Minimizing losses at red meat supply chain with circular and central slaughterhouse model

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MINIMIZING LOSSES AT RED MEAT SUPPLY CHAIN WITH CIRCULAR AND CENTRAL SLAUGHTERHOUSE MODEL

Abstract

Purpose: The aim of this paper is to find solutions to improve the red meat sector in an emerging economy, Turkey, from the circular economy point of view, and taking sustainability approach. The need for circular management within the red meat sector in Turkey is emphasized by using Grey method. As theoretical contribution of this study, the investigation of the causes of losses at the slaughter stages of the red meat supply chain leads to proposals for sustainable and circular solutions.

Design/methodology/approach: Grey Method is used to predict the number of slaughtered cattle and the amount of bone and blood waste in the slaughtering process between 2018-2020.

Findings: It is revealed that according to Grey prediction calculations, although the amount of slaughtered cattle, bone and blood waste seem have decreased between 2018-2020, there are still significant losses in Turkish red meat sector. For bone waste, this is expected to be 56,581,200 kg in 2018, 48,235,840 kg in 2019 and 41,121,380 kg in 2020. For blood waste, it is expected to be 24,754,275 kg in 2018, 21,103,180 kg in 2019 and 17,990,604 kg in 2020.

Originality/value: This paper represents policymakers with a proposal for triple bottom line based circular and central slaughterhouse model, based on triple bottom line, which brings social, economic and environmental benefits for the red meat sector in Turkey.

Key Words: Circular Economy, Emerging Country, Red Meat Loss, Food Supply Chain, Sustainability, Grey Prediction

1. Introduction

In recent years, combating food loss and waste has become a major societal challenge throughout the world. Especially, the implementation of circular business models and policies can make sustainable contributions to this initiative in a sustainable way by conserving limited natural resources, and by reducing greenhouse gas emissions (GHGe) (Sharma et al., 2019; Ali et al., 2019). Food loss and waste refers to the decrease in the amount of edible food from plants and animals that are harvested or produced for human consumption across all stages of the food supply chain (Lipinski et al., 2013; Sawaya, 2017; Verma et al., 2019). Food loss and food waste occur at different stages in the food supply chain (Salihoglu et al., 2018).These terms have different meanings: food loss is defined as the reduction in quantity or quality of food at the pre-consumer stages in production, postharvest and processing, whereas food waste is the removal from the food supply chain of food which is appropriate for human consumption, or which has spoiled or expired for various reasons, mainly due to economic behavior, poor stock management, or neglect at the consumer stages in food services and household (Parfitt et al., 2010; Grimm et al., 2014; Aktas, et al., 2018; Mangla et al., 2018). From this point of view, both food loss and waste have a serious impact on the sustainable development in terms of environmental, economic and societal aspects (FAO, 2013a). According to the U.N. Food and Agriculture Organization (FAO), one-third of the edible parts of food production lost or wasted, approximately 1.3 billion tons worldwide annually; furthermore, almost half of all fruit and vegetable production wasted before reaching consumers (FAO, 2011). Moreover, many food issues including safety, hygiene, temperature control, and trace & tracking seriously impact human health, and cause economic loss for farmers and businesses, and consequently, restrict food access to the poor in both develop and developing countries (Verma et al., 2019). Food is wasted at all stages of the food supply chain, between initial agricultural production, and final household consumption; during transportation and distribution, in production, postharvest, processing, in storage, at restaurants, and in markets. This waste costs around $680 billion in developed countries and $310 billion in developing countries (FAO, 2011). The most significant food loss and waste from farm to fork occurs in early and middle stages of the food supply chain (close to the farm) in developing countries, whereas mainly at later stages at the retail and consumption (close to the fork) in developed countries (Parfitt et al., 2010). In Europe and the US, a greater amount of food loss and waste at the consumer and pre-consumer stage than in the rest of the world. Global quantitative food loss and waste is raising (FAO, 2011) and account for roughly 30% for cereals, 40-50% for root crops, and fruit and vegetables, 20% for oil seeds, meat and dairy, and 35% for fish per year. Also, this waste and loss causes about 4.4 gigatons of GHGe annually (FAO, 2011), almost four times greater than generated in aviation industry, and is comparable to emissions from all road transport. The challenges in each stage of food supply chain need to be measured to ensure appropriate interventions as part of overall food security practices. From this perspective, food loss and waste not only create a distortion in food availability and exacerbates rising food prices, but also puts excessive pressure on the environment. Avoiding food loss and waste would therefore avoid unnecessary GHGe and help mitigate climate change.

It is essential to focus on sustainability to reduce losses in the food supply chain (Ali et al., 2019). In this study, losses in the red meat supply chain are investigated, since this is an important area in an emerging economy, like Turkey, in which agriculture and livestock are major sectors (FAO, 2013b). The red meat sector has structural problems in Turkey, including the informal nature of slaughterhouses, lack of knowledge about slaughtering processes, uneducated employees, unhygienic conditions, and inadequate governmental policies (Us, 2010). Previously implemented governmental policies were not effective in the long term because they did not consider the structural problems and were limited to import regulations. The governmental regulations were based on linear economy and provided no long-term benefits in terms of sustainability, leaving a problematic environment in the red meat sector. Thus, the problematic structure of the red meat sector in Turkey, continues to cause social, environmental and economic impacts.

Hence, this study stands on the research question of how to improve the red meat sector from circular economy perspective and sustainability approach. The study proposes models to find sustainable solutions by investigating the causes of losses at the initial stages of the red meat supply chain, and specifically, the slaughtering process. By considering the related literature, although there are many studies about prevention of food loss, these studies are either limited with current state analysis or focusing solely on environmental solutions (Gobel et al., 2015; Kummu et al., 2012; Parfitt et al., 2010; Verghese et al., 2015). In addition to that, a food supply chain needs to meet sustainability concerns based on TBL to reduce food losses, energy consumption while to increase social and economic welfare (Foran et al., 2005; Fritz and Schiefer, 2008; Kucukvar et al., 2019; Miemczyk and Luzzine, 2019; Tsolakis et al., 2018).

Moreover, according to Sgarbossa and Russo (2017), waste should be reused as raw material to prevent disposal of valuable wastes. In addition, circular economy is not only about reducing the waste which damage on environment, but also about reusing of waste as new input in food supply chain (Genovese et al., 2017; Secondi et al., 2019).

Furthermore, the sustainability of a food supply chain involves being circular such as reusing wastes as resource (Jurgilevich et al., 2016). In addition, the sustainability of food supply chain depends on the recycling operations and the circularity of waste management (Borrello et al., 2017; Ciulli et al., 2019; Cristobal et al., 2018).

Therefore, the purpose of the study is trying to find the best solution to avoid food loss with the help of a new model on slaughterhouse which is sustainable and meeting circular concerns. To sum up, with this study, the gap in practical solutions for food waste in food supply chain is tried to be filled by proposing a sustainable and circular slaughterhouse model. Therefore, in this study, after a prediction of the amount of slaughtered cattle and bone and blood waste caused by slaughtering process, and a new model is proposed based on sustainability for the Turkish red meat sector to decrease supply chain losses.

In this study, Grey prediction is used to forecast the number of slaughtered cattle, and the amount of bone and blood waste caused by slaughters. Grey prediction method is practical in case of limited data and uncertain environment. In other words, grey prediction is based on uncertainty and limited data set, and not past observations like fuzzy time series method (Tien, 2009). When there is problematic environment and information inaccuracy, grey prediction method is more appropriate than fuzzy time series (Tien, 2009). Thus, Grey method is better suited for predicting potential losses due to the problematic environment of the meat sector in Turkey, and this forecast can be a basis for solutions that reduce potential losses.

Moreover, the traditional forecasting methods for time series are based on accessible and practical data (Song and Li, 2008; Wen, 2004), and is therefore unviable for limited data and problematic environment (Wen, 2004). Grey Prediction is more suitable than traditional methods for predicting values that emphasizes the rapidly increasing losses in slaughtered cattle and by products i.e. bone and blood.

Therefore, based on the expected number of slaughtered cattle, and losses, calculated by the Grey Prediction method, we may arrive at permanent and sustainable solutions essential for the red meat sector in Turkey.

Before explaining methodology, literature review about sustainable supply chain management, sustainable food supply chain and meat supply chain are explained in detail in the following section.

2. Literature Review

In this study, literature review focuses on sustainable supply chains, food supply chains and meat supply chains.

2.1. Sustainable Meat Supply Chain Management

Sustainability and sustainable supply chain management has increased in importance due to concerns about the environment. Sustainability has become an important concept for developing country, confronting overpopulation, health issues, political issues, and meeting growing needs with limited resources (Mensah and Castro, 2004). These problems affect the countries economically, socially and environmentally, and it is crucial to consider sustainable solutions to avoid serious adverse consequences.

"Sustainability is defined as maintaining the ability to be permanent while ensuring the continuity of diversity and productivity as a term" (Business Dictionary, 2018). According to Brundtland Report which is published by the World Commission on Environment and Development (WCED) in 1987, sustainable development is defined as "the desire to develop the environmental and social performance of the current generation without ignoring the ability of the next generation to meet the social and environmental needs" (WCED, 1987). Sustainable supply chain management is a specific approach that seeks to provide the requirements of social, environmental and economic dimensions in the flow of materials and services between the supplier, the producer and the client, by focusing on creating value for all stakeholders (Ince and Ozkan, 2015). Moreover, sustainable supply chain considers not only economic, but also social and environmental effects on supply chain operations, i.e. the "triple bottom line" (TBL), in sustainable point of view.

According to Elkington (1997), environmental sustainability covers "planet" issues, such as reducing air pollution, avoiding waste, considering emissions and hazardous materials; economic sustainability covers "profit" issues such as market share, profit maximization, financial conditions; and social sustainability covers "people" issues, such as living conditions, job opportunities, educational and healthy working conditions.

In this study, meat losses in supply chain are mentioned. Therefore, food supply chain is crucial issue for this study.

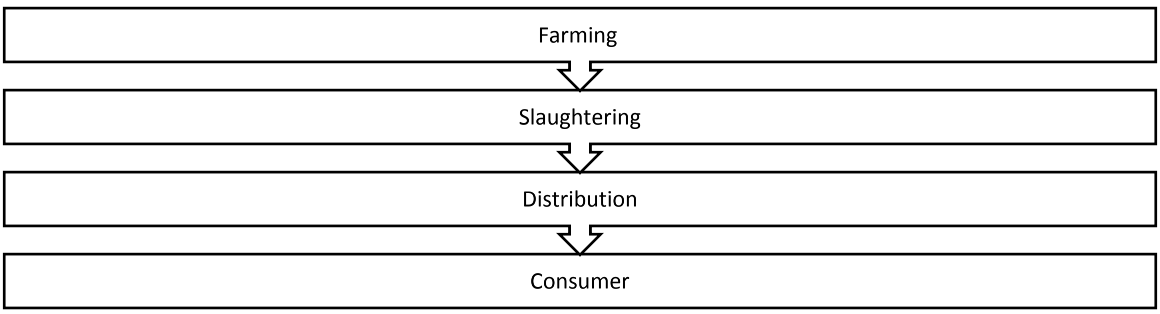
A food supply chain includes processes from food production to consumer (Bendeković et al., 2015), and comprises various products and firms selling food products or operating in the markets (European Commission, 2014). Food supply chain, from production to consumption, is facilitated by logistics and transport companies (Dani, 2015). The most important duty of logistics and transportation companies is to deliver the food to the consumers in a timely and accurate manner. Food supply chain includes food producers, food processors, i.e. food manufacturers, retailers and distributors as well as hospitality sectors, which create links between producer and consumer (Dani, 2015).

It is crucial for food supply chains to be sustainable in current world conditions (Smith, 2008). Sustainability and quality can be achieved by “Triple Bottom Line (TBL)”; in other words, sustainable in terms of social, environmental and economic factors.

There are many studies about sustainable food supply chain in the literature. For instance, Pullman et al. (2009) studied sustainable food supply chain from the environmental and social point of view, Zanoni and Zavanella (2012), focused sustainable supply chain based on decision strategies. In 2008, Fritz and Schiefer studied sustainable food chain management, and Darkow et al. (2015), the sustainable food service supply chain. In 2010, Akkerman et al. studied sustainability in food distributions. Sgarbossa and Russo (2017) suggested a Closed-Loop Supply Chain model for sustainability in food sector. Becker and Ellis (2017) focused on sustainability in food supply chain. Additionally, Parfitt et al. (2010) analyzed waste in the food supply chain, particularly losses in the meat supply chain which is important for the current study.

Red meat and products, which have an important place in human nutrition and health, are among the basic foods to meet the need for animal protein (FAO, 1992). Red meats are obtained from butchery animals such as cattle, sheep, goats and pigs worldwide. Since red meat products are perishable, the management of supply chain process is critical. The red meat supply chain consists of farming, slaughtering, distribution and consumer stages. In Figure 1, the meat supply chain is shown.

Figure 1 Meat Supply Chain (USDA, 2015)



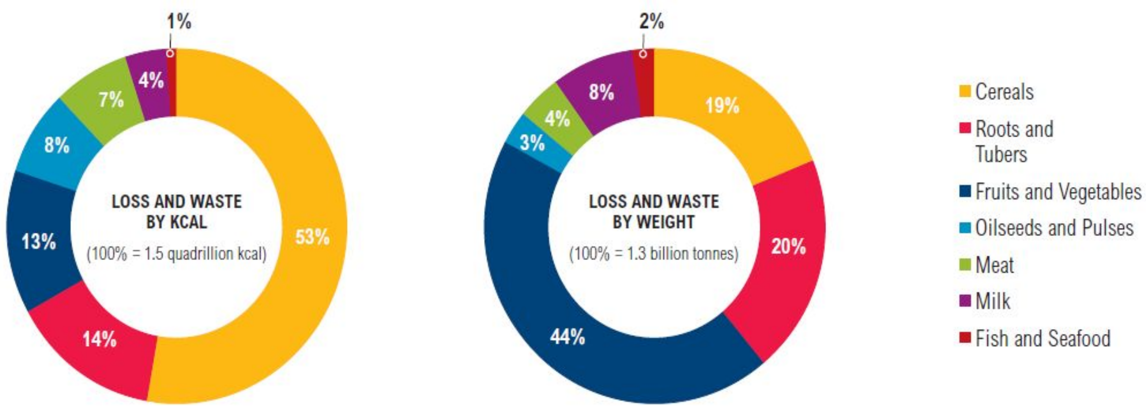
The meat supply chain begins with breeding, and in farming process, the animal is fed and raised to be sent to the slaughterhouse. After feeding and growing by the producer, carcass meat production starts with the purchase of live animals from the producer, and it is the health of the animal and its quality of meat is checked by veterinary control (USDA, 2015). The slaughtering process includes cutting, packaging and storage in cold depots. Then the head and feet of the animal is separated from its body by cutting process, and blood is poured. The skin of the carcass is stored at 4-6 ° C in cold storage depots (USDA, 2015). Products such as bone, cartilage and blood, which appear as residues from meat production, are referred to the rendering process for evaluation in the feed industry (USDA, 2015). After the manufacturing process, carcass meat is sent to retailers or food services and eventually reaches the consumer on food.

In the following part, meat loss and animal waste are explained by considering circular economy.

3. Preventing Meat Loss by Circular Economy

Not all food loss or waste is equally wasteful. Different types of food waste cause various degrees of adverse externalities to society, economy and the environment. Particularly, livestock production is relatively natural resource, as well as the most carbon intensive industry, according to emission intensity factor, with 2.58 kg CO2eq/$, higher than the direct production of all other foods for humans (Borello et al., 2016, Boehm et al, 2018). Therefore, it has greater negative environmental impacts associated with fueling climate change, polluting landscapes and waterways (Abecassis et al., 2018). This energy intensity, combined with the high production cost of meat, may indicate that reducing meat loss and waste should receive at least as much attention as other commodities, despite its relatively small share of food loss and waste (Searchinger et al., 2013; Sawaya, 2017). Although meat waste, only 7 percent, to relatively lower than fruit and vegetables, seen in Figure 2 (Lipinski et al., 2013), meat waste causes by far the most CO2e.

Figure 2 Shares of Global Losses and Waste by Commodity (Lipinski et al., 2013)



In the case of meat and meat products, consumption rates and waste proportions per capita are highest in industrialized countries. This waste at the consumption level account for approximately half of total meat loss and waste (FAO, 2011). However, the amount of energy required for meat production is significantly higher than for plant-based food production because farms use a lot of diesel fuel and other utilities from fossil fuels in order to feed and maintain livestock, and plant and harvest animal feed crops. If meat and meat products are wasted during purchasing and preparing stages, these fuels as well as fertilizers are also wasted. Avoiding consumption of meat would significantly reduce associated GHGe in food system (Boehm et al, 2018; Xue et al., 2019). Consequently, not only the amount, but the types of food being wasted is an important consideration.

Meat is generally subject to a long production and distribution chain, and as a product it can be adulterated with other animal meats, and easily contaminated with bacteria. As a relatively sensitive product, meat is highlighted by major food crises and safety scandals, such as the BSE (or commonly called mad cow disease), Escherichia coli contamination, avian flu, and replacing beef with horsemeat, or pork meat contained halal products (Marucheck, et al., 2011, Stamatis et al., 2015). Meat can quickly become wasted, unless properly processed in the system with proper storage, handling and distribution of the meat product. Above mentioned inefficiencies of meat the economy cost trillions of dollars globally, and even more if social and environmental cost are added. On the other hand, there is increased public awareness about the origin and quality of meat. Therefore, establishing transparency in meat supply chain is necessary to guarantee the safety, quality and consumer faith in meat products (Kassahun, et al., 2014). Furthermore, implementing circular economy in food supply chain can be a solution to tackle the meat waste problem. The circular economy briefly means reuse, repair, refurbishing and recycling of the existing materials and products, so that wastes, become a resource (Jurgilevich et al., 2016; Jakhar et al., 2018). The goal of circular economy is to generate more value and economic opportunity with less material and energy consumption (Jakhar et al., 2018; Sharma et al., 2019). More specifically, progress towards circular economy in food production system means waste prevention, better recycling, and sustainable management of nutrients. The circular food economy aims at the efficient use of resources, as well as creativity in inventing uses for food waste and food surplus (Jurgilevich et al., 2016). Meat waste at the pre-consumer and consumer stages can be evaluated in the frame of circular economy, although some regulations and laws prohibit meat waste processing, which can limit the possibility of achieving a fully circular system in the meat supply chain (Borello, 2016).

In the following section, animal waste based on byproducts is explained in detail.

3.1. Animal Waste

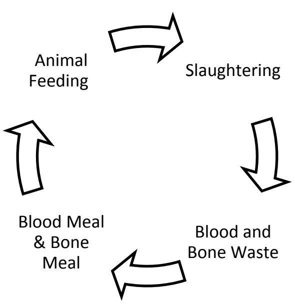
Disposal of waste in the food processing industry or by-product management causes problems in terms of sustainability (Russ and Pittroff, 2004). For a sustainable environment, a waste management system should be established to provide economic benefits to individuals and countries, helping to minimize the harmful effects of degraded materials on the environment and human health. It is important to classify waste according to its source, composition and properties; to design, install and operate collection, transportation and disposal systems; to integrate recoverable substances into the economy, and to produce energy from these wastes.

Animals can play an important role in the meat supply chain, by turning food waste into edible proteins. Animal wastes consist of feces of animals such as cattle, horses, sheep and chickens, dead animals, slaughterhouse losses and waste generated during processing of animal products (Jayathilakan et al., 2012). Although there are wastes caused by animal deaths, most of the animal wastes occur during slaughter in the meat industry (Jayathilakan et al., 2012).

Slaughterhouse waste consists of inedible parts of animals obtained from meat and blood, bone, and other animal by-products (Franke-Whittle and Insam, 2013). Inedible animal tissues (tendons, organs, blood vessels, integers, bone, feathers, ligaments) correspond to almost 50% of the slaughtered animal (Franke-Whittle and Insam, 2013). The two main uses of traditional waste as fertilizer or animal feed (Russ and Pittroff, 2004). However, many slaughterhouse wastes are generated worldwide, and these wastes are improperly disposed of because they are too costly to utilize in the sector. Such practices cause environmental problems (Arvanitoyannis and Ladas, 2008). Instead of other wastes of by-products, blood and bone are crucial resource for animal husbandry in terms of feed, including protein and iron (Jedrejek et al., 2016). The share of blood and bone by-products is 3,5% and 8% respectively (FAO,1992).

In addition, blood and bone from animal wastes arising in slaughterhouses are important in terms of their potential as raw material for fertilizer, animal feed, biodiesels or raw material for other sectors, such as medicinal, furniture, pharmaceutical (Jedrejek et al., 2016). In Figure 2, the cyclical nature of blood and bone wastes is shown. Blood and bone wastes from animals can be converted into animal feed or fertilizer.

Figure 3. Circular Motion of Blood and Bone Waste



Animal blood contains high levels of iron and protein and is an important edible by-product for animals (Jedrejek et al., 2016). On the other hand, when compared with other slaughtering process wastes blood has the highest pollution load (FAO,1992). Blood can be used as fertilizer and feed. Blood is used as blood meal in animal feed (Jayathilakan et al., 2012). Protein supplementation is used as a milk substitute, vitamin stabilizer etc. (Jayathilakan et al., 2012). Moreover, blood can be used in other sectors, such as medicinal, biodiesels and pharmaceutical.

Furthermore, bone is another slaughterhouse animal waste. Bone meal is a source of minerals, amino acids, and vitamin B12 in animal nutrition. Bone meal-processed protein products have the potential to be used to make cutlery handles, and collagen i.e. uses other than animal feed, and is also used as poultry feed (Auvermann et al., 2004; Irshad et al., 2015). In addition, bone is a raw material for other sectors, such as furniture and medicine.

In the following section, meat loss in Turkey is explained in detail as problem definition.

4. Problem Definition

In this part of the study, general information about meat sector in Turkey is given and the meat sector in Turkey is analyzed in detail.

4.1. Meat Sector in Turkey

Turkey is an agricultural country, which has valuable agricultural resources, and the food industry is the major sector (Ministry of Food, Agriculture and Livestock, 2018), and essential for the economy. Animal husbandry has a prime position within Turkey's economy for two reasons. It provides a balanced diet and its outputs can be used as raw materials in many sectors (Ministry of Food, Agriculture and Livestock, 2018).

Livestock, i.e. animals raised on farms for commercial sale, includes cattle, sheep, goats, cows, and chickens (Thorntons, 2010). The products that are required for human health and nutrition are animal products. Especially, red meat is a common source of protein, iron, zinc and contains

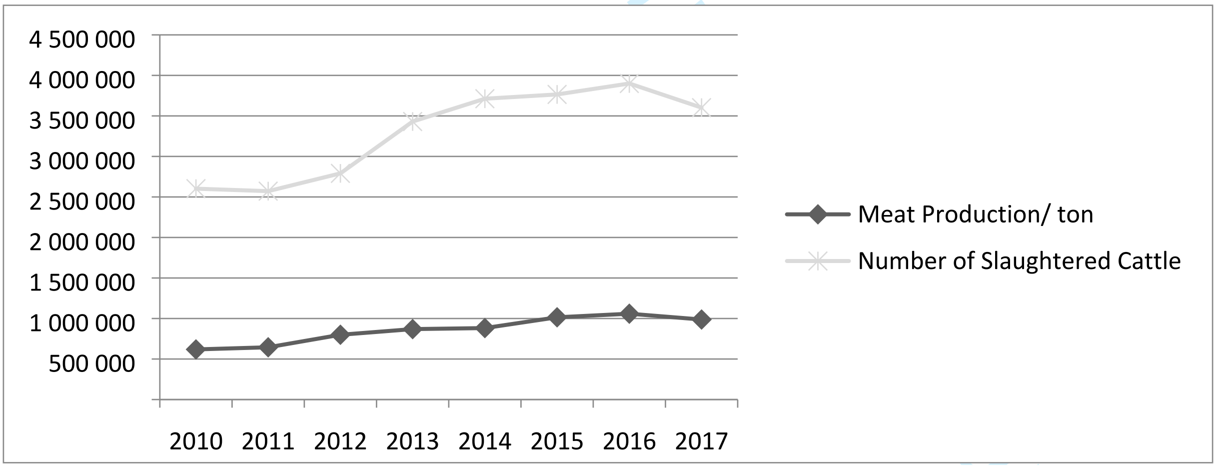
B group vitamins (Sharma et al., 2013). It helps to decrease the nutritional deficiencies and is the most valuable source of animal protein. Moreover, it is often consumed because its benefits are known in Turkey. Red meat are cattle, sheep, buffalo in Turkey (Us, 2010).

Cattle accounts for 88% of the total red meat production in Turkey. Moreover, according to FAO statistics, Turkey accounts for 12% of the EU cattle population with only France and Germany having greater number (FAO, 2017). For this purpose, the article is focused on importance of cattle for Turkey.

Cattle has the benefits such as year-round milk production, its suitability to different climatic zones, and economic value of its meat. To these reasons, cattle is more important than buffalo and sheep for Turkey. In addition, according to FAO data, cattle raising provides 83% of world milk production and 21% of meat production in 2016, and it has a large share in nutrient production (FAO, 2017).

According to TUIK (2018) data, the meat production (tons) and the number of slaughtered cattle in Turkey is shown in Figure 4.

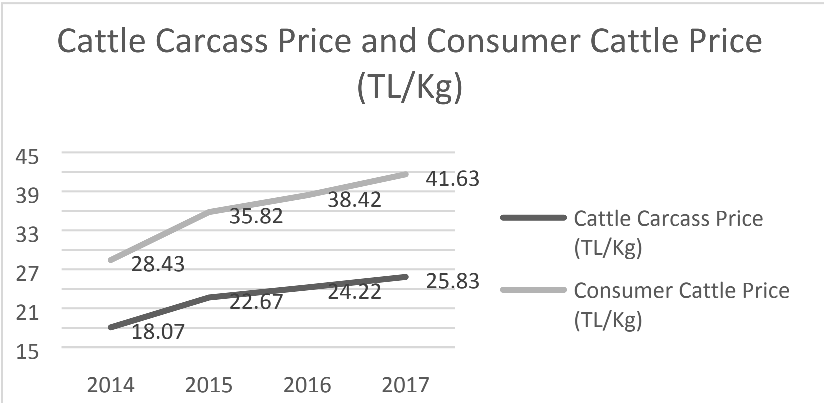
Figure 4. The meat production (tons) and the number of slaughtered cattle in Turkey (TUIK, 2018)



As seen in Figure 4, the number of slaughtered cattle increased between 2010 and 2014. Due to the livestock import regulation applied by the government in 2010 to meet increasing red meat demand in Turkey. However, the import regulation failed to meet demand in Turkey, since the slaughtered animals could not be replaced due to increased input costs, such as feed, medicine, fuel. Moreover, in addition to domestic animals, imported livestock are also slaughtered. However, this regulation was insufficient due to the relatively increasing demand. After that, in order to decrease red meat prices in Turkey and to meet customer demand from consumers, carcass meat import regulation was permitted by the government on August 2014. Import regulation temporarily increased the amount of meat available and reduced prices, but after 2014, the number of slaughtered cattle stabilized, and meat production decreased. In 2017, total amount of red meat production decreased to 982.487 tons, and the number of slaughtered cattle decreased to 3,602,115 (TUIK, 2018). According to TUIK (2018) data, countries that imported carcass meat to Turkey are as follows: Poland (83%), France (14%) and others (3%).

Import regulation failed to reduce meat prices, its main aim. Cattle carcass meat prices and consumer cattle prices are shown in Figure 5.

Figure 5. Cattle Carcass Meat Prices and Consumer Cattle Prices (TUIK, 2018)



As shown in the Figure 5, for 2014, 2015, 2016 and 2017, cattle carcass prices are calculated as 18.07 TL/kg, 22.67 TL/kg, 24.22 TL/kg and 25.83 TL/kg respectively. Moreover, consumer cattle prices are calculated as 28.43 TL/kg, 35.82 TL/kg, 38.42 TL/kg and 41.63 TL/kg (TUIK, 2018).

As seen in the figures, the Turkish red meat sector has structural problems that cannot be resolved by just establishing import regulations. The red meat sector in Turkey based on local farmers and local producers; fluctuations in the production of local farmer and producers cause structural problems and, problematic environment. Although the governmental subsidies and support for livestock has increased, untrained the uneducated employees and the continuation of migration to the city are the obstacles to the sector (Aydogdu and Kucuk, 2018). In addition, after import regulations, dependency on other countries, and the lack of enthusiasm of local farmers and producers cause problematic environment in Turkey. Two major regulations regarding Turkey's red meat sector, have added to difficulties for local farmers and producers in Turkey. One was livestock import in 2010 and the other was carcass red meat import in 2014. Important fact for Turkey's red meat sector are animal deaths resulting from the disease, inadequate governmental controls, lack of attention to hygiene, the informal nature of slaughterhouses, lack of knowledge about technology and slaughtering processes, and the losses and wastes due to the absence of regulation (Ministry of Food, Agriculture and Livestock, 2018). Furthermore, by-products i.e. skin, blood, bone, feet, fatty issues are disposed of in Turkey, although most can be used as raw material in other sectors, e.g. production of biodiesel or feed for animals. Especially, bone and blood waste can be transferred to feed, fertilizer or raw material in other sectors (Jayathilakan, 2012). For all these reasons, the number of animals decreased, and losses in the meat sector increased due to improper cutting procedures, unhygienic conditions, informal slaughterhouses, and lack of trained labor. Turkey's competitive advantage is low in the sector since cause a confused environment. To sum up, chaos in Turkey's red meat sector in Turkey was caused by structural problems that were not adequately addressed by the livestock import in 2010 and carcass red meat import in 2014 legislation. These solutions were part of the linear economy, and did not consider sustainability, and eventually did not work out. Therefore, local farmers and local producers lost their source of income. According to FAO Turkey (2013b), the biggest meat loss occurs in the initial stages of meat supply chain at the level of farmer, slaughterhouse and meat processor in Turkey, and this loss accounts for about 10%. Small and fragmented farms, and lack of cooperation culture are generally indicated as the most important reasons for food losses. Nonetheless, new production systems for sustainable agriculture are much more knowledge intensive, requiring farmers to learn to use additional technologies, management methods, risk avoidance plans, financial literate and familiar with environment protection practices (Jöhr, 2012). Most farmers use still traditional methods with outdated farming practices, and avoid using new agricultural system and technologies (Salihoglu et al., 2018). Furthermore, the aging of Turkish farmers is an important issue since the young generation tends give up farming and move to cities, likewise, many developing countries suffer the same phenomenon: a massive brain drain from rural to urban areas (Jöhr, 2012, FAO, 2013b).

As mentioned before, the structural problems of the sector, and temporary solutions such as import regulations, not only made the country dependent on imports, but also failed to stop the increase of consumer meat prices. This damaged farmers' income sources and decreased productivity in meat production. In this study, it is aimed to find solutions for the structural problems in the sector and to provide additional income sources via circular and sustainable approaches. From the point of circular view, bone and blood waste, discussed in the Animal Waste Section, will be examined here.

To do so, firstly, it is crucial to predict the number of slaughtered cattle, and secondly, the amount of bone and blood waste caused by slaughtering process, to create a roadmap for eliminating meat sector losses, and benefit from byproducts based on sustainability goals.

This study is an investigation of the effect of irregularities and problems in the red meat sector. In the literature, there are studies about consumption of the red meat in Turkey (Adisen, 1999; Atay et al., 2004, Yaylak et al., 2010), consumer perception in red meat sector (Tosun and Hatırlı, 2009; Saçlı, 2018), analysis of red meat prices based on regions in Turkey (Kan and Direk,2004). However, here is a notable lack of forecasting-based studies relating to the red meat sector in Turkey. For this purpose, the losses from structural problems, inappropriately trained cutters, lack of technology, and loss of byproducts (blood and bone) is revealed with numeric data.

Therefore, in this study, Grey method is used for the prediction of the amount of slaughtered cattle, and bone and blood waste, to emphasize the growing problems in red meat sector in Turkey. Grey method is expedient method for explaining the potential problems from losses due to the fluctuating environment in the sector in Turkey. Grey System Theory (GST) is appropriate for discrete data and uncertain systems, since GST is related with incomplete information in the research area (Song and Li, 2008; Liu et al., 2012). Moreover, grey prediction method is practical for dealing with inaccuracy and partial knowledge, as in the real world (Wen, 2004; Liu and Forrest, 2007).

Moreover, traditional estimation methods include Box Jenkins methods, regression analysis, or neural networks. In order to get correct results these methods require large scale statistical data (Chiang, 1997; Song and Li, 2008). However, the mixed and problematic structure in the Turkish red meat sector makes it difficult to predict the actual losses in by-products, preventing the use of traditional statistical methods. In addition, the method is appropriate for the study since the analysis includes analysis of error, which is low in this study, to indicate the reliability of the method, as mentioned in Grey Prediction Section.

Furthermore, other alternative methods for example system dynamics modelling can be used for problematic problems in uncertain environment (Sterman, 2000). Dynamics system modelling is similar to Grey Prediction in that it is more reliable (Lyneis, 2000). It was designed to understand the behavior of the systems (Aiguer et al., 2013). “Dynamics” refers to “changing over time” (Barlas, 2002) and can be used in many different fields, e.g. social science, engineering and economics when there is problematic environment with interrelations can haven many elements (Saraji and Sharifabadi, 2017). The three main steps of system dynamics modelling forecast are defining the problem, designing dynamic hypothesis to describe the causes of the problem, and developing a problem formulation which is used as a simulation to analyze different scenarios (Aiguer, 2013; Nair and Rodrigues, 2013; Saraji and Sharifabadi, 2017). System dynamics modelling includes feedbacks, causal relationships, analysis, simulation and different scenarios to understand fluctuations across different data (Aiguer et al., 2013). However, system dynamics modelling has some drawbacks: it needs other tools to forecast, and requires expert modelers (Suryani, 2012). Furthermore, discontinuities are not calculated in the system (Barlas, 2002; Suryani et al., 2012).

Compared to Grey Prediction, system dynamics modelling requires more data to analyze interrelations between elements of the problematic environment. System dynamics modelling is more suitable when there are many parameters, and understands their interrelations is essential for forecasting (Lyneis, 2000; Aiguer et al., 2013; Saraji and Sharifabadi, 2017). In addition, although used in a short-term forecast, system dynamics modelling is more useful for long-term forecasts (Lyneis, 2000). Although both grey prediction and system dynamics modelling can be used in problematic systems, the system dynamic modelling is a more comprehensive model (Nair and Rodrigues, 2013). Therefore, it needs more data for the study. In this study, only 4 years which is inadequate for data are available, system dynamics modelling to be built and understand the relations within the study. System dynamics modelling is a comprehensive scenario-based model and it is a computer-based system which uses simulation (Nair and Rodrigues, 2013); however, in this study it is only aimed to forecast losses in red meat sector in Turkey, without forecasts different parameters and therefore scenario-based models are not applicable. Although not used in the study, the model can be applied for different scenarios, and when different parameters will be forecasted. Moreover, in this way, there is no consideration of meat consumption in relation with any other parameters.

To achieve this aim, considering the condition of Turkey’s red meat sector and from circularity point of view, in this study, Grey Prediction is firstly used to predict the number of slaughtered cattle, and secondly, to predict the amount of bone and blood waste caused by improper cutting.

By using Grey Prediction, the structural problems of the red meat sector in Turkey is emphasized with numerical data to show the current status of the red meat sector in Turkey. To understand and find solutions for the problematic environment, it is necessary to know future values about the sector.

In the following part Grey Prediction is explained in detail.

5. Grey Prediction & GM (1,1) Rolling Model

The grey system theory is proposed by Ju-Long Deng in 1982. Grey numbers are represented as known or unknown information in grey system theory. A system that can be fully known is described as white, unknown, as black, and partially known, as grey (Papageorgioua and Salmeron, 2012; Bayramoğlu and Hamzacebi, 2016). The grey system is practical when there are uncertain systems (Liu et al., 2012).

GM (1,1) is used for time series problems, and it is defined as a first-order univariate estimation model (Cui et al., 2013). GM (1,1) model is preferred for time series forecasting since it is practical for problematic system within a limited data (Cui et al., 2013). GM (1,1) model is "Grey Model First Order One Variable" in the literature Mostafaei and Kordnoori (2012). The GM (1, 1) model needs only four recent sample data to make forecast (Hu, 2017; Liu and Forrest, 2007; Hui et al., 2013; Li et al., 2011). The grey model can be presented by GM (n,h) model. In this model, "n" represents the degree of grey differential equation and "h" symbolizes the number of the variables. GM (1,1) model is sub pattern of grey models. The Rolling GM (1,1) model is preferred to GM (1,1) model. GM (1,1) model is less recommended and more inaccurate because it does not consider fluctuations in data. The Rolling GM (1,1) model takes consideration of changes in data (Hsu, 2011), and is therefore used in this study.

Rolling GM (1,1) model has the following steps;

1st Step: Original data set (x_0) is expressed as:

$$x_0 = \left(x_1^0 \; , x_2^0 , \ldots\ldots x_n^1\right) \quad [1]$$

In the notation; x_0 = non-negative sequence and n = sample size of the data set.

$x_0 k \geq 0 \quad k = 1,2, \ldots\ldots, n$

2nd Step: x_1 is calculated by applying AGO for x_0 series. The Equation 2 is used to calculate x_1.

$$x_k^1 = \sum_{i=1}^{k} x^0 i \quad [2]$$

x_1 series is expressed after calculating the AGO for x_0 .

$$x_k^1 = x_1^1 , x_2^1 , ..., x_n^1 \quad [3]$$

3rd Step: In this step, z_k^1 of x_k^1 means that generated mean sequence is calculated by using Equation 4 and it is expressed as in [5].

$$z_k^1 = 0.5x_k^1 + 0.5\, x_{(k-1)}^1$$

[4]

k = 1,2,.....,n

$$z_k^1 = z_1^1 , z_2^1 , ..., z_n^1 \quad [5]$$

4thStep: Before moving other steps, a and b parameters is found for analytical solution of corresponding grey equation. Firstly, a and b are calculated with 2 different ways Least Square Method or Parameter Method (Wen, 2004; Chen and Chang, 2000). In this study, Least Square Parameter Method will be applied. Therefore, equations for Least Square parameter method are expressed as below:

All data are substituted as Equation 7 with using Equation 6.

$$b = x_{(k)}^0 + az_k^1 \quad [6]$$

$$x_{(2)}^0 = az_2^1 + b$$

$$x_{(3)}^0 = az_3^1 + b \ldots\ldots\ldots\ldots\ldots\ldots$$

$$x_{(n)}^0 = az_n^1 + b \quad [7]$$

After defining equations, x and z series are represented with B and Y matrices as Equation 8.

$$Y=\begin{matrix} x_2^0 \\ x_3^0 \\ x_n^0 \end{matrix} \qquad B=\begin{matrix} -z_2^1 & 1 \\ -z_3^1 & 1 \\ -z_n^1 & 1 \end{matrix} \qquad [8]$$

For finding a and b parameters is applying Equation 9.

$$\alpha = [a,b]^T = (B^T B)^{-1}(B^T.Y) \qquad [9]$$

5thStep: After obtaining a and b parameters, Equation 10, grey differential equation, is applied to calculate predicted data.

$$x^1_{(k+1)} = \left[x_1^0 - \frac{b}{a}\right]e^{-ak} + \frac{b}{a} \qquad [10]$$

6th Step: At the last step, the control of the method is making with using Equation 11.

$$x^0_{(k+1)} = x^1_{(k+1)} - x^1_k \qquad [11]$$

k = 1, 2, …..,n

7th Step: Error Analysis in GM (1,1) Model

In GM (1,1) model, error analysis is needed to determine the average error rate for the prediction. Therefore, while applying error analysis, it is possible to identify the error rate can be seen between actual data and predicted data to continue further studies (Yılmaz and Yılmaz, 2013; Wen, 2004). To calculate average error rate of the model, Equation 12 is used.

$$e(k+1) = \left|\frac{x^0_{(k+1)} - \hat{x}^0_{(k+1)}}{x^0_{(k+1)}}\right| x\ 100\% \qquad [12]$$

6. Implementation

As explained in the "Meat Sector in Turkey" section, implementation of the study is focused on the number of slaughtered cattle of Turkey. Since carcass meat imports began in Turkey in August, 2014, the number of slaughtered cattle by farmers is expected to change over the years.

Therefore, in this study, GM (1,1) model provided data on the number of slaughtered cattle for Turkey over three years in yearly periods. To facilitate the GM (1,1) model, the number of slaughtered cattle in Turkey in 2018, 2019 and 2020 were predicted to see how carcass meat imports affect these numbers.

In this study, the number of slaughtered cattle is predicted for each of the 3 years after carcass meat imports began, i.e., the number of slaughtered cattle is predicted by using data between 2018-2020.

Table 1 Actual data of the amount of slaughtered cattle in Turkey

X $_{(0)}$ original non-negative data series represent as;

X $_{(0)\,=}$ (3,765,077, 3,900,307, 3,602,115)

After determining x_0, x_1 was found. x_1 means that new series of the actual data set with finding the AGO, the cumulative sum of the series $_{(0).}$

X$^{(1)}$ = (3,765,077, 7,665,384, 7,502,422)

After calculating AGO, the following step was calculation of the generated mean sequence z_k^1 of x_k^1.

z_k^1 = (5,715,231, 7,583,903)

The following step was to determine a and b values. To find a and b values, after finding Y and B matrices by using Equation 7, the least square method is calculated.

$$Y = \begin{vmatrix} 3900307 \\ 3602115 \end{vmatrix} \qquad B = \begin{vmatrix} -5715231 & 1 \\ -7583903 & 1 \end{vmatrix}$$

To find a and b values, (B^T.B) , (B^T.B)$^{-1}$ and [(Bt.B)^-1]Bt.Y is calculated respectively.

$$(B^T.B) = \begin{vmatrix} 9{,}019E+13 & -1{,}3299E+07 \\ -1{,}3299E+07 & 2 \end{vmatrix}$$

$$(B^T.B)^{-1} = \begin{vmatrix} 5{,}72748E-13 & 3{,}80853E-06 \\ 3{,}80853E-06 & 25{,}82504972 \end{vmatrix}$$

$$[(Bt.B)\text{^-1}]Bt.Y = \begin{vmatrix} 0{,}1596 \\ 4812310{,}582 \end{vmatrix}$$

After calculations, results are shown as below:

a = 0,1596

b = 4812310,582

e = 2,7183

Thereafter, all parameters were obtained, predicted values were found by using Equation 10. The prediction results are presented in Table 2.

Table 2 Prediction Results

According to prediction analysis, the number of slaughtered cattle was expected to be 2.829.060 in 2018, 2.411.792 in 2019 and 2.056.069 in 2020, i.e. it was expected to decrease over the years.

After predicted data was found, error analysis was performed for the accuracy of the method. In table 3, error analysis is shown.

Table 3 Error Analysis

Average Relative Error = $\Delta = \frac{1}{3}\sum_{k=2}^{4}\Delta k = 2,69\ \%$

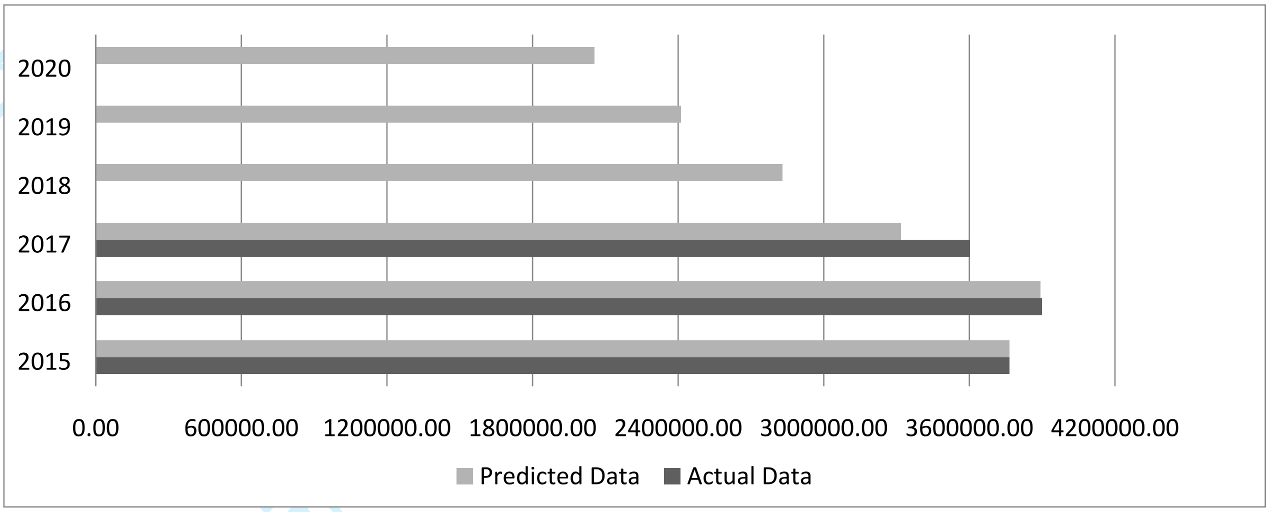
The error analysis was found by traditional error formula in Equation 12. According to calculation, the average relative error was found as 2.69%, i.e. the predicted data is reliable.

Table 4 shows the summarized results between actual and predicted data for 2015-2020.

Table 4 Summary of the Results

According to predicted values between 2018 and 2020, it can be seen that the number of slaughtered cattle would decrease after the carcass import started in 2014. Figure 6 shows the comparison of actual and predicted values for the number of slaughtered cattle in Turkey between 2015 and 2020. Therefore, farmers seem to have accepted the import of carcass meat as a replacement for slaughtered animals.

Figure 6. Comparison of actual values and predicted values of slaughtered cattle in Turkey between 2015-2020



After calculation of the number of slaughtered cattle for 2018,2019 and 2020, the amount of bone waste and blood waste are calculated. In this study, the main aim is to identify the amount of blood and bone waste relative to the number slaughtered cattle. Bone and blood waste were calculated as shown in Equation 13. In this calculation, average weight for cattle was considered as 250 kg in Turkey data, and the waste rates were gathered from Meat and Milk Board (2017).

$$Waste\ Calculation = Forecasted\ number\ of\ slaughtered\ cattle * average\ weight * waste\ rate \quad [13]$$

Table 5 shows bone and blood waste calculation.

Table 5 Bone and Blood Waste Calculation

According to bone and blood waste calculation, despite a small reduction between years, the amount of waste is still high. Bone waste was expected to be 5,658,1200 kg in 2018, 48,235,840 kg in 2019 and 41,121,380 kg in 2020. Blood waste was expected to be 24,754,275 kg in 2018, 21,103,180 kg in 2019 and 17,990,604 kg in 2020.

7. Proposed Central and Circular Slaughterhouse Based on TBL

Turkey has a problematic environment in the meat sector, as mentioned, and the sector is based on local farmers and producers, which makes it more vulnerable to the consequences of its chaotic nature. There are several reasons for the problematic structure in meat sector in Turkey: livestock quantity, the lack of sufficiency qualified labor force, lack of training, the quantity and quality of meat processing and storage facilities, the absence integrated slaughter facilities, the informality of milk and meat production, lack of attention to hygiene, inefficiency of the system, and underuse of technology. Thus, overall, there is a lack of competitiveness in meat and meat production.

This problematic environment leads to increased meat prices and dependence on imports. Factors affecting red meat prices in Turkey are: feed and labor costs, fluctuations in the currency rate that affect cost of raw materials, decreasing livestock population, meat import regulations, government interventions, livestock government support for, unstable of milk prices, consumer demand, consumer preferences and purchasing power. Among these, the most influential are import regulations and government interventions.

The aim of imports of carcass meat after August 2014 was to reduce meat prices in Turkey. This import regulation increased the amount of meat, and briefly decreased market prices but it did not provide long-term benefits. With the start of carcass meat imports, the sector became dependent on import, therefore, local producers and farmers lost their source of income.

Most meat cutting and processing plants in Turkey are hybrid plants for cattle and small ruminants. There are around 650 private sector and state-owned facilities (USDA, 2017). This number can be regarded as large, however, considering the large geographical farmers area and the current locational distribution of the slaughterhouses, many farmers have difficulties to finding slaughterhouses nearby. In addition, there are informal slaughterhouses, where animals often die due to diseases, or diseased animals are slaughtered, causing a huge risk for society. On other hand, in private or state-owned slaughterhouses, economic and environmental losses caused by improper cutting and regarding potential by-products as waste. Indeed, these wastes can be transformed to value added products and may even be used as raw materials in other sectors. Therefore, as mentioned in the case of slaughtering, the problematic condition in the meat sector affects the country socially, environmentally and economically.

In Turkey's meat sector, large amounts of slaughterhouse byproducts, such as skin, bones, internal organs, fatty tissues, horns, hoofs and bumps are discarded. However, most byproducts of slaughter can be converted into useful products that are input for other sectors. An important category of these byproducts are bone meal and blood meal. The recovery and recycling of these has important economic, environmental and social benefits.

As mentioned, the related literature highlights that food supply chains, especially within emerging countries need sustainable and permanent solutions. Using resources efficiently and decreasing the impact of food supply chains impact on the environment (Zaragoza et al., 2016) are crucial to meeting consumer demands, since non-sustainable food supply chains will not be able to do this (FAO,2017). Moreover, all food supply chain operations should be sustainable to avoid negative environmental, economic and social effects (Akkerman et al., 2010; Beske et al., 2014; Pullman et al., 2009; Sgarbossa and Russo, 2017). Furthermore, the relationship between food supply chain and sustainable concerns should be considered (Beske et al., 2014; González-García et al., 2013; Sgarbossa and Russo, 2017) because a sustainable food supply chain contributes not only to the environment, but also to the improvement of food markets and of food security (FAO, 2017; Xiao-hui, 2012). Moreover, from climate change perspective, the agriculture and livestock sectors are two of the most influential sectors for greenhouse gas emissions. Even the smallest change in precipitation influences productivity, and causes more greenhouse gas emissions (Ali, 2017; FAO,2017). Losses constitute a great importance for achieving sustainable food supply chains. For sustainable solutions, it is necessary to have accurate and reliable predictions (FAO,2017; Xiao-hui, 2012). Therefore, it is essential to be able to forecast losses in the food sector. In this study, grey prediction model was used to understand changes of the number of slaughtered cattle, and the amount of bone and blood waste and to propose sustainable solutions.

Although the expected number of slaughtered cattle is decreasing, between 2018-2020 no dramatic change in expected in the current structural problems in red meat sector, i.e. high prices, informal slaughtering, and the losses in byproducts, e.g. bone and blood are remained. Therefore, problematic situation and structural problems of the sector shows that the sector needs permanent and sustainable solutions to avoid losses of bone and blood wastes. Furthermore, sustainability should embrace environmental, social and economic concerns. By using Grey prediction, the expected numbers of slaughtered cattle, bone and blood wastes were examined to present the basis for permanent solutions for the sector in Turkey.

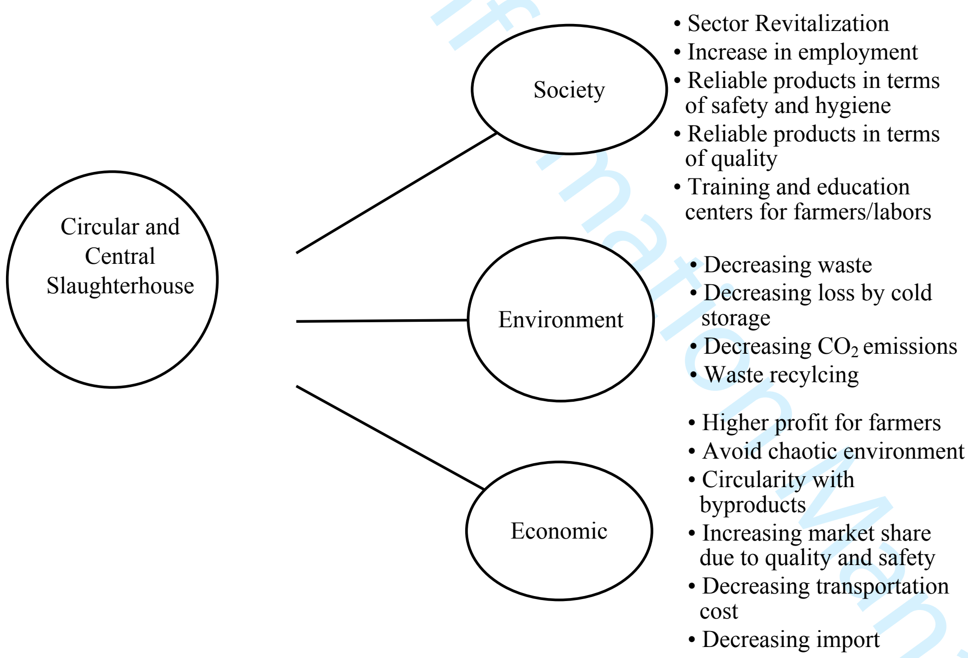
The sustainable solutions are essential to avoid losses in the red meat sector as shown in the Grey prediction calculations.

Therefore, in this study, a new circular and central slaughterhouse model is proposed based on "triple bottom line" approach. It is essential to be in a central location where farmers/local producers can provide easy transportation. Moreover, the proposed place does not involve only slaughtering process, it also involves circularity of wastes. Therefore, the new proposed model includes slaughterhouses, cold storage depots, waste recycling units, and other facilities which include training, hygiene and veterinary units. It is useful model for meat supply chain involving all parts of slaughtering. Especially, the circularity makes the slaughterhouse more practical and efficient.

According to the proposed model, the production process of the meat product begins with the arrival of live animals from the producer, and the meat is transformed into carcass meat by processing. Then the carcass meat is stored in cold storage depots. The wastes such as blood and bone, are separated and transferred to the waste recycling unit. In this study, a model has been proposed to reduce the waste by converting it into other useful products. Being more practical, it is essential to involve sustainable and circular concerns for meat supply chain.

Moreover, the new circular and central slaughterhouse model provide not only environmental advantages but also social and economic advantages. In the Figure 7, proposed circular and central slaughterhouse model based on TBL is expressed and after the figure, detailed explanations are mentioned.

Figure 7 TBL Based Circular and Central Slaughterhouse



After the meat industry relied on import, local farmers and local producers began to lose their competiteveness. It is essential for emerging economies, like Turkey, to protect local farmers and producers for sustainable growth. For revival, the meat sector requires a comprehensive model that includes local farmers and local producers. Therefore, from the point of view of a sustainable society, the proposed circular and central slaughterhouses should support local producers and local farmers in the sector.

It is necessary to focus on farmers' and labors' education to decrease losses and increase quality in the sector. The training operations for labor includes animal slaughter, storage, transport operations etc. whereas the training for farmers includes feeding, hygiene, and vaccination. In addition, the proposed model provides job opportunuties for local society, and increases employment rate in the sector. Furthermore, the presence of training units in the circular and central slaughterhouse increases the knowledge of labor on slaughtering process and contribute to increasing the product quality and minimizing the losses in slaughter operations. In addition, with the provided cold storage depots, the product is slaughtered, stored and distributed in hygienic and safe conditions, which are indispensable for public health.

Therefore, in order to revive the sector and to protect local farmers and producers against chaos, the proposed model offers increasing employment, and higher meat quality, safety and hygiene. All these benefits can be considered under social dimensions of the circular and central slaughterhouse model.

The location selection of the central slaughterhouse is critical to minimize the distance from farmers to slaughterhouse and from slaughterhouse to meat processing facilities. Thus, the term "central" is included in the name of the proposed model. The number of trips and travelled distance decreases, the proposed center helps to decrease CO_2 emissions, discussed as the environmental dimension in the model. Moreover, the model helps to decrease waste by providing safe and hygienic conditions, which is term prevent losses that may end up as waste. The existence of cold storage depots also contributes to this aim. The cold storage depots provide the safe meat conditions, and help to decrease waste caused by spoilages. All these benefits can be seen under environmental dimensions of circular and central slaughterhouse model.

As mentioned earlier in this section, problematic situation in the meat sector not only causes social and environmental problems, but also many economic problems. With the circular and central slaughterhouse model, it is aimed to minimize the effects of problematic environment in the meat sector by increasing the value of the local production. The initial economic aims are minimizing losses, converting waste into byproducts with circularity, minimizing transportation costs, increasing local producers' market share with improved quality, safety and hygiene of the products and eventually, to provide higher profits for the local farmer and to decrease imports of carcass meat. Therefore, with the proposed model, it is aimed to recover the loss of added value within local production.

The potential by-products produced in the meat sector are currently disposed of waste. As mentioned, by-products especially, bone and blood are important ingredients of animal feed and fertilizer. The quality of feed used in animal husbandry directly affects the product quality. Bone and blood flour are an organic fertilizer which is a good source of phosphorus. Therefore, blood and bones can be used as an additional source of income. With the circular and central slaughterhouse model, blood and bone wastes can be converted into meal for fertilizer. Eventually, in terms of circularity, the conversion of by-products such as blood and bone will be the input of another sector.

In addition, as mentioned before, the location selection of the central slaughterhouse is critical and should be based on the minimizing transportation cost. This will contribute to the reachability and the attractiveness of the circular and central slaughterhouses.

To sum up, the slaughterhouse waste management system in Turkey is ineffective and most potential byproducts generated in slaughterhouses are perceived as waste. Therefore, circular and central slaughterhouse model contributes not only to environment benefits, but also to social and economic benefits in this study. Since, the proposed circular and central slaughterhouse aims to reduce the amount of slaughter waste, and recover waste to byproduct, it is a long-term solution to meat sector in Turkey.

8. Managerial Implications

As mentioned before, Turkey has major problems in the meat sector. These problems have damaging effects on environment, economy and society. Therefore, the sector needs structural changes based on sustainability. From the managerial point of view, the proposed circular and central slaughterhouse model enables the meat sector to minimize these problems.

With the proposed circular and central slaughterhouses, by-products which are disposed of waste are considered as reusable in food supply chain. Especially, bone and blood waste are the most important raw materials for animal feed and fertilizer. In the proposed model, bone and blood waste are changed into bone meal and blood meal for animal feeding. Therefore, the circularity process provides new input of another sector.

The proposed model does not only aim to reuse wastes as raw materials, but also aims to bring new opportunities from the business perspective, based on finance, marketing, production, and human resources. While the proposed model aims an increase in market share from the marketing point of view, the model also facilitates an increase in local production volume, quality, reliability and safety of products, from the production perspective. Furthermore, the proposed model enables new career opportunities, training and education opportunities for farmers and labors, from the human resources point of view. In addition, from the finance perspective, with the proposed model, it is aimed to minimize transportation costs, CO2 emissions, wastes and import rate.

As mentioned in one of the most recent food waste studies, Ellen McArthur Foundation's "Cities and Circular Economy for Food" report (2019), there are three approach to creating a circular economy for food: growing food locally and regeneratively; decreasing food waste with redistribution of excess foods or conversion of by-products to organic fertilizers, biomaterials, drugs and bioenergy; and concentrating on healthy food marketing with changing food preferences and habits to become healthy. The proposed circular and central slaughterhouse model in this study includes the first two suggestions of the report to build circular economy for meat sector.

On the other hand, circular and central slaughterhouses based on sustainability require an investment for both the construction process, and for necessary equipment and installation. In addition, there can be a trade-off between environmental impact caused by by-product losses in slaughtering process, the cost of infrastructure of the circular and central slaughterhouse, and economic loss. In Turkey, only 30 percent of the bone and blood wastes are collected and converted to almost 150 thousand tons of animal feed annually. The economic return of this transformation of the byproducts is estimated to bring 200 million TL, according to statement of "Association of Renderings and Oil Industry", published in Lubricant World Journal in 2016. The proposed sustainable based circular and central slaughterhouse model aims to by transform waste into byproducts at the slaughtering process. Even if the proposed model achieves only 50 percent of aforementioned waste and enable them to be used as raw material other sectors, the expected income is more than 500 million TL.

Conclusion

Red meat sector and meat waste in the supply chain are critical environmental, economic and social problems for Turkey. In this study, meat waste and waste of by-products are discussed for Turkey red meat sector. Turkey is an agricultural country and red meat is a critical economic sector. Red meat sector is crucial due to the its rate in human diet, and widespread consumption habits in Turkey. The domestic production was unable to satisfy this high demand and the government decided on a solution based on classical linear economy perspective as to increase supply via import regulation. The two important import regulations were established in 2010 and 2014. In 2010, livestock import was allowed in order to meet red meat demand; however, the regulation was failed to satisfy demand, and a new regulation, carcass meat import, was introduced in 2014. However, in recent years, the number of slaughtered cattle and meat production decreased. After a temporary decrease, consumer prices increased significantly as mentioned above. Thus, the import regulations were ineffective in bringing a permanent solution to the sector, neglecting both the structural problems of the sector and sustainability as an objective. The structural problems can be listed as: untrained employees, animal deaths caused by disease and improper cutting, informal slaughterhouses, and underuse of technology causing wastes. In addition to wastes caused by improper cutting, by products i.e. skin, blood, bone, feet, fatty issues are considered as waste in Turkey. Most byproducts, such as blood and bone can be used as raw material in other sectors, feed for animals or fertilizer, but the importance given to these is limited in Turkey. Therefore, the structural problems of red meat sector pose a problematic environment, causing local farmers and producers to lose their source of income. This study proposes the circular rather than linear economy, and long-term sustainability-based solutions instead of temporary import solutions. More specifically the initial step is from circularity point of view; the bone and blood, which are currently wastes, can be a transformed to byproducts bringing additional income for local farmer and producers. The second step will be proposing a facility in which the aforementioned circular concepts may became to reality, and in which sustainability of the sector can be improved. The suggested circular and sustainable slaughtering center will not if itself solve all the structural problems nor change the problematic environment of the sector, but may significantly contribute to overcome these problems at the slaughtering stage.

To achieve this, Grey Method is used to predict the number of slaughtered cattle and the amount of blood and bone waste caused by slaughtering process in this study.

According to the analysis, the number of slaughtered cattle was 3,765,077, 3,900,307, 3,602,115 between 2017-2019 respectively. According to calculations, the number is expected to be 2,056,069 in 2020. Moreover, with the fluctuations in the amount of slaughtered cattle, the losses in byproducts is affected, and especially in 2020 and, bone and blood waste are expected to be 41,103,180 kg and 17,990,604 kg respectively. The results showed that the sustainable solutions are essential for red meat sector to avoid structural problems, i.e. informal slaughterhouses, uneducated employee, and unhygienic conditions.

Managerial implications are given based on the proposed circular and central slaughterhouse model with its "triple bottom line" benefits. The expected economic and social benefits can be summarized as safety and hygiene for slaughtering, enhanced storing and transportation process, increased knowledge of technology, better educated farmers and laborers, increased product quality, better protection for local farmers and producers against problematic environment, increase circularity via by-products, the realization of additional income resources for farmers, decreasing transportation costs, lower import rates and the end of dependency on imports.

In addition to social and economic benefits, the proposed model has potential environmental benefits, such as decreasing wastes caused by improper cutting and unnecessary disposed of by-products, decreasing losses in the storage process, lower CO_2 emissions, and lower fuel consumption due to decreased travel distance, and increasing recycling. Thus, circular and central collection centers are crucial for red meat sector not only in Turkey, but in all emerging countries with increasing population, facing the need to satisfy the increasing food demand without sacrificing economic, social and environmental aspects.

For future research, red meat sector losses should be analyzed in the other stages of the red meat supply chain to final sustainable and circular solutions. Moreover, managerial implications can be developed for other types of animals in the slaughter process, in order to prevent losses and to develop the red meat sector in Turkey. In addition, network optimization models or facility location methods can be employed to determine the appropriate location of the proposed circular and central slaughterhouses.

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TABLES

Table 1 Actual data of the amount of slaughtered cattle in Turkey

Year	2015	2016	2017
Number of slaughtered animals	3765077	3900307	3602115

Table 2 Prediction Results

Years	2018	2019	2020
Predicted Data	2829060	2411792	2056069

Table 3 Error Analysis

2015	**2016**	**2017**
0 (Accepted)	0,2%	7,9%

Table 4 Summary of the Results

Years	Actual Data	Predicted Data
2015	3765077	3765077
2016	3900307	3892660
2017	3602115	3318519
2018	-	2829060
2019	-	2411792
2020	-	2056069

Table 5 Bone and Blood Waste Calculation

Years	Number of Slaughtered Cattle	Average Weight (kg)	Bone Waste (%8)	Blood Waste (%3,5)

2018	2829060	250	56581200	24754275
2019	2411792	250	48235840	21103180
2020	2056069	250	41121380	17990604

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