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MORALITY BEFORE KNOWLEDGE

The potential carbon emissions reduction from warehousing activity using vegetation projection planting

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ABSTRACT

Large energy consumption and environmental impact from logistical operations which majorly caused by the lighting, heating, cooling, and air conditioning systems alongside fixed and moving material handling equipment are now a major contributor to GHG (Greenhouse Gases). This research objective is to calculate the potential carbon emissions reduction by implementing vegetation projection planting on the company and alternative energy implementation. The method used in this study is by recording and calculating data from the company operational which then convert into data activity. The results from this study stated that company operational contribute 6,588,252.19 KgCO2/month. The existing vegetation capable to absorb 3,810 KgCO2/month, meanwhile the potential carbon emissions reduction which come from planting projection and alternative energy implementation is 6,928,718.7 KgCO2/month. With the increasing of environmental impact from logistical operations, it is necessary to conduct environmental assessment regarding the company business process. Calculating GHG emissions in form of carbon emissions can be the first step to conduct the assessment. Utilization of available green open space area and alternative energy implementation is some potential method to direct or indirectly reduce carbon emissions from warehousing operations.

KEYWORDS: carbon absorption; greenhouse gases; green open space; vegetation; warehouse

1. Introduction

Due to constantly increasing carbon dioxide (CO2) production during the past 20 years, the emission of greenhouse gases (GHG), which are thought to cause significant environmental harm and to be a key cause of climate change, has increased dramatically. Even while CO2 emissions, in particular, have recently increased in emerging nations, the majority of pollution to the environment is still brought on by a small number of developed countries. The most significant individual causes of environmental harm in global supply chains are thought to be logistical activities, particularly the shipping and storing of raw materials and finished goods, which are nevertheless necessary for maintaining economic prosperity (Piecyk and McKinnon, 2010). According to estimates from the IPCC (The Interngovernmental Panel on Climate Change) and WEF (World Economic Forum), supply chain logistics are responsible for 5.5% to 13% of all worldwide GHG emissions. Over 23% of these emissions are produced by the transport industry globally. Road transport emissions dominate this group, making up much to 40% of the greenhouse gas emissions from the road sector. For instance, in the United States, transport contributes 27% of all GHG emissions, with CO2 accounting for approximately 96% of these emissions (EPA,

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2013). In addition to transportation, warehousing and material handling in logistics facilities are two of the most major categories of supply chain emissions. However, aside from a few notable instances, the literature has mainly ignored the environmental impact that warehouses have on the environmental impact that warehouses have on the environment due to heating, cooling, lighting, and material handling. However, 13% of the total emissions from the supply chain are attributable to material handling operations in logistics buildings, which include warehouses and sorting facilities (Dhooma and Baker, 2012).

Environmental impact from the warehouse operational which especially in the form of carbon emissions can be reduced by planting more vegetations around the company area. The leading causes of climate change is carbon emissions which come from many sources that majorly occur by the accumulation of greenhouse gases in the atmosphere, arising from the combustion of fossil fuels (Piecyk and McKinnon, 2010). Other major environmental results lead by carbon emissions is air pollution. Air pollution is determined as the presence of pollutants in the air in large quantities for long periods. Air pollutants are dispersed particles, hydrocarbons, CO, CO_2, NO, NO_2, SO_3, etc. The six main air pollutants that the World Health Organization (WHO) measures are lead, sulfur oxides, nitrogen oxides, carbon monoxide, ground-level ozone, and particle pollution. Groundwater, soil, and air can all suffer greatly as a result of air pollution (EPA, 2013).

In this study, the location of research is focused on all area of the warehouse company since the carbon emissions from the operational are coming from different sources. The focus on this study is to calculate the total of carbon emission from each activities, carbon adsorption capability on the existing vegetation and plantation projection to achieve higher carbon adsorption on the existing green open space area on the company.

The results of this research resulted in the carbon absorption capability from the potential carbon emissions reduction on the company which come from alternative energy implementation and planting projection valued 6,928,718,7 $KgCO_2$/month. The total of carbon emissions from recorded data activity in one month is 6,588,252.19 $KgCO_2$ make the residual emissions after absorbed by existing vegetation and potential method of emissions reduction is -344,276.51 KgCO2/month which indicate that all the carbon emissions produced by company can totally be reduced.

The limitations used include: (1) Project located at PT. ZYX, Cikarang; (2) The calculated emissions on this study only in the form of carbon dioxide emissions; (3) The calculation of existing vegetation and green open space area are only inside the company; (4) The existing vegetation used in the calculation is a Pucuk merah trees and bushes on the company green open space area; (5) The planting projection is only calculate from green open space area covered by bushes; (6) The potential carbon emissions reduction on this study come from the installed alternative energy and trees planting projection; (7) Recorded and calculated carbon emissions from warehouse operational come from products handling, building management, and vehicles operated in company area; (8) Data activity from the company operational grouped and divided by GHG Protocol scopes (scope 1,2, and 3); (9) Calculated vehicles only come from company operational vehicle on scope 1 and vendor vehicle on scope 3; (10) Usages in data activity is in one month.

2. Methods

The research location was at PT. ZYX, Cikarang for collecting data activity and recording which conducted on September, 2022 until February, 2023. Collecting the data activity was done by analyzing the company operational and conducted during the researcher internship period. The first step is finding the problem identification which is the high number of environmental impact from logistic operations that in this study more specific on warehouse operational. Literature review in this study used to define the categories of emissions which is direct emissions and indirect emissions. There are three scopes used to define each emissions category: (1) Scope one, direct emissions from sources owned or under the control of the party responsible for the activity are included. Scope one come from burning fuel, driving with one's own fleet, and other sources like industrial process emissions (such as CO2 emissions from the decarbonization of calcium carbonate to make clinker in a cement-producing company) and fugitive emissions (such as flourinated gases from potential leaks in the organization's cooling equipment); (2) Scope two, indirect emissions associated with the production of heat, steam, electricity, and cooling; (3) Scope three, other indirect emissions, consists of all additional indirect emissions.

Carbon absorption capability by plants also used to calculate the potential carbon emissions reduction by plant projection planting which is used in this study *Glodokan tiang* (Polyalthia longifolia) plant with carbon absorption capability 393,125.59 Kg/year.

2.1 CO_2 Emissions from Warehouse Activity

In order to track and calculate all the activity that produced carbon emissions, the data recorded was already done during the authors internship period. Warehouse management and activities have been analyzed and chose for data calculation that generate carbon emissions. The first activities come from the product handling when it comes to the warehouse which brought by vendor vehicle using long truck with diesel type of fuel. Loading and unloading process until the product stacked into the rack is supported by electric material handling unit and human work. Products storing on the warehouse facilities equipped with several cooling and heating systems that come from energy usage by electricity. Other supporting facilities recorded usage come from fuel in generator set for backup energy system, operational vehicle and grass cutter fuel, and refrigerant usage for cooling system.

Using the scope from the IPCC Guidelines (2006), warehouse operational activities can be seperated by their own definition. In order to calculate carbon emission value of each data activity, equation or formula from suitable studies are used. Table 1 show each scopes and data activity with their formula to calculate the total emissions per month. Formula used to find the KgCO2eq is,

$$Q = n\ (usage) \times EF$$

Q = Kilograms CO2 equivalent
n (usage) = Recorded usage from data activity
EF = Emission factor for specific usage

Table 1. Data activity from company operation which categorized as GHG

Scope	Emission category	Data activity	Usage	Formula
Scope 1	Stationer energy	Generator set	594 L/month	Diesel fuel emission factor (IPCC 1996): 2,924.90 g/liter; *Q = n (usage) x EF*
		Grass cutter fuel	11.52 L/month	IPCC 1996, premium fuel: 2,597.86 $KgCO_2$; *Q = n (usage) x EF*
		Work unit gases (LPG)	6 Kg/month	*Q Emission CO_2 = Fuel consumption x Emission factor x NCV (Net calorific value)* *Q = n x EF x NCV*
		Referigerant R-404A & R-134A	3 Kg, with the GWP: - R-404a = 3922 $KgCO_2eq$ &	R-404a = 3 Kg x 3922 = 11,766 $KgCO_2$; R-134a = 3 Kg x 1430 $KgCO_2$ = 4,290 $KgCO_2$ *Q = n x EF*

			- R-134a = 1430 ($KgCO_2eq$)	
	Transport	Operational Vehicle (1 unit)	785 m of travel distance (785 m x 20 operational days on one month) = 15,7 km	Average efficiency fuel consumption (L/km) 1.500 cc = 0,092; IPCC 1996, premium fuel: 2,597.86 $KgCO_2$/L; Total fuel consumption (L) = 1,4 *Q = n x EF*
Scope 2	Energy consumption (Electricity, On-grid)	Energy usage on company operational	8,024,646 kWh (lwbp)	Emission factor grid JAMALI = 0,817 $KgCO_2$/kWh *Q = n x EF*
	Paper consumption	Paper usage during company activity	200 rim/month	Emisi CO_2 = EF x Paper usage (Kg), (FE = 1.22 $KgCO_2$); 1 rim = 2.5 Kg *Q = n x EF*
	Human respiration	Number of workers in company	210	Emisi CO_2 = n (total workers) x EF; (3.2 $KgCO_2$/men/day); 210 x 3,2 = 672 $KgCO_2$/day; *Q = n x EF*
Scope 3	Vendor transport	Vendor vehicle (operated in company area)	1670 Vehicle; Travel distance: 370 m = 617,9 Km	Diesel fuel emission factor = 2,68 Kg/L; Average fuel consumption efficiency (L/Km): 0,134; Total fuel consumption = 82,8 L *Q = n x EF*

2.2 CO_2 Reduction on Company

2.2.1 Existing Vegetation

The research will be conducted at PT. ZYX that operate on warehouse distribution services. The method will be using observation around the company area. It can be stated that the major existing vegetation is Pucuk Merah and bushes. The total area for existing vegetation on the company is 0.266 Ha which consist of area covered by bushes and Pucuk merah. Meanwhile, the total area of the company is 3.94 Ha which make the existing vegetation covering area on the company is 0.07%. According to the regulation that stated the minimum percentage of green open space from industrial area is 10% (Pengkaji Teknis, 2022), company haven't meet the standard. Figure 1 below will show the satellite imaginery for green open space area and building comparison around the company.

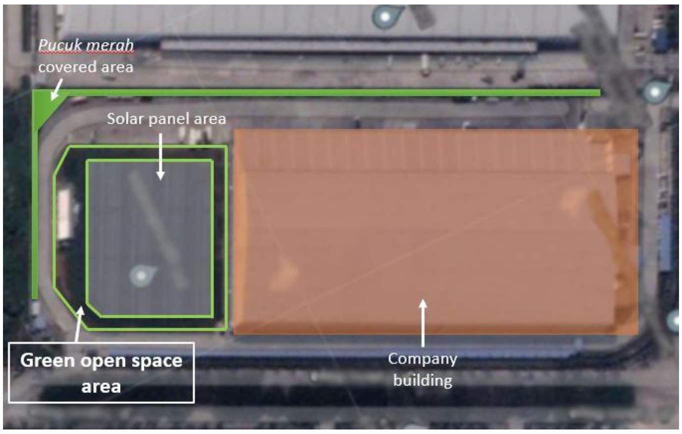

Figure 1. Company satellite imaginary

Regarding with the regulation of concept for green open space area in industrial area. The pattern of land use for industrial areas as regulated in the Regulation of the Minister of Industry of the Republic of Indonesia Number 40/M-IND/PER/6/2016 concerning Technical Guidelines for Industrial Areas is as follows:

Table 2. Industrial regulation of land use patterns

Type of use	Proportion of use (%)	Description
Industrial plots	Maximum 70%	Each plot must comply with the KDB (Basic Building Coefficient) provisions of 60:40
Roads and canals	8-10%	Road network consisting of primary roads, secondary roads and drainage canals
Green open space	Minimum 10%	Can be in the form of green belts, parks and perimeters
Other basic infrastructure, supporting infrastructure and supporting facilities	8-10%	Other basic infrastructure in the form of raw water treatment plants, waste water treatment plants, street lighting installations

This study will focus on utilization of existing green open space by using vegetation projection planting.

Software used to calculate the total area is My Maps by Google that create satellite imaging for precise location to be analyzed. Total area of the company on this study is 3.94 Ha or 39,400 m^2. The company building take place for 1.74 Ha and installed solar panel area is 0.440 Ha. Using the equation below to calculate the carbon adsorption, the total area covered by existing vegetation can be known.

$$C_{sink} = LT \times CO_2\ absorption\ coefficient\ in\ unit\ area$$

C_{sink} : Plant carbon absorption per hour
LT : Header area

2.2.2 Alternative Energy Implementation

In a solar panel, photovoltaic cells convert sunlight into direct current (DC) power. After being transformed from direct current (DC) to alternating current (AC) by an inverter, the electricity can then be utilized, sent into the grid, or stored in a battery. The installed solar panel can produce approximately 800 kWp (kilo-watt peak). According to the recorded data on the solar panel specification and from the Engineering Department Supervisor statement on the company at PT. ZYX, the average of electricity that can be produced is 60,000 kWh/month.

3. Results and Discussion

3.1 Carbon Emissions Calculation From Company Operational

Reducing emissions from deforestation and forest degradation (REDD) has gained major attention in international climate negotiations. There are some standard and international guidelines which already defined by the Intergovernmental Panel on Climate Change (IPCC) and Voluntary Carbon Standard (VCS). Some methods used to measure forest carbon estimation need biomass measurement, land-use, vegetation, soil type, and topography which already stated on many study (Bhishma et al., 2010). Measuring the direct and indirect emissions of carbon dioxide and its equivalent gases from industrial operations to the Earth's biosphere is known as carbon accounting. EFs are described as "a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant" by the U.S. Environmental Protection Agency (US EPA). The mass of a gas per unit of the activity or material input that produces emissions is often how EFs for greenhouse gases (GHGs) are expressed. For example, kilograms of carbon dioxide (CO2) are released for every tonne of bituminous coal that is burned. An EF is multiplied by the associated activity data, such as a manufacturing plant's production output, the energy in a mass of fuel burned, or the quantity of electricity used, to estimate emissions. The units used by the EF to compute GHG emissions must be matched in the activity data (Colbert-Sangree, 2022).

Table 3. Data activity from company operation

Scope	Data activity	Emission factor	Calculation	CO_2 emissions ($KgCO_2$/month)
1	Generator set	Diesel fuel (IPCC 1996) is 2,940.90 g/liter	$Q = n\ (usage)\ x\ EF$ $= 594\ x\ 2{,}924.90$ $= 1{,}737{,}152\ gCO2\ /liter\ to\ 1{,}737.15\ KgCO_2\ /liter$	$1,737.15\ KgCO_2/liter$
	Grass cutter fuel	Premium fuel = 2,597.86 $KgCO_2$/L	$Q = n\ (usage)\ x\ EF$ $= 11.52\ x\ 2{,}596.86$ $= 29.91\ KgCO_2$	$29.91\ KgCO_2$
	Work unit gases (LPG)	(1) EF = 63,100 Kg/Tj, (2) Net Calorific Value = 0.0000473 Tj/Kg	$Q = n\ x\ EF\ x\ NCV$ $= 6\ Kg\ x\ 63{,}100\frac{Kg}{Tj}\ x\ 0.0000473\frac{Tj}{Kg}$	$17.90\ KgCO_2$
	Refrigerant R-404a & R-134a	GWP: (1) R-404a = 3922 $KgCO_2eq$ (2) R-134a = 1430 ($KgCO_2eq$)	$Q = n\ x\ EF$ $Total$ $= 11{,}766 + 4{,}290$ $= 16{,}056\ KgCO_2$	$16{,}056\ KgCO_2$
	Operational vehicle (1 unit)	Premium fuel = 2,597.86 $KgCO_2$/L	$Q = n\ x\ EF,$ $CO2\ emissions =$ $1.4\ L\ x\ 2{,}596.86\ gCO_2/L = 3.63\ KgCO_2$	$3.33\ KgCO_2$

2	Energy consumption	Emission factor grid JAMALI = 0,817 $KgCO_2$/kWh	$Q = n \; x \; EF$ $= 0{,}817 \; x \; 8{,}024{,}646$ $= 6{,}556{,}136 \; KgCO_2$	6,556,136 $KgCO_2$
	Paper consumption	1.22 $KgCO_2$	$Q = n \; x \; EF$ $Total \; paper \; emission$ $= 500 \; Kg \; x \; 1.22$ $= 610 \; KgCO_2$	610 $KgCO_2$
	Human respiration	3.2 $KgCO_2$/men/day	$Q = n \; x \; EF$ $= 672 \; x \; 20 \; operational \; dc$ $= 13{,}440 \; KgCO_2$	13,440 $KgCO_2$
3	Vendor transport	2,68 Kg/L	$Q = n \; x \; EF$ $CO2 \; emission$ $= 82.8 \; L \; x \; 2.68 \; Kg/L$ $= 221.9 \; KgCO_2$	221.9 $KgCO_2$

3.2 Carbon Dioxide (CO_2) Absorption

3.2.1 CO_2 Absorption by Existing Vegetation

Green open space area in the PT. XYZ is more dominantly covered by Pucuk Merah and bushes, with following Pucuk Merah total covered area is 0.077 Ha and bushes 0.0189 Ha, sum up the total covering area from existing vegetation is 0.0959 Ha. Using the equation to calculate the carbon dioxide absorption with the CO_2 absorption coefficient for each covering type, total plants absorption by existing vegetation is,

Csink = Plant CO_2 absorption per day
LT = Header area
Pucuk merah = 0.077 Ha x 1,559.1 Kg/Ha/day
= 120.043 Kg/Ha/day
Bushes = 0.0189 Ha x 150.68 Kg/Ha/day
= 2.85 Kg/Ha/day

If the plant covering type combined, total plant CO_2 absorption from existing vegetation is 122.9 $KgCO_2$/day, for every month is 3,810 $KgCO_2$/month and 45,720 $KgCO_2$/year.

3.2.2 Carbon emissions saving by solar panel

The average electricity which solar panel can produced is 60,000 kWh/month. With that energy produced, using the emission factor for JAMALI grid which is 0.817 kWh/$KgCO_2$, the total of carbon emission reduction from alternative energy can be known,

$$Q = n \; x \; EF$$
$$= 60{,}000 \; x \; 0.817$$
$$= 49{,}020 \; KgCO_2/month$$

From the original usage of electricity which is 8,024,646 kWh/month and the carbon emission is 6,556,136 $KgCO_2$, the using of renewable energy can reduce carbon emissions as big as 0.75 percent.

3.2.3 Net Emissions from Existing Vegetation

From the calculation of company data activity, total carbon dioxide emission emitted from their operational is 6,588,252.19 $KgCO_2$/month. Meanwhile, the total CO2 reduction by existing vegetation is 3,810 $KgCO_2$/month. The following calculation will be show the residue emissions,

Net emissions = 6,588,252.19 $KgCO_2$/month - 3,810 $KgCO_2$/month
= 6.584.442,19 $KgCO_2$/month

Existing vegetation which consist of area covered by Pucuk merah and bushes on the company can absord around 0.0006% from the total company operational carbon emissions.

3.3 Vegetation Projection Planting

The available area is based on the green open space area which covered by bushes that has the potential to be applied by new vegetation which is Glodokan tiang plant and make the simulations through emission calculation using available data. There are 6 locations of plotted green open space area on the company. Total green open space area for planting vegetation is 1,890 m^2. To find out the potential trees absorb from the planting projection, each green open space area will show the approximate of total trees can be planted by assuming the planting space is 1.5 meters x 1.5 meters, which automatically total area for one tree is 9 m^2 to the other trees. Spacing area from each trees will have a distance as big as 3 meters that is the average planting plot for Glodokan tiang plant. Table below will show the amount of trees that can be plant on each green open space area by dividing towards spacing area for one plant and their absorption capability.

Table 4. Green open space carbon absorption capability

Location (green open space area)	Area (m2)	Available planted trees	CO_2 absorption by trees ($KgCO_2$/month)
A	280	31	1.015.574,57
B	170	19	622.448,93
C	330	37	1.212.137,39
D	460	51	1.670.783,97
E	530	59	1.932.867,73
F	120	13	425.886,11

3.4 Potential Carbon Emissions Reduction

As stated on the calculation before, the existing vegetation on the company which consists of area covered by *Pucuk merah* and bushes have carbon absorption capability 3,810 $KgCO_2$/month. Meanwhile, installed alternative energy produce around 60,000 kWh that can reduce 49,020 $KgCO_2$ from total carbon emissions by energy usage which is 6,556,136 $KgCO_2$. The utilization of green open space area which capable to be planted by trees is necessary to conducted. Total area that has chose to conduct projection planting with Glodokan tiang tree is 1,890 m^2 which can be planted by 210 trees. From the planting projection, 210 Glodokan tiang trees can absorb 6,879,698.7 $KgCO_2$/month. Calculated potential carbon emissions reduction on this study is based on installation of alternative energy which is solar panel and trees planting projection. Therefore, the total of potential carbon emissions on this study is 6.928.718,7 $KgCO_2$/month. So, the residue emissions from company carbon emissions after absorbed by existing vegetation and potential method of carbon emissions reduction are,

Residue emissions = 6,584,442.19 $KgCO_2$/month - 6,928,718.7 $KgCO_2$/month
= -344.276,51 $KgCO_2$/month

4. Conclusions

Total carbon emissions from warehouse operational in one month is 6,588,252.19 $KgCO_2$. Existing vegetation on the company consists of Pucuk merah plant and bushes able to reduce 3,810 $KgCO_2$/month. The utilization of alternative energy for company operational which is solar panel can reduce approximately 49,020 $KgCO_2$/month with the percentage reducing 0.75 % of total usage from main energy usage. Vegetation projection planting method used on this study capable to absorb 6,879,698.7 $KgCO_2$/month. Therefore, the total potential carbon emissions reduction from company operational which come from alternative energy implementation and planting projection on this study is 6,928,718,7 $KgCO_2$/month. The residual emissions from company operational after absorbed by existing vegetation and potential method of emissions reduction are -344,276.51 $KgCO_2$/month which indicate that all the carbon emissions produced by company can totally be reduced.

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Author Contribution

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