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AL KAUSAR INTERNAT SMP CARBON FOOTPRINT MODELING PARUNGKUDA DISTRICT, SUKABUMI DISTRICT, WEST JAVA PROVINCE

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Abstract

Carbon Footprint Modeling of Al Kausar Boarding School in the Parungkuda area is the first step in realizing low-carbon educational activities based on boarding school life. This research aims to analyze carbon emissions from the direct and indirect activities of current Al Kausar Internat Middle School residents, as well as develop a model based on a dynamic systems approach to reduce carbon emissions in the future. The research method uses a quantitative approach by collecting data through literature study, observation, questionnaires, interviews, documentation, measuring waste generation, calculating secondary and primary data, calculating gas usage, and calculating the duration of social media access. The research results show that the total carbon emissions from several dominant activities of Al Kausar Boarding School are currently 839,721,408 KgCO $_2$ eq. Teak gardens and various trees in the school environment absorb carbon dioxide (CO_2) as much as 592,675.64 KgCO_2 per year. Using carbon uptake by trees cultivated in Al Kausar, total carbon emissions are corrected to 607,888.82 KgCO $_2$ eq, reducing total emissions to 231,832,588 KgCO $_2$ eq in scenario I. Scenarios II, III, and IV show further reductions in carbon sequestration from various plants, even reaching harmful total carbon emissions. Scenario V shows an increase in the absorption capacity of trees, which causes total carbon emissions to be corrected to -12,967,412 KgCO $_2$ eq. Scenario VI shows an increase in the carbon absorption capacity of trees, reducing total carbon emissions to 252,845,358 KgCO $_2$ eq. With this intervention, it is hoped that Al Kausar Boarding School can become a sustainable education with a lower carbon footprint."

Keywords: *Carbon footprint, Dynamic systems approach, Sustainable education.*

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Introduction

According to United States Aeronautics and Space Administration (NASA) publications, the level concentration of carbon dioxide (CO_2) in the global atmosphere already reached number an average of 417.6 parts per million (ppm) in mid-2022 (Ardes, Damayanti, & Leta, 2020). That figure shows an increase of about 6.2 % compared to 2011. Compared to the beginning of the industrial era 1750, even the increase had already increased by around 50%. NASA said that enhanced CO_2 levels originate from human activity, like the denudation of forests or deforestation, as well as burning material and fossils. Increasing CO_2 and house gas levels, glass, and others in the atmosphere potentially raise the earth's temperature, which will then trigger a change in climate and disaster nature, which will impact the disruption of the activity economy (Setiani, 2020).

Responding to threats such as climate change, natural disasters, and economic disturbances, Indonesia has set the Kyoto Protocol through Law No. 17 of 2004 to carry out development sustainability and follow in efforts to lower greenhouse gas emissions globally glass. There are 6 house gases targeted glass its decline in Kyoto Protocol viz carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbon (PFC), and hydrofluorocarbon (HFC). To withhold an increase in global temperature up to 2˚C, everyone is advised to keep track of average carbon annual as big as 1.87 tons in 2050.

As a comparison moment, US citizens' average trace carbon per capita is 14.7 tons, and emissions in China's carbon per capita are 8.2 tons. In contrast, Indonesian citizens are 2.3 tons per year.

Convention Framework Work Climate Change United Nations (UNFCCC) is an agreement on international environmental negotiations negotiated at the Earth Summit in Rio de Janeiro from 3 to 14 June 1992 and entered into force on 21 March 1994. The UNFCCC aims to stabilize the concentration of house gas glass in the atmosphere until capable level prevents mixed hand man with system climate (Iqbal & Ruhaeni, 2022). Framework Work: No set limits on house gas emissions binding glass to every country and does not include mechanism enforcement law. Framework Work This determines How international agreement specific (called "protocols") can set home gas limits for real glass binding and impactful real (Khalisah Hayatuddin & Serlika Aprita, 2021). The government invites stakeholders related interests (*stakeholders*). To support achieving the Net Zero Emissions (NZE) target by 2060 or more fast.

Study This focuses on one of the house gases, glass, CO2 (carbon dioxide), the most significant contributor to changing global climate. Indonesia is committed to reducing the emission of carbon. It can be seen in Regulation President Number 61 of 2011 concerning the National Action Plan for Decline Greenhouse Gas Emissions and Regulation President Number 71 2011 concerning the Maintenance of the National Greenhouse Gas Inventory. On Regulations, President Number 61 of 2011 Article 4 stated that perpetrator businesses also follow share to decline GHG (Prafitri & Zulaikha, 2016). Indonesia has committed to reducing carbon emissions by 26 percent in 2020, i.e., more than 0.67 gigawatts is needed (Mujiani, Juardi, & Fauziah, 2019).

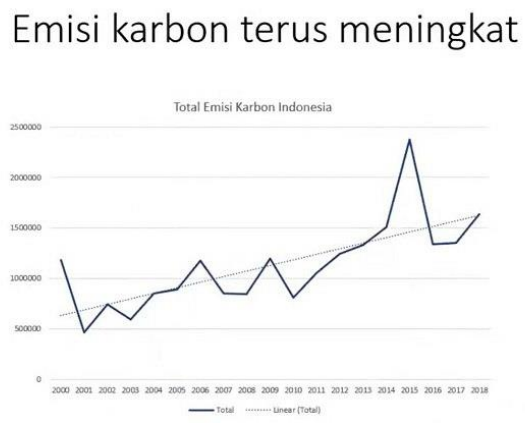
Reduction efforts for GHG emissions (including emission carbon) are done. They are known by disclosure of emission carbon (*carbon emission disclosure*) (Mustikaningrum, Kristiawan, & Suprayitno, 2021). Meanwhile, *carbon emission disclosure* in Indonesia is still low voluntary (*voluntary disclosure*), so not all companies disclose information mentioned in the report Company (Irwhantoko & Basuki, 2016). Disclosure of carbon carried out by the company is one of the forms of commitment company in handling the problem (Bahriansyah & Ginting, 2022).

One of the documents issued by the Indonesian government via the institution *Second National Communication* states that emissions at Indonesia's national level in 2000 reached

556,499 Ggram CO 2 $_{eq}$: emission Origioriginatesm all oversectorsept LULUCF (*Land Use, Land Use Change and Forestry*) and land peat. Second National Communication1 also mentioned that CO_2 emissions from consumption material burn fossil from 2000 - to 2005, rising to 6.4% per year. Source material burns mainly from category emission. This originates from electricity, refining oil, earth, and gas (35%), transportation (23%), residential (9%), and industry manufacture as well as construction (27%). In 2000, house gas emissions as a consequence of burning fossil material moved from 240,877 Ggrams 2000 to 333,438 Ggrams in 2005.

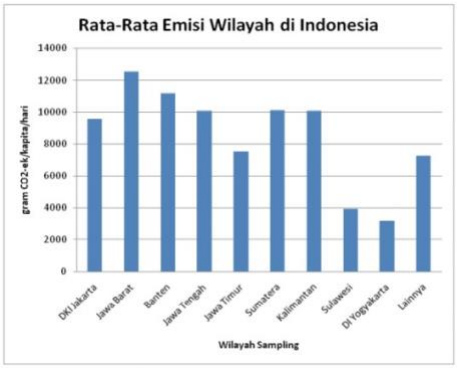
The Ministry of Environment and Forestry (KLHK) stated that Indonesia produced *67.8 million tons of waste throughout 2020.* **From numbers, approximately** *40% is rubbish food (food waste)***. More carry-on published that l** waste and rubbish contribute to house gas emissions. Glass big often escapes attention.

In 2011, the institution non-profit WRI published data that Indonesia is a country with intense house gas emissions glass, the world's largest if refers to the GDP value. It can be seen in the data diagram presented in million tons of CO $_2$ eq per 1 million US $. From the data above, it looks that, nationally, from 2000 to 2016, house gas emissions gradually increased. The highest data shows that house gas emissions are caused by waste; therefore, research on production waste and its impacts on enhanced carbon emission per unit of heavy emergence rubbish is part of a critical study.



Based on the diagram above, the average increase in Carbon in Indonesia is recorded at 8% per year (Misbah, 2021 in Gatra). If counted from 2000 to 2018, the total increased emissions of Indonesia's carbon reached 38%.

A study of emission-carbon provinces in Indonesia found that West Java Province owns house gas emissions the highest glass, as seen in the table below.



Average Chart Regional Emissions in Indonesia (Source *IESR, 2010*).

Research conducted by IESR places West Java in the position of average emissions carbon among provinces. Calculator footsteps IESR-made carbon covers several activities: use of electricity at home, use of drinking water in packaging, quantity of rubbish organically produced, use of paper, and usage of motorized vehicle.

In early April 2019, the area of West Java Province committed to signing a Memorandum of Understanding between the Ministry of National Development Planning/and Bappenas. With the signing of the agreement, the Low Carbon Development Planning (PPRK) agenda is now at the province level. Ready to start. As a province PPRK pilot, West Java Province targets a decline in greenhouse gas (GHG) emissions equivalent to 13.45 million tons of CO_2 through strategic sector activities like forestry, agriculture, energy, transportation, and waste management.

Vice-regent Sukabumi Yes Somantri accepts a visit to the Strategic Study Preparation Team Field Environmental and Social Policy Agency Fiscal Indonesian Ministry of Finance in Bale Pangripta Bappelitbangda, Monday, (29/5/23). Fieldwork the in-frame consultation on Net Zero Emission Indonesia in 2060.

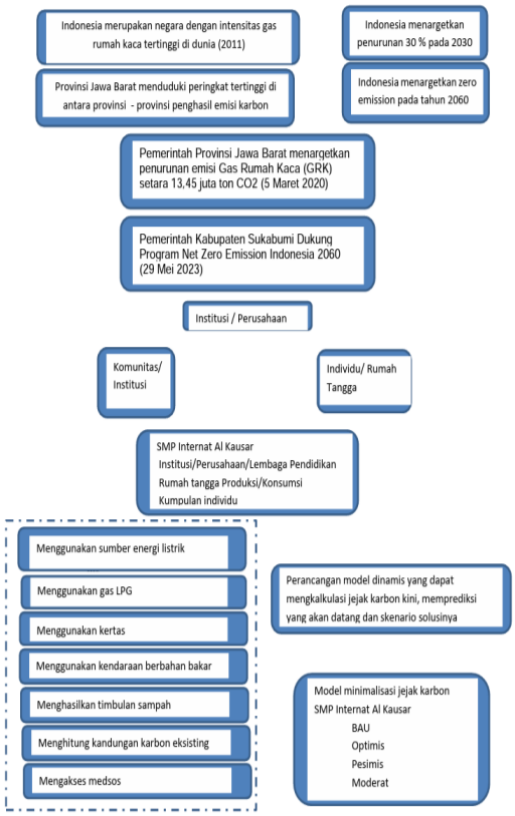
Policy Board Indonesian Ministry of Finance Fiscal, Bramantya Saputro, explained that the Indonesian government, in various Transition Forums, The G20 International, has conveyed its commitment To lower emission carbon in 2030 from 29 percent to 30.89 percent in an independent way.

Based on exposure to the level concentration of carbon dioxide (CO2) in the global atmosphere, it is experiencing potential improvement in rising temperature of the surface earth, which then will trigger change climate, disaster nature, up to impact disruption activity economics, necessary perhaps do data collection beginning rate carbon dioxide in the Al Kausar environment, temperature and humidity as identification beginning condition environment of physical parameters. That l waste and rubbish, it turns out, are significant contributors to house gas emissions glass big However, it often escapes the attention of society That efforts to study the emergence of trash at school boarding become part of the initial data inventory related to

disclosure of carbon from waste produced from activity daily environment settlements in general. As an effort To withhold an increase in global temperature up to 2˚C, everyone is advised to keep track of average carbon annually at a certain level; therefore, counting individual media access becomes a vital growth concern at a striving step mitigation. Usage of vehicle service, usage of material burned fossil, usage of paper, and usage of equipment in the learning process need supply electricity. All activities are accumulative and will produce emission-impactful carbon damage to natural Goods direct No direct.

A form action real, for support achieving the Net Zero Emissions (NZE) target by 2060, then modeling with approach system dynamic used for representing condition footsteps carbon from various activities. Al Kausar International Middle School student. System dynamics describes the relevance between mutual factors interacting (Fortunella, Tama, & Eunike, 2015). This model can estimate the footsteps of Al Kausar Internat Middle School carbon with options - options BAU *business as usual* scenario, scenario optimistic, scenario moderate, and scenario pessimistic through model simulation with various interventions. Understanding the influence of change *leverage* in some systems to decrease total carbon is applied to realize sustainable (*sustainable education*) draft education at Al Kausar International Middle School.

According to Roland Barth (1990), in his book *"Improving Schools from* Within," changes at school can initiated by the party outside, but continuous change only comes from within the school Alone. In connection with this matter, the writer means to research footsteps carbon at Al Kausar Internat Middle School to find out the trend of emissions carbon produced at a time and



compile solutions - solutions from scenarios of its decline in a sustainable way. Following This is a linkage diagram problem in the study;

Research methods

A. **Research sites**

Legend:

★1 Dormitory A	★2 Mosque	★3 Basketball Courts	★4 Gazebo A	★5 Parking A	★6 Canteen	★7 Parking B
★8 Dormitory B	★9 Parking C	★10 Parking D	★11 Gazebo B	★12 R Class A	★13 R Teacher	★14 R Class B

Information picture:

	Gedung Asrama	; pusat kegiatan parsial *in door* di luar gedung sekolah
	Masjid, Kantin	; pusat kegiatan kolosal *in door* di luar gedung sekolah
	Parkir	; pusat kendaraan, *outdoor*
	Gazebo	; pusat kegiatan *semi indoor* di luar gedung sekolah
	Ruang Kelas, Ruang Guru	; pusat kegiatan *indoor* di gedung sekolah

Image: Google map with 2023 modifications

The astronomical location of Al Kausar Internat Middle School is (6,804 ° to 6,808°) South Latitude and (106,759 ° to 106,763°) East Longitude. Data sources satellite image coordinates 2023 CNES, Airbus Maxar Tecnologies Map Data ©2023.

B. Research design

Carbon footprint modeling is a way to calculate and map the amount of greenhouse gas emissions produced by a particular system or activity and the ability to absorb carbon from natural resources. (Widyarini, 2022). Carbon footprint modeling can be used to plan mitigation and adaptation strategies to climate change and encourage low-carbon development (Baroleh, Massie, & Lengkong, 2023).

In West Java, several studies have analyzed the carbon footprint of various sectors, such as housing, transportation, waste, agriculture, livestock, and tourism. They are calculating CO_2

emissions from residential activities in three villages in Bogor Regency, analyzing the ability to reduce CO_2 by planting trees, calculating CO_2 emissions from coastal and marine tourism activities in the Pangandaran tourist area, and analyzing the potential for carbon uptake by the mangrove ecosystem.

The West Java Provincial Government has also signed a memorandum of understanding with the Ministry of National Development Planning/Bappenas to implement the Low Carbon Development Planning (PPRK) agenda at the provincial level. This agenda aims to integrate climate change mitigation and adaptation aspects in regional development planning and improve environmental performance and community welfare (Triastuti, Sholihah, Nugraha, & Nugroho, 2022).

Several institutions conduct research related to carbon emissions within the institution. BNI, one of the institutions operating in the financial sector, has initiated a sustainable finance program. BNI is committed to implementing *Sustainable Finance* as a whole as a form of support for sustainable growth resulting from the harmony between economic, social, and environmental interests, as well as complying with the directions of the Financial Services Authority, especially POJK No. 51/POJK.03 - 2017 concerning the Implementation of Sustainable Finance. BNI's commitment is realized, among other things, by calculating Scope 1, 2, and 3 Green House Gas (GHG) emissions so that in the future, it can become a reference in measuring the company's success in reducing carbon emissions. In the 2022 reporting period, BNI adjusted the calculation methodology in terms of the classification of emission sources to calculate emissions, significantly Scope 3, which includes land service travel, air service travel, and financing emissions by adopting the methodology from PCAF. BNI has also started calculating financing emissions for medium and corporate segment debtors, namely the plantation sector, plantation product derivative industries, mining and commodity trading, processing industry, trading industry, *pulp and paper*, construction, and PLTU. Based on BNI's calculations of greenhouse gases (GHG) produced in 2022, it is known that Scope 1, which includes fuel use in buildings, is recorded at 121.64 tonnes of CO_2 eq. Scope 2, including electricity use emissions, was recorded at 295,208.86 tons of CO_2 eq. For Scope 3, which includes air service travel, land service travel, and financing emissions, respectively, it was recorded at 2,013.87 tons of CO_2 eq, 889.12 tons of CO_2 eq, and 13,392,779.24 tons of CO_2 eq. The total GHG emissions from these three scopes are 13,691,012.79 tons of CO_2 eq.

They are conducting research entitled Carbon Footprint of LPG and Electricity Consumption in Household Activities in Denpasar City, Bali, which examines the carbon footprint of LPG and electricity consumption in housing (Wiratama, Sudarma, & Adhika, 2016). There are 2 objectives of this research: calculating total primary and secondary carbon emissions and determining the factors that most influence the carbon footprint value. This quantitative descriptive research is supported by survey data (Sari, Rachman, Astuti, Afghani, & Siroj, 2023).

The method used is multiple linear regression analysis (Yuliara, 2016). The total carbon footprint of LPG and electricity consumption in Denpasar City, comprising 15,908 households, is 2,195,892,938 g of carbon/month, equivalent to 2,195.89 tonnes of CO2 e/month.

Conducted research entitled Potential Greenhouse Gas Emissions (CO_2, CH_4, and N_2O) at the Faculty of Law, Islamic University of Indonesia, analyzing $CO_{2\ emissions}$ resulting from population and rice field areas from 2010 to 2024 using serial data on the number of residents and the area of rice fields in Prabumulih City. Based on simulation results, the amount of CO_2 emissions residents produce is predicted to continue to increase. In 2010, the amount of emissions produced was 55.98 Gg CO_2 with a population of 161984 people, in 2017, it was 64.01 Gg CO_2 (185,220 people), and a simulation was carried out for the next 7 years, in 2024, it is predicted that it will increase to 73.31 Gg CO_2 (212 132 people). The emissions produced by rice fields in 2010 were 1.61 Gg CO_2 with a land area of 1,625.75 ha, in 2017, they were 1.22 Gg CO_2 with a land area of 1,233.21 ha, and in the simulation for 2024, the emissions produced were 0.772 Gg CO_2.

Compare the intensity of carbon dioxide ($CO_{2)}$ levels in 2 rooms. Data was taken in 2 computer laboratories located in the basement of the building, namely the Computer Laboratory of the Faculty of Economics and the Computer Laboratory in the Library. The tools used in this research are cameras to document existing conditions, and *indoor atmosphere monitors* to measure the intensity of carbon dioxide (CO2) levels in the room.

Modeling footsteps carbon in Sukabumi is a method for calculating and mapping house gas emissions produced by various activities in the district area Sukabumi, as well potency uptake carbon by source Power natural like mangrove ecosystem. Modeling footsteps carbon in Sukabumi can used for planning mitigation and adaptation strategies to change climate, as well as for pushing the development of low carbon.

Some research has been done to model the climate change areas using decreased MAGIthe CC/Sof the 5.3 software. Sarah (2016) projects change in average global temperature and precipitation regional monthly for 2000-2100 by using two scenarios house gas emissions glass, namely A1-BIM (high) and B2-MES (low), using the global circulation models UKHADCM3 and UKHADGEM. Study This shows that changes in average global temperatures are increasing until reaching 2.96°C in 2100 for scenario A1-BIM and 2.6°C for the B2-MES scenario. Change precipitation regional monthly shows that enhancement maximum in April 2100 of 25.2% for scenario A1-BIM and 21.8% for B2-MES scenario in the western region of the Regency Sukabumi, and 32.7 % and 28.2% for A1-BIM and B2-MES scenarios in the eastern region Regency Sukabumi.

Several schools in Indonesia have implemented the concept of low carbon emissions or *net zero carbon*, namely buildings that have very low or zero carbon emissions. For example, four schools in DKI Jakarta have been rehabilitated with the *net zero carbon concept* and received

healthy building certificates from *the Green Building Council Indonesia*. The four schools are SDN Duren Sawit 14, East Jakarta; SD Grogol Selatan 09, South Jakarta; SDN Ragunan 08 and 09, South Jakarta; and SMAN 96 Cengkareng, West Jakarta. These schools use solar panels to meet their electricity needs. They have environmentally friendly facilities such as vertical gardens, green roofs, and rainwater harvesting systems.

In this study, measurements of the intensity of carbon dioxide (CO2) levels $_{\text{were}}$ carried out at 14 location points with details of 2 classrooms, 1 teacher's room, 4 vehicle parking lots, 2 dormitory buildings, 1 mosque, 1 canteen, 2 gazebos, 1 basketball/futsal court to get an idea of the intensity of indoor *and* outdoor *carbon dioxide levels*. The tool used to collect data in this research is a *gadget camera* to document existing conditions ($CO_{2\ \text{levels}}$, temperature, and humidity). Indoor/Outdoor Air Quality is used.

Study This is a study quantitative in nature projective. Modeling is done using several reference data obtained from measurement, comparison of secondary data related, compilation data, and estimation for period time specific and projected done from the collected trend data using tools to help regression modeling using Powersim 10 software. The comparison was carried out to test the model's validity visually for comparing reference data and results in data simulation.

Analysis was carried out from changed sub-model factors and their influence on the model and *feedback* that emerged as a consequence of changes to other sub-models in arrangement system dynamics. Several related sub models activity productive learning emission carbon, combined with condition environment biotic, and non- abiotic environments/physique school, *behavior* (behavior) of citizens school and dynamics in the learning process furthermore processed in form use model scenarios get objective specific including levels emission expected carbon, year achievement, and form intervention that will take To use achievement of designed targets. Data collection consists of primary data based on surveys and interviews, secondary data from study stake related, data from results study kind previous, standard data from policy/legislation, validity, reliability, source location, and assessment instruments as well as development instruments. Measurement and data collection were done using equipment tool scales*, Portable digital scales, and air detectors*, compared with applications related to " breath " and *Water IQ*. Results data measurement in a way *time series* compared to with more data coverage wide For analyzed the tendency. Waste data measurement is done manually to get the average daily emergency rubbish actually used as model and analysis input. Data was collected with the ng vehicle, usage paper, gas, and electricity consumption to reanalyze collected time series data. The observation system is done from the behavior of each sub-model, the possibility of intervention carried out, and its impact on model output, primarily total emissions expected carbon from objective model making.

To sort and select the data used in data processing, mathematical required formulated stages in the chart following:

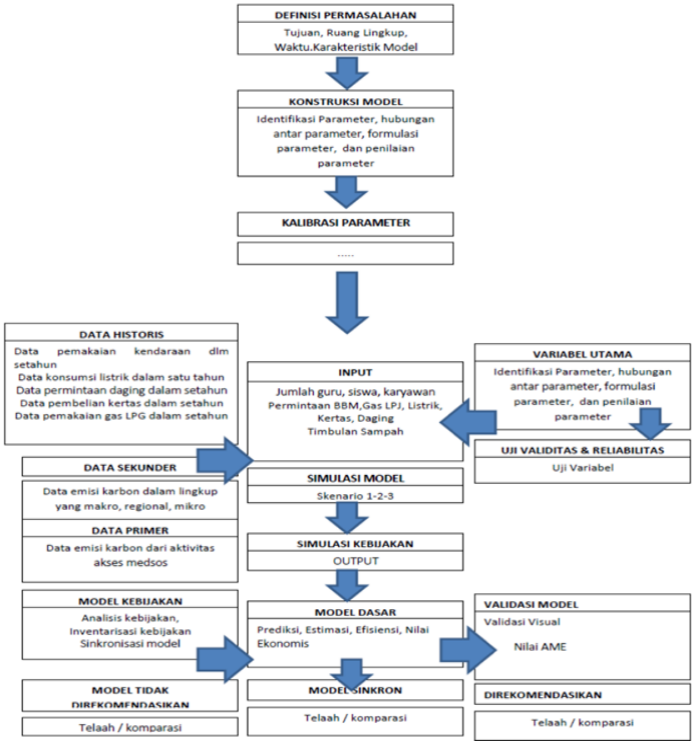


Figure 1. Design scheme study

Data collection consists 2 from primary data based on surveys and interviews, secondary data from study stakeholders, data from results study kind previous, standard data from policy/legislation, validity, reliability, sources location, and assessment instrument as well as development instrument. Measurement and data collection were done with the use of equipment tool scales*, Portable digital scales, and air detectors*, compared with related online applications "Breath" and *IQ Air*. Results data measurement in a way *time series* compared to with more data coverage wide for analyzed the tendency. Waste data measurement is done manually to get the average daily emergency rubbish. Then, it is used as a model and analysis input. Data was collected using vehicles, usage paper, gas, and electricity consumption for trend analysis of collected *time* series data.

The observation system is done from the behavior of each sub-model, the possibility of intervention carried out, and its impact on model output, primarily total emissions expected carbon from objective model making.

Data - data needed for an analysis v variable The system consists of numbers of internal gas requirements a month, total need for meat, chocolate, and cheese in a month, total payment bill electricity per month, amount usage paper in a month, total distance total travel for each type vehicles, quantity emergence rubbish within 10 days, total Al Kausar residents living in the neighborhood schools, total junior high school students, number of teachers and employees.

Supporting data for analysis includes existing data on carbon dioxide, k data on available temperature, and k data on humidity at 14 points sample locations to describe the physical conditions of the school environment. Quantity and type data trees in the environment schools

and their characteristics related to carbon uptake. *Time series* data (*historical data*) includes usage paper, gas usage, electricity consumption, vehicle service usage, and mileage for all service vehicles. Predicted employee data and the amount of carbon emissions studied are simulated in models and scenarios with deliberate intervention to obtain the designed model output values.

Testing model This includes, among other things, visually testing the model's validity and testing the model's validity using AME mean. Simulation of a similar model system to the original done 6 times for each pattern scenario to use achieved mark expected emissions.

Causal Loop Diagrams

In the following diagram, all variables identified connections between sub-models and *the feedback* that arises. Positive sign for state connection *similar* or connection compared straight, whereas the sign negative for state connection *opposite* or connection compared backward.

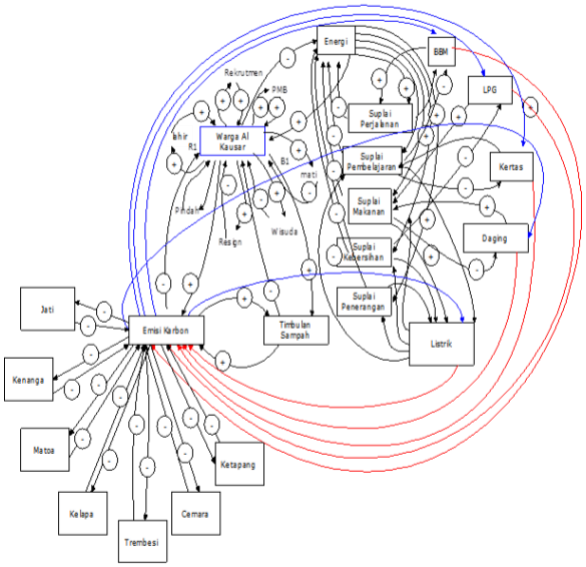
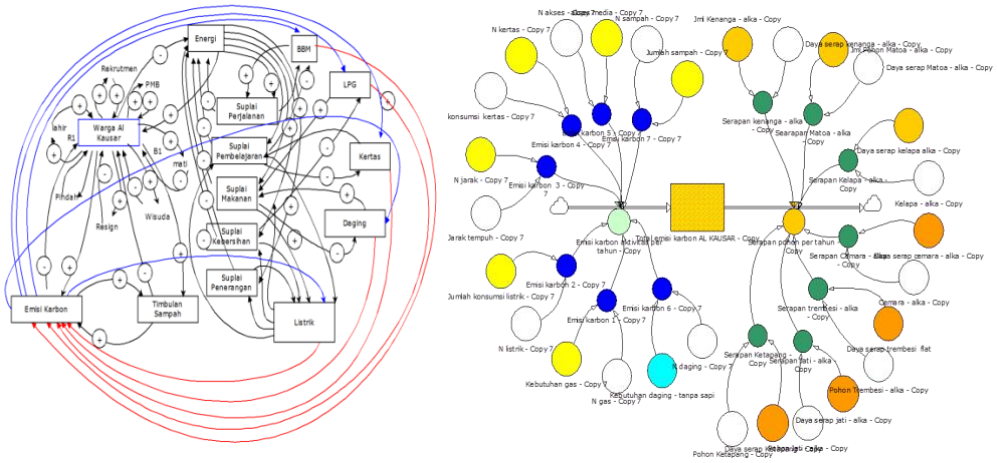


Figure 2. *CLD Causal Loop Diagram*

Making *Play models*

Referring to relationship causality in the CLD above, a basic model will be prepared for selection from every intervention. Following This is SFD (*Stock Flow Diagram*), which is configuration from various variables in the sub-models that make up the SMP Internat AL Kausar Carbon footprint model as follows:

Image of SFD (*Stock Flow Diagram*) Modeling Al Kausar's Carbon Footprint



Validity test: The model is carried out to measure the validity of the designed model by using 2 model validity tests, including a validity test done with count AME mean and a validity test v visual with create diagrams on reference data and simulation data.

C. Source information

Study This uses technique studies. References are used to get secondary data related to the initial data study. Primary data was obtained from interviews involving the laundry supervisor, canteen supervisor, dan *security,* park supervisor, treasurer of BUP (Agency Affairs maintenance), and head of *TU* (administration). Interview done for Get type and quantity data tree, distance data travel all over vehicle service, gas use, consumption of meat, chocolate, and cheese, payment bill electricity monthly, usage paper, and quantity employee taught/non taught. Primary data is also collected from the results of physical data measurements in the field (temperature, humidity, and $CO_{2\ levels}$). Population in the study: This is all over Al Kausar, including students and all employees taught. The sample used was 50 Al Kausar International Middle School students. Unit of Analysis study This is the emission of carbon resulting from activities certain per unit of time.

Resources in making model simulations include information distance travel vehicles. This data is obtained from book reports recording kilometers of distance traveled by vehicle service going out and entering the security post with section supervisor resource person *security*. Information about the gas obtained from book records of monthly gas orders for laundry and canteen units will confirm the explanation of the laundry department supervisor and section supervisor canteen.

Information consumption meat, cheese, and chocolate obtained from book notes shopping material Cook monthly canteen unit, with section supervisor resource person canteen. Information on the emergence of rubbish obtained from weighing was collected for 10 days with a pattern of

weighing Wednesday, weighing in Saturday, weighing in Wednesday, weighing in Saturday, and up to 10 days of data collection. The equipment used for moment-do weighing is a *portable electronic scale*, pen, and book note for data collection. Information uses electricity and consumption data electricity obtained from the BUP unit (part utility and maintenance) with part confirmation BUP finances, so 6 months of data were obtained for payment bill electricity from building units dominant. Information is obtained from b recording book-taking papers by teachers, dormitory supervisors, and employees with confirmation from TU officers for later compilation. To use the data series for 16 16-month walks.

Information media access was obtained from student class 7, as many as 15 students out of a total of 32 students from class 8, as many as 18 students of 18 students; and class 9, as many as 29 students from a total of 40 students. The data collected was 62 students. Furthermore, data was collected using the method of eliminating missing data. Hence, the data is 50 students used as reference calculation trend access media with calculator emission carbon. Information CO_2 levels, temperature, and humidity were obtained from measurement directly with the use of a tool *water detector.*

The following equipment is used:

Image of digital water detector and portable scale

The Air Quality Detector measure$_{s\ CO2}$ levels in 14 locations selected in the morning, afternoon, and evening. Scales / *portable digital scale* used to measure heavy rubbish done daily in 10 x data collection. A questionnaire was also used in data collection for this research. Instrument This is for digging and accessing data selected from social media, and respondents fill in available applications (calculator emission carbon), then capture data input results for recap. To use more data analysis, carry on. **Interviews with key figures were also conducted** to get quantity data usage electricity, payment bill electricity, quantity data LPG gas consumption in laundry units and canteen units, shopping data meat beef, sheep/goat, cheese, and chocolate for average consumption in One month. Interviews were done with the canteen supervisor, laundry supervisor, Dan (commander team officer *security*), BUP treasurer, TU head, and TU operator. Documentation is carried out to complete the physical data of the region. Take pictures using an HP usinginix camera to document every sampling data element, like CO_2 levels, humidity air, and temperature air. Doubling document recording distance travel vehicle service is also carried out. It makes it easier to calculate and compile data travel from various types of available services. Observations were carried out in the classroom, school toilet room, and mosque room regarding the lights' presence and installation location. Observations were also carried out to confirm several data related to numbers tree / stand cypress, teak, trembles, ylang ylang, bamboo, keta pang, and coconut on-site study. Other supporting tools used for registering include, among other things, book notes, pens, and counters.

Results and Discussion

Due to calculations for various activities, the total amount of carbon emissions from existing Al Kausar is 839721.41 KgCO $_2$ eq. The total amount of CO2 absorption by the presence of existing trees in Al Kausar is 592675.64 KgCO $_2$ eq (Results of primary data calculations 2023). If there was an 8% increase in carbon national (Indonesia) in 2000, then each variable reaches the following:

With the current total carbon emissions of 839721.41 KgCO $_2$ eq, it is predicted that in 2030, Al Kausar's carbon emissions will be 1309965.643 KgCO $_2$ eq. In 2045, Al Kausar's carbon emissions are predicted to be 2317631.52 KgCO $_2$ eq; in 2050 emissions, Al Kausar's carbon is predicted to be 2653520.148 KgCO $_2$ eq, and in 2060, Al Kausar's carbon emissions will be 3325297.40 KgCO $_2$ eq with a constant emission growth rate of 8% per year. Predictive data for Al Kausar's total carbon emissions until 2060 at a constant trend of 8% is as follows:

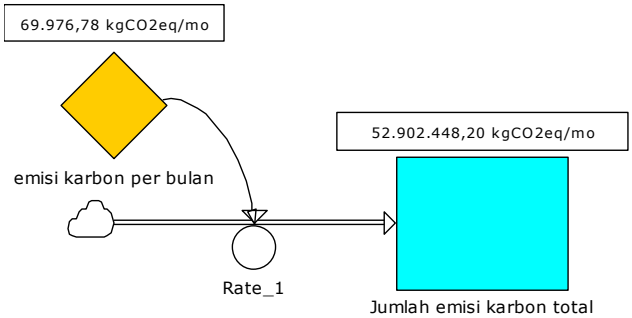
Tahun	2024	2030	2045	2050	2060
pertumbuhan	8%	8%	8%	8%	8%
daging	279654,4	436260,3959	771845,3159	883706,9558	1107430,236
listrik	51898,581	80961,75635	143240,0305	163999,4552	205518,3046
kertas	10886,4	16982,78439	30046,46469	34401,02479	43110,14499
kendaraan	13535,031	21114,65104	37356,69031	42770,7034	53598,72957
sampah	9663,377	15075,08178	26671,29854	30536,70412	38267,51529
gas	4112,64	6416,210512	11351,75706	12996,93924	16287,30361
akses sosmed	469970,979	733154,7628	1297119,965	1485108,366	1861085,167
Emisi karbon	839.721	1.309.966	2.317.632	2.653.520	3.325.297

Relationship Table scenario with the composition of each variable

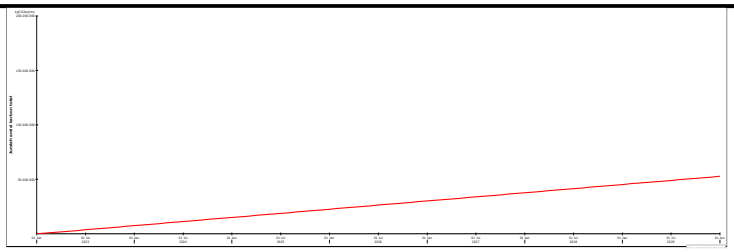
Variable Determinant (consumption)	Scenario		
	I	II	III
	30%	65%	85%
	2030	2045	2050
meat	195758,1	97879.03	48939.51
electricity	36329.01	18164.5	9082.2517
paper	7620.48	3810.24	1905,12
vehicle	9474,522	4737,261	2368.6304
rubbish	6764,364	3382,182	1691,091
gas	2878,848	1439,424	719,712
access social media	328979.7	164489.8	82244,921
	587805	293902.5	146951.24

2023 modeling calculation results

Prediction with models



Prediction emission carbon per month amounting to 69976.78 KgC O 2eq in 2030

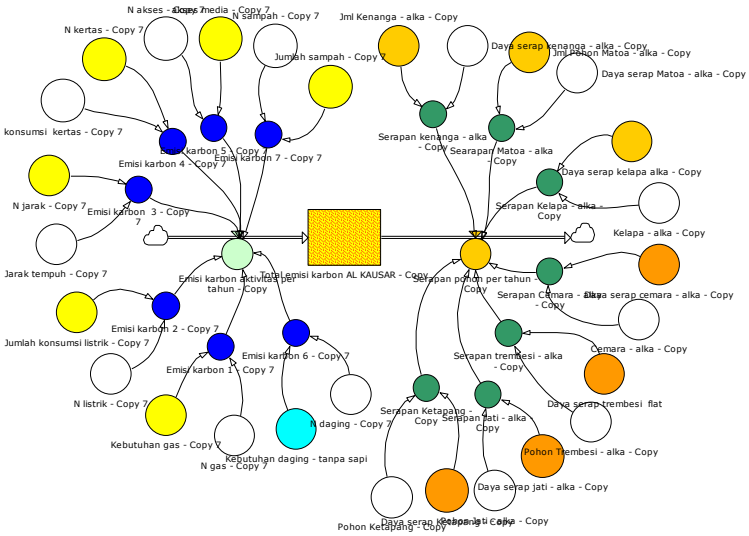


Graph of prediction results using Powersim

For lower emission carbon required step intervention that is with do various scenarios as following:

Scenario I (No menu policy meat cow)

Model 1 with scenario Change consumption meat cow in the daily menu with consume tilapia fish as results cultivation-independent system biofloc. Then, the model will be changed, and the total emission output value carbon produced becomes the same as in the models and tables following this.



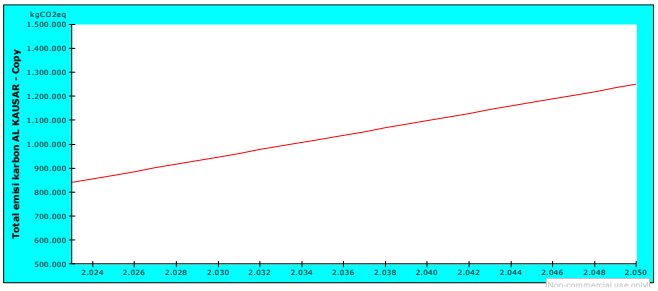
In the scenario with the policy eliminating the meat menu cow and replacing it with tilapia fish on the menu, the creation of a model will experience enhancement gradually. In 2050, the value emission will only be 1.5 times the mark emission now. Interventions carried out result in a decline in emissions as significant as 231832.6 $KgCO_2$ eq. From the start, 839721.4 1 $KgCO_2$ eq to 607888.82 $KgCO_2$ eq.

In the scenario with the policy, you are eliminating the meat menu cow and replacing it with tilapia fish on the menu, resulting in production. Alone with the Biofloc system, creating a model will experience enhancement gradually, and in 2050, the value emission will be only 1.5 times the mark emission now.

The table:

(kgCO2eq)			
year	Total emisi karbon AL KAUSAR - Copy	Emisi karbon aktivitas per tahun - Copy	Serapan pohon per tahun - Copy
2.023	839.721,41	607.888,82	592.675,64
2.024	854.934,59	607.888,82	592.675,64
2.025	870.147,78	607.888,82	592.675,64
2.026	885.360,96	607.888,82	592.675,64
2.027	900.574,15	607.888,82	592.675,64
2.028	915.787,33	607.888,82	592.675,64
2.029	931.000,52	607.888,82	592.675,64
2.030	946.213,70	607.888,82	592.675,64
2.031	961.426,89	607.888,82	592.675,64
2.032	976.640,07	607.888,82	592.675,64
2.033	991.853,26	607.888,82	592.675,64
2.034	1.007.066,44	607.888,82	592.675,64
2.035	1.022.279,63	607.888,82	592.675,64
2.036	1.037.492,81	607.888,82	592.675,64
2.037	1.052.706,00	607.888,82	592.675,64
2.038	1.067.919,18	607.888,82	592.675,64
2.039	1.083.132,37	607.888,82	592.675,64
2.040	1.098.345,55	607.888,82	592.675,64
2.041	1.113.558,74	607.888,82	592.675,64
2.042	1.128.771,92	607.888,82	592.675,64
2.043	1.143.985,11	607.888,82	592.675,64
2.044	1.159.198,29	607.888,82	592.675,64
2.045	1.174.411,48	607.888,82	592.675,64
2.046	1.189.624,66	607.888,82	592.675,64
2.047	1.204.837,85	607.888,82	592.675,64
2.048	1.220.051,03	607.888,82	592.675,64
2.049	1.235.264,22	607.888,82	592.675,64
2.050	1.250.477,40	607.888,82	592.675,64

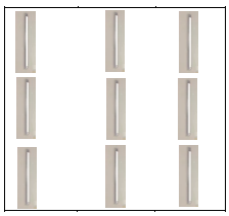
The graphic:

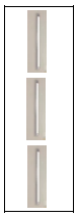


Interventions carried out result in a decline in emission as significant as 231832.6 KgCO $_2$ eq From the start, 839721.4 1 KgCO $_2$ eq to 607888.82 KgCO $_2$ eq.

Scenario II Engineering behavior and settings of the switch button connection against light

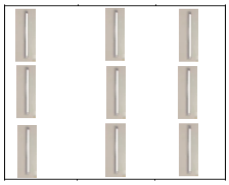
From observation, the design room looks like all room classes own maximum windows to give lighting room depending on the sun's rays through glass installed in windows, especially during the day. In the placement light lighting room, there is a uniform pattern where each room class 9 neon lights are installed in a way parallel, as seen in the following illustration:

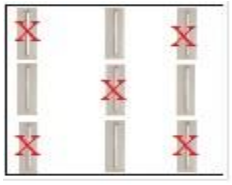




Type A (classroom), type B (toilet area)

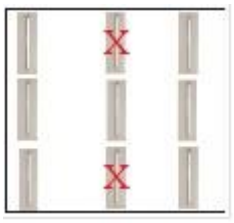
The connection switch against the lights is patterned the same way without considering the presence of light entering from the window. As for patterns, the connection switch to the light installed as follows:

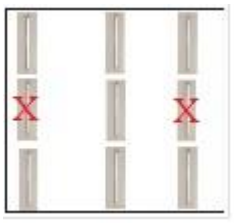


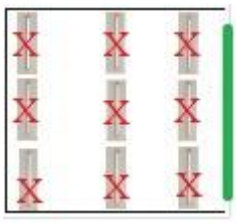


When not turned on, when the button 1 illustration is turned on, it turns on the light.

When turned on the knob left, then turned on the configuration light, patterned class “front behind," and when turned on the knob right, then turned on the configuration light, The class has a " right" pattern left."

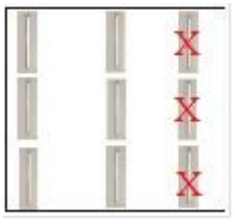

front – back

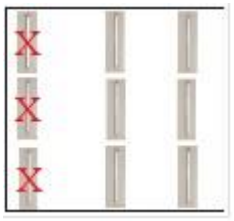

right – left


combination of 3 buttons

So one moment, the third knob is turned on, and then turn on the configuration light, and the class becomes as in the last picture.

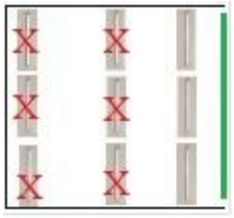
By referring to eco-efficiency, the switch connections to the lights can be rearranged by considering the presence of large glass windows on the side of the room towards the outside of the building. The switch connection settings for the lights are rearranged to:


Right switch "on"


left switch “on”


bottom switch “on”

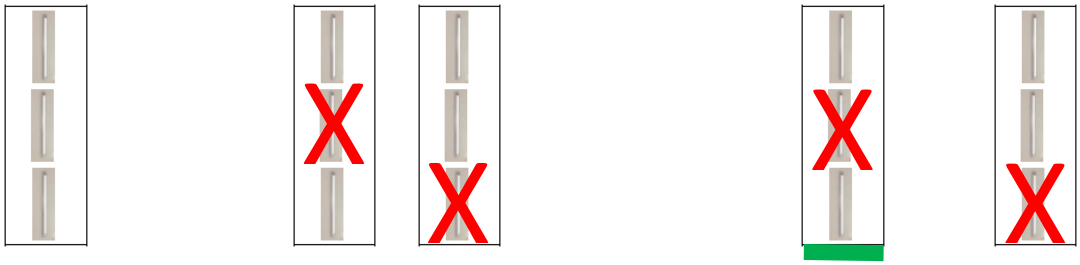
With manipulation pattern connection, Light switches are made per lane, so efficiency can be done with only the use of the left knob and lower buttons, as well as optimizing function glass on the window (opening behavior curtain closing moment learning in the afternoon day).



Two light switches to ignite the 6 lights in the room are used together with the glass window function, saving 30% electricity usage for all classrooms.

The toilet rooms were also engineered similarly so that the functions of the right and left switches were deliberately differentiated by optimizing the role of the glass windows on the outside of the building. Two lights that are on combined with light from outside the building during the day will save 30% of electrical power consumption from what was used before engineering the switch connection settings for the lights.

X X

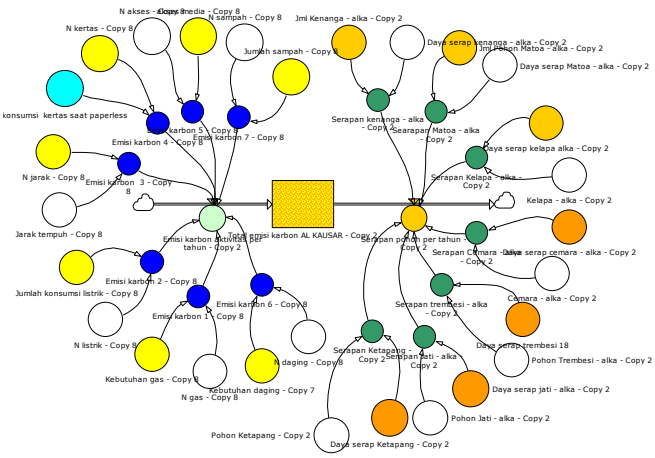


On/off condition of switch A, switch B is engineered into switch A' and switch B'

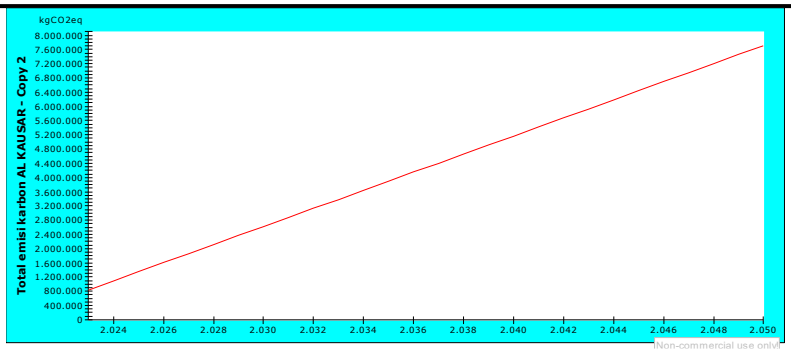
Concerning the implementation draft, The eco-efficiency of using switch A, which combines lighting with lighting from window glass, will save 30% on electricity consumption. Switch B is an addition when necessary, for example, if conditions are dark due to thick clouds or at night. With consider draft *green building*, existence windows with glass very supportive circulation of air from the outside room enter to the in-room or the contrary, and helpful lighting natural in the space, so configuration turns on the light class can be modified with a change arrangement connection knob a switch for a light that is associated with the presence of a window. This scenario will reduce emissions by 2602,158 KgCO $_2$ eq.

Scenario III. *Paperless* policy

Suppose the paperless policy can lower paper use to 50% of the existing usage condition. In that case, modeling will produce a decline in emission carbon until -7524.21 KgCO $_2$ eq due to the initial one emission carbon A l K wearing out as much as 839721.408 KgCO $_2$ eq by the presence of policy *paperless* to 847245.62 KgCO $_2$ eq.



Scenario policy *paperless* assumed give impact decline usage paper only half you h of amount usage now because document letter writes related officialdom Not yet entirely can omit, for example, related to alums who take care of it file legalize For continuation study at the agency-specific need filing Lots document, then the behavior of the model above it turns out cause an increase in total emissions Al K carbon wears out to 10 times the projection until in 2050, as shown in the following diagram:



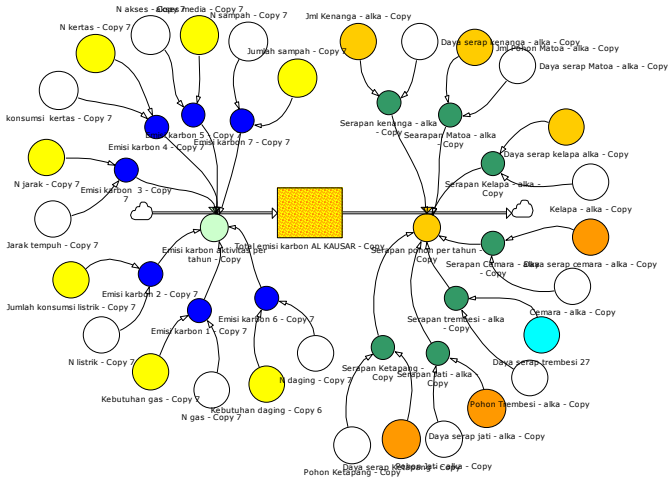
Results _ policy *paperless* looks in the table following:

(kgCO2eq)

year	Total emisi karbon AL KAUSAR - Copy 2	Emisi karbon aktivitas per tahun - Copy 2	Serapan pohon per tahun - Copy 2
2.023	839.721,41	847.245,62	592.675,64
2.024	1.094.291,39	847.245,62	592.675,64
2.025	1.348.861,38	847.245,62	592.675,64
2.026	1.603.431,36	847.245,62	592.675,64
2.027	1.858.001,35	847.245,62	592.675,64
2.028	2.112.571,33	847.245,62	592.675,64
2.029	2.367.141,32	847.245,62	592.675,64
2.030	2.621.711,30	847.245,62	592.675,64
2.031	2.876.281,29	847.245,62	592.675,64
2.032	3.130.851,27	847.245,62	592.675,64
2.033	3.385.421,26	847.245,62	592.675,64
2.034	3.639.991,24	847.245,62	592.675,64
2.035	3.894.561,23	847.245,62	592.675,64
2.036	4.149.131,21	847.245,62	592.675,64
2.037	4.403.701,20	847.245,62	592.675,64
2.038	4.658.271,18	847.245,62	592.675,64
2.039	4.912.841,17	847.245,62	592.675,64
2.040	5.167.411,15	847.245,62	592.675,64
2.041	5.421.981,14	847.245,62	592.675,64
2.042	5.676.551,12	847.245,62	592.675,64
2.043	5.931.121,11	847.245,62	592.675,64
2.044	6.185.691,09	847.245,62	592.675,64
2.045	6.440.261,08	847.245,62	592.675,64
2.046	6.694.831,06	847.245,62	592.675,64
2.047	6.949.401,05	847.245,62	592.675,64
2.048	7.203.971,03	847.245,62	592.675,64
2.049	7.458.541,02	847.245,62	592.675,64
2.050	7.713.111,00	847.245,62	592.675,64

Scenario Plant Trembesi plus 50% of the condition existing

Now 18 trees were recorded trembles embedded in Al Kausar. If 9 trees are planted, it will result in a total of 27 trees so that it will impact the model:

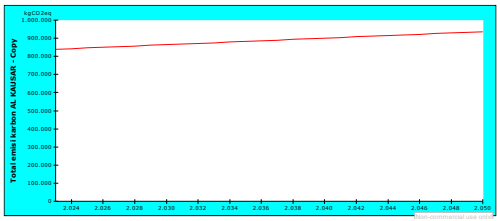


So, the data table resulting from modeling :

(kgCO2eq)

year	Total emisi karbon AL KAUSAR - Copy	Emisi karbon aktivitas per tahun - Copy	Serapan pohon per tahun - Copy
2.023	839.721,41	852.688,82	849.071,15
2.024	843.339,08	852.688,82	849.071,15
2.025	846.956,76	852.688,82	849.071,15
2.026	850.574,43	852.688,82	849.071,15
2.027	854.192,11	852.688,82	849.071,15
2.028	857.809,78	852.688,82	849.071,15
2.029	861.427,46	852.688,82	849.071,15
2.030	865.045,13	852.688,82	849.071,15
2.031	868.662,81	852.688,82	849.071,15
2.032	872.280,48	852.688,82	849.071,15
2.033	875.898,16	852.688,82	849.071,15
2.034	879.515,83	852.688,82	849.071,15
2.035	883.133,51	852.688,82	849.071,15
2.036	886.751,18	852.688,82	849.071,15
2.037	890.368,86	852.688,82	849.071,15
2.038	893.986,53	852.688,82	849.071,15
2.039	897.604,21	852.688,82	849.071,15
2.040	901.221,88	852.688,82	849.071,15
2.041	904.839,56	852.688,82	849.071,15
2.042	908.457,23	852.688,82	849.071,15
2.043	912.074,91	852.688,82	849.071,15
2.044	915.692,58	852.688,82	849.071,15
2.045	919.310,26	852.688,82	849.071,15
2.046	922.927,93	852.688,82	849.071,15
2.047	926.545,61	852.688,82	849.071,15
2.048	930.163,28	852.688,82	849.071,15
2.049	933.780,96	852.688,82	849.071,15
2.050	937.398,63	852.688,82	849.071,15

The behavior of the model is shown in the following graph :



Model behavior tends to increase slowly with the number of trees plus 9 sticks of the 18 available for 27 trees trembling.

Treatment model intervention will change drastically. In addition, it has up to 12 trees so that the total number becomes 30. Hence, model behavior decreases sharply, and emission zero can achieved between 2032 and 2034.

Scenario VI: Using scenario composite 2 to 3 years to front emission carbon in Al Kausar achieves Net Zero Emissions.

So if the emission Al Kausar carbon is only calculated based on activities learning and service, the emission causative Al carbon is as big as 839721.408 $KgCO_2eq$.

If 7 plants dominant taken into account as absorbent carbon and directly impact the decline emission carbon mark emission of Al Kausar carbon will be changed, confirmed in the following table:

Calculation table:

SCENARIO	Emission total carbon	Absorption tree	Total Al Kausar emissions	Residual emissions
1	607888.82	592675.64	231832,588	15213.18
2	837119.25	592675.64	2602,158	244443.61
3	847245.62	592675.64	-7524,212	254569.98
4	852688.82	849071.15	-12967,412	3617.67
5	852688.82	934536.32	-12967,412	-81847.5
6	586876.05	934536.32	252845,358	-347660.27

Negative numbers show that Power absorbed by trees is taller than the carbon emission generated by various activity learning.

Of the 6 scenarios, the most recommended is scenario composite 6 because scenario This only needs 2 years just for Al Kausar to achieve Zero emissions.

V alias Model

Analysis AME Average Mean Error value:

$$AME = \frac{|Xs - Xr|}{} 100\%$$

Xr

Xs = average of simulated data

Xr = average of reference data

From the table following:

Tahun ke	Referensi Data Sektor Energi Provinsi Jawa Barat	Simulasi Data Emisi Karbon Alkausar
1	453.235	839.721
2	507.357	855.027
3	540.419	870.332
4	496.030	885.638
5	531.142	900.943
6	536.306	916.248
7	538.025	931.554
8	562.244	946.859
9	595.665	962.165
10	638.808	977.470
Rerata	539.923	908.596

Source: Calculation results simulation with unit $KgCO_2eq$

Xs = average simulation data = 908596 $KgCO_2eq$

Xr = average reference data = 539923 $KgCO_2eq$

Then, the value AME mean

$$AME = \left| \frac{Xs - Xr}{Xr} \right| 100\%$$

$$AME = \left| \frac{908596 - 539923}{539923} \right| 100\%$$

$$= 0.682825 \text{ or } 0.68$$

According to Soesilo (2020) stated that the tolerance limit error maximum possible accepted with the AME test is 10% (if the model is created in a scale model laboratory Where almost all variables can controlled) or 30% (if the model is created is scale accurate, where Lots variable No can We control)

Tahun ke	Simulasi Alkausar	Referensi Jabar
1	839721	341.919
2	757874	349.485
3	676026	378.050
4	594179	380.434
5	512331	376.988
6	430484	386.100
7	348636	402.989
8	266789	391.784
9	184941	405.653
10	103094	453.235
Rerata	471408	386663,7

Based on the table above

Average value simulation (Xs) = 471408 $KgCO_2eq$

Average value reference (Xr) = 386664 $KgCO_2eq$

AME value =

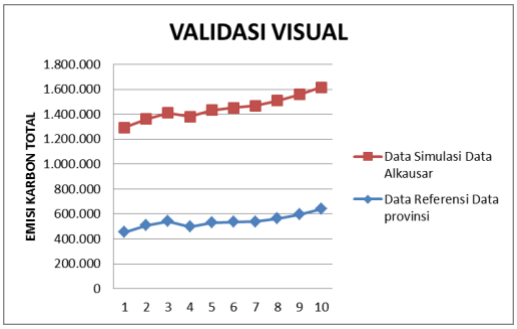
$$AME = \left| \frac{Xs - Xr}{Xr} \right| 100\%$$

$$AME = \left| \frac{471408 - 386664}{386664} \right| 100\%$$

= 0.219167148

Validation:

Data Referensi Data provinsi	Data Simulasi Data Alkausar
453.235	839.721
507.357	855.027
540.419	870.332
496.030	885.638
531.142	900.943
536.306	916.248
538.025	931.554
562.244	946.859
595.665	962.165
638.808	977.470



Model validation was carried out with count AME values and Visual Validation.

$$AME = \left| \frac{Xs - Xr}{Xr} \right| 100\%$$

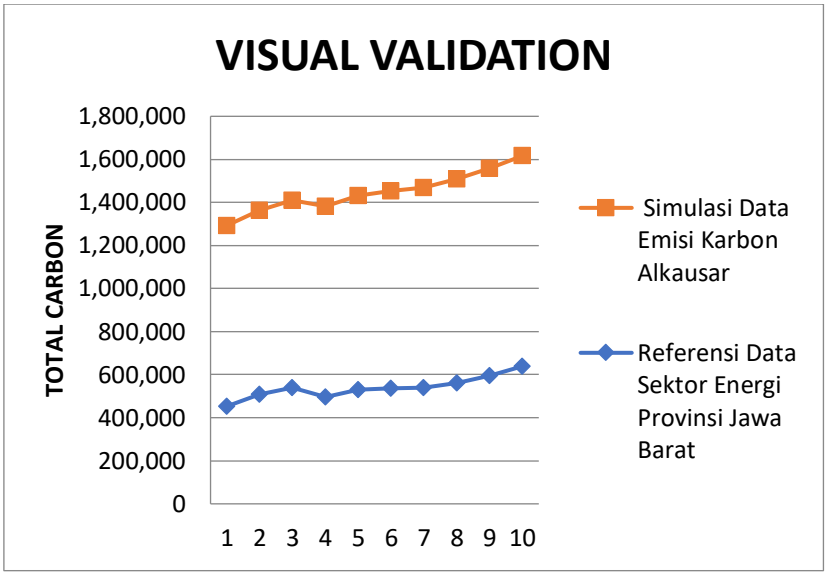
Validation of the Al Kausar Carbon Footprint Model

Validation: This is done by creating a chart from average reference data and an average of simulated data. Then, compare his tendencies from the collected time *series* data.

Year	Reference	Simulation

to	Energy Sector Data West Java province	Alkausar Carbon Emission Data
1	453,235	839,721
2	507,357	855.027
3	540,419	870,332
4	496,030	885,638
5	531.142	900,943
6	536,306	916.248
7	538,025	931,554
8	562,244	946,859
9	595,665	962.165
10	638,808	977,470

Source: Results of data compilation and calculations



In the chart, both data have similar pattern trends, so the simulation model is declared valid visually.

Validation Statistics with Average Value AME (Absolute Mean Error) AME (absolute mean error) is the average absolute difference between the actual value and the predicted value (forecast). The AME value is used to measure the accuracy of a statistical model in making predictions or forecasting.

Conclusion

From data collection, analysis trends and modeling carried out can conclude several matters as follows:

1. Carbon emissions resulting from learning activities at Al Kausar International Middle School are currently 839721.41 KgCO $_2$ eq, which is calculated from electricity consumption, gas consumption, paper consumption, vehicle pick-up and drop-off services, media access

services, healthy nutritious menu services (beef consumption), and also waste generation from various daily activities carried out during the learning process. TeakTeak gardens and various trees in the school environment can absorb carbon dioxide (CO2) as much as 592675.64 $KgCO_2$ per year.

2. Carbon emissions from current school community activities include media access, gas, electricity, beef consumption (195758.1 KgCo2eq), fossil fuel use from business trips, paper use, and waste generation from daily activities.
3. Carbon emissions from indirect emissions from school community activities include emissions from power plants, which is 36329.01 $KgCO_2$ eq.
4. The dynamic system approach-based model for reducing carbon emissions at Al Kausar Internat Middle School consists of scenario 1, scenario 2, scenario 3, scenario 4, scenario 5, and scenario 6. Each alternative model simulated will reduce carbon emissions with details in scenario I value Carbon emissions in 2050 will increase to 1.5 times the existing emission value, scenario II behavior **engineering** and lamp composition efficiency will reduce total carbon emissions to 2602.158 $KgCO_2$ eq, scenario III will reduce total carbon emissions to -7524,212 $KgCO_2$ eq, scenario IV will reduce total carbon emissions to -12967,412 $KgCO_2$ eq, scenario V will reduce total carbon emissions to -12967,412 $KgCO_2$ eq and scenario VI will reduce total carbon emissions to 252845.358 $KgCO_2$ eq.

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