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Modeling and Estimation of Camel Population in Turkey with Time Series Analysis and Artificial Neural Networks

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ABSTRACT
The aim of this study was to establish appropriate models of the camel population in Turkey over the years and estimate future population using artificial neural networks (ANN) and time-series analysis.
In the development of ANN and time series analysis, the year variable was used as the input parameter and the number of camels as the output parameter. The efficiency of the created model was determined by Mean Square Error (MSE) and Mean Absolute Error (MAE) statistics. The results estimate that the number of camels will fluctuate between the years 2021 and 2025.
ANN models gave better results than time series analysis in estimating animal population.
Keywords: *Artificial neural network, time series, forecasting, camel.*

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I. INTRODUCTION

The camel (*Camelus dromedaries*) is one of the oldest domesticated animals. People have been using them for more than 10000 years. A camel is an animal with a hump and they are mostly in light brown colors. A camel's hump stores fat no water. Fat is a source of energy when food is scarce. Most camels are fed by people. They usually eat grass and grain [1]. Camel's milk is rich in iron, vitamins and minerals and it is healthier than cow's milk because it contains less fat. Camels live 40-50 years [2].

Camel is a seasonal breeder and their reproduction is different as compared to other livestock as both male and female come into heat during the breeding season. The female camel matures at an age of 3-4 years while males at the age of 4-5 years [3]. The gestation period in camels is 390 days with average birth weight 35-40 kg. The adult camel weighs 450-750 kg [4].

Camels are ruminant animals belong to family Camelidae, suborder Tylopoda which belong to the Order artiodactyla even-toed ungulates, genus Camelus and species dromedaries [5]. Improvement of the reproductive and productive performance and reduction of animal losses by management measures that are applicable to a mobile system appear to offer possibilities of increasing camel productivity of the herd in terms of milk production and growth of calves [6].

Camels are reared under extensive systems on poor levels of nutrition and mostly slaughtered at old ages after completing a career in physical work, racing or milk production [7]. Meat production is the main product derived from camels under extensive management in areas where the climate adversely affects other animals‟ production efficiency [8]. Thus, camel meat could be a good option to meet the growing needs for meat in arid and semi-arid environments of developing countries [9].

Camels produce under the adverse conditions of high environmental temperature, water shortage and feed scarcity. Low reproductive performance seems to be characteristic for camel production [10].

Camels (*Camelus dromedarius*) produce milk and offspring and provide transport in pastoral husbandry systems in the Afro- Asian dryland belt [11].

The aim of this study is to achieve the modeling and further prediction for the number of camel in Turkey through the Artificial Neural Network and Time Series Analysis.

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Materyal

The material of the study is 1961-2020 number of camel values supplied from the www.tuik.gov.tr web address of Turkish Statistical Institute [12] and Food and Agriculture Organization of the United Nations [13]. The dependent variable was number of camel figures whereas the independent variable was year series. These variables were selected to be able to make reasonable estimations with the models to be performed using ANN and time series analysis methods.

Method

ARIMA Models

The AR in ARIMA stands for Autoregressive which is displayed by p in the model. It refers to the number of lags of Y to be used as the predictor. A pure AR model will be where Y_t depends only on its own past values (Y_{t-1}, Y_{t-2}, ...) . A common representation of an autoregressive model of order p can be written as follow [14].

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + e_t$$

here ε_t indicates white noise. While the MA in ARIMA means Moving Average, displayed by q in the model. MA model depends only on past forecast errors [14]. A moving average model of order q can be written follow [15].

$$y_t = -\theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-q} + e_t$$

here ε_t indicates white noise, which forecast error follow on.

ARMA(p,q) model composed of a pth-order autoregressive and qth-order moving average process and it is characterized by [16].

$$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-q}$$

Identifying the AR term (p) is done by inspecting the Partial Autocorrelation (PACF) graph. The PACF is the correlation between any two points with a specific time shift, called lag where the linear effects of the points in between is removed [17].

Artificial neural networks (ANN)

Artificial neural networks (ANN) is a calculating system that mimics biological neural networks. ANN; inspired by the human brain, is the result of the mathematical modeling of the learning process. A nerve cell sends the information it processes to other cells by means of axons. As nerve cells, artificial nerve cells summate external information with a collecting function and pass through the activation function to produce the output and send it to other cells over the network's connections. Artificial cells come together in 3 layers as the input layer, hidden layer and output layer, parallel to each other and form a network. The information is transmitted to the network from the input layer. They are processed in the hidden layers and sent to the output layer. In order to produce correct outputs weight, assigned randomly at initial, must have the correct values. The process of finding the correct weights is called training the network [18].

ANN, which is a computational intelligence technique has been found to be more efficient than the standard empirical models. Neural networks have been very effective for modeling and for characterization of complex systems for a number of applications [19, 20].

One of the most common used type of ANN is the feedforward network. The architecture of a feedforward neural network is nonlinear. Therefore, the output is obtained from the input through a feedforward arrangement. The multi-layer perceptron (MLP) is a type of feedforward neural network, consisting of input, hidden and output layers [21, 22].

The used activation function in configuration of ANNs in the study is Hyperbolic tangent sigmoid function [23].

$$f = \frac{2}{1 + e^{-net_j}} - 1$$

Normalization method standardizes the values of the input variables. Min Max normalization: Implements a linear transformation on the actual data. It normalizes the data in the range 0 to 1 by the formula [24]:

$$X' = \frac{X_i - X_{max}}{X_{max} - X_{min}}$$

Where, X_i: Data value to be normalized, X': Normalized value of X_i, X_{min}: Minimum value, X_{max}: Maximum value.

To evaluate the precision of the predicted discharge volume, Mean Square Error (MSE) and Mean Absolute Error (ME) were used [25]:

$$MSE = \frac{\sum_{i=1}^{n}(y_i - y_{ip})^2}{n}$$

$$MAE = \frac{1}{n}\left|\sum_{i=1}^{n}(y_i - y_{ip})\right|$$

Here, y_i is the real value of the dependent variable (number of camel), y_{ip} is the predicted value of the dependent variable (number of camel) and n is the number of samples.

II. RESULTS AND DISCUSSION

The artificial neural networks and ARIMA method goodness of fit statistics (MSE and MAE) of number of camel between the years 1961-2020 in Turkey are displayed in Table 1. The time series graph is shown in Figure 1.

Table 1. Model performance values

Fit Statistic	ARIMA(2,1,2)	ARIMA(0,1,2)	ARIMA(2,1,0)	ANN
MSE	3 151 892.477	3 097 934.409	3 047 534.833	1 779 757.833
MAE	1060.270	1144.977	1062.442	849.135

According Table 1, when the time series analysis and artificial neural network methods are compared according to MSE and MAE, artificial neural networks (ANN) with minimum MSE and ME values (MSE=1 779 757.833 and MAE=849.135) are the most suitable model. The hyperbolic tangent function was used as activation function when creating a model with the ANN method. The number of neurons in the input layer, the hidden layer and the output layer was determined as 12-12-1 each. 1000 iterations were used for the ANN method in the data series consisting of 60 observations between 1961-2020.

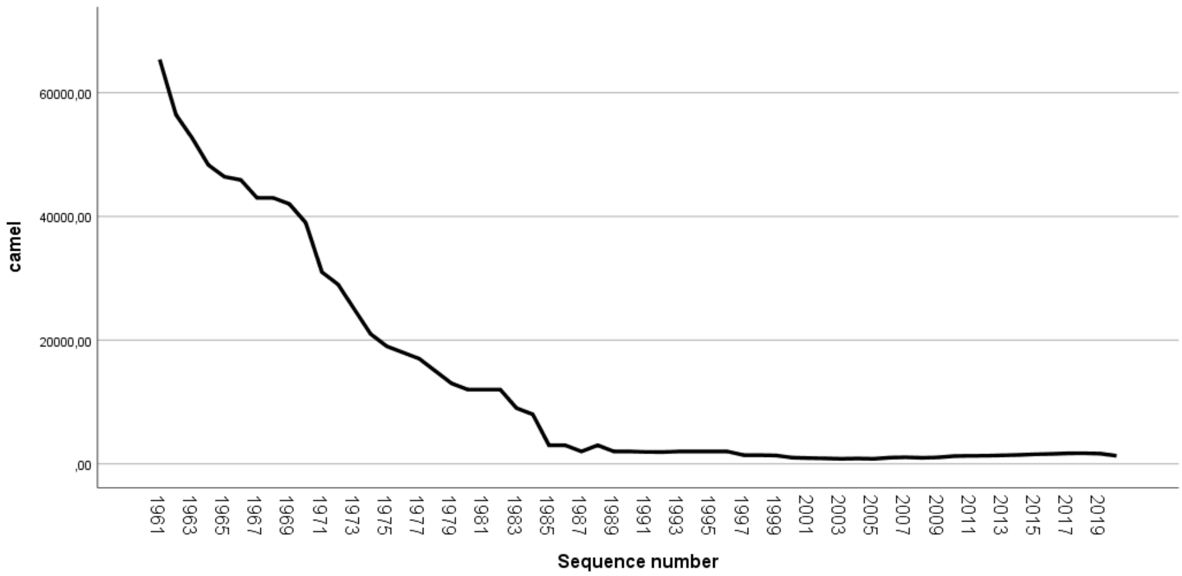

Figure 1. Time series graph

Parameter coefficients of the time series model constructed as ARIMA(2,1,0) are:
$\phi_1 = 0.370$ and $\phi_2 = 423$,

$$(1 - B)(1 - 0.370B - 0.423B^2)X_t = e_t$$

If the linear difference equation above is rearranged with back shift, the following model is obtained:

$$X_t = 1.37X_{t-1} + 0.53X_{t-2} - 0.423X_{t-3} + e_t$$

The Ljung-Box statistic of this model is 16.767 and p = 0.401 (>0.05), so the model is suitable. However, when the ARIMA and ANN methods were compared, it was seen that the ANN method gave better results (Table 1). This is because MSE and MAE values are smaller in the ANN method.
The estimated and residual values are presented in Table 2 together with the real values of the ANN method for 2000-2020 period.

Table 2. Observed, predicted and residual values

Years	Actual	Predicted	Residual
2000	1000	1684.535	-684.535
2001	930	1261.436	-331.436
2002	887	1298.640	-411.640
2003	808	1176.238	-368.238
2004	865	1097.963	-232.963
2005	811	1169.159	-358.159
2006	1004	1201.596	-197.596
2007	1057	1153.974	-96.974
2008	970	1332.593	-362.593
2009	1041	1152.165	-111.165
2010	1254	1214.883	39.117
2011	1290	1294.728	-4.728
2012	1315	1246.247	68.753
2013	1374	1215.527	158.474
2014	1442	1218.801	223.199
2015	1543	1153.746	389.254
2016	1599	1228.137	370.863
2017	1703	1194.611	508.389
2018	1708	1205.572	502.429
2019	1651	1215.778	435.222
2020	1293	1167.710	125.290

The graph of the actual and estimated values obtained with ANN method is displayed in Figure 2.

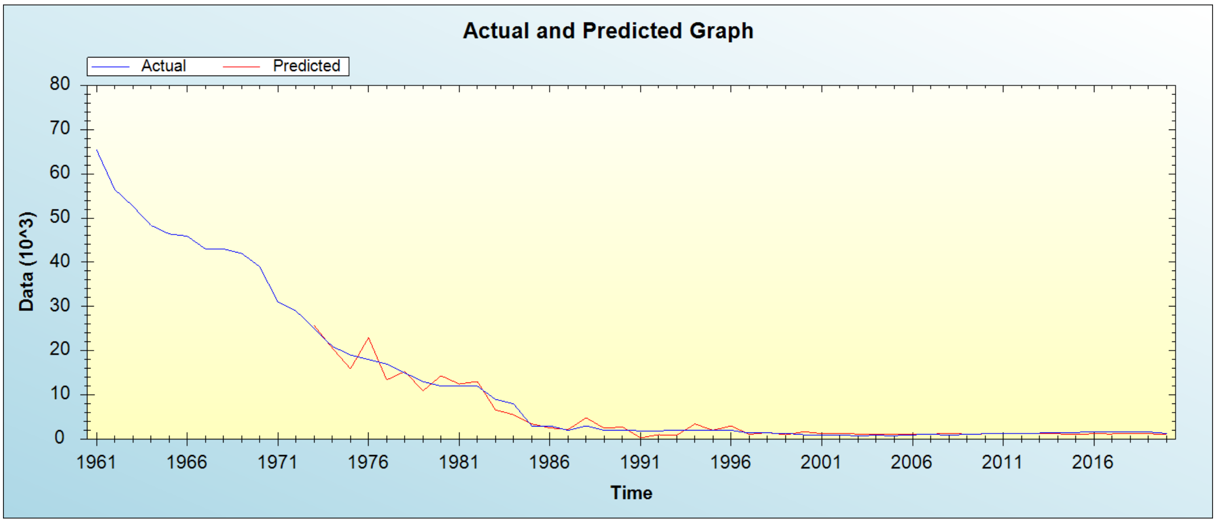

Figure 2. The combined graph of observed and estimated values for number of camel

In Figure 3, when the joint graph of observed and residual values, residual and observed values were found to be scattered free from each other and randomly. This situation indicates that important hypotheses regarding the model are assured.

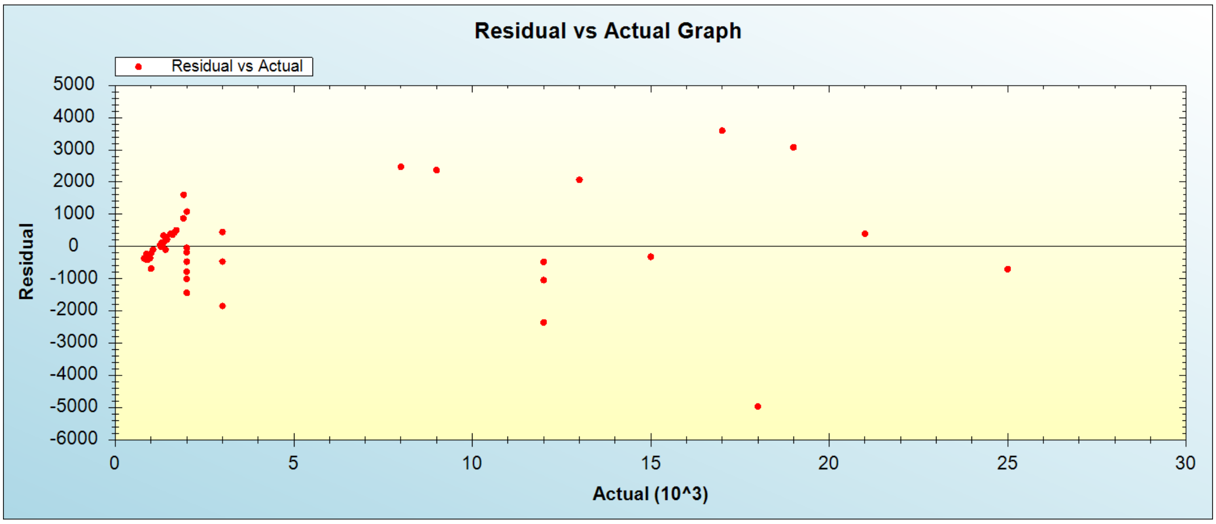

Figure 3. Joint graph of observed and residual values

The possible 2021-2025 number of camel forecasted with ANN is given in Table 3.

Table 3. Number of camel forecasting

Years	ANN
2021	1174
2022	1226
2023	1313
2024	1258
2025	1218

Table 3 indicates that the number of camel will fluctuate between from 2021 to 2025. The graph showing the observed and predicted values of the number of camel is shown in Figure 4.

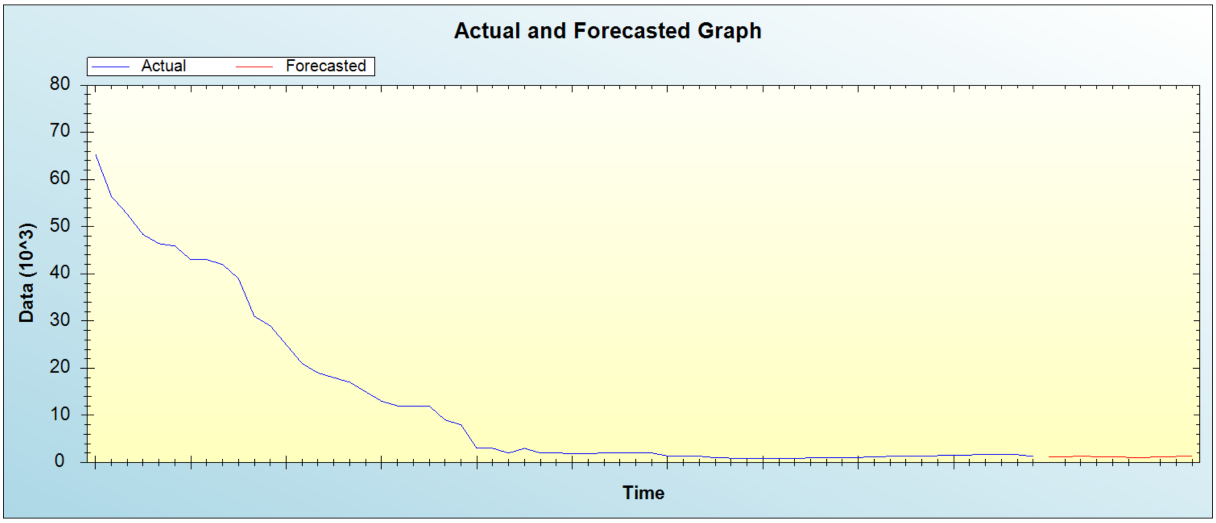

Figure 4. The joint graph of observed and estimated values

In this study, it was obtained suitable model for forecasting with ANN. After using this models, it can be said that forecasted number of camel will fluctuate in future.

Other studies in the field of agriculture with time series and artificial neural networks have also yielded interesting results.

[26] used exponential smoothing with ARIMA models for forecasting banana production in Turkey. In the study, Brown's method was chosen as the most appropriate method. [27] modeled tobacco production in Turkey using artificial neural networks. In this study, model suitability was tested according to MSE and MAE,

and a fluctuating course in tobacco production was predicted for the period of 2020-2025, similar to the estimations in the present study. In a study using time series analysis, fodder crop production was examined and a forecast was made for the period of 2017-2025. The vetch plant was modeled as ARIMA(0,1,1) [28]. In a time series analysis of peanut production in Turkey, ARIMA(0,1,1) model was obtained and the model was used to forecast production between the years 2016-2030. According to the forecast results, it was estimated that the amount of peanut production will increase in this period [29]. Production quantity of orange, tangerine, dried bean and lentil plants was modeled with ANN [30-33]. Regarding camels, a MARS algorithm was developed to estimate the live weight of camels of different breeds in Pakistan. Correlation coefficients were determined between body measurements, and hierarchical cluster analysis was used to classify body characteristics according to camel breeds [34].

III. CONCLUSION

In the present study, artificial neural networks and time series analysis were used to estimate the number of camels in Turkey. Years (1961-2020) were used as input variables, one independent variable was used, and camel number was used as the output variable. In the next stage, the network was trained, tested, and verified, and the estimation process was carried out.

The results obtained revealed that the ANN method gave better estimates than time series analysis. The low MSE and MAE values at the training, testing and verification stages also confirm these results.

Estimation of camel population revealed that the number of camels would decrease by 5.8% and drop from 1293 in 2020 to 1218 in 2025. During this period, however, camel population will decrease in some years and increase in others. In other words, the estimations show that there will be fluctuations in the number of camels.

In general, when compared to time series analysis, it has been observed that artificial neural networks give better results in estimating the available data. Further estimation studies can be conducted in the field of agriculture by comparing artificial neural networks and alternative techniques.

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