Household Activities and Greenhouse Gas Emissions Value: Lessons from a Neglasari Household Survey

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The escalating threat of global warming stems from greenhouse gas emissions resulting from various household activities, profoundly impacting climate change. This study delves into Neglasari Village, Bogor Regency, scrutinizing emissions' correlation with household consumption. Predominantly focusing on carbon dioxide, methane, and nitrous oxide, emissions arise from electricity, cooking and oil fuel usage, waste, agriculture, and livestock farming. Objectives encompass elucidating and computing greenhouse gas emissions, discerning influential factors, and gauging their economic ramifications. Employing IPCC's 2006 emission valuation, multiple linear regression, descriptive analysis, and carbon economic metrics, findings reveal Neglasari Village's emissions total 1,247,364.80 kg CO_2-e/month, averaging 411.40 kg CO_2-e/month per household. Key influencers identified are household income and house ownership status. The calculated carbon economic value stands at IDR138,646/month per household, aggregating to IDR421,809,752/month across Neglasari Village, fortifying the imperative for sustainable practices.

Keywords: Carbon Economic Value, Global Warming, IPCC, MRA

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INTRODUCTION

Global warming arises because of the dominant activity in using fossil fuels, so greenhouse gases are formed. The highest percentage concentration of greenhouse gas (GHG) emissions is carbon dioxide (CO_2) emissions by 90%, methane (CH_4) emissions by 9%, and nitrogen oxide (N_2O) emissions by 1% (Rifai et al. 2018). In line with Pratama and Parinduri's research (2019), CO_2, the most significant GHG in causing global warming, is obtained from human activities that support the use of fossil fuels, namely coal, petroleum, and natural gas. About 68% of CO_2 emissions come from the energy sector, 14% from other sectors, 11% from the agricultural sector, and 7% from the industrial sector (International Energy Agency 2016).

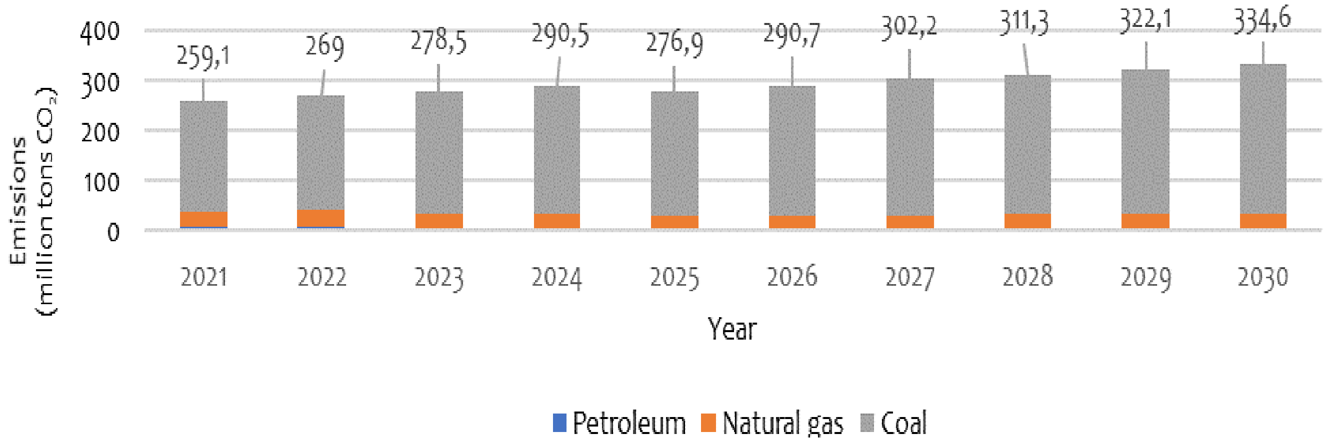

Figure 1 Projected greenhouse gas emissions from fossil fuels in 2021-2030 (modified from PLN, 2022)

According to PT Perusahaan Listrik Negara (PLN) Persero, GHG emissions in Indonesia are projected to increase between 2021 and 2030. This will occur in line with the increased use of fossil fuels. National GHG emissions reached 259.1 million tons of CO_2 in 2021. However, this number is estimated to increase by 29.13% to 334.6 million tons of CO_2 in 2030 (Figure 1). Most of the emissions are due to coal combustion, which is about 298.9 million tons of CO_2 or equal to 89.3% of total GHG emissions in 2030. Fuel oil emissions reached 34 million tons of CO_2, while natural gas emissions reached 1.7 million tons of CO_2.

In 2018, energy consumption grew by an average of 3% per year, reaching 126.9 million tons of oil equivalent. The transportation and industrial sectors are the most significant contributors to energy consumption, followed by the household, commercial, and other sectors. Energy consumption from the transportation sector decreased from 46% in 2013 to 45% in 2018, followed by the industrial sector at 34%, households at 15%, commercial at 5%, and other sectors at 2%. Although households are not the sector with the most significant energy consumption compared to the industrial sector, the household sector is one of the consumers in the production of the industrial sector, so it also contributes to GHG emissions.

GHG emissions arise from activities carried out by the population at any given time. Daily household activities can contribute to GHG emissions from electricity consumption, cooking fuel consumption, fuel oil consumption, waste, farming and livestock activities. The value of GHG emissions is different for each household, which is influenced by household characteristics, such as household income (Irfany & Klasen 2017). An increase in income is followed by increased emissions caused by increased expenditure and consumption (Rifai et al. 2018).

The population density in Bogor District, West Java Province, indicates the diverse activities undertaken as livelihoods by various income groups. This diversity leads to differences in the value of GHG emissions from each household activity. West Java Province is divided into 18 regencies and 9 cities, with 5,312 villages, 645 urban villages, and 627 sub-districts. In 2022, West Java is the province with the highest population in Indonesia, reaching 48.64 million people (17.6%) of the total population of Indonesia (Figure 2). About 3 million of them are residents of Bogor Regency. Bogor Regency is located in West Java, with an area of 1,273.88 square kilometers and a population density of 2,444 people/square kilometer (BPS 2020).

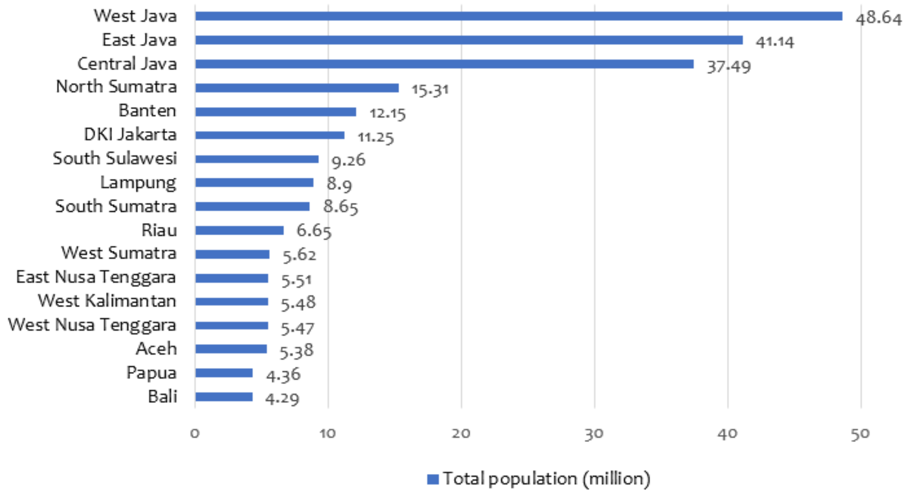

Figure 2 Provinces with the highest population in Indonesia 2022 (modified from BPS 2022)

This research is essential to look at data on household consumption patterns for household activities carried out, which will contribute to GHG emissions. The high level of household consumption indicates the high GHG emissions generated by household activities. By the problem formulation above, the general objective of this research is to calculate GHG emissions from household activities in Neglasari Village. The general objective can be achieved by answering three specific objectives as follows:

1. Describe and calculate the greenhouse gas emissions value produced by household activities.
2. Identify the factors that affect greenhouse gas emissions in Neglasari Village.

Calculate the economic value of greenhouse gas emissions produced.

METHOD

Data

The research was located in Neglasari Village, Dramaga Sub-district, Bogor District, West Java Province. The selection of the research location was purposive. The location was chosen because the province has the highest population in Indonesia, then Neglasari Village is a village around the campus with the 4th highest population in Dramaga Sub-district. The primary data used was taken in June 2023. The data types to be collected in this study are primary and secondary. Primary data was obtained using a questionnaire during the survey along with interviews. The primary data needed are the type of household activity and the amount of household income. Secondary data is collected through BPS, village websites, journals, the internet, and previous research literature studies. The secondary data required were population, number of households, carbon emission factor, and carbon pricing value.

The data collection method is determined through probability sampling. Probability sampling is a sampling method in which the population has an equal chance of being selected as a sample. The sample selection method used is cluster random sampling. Cluster random sampling is a sample selection that determines the group sample first, and then random sampling is taken from each group (Suriani & Jailani 2023). The number of samples was determined using the Slovin formula with an error rate of 10%:

$$n = \frac{N}{1 + Ne^2}$$

Notes:

n = Number of samples (people)
N = Number of households (people)
e = Percentage error rate (10%)

Based on the Slovin formula calculation, the result is 96.8071 people, rounded to 100 people. So, the number of samples to be used is 100 households. There are 6 Rukun Warga (RW) in Neglasari Village, to determine the number of samples for each RW, a stratified sample formula will be used (Sugiyono 2015).

$$n_i = \frac{X_i}{N} \times n$$

Notes:

n_i = Total sample RW_i (people)
X_i = Total household RW_i (people)
N = Total household (people)
n = Total sample (people)

Table 1 Total household and total sample in Neglasari Village

RW	Total Household	Total Sample
01	542	18
02	445	15
03	508	17
04	461	15
05	625	20
06	451	15
Total	3,032	100

Source: processed from Neglasari Village Website

Data Processing and Analysis Methods

Greenhouse Gas Emissions Value Analysis

The GHG emissions value analysis focused on the three GHG emission sources with the highest concentrations, namely carbon dioxide, methane, and nitrous oxide. These emissions are generated from five activity sources: electricity consumption, cooking fuel consumption, fuel oil consumption, waste, farming and livestock activities. The value of GHG emissions generated from household activities was calculated using the method established by the IPCC 2006. To calculate the total emission value, non-CO_2 emissions will be converted to CO_2 using the Global Warming Potential (GWP) value because CO_2 emissions have a much lower GWP value than CH_4, and N_2O emissions. For example, CH_4 emissions have a GWP value of 28, meaning each unit of CH_4 emissions has the potential to contribute to global warming 28 times greater than CO_2 emissions.

Emission Value of Electricity Consumption

The electricity consumption is reflected in the monthly electricity costs and depends on the electricity power connected to each household. The electricity costs incurred will be deducted first with Street Lighting Tax (SLT) of 3%, then can only be accumulated into electricity consumed by each household (Perda Bogor Regency No. 2 of 2016). The emission caused by electricity consumption is CO_2.

$$K = \frac{X - Y}{Z}$$

Notes:

C = Electricity consumption (kWh)

X = Electricity cost (IDR)

Y = SLT (IDR)

Z = Electricity price (IDR/kWh)

Table 2 Electricity Price

Power (VA)	Subsidy (IDR/kWh)	Non-subsidy (IDR/kWh)
450	415	-
900	605	1,352
1,300 – 2,200	-	1,444.70
3,500 – 5,500	-	1,699.53

Source: PLN 2023

After knowing the amount of electricity consumption in households, it can calculate the electricity emissions using the following formula:

$$Q = EF \times C$$

Notes:

Q = Electricity emissions (kg CO2)

EF = Electricity CO2 emission factor (0.794 kg CO2/kWh)

C = Electricity consumption (kWh)

Emission Value of Cooking Fuel Consumption

The cooking fuel consumption amount is denoted by each household's cooking fuel sources, such as LPG, kerosene, or firewood. This study uses cooking fuel in the form of LPG. The emissions caused by LPG consumption are CO2, CH4, and N2O.

Table 3 Emission Factors, Net Calorific Value, and Glonal Warming Potental of LPG on CO_2, CH_4, N_2O emissions

GHG emissions	LPG EF	LPG NCV	GWP
CO_2	63,100	0.0000473	-
CH_4	5	0.0000473	28
N_2O	0.1	0.0000473	265

Source: IPCC 2006

The emissions value of LPG consumption is calculated using the following formula:

$$Q = Q_{CO_2} + Q_{CH_4} + Q_{N_2O}$$
$$Q_{CO_2} = EF_{CO_2} \times C \times NCV$$
$$Q_{CH_4} = EF_{CH_4} \times C \times NCV \times GWP_{CH_4}$$
$$Q_{N_2O} = EF_{N_2O} \times C \times NCV \times GWP_{N_2O}$$

Notes:
Q = LPG total emissions (kg CO_2-e)
Q_{CO_2} = LPG CO_2 emissions (kg CO_2-e)
Q_{CH_4} = LPG CH_4 emissions (kg CO_2-e)
Q_{N_2O} = LPG N_2O emissions (kg CO_2-e)
EF_{CO_2} = LPG CO_2 emission factor (kg/Tj)
EF_{CH_4} = LPG CH_4 emission factor (kg/Tj)
EF_{N_2O} = LPG N_2O emission factor (kg/Tj)
C = LPG consumption (kg)
NCV = *Net Calorific Value* of LPG (Tj/kg)
GWP_{CH_4} = Conversion of CH_4 to CO_2
GWP_{N_2O} = Conversion of N_2O to CO_2

Emission Value of Fuel Oil Consumption

The amount of fuel oil consumption is denoted by the amount of fuel oil sources used by each household. The fuel oil studied is gasoline, which includes pertalite and pertamax. The emissions caused by gasoline consumption are CO2, CH4, and N2O.

Table 4 Emission Factors, Net Calorific Value, and Global Warming Potential of gasoline on CO_2, CH_4, N_2O emissions

GHG emissions	Gasoline EF	Gasoline NCV	GWP
CO_2	69,300	0.000033	-
CH_4	33	0.000033	28
N_2O	3.2	0000033	265

Source: IPCC 2006

The emissions value of gasoline consumption is calculated using the following formula:

$$Q = Q_{CO_2} + Q_{CH_4} + Q_{N_2O}$$
$$Q_{CO_2} = EF_{CO_2} \times C \times NCV$$
$$Q_{CH_4} = EF_{CH_4} \times C \times NCV \times GWP_{CH_4}$$
$$Q_{N_2O} = EF_{N_2O} \times C \times NCV \times GWP_{N_2O}$$

Notes:
Q = Gasoline total emissions (kg CO_2-e)
Q_{CO_2} = Gasoline CO_2 emissions (kg CO_2-e)
Q_{CH_4} = Gasoline CH_4 emissions (kg CO_2-e)
Q_{N_2O} = Gasoline N_2O emissions (kg CO_2-e)
EF_{CO_2} = Gasoline CO_2 emission factor (kg/Tj)
EF_{CH_4} = Gasoline CH_4 emission factor (kg/Tj)
EF_{N_2O} = Gasoline N_2O emission factor (kg/Tj)
C = Gasoline consumption (liter)
NCV = *Net Calorific Value* of gasoline (Tj/liter)
GWP_{CH_4} = Conversion of CH_4 to CO_2
GWP_{N_2O} = Conversion of N_2O to CO_2

Emission Value of Waste

Emissions are generated based on household waste generation. In Windraswara and Prihastuti (2017), house types are classified into permanent, semi-permanent, and non-permanent houses. Permanent houses have characteristics of building walls made of wall material, floors made of cement or ceramics, and roofs using roof tiles. Semi-permanent houses are characterized by walls and bamboo or wood, floors made of cement, and roofs using zinc, roof tiles, or asbestos. Non-permanent houses are characterized by walls made of wood or bamboo, no cement or ceramic floors, and roofs using zinc and asbestos. Household waste can be differentiated based on house type (Table 5). The emissions caused by waste is CO2.

Table 5 Household waste by house type

House type	Waste (kg/person/day)
Permanent	0.35 – 0.4
Semi-permanent	0.3 – 0.35
Non-permanent	0.25 – 0.3

Source: Damanhuri *et al.* 2009

Emissions value of waste is calculated using the following formula:

$$Q = EF_{CO_2} \times C$$

Notes:
Q = Waste total emissions (kg CO_2-e)
EF_{CO_2} = Waste CO_2 emission factor (1,09 kg /Tj)
C = Waste (kg)

Emission Value of Farming and Livestock Activities

The emissions caused by farming activities is CO_2. The emissions value of farming activities is calculated using the following formula:

$$Q = EF_{CO_2} \times C$$

Notes:
Q = Farming total emissions (kg CO_2-e)
EF_{CO_2} = Farming CO_2 emission factor (16,67 kg/month)
C = Fertilizer consumption (kg/month)

The emissions caused by livestock activities are CH_4 and N_2O. CH_4 emissions come from the digestion and processing of livestock manure. N_2O emissions come from the processing of livestock manure. In this study, the livestock were chickens and goats with body weights (BW) of 0.125 kg/tail/month and 3.75 kg/tail/month (IPCC 2006).

Table 6 Emission factors and Global Warming Potential of livestock on CH_4 digestion, CH_4 manure, N_2O manure emissions

GHG emissions	Livestock EF		GWP
	Chicken	Goat	
$CH_{4\ digestion}$	0	0,4167	28
$CH_{4\ manure}$	0,00167	0,0183	28
$N_2O_{\ manure}$	1,5	41,1	265

Source: IPCC 2006

The emissions value of livestock activities is calculated using the following formula:

$$Q = Q_{CH_4\ digestion} + Q_{CH_4\ manure} + Q_{N_2O\ manure}$$
$$Q_{CH_4\ digestion} = EF_{CH_4\ digestion} \times C \times GWP_{CH_4}$$
$$Q_{CH_4\ manure} = EF_{CH_4\ manure} \times C \times GWP_{CH_4}$$
$$Q_{N_2O\ manure} = EF_{N_2O\ manure} \times C \times BW \times N\ average\ excretion \times \frac{44}{28} \times GWP_{N_2O}$$

Notes:
Q = Livestock total emissions (kg CO_2-e)
$Q_{CH_4\ digestion}$ = Livestock CH_4 digestion emissions (kg CO_2- e)
$Q_{CH_4 manure}$ = Livestock CH_4 manure emissions (kg CO_2- e)
$Q_{N_2O\ manure}$ = Livestock N_2O manure emissions (kg CO_2- e)
$EF_{CH_4\ digestion}$ = Livestock CH_4 digestion factor emission (kg /tail/month)
$EF_{CH_4\ manure}$ = Livestock CH_4 manure factor emission (kg /tail/month)
$EF_{N_2O\ manure}$ = Livestock N_2O manure factor emission (kg /tail/month)
C = Livestock total population (tail)
BW = Body weight (kg /tail/month)
N average excretion = 0,05 kg /tail/year atau 0,004167 kg /tail/year
$\frac{44}{28}$ = Conversion of N_2O-N to N_2O
GWP_{CH_4} = Conversion of CH_4 to CO_2
GWP_{N_2O} = Conversion of N_2O to CO_2

Analysis of Factors Affecting Greenhouse Gas Emission Values

According to Rifai et al. (2018), different income brackets will result in emissions variations depending on the household's characteristics. As the most significant factor, household income plays a major role in determining emission levels. A high household income is in line with the value of emissions produced.

Multiple linear regression analysis can be conducted to determine the factors that influence the value of GHG emissions. Mona et al. (2015) explained that multiple linear regression determines the effect of at least two independent variables on one dependent variable. The general equation of the multiple linear regression method in this study is as follows:

$$Y = a + b1(X1) + b2 + e$$

Notes:

Y = Dependent variable
a = Constant
b = Regression coefficient
X = Independent variable
e = *Error*

The dependent variable is the value of GHG emissions, while the independent variables are household income and house ownership status dummies. To obtain an optimal regression model, it is essential to ensure the data distribution is normal or close to normal. If the data does not follow a normal distribution, it is necessary to transform the data first using Ln. Before conducting multiple linear regression analysis, it is necessary to conduct a classical assumption test consisting of normality test, linearity test, and heteroscedasticity test (Jannah et al. 2022).

The hypotheses used in this study related to the factors that influence the value of GHG emissions are:

1. Household income has a positive influence on the value of GHG emissions.
2. House ownership status dummy shows the difference in the value of GHG emissions caused between households with their own house and those living in rented houses. Households living in their own house will produce a higher value of GHG emissions than households living in rented house because households with their own house have a more significant income than households living in rented house.

If household income increases, expenditure and consumption also increase, impacting the value of GHG emissions. According to BPS (2016), income is classified into four groups as follows:

Group I = Income ≤ IDR2,000,000
Group II = Income > IDR2,000,000 - IDR4,000,000
Group III = Income > IDR4,000,000 - IDR6,000,000
Group IV = Income > IDR6,000,000

Carbon Economic Value Analysis

The Carbon Economic Value (CEV) is part of a comprehensive policy to reduce global warming. According to economist Joseph Stiglitz, the carbon price used in this study is the world carbon price, which is 22 USD/ton CO_2-e. Implementing CEV aims to reduce GHG emissions, encourage green investment, and promote sustainable growth (Ministry of Finance 2021). The economic value of carbon can be calculated using the following formula:

$$CEV = emission\ total \times carbon\ pricing$$

Notes:

CEV = Carbon economic value (IDR)
Emission total = Emission value produced (CO_2-e)
Carbon pricing = Global carbon pricing (IDR/ton CO_2-e

RESULT AND ANALYSIS

Greenhouse Gas Emissions Value

Emission Value of Electricity Consumption

Household electricity use generates CO_2 emissions, contributing 99% to the total GHG emissions from electricity generation (Ministry of Energy and Mineral Resources 2018). The emission value produced by electricity depends on the amount of electricity used and the household electricity consumption level.

The majority of respondents, 56% of the total sample or 56 households, use 450 VA electricity, 33 households use 900 VA electricity, and the remaining 11 households use 1,300 VA electricity. There is an inverse relationship between the amount of electricity used and the number of households because the more significant the electricity used, the fewer households use it.

Based on the electricity power data above, the total electricity consumption is 19,525.13 kWh/month or the average electricity consumption per household is 195.25 kWh/month. Total electricity emissions is 15,502.95 kg CO_2-e/month, or the average electricity emissions per household is 155.03 kg CO_2-e/month.

Based on the averages above, the total electricity consumption in Neglasari Village is 591,998 kWh/month with total electricity emissions of 470,050.96 kg CO_2-e/month. The level of electricity emissions generated is influenced by household electricity consumption.

Emission Value of Cooking Fuel Consumption

In addition to requiring electricity, households also require cooking fuel, which produces emissions from its use. Following the research of Wiratama et al. (2016), which states that electricity dominates household needs, followed by cooking fuel. Emissions from cooking fuel consumption are CO_2, CH_4, and N_2O. The level of emission value depends on the type of cooking fuel and the level of household cooking fuel consumption. 100% of respondents, or 100 households, use cooking fuel as LPG.

Based on the cooking fuel type data, the total LPG consumption is 2,235 kg/month, or the average LPG consumption per household is 22.35 kg/month. Total LPG emissions are 6,688.25 kg CO_2-e/month, or the average LPG emissions per household is 66.88 kg CO_2-e/month. Based on the above average, the total LPG consumption in Neglasari Village is 67,765.2 kg/month with total LPG emissions of 202,780.16 kg CO_2-e/month. The level of LPG emissions generated is influenced by household LPG consumption.

Emission Value of Fuel Oil Consumption

Transportation makes it easier for people to mobilize themselves or their goods through delivery services. However, in addition to its positive impact, transportation also has a negative impact. Emissions caused by fuel oil consumption are CO_2, CH_4, and N_2O. The level of emission value depends on the type of fuel oil used, the number of vehicles owned, and the level of fuel oil consumption.

All respondents, namely 100 households, use fuel oil as gasoline. The gasoline is used for personal vehicles such as motorcycles and cars. The number of motorized vehicles is more dominant at 86% compared to the number of cars, which is only 14%.

Based on the data on the type of fuel oil and the number of vehicles above, the total gasoline consumption is 4,751 liters/month, or the average gasoline consumption per household is 47.51 liters/month. Total gasoline emissions are 11,142.88 kg CO_2-e/month, or the average gasoline emissions per household is 111.43 kg CO_2-e/month.

Based on the above average, the total gasoline consumption in Neglasari Village is 144,050.32 liters/month with total gasoline emissions of 337,855.76 kg CO_2-e/month. The level of gasoline emissions generated is influenced by household gasoline consumption.

Emission Value of Waste

Akmalina (2021) mentioned that waste results from human activity and can contribute to global warming, which affects climate change. When waste accumulates over a certain period, it decomposes and releases gases into the atmosphere. As stated by Vergara and Tchobanoglous (2012), one of the causes of GHG emissions is waste management, which contributes to 4% of the total GHG emissions on earth. It is also stated that the primary source of GHG emissions in waste management is waste transportation from its source to the final processing site (TPA). The emissions generated from waste in this study are CO_2. The level of emission value produced by waste depends on the level of household waste generation.

The total waste generation is 5,667 kg/month, or an average of 56.67 kg/month per household. The total waste emission is 6,177.03 kg CO_2-e/month, or the average waste emission per household is 61.77 kg CO_2-e/month. Based on the above average, the total waste generation in Neglasari Village is 171,823.44 kg/month with total waste emissions of 187,286.64 kg CO_2-e/month. The level of waste emissions generated is influenced by household waste generation.

Emission Value of Farming and Livestock Activities

In addition to contributing to the population's welfare, the agricultural sector also contributes to GHG emissions. The agricultural sector accounts for around 8% of total GHG emissions nationally (Sasmita et al. 2018). One of the main contributors to these emissions is CO_2 emissions from using fertilizers on agricultural land. Most respondents, 90% of the total sample or 90 households, do not have agricultural land as one of their household activities because these households are not farmers. There are only 10 households that own agricultural land, which means that these households are farmers.

Based on the agricultural land data above, the total fertilizer use is 28.50 kg/month or the average fertilizer use per household is 0.285 kg/month. Total emissions from farming activities by households are 475.10 kg CO_2-e/month, or the average emissions from farming activities per household is 4.75 kg CO_2-e/month. Based on the above average, the total fertilizer use in Neglasari Village is 864.12 kg/month, with total emissions from farming activities by households of 14,402 kg CO_2-e/month. The amount of fertilizer households influences the level of emissions generated use.

Waste from livestock contributes to GHG in animal husbandry (Ishak et al. 2019). Livestock waste includes treated waste, manure piles, and manure spread on the ground. Emissions generated from livestock activities are CH_4 and N_2O. Most respondents, 89% of the total sample or 89 households, did not have livestock as one of their household activities because the household was not a farmer. There are only 11 households that own livestock, which means that the household is a farmer. The total number of farmer households that own livestock is 78, with 95% or 74 chickens and 5% or 4 goats.

Based on the livestock data above, the total livestock is 78 heads, or the average livestock per household is ± 8 heads. The total emissions from household livestock activities is 1,153.85 kg CO_2-e/month, or the average of livestock activities per household is 11.53 kg CO_2-e/month. Based on the above average, the total livestock in Neglasari Village is 24,256 heads, with total emissions generated from livestock raising activities by households of 34,958.96 kg CO_2-e/month. The number of livestock households influences emissions from household farming activities.

Total emissions from farming and livestock raising activities by households are 1,628.95 kg CO_2-e/month or an average per household of 16.29 kg CO_2-e/month. Based on the above average, the total emissions from farming and livestock activities by households in Neglasari Village is 49,391.28 kg CO_2-e/month.

Greenhouse Gas Emissions Value in Neglasari Village

The average value of GHG emissions per household and the total value of GHG emissions generated by household activities vary according to the level of consumption.

Table 7 Greenhouse gas emissions in Neglasari Village

Emissions source	**Emissions total (kg CO_2-e/month)**	**Emissions average (kg CO_2-e/month)**	**Emissions total (kg CO_2-e/month)**
	100 respondents	**per household**	**one scope Neglasari Village**
Electricity emissions	15.502,95	155,03	470.050,96
LPG emissions	6.688,25	66,88	202.780,16
Gasoline emissions	11.142,88	111,43	337.855,76
Waste emissions	6.177,03	61,77	187.286,64
Farming and livestock activity	1.628,95	16,29	49.391,28
Total	**41.140,06**	**411,40**	**1.247.364,80**

Source: processed from primary data 2023

With 100 households as respondents, the total value of GHG emissions generated is 41,140.06 kg CO_2-e/month. The average GHG emission value of each household is 411.40 kg CO_2-e/month. Suppose it is assumed that each household has the same amount of emission value. In that case, the total value of GHG emissions within the scope of Neglasari Village is 1,247,364.80 kg CO_2-e/month with the highest total emissions found in electricity emissions, namely 470,050.96 kg CO_2-e/month and the lowest total GHG emissions found in farming and livestock activities emissions, namely 49,391.28 kg CO_2-e/month (Table 7). This is in line with several literature studies that explain that the highest GHG emissions are in energy consumption emissions.

Factors Affecting the Greenhouse Gas Emissions Value

The influence of household income and house ownership status dummy on the value of GHG emissions is known using regression analysis. This study used multiple linear regression analysis to see the effect of the independent variable (X) on the dependent variable (Y). The independent variables used are household income and house ownership status dummy, while the dependent variable is the value of GHG emissions. Before regression analysis is conducted, the variables must pass the classical assumption test consisting of normality, linearity, and heteroscedasticity tests. The tests were conducted with the help of SPSS (Statistical Package for the Social Sciences) software.

Clasical Assumption Test

The normality test is carried out to test whether the variables in the regression model are normally distributed. In this study, the Kolmogorov-Smirnov Test method was used. If the significance value> 0.05, the variable is normally distributed. Conversely, if the significance value <0.05, the variable is considered not normally distributed (Jannah et al. 2022). The significance value is 0.2. The conclusion is that the significance value is> 0.05, so the data is normally distributed and passes the normality test.

The linearity test is carried out to test whether the variables in the regression model have a significant linear effect. If the significance value> 0.05, the variable is considered to have a linear effect. Conversely, if the significance value <0.05, the variable is considered to have no linear effect (Jannah et al. 2022). The deviation from the linearity value is 0.439. The conclusion is that the significance value is> 0.05, so the data has a linear effect and passes the linearity test.

The heteroscedasticity test is carried out to test whether the variables in the regression model cause inequality of variance from one observation to another. If the significance value > 0.05, the variable is considered to have an inequality of variance from one observation to another. Conversely, if the significance value <0.05, the variable is considered to have no inequality of variance from one observation to another (Khatijah et al. 2020). The sig value of the household income variable (X1) and the dummy variable of house ownership status (D_SKR) are 0.860 and 0.413. The conclusion is that each significance value > 0.05, so this regression model has an inequality of variance from the residuals of one observation to another to pass the heteroscedasticity test.

Multiple Linear Regression

Multiple linear regression analysis in this study is used to see the influence of independent variables (household income and house ownership status dummy) on the dependent variable (GHG emission value). If the significance value is < 0.05, then there is an influence of the independent variable (X) on the dependent variable (Y). If the significance value > 0.05, then there is no influence of the independent variable (X) on the dependent variable (Y).

Table 8 Regression ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.686	2	2.343	16.345	.000[b]
	Residual	13.906	97	.143		
	Total	18.592	99			

a. Dependent Variable: Ln_Y
b. Predictors: (Constant), D_SKR, Ln_X1
Source: processed from primary data 2023

The sig value or significance value is 0.000 < 0.005 (Table 8), which shows the influence of household income and house ownership status dummy on the value of GHG emissions

Table 9 Regression model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.502[a]	.252	.237	.37862

a.Predictors: (Constant), D_SKR, Ln_X1
Source: processed from primary data 2023

The coefficient of determination or R square is 0.252 (Table 9), which shows that the effect of household income and house ownership status dummy on the value of GHG emissions is 25.2%. While other variables influence the remaining 74.8%.

Household income and house ownership status dummy significantly influence GHG emission values (Table 10). The regression equation is as follows:

$$Y = a + b1(X1) + b2(X2) + e$$
$$Ln\, Y = 1{,}392 + 0{,}284\, Ln\, X1 + 0{,}291\, D_{SKR} + e$$

Notes:
Y = Greenhouse gas emissions value (kg CO_2-e)
X1 = Household income (IDR)
D_{SKR} = House ownership status dummy (contract house = 0; self-owned house = 1)

The equation shows that the constant value (a) is 1.392, which means that the consistent value of the dependent variable (GHG emission value) is 1.392. The income variable has a significance value of 0.000 < 0.05, so household income influences the value of GHG emissions. The coefficient value of the income variable is 0.284, which means that for every 1% increase in household income, the value of GHG emissions increases by 0.284 (Table 10).

The dummy variable of house ownership status has a significance value of 0.031 < 0.05, so house ownership status influences the value of GHG emissions. The coefficient value of the dummy variable of house ownership status is 0.291, which means that the difference in the value of GHG emissions generated between households with their own home and those living in rented house is 0.291 (Table 10).

Table 10 Regression Coefficients

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients *Beta*	t	Sig.
1	(Constant)	1.392	.801		1.738	.085
	Ln_X1	.284	.052	.483	5.474	.000*
	D_SKR	.291	.133	.193	2.186	.031*

a. Dependent Variable: Ln_Y

Source: processed from primary data 2023

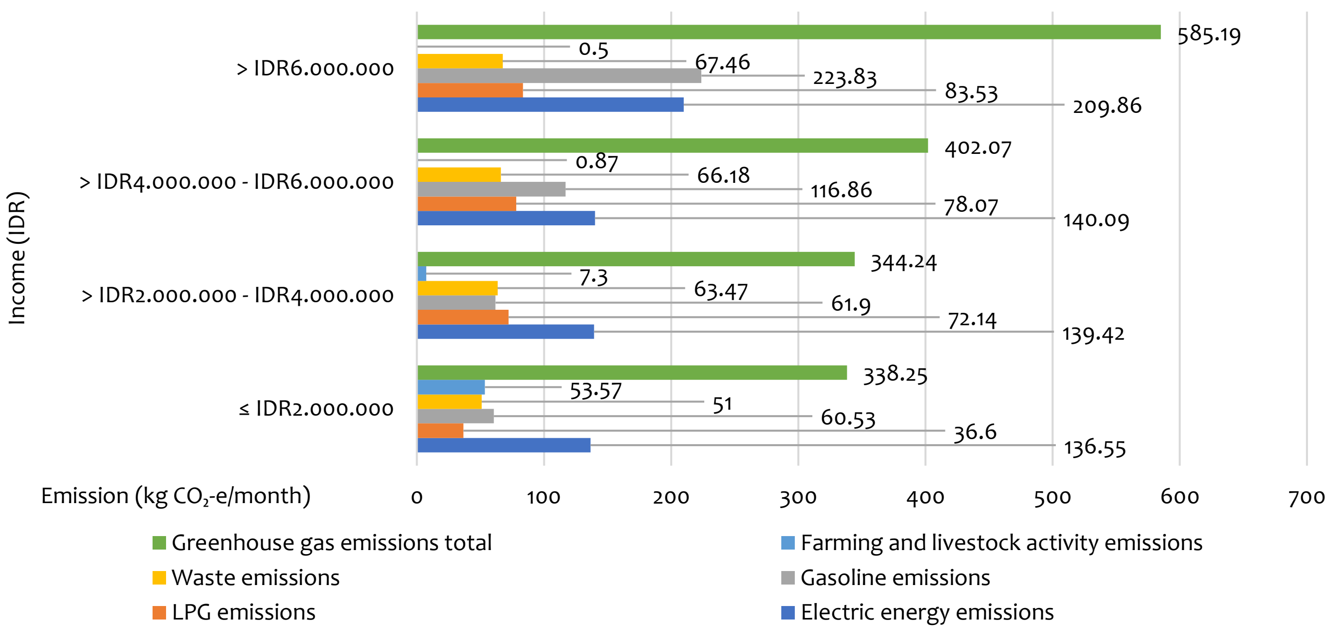

Figure 3 Average greenhouse gas emission value of RW 01-06 Neglasari Village by household income group (processed from primary data 2023)

The emission values of electricity, LPG, gasoline, and waste energy increased with household income (Figure 3). This is because household electricity, LPG, gasoline, and waste consumption have increased, resulting in increased emissions. Conversely, the emission value of farming and livestock activities decreased, which was not in line with the increase in household income (Figure 3). This is because the higher the income bracket of the household, the more likely it is that they are not working as farmers or livestock breeders.

However, in total, an increase in household income is followed by an increase in the value of GHG emissions (Figure 3). As income increases, consumption to meet the needs of household activities will also increase, increasing the value of GHG emissions produced.

Carbon Economic Value

CEV is used to assess the economic losses households would experience if a carbon price were implemented. CEV is also used to reduce the value of GHG emissions, which will reduce global warming and impact climate change for the better. In this study, the world carbon price, according to economist Joseph Stiglitz is 22 USD/ton CO_2-e or equivalent to IDR338,162/ton CO_2-e (exchange rate of IDR15,371 as of September 18, 2023). The calculation of CEV using the world carbon price is as follows:

$$CEV = emission\ total \ \times carbon\ pricing$$

Under the above calculations, it is concluded that if the world carbon price is applied, the average CEV per household is IDR138,646/month, or the value of economic losses per household is IDR138,646/month with an average value of emissions generated per household of 0.41 tons CO_2-e/month. The CEV of one scope of Neglasari Village is IDR421,809,752/month, or the economic loss value of one village scope is IDR421,809,752/month, with a total value of emissions generated by the village of 1,247.36 tons of CO_2-e/month.

CONCLUSION

The conclusions in this study are: (1) The total value of GHG emissions from electricity, LPG consumption, gasoline consumption, waste, farming and livestock activities generated by 100 respondent households in Neglasari Village is 41,140.06 kg CO_2-e/month. The average value of GHG emissions per household is 411.40 kg CO_2-e/month. Meanwhile, suppose it is assumed that each household has the same amount of emission value. In that case, the total value of GHG emissions within the scope of Neglasari Village is 1,247,364.80, with the highest total emissions contained in electricity emissions, namely 470,050.96 kg CO_2-e/month and the lowest total GHG emissions contained in emissions from farming and livestock activities, namely 49. 391.28 kg CO_2-e/month; (2) Factors that influence the value of GHG emissions are household income and house ownership status dummy; (3) The average CEV per household is IDR138,646/month with an average value of emissions generated per household of 0.41 tons CO_2-e/month. The CEV of Neglasari Village is IDR421,809,752/month, with a total value of emissions generated by the village of 1,247.36 tons of CO_2-e/month.

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