Optimization of energy use of dairy farms by DEA approach (Case Stude: Mazandaran province)

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Abstract
The aim of this study wasthe use of data envelopment analysis for determined the energy efficiency and find the optimum energy consumption in dairy farms of Mazandaran Province of Iran. In this study have been used from two approaches constant returns to scale and variable returns to scale model of data envelopment analysis for determined the degrees of technical efficiency, pure technical efficiency and scale efficiency. Moreover, the effect of optimum energy consumption on greenhouse gas emissions has been studied and the total amount of greenhouse gas emissions. The results showed that from total number of dairy farms 42.55% and 53.19% were efficient based on constant returns to scale and variable returns to scale model, respectively.Accordingly, the average score of technical, pure technical and scale efficiencies of farmers werecalculated 0.9, 0.94 and 0.953, respectively. The total optimum energy required wasestimated 129932 (MJ cow^{-1}). Energy saving target ratio for dairy farms was calculated as 12%.According to results feed intake had the highest share (85.44%) from total saving energy, followed by fossil fuels (11.19%). The total greenhouse gas emissions was calculated 5393 (kgCO2eq. $cow^{-1}year^{-1}$) in dairy farms that this amount can be reduced to 4738 (kgCO2eq. cow^{-1} year-1) with optimum energy consumption. The enteric fermentation had the highest potential to reduction of total GHG emissions with 47% that has a direct connection to the amount of feed intake.

Keywords: Data envelopment analysis, Dairy farm, Energy, Greenhouse gas emission, Optimization.

Introduction

Energy is one of the basic requirements for the economic and social development of a country or area. Analysisand scientific forecasts of energy consumption have of major importance for the planning strategies and policies of energy use[1].

Nowadays, agricultural sector has become major energy consumer in order to supply more food to increase population and provide enough and adequate nutrition [2]. So analysis energy consumption in this sector is essential as well as other manufacturing sectors. On the other hand, high energy consumption in agricultural and reducing the known energy resourceshas developed the philosophy of optimum energy consumption. Optimum consumption of energy helps to attain increased production and contributes to the economy, profitability and competitiveness of agricultural sustainability of rustic communities [3]. So in addition to energy analysis is need to determine the optimal energy consumption in agricultural production.Energy efficiency in production is a way to achieve optimum energy consumption. Efficiency is defined as the capability to produce the outputs with a minimum resource amount needed [4]. Energy efficiency improvements contribute to the reductions of emissions and climate change [5].

Therefore, effective energy use in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil resources preservation and air pollution reduction [6]. There are several ways to determine the efficiency that of one of them is method nonparametric of data envelopment analysis (DEA).DEA is an evaluation technique based on mathematical programming, it can determine the relative efficiency ofdecision making units (DMUs)[7]. Many researchers have endorsed DEA as being a useful method for estimating relative energy efficiency in agriculture and livestock. The main reason for using this method in agricultural and livestock activities in is that it does not need any prior assumptions on the underlying functional relationships between inputs and outputs [8]. For example, Mohammadi et al. [9] used DEA to calculate energy efficiency forkiwifruit production in Iran. Nabavi-Pelesaraei et al. [10] applied DEA in an analysis of energy consumption and carbon dioxide emissions in the rice production. Mousavi-Avval et al. [11] examined the energyefficiency of soybean production using a DEA approach. Sefeedpari [12] employed a DEA approach to determine energy-saving targets for the dairy farms in Iran. Pahlavan et al. [13] used DEA to assess the energy efficiency of rose production in Iran. Heidari et al. [14] also used DEA method fordetermination optimum consumption of energy inbroiler production farms.

In comparison to crop production, few studies have been conducted on the energy efficiency of livestock farms. However, thenumber of intensive livestock systems is increasing, and the land and livelihood needs of extensive systems are crucial