*Livestock Studies, 2020; 60 (1): 25-32*

ORIGINAL ARTICLE

LIVESTOCK STUDIES

# A comparative forecasting approach to forecast animal production: A case of Turkey

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**Article History**
Received: 13 April 2020
Accepted: 17 July 2020

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**Key words**
Red meat, forecasting, animal production, comparative method

## Abstract

A number of reasons such as the increase in the world population, changes in the climate due to global warming and pandemic diseases affecting many regions have brought the importance of vegetative and animal production to the agenda, which is necessary for the healthy and balanced nutrition of the societies. Due to the global changes occurring for many years, researchers and policy makers have carried out studies on sustainable agriculture and livestock policies at the national and international level of food supply. In the literature, a limited number of forecasting studies on animal production have been carried out. The aim of our study is to develop a comparative forecasting approach and determine the best forecasting methods and models for each type of red meat (i.e. goat, seep, buffalo carcass, and cattle and calf carcass). Accordingly, we used ARIMA, exponential smoothing and STLF forecasting methods. Quarterly data between 2010 and 2018 published by Turkish Statistical Institute were used. As a result, ARIMA method was successful in forecasting amount of red meat production of cattle and calf carcass, and goat; exponential smoothing method was the best for other red meat resources. On the other hand, STLF method performed better than ARIMA and exponential smoothing methods in the training process of all forecasting models. The results of the study showed that comparing more than one forecasting method rather than using a single method in estimating the amount of red meat production will produce more reliable and accurate results.

## Introduction

Livestock is one of sub-branches of agriculture sector and provides raw materials for different industrial sectors. It is also crucial for societies due to supplying essential nutrients [1]. The livestock sector is an indispensable production branch in terms of adequate and balanced nutrition for people. Basic animal products (i.e. egg, milk and meat) constitute the main protein sources that people have to intake for a balanced and healthy life. Moreover, the existing studies in the literature proved that the amino acids contained in animal products have a very high positive effects on human brain development [2]. In addition, animal products have been used to produce different industrial products for people to benefit from. For example, the hide is used in the manufacture of shoes, bags and belts; the wool in the weaving industry; the feather in bedding industry; the bowl in the production of the suture.

According to the statistical data of the United Nations Food and Agriculture Organization, 35% of gross revenue in the total agricultural sector is covered by the livestock sector [3]. This rate changes in parallel with the level of development of countries. For example, this rate is 49% for EU countries, 43% for USA and 33% for the developing countries. Although Turkey is a rich country for the livestock industry in terms of geographical location, climate and agricultural diversity, Turkey has around 36% of gross revenue in the agricultural sector by their livestock activities. It means that Turkey has a great potential to use its existing resources in producing both plant and animal products and access the desired or targeted level of production (i.e. encouraging sheep and goats meat consumption in the red meat sector and increasing its market share as mentioned in the final declaration of the 3rd Agricultural Forest Council in Turkey [4]). Turkey has been conducting a number of projects for this purpose over the country. With the "Project of Ovine Animal Breeding in the Hands of the People" project carried out by the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies (TAGEM), which is the best example of this purpose, the desired yields per unit have been increased with the breeding studies of the animals within the scope of the project. In addition, the producers in the Turkish agricultural sector aim to reduce raw material costs and increase profits by making crop production to meet roughage needs required by animal production. The vast majority of agricultural companies in Turkey (62.3%) are interested in both plant and animal production. On the other hand, 37.2% of these companies focuses on only plant production whereas the remaining (0.5%) makes animal production [5].

In addition, population has been on the rise in Turkey as well as over the world. The increasing population will increase the demand for basic food resources and livestock-based industrial products. On the other hand, the effects of some factors increase on animal production. For example, it is assumed that global warming will affect livestock system directly and indirectly. Direct effects (i.e. temperature-based disease and death) are assumed to be occurred whereas indirect effects (i.e. feed and water shortage, and the effects of climate changes on microbial population) are considered to be emerged in the livestock systems and animal production [6]. The governments should give importance to the development of the livestock sector in order to meet the basic food needs of population, to ensure the sustainability of economic activities, and to support the farmers. In the light of all these reasons, it is of great importance to anticipate the amount of future animal production and to take necessary measures beforehand.

In this study, we aimed to develop a comparative forecasting approach to determine the best forecasting methods for each type of red meat (i.e. goat, sheep, buffalo carcass, and cattle and calf carcass) to generate more accurate forecasts for red meat production in Turkey. In this context, the data from the Turkish Statistical Institute over the period between 2010 and 2018 were used. Three different forecasting methods were applied: Autoregressive integrated moving average (ARIMA), exponential smoothing (ES) and the function of the seasonal and trend decomposition using loess (STLF). We contributed to the knowledge as follows: 1) Developing a comparative forecasting approach to better understand the future of livestock and animal production in Turkey, 2) Using the STLF method which has never been applied in agriculture and livestock industries before, and 3) Presenting a strategical framework for Turkish livestock and animal production.

Section 2 reviews the related literature and Section 3 presents the comparative forecasting approach and explains methodologies used in the study. Sections 4 discusses results and Section 5 concludes the study, respectively.

## Literature Review

In literature, a number of forecasting studies has been carried out on agricultural sector. A various of studies is related to red meat production. For example, Yavuz and Zulauf [7] proposed a novel estimation method based on biological parameters (i.e. proportion of animals that give birth to twins, average carcass weight and so on). Akgül and Yıldız [8] used ARIMA technique to forecast red meat production in Turkey and discussed a number of recommendations to access the 2023 targets of Turkey. Tutkun [9] presented the overall assessment of red meat production with the last previous year in Turkey and discussed the existing problems and solutions. Alhas Eroğlu et al. [10] developed a forecasting model using ARIMA method for a 10-year projection. In addition, a number of researchers studied on forecasting of dairy products. For instance, Karkacıer [11] analysed a number of variables affecting the import of the Turkish dairy products. Lohano and Soomro [12] applied an ARIMA model including randow walk model with drift and trend-stationary for forecasting milk production in Pakistan and found an annual increase of 4.17%. Kaygısız and Sezgin [13] forecast goat milk production by comparing artificial neural network (ANN), ARMA and ARIMA methods and determined ANN was more successful forecasting technique. Doğan et al. [14] used contingent valuation method to forecast the potential demand of organic milk. Akın et al. [15] evaluated how red meat price affects the chicken meat price in Turkey and determined red meat price and chicken meat price are inversely proportional.

Table 1 shows the past and current studies on forecasting red meat production. A limited studies used multivariate time series forecasting methods which take into account explanatory variables to produce robust and accurate estimates of red meat production or consumption. They applied linear regression, Vector Error Correction Model and the estimation method based on the biology. On the other hand, univariate time series forecasting methods (i.e. ARIMA and exponential smoothing method) were used in a number of studies. In this study, our contribution to the knowledge is to develop a comparative forecasting approach to prove the using more than one forecasting method generates more accurate forecasted results rather than using a single method for different red meat resources. We then included ARIMA and ES methods since these methods have been widely used in the literature. Second contribution is to include a different forecasting method (i.e. STLF) which has never been used in forecasting studies related to agricultural sector.

**Table 1.** Past and current studies on forecasting red meat production. AIDS: Almost Ideal Demand System Model, AIM: Asymptotic Ideal model, DGM: Directed Graph Model, VECM: Vector Error Correction Model, MSE: Mean Square Error, MAPE: Mean Absolute Percentage Error, ES: Exponential Smoothing

| References | Aims | Methods | Type of Methods | Forecast Accuracy |
|---|---|---|---|---|
| Yavuz and Zulauf [7] | Introducing a new approach based on the biology to estimating red meat production | Estimation method based on the biology | Multiplicative | - |
| Wang and Bessler [16] | Short-term forecasting US meat consumption | AIDS, Rotterdam, AIM, DGM and VECM | Univariate and Multiplicative | MSE |
| Yavuz et al. [17] | Forecasting red meat production in Turkey | ARIMA | Univariate | $R^2$ |
| Nouman and Khan [18] | Modelling and forecasting Beef, mutton, poultry meat and total meat in Pakistan | ARIMA | Univariate | $R^2$ |
| Sherafatmand and Baghestany [19] | Determining demand model for red meat and fish in Iran | AIDS, Rotterdam | Univariate | - |
| Akgül and Yıldız [8] | Forecasting red meat production in Turkey | ARIMA | Univariate | $R^2$ |
| Aujla et al. [20] | Estimating beef meat projection in Pakistan | Linear regression, Polynomial price lag models | Univariate and Multiplicative | $R^2$ |
| Özen et al. [21] | Modelling and Forecasting Meat Consumption | ARIMA, ES | Univariate | $R^2$, MAPE |
| Mgaya [22] | Forecasting egg, cattle meat, cow milk and chicken meat in Tanzania | ARIMA | Univariate | $R^2$, MAPE |
| Alhas Eroğlu et al. [10] | Forecasting Beef Production in Turkey | ARIMA | Univariate | - |

## Material and Method

The hypothesis of the study is various forecasting methods can produce more accurate and robust estimates of red meat production for different red meat resources (i.e. goat, sheep, buffalo carcass, cattle and calf carcass).

The limitations of our study are two ways. First is the study used univariate time series excluding some factors affecting the amount of red meat production or consumption. We will take into account this situation in our future work as mentioned in Conclusion Section. Second is the data period is between 2010 and 2018. Thus, our study assumed this time series represent the Turkish red meat sector.

### 1. Data

The data used in this study is extracted from Turkish Statistical Institute (TSI) which records a number of statistics under many themes (i.e. agriculture, foreign trade, inflation & price, population & demography and so on). TSI collects agricultural statistics into six categories: agricultural equipment and machinery, agricultural holding structure, agricultural prices and economic accounts, crop production, fishery and livestock. Statistics related to red meat production are presented by TSI according to types, time period (i.e. quarter, month, year) and region. We used the quarterly data over the period between 2010 and 2018. Figure 1 illustrates data patterns based on type of resources for red meat production in Turkey over the study period. The data were divided into two: training set (75%) and validation set (25%).

A total amount of goat meat over the data period in Turkey is 230262 tones with 925413 tones sheep meat, 10017 tones buffalo carcass and 7879586 tones cattle and calf carcass. A breakdown of all activity for each meat resource is presented in Table 2.

**Table 2.** Number of animal production in Turkey for each meat resource over the study period.

| Types of Meat | Mean | Standard Deviation |
|---|---|---|
| Goat | 25585 | 7662.90 |
| Sheep | 102824 | 14036.69 |
| Buffalo Carcass | 1113 | 1031.82 |
| Cattle and Calf Carcass | 875510 | 160957.99 |

### 2. The Proposed Comparative Forecasting Approach

In this study, a comparative forecasting approach (see Figure 2) is proposed for the purpose of enabling the truer and more reliable forecasts of animal production in Turkey. Our approach is flexible and therefore allows to include any forecasting method to compare each other. We consider two widely used forecasting techniques (i.e. ARIMA and exponential smoothing) along with the function of the seasonal and trend decomposition using loess (STLF) method. The first step is to gather data from Turkish Statistical Institute and extract the related information from the data. The second step consists of forecasting process using forecasting methods. The last step is to compare forecast accuracy value and determine the best forecasting method.

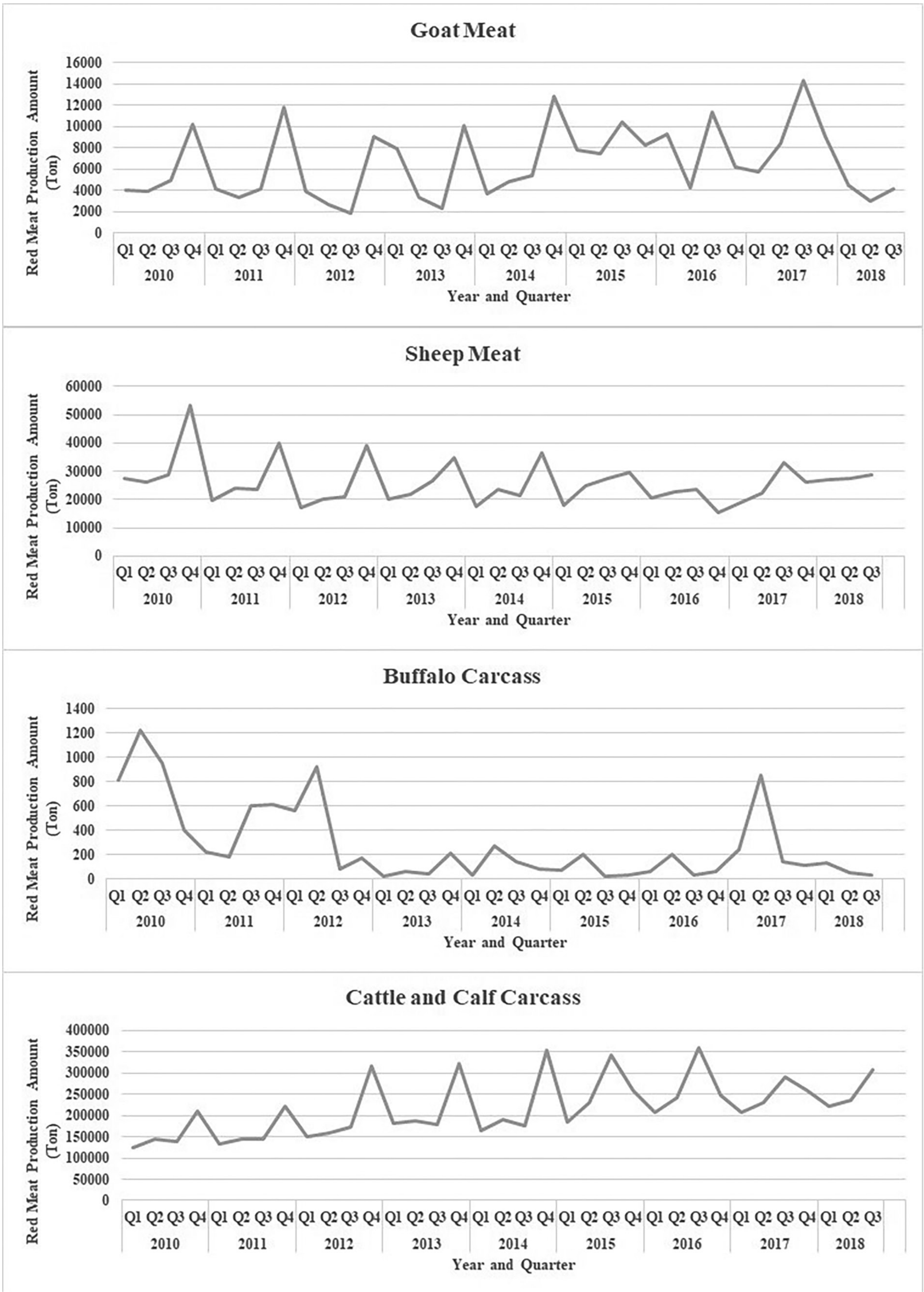


**Figure 1.** Data patterns based on type of resources for red meat production in Turkey over the study period (2010 - 2018)

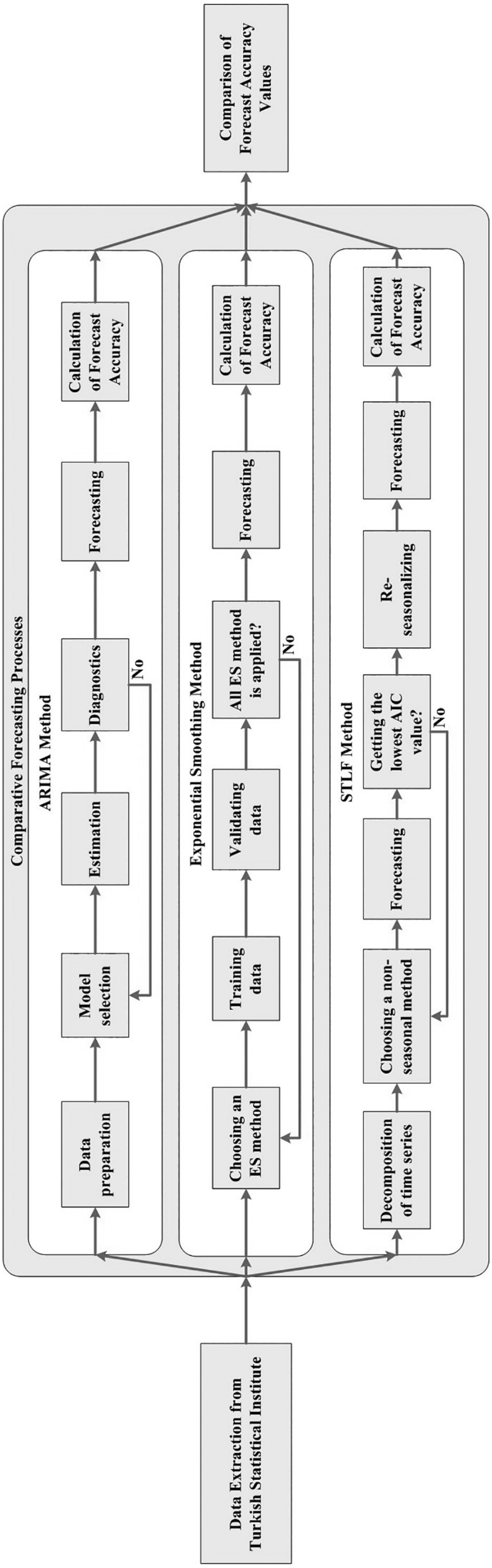


**Figure 2.** The proposed comparative forecasting approach

## 3. Methods

We used three forecasting methods: Autoregressive Integrated Moving Average (ARIMA) Method, Exponential Smoothing (ES) and The function of the seasonal and trend decomposition using loess (STLF). These are explained in greater detail below.

### 3.1. Autoregressive Integrated Moving Average (ARIMA) Method

The autoregressive integrated moving average (ARIMA) method has been widely used and generates forecasts by autocorrelations in the time series [23]. In the ARIMA method, three parameters (i.e. p, d and q) are taken into account and p denotes the order of autoregression, d is the order of differencing and q is the order of the moving average [24]. Firstly, a data preparation section lets to conduct a stationarity analysis. Secondly, p and q parameters are determined in model selection section. p is autoregression that dependent variable at time t depends on previous observation (i.e. at time t-1) while q is moving average that dependent variable relates to error at previous time in the data. The auto.arima package in R developed by Hyndman and Khandakar [25] automatically calculates the values of the parameters. It takes into account Akaike's Information Criteria (AIC) as a criterion to obtain the orders of p and q in ARIMA models. Least squares or maximum likelihood estimation methods are applied to specify the ARIMA models in the estimation section. The diagnostic section presents ARIMA model determined in the estimation section is an appropriate model or not by using the statistical methods (i.e. portmanteau test) [26]. Finally, the estimated values are generated by the selected ARIMA model in the forecasting section.

### 3.2. Exponential Smoothing (ES)

Exponential smoothing method takes into account the larger weights for the closest observation than the furthest one in forecasting [26]. A total of 15 exponential smoothing methods have been developed without the error terms. Along with the additive and multiplicative errors for each ES model, total 30 ES models are available [27]. One of ES methods is selected, and the data is divided: training data and validation data. This process is applied until all ES models are developed for all ES methods. The best ES model is determined using the ets() package developed by Hyndman and Khandakar [25].

### 3.3. The function of the seasonal and trend decomposition using loess (STLF)

The STLF method decomposes the time series using the loess which is known as locally estimated scatterplot smoothing [23]. The STLF method applies a non-seasonal forecasting method (i.e. Holt's method or nonseasonal ARIMA method) to estimate the time series. After getting the lowest AIC value, re-seasonalizing procedure is carried out by using "the last year of the seasonal component" [28]. The STLF method was found as successful forecasting method in some forecasting studies [29].

## Results and Discussion

We developed a total of 12 forecasting models using the modelling framework shown in Figure 2. 4 forecasting models for each type of red meat resource were developed. This process is carried out by applying RStudio software to estimate red meat production. Table 3 gives all forecasting models developed, for example, each data is stationary for goat and sheep meat whereas the related data is needed to be taken first differences of time series in forecasting buffalo, and cattle and calf carcasses. In all ARIMA models excluding one for sheep meat resource, dependent variables do not relate to error at previous time in the data. In addition, the ARIMA model for cattle and calf carcass involves dependent variable depends on previous three observations whereas others are uncorrelated for other time-lags.

The best exponential smoothing method was found to be with additive error, no trend and no seasonality for goat and sheep meat production. In addition, the best ES model involved multiplicative error, no trend and no seasonality for buffalo carcass whereas the best ES model was determined to be with multiplicative error, additive trend and no seasonality for cattle and calf carcass production.

After decomposition of time series, an exponential smoothing method (with different parameters) as non-seasonal forecasting method was applied to forecast the red meat production for all types of meat. Multiplicative error as error term was determined in the applied ES model in the STLF model for goat meat. All ES models used in the STLF models for goat, sheep and buffalo meat resources included different error terms than theirs ES models.

**Table 3.** Forecasting models. ETS: Exponential Smoothing, STL: The seasonal and trend decomposition using loess, A: Additive, M: Multiplicative, N: No

| Type of red meat | Forecasting methods | | |
|---|---|---|---|
| | ARIMA | ES | STLF |
| Goat meat | ARIMA(0,0,0) with non-zero mean | ETS(A,N,N) | STL+ETS(M,N,N) |
| Sheep meat | ARIMA(0,0,1) with non-zero mean | ETS(A,N,N) | STL+ETS(M,N,N) |
| Buffalo carcass | ARIMA(0,1,0) | ETS(M,N,N) | STL+ETS(A,N,N) |
| Cattle and calf carcass | ARIMA(3,1,0) with drift | ETS(M,A,N) | STL+ETS(M,A,N) |

RStudio uses AIC as goodness of fit (or forecast accuracy) to determine the best forecasting model. We also present the corrected AIC (AICc), Bayesian information criterion (BIC) and log likelihood along with Akaike's information criterion (AIC) in Table 4.

Mean absolute percentage error (MAPE) was used as goodness of fit in this study. MAPEs are calculated for both training set and validation set. MAPE values are illustrated in Table 5 for each forecasting model. According to the results, the STLF models are well trained, however, theirs MAPE results for validation sets are the worst for goat, sheep, and cattle and calf carcass. ARIMA method performs than others in forecasting goat, and cattle and calf carcass production whereas ES method provides the best results to estimate sheep meat and buffalo carcass. Figure 3 illustrates the validation graph of the amount of red meat production for cattle and calf carcass.

The livestock sector is an indispensable strategic activity for communities and states over the centuries. Fattening and red meat production are also very crucial for the states to provide a sufficient and balanced amount of food needs of their communities in each step from the production of agricultural products to consumption. This activity is associated to many sectors. Whereas animal production increases red meat production, on the one hand, it also supplies raw materials to many sectors, particularly the manufacturing sector. When we also consider the products that are produced with export focus, it is of great importance for the strategic development of countries. Therefore, countries should have plans with high efficiency and applicability in the period from production to consumption. The right approaches to support the producers will provide the consumer with products that are of good quality and reasonable prices. In order to do this, it is very important to maintain plant and animal production together. At this point, sustainability should be based on the robust planning of production models. Thus, by an efficient and effective planning, it will be possible to get rid of many negative scenarios that may occur. For example, negative reflections of disasters such as global warming, price imbalances, earthquakes, floods, fires and epidemics can be kept to a minimum with the right planning and predictive model. In conclusion, such countries can obtain a serious economic gain by exporting their surplus products to other countries that are caught unprepared in the event of a possible crisis affecting the world.

**Table 4.** Akaike's information criterion (AIC), the corrected AIC (AICc), Bayesian information criterion (BIC) and log likelihood

| Forecasting method | Type of red meat | AIC | AICc | BIC | log likelihood |
|---|---|---|---|---|---|
| ARIMA | Goat meat | 496.50 | 497.02 | 499.01 | -246.25 |
| | Sheep meat | 545.87 | 546.96 | 549.65 | -269.94 |
| | Buffalo carcass | 353.30 | 353.48 | 354.52 | -175.65 |
| | Cattle and calf carcass | 613.95 | 617.11 | 620.04 | -301.98 |
| ES | Goat meat | 507.43 | 507.95 | 509.94 | - |
| | Sheep meat | 557.43 | 557.95 | 559.95 | - |
| | Buffalo carcass | 365.22 | 365.74 | 367.74 | - |
| | Cattle and calf carcass | 657.43 | 659.33 | 662.46 | - |
| STLF | Goat meat | 480.36 | 480.88 | 482.87 | - |
| | Sheep meat | 517.92 | 518.44 | 520.43 | - |
| | Buffalo carcass | 371.55 | 372.08 | 374.07 | - |
| | Cattle and calf carcass | 631.45 | 633.35 | 636.48 | - |

**Table 5.** Mean absolute percentage errors (MAPEs). TS: Training set, VS: Validation set

| Type of red meat | Forecasting methods | | | | | |
|---|---|---|---|---|---|---|
| | ARIMA | | ES | | STLF | |
| | TS | VS | TS | VS | TS | VS |
| Goat meat | 59.69 | **40.04** | 59.70 | 40.05 | 31.32 | 52.44 |
| Sheep meat | 20.99 | 20.71 | 22.92 | **19.71** | 12.58 | 32.23 |
| Buffalo carcass | 169.84 | 202.38 | 237.90 | **99.53** | 131.86 | 109.28 |
| Cattle and calf carcass | 11.92 | **15.01** | 22.81 | 17.72 | 11.04 | 24.14 |

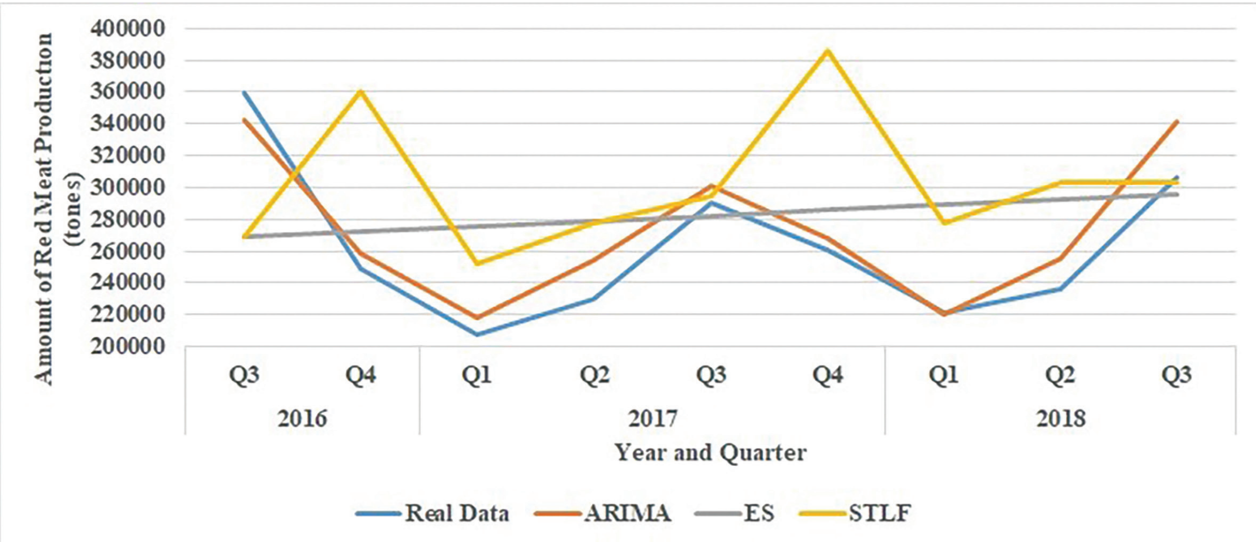


**Figure 3.** The validation graph of the amount of red meat production for Cattle and Calf Carcass

## Conclusion

The livestock sector and the chain from production to consumption in this sector are very important for the development of countries and for the societies to provide healthy and balanced nutrition and development. For example, countries set themselves as the target of making value added productions in many fields for economic development, and for this purpose, they produce innovative and high-economic products in many fields. Undoubtedly, the livestock sector has an indispensable importance for the development of the country. This importance covers a wide range from rural development to the economic development of the country.

This study indicates that the usage of a comparative forecasting approach might produce more accurate forecasted results for animal production instead of using a single forecasting method. The results show that the best animal production estimates are generated by using ARIMA method for goat, and cattle and calf carcass. This study addresses that policy makers will need to consider different forecasting techniques to better estimate animal production.

Our study proved the various forecasting methods can be more suitable techniques for different red meat resources. Therefore, all stakeholders in forecasting processes can include the most appropriate methods to their works, for example, along with univariate forecasting techniques, multivariate time series forecasting methods such as artificial neural networks, regression analysis, data mining or deep learning. We are planning to compare univariate and multivariate forecasting methods for our future studies.

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