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CARBON FOOTPRINT ESTIMATION IN CLOSED BREEDERS' FARMS

Nourhan KASSAB, Tarek FOUDA

Tanta University, Faculty of Agriculture, Agriculture Engineering Department, Egypt, Emails: nourkassab2308@gmail.com, tfouda628@gmail.com

Corresponding author: tfouda628@gmail.com

Abstract

The study was conducted to determine the carbon footprint of poultry farms. Breeder farms were included in the study. The fuel and electricity bills from farm, house size and age, flock size and number of flocks per year, and manure management were all collected. The methane, nitrous oxide, and carbon dioxide equivalent emissions were calculated, as well as the effect of these gases on breeder farms productivity, as well as determining the carbon footprint of breeder farms to reduce the negative effects of greenhouse gas emissions. In addition to providing necessary information on breeder's chicken performance and advising poultry farmers on the relative merits of different climatic conditions to help set standards for different production traits. The experiments were conducted of closed farms in the city of Mansoura during the period from May 2019 to December 2021 and the capacity of the farm was 43,300 breeders' chickens. The results showed that the amount of methane gas produced from the farm was 1.76 ton ch_4 yr^{-1} and nitrous oxide gas was 0.13 ton n_2o yr^{-1} for manure management. Thus, the total emissions of manure management are estimated at 81.65 tons of co_2-eq. The amount of greenhouse gas emissions for diesel is 5.23 tons of co_2-eq. The amount of greenhouse gas emissions (GHG) for the electricity used in the farm is 0.15 tons of co_2-eq. In the end, the total amount of emissions produced from the farm is 87.04 tons of co_2-eq. In the end, the total amount of carbon dioxide equivalent emissions generated from Egypt's farms is 271.8 (kiloton co_2-eq).

Key words: *breeder chicken, nitrous oxide, methane, carbon footprint, carbon dioxide equivalent*

INTRODUCTION

The poultry industry is one of Egypt's most important agricultural industries, with an estimated investment of 90 billion LE. The labor force consists of approximately 3.5 million permanent workers and approximately two million temporary workers. The industry provides a significant portion of the country's animal protein supply (white meats and eggs). Local meat production averaged 1,454.856 kt in 2019, while egg production averaged 617.521 kt in the same period [4].

Broiler meat production has increased exponentially in order to meet global demand and increase business profits. Low production costs and rapid economic progress are critical to its growth. Broiler chickens are raised specifically for meat production due to their characteristic soft, tender meat, low fat content, and short production period. Broilers take the place of valuable food animals around the world, significantly contributing to food security, protein supply, and job creation [8].

The poultry industry has grown rapidly as a result of the effective implementation of high-yielding strains of meat-type chickens and the availability of nutritionally balanced feed. Broiler farming is critical to increasing income, improving food safety, and alleviating scarcity in developing countries' rural and semi-urban communities. For several decades, the poultry industry has played an important role in the country's economic development by providing job opportunities, food security, and high-quality protein. By modifying animal protein sources such as beef and mutton, the poultry industry has helped to change people's eating and living habits [6].

Poultry meat is an essential source of animal protein in human growth and development, so it is in high demand worldwide. Poultry meat has several advantages, including adequate nutrition, a delicious taste, a relatively low price, ease of availability, and acceptance at all levels of society from diverse backgrounds [11].

Carbon footprint is a calculation of a person's contribution to global warming in terms of greenhouse gas emissions, expressed in carbon dioxide equivalent units. It consists of two parts in total. The direct or primary footprint is a calculation of our direct carbon dioxide (CO_2) equivalent emissions from fossil fuel combustion, which includes home energy use, transportation (e.g., automobiles and aircraft), and other activities. The indirect or secondary footprint measures the indirect carbon dioxide (CO_2) equivalent emissions caused by the entire life cycle of the products and services we use, including those associated with their manufacture and final decomposition [7].

The fundamental cause of climate change is greenhouse gases produced into the atmosphere by human activities and other sources. Livestock production contributes significantly to air pollution, especially carbon dioxide (CO_2), methane (CH_4), and nitrogen oxides (NOx) [10].

The Middle East's poultry industry expanded significantly in the final two decades of the twentieth century. Construction of environmentally controlled chicken houses with evaporative cooling systems has cost a lot of money. The Arab world produces over 22 billion table eggs per year, accounting for more than 2.5 percent of total global output (the top producers being Morocco, Algeria, Egypt, and Syria) [2].

When compared to ruminant N2O emissions, the non-ruminant sector contributes only a small amount. The poultry industry is the non-ruminant animal industry's largest direct N2O generator, accounting for 92.8 percent of total non-ruminant N2O emissions [3].

The term "carbon dioxide equivalent" or "CO_2-eq" is used to describe the various greenhouse gases in a single unit. CO_2-eq is the amount of CO_2 that has the same greenhouse effect as any other amount and type of greenhouse gas. The amount of greenhouse gases can be represented as CO_2-eq by multiplying the amount of greenhouse gases by the global warming potential. For example, one kilogram of methane released equals 25 kilograms of carbon dioxide (1 kg CH_4 * 25 = 25 kg CO_2 equivalent). "CO_2-eq" is a very useful term for several reasons: it allows a "package" of greenhouse gases to be stated as a single quantity; it allows for simple comparison of various packages of greenhouse gases; and it allows for simple comparison of various packages of greenhouse gases (in terms of the overall effect of global warming) [1].

A substance's carbon dioxide equivalent is calculated over a specified time period and must be provided whenever a global warming potential (GWP) is mentioned. It is expected to have an impact on global warming. Nitrous oxide, for example, has a GWP of 298 over a 100-year period. This means that emitting 1 million ton of N_2O is equivalent to emitting 298 million ton of CO_2-eq over a 100-year period. Methane has a global warming potential of 25 over the next 100 years [9].

The total CO_2-equivalent emissions from manure management from laying hens housing are estimated to be 50.365 tons. Diesel produces 434.59 tons of CO_2-equivalent greenhouse gas emissions. The greenhouse gas emissions from the farm's electricity use are 8 ton of CO_2-eq. In the end, the farm's total emissions are 492.96 tons of CO_2-equivalent [5].

The increase in CO_2 and NH_3 concentrations inside broiler chicken housing was the research problem. Carbon emissions have a negative impact on chicken growth rates due to increased mortality rates, resulting in a decrease in the amount of meat produced.

The study's aim was to calculate the nitrous oxide, methane, and carbon dioxide equivalents produced by breeder over the course of a year, as well as the carbon footprint of poultry production.

MATERIALS AND METHODS

The experiment was carried out in a farm in Dakahlia Governorate, Mansoura, Egypt, from May 2019 to December 2021. To calculate the carbon footprint and other greenhouse gas emissions. A cup 500 chicken was used, and the farm had a capacity of 43,300 hens.

Work was done on a farm with a closed system for breeder hens. consists of 8 floors, each floor has one house without side dimensions (12 m wide x 90 m long), house dimensions (80 m x 10.5 m x 3 m) with a nominal capacity of 7,200 hens during the production period, house system is dark for breeding.

The drinking system was used on three lines, each with 17 pieces. Each piece is 3 meters long and has 12 nipples, one of which is enough for ten birds. An air-driven heater's heating system consists of (stainless steel furnace, counter flow heat exchanger, axial fan) and an electronic control box. And a ventilation system with 5 hoods, each 140 cm long and 140 cm wide, circulating air for 44,000 m^3/h with 6 brushes. A stainless steel, 3-phase electrically operated, evaporative cooling system was used, and a closed floor chain feeding system was used.

A set of mathematical equations and program was used to estimate greenhouse gas emissions from poultry farms such as methane gas, nitrous oxide, carbon dioxide and carbon dioxide equivalent, as presented below.

Input data:

Enter number of hens (N), emission factor for layers (EF), default N secretion rate (Nrate), standard layers mass (TAM), emission factor for direct N_2O emissions (ES_3), part of total annual nitrogen secretion for layers (MS), percent of manure nitrogen for hens that volatilises as NH_3 and NO_x ($Frac_{GasMS}$), emission factor for N_2O emissions (EF_4), quantity of fuel combustion (Q), the energy content factor of the fuel (EC), emission factor for the fuel (EF), quantity of electricity purchased from the electricity grid (Q_e), emission factor for the electricity in the farm (EF_e).

Calculate data

- $CH_{4manure} = (EF \times N)/10^6$
- $Nex = (N_{rate} \times (TAM \times 1{,}000)/365)$
- $N_2O_D = ((N \times Nex \times MS) \times ES_3)/(44/28))$
- $N_{volatilization\text{-}MMS} = ((N \times Nex \times MS) \times (Frac_{GasMS/100}))$
- $N_2O_G = (N_{volatilization\text{-}MMS} \times EF_4 \times (44/28))$
- $Kg\ CO_2e = Kg\ CH_4 \times 25 + Kg\ N_2O \times 298 + E_{generator} + E_{electricity}$
- $E_{generator} = ((Q \times EC \times EF)/1{,}000)$
- $E_{electricity} = ((Q \times EF)/1{,}000))$

Output data

Methane emissions ($CH_{4manure}$), direct and indirect nitrous oxide emissions (N_2O), Carbon dioxide equivalent)CO_2-eq), GHG emissions from generator ($E_{generator}$), GHG emissions from purchased main electricity grid ($E_{electricity}$).

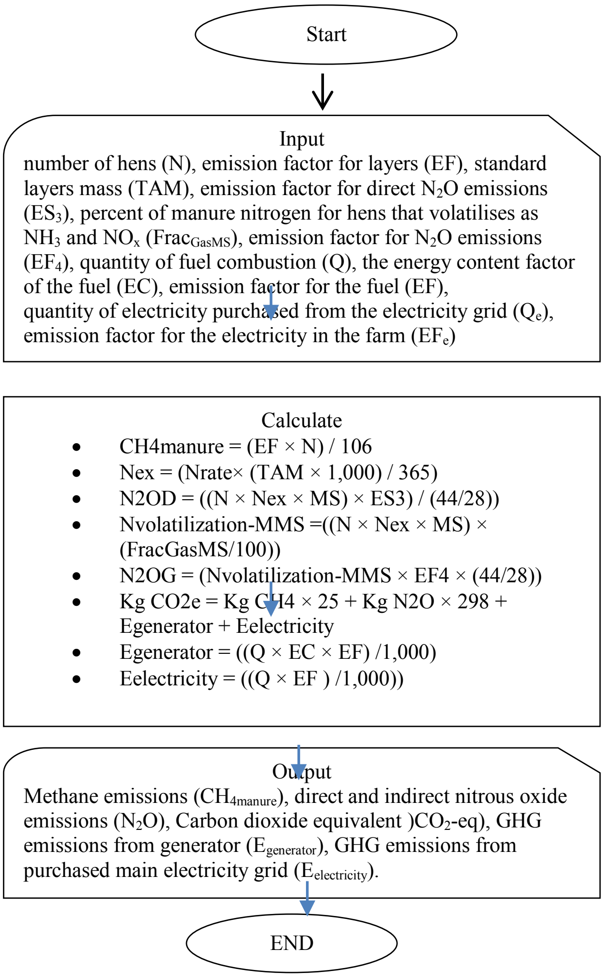

Fig. 1. Showing the inputs and outputs
Source: Authors' drawing.

Carbon Footprint Estimation Toolkit For Poultry On-Farm Emissions

Data is entered such as the number of poultry in the farm, the amount of fuel used in the heating meter (KL), and the amount of electricity, (kw/hr). Then the program starts calculating and updating the results for the current year. Also, **several** recommendations designed to reduce energy consumption on the farm are selected, and the implementation of these recommendations will affect the next year's figures. The numbers below the "expected year" reflect energy savings.

Calculating Direct GHG emissions from Primary Aluminum Production Calculation worksheets.

(a)Introduction Page

The spreadsheet has an introductory page or tab as showing in Fig 2, which informs the user of the capability and it uses it. It provides specific directions on how to enter the information into the spreadsheet. This page also gives the growers options that can be used to reduce their energy use and subsequently to reduce their carbon footprint.

Definitions:

CO_2: Carbon dioxide.
CH_4: Methane.
N_2O: Nitrous Oxide.
LPG use: emissions from stationary sources such heaters and incinerators.
Purchased electricity: emissions from electricity due to usage on farm.
Diesel use: emissions from sources such as equipment used in the operation (tractors, generators etc.).
CO_2-eq Tones: metric tons of carbon dioxide equivalent.
AAP: Annual average population.
NAPA: number of animals produced annually.
NEX: Annual average nitrogen excretion.
NEMMS: Nitrogen excretion from manure management system.
N_{vol}.MMS: Nitrogen losses due to vitalization from manure management.
TAM: Typical animal mass.
Global Warming Potential (IPCC 2006):
CO_2: 1 CH_4: 25 N_2O: 298

Fig. 2 The introductory page can be viewed by selecting the “Introduction” tab on the bottom left of the spreadsheet.
Source: www.ghgprotocol.org for other GHG calculation tools.

(b)Interface Page

Farm Information and Energy Consumption the “Interface” tab is the only page where the user can enter data into the tool. The user will need to select from the first drop-down box Fig 3 the type of poultry (laying, pullet, or breeder) they have. Based on the type of bird, appropriate boxes for that operation will be available for the user to input data. This information will determine the non-mechanical emissions. The non-mechanical emissions are those GHG emissions that occur from manure management and will depend on the type of poultry, the number of birds/flocks grown per year, and the type of manure management system that is used on the farm. The user will next enter energy consumption information. Users have the option of entering LP gas, diesel, and/or natural gas. This will determine the mechanical emissions from the farm. These emissions occur from heating, incineration, diesel for tractors, generators, and other equipment on the farm. Users will also need to enter the amount of electricity used in kilowatt-hours. Electricity is used for ventilation, lighting, feed motors, and water pumps, as well as other electrical equipment for daily bird management and house maintenance.

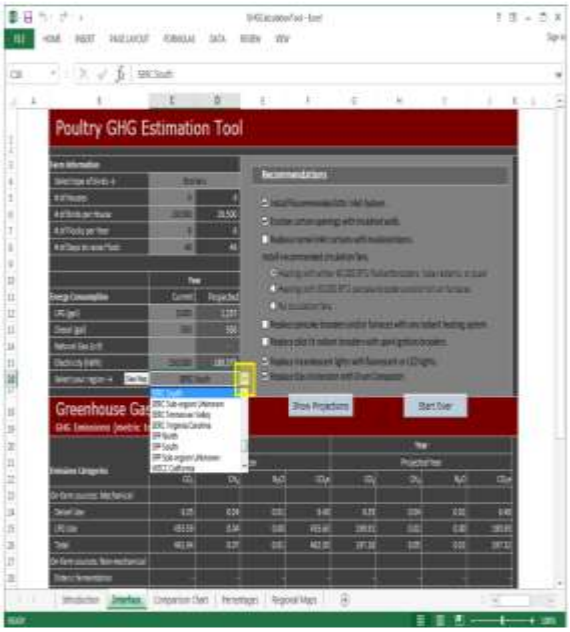

Fig. 3. The data input section of the “Interface” tab. The drop-down box for selecting the user’s region is indicated.
Source: www.ghgprotocol.org for other GHG calculation tools.

After the user selects options from the “Recommendations” section, he or she should click the “Show Projections” button. The projected year fields of the "GHG Inventory" section will be populated with the estimated emissions (Figure 5).

(c)Recommendations

The calculation tool also allows the user to choose house adjustments or renovations (Figure 4) that will result in reductions in energy use and GHGs. This can be done by selecting recommendation options to reduce energy use in the "Interface" tab. The tool will show the user what the emissions would be if these adjustments were made on the farm. The recommendations selected will affect the electricity, LPG, and/or natural gas use projections. Therefore, changes in the GHG emissions will be reflected in the mechanical and off-farm emissions inventory.

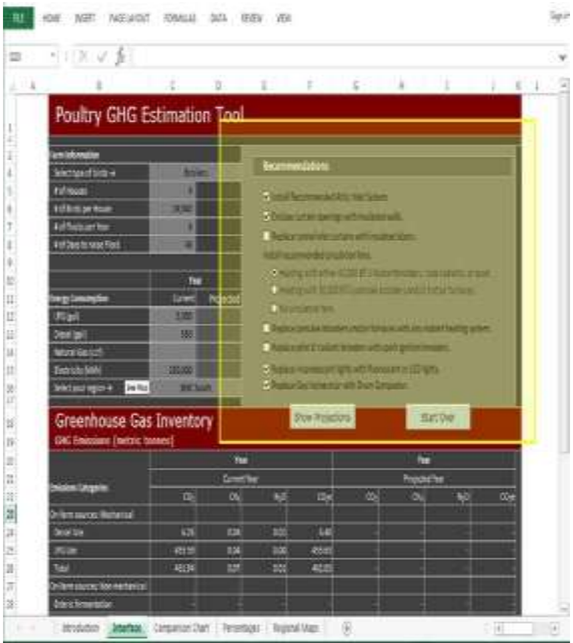

Fig. 4. Recommendations can be selected to see how emissions would be reduced
Source: www.ghgprotocol.org for other GHG calculation tools.

After the user selects options from the "Recommendations" section, he or she should click the "Show Projections" button. The projected year fields of the "GHG Inventory" section will be populated with the estimated emissions Figure 5.

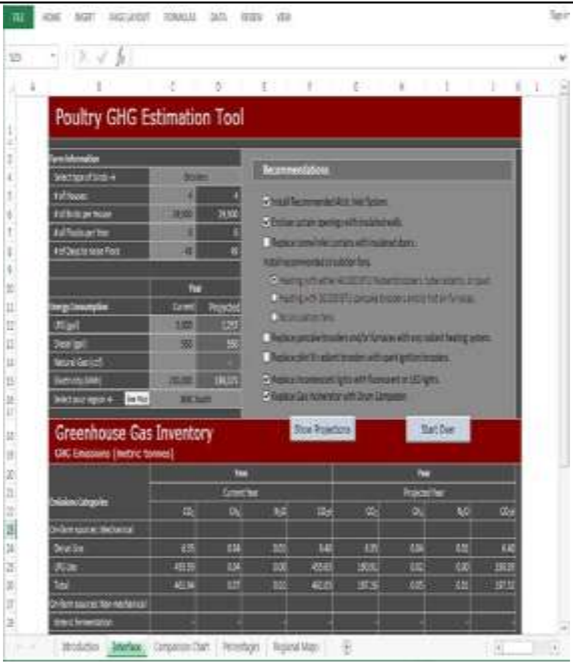

Fig. 5. The projected fields are calculated based on the selected recommendations.
Source: www.ghgprotocol.org for other GHG calculation tools.

(d)Greenhouse Gas Inventory

The "GHG Inventory" section Figure 6 and Figure 7 on the "Interface" page shows users the sources of the emission and also the amount of each GHG emitted.

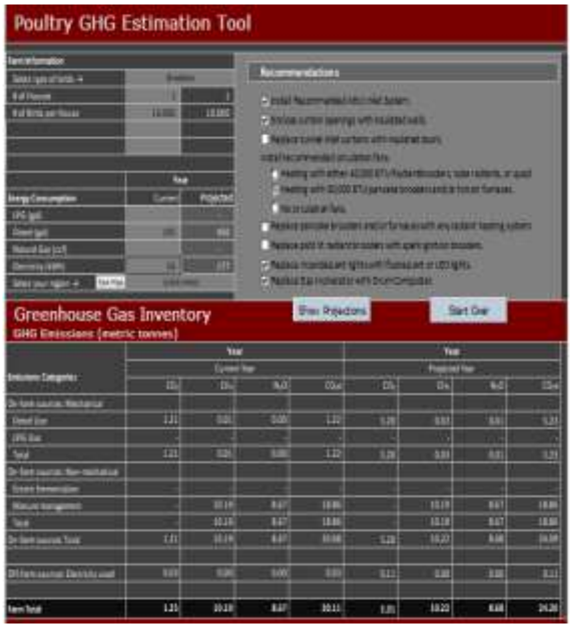

Fig. 6. The Greenhouse Gas Inventory on the Interface page shows current and projected emissions
Source: www.ghgprotocol.org for other GHG calculation tools.

The inventory separates the emissions based on their source (mechanical, non-mechanical, and electricity use) and also on-farm and off-farm sources. It gives the total of each source and the total farm emissions. The inventory is divided into two sections, "Current Year" (the actual farm emissions) and "Projected Year" (the emissions based on the energy reduction options selected). All the emissions are represented as metric tons of CO_2-eq.

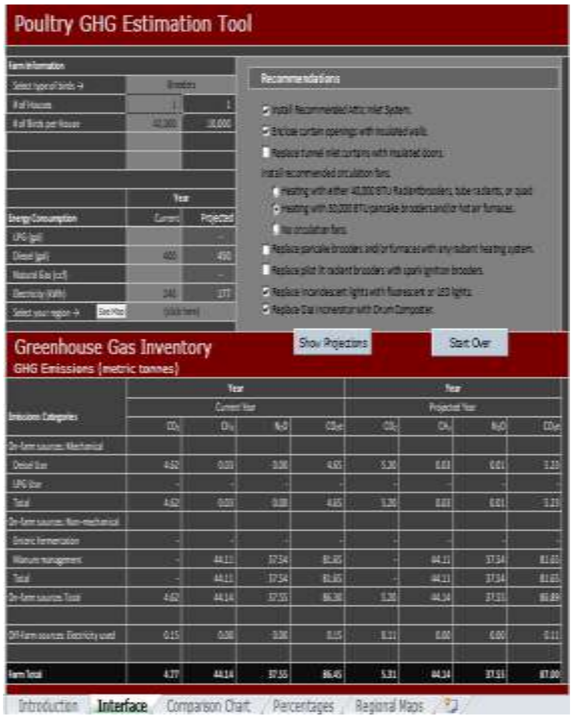

Fig. 7. Interface for breeder farm.
Source: www.ghgprotocol.org for other GHG calculation tools.

RESULTS AND DISCUSSIONS

Emissions of CH4 for layers from manure management by (ton CO_2-eq)

Figure 8 depicts CH4 emissions for breeder hens, which were estimated to be 0.41 ton of methane per year for 10,000 chickens, which is equal to 10.19 ton of CO_2-eq per year. While the annual emissions from 100,000 chickens were 4.1 ton CH4 yr^{-1}, which is equal to 101.87 ton CO_2-eq per year.

Nitrous oxide emissions (ton CO_2-eq) for breeder hen from manure management

Figure 9 depicts N_2O emissions for breeder hens, which were estimated to be 0.03 ton of Nitrous oxide per year for 10,000 chickens, which is equal to 8.67 ton of CO_2-eq per year. While the annual emissions from 100,000 chickens were 0.3 ton N_2O yr^{-1}, which is equal to 86.71 ton CO_2-eq per year.

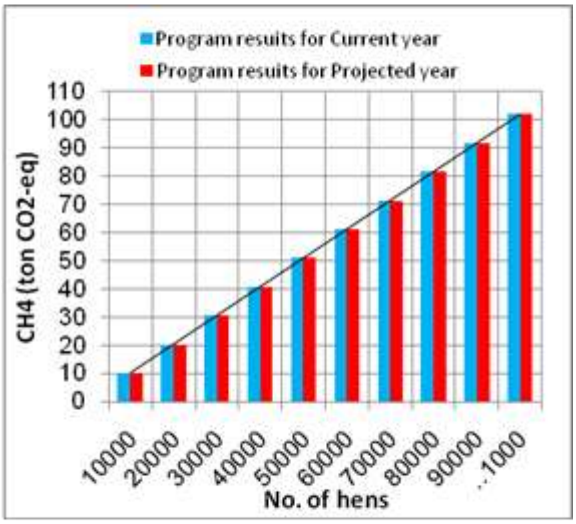

Fig. 8. Methane emissions (ton CO_2-eq) for breeder hen
Source: Authors' determination.

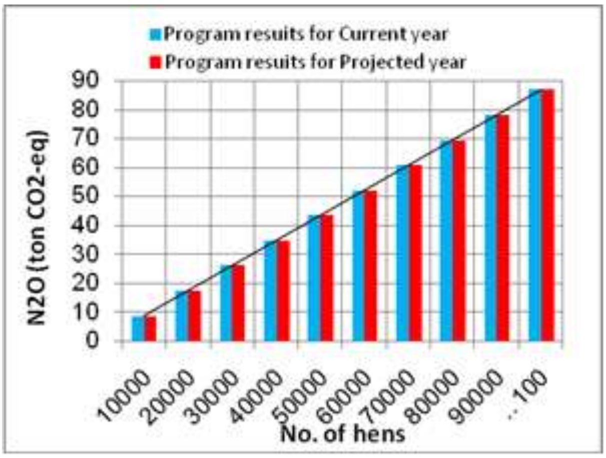

Fig. 9. Nitrous oxide emissions (ton CO_2-eq) for breeder hen.
Source: Authors' determination.

Fuel emissions from laying hens farms

Figure 10 depicts the diesel emissions from the farm's heating heaters and generators, which were calculated for breeder hens and were estimated to be 1.22 ton CO_2-eq for 10,000 chickens. While the annual emissions from 100,000 chickens were 12.2 ton CO_2-eq.

Emissions from electricity from laying hens farms

Figure 11 depicts the farm's electricity use emissions, which were calculated for breeder hens and were estimated to be 0.03 ton CO_2-eq for 10,000 chickens. While the annual emissions from 100,000 chickens were 0.35 ton CO_2-eq.

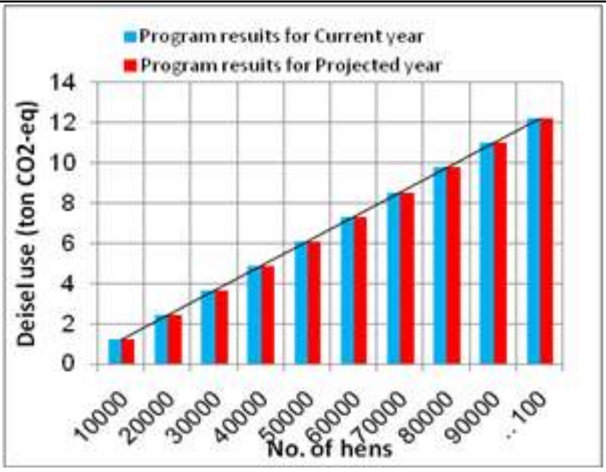

Fig. 10. The fuel emissions used (ton CO_2-eq) for breeder hen.
Source: Authors' determination.

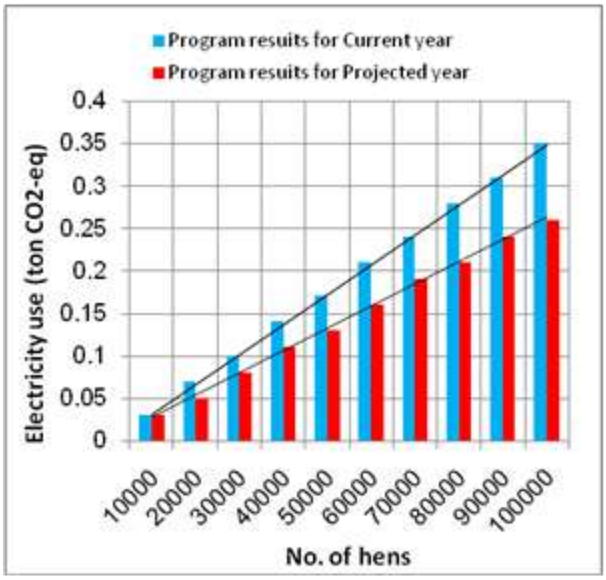

Fig. 11. The electricity emissions used (ton CO_2-eq) for breeder hen.
Source: Authors' determination.

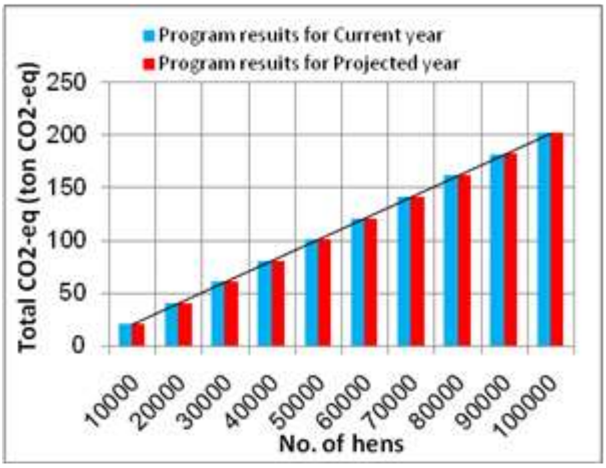

Fig. 12. Total CO_2-eq Emissions (ton CO_2-eq) for breeder hen
Source: Authors' determination.

Total CO_2-eq Emissions from Poultry Farms

Figure 12 shows Total CO_2-eq emissions from poultry farms were calculated and estimated to be 20.11 ton CO_2-eq for 10,000 chickens. While the annual emissions from 100,000 chickens were 201.14 ton CO_2-eq.

CONCLUSIONS

For manure management, the farm produced 1.76 ton CH_4 yr-1 of methane gas and 0.13 ton N_2O yr-1 of nitrous oxide gas. Thus, the total CO_2-equivalent emissions from manure management are estimated to be 81.65 ton. Diesel produces 5.23 ton of CO_2-equivalent greenhouse gas emissions. The greenhouse gas emissions (GHG) from the farm's electricity use are 0.15 ton of CO_2-eq. Finally, the farm produces 87.04 ton of CO_2-equivalent emissions. Finally, the total amount of CO_2 equivalent emissions generated by Egypt's farms is 271.8. (Kiloton CO_2-eq).

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