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Modeling Avocado Production in Mexico with Artificial Neural Networks

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ABSTRACT: An Artificial Neural Network (ANN) model was created in this research to estimate and predict the amount of avocado production in Mexico. In the development of the ANN model, the years that are time variable were used as the input parameter, and the avocado production amount (tons) was used as the output parameter. The research data includes avocado production in Mexico for 1961-2020 period. Mean Squared Error (MSE) and Mean Absolut Error (MAE) statistics were calculated using hyperbolic tangent activation function to determine the appropriate model. ANN model is a network architecture with 12 hidden layers, 12 process elements (12-12-1) and Levenberg-Marquardt back propagation algorithm. The amount of avocado production was estimated between 2021 and 2030 with the ANN. As a result of the prediction, it is expected that the amount of avocado production for the period 2021-2030 will be between 2,410,741-2,502,302 tons.

KEYWORDS: Artificial neural network, neuron, avocado.

1. INTRODUCTION

Avocado fruit is originally a culture that has tropical origin. This fruit has only been able to adapt to specific microclimate regions along the Mediterranean coastline. Avocado consumption as a food has grown as a result of the high nutritional content in terms of different oils, proteins, and minerals (Kaygisiz, 2007).

Mexico has the highest avocado production in the world. In 2020, Mexico ranked first in the world with 2,393,849 tons of production. Colombia ranked second with 876,754 tons of production, and Dominican Republic ranked third with 676,373 tons. Peru was fourth with 660,003 tons and Indonesia was fifth with 609,049 tons (FAO, 2020). Figure 1 shows the top 10 avocado producing countries in the world as of 2020.

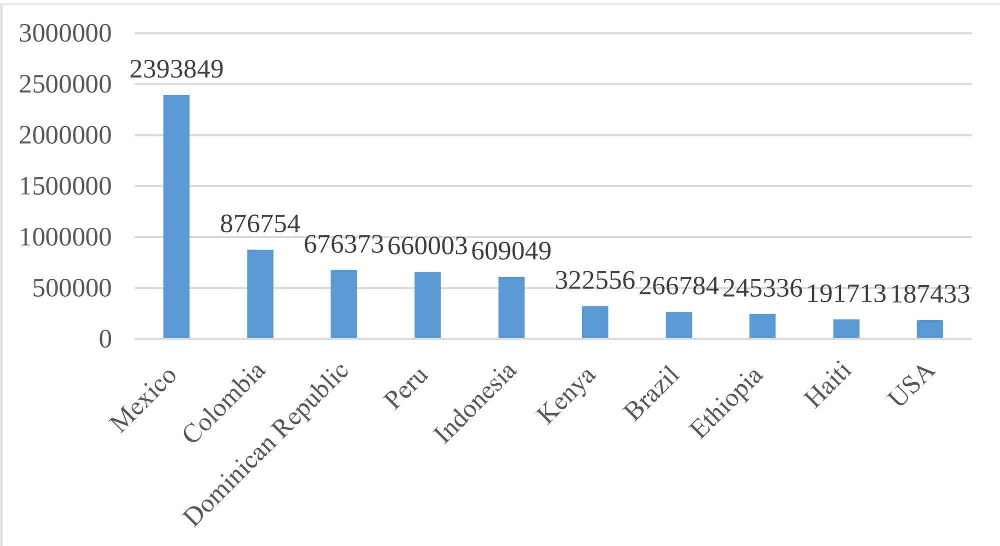

Figure 1. Countries with the highest avocado production in the World

There are studies being conducted in the field of agriculture with artificial neural networks. In one of these studies, the prediction of the amount of apple production in Turkey for the period of 1966-2018 was modeled with artificial neural networks (Yildirim and Karaatli, 2022). In another study, the appropriate model was researched by using Backpropagation Artificial Neural Networks (BPNN) and Nonlinear External Input Autoregressive Network Model, and the future wheat price was predicted (Khamis and Abdullah, 2014). In the study by Dahikar and Rode (2014), agricultural product yield was predicted by using artificial neural networks. The product estimation method was used to estimate the appropriate product by sensing various soil parameters as well as atmospheric parameters. Bean production in Turkey was modeled and estimated using artificial neural networks and time series analysis (Celik, 2020a). In another study on the estimation of plant production amount, a tobacco production model was developed in Turkey using artificial neural networks and multiplicative decomposition methods (Celik, 2020b). Energy consumption in agricultural production (Khoshnevisan et al., 2015), production management in agriculture (Kamilaris and Prenafeta, 2018), lentil production model in Turkey (Celik, 2020c) are some of the examples of artificial neural networks studies. Avocado production can be possible along the Mediterranean coast in areas where the temperature is usually above zero (0) degrees.

In this study, it was aimed to model the production amount of the most produced avocado in the world by using artificial neural networks and to estimate its future.

2. MATERIAL AND METHOD

The data used in the study formed the amount of avocado production (tons) under the title of "Crops primary" compiled from the www.fao.org website of the United Nations Food and Agriculture Organization (FAO). In the study, data between 1961 and 2020 were used and analyzed with artificial neural networks (ANN). After the appropriate model was determined, the avocado production amount between 2021-2030 was predicted.

The methodology displayed in this section can be used efficiently to provide avocado production forecasts. The adequacy of observed production of avocado data makes it possible to use this technique for prediction. To formulate an ANN with high prediction accuracy that generalizes well, it is necessary to consider several issues, especially the design and training parameters.

In this research, [-1, 1] data normalization was selected. The process of data normalization using the minimum/maximum method employed is demonstrated in below (Brahmi et al., 2010).

$$x' = \frac{x - Min(x)}{Max(x) - Min(x)} + \left(newMax(x) - newMin(x)\right) + newMin(x)$$

where x' is the new value, x is the old value, and min(x) and max(x) are the minimum and maximum values of attribute x, respectively. All noted that transform sample outputs are in the domain of [-1,-1] former to ANN training.

One of the activation functions, the tangent sigmoid (tansig) function was used. The tansig function is expressed as (Chen et al., 2013).

$$tansig(x) = \frac{2}{1 + e^{-2x}} - 1$$

To train the ANN, production amount of avocado parameter measured in Mexican for the last 60 years (1961–2020) were utilized for training and testing. During the training process, the weights were adjusted to make the actual outputs (predicted) close to the target (measured) output of the network, as mentioned in the previous section, using the L-M algorithm in accordance with the mean squared error (MSE).

3. RESULTS AND DISCUSSION

The number of input, hidden and output layers was determined as 12-12-1, respectively, with ANN. It was applied with back propagation learning with 1,000 iterations. The hyperbolic tangent activation function was used for avocado production in ANN method. The lowest MSE=5852359782.476 and MAE=58893.433 were obtained in ANN management for avocado production amount.

Table 1 shows the estimated and observed values as a consequence of the ANN method together with the error terms values. Figure 2 shows the graph of the progression and distribution of the real and estimated values as a consequence of the ANN application for avocado production estimation. Production growth in Mexico was generally seen between 1961 and 2020. However, in 1972, 1974, 1979, 1983, 1987, 1989, 1993, 1995, 1997, 2002 and 2012, there was a decrease compared to the previous year. In other years, there was a constant increase compared to the previous year.

Table 1. Observed, estimated and residual values

Years	Actual	Predicted	Residual
2000	907439	815430	92008,9
2001	940229	808718	131511
2002	901075	1009724	-108649
2003	905000	1060777	-155777
2004	987000	987897	-896,91
2005	1021515	1010928	10587
2006	1134250	1163094	-28844
2007	1142892	1155868	-12976
2008	1162429	1164267	-1837,9
2009	1230973	1178315	52658
2010	1107135	1278521	-171386
2011	1264141	1323545	-59404
2012	1316104	1347953	-31849
2013	1467837	1447696	20140,7

2014	1520695	1516782	3913,32
2015	1644226	1637940	6285,97
2016	1889354	1800947	88407,5
2017	2029886	2058745	-28859
2018	2184663	2203113	-18450
2019	2300889	2304226	-3337,4
2020	2393849	2349537	44312,2

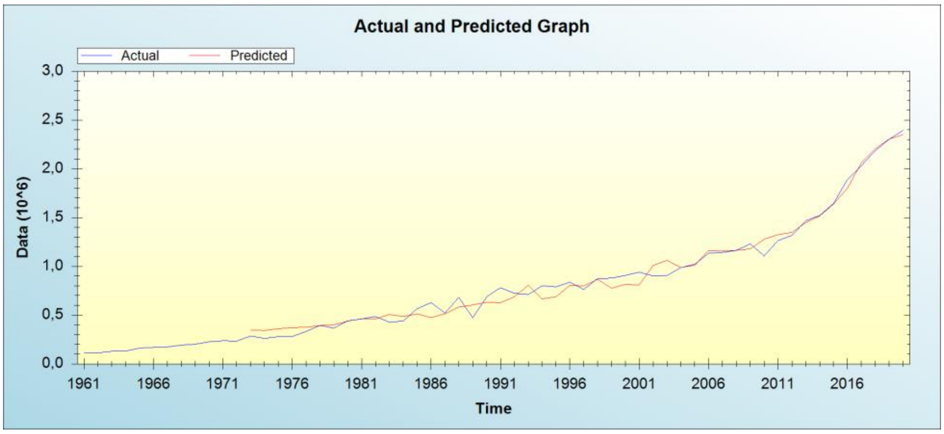

Figure 2. Graph of observed and predicted values

Figure 3 shows the graph of the error terms obtained by the ANN application. In Figure 3, it is seen that the error terms are distributed randomly. Figure 4 shows the graph of the avocado production's real values and error terms. Real values and error terms are distributed randomly and are independent from one another.

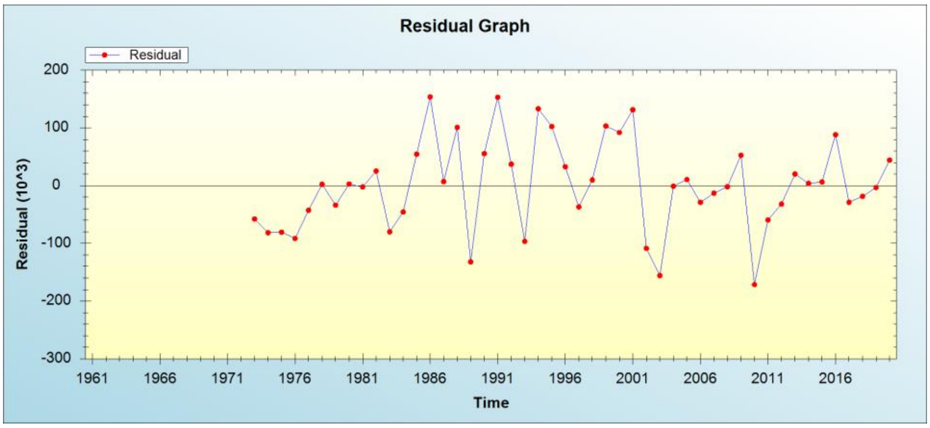

Figure 3. Graph of residual values

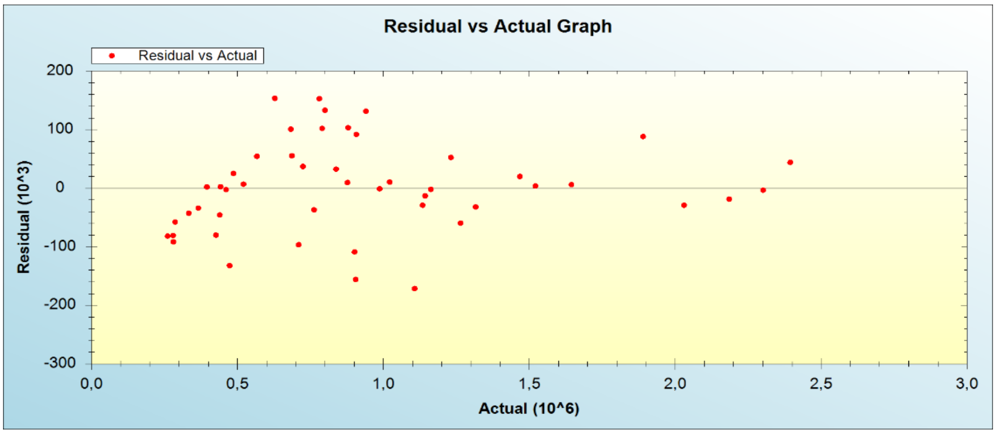

Figure 4. Graph of actual values and residual values

Following this, a prediction for avocado production in the following years was made. In Table 2 and Figure 5, the estimated production amount for the years 2021 to 2030 is shown.

Table 2. Forecast of avocado production for the following period

Years	Forecasted
2021	2410741
2022	2437446
2023	2466472
2024	2480358
2025	2488751
2026	2493096
2027	2496574
2028	2500062
2029	2501494
2030	2502302

As seen in Table 2, it is anticipated that there will be a constant increase in the amount of avocados production in the ten-year period from 2021 to 2030 in Mexico. The production amount, which was 2,393,849 tons in 2020, is predicted to rise by 4.53% to 2,502,302 tons in 2030.

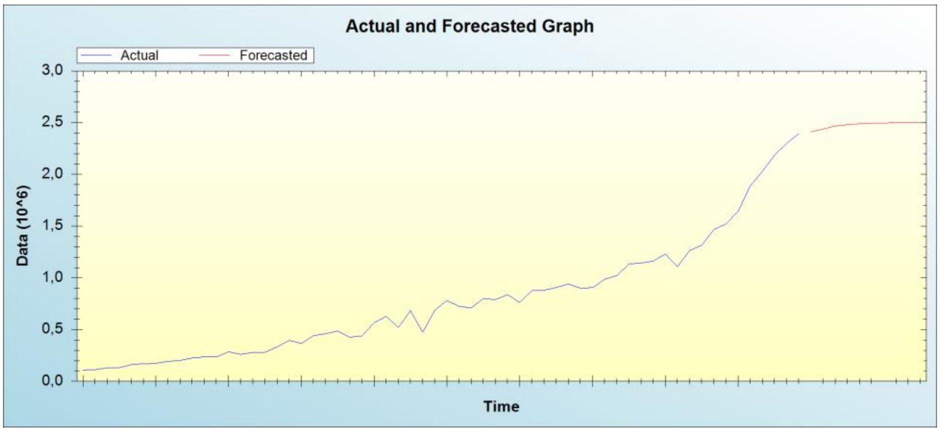

Figure 5. Actual values and forecasting for the future

In the study of Celik (2019), tangerine production estimation in Turkey was made with ANN. Predictions were made for the period 2020–2025, and it was anticipated that tangerine production would rise continuously. In an artificial neural network model of Tatli and Kahvecioglu (2016), it was observed that networks with high training success also had high test success in an artificial neural network model. During the training and testing stages, the RMSE value for the most successful network was 0.158258 and 1.482981, respectively.

4. CONCLUSION

In this study, the amount of avocado production in Mexico was modeled with artificial neural networks. The hyperbolic tangent function, one of the activation functions, was used. The lowest possible MSE and MAE values were obtained in the training, testing, and validation stages.

With the ANN analyzed using the hyperbolic tangent function, the avocado production amount in Mexico is predicted to range between 2,410,741 and 2,502, 302 tons in the period of 2021–2030. Production of avocado is predicted to rise in the next 10-year period compared to 2020. After 10 years, this increase is expected to be 4.53% in 2030. It is hoped that employing artificial neural networks and alternative methods in future forecasting studies could result in positive results for agricultural data.

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