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MORALITY BEFORE KNOWLEDGE

Potential reduction of CO_2 emissions which is the cause of greenhouse gasses during COVID-19

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ABSTRACT

Background: Greenhouse Gas Carbon Emissions produced in the implementation of education in tertiary institutions can be said to be quite high. Activities during the COVID-19 pandemic carried out by countries in the world have had many unexpected positive impacts by reducing CO_2 emissions by up to 70%. At the beginning of 2020, various countries in the world including Indonesia and Jakarta experienced the COVID-19 pandemic, which prompted the government to implement the Large-Scale Social Restrictions (PSBB) policy to suppress cases of the spread of COVID-19. The existence of the PSBB has an impact on various aspects of people's lives, including limitations on community activities and mobility using motorized vehicles. The purpose of this study was to determine the amount of CO_2 emissions during the PSBB policy period. **Methods**: The method and results given are a calculation method taken from several journals, and websites that are methods and models of emission reduction using expert opinion methods. One of them is the method used by the Intergovernmental Panel on Climate Change (IPCC), which is the most up-to-date method today. **Findings:** The decrease in CO_2 emissions during lockdown is caused by changes in people's activities outside the home, fuel consumption, and people's mobility using motorized vehicles. The COVID-19 pandemic, especially the implementation of lockdown, can be used as a momentum in increasing efforts and strategies to reduce the amount of CO_2 emissions from motorized vehicles, one of which is by implementing low-carbon development. **Conclusion**: As we know in 2019, there is a COVID-19 pandemic which is one of the factors for reducing carbon dioxide emissions. **Novelty/Originality of this Study:** This study provides a novel contribution by quantitatively assessing CO_2 emission reductions during the COVID-19 lockdown, emphasizing the unique context of an unprecedented global event. It conducts a comprehensive literature review to integrate various CO_2 calculation methods, particularly highlighting the sophisticated IPCC method, and offers a comparative analysis of emission reduction techniques.

KEYWORDS: greenhouse gas emissions; COVID-19 lockdown; low-carbon development.

1. Introduction

The World Meteorological Organisation (WMO) says that the world is at its warmest point in history towards the end of 2019. High concentrations of greenhouse gasses, a major contributor to global warming, are thought to be to blame. The atmospheric CO_2 content was measured at 405.6 ppm in 2017. The amount of CO_2 in the atmosphere continues to increase, which is followed by an increase in the earth's temperature and the development strategies need to follow the increasing temperature (Bosca and Maulana, 2024).

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Various theories and opinions on environmental damage suggest that the wasteful or inefficient use of energy is one of the main factors of environmental damage. All waste substances from any energy use will eventually become pollutants or substances that harm nature. Continuously, these substances cannot be synthesized by nature and will accumulate in the ozone layer, the accumulation of pollutants is then known as greenhouse gasses or GHGs. These greenhouse gas emissions gradually fill the earth's atmosphere and become the ozone crust that can keep heat out of the atmospheric layer, the accumulated heat will accumulate and increase the earth's temperature called global warming.

Indonesia has faced a strategic development challenge due to climate change. Global warming caused by greenhouse gas (GHG) emissions, including the use of carbon dioxide (CO_2) emissions, is the ultimate cause of climate change. Urban communities' basic need for living standards has an effect on how much CO_2 is produced in the atmosphere. However, research by (Sari and Sofwan, 2021) found that a high number of vehicles cannot be used resulting in emissions being high too. Still, the CO2 emission of vehicles depends on the fuel consumption of the vehicle itself. Agasalim, 2024 found there between energy consumption and GDP, an increase in per capita income reduces CO_2 emission, and there is a unidirectional causality running from CO_2 emissions to to an increase in per capita income. A result shows a 1% increase in energy consumption per capita, a 0.946% increase in CO_2 emission, and a 1% increase in gross domestic product per capita does not cause a 0.086% decrease in CO_2 emission (Agasalim, 2024). Based on Our World in Data, 2024, Indonesia's CO2 emission per capita is 2.65 tons with a GDP per capita of $12,802 in 2022.

The inter-correlation between COVID-19 incidence and environmental factors showed three findings. One is that the impact of individual environmental factors on the occurrence of COVID-19 is unknown and varies geographically. Two environmental factors interact to affect the occurrence of COVID-19. Second, the interplay of natural elements, in particular, can influence human movement and behaviors, SARS-CoV-2 survival, and COVID-19 transmission in both micro and macro-level ways. Third, the effects of COVID-19 on the environment can be attributed to lockdowns brought on by the virus, which improved air quality, changed the behavior of wildlife, and created socioeconomic despair (Han et al., 2023).

The lockdown policy in China reduced the CO_2, CH_4, and CO concentrations sharply during the lockdown period, and gradually increased again after the lockdown or in the recovery period (Liang et al., 2023). The CO_2, CH_4, and CO concentrations impacted meteorological variables related to the vertical stability and horizontal diffusion were used, including boundary layer height, lower tropospheric stability, and wind speed (Liang et al., 2023).

1.1 COVID-19 pandemic

It started in December 2019 in Wuhan, Hubei Province, China. The emergence of a new strain of COVID-19 known as Coronavirus Disease 2019 (COVID-19) has attracted worldwide attention (Hui et al., 2020). As a result, several countries adopted restrictive policies or access restrictions, which were also implemented in Indonesia. One of the consequences of the lockdown implemented by several countries is the reduction of global warming. However, according to a study by the Global Carbon Project, 36.4 billion metric tonnes of CO_2 will be produced globally in 2021 after a record 5.4% drop in 2020 (Global Carbon Project, 2021)). This implies that after the COVID-19 epidemic, countries will emit a significant amount of CO_2 thus affecting the earth's temperature which is an important change in the global climate.

Initially, the spread of COVID-19 from one person to another occurs either directly through coughing or coughing up clear saliva from an infected person or indirectly through contaminated surfaces. However, at certain temperatures and rooms, airborne transmission continues to increase its transmission pattern. This has forced governments to adopt regulations to maintain social and physical barriers to stop the spread of disease

(Rothan and Byrareddy, 2020). However, many people still do not take this lightly, causing everyone to stay at home and postpone or limit most daily activities.

Due to the lockdown, various human activities and daily movements have a positive impact on the ecosystem by causing auto-repair. If based on observation, there is a considerable saving or increase in efficiency, at least in terms of energy use. This is thought to improve air quality and reduce greenhouse gas emissions in the atmosphere (Rahim, 2021). In research by (Arndt et al., 2023) the effect of video consultation on CO_2 emission during the Covid-19 pandemic in an outpatient clinic of the Department of Orthopaedic and Traumatology Surgery at a German University Hospital showed the video consultation can be a very important part of the reduction of greenhouse gas emissions in the health care system. It also saves time for the doctor and patient and can form an essential part of individual patient care (Arndt et al., 2023).

Virtual visits replaced many in-person visits in CancerCare Manitoba at the beginning of the COVID-19 pandemic (Lambert et al., 2023), the percentage of virtual visits peaked and accounted for over 50% of all monthly visits. The frequency of virtual visits rose with age, peaked in men with urogenital cancer, and declined in people living in northern Manitoba. In Winnipeg, the average travel time each visit was 30 minutes, but in the Northern Region, it was 15 hours. The monthly travel distance saved was predicted to range from 420,000 to 750,000 km, and saved travel time was estimated at 5500 to 9600 hours. The estimated monthly CO_2 emissions avoided ranged from 87 to 155 metric tons (Lambert et al., 2023).

Significantly, the various daily human activities and mobility due to the lockdown have caused positive symptoms to the environment, namely auto repair. If based on observations, at least in terms of energy consumption, it has resulted in significant savings or efficiency. This is believed to contribute to improving air quality and reducing greenhouse gas emissions in the atmosphere (Rahim, 2021). The impact of high CO_2 levels on human health according to Jacobson et al, 2019 causes inflammation, reductions in higher-level cognitive abilities, bone demineralization, kidney calcification, oxidative stress, and endothelial dysfunction. The impact of high levels of CO_2 on the environment is that it can increase the earth's temperature and cause the greenhouse effect (Kabir et al., 2023). The increase in the earth's temperature is due to the increasing concentration of greenhouse gasses in the atmosphere, causing the earth to become hotter. The greenhouse effect is caused by CO_2 in the atmosphere. Therefore, it is necessary to take policy and technological measures in order to realize the goal of reducing the adverse effects of CO_2.

The research from (Peschel et al., 2021) found that a lung aeration score (LAS) describes the severity of lung in COVID-19 patients and correlates with CO2 retention in patients with acute respiratory distress syndrome (ARDS). These results were gathered through a cross-sectional examination, hence a long-term prospective investigation is required to verify the score's accuracy (Peschel et al., 2021). The CO_2 emission from human activities observed from the ship flow, especially of ferries, between two shores at the strait of Messina (Marino et al., 2023), an overall reduction of 13.2% in CO2eq yearly emission rates was observed, with a major reduction of 2784 tCO_{2eq} due to maritime traffic. Predicting the CO_2 emission using artificial intelligence shows good agreement with the IPCC model in predicting the past emissions, the current emissions due to COVID-19, and the emissions of the upcoming future (Meng and Noman, 2022).

The evaluation of the impact of COVID-19 on carbon footprint was done for two different projects (Papadogiannaki et al., 2023). In the first scenario, the projects are assumed to have been implemented before the pandemic, but in the second, the initiatives are assumed to have been conducted exclusively during the pandemic. Of the two projects that are currently being reviewed, one has a strong emphasis on innovation and involves business and academia working together. The other initiative comprises a greater number of partners from Greece and Italy and is more focused on policy-making. Dissemination is its top priority. The primary sources of carbon dioxide emissions linked to project activities include personnel travel, equipment, electricity use, materials consumption, project-hosted events, and project involvement in events. The projects in the first scenario

have CO_2 emissions that are more than 40% higher than those of the Base Case, according to the results, whereas in the second scenario, the use of teleworking, virtual engagement in events, and the digitization of administrative procedures result in a decrease in emissions by 20% or more (Papadogiannaki et al., 2023).

The global outbreak of COVID-19 has presented serious concerns to the environment, economics, energy, and human health worldwide. Stricter controls on the COVID-19 pandemic caused a major slowdown in economic activity, which in turn had an impact on the environment by lowering greenhouse gas (GHG) emissions and, more especially, atmospheric CO_2 levels. In an effort to assist scholars in evaluating the worldwide environmental and energy-related ramifications, the paper closes with a perceptive synopsis of the difficulties and prospects facing sustainable development aspirations (Kumar et al., 2022).

1.2 Greenhouse gas

The greenhouse effect is a condition in which the temperature of an object on the surface of the sky, such as planets and stars, increases drastically. This temperature increase is caused by changes in the composition and state of the atmosphere surrounding the celestial body (Phelia et al., 2021c). When sunlight hits the atmosphere and Earth's surface, about 70 percent of that energy remains on Earth, absorbed by soil, plants, oceans, and other objects. The remaining 30 percent is reflected back through clouds, rain, and other reflective surfaces. But that 70 percent of heat doesn't stay on Earth forever. Objects around the planet that absorb sunlight often re-radiate the heat they have absorbed Phelia and Sinia, 2021; Fitri et al., 2021d).

The sun as the center of the solar system has a great influence on the planets, including the earth. Solar energy has a great influence on life on earth. Sunlight entering the earth is partly deflected by the atmosphere and reflected back into space and partly reaches the earth's surface and is reflected into the atmosphere as a slow-moving type of energy called infrared radiation (Myori et al., 2019; Fachri et al., 2015; Nugrahanto et al., 2021). This infrared radiation produces heat and is absorbed by greenhouse gases such as water vapor, carbon dioxide, and methane which are then trapped in the atmosphere so that it continues to have an impact on increasing the temperature of the earth's surface (Putra et al., 2019; Julisman et al., 2017).

Decreasing human activities because of COVID-19 could decrease air pollution and greenhouse gases. The study of (Guevara et al., 2023) comparing a selection of such near-real-time emission estimates with the official inventories that were subsequently reported in 2022 under the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Long-Range Transboundary Air Pollution (CLRTAP), this study examines the impact of the COVID-19 pandemic on 2020 European (the 27 EU member states and the UK) emissions. The findings show that, for the majority of chemical species, the annual changes in total 2020 emissions indicated by official and near-real-time estimates are roughly in line. In every instance, NOx and fossil fuel CO_2 were reported as having undergone the greatest drop in Europe.

When comparing annual results at the sector and national levels, there are significant differences between the official and non-official datasets. This suggests that care should be taken when estimating changes in emissions using particular near-real-time activity datasets, like time mobility data obtained from smartphones. The industrial sector's NOx emissions (which vary between -21.4% and -5.4%) and the transportation sector's CO_2 emissions (which vary between -29.3% and -5.6%) in relation to overall European emissions are the primary instances of these disparities. Furthermore, notable disparities are noted between the quarterly and monthly distribution of emissions decreases provided by the several near-real-time inventories; for total NOx in April 2020, when limitations were at their highest, deviations of up to a factor of 1.5 were recorded (Guevara et al., 2023).

The results show that non-COVID-19 factors, such as weather, the Global Sulphur Cap's implementation, and the closure of coal-fired power plants as part of national decarbonization efforts, dominated changes in emissions that happened between 2019 and 2020 for residential combustion, shipping, and the public energy industry, respectively. The study's conclusions can be applied to gain a better understanding of the uncertainties associated with near-real-time emissions and the potential applications of such emissions in the future to deliver fast updates to emission datasets that are critical for modeling and monitoring applications (Guevara et al., 2023).

The relationship between individual air pollution and the COVID-19 pandemic is shown in Fig 1. From Fig 1, the orange and blue arrows show the relationship between individual air pollution and the COVID-19 pandemic. The orange arrow indicates increasing effects. The blue arrows indicate decreasing effects. Air pollutants surrounded by red dotted lines share a similar relationship with the COVID-19 pandemic. The colored ring indicates the study's focus. As the yellow color darkens, more studies are focused on the corresponding air pollutants (Han et al., 2023). Air pollution and COVID-19 infection are significantly correlated, which may help to explain some of the effects of the country's lockdown and have implications for the management and prevention of this unusual illness (Zhu et al., 2020). According to a short-term exposure research conducted in China, the frequency of COVID-19 confirmed cases rose with each 10 μg/m 3 increase in O_3 and CO concentrations (4.76%, 95% CI: 1.99-7.52%), conversely, verified cases decreased with each increment of 10 μg/m 3 in SO 2 concentration (7.79%, 95% CI: -14.57%–1.01%) (Zhu et al., 2020).

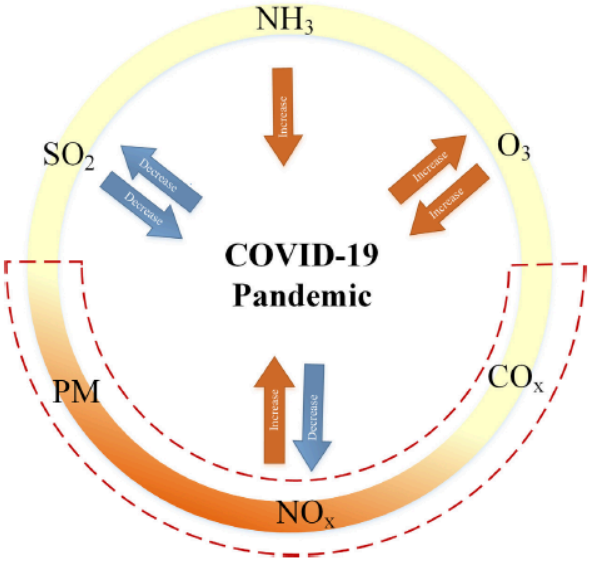

Fig. 1. The relationship between individual air pollution and the COVID-19 (Han et al., 2023)

Ozone and toluene levels have been found to have increased during the lockdown period based on laboratory study. Additionally, it has been determined that ozone, NH3, NO2, and PM10 are the pollutants that can affect COVID-19-related mortality rates. The lockdown caused by the new coronavirus has resulted in environmental rehabilitation. But since the concentration of ozone pollution has significantly increased and because it affects the COVID-19 death rate, action must be taken to limit it (Sethi and Mittal, 2022).

1.3 Global warming

Global warming is a natural phenomenon that is still a hot topic of discussion in the world (Phelia et al., 2021a; Safuan, 2014; Fitri et al., 2020). There are various activities

that can cause a global warming process, including industrial activities, motor vehicle exhaust gasses, electricity production activities and forest fires that are global warming, which results in many changes on earth and proves that there are too many emission gasses or exhaust gasses in the air so that the hot air contained in it has difficulty reflecting into outer space (Adma et al., 2020; Phelia et al., 2021b). The presence of too much atmospheric greenhouse effect can cause global warming. Globally, Indonesia ranks sixth in gas emitters or exhaust emissions at around 4.47%. The greenhouse effect is a condition in which the temperature of space objects (planets, stars and the moon) increases dramatically (Fitri et al., 2021a; Fitri et al., 2021b). This temperature increase is caused by changes in atmospheric conditions when circling celestial bodies (Shi et al., 2021; Fitri et al., 2021c).

Global warming is a mechanism for the release of carbon dioxide into the earth's atmosphere. This release process results in the trapping of these gasses in the earth's atmosphere and radiates energy in all directions, some of this radiation towards the earth's surface to produce heat. The consequences of this warming can be in the form of extreme weather changes, 350 various kinds of natural disasters, and ultimately can damage ecosystems and threaten the survival of living things on earth. The trend of increasing Earth's average surface temperature between 1880 and 2020 can be seen in Figure 2.

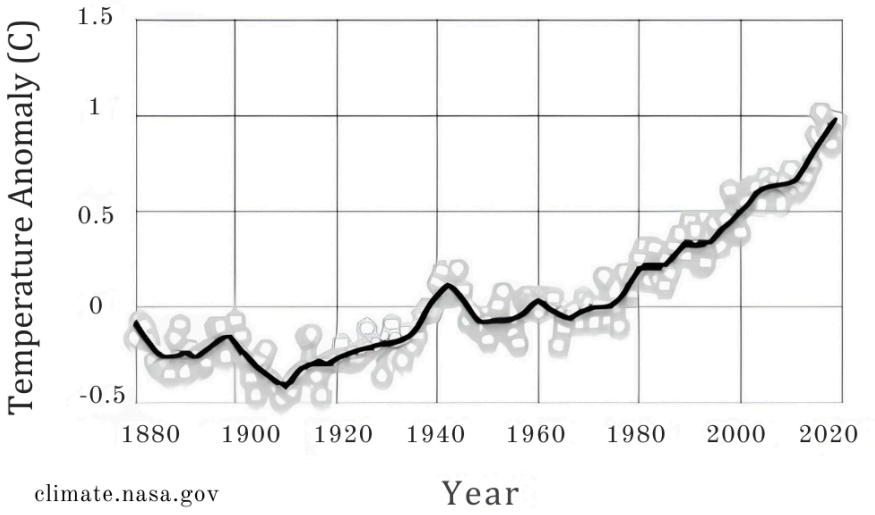

Fig. 2. Trends in the increase of the average temperature of the Earth's Surface (1880-2020)

Earth's average surface temperature has increased by 1.62 degrees Fahrenheit (0.9 degrees Celsius) since the end of the nineteenth century. This change is largely due to increased levels of carbon dioxide and other greenhouse gasses in the atmosphere. There are many indications of this warming, including rising ocean temperatures. The ocean absorbs most of the heat generated by global warming. This is shown by the data that the ocean has experienced a temperature increase of more than 0.4 Fahrenheit at depths up to 700 metres since 1969. In addition, another clear indication of the global warming process is the melting of ice at both poles of the earth. The ice in Greenland and Antarctica has decreased in mass over time. Data from NASA's Gravity Recovery and Climate Experiment show that Greenland lost an average of 286 billion tonnes per year between 1993 and 2016, while Antarctica lost 127 billion tonnes per year during the same period. In the last decade, Antarctica has experienced three times the ice melt (National Aeronautics and Space Administration, 2020). Global warming is a result of high CO_2 emissions from multiple sources, including transportation and industry (Kurniarahma et al., 2020). The largest factor in the decrease in carbon dioxide emissions worldwide is the transportation sector.

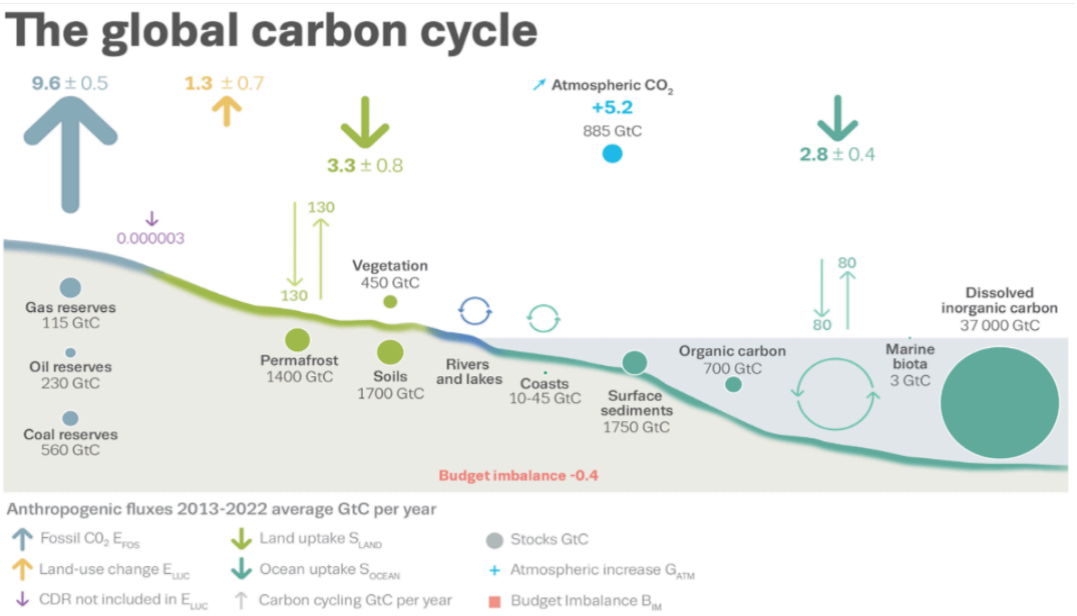

Fig. 3. The human and natural sources and sinks of CO_2, updated to 2020 (Global Carbon Project, 2021)

Since the industrial revolution, CO_2 levels have risen from 280 to 379 parts per million (ppm), according to data from the industrial sector from the Environment Agency (DLH) (DLH, 2019). According to Safitri (2022) homes account for 10% of CO_2 emissions, followed by the industrial sector (25%), the transportation sector (which contributes 60% of them), and the garbage sector (which contributes 5%). Certain measures have been proposed, such as establishing electricity consumption standards for infrastructure construction projects to reduce electricity consumption caused by the fixed capital formation and attaching energy efficiency labels and carbon footprint labels to metal products (such as iron and steel, aluminum, and fabricated metal products), large quantities of which are used for fixed capital formation. These lessons from the 2008 financial crisis can help achieve a low-carbon recovery following the COVID-19 crisis (Zhang et al., 2023). The effect of high CO_2 levels on human health results in respiratory acidosis, in which excessive blood acidity is brought on by a buildup of carbon dioxide in the blood such that the body is deficient in oxygen. High CO_2 levels have an adverse influence on the environment because they can raise the temperature of the planet and result in the greenhouse effect (Faradilla et al., 2016). The concentration of greenhouse gasses in the atmosphere has increased, making the planet warmer and contributing to the rise in global temperatures. CO_2 in the atmosphere is the primary cause of the greenhouse effect. Therefore, in order to achieve the objective of minimizing the negative impacts of CO_2, legislative and technical activities are required.

2. Methods

This paper aims to better understand the why and how of CO_2 reduction calculations and also to find out CO_2 calculations from various studies. This literature review uses a literature study method taken from journals, books, and websites. Literature research is a type of research where the researcher collects a number of books and magazines that are relevant to the problem and learning objectives. This method is used with the aim of uncovering many theories related to the problem being investigated or the difficulties encountered as reference material in the discussion of research results. Looking for theoretical references that are relevant to the case or problem found is another definition of literature study.

This literature review uses research methods that are sourced from various literary works of literature studies to answer the research results. This research uses sources from

several previous sources such as studies with written materials or literature studies that can answer. The purpose of this literature study is to analyze the emission reduction methods and models used by using expert opinion methods.

3. Results and Discussion

Isnaeni (2001) successfully calculated CO_2 reductions with various scenarios in the transport sector as done at the Asian Institute of Technology (2004). Prayudyanto (2009) similarly used the Necten model, but did not calculate CO_2 emission reductions and only calculated air pollutant emissions. From these three studies, several methods of calculating CO_2 emissions and other air pollutants were obtained. Power generation and related CO2 emissions have decreased and then increased in major nations since the COVID-19 epidemic broke out (Zhang et al., 2023).

This emission calculation method was actually started by Papacostas and Prevedourous (1993). Table 1 provides an explanation of several calculation methods for air pollutants and CO_2. It can be said that the method used by the Intergovernmental Panel on Climate Change (IPCC) is the most up-to-date method at present. The IPCC method uses various classifications of data, including fuel consumption data, vehicle technology type, and supporting data, such as fuel consumption, vehicle technology type, and vehicle kilometers traveled.

Table 1. Review of air pollutant and CO_2 emission calculation methods from various studies

No.	CO_2 calculation method	Study
1.	Papacostas and Prevedourous, 1993	Emission factors can be influenced by speed, but the energy consumption factor, determined by the type of technology and the average travel distance, is the most crucial factor in determining CO_2 emissions in the air.
2.	Van Vliet, 1994	
3.	BAPPEDAL and PPE-ITB, 1995	Determining emission factors for various types of vehicles, but not for CO_2 emissions
4.	PPE-ITB, 1991	
5.	PPE-ITB, 1995	
6.	IPCC, 1996	Determination of CO_2 emission factors considering Vehicle Kilometers Traveled (VKT), accounting for vehicle technology type and average travel distance
7.	Netcen, 2003	Calculation of various vehicle technologies, such as EURO I, EURO II, and EURO III, using speed without including average travel distance in the calculation
8.	IPCC, 2006	This is a development from the 1996 IPCC guidelines, where several methods (TIER 1, 2, and 3) are used for calculating CO_2 emissions. TIER 3 is the most advanced method, considering VKT (vehicle technology type and average travel distance). For the transportation sector, this method has not yet been tested for calculating greenhouse gas emissions.

(Dharmowijoyo and Tamin, 2010)

In the top ten most polluting economies (China, USA, India, Russia, Germany, Japan, Iran, South Korea, Indonesia, and Saudi Arabia), the study examines the asymmetric effects of pandemic uncertainty on CO_2 emissions. A novel method known as "Quantile-on-Quantile (QQ)" is used using panel data spanning the years 1996 to 2018 (Chang et al., 2022). The results indicate how the pandemic uncertainty quantiles affect the quantiles of carbon emissions asymmetrically by offering a useful paradigm for understanding the framework of overall dependency. Reducing CO_2 emissions in our environment, and pandemic uncertainty improves environmental quality in sample nations at different quantiles. Japan, however, has contradictory results (Chang et al., 2022).

The work uses high-resolution measurements of near-surface CO_2, CH_4, and CO concentrations above the background conditions at Lin'an station (LAN), a regional background station in the Yangtze River Delta region, to analyze the temporal variation of greenhouse gas concentrations in China during the COVID-19 lockdown (Liang et al., 2023). In comparison to the 2011–2019 climatological mean, both CO_2 and CH_4 showed a notable growth trend during the pre-lockdown observational period, over the lockdown observing period, which also fell over the Chinese New Year Holiday, there was a fall of CO_2, CH_4, and CO that reached as high as 15.0 ppm, 14.2 ppb, and 146.8 ppb, respectively. The reduction of CO_2/CO was likely caused by a sharp decline in pollution from industry. During the post-lockdown easing phase, it was noted that CO_2, CH_4, and CO continued to decline. This is the artificial outcome of lower-than-usual CO_2 emissions from rural areas surrounding LAN combined with robust uptake of the terrestrial environment. CO_2 decreased dramatically on average over the second period, whereas it increased progressively over the fourth period. The results demonstrate how important emission reduction is in explaining the sharp variations in observed levels of CO_2 and CH_4 in the atmosphere related to the COVID-19 shutdown and recovery (Liang et al., 2023).

Selecting the best strategies for lowering CO_2 emissions requires accurate CO_2 emission projections. The models used to predict the impact of COVID-19 on CO_2 emissions worldwide from 2022 to 2027 in the near future, 2022 to 2054 in the future, and 2022 to 2072 in the long future (Meng and Noman, 2022). The mean absolute percentage error, or MAPE, is selected for accuracy comparison among the several error measurements. The four SARIMAX models produce varying accuracy results from the calculation. The four techniques have the following MAPEs: post-COV (MAPE: 0.09), trans-COV (MAPE: 0.19), start-COV (MAPE: 0.28), and pre-COV (MAPE: 0.32). For post-COV, the MAPE value is comparatively low (MAPE: 0.09). Therefore, it may be concluded that post-COV models are appropriate for predicting future global total CO2 emissions. For the years 2022 to 2027, the post-COV estimates for the total worldwide CO2 emissions are as follows: 36,218.59, 36,733.69, 37,238.29, 37,260.88, 37,674.01, and 37,921.47 million tons (MT) (Meng and Noman, 2022).

Many strategies created by the government to response the reducing of CO_2 emissions during COVID-19, in research of (Abbasi and Erdebilli, 2023), examines three of the most prevalent forms of standard CO_2 restrictions, which are carbon tax, carbon cap-and-trade, and strict carbon caps. The models that have been suggested optimize both costs and emissions. The models show the tensions that arise between competing priorities when it comes to supply chain (SC) activities, such as location selection, the numerous options for shipments, and fees and releases. The models also show the impact that different policies have on costs in addition to their efficiency in reducing emissions. Managers can forecast how regulatory changes may affect overall emissions from SC operations by analyzing the model results (Abbasi and Erdebilli, 2023).

COVID-19 will not be eradicated very soon because it is still widespread in many nations worldwide. Despite considerable spatial variation and ambiguity, the COVID-19 pandemic, the natural world, and human surroundings are all intricately linked. The COVID-19 epidemic provides important information about climate change worldwide. Globally, the pandemic shutdowns, even for brief periods of time, typically resulted in a significant drop in greenhouse gas emissions, highlighting the importance of cutting back on the usage of fossil fuels and industrial emissions (Kumar et al., 2022). Furthermore, the dynamics of COVID-19 transmission can be better explained by the interactions of environmental elements. Due to its influence on human mobility and behavior, the natural environment can have an impact on both individual survival and the survival of SARS-CoV-2 in the environment (Marino et al., 2023).

Further research is also needed to fully understand the effects of climate change-related disasters, identify safe thresholds for major air pollutants at a more precise spatial scale, and identify additional potential sources (such as wastewater) that could exacerbate the COVID-19 pandemic. Furthermore, increased awareness is required regarding the effects of COVID-19-induced changes, such as atmospheric events and the

spread of zoonoses brought on by wildlife. Furthermore, we propose that public policy responses and the preservation of a sustainable ecosystem should be the key priorities of future adaptation measures.

4. Conclusions

Based on the discussion above, it can be concluded that there are positive and negative impacts arising from the COVID-19 pandemic. Overall, there is a decrease in CO_2 emissions during lockdown. The decrease in CO_2 emissions during lockdown is caused by changes in people's activities outside the home, fuel consumption, and community mobility using motorized vehicles. The COVID-19 pandemic, especially the implementation of lockdown, can be used as a momentum in increasing efforts and strategies to reduce the amount of CO_2 emissions from motorized vehicles, one of which is by implementing low-carbon development. The impact of COVID-19 is shown in natural, and meteorological factors, human behavior, and human activities on different scales. The lockdown policy to decrease the COVID-19 impact gives several impacts in doing human activities.

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Author Contribution
Conceptualization, Y.I.M., A.K.; Methodology, Y.I.M., A.K.; Software, Y.I.M., A.K.; Validation, Y.I.M., A.K.; Formal Analysis, Y.I.M., A.K.; Investigation, Y.I.M., A.K.; Resources, Y.I.M., A.K.; Data Curation, Y.I.M., A.K.; Writing – Original Draft Preparation, Y.I.M., A.K.; Writing – Review & Editing, Y.I.M., A.K.; Visualization, Y.I.M., A.K.; Supervision, Y.I.M., A.K.; Project Administration, Y.I.M., A.K.; and Funding Acquisition, Y.I.M., A.K.

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Data Availability Statement
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