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Article

Analysis of Greenhouse Gas Emissions from Household Activities

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Abstract. Waste is a very significant issue in increasing greenhouse gas emissions. Cibitung sub-district is an industrial and densely populated area, which can trigger large amounts of greenhouse gas emissions. Settlement as an area where there are various human activities that consume energy, both electrical energy and energy derived from fossil fuels, is one of the sources of greenhouse gas emission. This study aims to determine the rate of generation and composition of household waste, estimate greenhouse gas (GHG) emissions with an IPCC approach and measurement using SPSS statistics. The independent variables used in this study are house type, household income, and electricity power with the type of GHG emissions coming from operational vehicle use, LPG use, and electricity use in household activities. Information on the management of household activities was obtained through the distribution of questionnaires with the target respondents being the community around Cibitung Sub-district. Based on the research results, the total value of GHG emissions generated by Cibitung Sub-district is 34.9565811 $KgCO_2eq$/ month. Kelurahan Wanasari produces the highest GHG emission of 18.6809624 $KgCO_2eq$ /month while Kelurahan Sarimukti produces the lowest GHG emission of 676.9651 $KgCO_2eq$/month. Based on the results of statistical tests, the factors that influence the high GHG emissions from household activities are the type of house, the amount of income of the family head, and electricity power.

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1. Introduction

Environmental protection and management is the unity of space with all objects, forces, conditions, and living things including humans and their behavior, which affect nature itself, the continuity of life, and the welfare of humans and other living things [1]. Environmental sustainability is important in our survival as humans, but since ancient times the decomposition of plants, animal matter, and volcanic eruptions have produced pollutants in the form of gases and particles into the atmosphere and the development of the era and technological advances in various fields also support the occurrence of pollution problems in the environment [2].

Global warming is a form of ecosystem imbalance on earth due to the process of increasing the average temperature of the atmosphere, sea, and land on earth. According to [3] Global warming is the increase in average temperatures across the earth's surface due to the emission of greenhouse gases in large quantities which can trap heat energy in the earth. Global warming is one of the topics that is always hot to discuss, because its effects are increasingly felt in various countries. The greenhouse gas (GHG) effect is considered as one of the causes of global warming that has the greatest influence, the greenhouse effect causes energy from sunlight to not be reflected off the earth [4]. GHGs cause the temperature on the earth's surface to increase, where GHGs can be produced from various activities and sectors [5]. According to [6] the main gases categorized as greenhouse gases and have the potential to cause global warming are CO_2, CH_4, and N_2O.

In the BaU (Business as Usual) scenario, greenhouse gas emissions in 2010 were 105 million tons of CO_2e and in 2025 rose to 645 million tons of CO_2e. According to the National Greenhouse Gas Inventory and MRV Report, "Indonesia had expressed its commitment at the Conference of Parties (COP) 15, in 2009, to reduce greenhouse gas (GHG) emissions by 26% (by its own efforts) and by 41% (with international assistance) by 2020. Indonesia's commitment was confirmed in the Republic of Indonesia's first Nationally Determined Contribution (NDC) document in November 2016 by setting an unconditional target of 29% and a conditional target of up to 41% compared to the (BAU) scenario in 2030 [7]. Based on the NCD, "Nationally, the 2030 emission reduction target is 834 million tons CO_2e in the unconditional target (CM_1) and 1,081 million tons CO_2e in the conditional target (CM_2). In implementing the target, nationally, various forms of mitigation have been implemented in all sectors by the person in charge of mitigation actions"[8].

Increased energy use results in the use of fossil fuels such as, oil, coal, and gas, as energy sources also increase where the exhaust gas from the energy such as CO_2 is an air contribution to greenhouse gases (GHG) [9]. In Wiratama said that the household is a place where humans do many kinds of activities [10]. Some of the sectors that can lead to increased greenhouse gases are transportation, energy, waste, housing, income levels, and water supply. According to Wulandari, "upper-class housing or with a higher economic level usually uses more household energy, resulting in greater CO_2 emissions" [11]. The clean water sector is usually related to electrical energy which in its use uses a water pump. With the whole must have a variety of activities with the acquisition of different footprint assessments for each household member. Everyone when doing their activities in daily life that use energy will produce carbon dioxide (CO_2) emissions where the more human activity, the more energy used so that the greater the carbon footprint value [12]. According to Wiratama, that the factors that drive the growth of the household/settlement energy sector are population growth (number of households) and purchasing power (GDP/capita) [10].

According to Nugrahayu in Latifa, the lifestyle of cooking fuel consumption, the number of family members, and the economic growth and per capita income of an area are other factors that affect the amount of CO_2 emission production [13-14]. High and low emissions are influenced by the number and type of electronic appliances, as well as the electrical power of the house as it affects energy consumption [15]. While other factors are influenced by the number of settled family members, income, house size, number of floors in the house, number of rooms in the house.

Based on the situation and analysis, the research location was chosen in Cibitung District. Cibitung Sub-district is one of the sub-districts in Bekasi Regency which consists of 233,442 residents according to data from the Central Bureau of Statistics (BPS) of Cibitung Sub-district in 2022, which is located around industrial areas and is quite densely populated. The development of an area can be seen from the physical development marked by the increase in built-up land for settlements, industries, and public facilities. The more extensive built-up land can trigger an increase in the population of the region. In addition to the factors of birth and death of the population, a significant influence on the causes of population growth, especially in urban areas, is urbanization. The lack of jobs available in villages has resulted in many villagers moving to urban areas where there are potentially more jobs. Therefore, the existence of urbanization has resulted in an increasingly dense population in urban areas [16]. The denser the population in residential areas, the more fuel and electricity energy consumption in household use [10]. The use of high fuel and electricity consumption can contribute to a high emission footprint [11]. The household sector in Indonesia contributes 3.8% of direct CO_2 emissions and 20.7% of indirect CO_2 emissions. The resulting emission of 0.58 tons of CO_2/capita is far below the average climate action towards net zero of 1.46 tons of CO_2/capita [17].

Emissions from fuel combustion with an average growth in LPG energy consumption of 14.46%. The movement of LPG consumption increased emissions periodically to 620 $MtCO_2$ in 2018 [18]. The policy of converting kerosene to LPG is one of the important factors in increasing the movement of LPG emissions [19]. Emissions from electricity are the largest contributor at 35%. GHG emissions from electricity are projected to remain the largest by 2030, not only because of the increased demand for electricity due to economic and population growth, but also because the construction of new power plants is still dominated by fossil fuels [20].

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An inventory of GHG emissions is needed to make the calculation of GHG emissions more clusterized and easier to mitigate [23]. The calculation of GHG emissions will be a measure of how much greenhouse gas emissions are produced, which is called the carbon footprint [24] [25]. This activity also aims to determine the results of carbon footprint measurements of GHG emissions from household activities in Cibitung Sub-district, determine the correlation of household activities in Cibitung Sub-district to the carbon footprint of GHG emissions in Cibitung Sub-district, and determine the mapping of GHG emissions in Cibitung Sub-district by using equations and emission factors that are already available in IPCC, analysis using SPSS, and the resulting GHG emission measurements are also in line with Indonesia's commitment to reduce 29% of GHG emissions by 2030.

2. Experimental Section

2.1. Materials

This research was conducted using a quantitative method where the quantitative approach method is because this method has clear elements such as objectives, subjects, data sources that are concrete and detailed from the start, then this research uses samples, there is clarity of research, and data analysis is carried out after all data is collected [26] [27]. The quantitative approach helps to show the relationship between samples of household activities in Cibitung Sub-district and the results of GHG emission measurements. The tool in this research is using the help of SPSS 25 software.

The analysis used is validity test, reliability test, and correlation test. This study aims to determine the results of GHG emission measurements on household activities in Cibitung Sub-district, determine the correlation of activities in Cibitung Sub-district to GHG emission results in Cibitung Sub-district, and determine the mapping of GHG emission measurements in Cibitung Sub-district. This study was conducted to measure GHG emissions in Cibitung sub-district. Topographically, the area is an average plain located between Bekasi Regency and West Java Province. The area of Kecamatan Cibitung is 35.79 km^2.

This research was conducted by collecting primary and secondary data on household activities in Cibitung Sub-district. This research was conducted from September 2023. The preparation of this research flow chart aims to describe the stages that will be carried out during the research systematically. The flow chart starts from the research idea, problem formulation, literature review, data collection, data analysis, data interpretation, and conclusions and preparation of research reports. The following is the research flow chart:

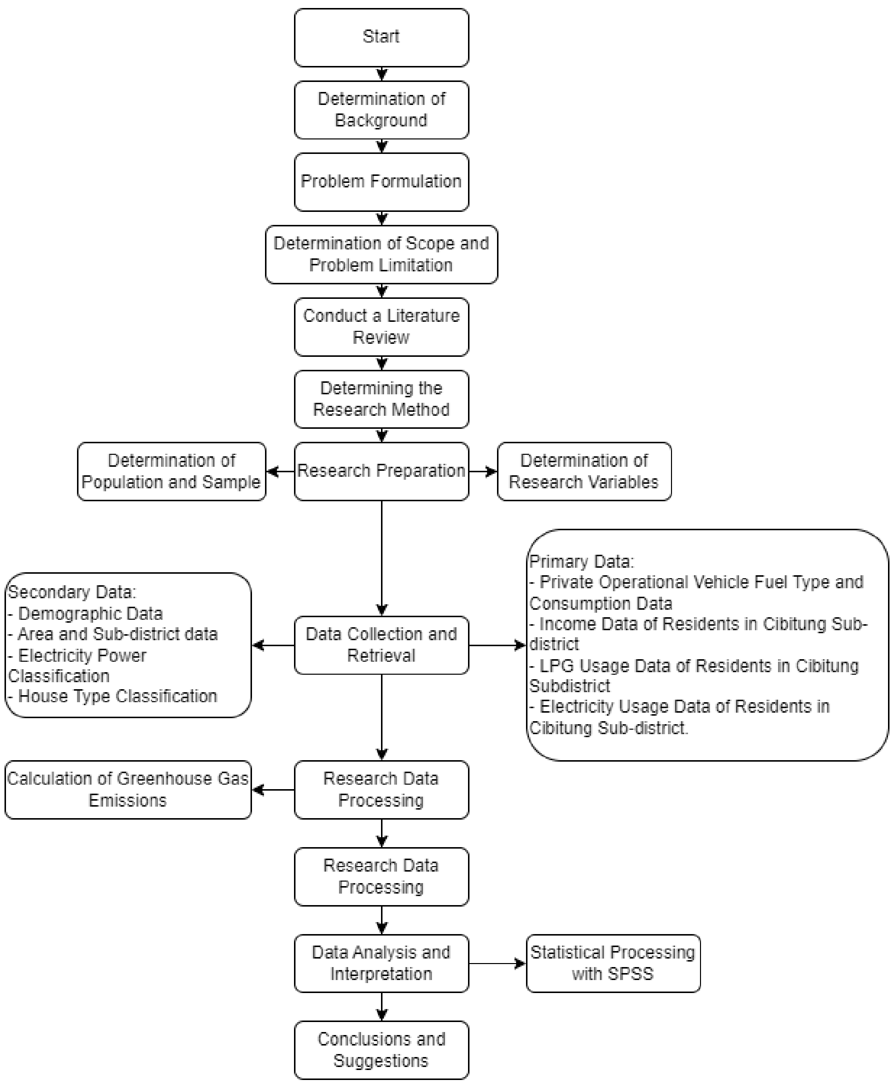

Figure 1. Research flow chart

2.2. Preparation of Sample and Population

Population according to [28] is a generalization area consisting of objects or subjects that have certain qualities and characteristics set by researchers to study, analyze, and draw conclusions [27]. The population in this study were all residents of Cibitung District. The sampling technique uses cluster random sampling technique, by using a random sample, not the entire population will be tested but only a certain number whose number is determined using the following equation [29]:

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

Description:
n : Number of samples at Pelita Bangsa University
N : Total population at Pelita Bangsa University
α : The degree of error used
Based on the above equation using an error degree of 10%, the number of samples in the study area is obtained:

$$n = \frac{233.442}{1 + 233.442(0{,}1)^2}$$

n=100 families
So, the number of studies that will be studied in this study is 233,442 samples. The following is Table 1 data on the number of sampling questionnaires to be taken:

Tabel 1. Data on the number of sampling questionnaires

No.	Neighborhoods	Population Count	Sample Quantity
1	Cibuntu	23.556	10
2	Wanasari	101.665	43
3	Wanajaya	50.835	22
4	Sukajaya	27.508	12
5	Kertamukti	13.917	6
6	Muktiwari	11.397	5
7	Sarimukti	4.564	2
Residents of Cibitung Subdistrict		233.442	100

Source: BPS Data, 2022.

2.3. Data Collection and Retrieval Phase

Primary data collection is obtained directly from the main source, namely respondents who are used as research subjects, where researchers collect primary data through questions contained in questionnaires distributed to residents in Cibitung District to be processed by researchers, besides that interviews and direct observations are also conducted with several residents' representatives. Secondary data collection obtained from various literatures, articles, internet sites, and related journals related to the research.

Primary data processing is carried out to obtain the estimated value of GHG emissions in Cibitung Subdistrict, while secondary data is used to support primary data processing such as population data of Cibitung Subdistrict residents, data on the area and size of Cibitung Subdistrict, data on the type and use of fuel for residents' vehicles, power data, and electricity use. Furthermore, the data obtained from the calculation results will be carried out a correlation test to ascertain the relationship between the GHG emissions produced and the independent variables that have been determined.

In this study, the authors used SPSS to conduct statistical tests where the analysis method used was the correlation test. The correlation test is conducted to determine the relationship between the variables to be tested, in this study the tested are electrical power, total income, and house type with their relationship to scope one emissions, scope two emissions, and scope three emissions. The correlation test used is the Pearson correlation test. Reliability testing was conducted to determine the consistency of the data, while validity testing was conducted to determine the accuracy of the data collected from the use of instruments.

2.4. GHG Emission Measurement Calculation

Scope One

Scope one is GHG emissions generated from an entity that come directly out of the facilities in that entity. An example is GHG emissions resulting from the combustion of fossil fuels that produce CO_2 emissions, where in this study scope one includes the use of fuel for residents' operational vehicles and the use of LPG by residents of Cibitung Sub-district. Scope one formula:
Calculation of GHG emissions from operational vehicle activities of residents of Cibitung Sub- district

GHG Emissions= Fuel consumption x NCV x FE x GWP

Description:
GHG emissions: $KgCO_2eq$
Fuel consumption : Liter
NCV : MJ/L
Emission Factor : Kg CO_2/ MJ
GWP : -

Table 2. NCV and GWP values of fuel

No.	Jenis	NCV (TJ/ L)	GWP Value		
			CO_2	CH_4	N_2O
1	Premium	33×10^{-6}	1	25	298
2	Solar	36×10^{-6}	1	25	298

Source: IPCC, 2006.

Calculation of GHG emissions from the use of LPG gas in the activities of residents of Cibitung Subdistrict

GHG Emissions = LPG Consumption x NCV x FE x GWP

Table 3. NCV and GWP values of LPG

No.	Type	NCV (TJ/ L)	Value GWP		
			CO_2	CH_4	N_2O
1	LPG	47.3×10^{-6}	1	25	298

Source: IPCC, 2006.

Scope Two

Scope two is GHG emissions generated from an entity that exit indirectly from the facilities in that entity. For example, in this study, scope two covers electricity use from household activities in Cibitung sub-district. Scope two formula:
Calculation of GHG emissions in electricity use from residents' activities in Cibitung Sub-district

GHG Emissions = Energy Consumption x SFC x NCV x FE x GWP

Table 4. SFC Value

No.	Generating	Fuel	SFC	Unit
1	PLTU	coal	0.54	Tfuel/ Mwh

Source: CDM-PDD-Version, 2004 in Kusuma, 2014

Table 5. NCV and GWP values of electricity

No.	Type	NCV (TJ/ Ton)	GWP Value		
			CO_2	CH_4	N_2O
1	Batubara	18.9×10^{-3}	1	25	298

Source: IPCC, 2006

3. Results and Discussion

Vehicles are used as a medium of transportation for the operational needs of private people so that their existence is very influential, especially on the environment. Based on the data obtained in Cibitung Subdistrict from 100 samples that were measured, the measurement results are shown in the following table:

Table 6. Measurement Results of GHG Emissions from Vehicle Use

No.	Neighborhood	Total Operational Vehicle GHG Emissions (KgCO₂eq/ Month)				Presentase (%)
		CO_2	CH_4	N_2O	Total GHG Emissions	
1	Cibuntu	1051.9740	12.5235	14.4756	1078.9731	10.57
2	Wanasari	5801.8653	69.0698	79.8363	5950.7715	58.28
3	Wanajaya	1477.3374	17.5874	20.3288	1515.2536	14.84
4	Sukajaya	834.7185	9.9371	11.4861	856.1417	8.39
5	Kertamukti	423.0765	5.0366	5.8217	433.9349	4.25
6	Muktiwari	311.0184	3.7026	4.2798	319.0008	3.12
7	Sarimukti	54.8856	0.6534	0.7553	56.2943	0.55
Total		9954.8757	118.5104	136.9837	10210.3698	100.00

Source: Research data processed, 2024.

It is known that the producer of GHG emission scope one from the use of operational vehicles amounted to 10,210.3698 $KgCO_2eq$/ month with a percentage of 29.21% of the total GHG emission produced. The highest producer of GHG emissions from the use of operational vehicles is Wanasari Village with 5,950.7715 $KgCO_2eq$/ Month with a percentage of 58.28% of the total GHG emissions from the use of operational vehicles, while the lowest is Sarimukti Village with 56.2943 $KgCO_2eq$/ Month with a percentage of 0.55% of the total GHG emissions from the use of operational vehicles, this happens because based on demographic data, Wanasari Village is the Village with the largest population in Cibitung Subdistrict and the majority of its residents also have private vehicles that are actively used every day.

LPG is used as fuel for cooking activities of residents in Cibitung Sub-district, which if known, is one of the contributors to GHG emissions from household activities in Cibitung Sub-district. The following is the calculation of GHG emissions based on the use of LPG:

Table 7. Measurement Results of GHG Emissions from LPG Use

No.	Neighborhood	Total GHG Emissions from LPG Use (KgCO₂eq/ Month)				Presentase (%)
		CO_2	CH_4	N_2O	Total GHG Emissions	
1	Cibuntu	98.4928	0.1951	0.0465	98.7344	6.13
2	Wanasari	859.5734	1.7028	0.4059	861.6822	53.53
3	Wanajaya	331.2939	0.6563	0.1565	332.1067	20.63
4	Sukajaya	143.2622	0.2838	0.0677	143.6137	8.92
5	Kertamukti	71.6311	0.1419	0.0338	71.8068	4.46
6	Muktiwari	74.6158	0.1478	0.0352	74.7988	4.65
7	Sarimukti	26.8617	0.0532	0.0127	26.9276	1.67
Total		1605.7309	3.1809	0.7583	1609.6702	100.00

Source: research data processed, 2024

It is known that the producer of GHG emissions in scope one from LPG use amounted to 1.6096702 $KgCO_2eq$/ Month with a percentage of 4.60% of the total GHG emissions produced which is the lowest percentage of the total GHG emissions. The highest producer of GHG emissions from the use of LPG is Wanasari Village 861.6822 $KgCO_2eq$/ Month with a percentage of 53.53% of the total GHG emissions from the use of LPG while the lowest is Sarimukti Village of 26.9276 $KgCO_2eq$/ Month with a percentage of 1.67% of the total GHG emissions from the use of LPG, this happens because based on demographic data Wanasari Village is the Village with the largest population in Cibitung District and the majority of its citizens are also families who actively cook or use LPG every day.

Measurement of GHG emission scope two which includes electricity use in Cibitung Sub-district. Based on the data obtained in Cibitung Subdistrict from 100 samples that were measured, the measurement results are as follows:

Table 8. Total GHG Emissions Electricity Usage ($KgCO_2eq$/ Month)

No	Neighborhood	Total GHG Emissions Electricity Usage ($KgCO_2eq$/ Month)				Presentase (%)
		CO_2	CH_4	N_2O	Total GHG Emissions	
1	Cibuntu	2.163,3623	0,5628	10,0627	2.173,9878	9,40
2	Wanasari	11.810,5008	3,0725	54,9354	11.868,5087	51,30
3	Wanajaya	3.391,4379	0,8823	15,7750	3.408,0952	14,73
4	Sukajaya	1.588,7164	0,4133	7,3898	1.596,5194	6,90
5	Kertamukti	1.684,8926	0,4383	7,8371	1.693,1681	7,32
6	Muktiwari	1.793,7088	0,4666	8,3433	1.802,5187	7,79
7	Sarimukti	590,8413	0,1537	2,7482	593,7433	2,57
Total		23.023,4603	5,9895	107,0914	23.136,5411	100,00

Source: research data processed, 2024

It is known that the producer of GHG emissions in scope two from electricity use is 23,136.5411 $KgCO_2eq$/month with a percentage of 66.19% of the total GHG emissions produced, which is the highest percentage of the total GHG emissions. The first GHG emitter from the highest electricity usage is Kelurahan Wanasari 11. 868.5087 $KgCO_2eq$ / Month with a percentage of 51.30% of the total GHG emissions from electricity use, while the lowest is Sarimukti Village at 593.7433 $KgCO_2eq$ / Month with a percentage of 2.57% of the total GHG emissions from electricity use. This happens because based on demographic data, Wanasari Village is the Village with the largest population in Cibitung Subdistrict and judging from the type of electricity use, residents in the Village use quite a lot of electronics such as more than one TV, more than one air conditioner, or even the use of a microwave. Based on the results of GHG emission measurements from scopes one and two, the combined measurement results in each Kelurahan in Cibitung Sub-district are shown in the following table:

Table 9. Combined GHG Emission Measurement Results in Cibitung Sub-district

No.	Neighborhood	Total GHG Emissions ($KgCO_2eq$/ Bulan)				Persentase (%)	Number of Residents (People)	Number of Respondents (People)	Average GHG Emissions (KgCO2eq)
		CO_2	CH_4	N_2O	Total GRK Emissions				
1	Cibuntu	3.3138291	132814	245848	3.3516954	9.59	23.556	10	335.1695
2	Wanasari	18.4719396	738451	1351777	18.6809624	53.44	101.665	43	434.4410
3	Wanajaya	5.2000693	191259	362603	5.2554554	15.03	50.835	22	238.8843
4	Sukajaya	2.5666971	106342	189435	2.5962749	7.43	27.508	12	216.3562
5	Kertamukti	2.1796002	56168	136927	2.1989098	6.29	13.917	6	366.4850
6	Muktiwari	2.1793430	43170	126583	2.1963183	6.28	11.397	5	439.2637
7	Sarimukti	6725886	08603	35162	6769651	1.94	4.564	2	338.4825
	Total	34.5840669	1276808	2448335	34.9565811	100	233.442	100	[redacted]

Source: research data processed, 2024

It is known that the combined GHG emission producer from scope one and two is the largest at 34956.5811 $KgCO_2eq$ / Month with the highest percentage of Wanasari Village at 18,680.9624 $KgCO_2eq$ / Month with a percentage of 53.44% of the total GHG emissions while the lowest is from Sarimukti Village at 6769651 $KgCO_2eq$ / Month with a percentage of 1.94% of the total GHG emissions overall.

Table 10. Scope 1 GHG Emission Measurement Results

No.	Neighborhood	Total GHG Emissions Scope 1 ($KgCO_2eq$/ Bulan)				Persentase (%)	Number of Residents (People)	Number of Respondents (People)	Average GHG Emissions (KgCO2eq)
		CO_2	CH_4	N_2O	Total GRK Emissions				
1	Cibuntu	1,150.4668	12.7186	14.5222	1,177.7076	9.96	23,556	10	117.7708
2	Wanasari	6,661.4387	70.7726	80.2423	6,812.4537	57.63	101,665	43	158.4292
3	Wanajaya	1,808.6313	18.2436	20.4853	1,847.3603	15.63	50,835	22	83.9709
4	Sukajaya	977.9807	10.2209	11.5538	999.7554	8.46	27,508	12	83.3130
5	Kertamukti	494.7076	5.1785	5.8556	505.7417	4.28	13,917	6	84.2903
6	Muktiwari	385.6342	3.8504	4.3150	393.7996	3.33	11,397	5	78.7599
7	Sarimukti	81.7473	0.7066	0.7679	83.2218	0.70	4,564	2	41.6109
	Total	11,560.6066	121.6914	137.7420	11,820.0400	100	233,442	100	[redacted]

Source: research data processed, 2024

It is known that the producer of GHG emissions in scope one is 11,820.0400 $KgCO_2eq$ / Month with the highest percentage of Wanasari Village at 6,812.4537 $KgCO_2eq$ / Month with a percentage of 57.63% of the total GHG emissions while the lowest is from Sarimukti Village at 83.2218 $KgCO_2eq$/ Month with a percentage of 0.70% of the total GHG emissions.

Table 11. Scope 2 GHG Emission Measurement Results

No.	Neighborhood	Total GHG Emissions Scope 2 ($KgCO_2eq$/ Bulan)				Persentase (%)	Number of Residents (People)	Number of Respondents (People)	Average GHG Emissions (KgCO2eq)
		CO_2	CH_4	N_2O	Total GRK Emissions				
1	Cibuntu	2,163.3623	0.5628	10.0627	2,173.9878	9.40	23,556	10	217.3988
2	Wanasari	11,810.5008	3.0725	54.9354	11,868.5087	51.30	101,665	43	276.0118
3	Wanajaya	3,391.4379	0.8823	15.7750	3,408.0952	14.73	50,835	22	154.9134
4	Sukajaya	1,588.7164	0.4133	7.3898	1,596.5194	6.90	27,508	12	133.0433
5	Kertamukti	1,684.8926	0.4383	7.8371	1,693.1681	7.32	13,917	6	282.1947
6	Muktiwari	1,793.7088	0.4666	8.3433	1,802.5187	7.79	11,397	5	360.5037
7	Sarimukti	590.8413	0.1537	2.7482	593.7433	2.57	4,564	2	296.8716
	Total	23,023.4603	5.9895	107.0914	23,136.5411	100	233,442	100	[redacted]

Source: research data processed, 2024

It is known that the producer of GHG emissions in scope one is 23,136.5411 $KgCO_2eq$ / Month with the highest percentage of Wanasari Village at 11,868.5087 $KgCO_2eq$/Month with a percentage of 51.30% of the total GHG emissions while the lowest is from Sarimukti Village at 593.7433 $KgCO_2eq$/ Month with a percentage of 2.57% of the total GHG emissions.

3.1 Factors Affecting GHG Emission Measurement Results

House Type

These house types are divided based on the size of the house. The house types used in the study are type 21 with an area of less than 60 m^2, type 36 houses with an area ranging from 60-75 m^2, type 45 houses with an area of 75-120 m^2, type 70 houses with an area ranging from 120-150 m2, and type 120 houses with an area of more than 150m^2. The results of GHG emission measurements by house type can be seen in the following table:

Table 12. GHG Emission Measurement Results Based on House Type

No.	House Type	Total GRK Emissions ($KgCO_2eq$/ Bulan)				Presentase (%)	Number of Respondents (People)	Average GHG Emissions (KgCO2eq)
		CO_2	CH_4	N_2O	Total GRK Emissions			
1	< 60 m^2	3,154.5904	5.9167	18.1155	3,178.6226	9.09	10	317.8623
2	60-75 m^2	23,159.1568	85.1145	163.4398	23,407.7110	66.96	73	320.6536
3	75-120 m^2	4,270.6865	14.9033	29.5489	4,315.1387	12.34	10	431.5139
4	120-150 m^2	2,257.1773	9.4936	16.6581	2,283.3290	6.53	5	456.6658
5	> 150 m^2	1,742.4560	12.2527	17.0712	1,771.7798	5.07	2	885.8899
	Total	34,584.0669	127.6808	244.8335	34,956.5811	100.00	100	[redacted]

Source: research data processed, 2024

It can be seen that different house types produce different average GHG emissions, where houses of type < 60 m^2 produce average GHG emissions of 317.8623 $KgCO_2eq$ / Month, houses of type 60-75 m2 produce average GHG emissions of 320.6536 $KgCO_2eq$ / Month, house type 75-120 m2 produces average GHG emissions of 431.5139 $KgCO_2eq$/ Month, house type 120-150 m2 produces average GHG emissions of 456.6658 $KgCO_2eq$, and house type > 150 m^2 produces average GHG emissions of 885.8899 $KgCO_2eq$/ Month. The larger the house type, the greater the GHG emission values from personal vehicle use, LPG use, and electricity use. This shows that the type of house affects the value of GHG emissions generated from a house. The research results obtained are in line with the results of research conducted by previous researchers in 2017, namely Huang, the study concluded that the building sector is one of the largest contributors to greenhouse gas emissions [30].

Total Income

The income used is divided into several scales. Total income <2,500,000, 2,500,000-5,000,000, 5,000,000-7,500,000, 7,500,000-10,000,000, and >10,000,000. The results of GHG emission measurement based on Total Income can be seen in the following table:

Table 13. GHG Emission Measurement Results Based on Total Income

No.	Total Income	Total GRK Emissions ($KgCO_2eq$/ Bulan)				Presentase (%)	Number of Respondents (People)	Average GHG Emissions (KgCO2eq)
		CO_2	CH_4	N_2O	Total GRK Emissions			
1	< 2.500.000	1,424.4904	4.6523	9.4806	1,438.6232	4.12	6	239.7705
2	2.500.000-5.000.000	6,342.7648	21.8366	43.0675	6,407.6689	18.33	21	305.1271
3	5.000.000-7.500.000	18,111.8352	67.2000	128.8066	18,307.8419	52.37	59	310.3024
4	7.500.000-10.000	6,119.3512	20.3724	41.8519	6,181.5756	17.68	11	561.9614
5	> 10.000.000	2,585.6253	13.6194	21.6268	2,620.8715	7.50	3	873.6238
	Total	34,584.0669	127.6808	244.8335	34,956.5811	100.00	100	[redacted]

Source: research data processed, 2024

It can be seen that different incomes produce different average GHG emissions, where family heads with income < 2,500,000 produce average GHG emissions of 239.7705 $KgCO_2eq$ / Month, family heads with income 2,500,000-5,000,000 produce average GHG emissions of 305.1271 $KgCO_2eq$/ Month, family heads with income 5. 000,000-7,500,000 produced an average GHG emission of

310.3024 $KgCO_2eq$/ month, family heads with an income of 7,500,000-10,000,000 produced an average GHG emission of 561.9614 $KgCO_2eq$/month, and family heads with an income > 10,000,000 produced an average GHG emission of 873.6238 $KgCO_2eq$/ month. This shows that the more income the greater the value of GHG emissions produced in the household, this can also explain that the more income the head of the family has, the more vehicles and goods or electronics are used which can have an effect on increasing the value of GHG emissions produced.

Electrical Power

The greater the electricity demand, the greater the electric power used. The electric power used in this study is 450 VA, 900 VA, 1300 VA, and 4400 VA. The results of GHG emission measurements based on electric power can be seen in the following table:

Table 14. GHG Emission Measurement Results Based on Electrical Power

No.	Total Electrical Power	Total GRK Emissions ($KgCO_2eq$/ Bulan)				Presentase (%)	Number of Respondents (People)	Average GHG Emissions ($KgCO_2eq$)
		CO_2	CH_4	N_2O	Total GRK Emissions			
1	450	522.5974	0.5396	2.6476	525.7846	1.50	2	262.8923
2	900	19,036.5720	75.0907	137.8719	19,249.5346	55.07	72	267.3546
3	1300	10,304.8121	33.4353	69.8624	10,408.1098	29.77	20	520.4055
4	2200	4,720.0853	18.6153	34.4515	4,773.1521	13.65	6	795.5253
5	4400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Total	34,584.0669	127.6808	244.8335	34,956.5811	100.00	100	[redacted]

Source: research data processed, 2024

It can be seen that different electric power produces different average GHG emissions, where houses with 450 electric power produce average GHG emissions of 262.8923 $KgCO_2eq$/ Month, houses with 900 electric power produce average GHG emissions of 267.3546 $KgCO_2eq$/ Month, houses with 1300 electric power produce average GHG emissions of 520.4055 $KgCO_2eq$/ Month, houses with 2200 electric power produce average GHG emissions of 795.5253 $KgCO_2eq$/ Month, and based on respondent data there are no houses with 4400 electric power. This shows that the higher the electric power, the greater the value of GHG emissions produced in the household, this can also explain that the higher the electric power, the more activities carried out such as the use of water, lighting with lamps, the use of air conditioners (AC) or fans or blowers, watching television, scrubbing, cooking rice, using a microwave or oven, and others. The research results obtained are in line with the results of research conducted by previous researchers in 2021, namely Akrour, the study concluded that electricity consumption factors can also influence to create large greenhouse gas emissions [31].

3.2 Validity Test Results

Table 15. Validity Test Results

No.	Variable	Rhitung	Rtabel	Description
1	House Type	0,2450	0,1654	Valid
2	Total Income	0,3470	0,1654	Valid
3	Electrical Power	0,6320	0,1654	Valid

Source: research data processed, 2024

Based on the results of the validity test research conducted on the independent variables of house type, total income, and electric power with five answer choices for each of the independent variables. Based on Table 4.11, it is known that the results of the validity test research are declared valid, with a Df value of 100 - 2 = 98, pearsom correlation 0.2450; 0.3470; 0.6320 so that Rtabel 0.1654 is obtained, then the value of Rhitung> Rtabel (0.1654). the calculation results of this study are in line with the provisions of Ghozali and Ikhsan in Ruslan, if the correlation number obtained is greater than the criticism number (Rhitung> Rtabel) then the instrument can be said to be valid or significant [27].

3.3 Reliability Test Results

Table 16. Reliability Test Results

No.	Variabel	*Cornbach's Alpha*	Kriteria	Description
1	House Type	0,6360	Reliabel jika CA > 0,6	Reliabel
2	Total Income			
3	Electrical Power			

Source: research data processed, 2024

Based on the test results of this study, it shows the Cronbach's Alpha value of 0.6360. So it can be concluded that the data is reliable because it exceeds the reliability threshold value of more than 0.60. the calculation results of this study are in line with the provisions of Supramono and Utami if the Cronbach's alpha coefficient> 0.6 then in general the instrument is said to be reliable or reliable [27].

3.4 Correlation Test Results

Table 17. Correlation Test Results

No.	Variable	Significance Value	Interpretation	*Pearson Correlation*	Correlation Test Results
1	House Type	0,0000	Reject H0	0,2450	Low Correlation
2	Total Income	0,0000	Reject H0	0,3470	Low Correlation
3	Electrical Power	0,0000	Reject H0	0,6320	Strong correlation

Source: research data processed, 2024

The type of house is significantly related to 0.0000 <0.05 so that the results obtained reject H0 and have a positive relationship with a Pearson Correlation value of 0.2450 so it can be concluded that the variable type of house with the results of GHG emission measurements has a low relationship. Based on Rinpropadebi's research, it is explained that the highest carbon emissions in Malang City are in simple houses rather than medium and luxury houses, so this research is in line because the results of the emissions produced are more likely to be high in simple houses with small houses (21 m_2 - 69m^2) and medium houses (70 m^2 - 100 m^2) than large houses whose area is above 120 m2 [32]. In urban areas, stationary emissions are more dominated in high-density informal housing compared to real estate housing [33] [34].

The amount of family head income is significantly related to 0.0000 <0.05 so that the result is rejected H0 and has a positive relationship with a Pearson Correlation value of 0.3470 so it can be concluded that the variable amount of family head income with the results of GHG emission measurements has a low relationship. Homes with higher monthly incomes tend to have higher CO_2 emissions. This is because the higher the amount of salary earned each month, the more household needs are affected. Starting from food needs in the form of LPG or similar fuel consumption, and the needs of electronic goods used. So from the results of both household consumption, the resulting CO_2 emissions are also greater.

According to Ghofrani, the effect of the amount of monthly bills on human behavior (indoor temperature, electronic use, energy consumption) has an accuracy rate of 84.6% in the regression results which are then returned to energy consumption to the salary earned where the greater the salary the tendency of the bills issued is also greater depending on the human behavior [35]. Based on the explanation of previous research, one of the trends in the influence of the amount of energy consumption comes from the income generated per month, which then has an impact on the amount of energy bills in the form of electricity and cooking fuel in the house, which then results in more CO_2 emissions from household stationary sources.

Electrical power is significantly related to 0.0000 <0.05 so that the results obtained reject H0 and have a positive relationship with a Pearson Correlation value of 0.6320 so it can be concluded that the variable electrical power with GHG emission measurement results has a strong relationship. Homes with greater types of electrical power will tend to produce higher CO_2 emissions indirectly. This means that the greater the electrical power used, the greater the technology with wattage used, this is also related to the greater income due to various technological needs that are increasingly sophisticated in the modern era of consumptive behavior so that a lot of electrical energy is released which has an impact on the amount of GHG emission production [13].

Therefore, it is necessary to limit the pattern of electricity consumption by means of energy conservation and energy efficiency and it is necessary to limit the number of subsidized kWh and re-record households that are able and unable to afford based on the number of kWh subsidized. Households based on income so that government subsidies are not used arbitrarily. For example, according to the Ministry of Finance, the policy of reforming electricity subsidies for R1/450 VA electricity users who consume up to 80kWh/month and R1/900 VA who consume up to 60 kWh/month is suggested, and if consumption exceeds the specified limit, the customer will not receive a subsidy [36]. Then the implementation of TDL (Basic Electricity Tariff) which is raised gradually (e.g. quarterly) so that in the end it is no longer subsidized.

4. Conclusion

The total GHG emission generated from Cibitung sub-district is 34,956.5811 $KgCO_2eq$/month, where coverage 1 generates 11,820.0400 $KgCO_2eq$/month and coverage 2 generates 23,136.5411 $KgCO_2eq$/month. Kelurahan Wanasari is the highest GHG emitter at 18,6980.9624 $KgCO_2eq$ /month and Kelurahan Sarimukti is the lowest GHG emitter at 676.9651 $KgCO_2eq$/month. The statistical test results obtained there is a significance value of 0.0000 for the independent variables of house type, total family head income, and electric power so that the results can reject H0 and the Pearson Correlation value of house type 0.2450 can be concluded as a low correlation; total income 0.3470 can be concluded as a low correlation; and electric power 0.6320 can be concluded as a high correlation. The most GHG emission problems come from the use of electricity, namely 23,135.5411 $KgCO_2eq$/ Month, so it is necessary to save energy and be more efficient in using electronic equipment at home, it can be done by saving water, turning off lights during the day as lighting, using air conditioners (AC) no more than 25°C, turning off fans or blowers when not in use, turning off televisions when not in use, making a regular schedule in scrubbing, washing, and cooking rice, using microwaves or ovens as needed, and others. The results of this study it can be concluded that household activities that have the potential to produce GHG emissions (CO_2, CH_4, N_2O) are caused by the use of motorized vehicles that use fossil fuels, income levels and also the electricity used.

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