making Business Work for The Poor*. New York (US): United Nation.

Usha K, Thakre M, Goswami AK, Deepak NG. 2015. *Fundamental of Fruit Production*. New Delhi (IN): Indian Agricultural Research Institute.

Vial V, Hanoteau J. 2015. Returns to micro-entrepreneurship in an emerging economy: A quantile study of entrepreneurial Indonesian Households' Welfare. *World Dev.* 74(1): 142-157.

Wang Z, Cao Q, Shen Y. 2019. Modeling light availability for crop strips planted within apple orchard. *Agric Syst.* 170(1): 28-38.

Wibowo WH, Junaedi A. 2017. Peremajaan kelapa sawit (*Elaeis guineensis* Jacq.) di Seruyan Estate, Minamas Plantation Group, Seruyan, Kalimantan Tengah. *Bul Agrohorti*. 5(1): 107-116.

Wijayanti SS, Darwanto. 2016. Implementasi pengembangan ekonomi lokal melalui pembentukan klaster di Kabupaten Semarang. *Ecconomics, Soc Dev Stud.* 3(1): 4-25.

Word Bank. 2015. *Growing, Innovation, Fostering Entrepreneurship info Dev Annual Report 2014-2015*. Washington DC (US): Word Bank Group.

Zhu Z, Jia Z, Peng L, Chen Q, He L, Jiang Y, Ge S. 2018. Life cycle assessment of conventional and organic apple production systems in China. *J Clean Prod.* 201: 156-168.