

Carbon Footprint from Settlement Activities: A Literature Review

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Abstract. One of the causes of increasing greenhouse gases is the increase in CO₂ emissions produced from both the industrial sector, transportation sector, and settlement sector. The settlement sector also contributes to CO₂ emissions based on household activities. Research on carbon footprint from settlement activities is currently focusing on carbon footprints from household energy use both electricity and heat energy for cooking and have not taken into account the activities of vehicle fuel use, domestic waste, and water consumption. This paper aims to conduct a literature study on matters relating to the method of estimating the carbon footprint of settlement activities and influencing variables. The results of this study are a framework for estimating the more comprehensive carbon footprint of housing activities by adding private vehicle fuel consumption, waste generation, and water consumption in addition to the use of fuel for cooking and electricity use.

Keywords: **carbon footprint; settlement; household activity; electricity.**

1 Introduction

Air quality has decreased due to various human activities both from the industrial sector, transportation, and settlements. One indicator of decreasing air quality is the emissions caused by CO₂ which will cause a decrease in the concentration of greenhouse gases (GHG). As a GHG prevention measure, the Indonesian Government issued Presidential Regulation Number 61 of 2011 concerning the National Action Plan for Reducing GHG Emissions. The initial step taken is to conduct a GHG inventory. According to [1] the GHG emission inventory carried out is an effort to meet the emission reduction target. Some of the benefits for GHG inventory, namely to find out the policy agreement that has been made [2], to determine the potential reduction in CO₂ emissions that can be done [3]. The largest source of emissions is estimated in regions that have a high population that requires GHG inventories starting from that region [4]. This GHG inventory is a big picture of GHG emissions that can be generated from several urban activities [5].

The increasing concentration of CO₂ in the atmosphere is caused by human activities from the residential sector which release CO₂ emissions. In some countries, residential energy consumption produces a sizeable proportion of the total amount of energy use [6]. Sources of CO₂ emissions from settlement activities can be identified based on the use of fuel for cooking, electricity use, transportation, and household waste. Each household has a variety of activities that produce different carbon footprints. These various household

activities certainly depend on the types of activities carried out by household members.

Calculation of GHG emissions from urban activities can be done by multiplying emission factors with activity data. Emission factors represent the number of emissions per unit of activity carried out while activity data are activities that produce GHG emissions. Many GHG inventory methods have been developed and studied. In developing countries research has been carried out regarding GHG inventory methods with limited data availability [1]. In developing countries, the GHG inventory method used is adjusted to the guidelines prepared by the IPCC (Intergovernmental Panel on Climate Change). With the guidance of the IPCC, it encourages each country to develop specific (local) emission factors so that the estimated GHG emissions do not overestimate or underestimate [7].

In order to comprehensively estimate the carbon footprint of settlement activities, in-depth literature studies are needed. This paper aims to review the literature related to the carbon footprint of settlement activities so that appropriate method are obtained in determining the carbon footprint of settlement activities.

2 Literature Review

2.1 Settlement

The definition of Settlement according to UU No.1 / 2011 is part of a residential environment consisting of more than one housing unit that has infrastructure,

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facilities, public utilities, and has support for other functional activities in urban areas or rural areas. Housing is a collection of houses as part of settlements, both urban and rural, which are equipped with infrastructure, facilities, and public utilities as a result of efforts to fulfill livable houses. Housing as part of settlements must be produced efficiently and sustainably to meet basic human needs for decent housing, a healthy, safe, harmonious and orderly environment and to give direction to the growth of a region and to support development in the economic, social and cultural fields. other fields in the context of improving and equitable distribution of welfare for all community groups in accordance with the policies of a balanced residential environment.

2.2 Carbon Footprint

A carbon footprint is a measure of the total amount of carbon dioxide emissions caused by an activity or accumulates both directly and indirectly in daily life [9]. The concept of carbon footprint has been very well known in recent decades as an indicator of greenhouse gas emissions originating from human activities [10]. The concept of carbon footprint known as primary carbon footprint and secondary carbon footprint. The primary carbon footprint is a measure of CO₂ emissions resulting from direct use of fuel such as oil or LPG for cooking [11], and transportation fuel oil while the secondary carbon footprint is indirect carbon dioxide emissions. Secondary carbon footprint is generated from household electronic equipment where the electronic equipment can be used by using electrical power sourced from power plants with fossil fuels so that consumers of electric power users indirectly have burned fossil fuels to obtain electricity. This certainly shows that there is a relationship between the secondary carbon footprint and the primary carbon produced. The carbon footprint unit is tons of CO₂ equivalent (tCO₂e) or kg-equivalent-CO₂ (kgCO₂e) [12].

Calculation of carbon footprint can be calculated by looking at the use of fossil fuels used. The fossil fuel is in the form of petroleum or natural gas which can directly produce carbon dioxide (CO₂). In addition, carbon footprint can also be calculated by looking at the use of electricity in everyday life. CO₂ emissions generated from electricity usage activities come from power plants as suppliers of electricity used [9].

Carbon dioxide emissions are calculated by multiplying the amount of fuel consumption by emission factors from the type of fuel consumed. This calculation method is a method of calculating CO₂ emissions based on fuel-used based which has a level of reliability so it is strongly recommended to calculate CO₂ emissions from fuel consumption [13].

2.3 Specific Emission Factor

Estimates of carbon footprint can generally be determined by simple equations, which are based on activity data multiplied by emission factors. Active data

are all activities that produce carbon dioxide emissions while emission factors indicate the number of emissions per unit of activity carried out [5]. An emission factor is the average value of an air pollutant parameter issued by a specific source. These factors are usually expressed as the weight of pollutants divided by units of weight, volume, distance, or duration of activity that can emit pollutants. The existence of these variations gives rise to emission factors with different units. The default emission factors are generally determined by the IPCC Guidelines, 2006. From these emission factors, specific emission factors and estimates of carbon footprint from an activity can be determined.

The general equation used to calculate the carbon footprint of fuel combustion is shown in equation (1).

$$Emission\ CO_2\ \left(\frac{kg}{yr}\right) = KE \times FE \quad (1)$$

Where: KE = Energy Consumption (Tj / yr)

FE = Emission Factor according to IPCC default (kg / TJ)

2.4 Factors that affect CO₂ emissions

Some of the research that has been done in one of them in China states that energy consumption is a factor that influences the value of carbon footprints from settlement activities [6]. The same thing was also found in several studies carried out in Indonesia such as research conducted by [2] in East Surabaya and North Surabaya, [3] in Western Surabaya, [4] in Pademangan District, North Jakarta, [5] in Semarang Regency, [6] in Ciherang Village, Bogor Regency, in Denpasar [7], [8] in the Limbungan Baru Village of Pekanbaru City, [9] and [1] in China and in Nordic City [10]. Energy consumption in this household is also influenced by economic factors, population level, and the type of fuel used.

3 Research Methodology

This research is a literature study by examining the latest scientific literature in the range of the years 2008-2019 in the form of journals, theses, and in the form of books related to the carbon footprint of settlement activities. The results of this literature review will be used to identify factors that influence the value of CO₂ emissions, and the potential for carbon footprint research from settlement activities.

3.1 Carbon Footprint Research

Research related to the carbon footprint in settlements has been researched and written in the form of scientific papers both in Indonesia and in the world. The results of the research that have been carried out can be summarized in Table 1.

Table 1. Research Matrix for Settlement of Carbon Activities.

Method	Definition	Reference
Index Decomposition Analysis	The IDA method is an established technique for decomposing aggregate energy or environmental indicators into several contributing factors that influence observed changes in the aggregate indicator	[11][12]
Mass balance approach	Quantitative analysis is applied to evaluate resource materials used in industrial processes: such as industrial production, manufacturing, processing, electricity supply, heating and road transportation, based on the Law of Mass Conservation	[9]
IPCC	Calculate CO ₂ emissions based on energy, industry, transportation, land use, agriculture and waste activities	[13][6][3][4][5][7][14][15][16][17]
Consumer Lifestyle Analysis	CO ₂ emissions are calculated based on direct energy use and indirect energy contained in the production of goods and services.	[18][19][20]

Factors affecting the carbon footprint of settlement activities vary greatly and depend on the focus of the research. From the literature study, the factors that influence the carbon footprint are shown in Table 2.

Table 2. Factors that affect the carbon footprint of settlement activities.

Factor	Definition	Reference
Energy Consumption	Energy use from fossil fuels for cooking, and electricity from the use of electronic equipment	[1][9][13][11][6][2][3][4][5][7][14][21][18][22]
Population	The population in an area that affects energy consumption	[1][9][13][11][6][2][3][4][5][7][14][21][18][22]
Type of house	The type of house that is related to the size of the house and the electricity subscription	[3][4][5]
Income	Large income in the household	[1][9][3][4][5][20][12]
Lifestyle	Community behavior in energy use in the household	[21][12]

Research on settlement carbon footprint is related to energy use both directly and indirectly. Direct energy use, for example, the use of heat energy for cooking and energy use of private vehicles. Indirect energy relates to the production of goods and services such as electricity and the use of clean water. In addition to the energy sector, transportation and settlement carbon footprint are also related to the household waste sector. The activities of settlements that produce carbon emissions and the research that has been carried out are shown in Table 3.

Table 3. The activities of settlement that produce carbon emission

Activity	Definition	Reference
Electricity	Energy consumption from using electric equipment	[1][5][8][9][14][17][18]
Energy for cooking	Energy consumption from using fuel for cooking	[5][7][9][17][23]
Energy for private transportation	Energy consumption from private vehicle fuel use	[9][17][14]
Waste Household	Solid waste household	[24][25][26]

4 Discussion

Based on a literature study conducted related to the carbon footprint of settlement activities in an area, it is always related to energy consumption. Energy consumption in households is related to economic factors, and household populations. The results of previous studies indicate that the higher the income, the higher the carbon footprint produced because lifestyle is more wasteful in energy consumption [6]. The method of calculating the carbon footprint that is commonly used is the IPCC method in which the default emission factor has been determined. Data collection process for estimating carbon footprint from settlement activities using secondary data from relevant agencies and survey or interview methods [15, 16, 17].

Research on the carbon footprint of settlement activities in Indonesia generally uses the calculation method set by the IPCC (Intergovernmental Panel on Climate Change). Only the difference between location and research variables. The research variables used are energy consumption from households both from energy for cooking (LPG, kerosene, fuelwood) and electricity from the use of electronic equipment [15, 16, 17]. However, from the literature study that has been carried out, there is gap research from previous studies, which have not included the carbon footprint of household waste, and household water consumption into the calculation of total carbon emissions from settlement activities. Future research that can be done to be able to estimate the carbon footprint of settlement activities is to add the variable waste generation, and household water consumption.

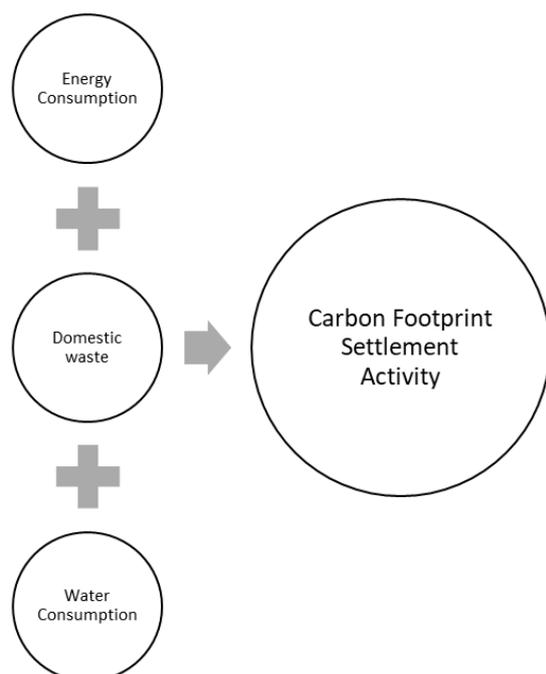


Fig. 1. Framework of carbon footprint from settlement activity

5 Conclusion

Based on literature review and expert opinion, it is necessary to conduct research related to carbon footprint from settlement activities by adding the calculation of carbon dioxide emissions generated from waste generation and consumption of clean water in households. The estimated carbon footprint of this carbon footprint activity is then mapped using a Geographic Information System to describe the distribution of the carbon footprint of an area. The results of this research will be expected to be used in making appropriate mitigation decisions or policies to reduce carbon emissions.

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