ISSN: 2146-1740
https://dergipark.org.tr/tr/pub/ayd,
Doi: 10.54688/ayd.1181140
Research Article

THE USAGE OF SYSTEM DYNAMICS IN AGRICULTURAL BUSINESSES AS STRATEGIC MANAGEMENT ACCOUNTING TOOL: EXAMINATION OF ALMOND PRODUCTION IN TURKEY

Mehmet TURSUN[1]

Article Info

***Received:* 27/09/2022**

***Accepted:* 11/12/2022**

Abstract

Nowadays, businesses are affected by the change and the transformation taking place globally in every field at different levels. This situation makes it difficult for the businesses in terms of their decision-making processes. Managers are obliged to analyze all the information regarding businesses as required by the necessities of the time for the purpose of maintaining the sustainability of the business. This study consists of practice regarding the system dynamics approach enabling agricultural businesses to conduct analyses on agricultural product sustainability. In this study where analysis is conducted on the sustainability of almond production in Turkey, the amount of almond production between the years of 2021-2050 was analyzed under different scenarios with the created model. The study exhibits that agricultural production sustainability can be analyzed effectively with the approach of agricultural product sustainability system dynamics.

Keywords: Agricultural sustainability, Agricultural enterprises, Almond production, Management accounting, System dynamics.

Jel Codes: C51, C53, M41.

[1] Assistant Professor, Adıyaman University, ORCID: 0000-0001-9731-2198, mtursun@adiyaman.edu.tr.
Atıf: Tursun, M. (2022). The usage of system dynamics in agricultural businesses as strategic management accounting tool: Examination of almond production in Turkey**.** *Akademik Yaklaşımlar Dergisi*, *13* (2), 592-608.

1. Introduction

Sustainable land usage and agriculture which is one of the most essential factors of sustainable development play a great role in the economic stability of developing countries such as Turkey. Agriculture is in a constant relationship with people and the environment whether a manufacturer or a consumer is of concern (Bastan et al., 2016: 1). Therefore, various factors must be taken into account for sustainable agriculture. Agriculture has been one of the most important industries for national economies throughout history. Consequently, the agricultural sector has an impact upon multiple factors, agricultural policies and strategic investment plans of agricultural businesses being in the first place. In the last 30 years, world resources began to run short rapidly along with global warming and population increase. The tendency of overconsumption has caused natural resources to run short, agriculture being in the first place, and problems such as climate change. This situation keeps food safety and agricultural sustainability on the agenda constantly in this day and time (Arısoy & Avcı, 2020: 3000).

Food and Agriculture Organization of the United Nations (FAO) attaches importance to the sustainability of the rural population which is an essential factor in the agricultural sector and agricultural production in the world. The organization indicates that agriculture is a source of employment for a substantial part of the rural population in many countries, hence agricultural sustainability has strategic importance. According to the report of mentioned organization it was stated that the world population will reach 9,3 billion in 2050 and that food production will have to increase by 70% in order to satisfy the food needs of the people. In the same report, it was stated that in 2050, 40% of the world's population will face water scarcity (Sheppard et al., 2011: 6). These developments in the world necessitate sustainable agricultural activities. Agricultural sustainability issues cause economic sustainability problems in agricultural businesses. This situation entails agricultural businesses examining all the factors affecting agricultural sustainability when conducting their activities and deciding upon investment projects accurately and through future time perspective. Factors affecting agricultural sustainability can be mostly dynamic rather than stable. For example, a war taking place in a certain region can trigger agricultural production and mass migration movement in that region. This situation can affect different internal dynamics, food safety of many countries being in the first place. Agricultural policies implemented by the governments within the framework of agricultural sustainability are one of the factors affecting the operations and investment decisions of agricultural businesses. Governments can implement agricultural policies determined on their own or recommended by United Nations (UN). Part of these policies is agricultural support programs introduced to enable agricultural sustainability. Support programs are also applied in Turkey in the agricultural sector and different sectors from time to time. For the agricultural support programs implemented by the governments to be effective, before determining the scope and size of the support package, a dynamic analysis must be conducted on all the factors affecting agricultural sustainability, and examinations must be made via simulations exhibiting future time perspectives.

Businesses benefit from management accounting when conducting their operations and taking investment decision. Strategic management accounting which is about businesses' important management decisions based on accounting information, is used as an effective management tool in recent years (Kayıhan, 2019: 3631). Traditional cost and management accounting techniques can remain incapable of providing the information required by the management in the fierce competition environment. Therefore, the strategic management accounting approach was developed as a management accounting method producing information businesses require in order to compete on a global scale and facilitate businesses in making future strategic decisions (Koçyiğit et al., 2019: 65). One of the most essential advantages of strategic management accounting in comparison to traditional management accounting is that it takes into account the conditions which play a part in businesses' external environment.

In this study, it was aimed to produce strategic management accounting information which will help agricultural businesses in their strategic decision-making in a way to include non-operating conditions. For this purpose, in recent years, the system dynamics approach used effectively in businesses' decision-making processes was utilized. Within the scope of the study, the sustainability of almond production in Turkey was examined via a future time perspective.

The term sustainability comes from the Latin word "*Sustinere*". In fact, the word sustainability is not used separately rather has a qualificative character for the words that come before it. Sustainability is a concept used to state that a certain thing is continuous. In the early 19th century, the concept of sustainability used especially in the agriculture, forestry, and fishery industries is an approach based on issues related to the future of humanity and the protection of natural resources (Tıraş, 2012: 59). Land takes an important role within the relevant natural resources. The total cultivable agricultural land in the world is approximately 3 billion 200 million hectares and that is public knowledge that cultivable agriculture is carried out in approximately 1 billion 475 million hectares of this amount. Nevertheless, the agricultural land per capita tends to decrease both in developed and developing countries (Doğan, 2011: 20). This situation and the fact that land is a non-renewable resource makes land usage, especially in agricultural activities considerably important (Eryılmaz & Kılıç, 2018: 101). Agricultural sustainability is agricultural practices carried out in a way not harm the agricultural ecosystem or enable nature to renew itself with minimum damage such as soil, water and climate. In other words, agricultural sustainability is ~~a~~ food production performed without consuming natural resources and harming the environment (Çeker, 2016: 832). Agricultural sustainability has social, economic, and environmental indications. These indications are used in determining agricultural sustainability.

When it is examined in terms of environmental, social, and economics aspect, almond, which is an agricultural product analyzed in terms of sustainability on the basis of production amount in the study, appears to be a sustainable product. There are many studies in the literature conducted on the sustainability of almonds. One of these studies was conducted by Bozzolan (2018). In his study, Bozzolan indicates that almond protects soil quality through their environmental dimensions and provides carbon sequestration. Furthermore, in the study, it was presented that almond production was significantly beneficial also in terms of socio-cultural and economic terms. Taking into account all of these, there are two conditions that might pose a threat to the sustainability of almond production. One of these is the decrease in product profitability along with excess supply and abandoning production as a result. The latter is the decrease in the production amount of almond due to the decrease in the rural population and in the almond production and more of the same as a result of diminishing utility in terms of the socio-cultural aspect of almond production. In fact, both conditions can cause the production amount of almond to decrease which is a sustainable product.

Production sustainability issues that might be related to conditions such as excess demand or excess supply in almond production, can pose a threat to the profitability, hence sustainability of agricultural businesses focusing on the product of almond. In the study, it was practiced to predict the almond production amount in Turkey by 2050 through the created system dynamics model. With this aspect, this study aims to help agricultural businesses take on successful investment decisions concerning the matter. Moreover, it was considered that the data obtained from the study will contribute to the Turkish Government's determination of efficient policies in respect of almond production.

2. Literature Review

Abugamea (2008), examined the effective indicators in Palestinian agricultural production via dynamic analysis by using time series procedures. In the study, it was indicated that regional agricultural product has a significant influence on the workforce. In addition, it was stated that agricultural performance can be improved by developing and implementing policies for decreasing the costs of agricultural input and improving workforce productivity.

In their study, Johnson et al. (2008), have developed an agricultural and rural development model with a system dynamics approach for the purpose of understanding rural regions' agricultural, ecological, economic and social dimensions better. In the model, data obtained from 11 countries were used. According to the model results, in the short-term, seasonal changes in the tourism industry led to dynamics patterns within 1-year periods. Moreover, feedback between income and migration forms dynamic models with 10 years or more periodicity. It was determined that the effect of demographic feedback creates periods that last several generations long. In addition, the model presents how the interactions between economy, ecology and quality of life contain the negative feedback effects such as the relationship between income and migration at times and positive feedback effects such as the factor process between the regional industries in other cases.

In their study, Li et al. (2012), have created a system dynamics model for the purpose of analyzing the environmental and economic effects of ecological agriculture and simulating its long-term tendencies. In the study focused on the eco-agriculture system in the Kongtong Region located in the Chinese city of Pingliang, state of Gansu, a system dynamics model called "AEP-SD" was developed to evaluate the integrated effects of the created system from 2009 to 2050. Simulations results reveal certain problems and disadvantages of the current agricultural system such as excessive increase in cattle cutting, inconsistent methane production, slow pace of development in organic agricultures and unsustainable energy structures. In the study, it was indicated that these problems can be reduced by certain policies simulated on the system.

In his study, Aksu (2013) have conducted a study with intent to exhibit that system dynamics approach can be used as a strategic management accounting tool. As a result of the study, it was emphasized that system dynamics can be used as a decision-making tool on several management accounting issues such as budgeting, profit planning and cost volume-profit analyses.

In their study, Ghasemi et al. (2017) have applied system dynamics approach on the purpose for simulating management strategies related to the water resources of the city of Tehran. In the developed model, the efficiency of water storage trend and water supply strategies was simulated for the next 30 years. The results showed that, although the water resources are gradually diminishing, the water deficit can be reduced for the next 30 years by using the existing resources optimally under the appropriate strategies.

In their study, Jafarpour and Khatami (2021), have modelled the cost structure of mining to emphasize the role of environmental costs by taking into account the causality relationship between the different factors affecting the costs of open cast mining via system dynamics. In the study, for the economic analysis based on system dynamics, a combination of different environmental strategies was taken into account including 7 scenarios and mine reclamation, a condensation and environmental strategy for the processing facility and environmental mining operations. According to the study result, it was observed that the simultaneous usage of green mining strategies for the processing facility has a high impact on the cost reduction in mining activities.

In their study, Huang et al. (2021), have developed a system dynamics model to contribute to the development of the decision-making tools for reducing emission in a container port. As a result of the study, it was determined that the model helped managers to make their decisions for the emission prediction process and reducing emissions. Furthermore, it was indicated that the system dynamics model can be used as a tool to evaluate the decisions taken and to analyze the environmental performance of the container port during the determined period. It was presented that system dynamics simulations can be used as decision-making tools in strategic management stages.

In their study on the purpose of examining the effect of capital structure policies playing a key role for company managers on firm value, Khan et al. (2021) have developed a corporate planning model based on system dynamics including operational and financial processes for an oil company. In the study, various scenarios were designed and simulated to specify the policies which help to increase the firm value. As a result of the study, it was indicated that the increase in the rate of liabilities in capital structure increases firm value.

In their study, Aksu and Tursun (2021), established a production business based on system dynamics model to measure the performance of the responsibility centers in a production business. It was practiced to predict the future performance of the business by evaluating the data obtained from the model by means of the model. Results were compared by experimenting with different scenarios on the model and it was exhibited that system dynamics can be used efficiently in the evaluation of responsibility centers and business performance.

3. Method

The research methodology is based on System Dynamics (SD) approach. This methodology was first established in 1950 by J. W. Forrester at the Massachusetts Institute of Technology (MIT). In time, the implementation area of this method expanded to social sciences along with fields such as mathematics, physics, engineering and urbanization. System Dynamics is an approach combining the theory, method and the philosophy for the purpose of understanding complex systems. System dynamics is a tool used in fields ranging from feedback control to policy analysis and decision-making processes and examines the effects of these components on system behavior (Guerra et al., 2010: 172). The modelling process in system dynamics can be summarized in basic steps as below (Sterman, 2000: 83).

(1) Determining and identifying the problem

(2) Developing dynamic hypotheses

(3) Developing mathematical model and formulation

(4) Simulating and validating the model

(5) Creating a policy and feedback

These steps can be modified accordingly and returned to the previous step to understand the system better.

In the study, a model was established on the almond production in Turkey taking into account the steps above. The established model is presented on Figure 1.

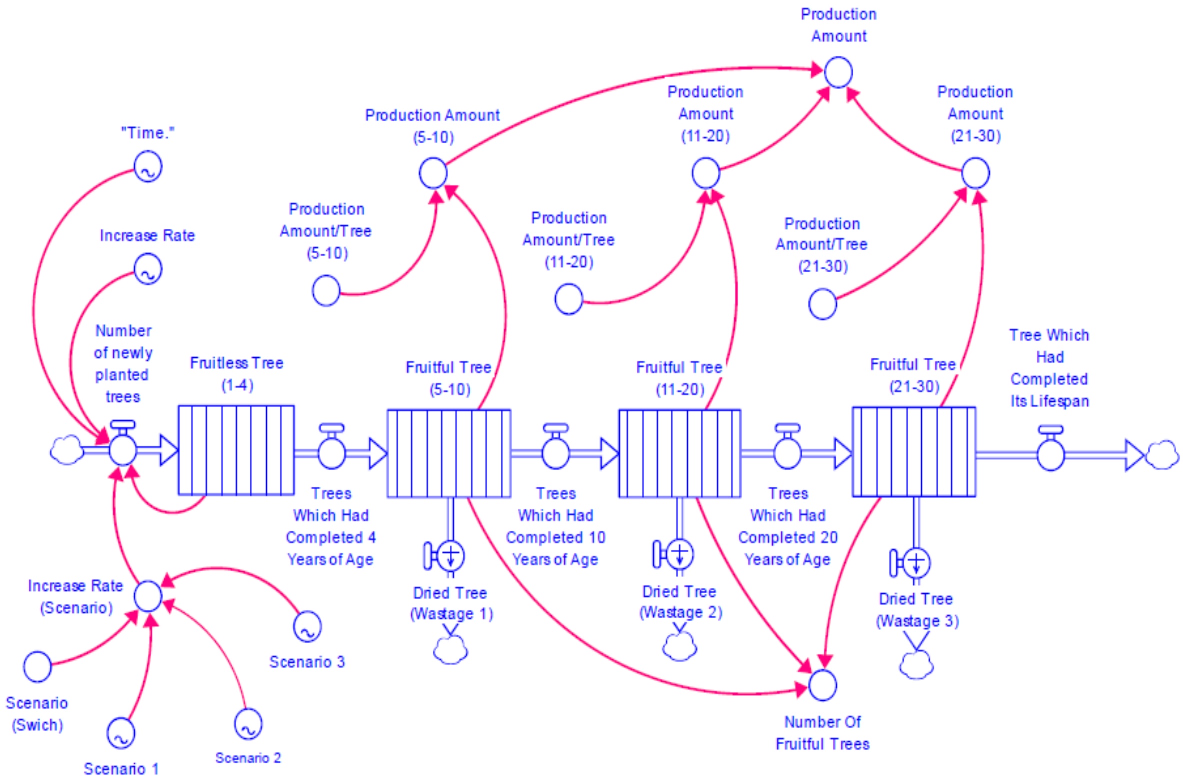

Figure 1.
System Dynamics Model on Almond Production in Turkey
Source: It has been prepared by the author.

4. Model Validation and Testing

After establishing the model, the study proceeded to the stage of validation and testing of the model. Sterman (2000) defines the validation of the model as the “process of building trust in the model”. However, it is nearly impossible for the models to be the same as the real systems since they are a simplified representation of the systems in the real world. Nevertheless, the model tests are an essential step in the system dynamics modelling (Sterman, 2000: 86). There are wide range of testing methods to test the reliability of the model. In the study, model was subjected to a behavioral test.

The behavioral test method examines to what extent the model satisfies real system’s behavior (Figure 2, 3 and 4). The congruence between the simulation data obtained from the model and the realized historical data is a significant determinant in predicting the mutual relationship between the variables of the model structure accurately both in the short and long term and in interpreting the simulation data realistically.

Information regarding the almond production in Turkey was obtained from The Turkish Statistical Institute (TURKSTAT). Within this framework, data regarding the number of fruitless trees, fruitful trees and their production amounts were obtained between 2007-2021 years (TURKSTAT, 2022).[1]

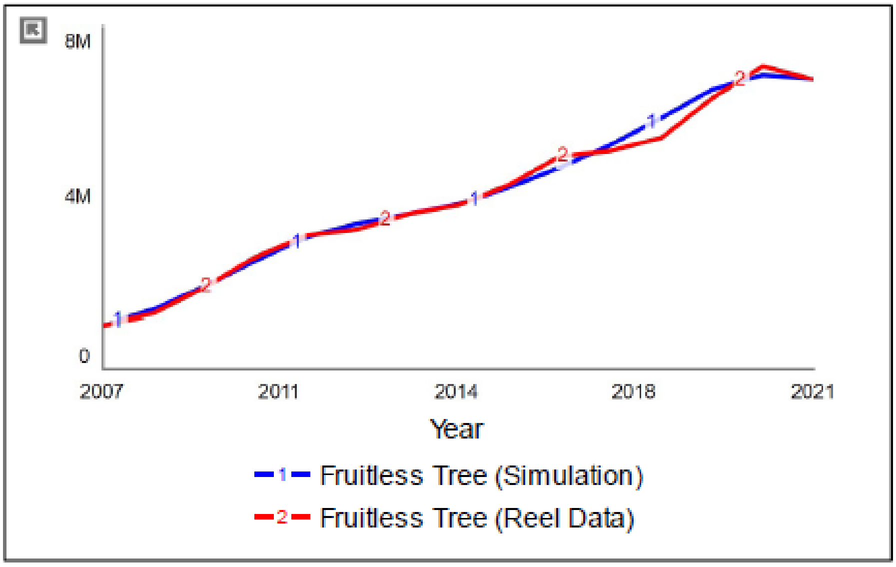

Figure 2.
Behavioral Test on Number of Fruitless Trees
Source: It has been prepared by the author.

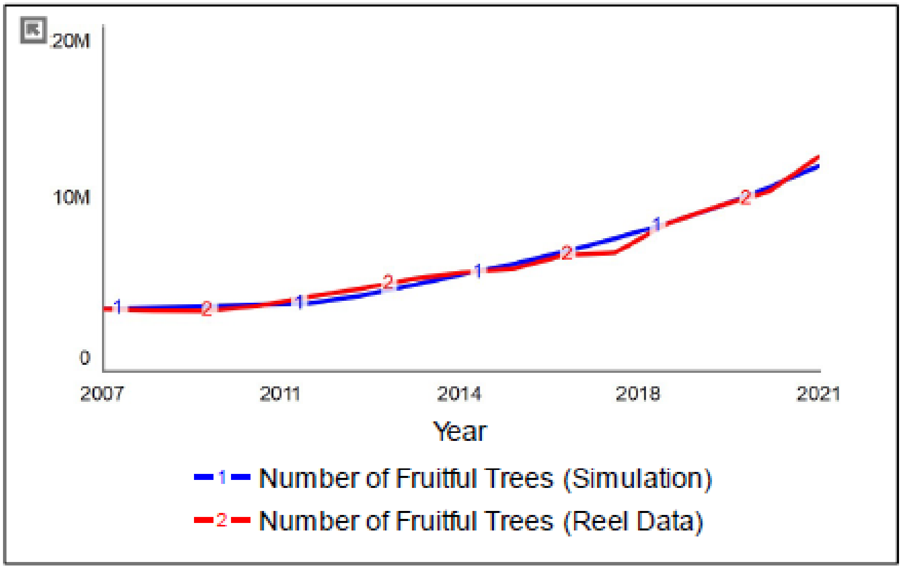

Figure 3.
Behavioral Test on Number of Fruitful Trees
Source: It has been prepared by the author.

[1] These data are open to the public and no permission is required, including the ethics committee's permission.

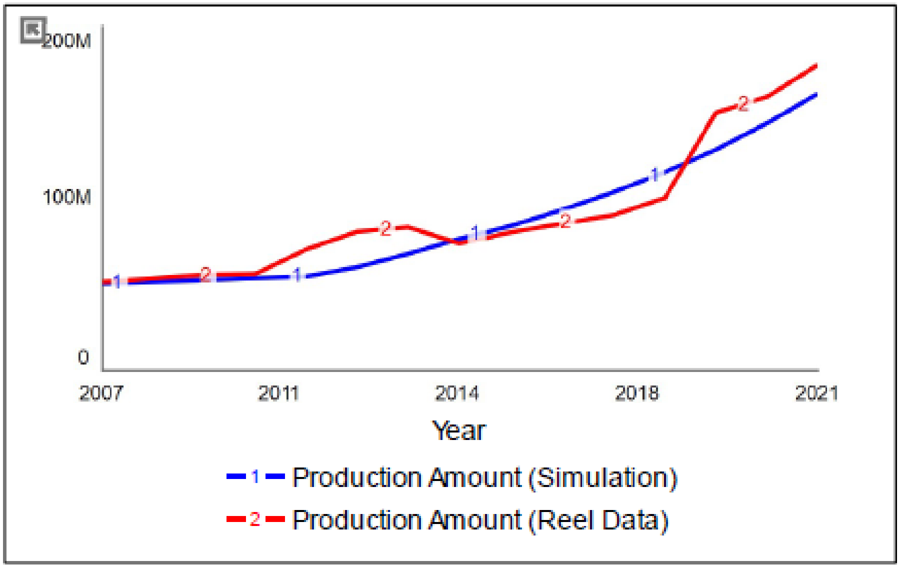

Figure 4.
Behavioral Test on Almond Production Amount
Source: It has been prepared by the author.

It is observed in Figure 2, 3 and 4 that the 15-year historical data regarding almond production in Turkey between 2007-2021 and the simulation data established with the model with respect to this period repeat each other successfully.

5. Establishing Scenarios

3 scenarios were created in the model established within the scope of the study. First of these scenarios was created under the assumption that average increase rate of the fruitless trees (20%) will continue rising also between 2021-2050 years according to 15-year data. Under this scenario, second simulation scenario was established in accordance with the assumption that the current number of fruitless trees will remain at the same increase rate (25%). The second was created under the assumption that the increase rate of the fruitless trees will gradually increase from 0,20 to 0,30 between the years of 2021-2050. The third one was established under the assumption that the increase rate of the fruitless trees will gradually decrease from 0,20 to 0,00 between the years of 2021-2050. It must be noted that many different scenarios can be created toward agricultural policies apart from these three scenarios that are established. For example, when considering the fact that government will provide sapling support for the farmers within the context of stimulus package between the years of 2025-2030, a new scenario can be created by adding the number of additional saplings which will be provided to the model for the relevant years.

6. Data Analysis

In this study, predictions were made regarding the almond production in Turkey between the years of 2021-2050. Within this context, analyses were conducted on the product amount obtained from the trees included within the age group of 5-10, 11-20 and 21-30 and the total product amount.

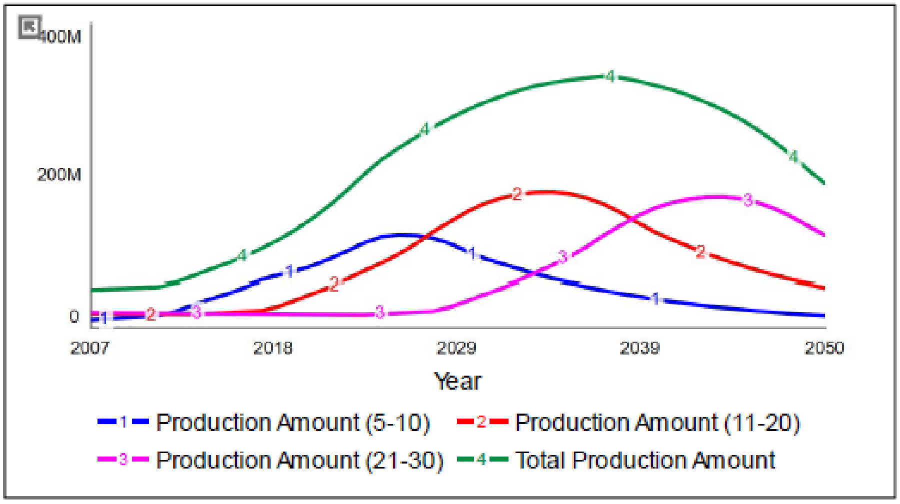

Figure 5.
Scenario 1 (20% increase rate)
Source: It has been prepared by the author.

"*Scenario 1*" was created by examining data on the number of almond trees and almond production obtained from the Turkish Statistical Institute for the past 15 years. Accordingly, the average increase rate in the fruitless trees is 20%. Scenario 1 was created for the purpose of examining the changes that might arise in the production amount in case the number of newly planted saplings increase annually by an average of 20% between the years of 2021-2050. In Figure 5, simulation information is provided on the product amount harvested from the trees within the age range of 5-10, 11-20 and 21-30 and the total amount of products. Accordingly, while almond production amount was 178.000 tons in 2021, after reaching up to nearly 332.000 tons in 2037, it decreased to approximately 189.000 tons in 2050.

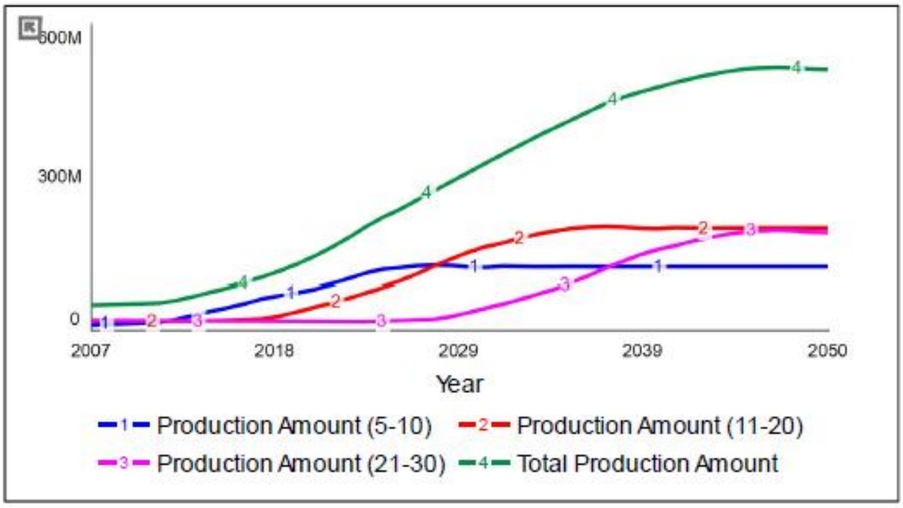

Figure 6.
Scenario 1 (25% increase rate)
Source: It has been prepared by the author.

For "*Scenario 1*", model was re-executed by increasing the increase rate of number of fruitless trees from 20% to 25%. 25% increase rate is one that constantly balances the number of fruitless trees. Under this scenario, changes that might arise in the production amount between the years of 2021-2050 were analyzed. In Figure 6, simulation information is provided on the product amount harvested from the trees within the age range of 5-10, 11-20 and 21-30 and the total amount of products. Accordingly, while the total almond production amount was 178.000 tons in 2021, after reaching up to nearly 520.000 tons in 2047, it decreased to approximately 517.000 tons in 2050.

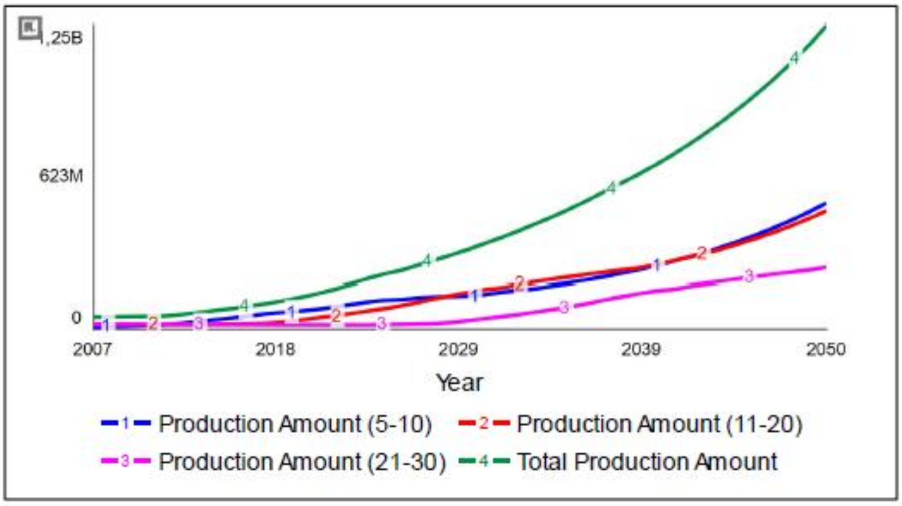

Figure 7.
Scenario 2
Source: It has been prepared by the author

According to the created "*Scenario 2*", it is assumed that the increase rate of number of fruitless trees will gradually rise from 20% to 30% within the context of agricultural policies between the years of 2021-2050. In Figure 7, simulation information is provided on the product amount harvested from the trees within the age range of 5-10, 11-20 and 21-30 and the total amount of products. Accordingly, while the total almond production amount was 178.000 tons in 2021, it reaches up to nearly 1.246.000 tons in 2050.

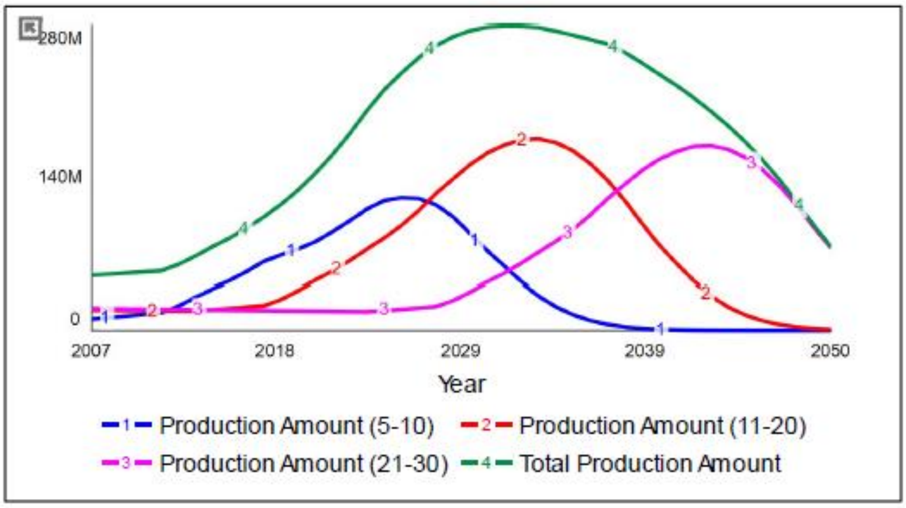

Figure 8.
Scenario 3
Source: It has been prepared by the author

According to the created "*Scenario 3*", it is assumed that the increase rate of number of fruitless trees will decrease rapidly from 20% to 0% between the years of 2021-2050. In Figure 8, simulation presentation is provided on the product amount harvested from the trees within the age range of 5-10, 11-20 and 21-30 and the total amount of products. Accordingly, while the total almond production amount was 178.000 tons in 2021, after reaching up to nearly 280.000 tons in 2032, it decreased to approximately 76.000 tons in 2050.

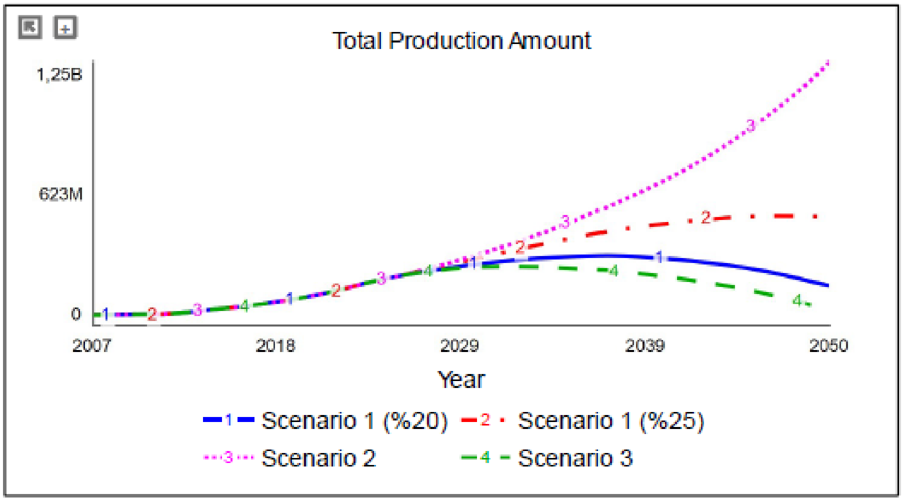

Figure 9.
Total Production Amounts According to All Scenarios
Source: It has been prepared by the author.

In Figure 9, production amounts obtained from all the created scenarios are shown collectively. It was determined that these scenarios can be designed differently according to goals of the business or agricultural policy and the information required.

7. Conclusion and Recommendations

In today's world, businesses are affected by several factors both in national and international dimensions. Among these factors, conditions such as constantly changing customer demands, competition, climate change, wars, etc. are the primary ones. Businesses must analyze both operational and non-operational information produced according to the necessities of the time in order to maintain their existence and to make the right investment decisions. In recent years, system dynamics approach enabling dynamic analysis is used as a strategic management accounting in businesses' decision-making processes.

Agricultural businesses must take into consideration the sustainability of the agricultural product they focus on while maintaining their operations and making investment decisions. Likewise, a problem related to the sustainability of the agricultural product, which is the business' area of activity, affects the business directly or indirectly. In the study, the projection of almond production in Turkey between the years of 2021-2050 was examined under different scenarios. In the model, 3 different scenarios were established. The first of these scenarios was created under the assumption that the average increase rate of the number of fruitless trees (20%) will remain the same also between the years of 2021-2050 according to data for the past 15-year, while the second one was created under the assumption that the increase rate of the number of fruitless trees will gradually increase from 0,20 to 0,30 between the years of 2021-

2050 and the third scenario was established under the assumption that the increase rate of the number of fruitless trees will gradually decrease from 0,20 to 0,00 between the years of 2021-2050. Simulation results obtained in accordance with all three scenarios were compared. It was regarded that in the determination of agricultural policies, taking into account the results obtained by simulations such as this one and such like simulations will be effective in establishing sustainable agricultural policies.

It was observed that the information obtained via system dynamics model can be used as an essential data for the agricultural businesses in the determination of their investment decisions. It was estimated that, through system dynamics approach, businesses can establish more specific models by taking into account the conditions such as their site of action, goals and investment strategies and use system dynamics approach in their decision-making processes effectively.

Peer-review: Externally peer-reviewed.

Conflicts of Interest: There is no potential conflict of interest in this study.

REFERENCES

Abugamea, G. (2008). *A dynamic analysis for agricultural production determinants in Palestine: 1980-2003*. In Proceedings of International Conference on Applied Economics, ICOAE (pp. 3-10). Kastoria-Greece.

Aksu, İ. & Tursun, M. (2021). Analysis of responsibility centers performance in businesses by system dynamics method. *Muhasebe ve Vergi Uygulamaları Dergisi, 14* (3), 949-966.

Aksu, İ. (2013). System dynamics approach as a tool of strategic cost management. *The International Journal of Social Sciences, 15* (1), 18-30.

Arısoy, H. & Avcı, Y. (2020). Türkiye'nin biyoekonomi politikalarının tarımsal açıdan değerlendirilmesi. *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 10* (4), 2999-3009.

Bastan, M., Delshad Sisi, S., Nikoonezhad, Z. & Ahmadvand, A. M. (2016). *Sustainable development analysis of agriculture using system dynamics approach*. In The 34th international conference of the system dynamics society, (pp. 1-20). Delft-Netherlands.

Bozzolan, N. (2018). *Integrated cost-benefit analysis of sustainable almond production*. (Unpublished Master Thesis). Wageningen University, Wageningen.

Çeker, A. (2016). Sürdürülebilir tarım ve Türkiye açısından bir değerlendirme. *Turkish Studies, 11* (2), 809-836.

Doğan, O. (2011). Türkiye'de erozyon sorunu nedenleri ve çözüm önerileri. *Bilim ve Aklın Aydınlığında Eğitim, 134* (1), 62-69.

Eryılmaz, G. & Kılıç, O. (2018). İyi tarım uygulamalarının konvansiyonel tarım yapan işletmelerdeki optimum organizasyona etkisi: Samsun ili Bafra ilçesi örneği. *Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi*, *15* (1), 101-106.

Ghasemi, A., Saghafian, B. & Golian, S. (2017). System dynamics approach for simulating water resources of an urban water system with emphasis on sustainability of groundwater. *Environmental Earth Sciences*, *76* (18), 1-15.

Guerra, L., Murino, T. & Romano, E. (2010). *A system dynamics model for a single-stage multi-product kanban production system*. In ICAI'10 proceedings of the 11th WSEAS international conference on Automation & information, (pp 171-176). Iasi-Romania.

Huang, Y., Mamatok, Y. & Jin, C. (2021). Decision-making instruments for container seaport sustainable development: *Management Platform and System Dynamics Model. Environment Systems and Decisions*, *41* (2), 212-226.

Jafarpour, A. & Khatami, S. (2021). Analysis of environmental costs' effect in green mining strategy using a system dynamics approach: A case study. *Mathematical Problems in Engineering, 2021* (Special Issue) 1-18.

Johnson, T. G., Bryden, J. M., Refsgaard, K. & Alva Lizárraga, S. (2008). *A System dynamics model of agriculture and rural development: The TOPMARD core model*. In Paper prepared for presentation at the 107th EAAE Seminar. Sevilla-Spain.

Kayıhan, B. (2019). Stratejik yönetim muhasebesi tekniklerinden marka değerleme ve bir uygulama. *MANAS Journal of Social Studies, 8* (4), 3630-3650.

Khan, A., Qureshi, M. A. & Davidsen, P. I. (2021). A system dynamics model of capital structure policy for firm value maximization. *Systems Research and Behavioral Science*, *38* (4), 503-516.

Koçyiğit, S., Doğan, E. & Sula, H. (2019). Hastane işletmelerinde stratejik maliyet yönetiminin uygulanabilirliğini tespit etmeye yönelik bir araştırma: Ankara ili özel hastaneler örneği. *Muhasebe ve Denetime Bakış, 18* (56), 6386.

Li, F., Dong, S. & Li, F. (2012). A system dynamics model for analyzing the eco-agriculture system with policy recommendations. *Ecological Modelling*, *227*, 34-45.

Sheppard, A. W., Gillespie, I., Hirsch, M. & Begley C. (2011). Biosecurity and sustainability within the growing global bioeconomy. *Current Opinion in Environmental Sustainability, 3* (1-2), 4-10.

Sterman, J. D. (2000). *Business dynamics*. Mc Graw-Hill.

Tıraş, H. (2012). Sürdürülebilir kalkınma ve çevre: Teorik bir inceleme. *Kahramanmaraş Sütçü İmam Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 2* (2), 57-73.

Turkish Statistical Institute (TURKSTAT) (2022). Fruits, beverage and spices crops. April 30 2022, https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111&dil=1.