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How Livestock and Industrial Energy Affect Indonesia's Surface Temperature

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ABSTRACT

As part of the agricultural sector, livestock is a source of food for Indonesia and consumers abroad. Therefore, the demand for livestock commodities tends to increase, aligning with the positive growth of the population. Additionally, as part of their efforts to promote higher consumption, one of the attempts made by producers and the government as policymakers is to encourage an increase in the livestock population from time to time. On the other hand, the industrial sector that engages in processing likewise continues to expand to improve products downstream. However, the increase in the number of livestock and industries can contribute to the rise in emissions that impact environmental conditions. In this study, the environmental situation referred to is temperature variations. Moreover, this research aims to determine the impact of livestock population and energy consumption in the industrial sector on temperature changes. The method used in this research is explanatory. The data sources used for multiple linear regression analysis came from the World Bank, Indonesia's Central Bureau of Statistics (BPS), and the Ministry of Energy and Mineral Resources. The analysis reveals that large and small livestock, as well as energy use in the industrial sector are factors that have an impact on Indonesia's temperature. Large and small livestock cause an increase in temperature due to the large number of emissions produced by enteric fermentation and excretion. Meanwhile, the rise in energy consumption is inversely proportional to changes in temperature. This condition occurred because of the higher proportion of renewable energy in total energy consumption.

INTRODUCTION

The increase in population needs to be followed by the rise in the food supply. Livestock is a business field that produces commodities to fulfill basic needs. According to Van Kernebeek et al. (2016), Claeys et al. (2014), and Bernacka (2011), the products produced by the livestock sector are not only for consumption but also for the production of protein, minerals, and vitamins. Furthermore, based on the Directorate General of Livestock and Animal Health (2019) publication, the demand for eggs, poultry meat, large and small livestock meat, and milk in Indonesia has increased by around 3.5%, 9.3%, 18.7%, and 0.3% per year, respectively. The increase was not only in raw materials but also in processed products, such as dried meat, canned meat, and sausage.

Even though it helps the community achieve its fundamental needs, the increasing cattle population has a negative impact on the environment. According to Seidavi et al. (2019), poultry (free-range chicken, laying hen, and broiler) contributes to increased exhaust gases released into the air. The gas produced is generated from the respiration process in the form of carbon dioxide and manure in methane. The highest comes from the excretion process in the form of nitrous oxide and ammonia. These gases contribute about 0.64% of agricultural emissions and lead to warmer temperatures. Like poultry, large and small livestock processes also contribute to exhaust gases that make the temperature warmer.

Moreover, Zervas & Tsiplakou (2012) along with Seidavi et al. (2019) explained that large and small livestock release greenhouse emissions from four processes such as respiratory (carbon dioxide), excretion (nitrous oxide and ammonia), enteric fermentation (methane), and manure storage (methane). In addition, Mandal et al. (2013) described that large and small livestock emitted higher emissions than poultry because livestock experienced enteric fermentation. This process releases higher methane than from manure management process. Furthermore, Swain et al. (2016) described that large and small livestock emitted gas from enteric fermentation, and manure is 23 times higher in a potentially degraded environment than from respiratory. These gases relatively increase the temperature higher than in the previous period.

In addition to meeting the community's needs, the government should always strive for the smoothness and

acceleration of production and service activities. One form of this effort is to encourage the enhanced performance of the industrial sector. According to the Ministry of Industry (2010), this sector contributes approximately 26.4% of Indonesia's GDP. The BPS publication (2022a) stated the number of industries in this sector grew by 2.45% per year. Along with increasing awareness of environmental sustainability, the government also encourages business actors in the industrial sector to increase the renewable energy mix to total energy consumption.

In terms of GDP and emissions from energy use, the industrial sector contributes significantly. Juntueng et al. (2012) explained that the industrial sector contributes to emissions from energy usage, such as electricity usage and fuel combustion process. Furthermore, Punyawadee (2010) discovered that energy usage of the industry has a positive impact on economic growth. However, increasing energy consumption will negatively impact the environment through the emissions spread to the air. Additionally, Sharvini et al. (2018) and Hidayatno et al. (2019) described that non-renewable energy used in the industrial sector emits carbon dioxide, increasing the temperature. These studies also draw attention to the government of Indonesia's initiatives to decrease non-renewable energy use and increase the use of renewable energy, which is more environmentally friendly and safe for the environment.

Studies on emission generally involve manure (Nugrahaeningtyas et al. 2018), enteric fermentation (Thakuri et al. 2020), and feces or urine (Seidavi et al. 2019). In other words, studies on the relationship between livestock population and energy use are still rare. In fact, in developing countries, especially Indonesia, these two variables play a strategic role. To meet the basic needs of Indonesian citizens as well as to produce goods for export, the population of livestock will therefore continue to grow. Additionally, as one of the tools for economic development, the industrial sector's energy consumption will undoubtedly continue to rise periodically.

This study aims to determine which factors can affect the surface temperature change in Indonesia. We use large and small livestock, poultry population, and industry sectors' energy consumption as independent variables to investigate the range of dependent variable values.

MATERIALS AND METHODS

Research Method

This research uses an explanatory approach to investigate the phenomena that occur among the variables involved and prepare recommendations for the future. The type of data used in this study is quantitative and statistical tests are used to assess the validity of the relationship between exogenous and endogenous variables (Sue & Ritter 2012).

Data Source

The data for this study is accessed from the World Bank, Indonesia's Central Bureau of Statistics (BPS), and the Ministry of Energy and Mineral Resources. Temperature data has been accessed from the World Bank (World Bank 2022a). The information accessed from BPS consists of the number of free-range chickens (BPS 2022b), laying hens (BPS 2022c), broilers (BPS 2022d), horses (BPS 2022e), beef cattle (BPS 2022f), dairy cattle (BPS 2022g), buffalo (BPS 2022h) and goat (BPS 2022i). Furthermore, the data obtained from the Ministry of Energy and Mineral Resources (2016, 2020) is energy use in the industrial sector. Moreover, the data interval used in this study is from the period 2000 to 2018.

Data Analysis

The data analysis used to estimate the determinants of temperature changes in Indonesia is multiple regression using the Ordinary Least Squares (OLS) (1). OLS is used because the data is normally distributed, and applicable with a relatively small observation size (Ahmad et al. 2021). The dependent variable in this study is the surface air temperature of Indonesia (°C) (World Bank 2022b). Meanwhile, the independent variables consist of the number of poultry, large and small livestock (Directorate General of Livestock and Animal Health 2021), and the use of energy in the industrial sector (both from fossil fuels and biomass) measured in barrels of oil equivalent (BOE) units (Ministry of Energy and Mineral Resources 2020)

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad \ldots(1)$$

Where; Y = temperature; β_0 = intercept; β_1–β_3 = coefficient of independent variable; X_1 = number of poultry (free-range chicken + laying hen + broiler); X_2 = large and small livestock (horse + beef cattle + dairy cattle +buffalo + goat); X_3 = industrial sector's energy consumption; ε = error term.

RESULTS AND DISCUSSION

Temperature

The average annual temperature in Indonesia from 2000 to 2018 was 26.16 °C, ranging from 25.9 °C to 26.4 °C (Fig. 1). The temperature in Indonesia tended to decrease between 2000 and 2008, then increase after that. According to Komariah et al. (2015), the increase or decrease in temperature cannot be separated from the area covered by clouds. Therefore, the larger/smaller the range of cloud cover, the

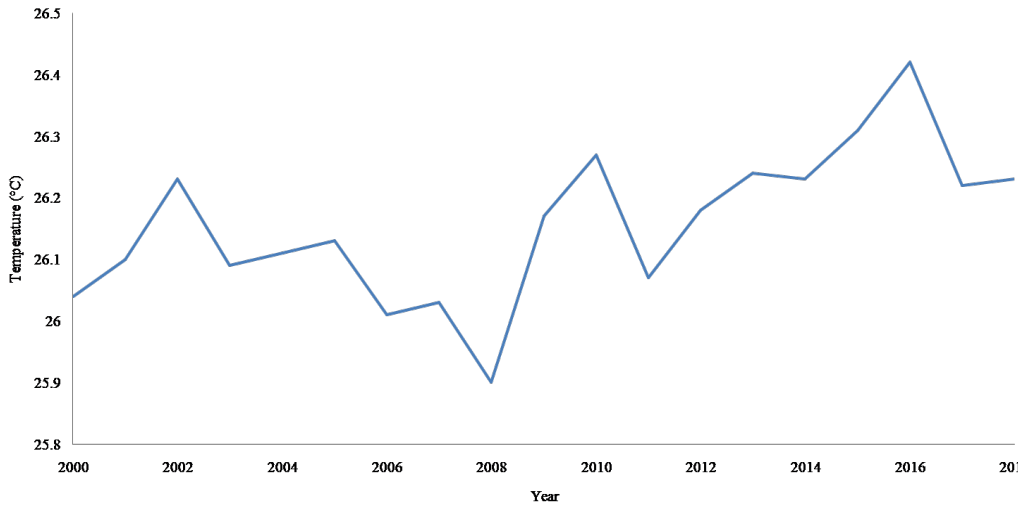

Fig.1: Indonesia's temperature in °C from 2000 to 2018.
(Source: World Bank 2022a)

temperature will tend to decrease/increase. This change is caused by the decreasing/increasing intensity of solar radiation pushing more/less water vapor carried to the clouds and then advancing/decreasing the probability of rain.

Furthermore, according to Megahed & Srikantaswamy (2020), a decrease in temperature can cause relative humidity to increase. Both of these phenomena can increase the chance of rain. In contrast to the incidence of increasing temperature, Cianconi et al. (2020) stated that an increase in temperature could cause a decrease in humidity and evapotranspiration and later cause dryness.

Free-Range Chicken

Free-range chicken is a general term for non-race chicken in Indonesia. From 2000 to 2018, the average population was 274,794,566 units (Fig. 2), increasing by almost 0.90% annually. According to the Ministry of Agriculture (2008), Java Island is the area with the highest number of free-range chickens in Indonesia. Therefore, as the population of this area declines, it immediately affects the national decrease in the total number of free-range chickens. When this incidence took place in 2007, the amount of this livestock in the Java Island region had fallen by 14.29%. As a result, there was a nationwide decline in that year of up to 6.47%. In addition, mortality instances caused a fall in the number of chickens that year, which meant that more free-range chickens died than in previous years. According to Nova et al. (2012), the increase in mortality was caused by the culling of free-range chickens due to the reappearance of bird flu cases in Indonesia in 2007.

In general, the part of free-range chicken consumed is eggs and meat. Therefore, another benefit of this livestock is a saving instrument for farming households. This condition happens because the selling price is relatively higher than other types of chicken (Kalangi et al. 2020).

Laying Hen

Laying hen is a common term for a female, grown chicken that is kept primarily for laying eggs, and whose eggs are mainly consumed by the Indonesian people compared to other types of poultry. According to the Directorate General of Livestock and Animal Health (2019) data, per capita consumption per year for laying hen eggs increases by approximately 3.65% per year. Furthermore, this institution reports that in 2017 the demand for laying hen eggs was relatively higher than in other periods, around 6.635%. Based on Astaman et al. (2020) study, the increase in demand occurred due to the decline in egg prices. This condition is in line with the Directorate General of Livestock and Animal Health (2019) data, which stated a decrease in egg prices by IDR 617, tended to increase egg prices in the previous period. Responding to this positive trend, these livestock producers are trying to increase the population to meet consumer needs and increase market penetration. The laying hen population, which tends to rise annually, is a good indicator of this effort (Fig. 3).

Broiler

Indonesia has various types of chickens, and broilers are the country's most abundant type of chicken. This fact is inseparable from the preferences of people who tend to choose broilers over other types of chicken because of the relatively lower costs and comparably larger portions of meat. Based

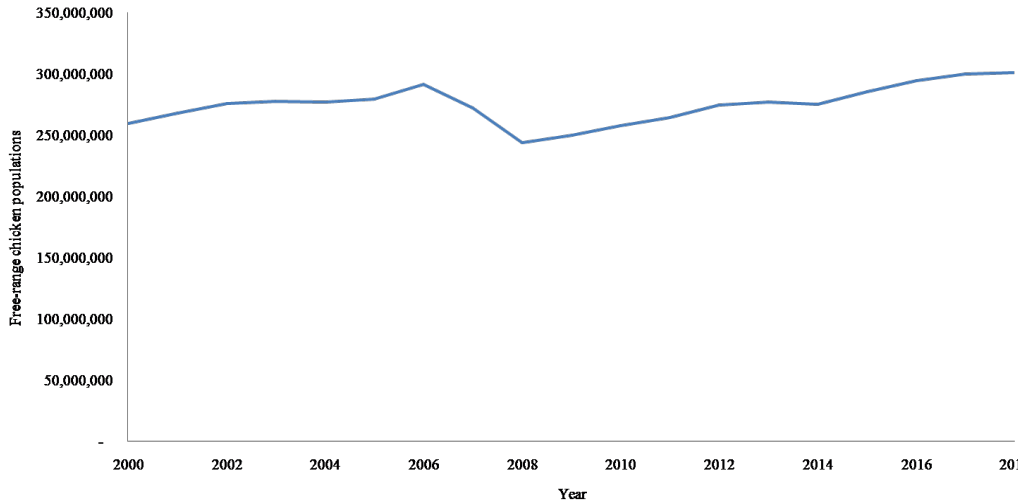

Fig. 2: Free-range chicken populations from 2000 to 2018.
(Source: BPS 2022a)

on Fig. 4, the broiler population continues to increase from time to time, increasing 11.67% per year.

Horse

East Nusa Tenggara, West Nusa Tenggara and South Sulawesi are the top three provinces with the largest horse populations in Indonesia (BPS 2022d). In these three regions and other provinces in Indonesia, horses are used for various purposes, including labor, transportation, sports, recreation, and consumption (Sihita et al. 2018). According to Kadir (2011), horse meat has advantages over beef, namely the relatively lower fat content. Furthermore, according to Ginting et al. (2019), another product from horses (horse milk) has good ingredients for treating several diseases, namely asthma, hypertension, and diabetes. Furthermore, the number of horses from 2000 to 2018 has consistently been above 300,000 heads (Fig. 5). However, there has been a downward trend in the last eighteen years. High demand for horse meat compared to supply and poor rearing practices are two factors in the declining horse population.

Beef Cattle

According to Akinsulu et al. (2019), the consumption of beef cattle increases when the number of household members increases (Fig. 6). In addition, higher income and education level have a positive effect on the amount of beef consumed.

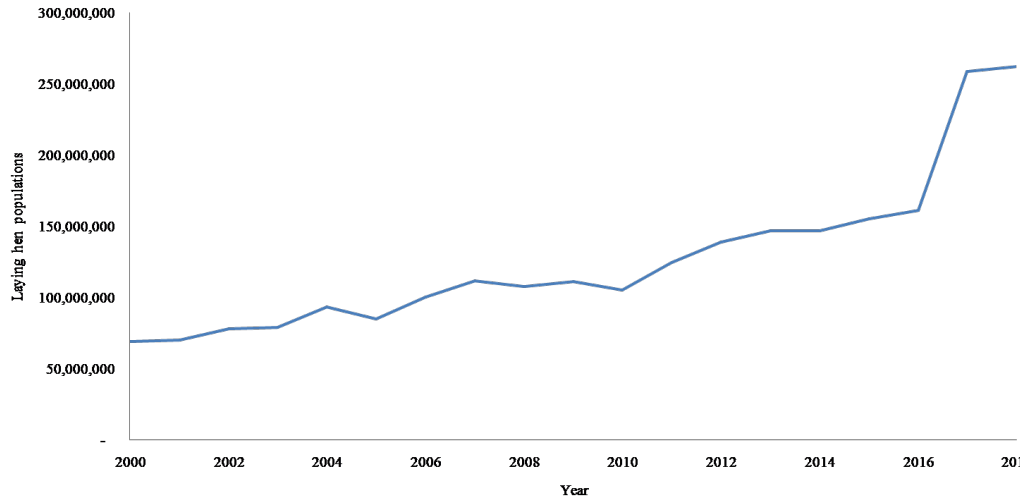

Fig. 3: Laying hen populations from 2000 to 2018.
(Source: BPS 2022b)

As one of the largest countries in the world, Indonesia has experienced an increase in population, economic growth, and an improving level of education from time to time. Thus, the number of beef cattle needed to meet beef consumption is also increasing. Based on this, cattle farmers look for more livestock to take advantage of opportunities to meet consumer demand.

Dairy Cattle

The main product of dairy cows is milk. Based on data from the Directorate General of Livestock and Animal Health (2021), the consumption level of cow's milk by the Indonesian people is around 16.27 kg per year. Therefore, with the existing population, the need for this product reaches 4.3 million tons per year. However, based on Fig. 7, there was a population decline of 167,674 units from 2012-2013. This decline impacts domestic cow's milk production, which is increasingly declining and encouraging more imports. On this basis, the government issued the Blue Print for Indonesian Dairy 2013-2025. Through this roadmap, it is hoped that the national demand for cow's milk can be dominated (>50%) by domestic producers. One of the efforts to achieve this target is

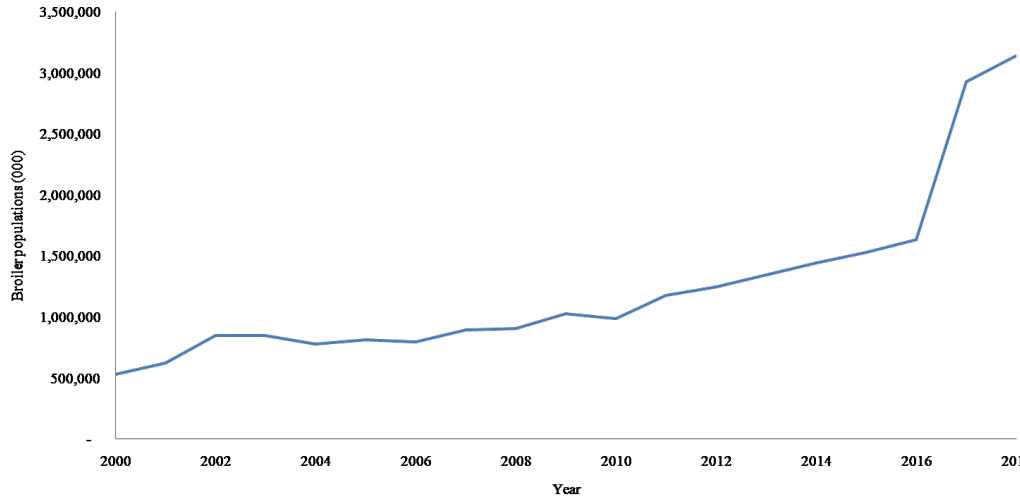

Fig. 4: Broiler populations from 2000 to 2018.
(Source: BPS 2022c)

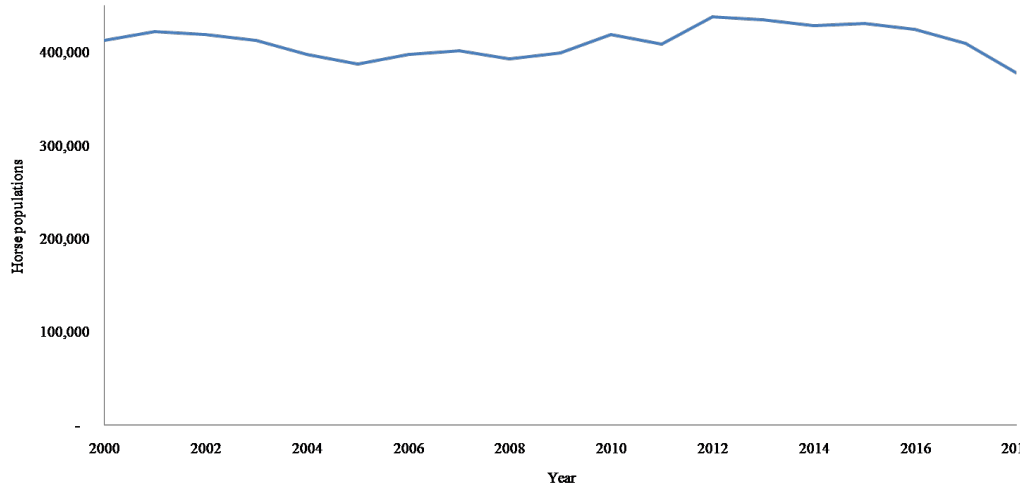

Fig. 5: Horse populations from 2000 to 2018.
(Source: BPS 2022d)

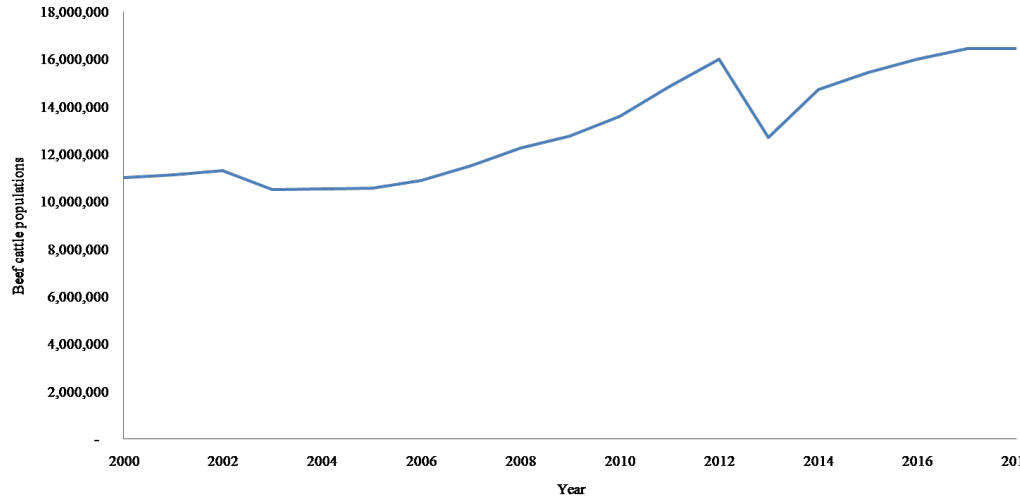

Fig. 6: Beef cattle populations from 2000 to 2018.
(Source: BPS 2022e)

to increase the dairy cattle population sustainably. The trend of the dairy cattle population, which has increased annually since 2013, provides evidence of this industry.

Buffalo

Buffalo is one of the ruminant animals kept by many people in Indonesia, especially farmers. This livestock is used to assist producers in ploughing the land. Based on the study of Amin et al. (2016), buffalo are relatively common in the central part of Indonesia, such as West Nusa Tenggara, Bali, and Sulawesi. However, Amin et al. (2016) explained that from 2003 to 2011, there was a decline in the buffalo population (Fig. 8). These findings align with this study. In the last 18 years, there has been a decline in the buffalo population by around 4.31% per year. This decline is thought to be caused by poor livestock cultivation, namely breeding the closely linked gene of buffalo.

Goat

The goat population in Indonesia tends to increase from time to time. This increase is inseparable from the role of goats as a source of protein for the Indonesian people and the tradition

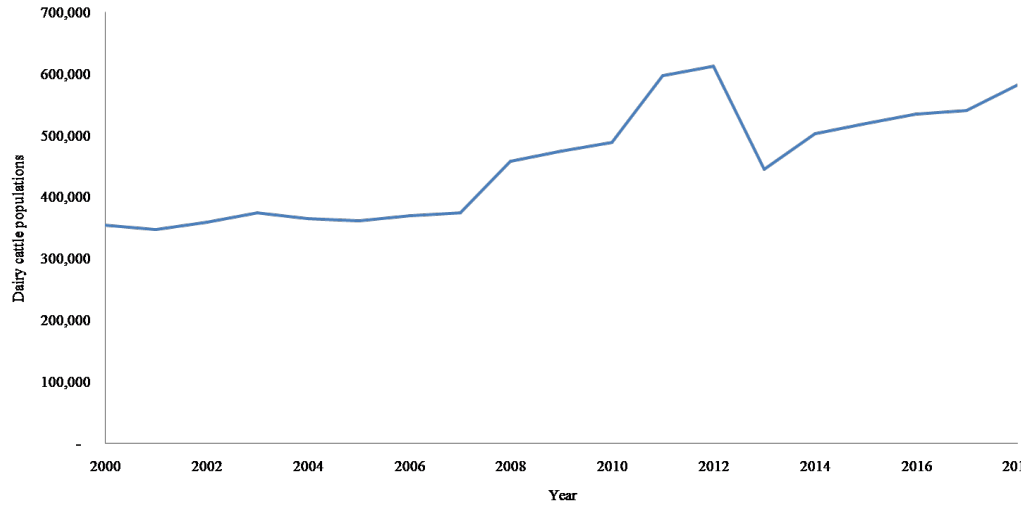

Fig. 7: Dairy cattle populations from 2000 to 2018

Source: BPS 2022f.

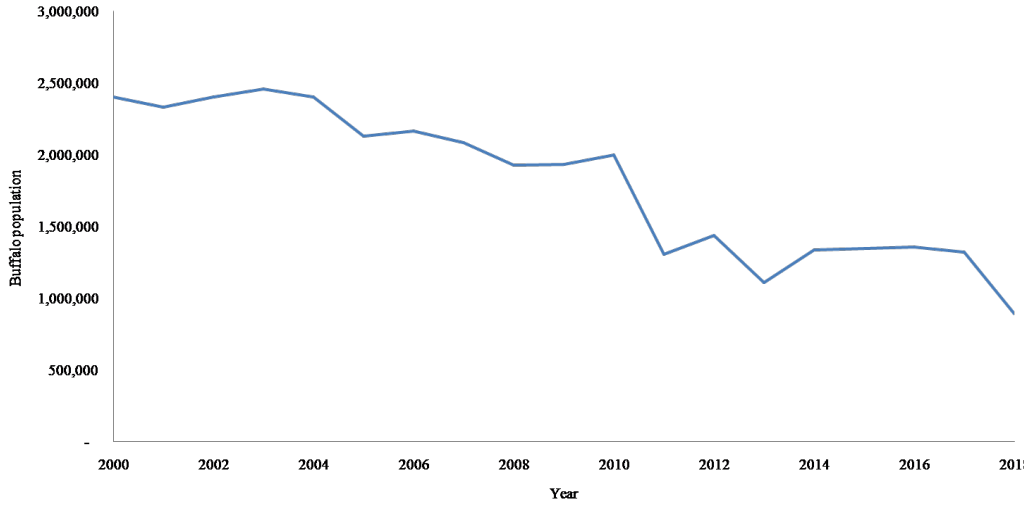

Fig. 8: Buffalo populations from 2000 to 2018.
(Source: BPS 2022g)

of some people in this country who use goats as sacrificial animals (Murray-Prior et al. 2010). Furthermore, from the agricultural side, goat manure is used as a combination of organic fertilizers to meet plants' nutrient needs (Kurniawati et al. 2021). On this basis, goat breeders continue to seek to increase the number of livestock to increase income through meeting community needs.

Industrial Sector Energy Consumption

The industrial sector plays a strategic role in contributing to Indonesia's GDP. Therefore, efforts are made to improve the quality and quantity levels in this economic sector. Additionally, the industrial sector has a direct impact on energy usage to support its activities. From 2000 to 2018 (Fig. 10), the amount of energy used for this sector fluctuated with an upward trend. The increase is around 1.94% per year. Furthermore, the increase or decrease is caused by the number of industries, which tends to change every year.

Effect of Livestock Population and Industrial Energy Consumption on Temperature

Large and small livestock contribute to air emissions through

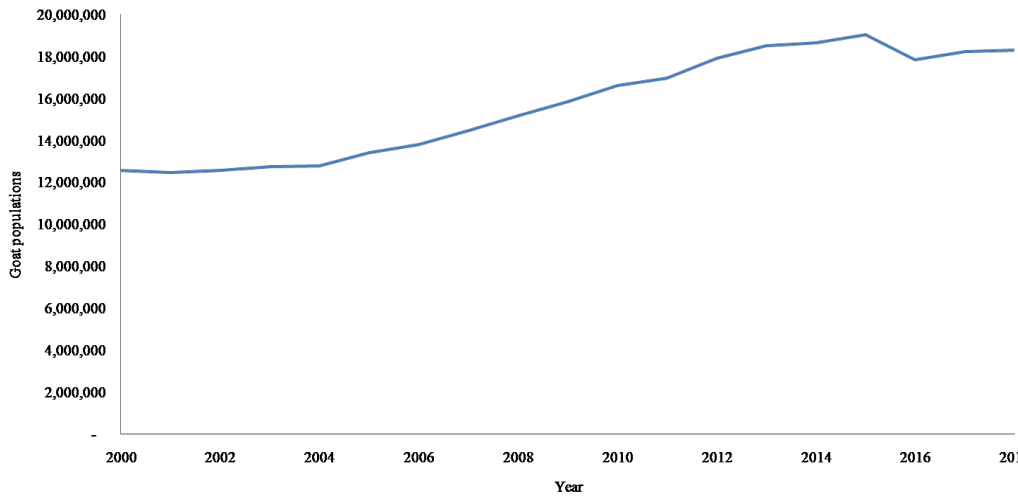

Fig. 9: Goat populations from 2000 to 2018.
(Source: BPS 2022h)

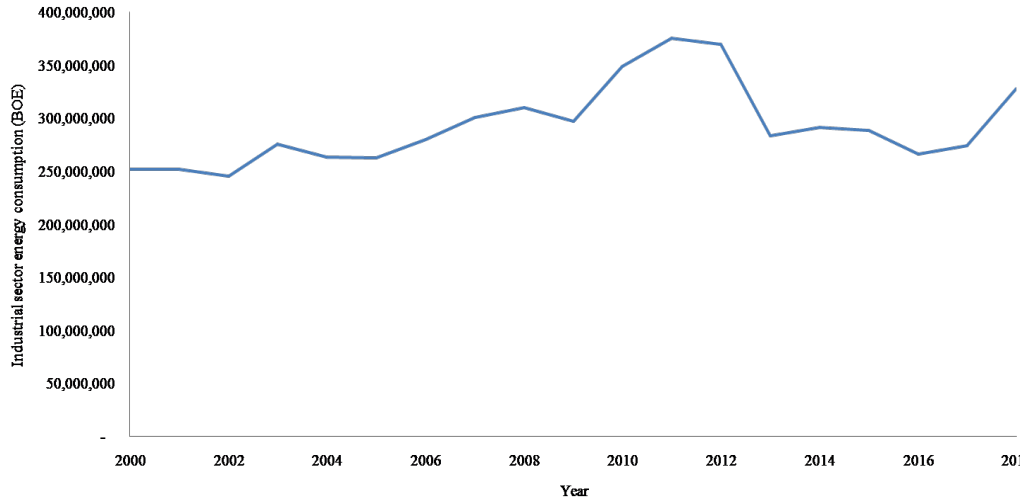

Fig. 10: Industrial sector energy consumption from 2000 to 2018.
(Source: Ministry of Energy and Mineral Resources 2016, 2020)

enteric fermentation and excretion. Enteric fermentation occurs in the digestive tract of ruminant animals, known as the rumen. When the feed enters the digestive tract of ruminants, it produces gas in the form of carbon dioxide. Methane is produced when the gas reacts in the rumen with hydrogen gas and microbes (Thakuri et al. 2020). According to Gibss et al. (2001), methane from enteric fermentation is released as a gas, either on exhalation (respiration) or flatulence. Furthermore, the process of excreting or removing waste from the body of ruminants and other large livestock, as well as small livestock is in the form of feces and urine (Dong et al. 2014). Ammonia and nitrous oxide, two volatile gases, are present in both types of contaminants. Ammonia gas is produced from the reaction between microbial enzymes in the feces and urea in the urine. This process can continue until ammonia is oxidized and turns into nitrate and nitrous oxide during nitrification (Cobellis et al. 2016, Wang et al. 2017).

Increasing the population of large and small livestock by 1 unit will lead to an increase in temperature of around 0.00000319°C (Table 1). This finding is in line with a study from Lynch (2019), who stated that livestock, dominated by large and small livestock, became the largest methane contributor through enteric fermentation. On the other hand, Nugrahaeningtyas et al. (2018) explained that emissions from the excretion of large and small livestock are relatively higher than different types of livestock. This rather large share occurs because the consumption of feed by these animals is increasingly intense than that of poultry.

In detail, Santiago-Juarez et al. (2016) and Zhuang et al. (2020) explained how the increasing livestock population leads to an increase in temperature: enteric fermentation and excretion produce exhaust gas in the form of methane. Additionally, excretory products are used as manure-making basic materials. Thus, the manure processing cycle also produces exhaust gases that are released into the air. This condition happens because there is an accumulation of around 7,222.1 g CO_2-eq in the processing cycle. Therefore, the more significant emission has a positive effect on the increase in temperature in Indonesia.

Furthermore, the energy consumption variable affects the dependent variable differently (Table 1). Increasing energy consumption by the industrial sector negatively impacts the increase in temperature. In Indonesia, the energy used by the industrial sector consists of non-renewable and renewable, such as coal, oil, gas, and biomass crop residue (rice, sugar, palm oil, and coconut) (ADB 2020). Over time, especially since 2002, the government has encouraged the use of more environmentally friendly energy than non-renewable energy. This effort is realized through Ministerial Decree No. 1122 K/30/MEM/2002 about Distributed Small Power Generation.

Empirically, a one-unit increase in energy use for the industrial sector will reduce the temperature by about 0.000000184°C (Table 1). Because the industrial sector uses less energy and creates less carbon dioxide, the temperature decreases. The increased biomass composition is what causes the reduction in emissions, and this kind of resource is relatively eco-friendly. This finding supports the results of Gyamfi et al. (2021) who concluded that the use of energy involving biomass could reduce pollution from carbon dioxide gas.

Table 1: Regression results.

Variables	Coefficient	Standard Error	P-value
C	2.57E+01	0.19E+00	0.0000
Poultry	-3.64E-11	4.31E-11	0.4125
Large and small livestock	3.19E-08	9.12E-09	0.0032
Industrial sector's energy consumption	-1.84E-09	6.70E-10	0.0151
Adjusted R-square	0.50E+00		
F-statistics	7.10E+00		0.003414

Source: Secondary data analysis

CONCLUSION

Livestock populations and energy consumption in the industrial sector tend to increase continuously to fulfill the community's demand. Empirically, large and small livestock, as well as the energy usage from the group of particular firms affect the temperatures inversely. The positive growth of the cattle, buffalo, horse and goat population encourages a warmer climate. This condition is caused by attention to waste gas management that has not been maximized and is oriented towards environmental sustainability. Based on this study, it is hoped that stakeholders in livestock farming will focus on economic and social aspects and the environment. On the contrary, higher energy consumption negatively impacts the temperature. Thus, the government's efforts to encourage business actors to increase the percentage of environmentally friendly energy for the production process need to be continuously stimulated and evaluated from time to time.

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