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BIBLIOMETRIC ANALYSIS OF RENEWABLE ENERGY USE IN LOW CARBON DEVELOPMENT

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Abstract:
Greenhouse gases are gases trapped in the earth's atmosphere that cause the earth's surface temperature to become hot, when during the day the sun emits rays that can penetrate the earth's atmosphere and warm the earth while at night the earth's surface becomes cold and can release the earth's heat back into the air, with the presence of these gases so that they can reflect the earth's heat to the earth again because that is called greenhouse gases. Greenhouse gases that occur due to excessive human activity release several greenhouse gases into the Earth's atmosphere. Greenhouse gases are caused by excessive human activity that releases several greenhouse gases into the earth's atmosphere. Greenhouse gases increased in 2020 due to factors such as the burning of coal, oil and natural gas produced from Indonesia's industrial energy sector. Then, there was a decrease in gas emissions due to COVID-19 in the use of fuel in the transportation sector, but in 2021, there was an increase caused by the energy sector and industrial activities. This analysis focuses on government efforts to reduce greenhouse gases. In this analysis, bibliometric analysis is a method used to analyze trends and developments regarding research on greenhouse gases. The results of this analysis refer to the government's actual steps in using renewable energy, such as solar energy and geothermal energy, to reduce the effects of greenhouse gases.

Keywords: Low Carbon Development, Greenhouse Gases, Renewable Energy

INTRODUCTION

Indonesia is an archipelago that often experiences climate change. According to the Environmental Protection Agency, climate change is a drastic temperature change, changes in rainfall, wind patterns, and so on. Climate change is also a Sustainable Development Goal (SDG) in Indonesia. This climate change is the impact of greenhouse gas emissions that continue to increase so that greenhouse gases are trapped in the earth's atmosphere, resulting in global warming and prolonged climate change. Greenhouse gases trapped in the earth's atmosphere are gases produced by human activities, both natural and artificial activities (Pristiandaru, 2023).

Greenhouse gases are gases trapped in the Earth's atmosphere, causing the Earth's surface temperature to heat up. During the day, sunlight penetrates the Earth's atmosphere and warms the Earth, while at night, the Earth's surface cools and releases the Earth's heat back into the air. However, greenhouse gases trap some of the earth's heat in the atmosphere, causing the earth's temperature to rise. These gases reflect the earth's heat to the earth again, which is why they are called greenhouse gases. These greenhouse gases arise from excessive human activity, releasing several greenhouse gases into the earth's atmosphere (Grid, 2023).

Greenhouse gases arise due to human activity. Carbon dioxide (CO2) is a gas consisting of carbon and oxygen produced by burning fossil fuels, such as new coal, oil, and natural gas, so carbon dioxide is the most influential gas in global warming. Methane (CH4) is formed from carbon and

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water produced by agricultural waste and livestock that smells bad, so this methane gas is the second gas that causes global warming. Chlorofluorocarbons (CFCs) are gases produced by refrigerators, air conditioners, and other cooling devices. Water vapor (H2O, carbon dioxide (CO2), methane (CH4), ozone (O3), nitrous oxide (N2O), and chlorofluorocarbons (CFCs) are greenhouse gases (Nailufar, 2019)

According to Climate Watch data (Ahdiat, 2023), in 2020, Indonesia became the world's 6th most significant greenhouse gas emitter after China, the United States, India, the European Union and Russia. In 2020, 44% of Indonesia's greenhouse gas emissions came from the energy sector, 34% from the forestry sector, 10% from agriculture, 9.4% from waste, and 2.3% from the industrial sector. Increasing greenhouse gases in Indonesia are produced by the energy sector, namely the burning of new coal, oil, and natural gas, which is the heart of the industry in Indonesia. In 2020, during the COVID-19 situation, there was a decrease in gas emissions due to reduced fuel use in the transportation sector. However, from 2021 until now, greenhouse gas emissions have increased due to the energy sector and industrial activities running again.

The increase of greenhouse gases in Indonesia requires mitigation, which aims to reduce greenhouse gas emissions. Global warming due to greenhouse gases cannot be eliminated, but greenhouse gases can be reduced. With the development of science and technology, this problem can be handled by reducing greenhouse gases. The commitment issued by the Indonesian government to realize the reduction of greenhouse gas emissions has been issued by Presidential Regulation (Perpres) No. 16 of 2021 concerning the National Action Plan for Reducing Greenhouse Gas Emissions (Wahyudi, 2018).

This paper will examine the solutions taken by the Indonesian government to deal with greenhouse gases in Indonesia. Many previous studies have examined the impacts and causes of greenhouse gases in Indonesia, especially in industrialized cities. However, there needs to be more mention of solutions by the local government or communities to reduce greenhouse gases. Government and community cooperation is necessary because it requires the awareness of the government and the local community. With the analysis conducted by the government to handle greenhouse gases in Indonesia, it is necessary to take advantage of the opportunities that exist and overcome the handling of greenhouse gases in Indonesia.

Definition of Greenhouse Gas. Air pollution, commonly called pollution, is a phenomenon of environmental energy deviation that can harm the environment and impact humans and the surrounding nature (Amheka et al., 2022). Pollution can come from natural sources or excessive human activities, and its impact can harm environmental health and the overall ecosystem (Fan & Li, 2022). Human activities due to increased urbanization in a country can affect urban density, which causes CO2 to increase (Nihayah et al., 2022). According to (Raihan et al., 2022), from the date of the phenomenon that occurred in the acceleration of economic growth in 2015, Indonesia became the largest producer of greenhouse gas emissions, which resulted from the burning of fossil fuels and deforestation of these causes of greenhouse gases.

The increase in greenhouse gases is caused by industrial activities carried out by humans, such as the construction of power plants and industrial plants in Indonesia (Purwanti, 2018). Greenhouse gases consist of carbon dioxide (CO2), hydrofluorocarbons (HFCs), nitrous oxide (N2O), perfluorocarbons (PFCs), methane (CH4), and sulfur hexafluoride (SF6) resulting from the activities of power plants and industrial plants (Iswara et al., 2022). The amount of gas produced from PLTU activities and industrial plants requires efforts to reduce greenhouse gases because efforts to reduce greenhouse gases are one way to support Sustainable Development Goal (SDG) number 13, namely handling climate change (Noviarini et al., 2022).

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Greenhouse Gas Reduction. Following Sustainable Development Goal (SDG) number 13, handling climate change must begin with reducing greenhouse gases. Greenhouse gases caused by human activities are so diverse that policies are needed to reduce greenhouse gas production. The most significant greenhouse gas is produced by human activity, namely fossil combustion, so it is necessary to have renewable energy or waste management from the company to reduce the increase in greenhouse gases (Siagian et al., 2017). The transition to a low-carbon economy is significant because it can reduce greenhouse gases and use more renewable energy resources than energy resources (Setiawan et al., 2021).

Under the United Nations Framework Convention on Climate Change, countries must report on the strategies to address the extreme climate change caused by increasing greenhouse gases that lead to increased global warming. The policy objectives of the UN need to be implemented in every sector at the national and local levels (Bakker et al., 2019). To reduce greenhouse gases or create low carbon, it must start from the agriculture, forestry and other land use sectors by implementing forest protection, reforestation and plantation efforts. On the other hand, it needs to be balanced from the industrial sector by using renewable energy to reduce the gas produced (Hasegawa et al., 2016).

METHODS

Bibliometric analysis can be interpreted as the primary method for exploring and analyzing the amount of scientific data available. The purpose of bibliometric analysis in a study is to see and find out the developments that have been carried out related to the coordination study of a program using the VOSviewer application (Herawati et al., 2022). Research using bibliometric analysis only focuses on quantitative assessments, namely, using publishers, publications, citations, contributors, and keywords related to one another. In this bibliometric analysis, this research usually describes current research trends or current topics (Tamala et al., 2022).

Publication data was taken from Scopus in the last ten years, from 2012 to 2022. These journals were downloaded through RIS and analyzed using VOSviewer, which will then be analyzed using bibliometric analysis. Journals discussing Low Carbon have five essential keywords related to Low Carbon: carbon, deforestation, emission, greenhouse gas emission, and low carbon development. The search for journals that discuss low carbon using important keywords produced 233 journal publications that can be used to conduct writing sourced from Scopuss. These were analyzed using VOSviewer and then analyzed using bibliometric quantitative research analysis.

In VOSviewer, which describes something in the image, namely the bibliometric map, the sharing of article data from the database is carried out (Hamidah et al., 2020). VOSviewers are used to make publication maps, country maps, or journal maps based on networks and also to build keyword maps based on a network connected to another, which will later become a single unit. In bibliometric maps, the frequency of keywords is used as the most relevant when the less relevant keywords are removed. The larger circle of items shows that the keywords appear more, but the circle's color shows the difference depending on the item's weight. The circle line and thickness are related to keywords (Nandiyanto & Husaeni, 2021).

The data in the review article was obtained through the following search strategy (REF("Low Carbon") AND REF("Indonesia")) AND PUBYEAR>2011 AND PUBYEAR<2023 AND(LIMIT-TO(OA, "all"))AND(LIMIT-TO(SRCTYPE, "j"))2023 AND(LIMIT-TO(OA, "all"))AND(LIMIT-TO(SRCTYPE, "j"))AND(LIMIT TO(AFFILCOUNTRY, "Indonesia") OR LIMIT-TO(AFFILCOUNTRY, "United Kingdom")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (EXACTKEYWORD, "Indonesia") OR LIMIT-TO (EXACTKEYWORD, "Climate Change") OR LIMIT-TO (EXACTKEYWORD, "Carbon Emission") OR

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LIMIT-TO (EXACTKEYWORD, "Sustainable Development") OR LIMIT-TO (EXACTKEYWORD, "Renewable Energy") OR LIMIT-TO (EXACTKEYWORD, "Emission Control") OR LIMIT-TO (EXACTKEYWORD, "Sustainability") OR LIMIT-TO (EXACTKEYWORD, "Energy Policy")). The following research strategy serves to identify relevant articles when writing review articles.

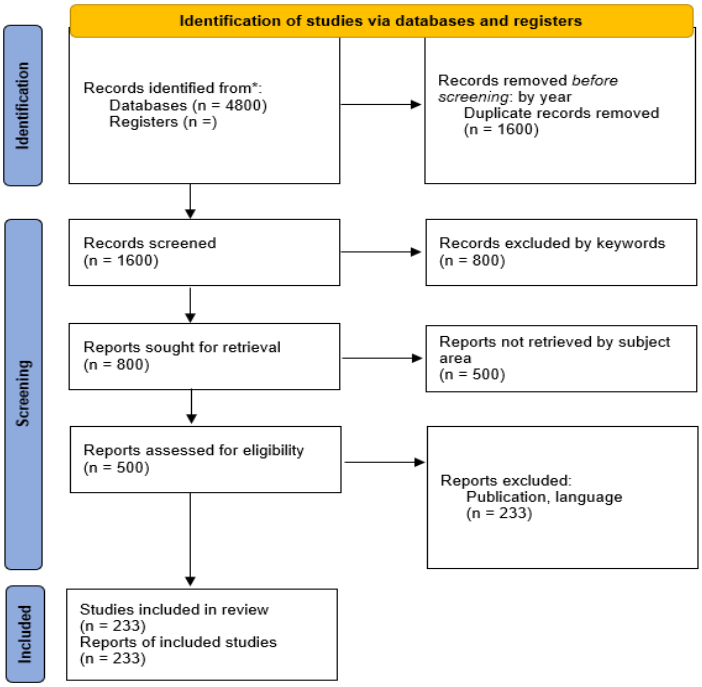

Figure 1.

RESULT AND DISCUSSION

Data Analysis. In the search, 233 journal publications were sourced from Scopus, which produced diverse data from 2012 to 2022. The many journals that the authors have published have different points of view or content, so this research is used to analyze and divide the data obtained starting from the journal year, journal source, author, affiliation, country that issued the most journals, document type, field, field, and research funding sponsor.

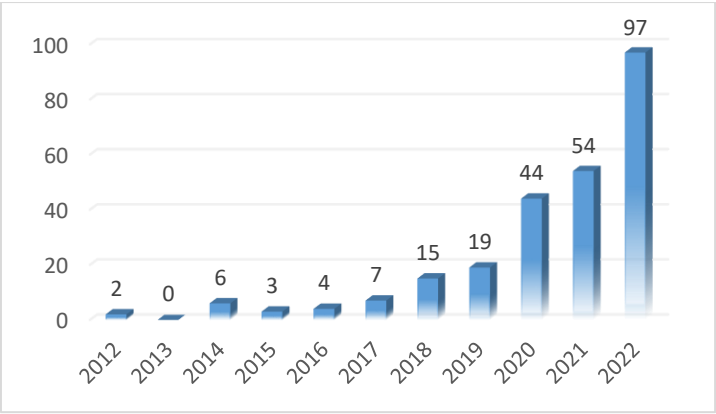

Figure 2. Analyze by Year

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Figure 2 above shows a bar chart showing the last ten years of journal publications discussing Low Carbon. 2012, there were two journal publications; in 2013, there were no journal publications. In 2014, there were six journal publications; in 2015, there were three journal publications; in 2016, there were four journal publications; in 2017, there were seven journal publications; in 2018, there were 15 journal publications; in 2019, there were 19 journal publications, in 2020 there were 44 journal publications, in 2021 there were 54 journal publications, and in 2022 there were 97 journal publications. From 2018 to 2022, journal publications that discuss low carbon levels have been increasing. Due to the increasingly alarming climate change, many researchers are researching this problem to find a solution.

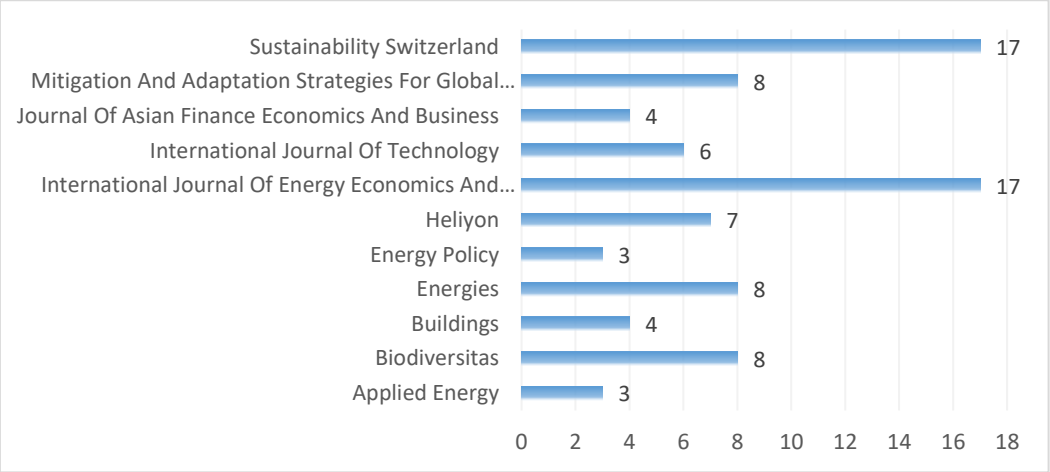

Figure 3. Analyze by Source

Figure 3 shows the ten highest publication sources in documents discussing Low Carbon. Sustainability Switzerland and International Documents of Energy Economics and Policy published the highest number of documents discussing Low Carbon with 17 journals. Then, Mitigation and Adaptation Strategies for Global Change, Buildings, and Biodiversity published 8 journals discussing Low Carbon. Heliyon published 7 documents, and the International Journal of Technology also published 6 documents. Journal of Asian Finance Economics and Business and Buildings published 4 documents. Energy Policy and Applied Energy published 3 documents.

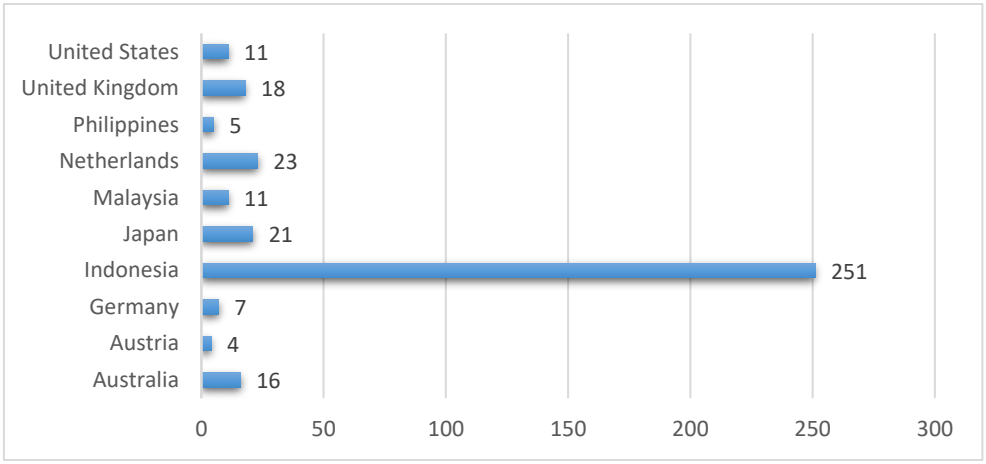

Figure 4. Analyze by Country/ Territory

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Bar chart 4 above shows the countries that published the most journals in this Pollution research. Indonesia published 233 documents on Low Carbon, followed by the Netherlands with 23 journals, Japan with 21 journals, the United Kingdom with 18 journals, Australia with 16 journals, the United States and Malaysia with 11 journals, Germany with seven journals, the Philippines with five journals, and Austria with four journals. Many countries are starting to research Low Carbon.

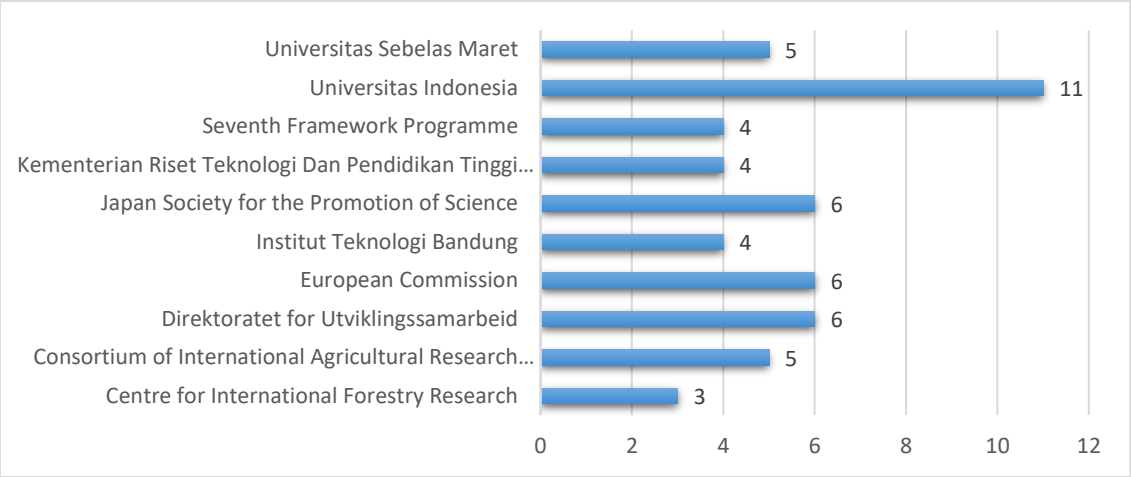

Figure 5. Analyze by Funding Sponsor

In Figure 5, the bar chart shows the ten most influential funding sponsors in the publication of the documents. The University of Indonesia is the most influential institution in funding low-carbon research with 11 documents, followed by the Japan Society for the Promotion of Science, the European Commission, and the Directorate for Utvilkingsamarbeid with 6 documents. Sebelas Maret University and the Consortium of International Agricultural Research published 5 documents. Seventh Framework Programme, Ministry of Research Technology and Higher Education, Bandung Institute of Technology published 4 documents. Center for International Forestry Research published 3 documents that discuss Low Carbon.

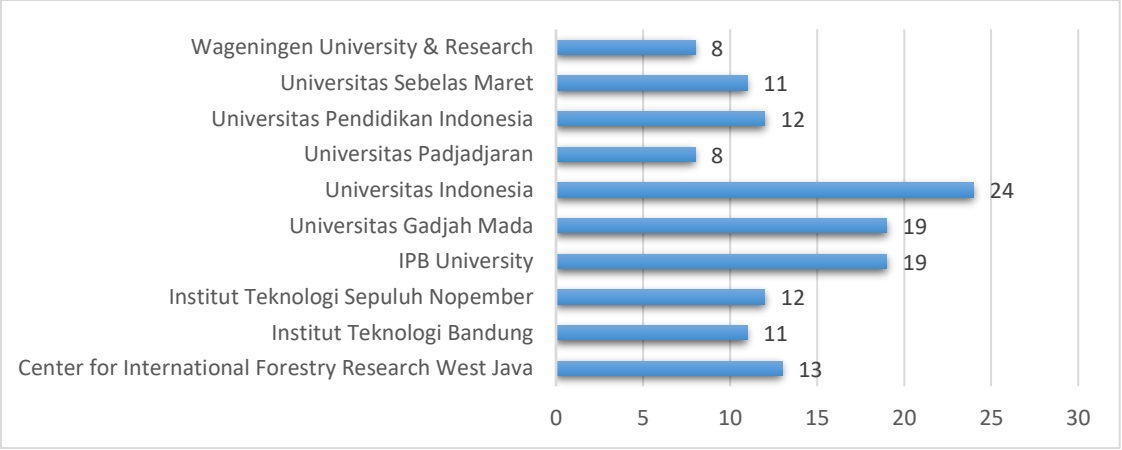

Figure 6. Analyze by Affiliation

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Figure 6 shows the analysis of journals by institution that contributed the most to the publication of low-carbon documents in Indonesia. The University of Indonesia contributed the most to the publication of 24 documents, while Gadjah Mada University and IPB University were the institutions that published the most documents, with 19 documents. The Center for International Forestry Research West Java issued 13 documents. Universitas Pendidikan Indonesia and Institut Teknologi Sepuluh Nopember also contributed 12 documents. Sebelas Maret University and Bandung Institute of Technology contributed with 11 documents. Padjajaran University and Wageningen University and Research each contributed 8 documents.

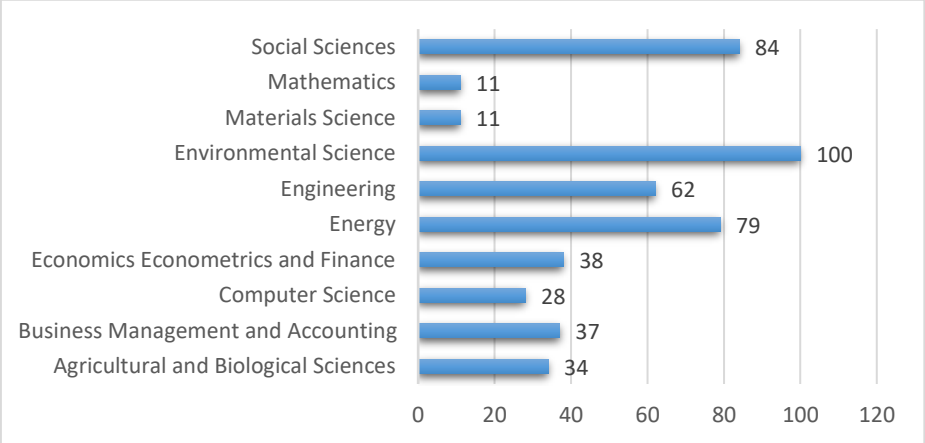

Figure 7. Analyze by Subject Area

Figure 7 shows the subject areas that discuss Low Carbon. The most influential subject in the research is Environmental Science, which has 100 publication documents. The subject of Social Sciences is also influential regarding Low Carbon with 84 documents. Energy is a subject area with 79 documents that appear. Engineering is a subject area with 62 documents found, Economics Econometrics and Finance 38 documents are keywords, Business Management and Accounting is also a subject area with 37 documents, Agricultural and Biological Sciences is also a subject area found 34 documents, Computer Science there are 28 documents, Mathematics and Materials Science there are 11 documents found.

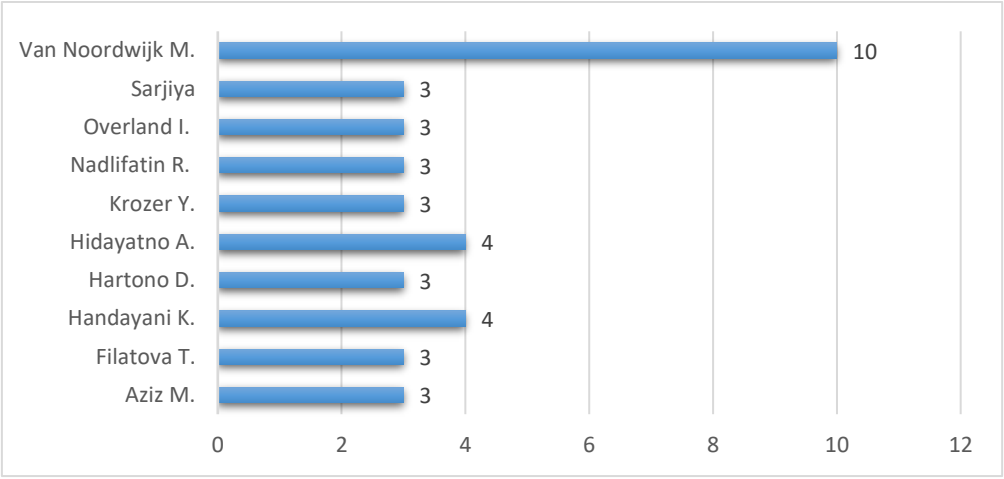

Figure 8. Analyze by Author

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Figure 8 shows authors who published research documents on Low Carbon; for example, Van Noordwijk M. wrote ten documents on Low Carbon (Khasanah & van Noordwijk, 2019), Hidayanto A., and Handayani K. wrote research on low carbon as many as four documents (B. D. Handayani et al., 2022). Sarjiya, Overland I., Nadilafatin R., Krozer Y., Hartono D., Filatova T., and Aziz M. also wrote research on Low Carbon, which contributed 3 documents discussing Low Carbon. The more researchers who discuss Low Carbon, it can be concluded that the air on earth is experiencing severe air pollution.

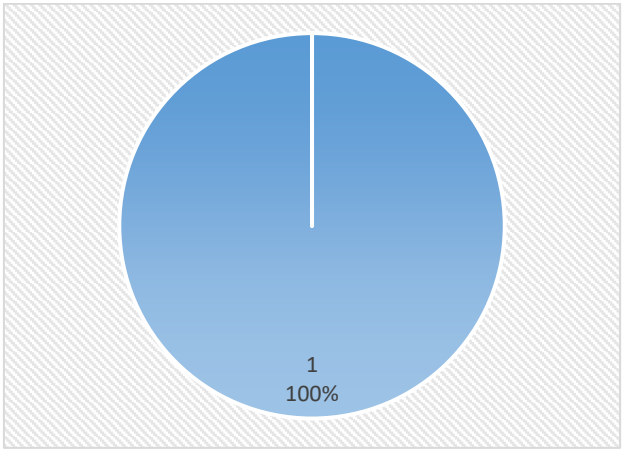

Figure 9. Analyze by Doc Type

Figure 9 shows that the authors used journal types to publish research on the low-carbon theme in Indonesia.

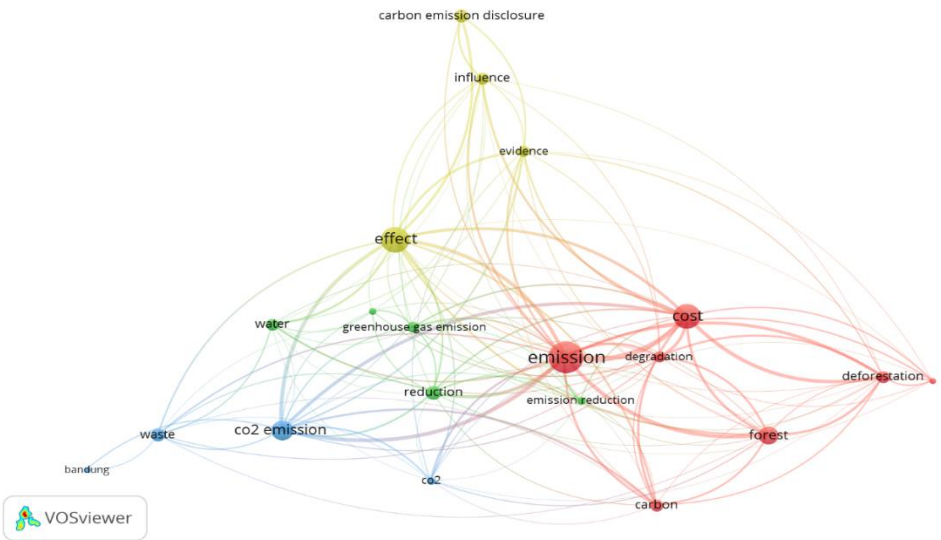

Figure 10. Mapping Visualization Networking, Visualization Overlay, and Visualization Density

The Vosviewer data results show the groups' colors in the picture. Cluster 1 in red is carbon, cost, deforestation, emission, forest, and forest degradation. Cluster 2 is green: emission reduction, greenhouse gas emission, low carbon development, reduction, and water. Cluster 3 in blue is

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Bandung, CO2, CO2 emission, and waste. Cluster 4 is yellow, which consists of carbon emission discourse, effect, evidence, and influence.

Table 1. Cluster, Item, Percentage

Cluster	Item	Percentage
Cluster 1	Carbon, cost, deforestation, emission, forest, forest degradation	6
Cluster 2	Emission reduction, greenhouse gas emission, low carbon development, reduction, water	5
Cluster 3	Bandung, CO2, CO2 emission, waste	4
Cluster 4	Carbon emission discourse, effect, evidence, influence	4

It can be seen from the type of color indicating the group, while the cluster table can show the keywords that often appear. Clusters are used to get an overview of bibliometric grouping, while this mapping image is used to get an overall picture of Greenhouse Gas. Cluster 1 has a Red color, Cluster 2 has a Green color, Cluster 3 has a Blue color, and Cluster 4 has a Yellow color.

Cluster 1 (Red): Carbon, Cost, deforestation, emission, forest, forest degradation. Cluster 2 (Green): Emission reduction, greenhouse gas emission, low carbon development, reduction, water. Cluster 3 (Blue): Bandung, CO2, CO2 emission, waste. Cluster 4 (Yellow): Carbon emission discourse, effect, evidence, influence.

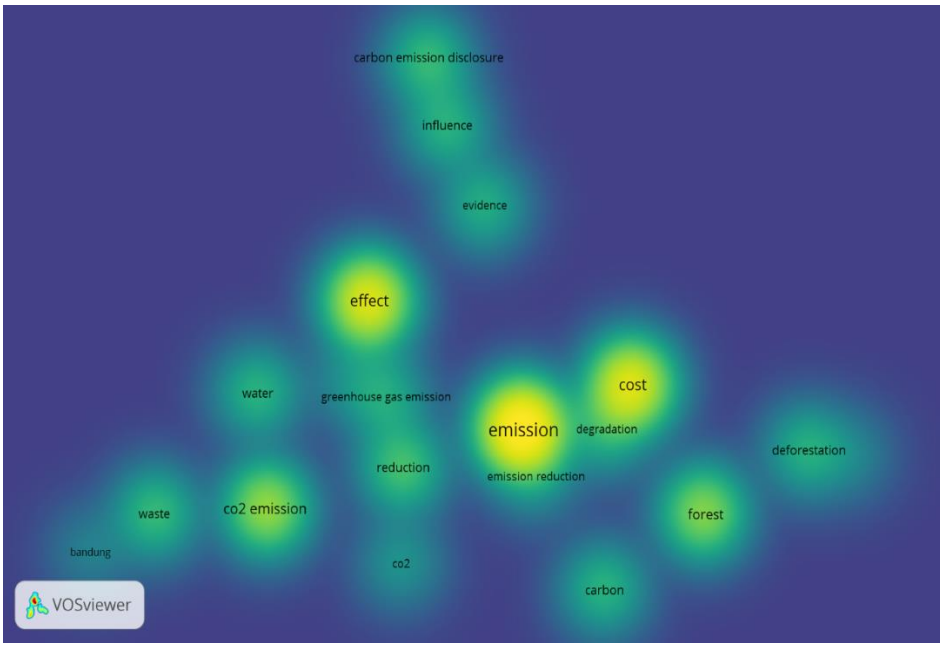

Figure 11. Visualization Density

The figure above shows the thickness of the color in the figure and how dominant the color is in each group. Groups with thick colors indicate that group topics are often discussed or researched, such as effect, CO2 emission, emission, forest, cost, deforestation, reduction, carbon emission disclosure, influence, and evidence. At the same time, the thin color in the picture above shows that the topic or words, such as water, greenhouse gas emission, Bandung, and carbon, have yet to be widely researched. Therefore, words that have this thin color have the opportunity to study the topic.

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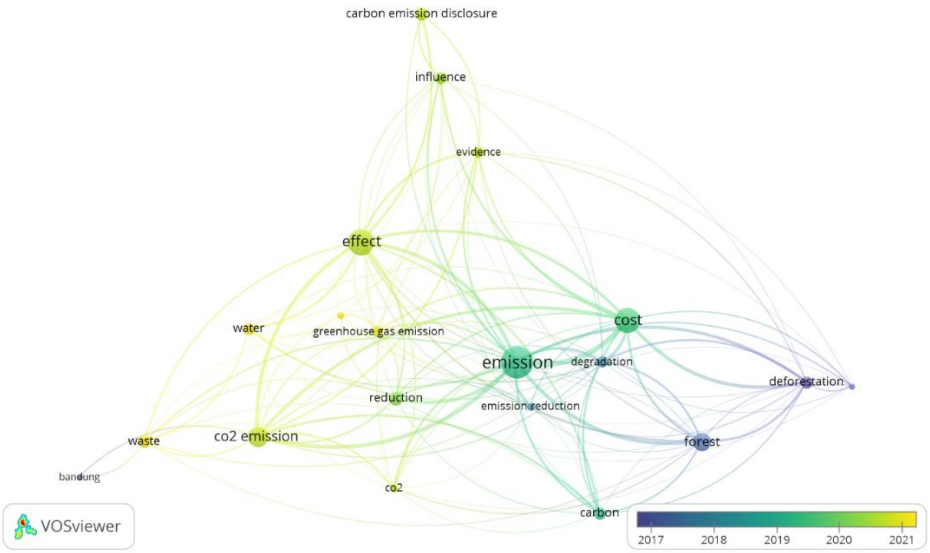

Figure 12. Visualization Overlay

Table 2. Team, Occurrences, Relevance

Team	Occurrences	Relevance
Carbon emission disclosure	29	2.33
Low carbon development	8	1.25
Deforestation	23	0.86
Forest degradation	7	0.83
Greenhouse gas emission	21	0.59
CO2	12	0.53
Waste	29	0.51
Emission reduction	11	0.50
Water	25	0.45
Forest	55	0.40
CO2 emission	62	0.39
Influence	24	0.38
Carbon	25	0.34
Cost	91	0.34
Reduction	34	0.32
Evidence	22	0.30
Effect	97	0.27

The table above shows the value of each word derived from 233 documents with the theme of Low Carbon indexed by Scopus from 2012 to 2022 so that eight keywords are displayed. From these eight keywords, 17 keywords with the most significant frequency or closely related to the theme, namely Low Carbon in Indonesia, can be taken. It can be seen from the table above that the most prominent word with a relevance score of 2.33 is the word carbon emission disclosure, which is very closely related to the Low Carbon theme. Then, the word low carbon development is at 1.25, deforestation is at 0.86, greenhouse gas emission is at 0.59, and CO2 is at 0.53. Followed by other words such as waste, emission reduction, water, forest, CO2 emission, carbon, cost, etc.

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The increasing amount of greenhouse gas (GHG) emissions produced on Earth due to human industrial activities carried out continuously using fossil fuels such as coal, gas and petroleum can pose the threat of disaster on Earth. This increase in greenhouse gas emissions is also supported by deforestation and forest degradation, which reaches 20% of the total greenhouse gas emissions yearly (Arisanti, 2017). Greenhouse gases accumulated in the earth's atmosphere have been formed since human activities, especially since the pre-industrialization period. This factor can increase greenhouse gas emissions in the earth's atmosphere. It can be a global warming or climate change problem (Patrianti & Shabana, 2020).

Climate change caused by increasing greenhouse gas emissions is challenging to reduce because human activities on earth that rely heavily on fossil fuels are difficult to eliminate. Therefore, research on low-carbon development is in high demand. It is due to the increasing demand of industries that cannot leave fossil fuels, but on the other hand, the increasing greenhouse gases produced are causing climate change. Not only that, the trend of low carbon development research is increasing from year to year, the publication of documents that discuss low carbon development is increasing, and the contribution of countries, institutions, publication sources and many authors from year to year researching low carbon development.

According to Yuan Zhou (Mungkasa, 2022) low carbon development states that low carbon development can be started by replacing fossil fuels with renewable energy that is low carbon and guarantees economic growth and improvement of people's welfare. Reducing greenhouse gas emissions is very important, including renewing power plants using renewable energy and low-carbon transportation. This low-carbon development has 3 essential elements that must be carried out, namely reducing greenhouse gases, utilizing low-carbon energy, and ensuring economic growth.

In a study conducted by Yuan (Adi et al., 2020), low carbon development is a new form of development from an economic and political perspective by emphasizing carbon emissions generated in industrial activities so that it can still achieve sustainable development economically, environmentally, and public health. According to Wiener (Andersen & Johnson, 2015), low carbon development is a global effort towards low carbon that requires coordination of global initiatives. Therefore, low-carbon development policies must occur in various countries that balance international regulations and preparation by local communities that need an introduction to low-carbon knowledge.

If connected with the opinion of Santiago (Lema et al., 2015), the goal of low-carbon development is not just a goal listed in a country's mission statement but in the broad view of reducing the rate of sustainable carbon increase as part of mitigating climate change that is getting worse every day and continuing sustainable development plans in various low- and middle-income countries. According to Geels (Lu et al., 2023), low carbon development is part of experimental and strategic governance aimed at reducing greenhouse gases globally, so most reviews can be classified as implementing policies to reduce greenhouse gases.

In this case, the increasing trend regarding publishing low-carbon development topics for society and industrial activities can be seen. In addition, countries worldwide also feel unrest due to global warming due to industrial activities, so the theme of low-carbon development from 2018 to 2022 has increased, as indexed by Scopus. Indonesia is one of the countries that contributes high enough greenhouse gases, so the publication of documents on low carbon development is often researched. It is evidenced by research from Meine van Noordwijk (van Noordwijk et al., 2014) entitled "Implementing REDD+ (Reducing Emissions from Deforestation and Degradation): Evidence on governance, evaluation and impacts from the REDD-ALERT project," which explains

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that the implementation of reducing carbon emissions caused by deforestation for industrial areas and the evaluation of the implementation.

As can be seen, more and more deforestation is being used for industrial activities. Forest burning and deforestation are some factors that trigger an increase in greenhouse gases. In addition, land clearing for industrial areas is increasing, so the electricity demand will also increase, and the demand for burning fossils such as coal, gas, and petroleum will also increase. It is difficult to avoid because human needs are increasing, so the government needs actual policies and public awareness. Indonesia has industrial activities that require very high electricity demand, even though Indonesia is the ninth country with the largest CO2 emitter from power plants in the world (Putri, 2023).

Other research from Handayani (K. Handayani et al., 2020) entitled "Seeking for a climate change mitigation and adaptation nexus: Analysis of a long-term power system expansion" which explains the mitigation of CO2 reduction against significant climate change due to the power generation sector that uses alternative energy models or renewable energy for the long term so that it can still support electricity supply and demand. This research is also related to low-carbon development that minimizes climate change due to greenhouse gases so that the low-carbon development plan can measure mitigation targets and the impact of implementation in the process.

In addition, this study found that Meine van Noordwijk was the author who contributed the most to low-carbon development-themed research publications. This is because he is a researcher and an expert in the environmental field. This study also displays a visualization jar based on keywords using occurrence analysis so that it can identify the direction of research. This study also displays 4 clusters with different colors and bibliometric clustering, which is used to see terms that appear frequently. Thus, this study found that the publication of documents with the theme of low carbon development for industrial areas from 2012 to 2022 indexed by Scopus has a close relationship.

On the other hand, VOSviewer is used to analyze and visualize bibliometric data such as citation networks, keywords, and collaboration between authors. VOSviewer visualization is used to see the analysis of the density of frequently researched topics so that it can be seen that thick colors will describe topics that have been frequently researched. In contrast, faded colors describe topics that have yet to be frequently researched (Trinarningsih et al., 2021). In the VOSviewer results, the faded color is greenhouse gas, meaning only a few people have researched greenhouse gases. However, it can be seen that this greenhouse gas is the cause of climate change on Earth, so mitigation of climate change is needed.

This study explains that lately, many researchers have been planning to mitigate climate change disasters, especially in this day and age of increasing carbon emissions. Then, the government, especially in large countries, is competing to implement the concept of low-carbon development, which is used to mitigate greenhouse gas reduction. Academic researchers worldwide are also interested in discussing this topic because of the increasing greenhouse gases caused by industrial activities and the increase in industrial demand. In line with that, many publications have also taken up this topic.

Research publications in 2022 focus on low-carbon development research, such as a study entitled "Breaking Barriers to Low-Carbon Development in Indonesia: Deployment of Renewable Energy." This research focuses on the Government of Indonesia incorporating low-carbon development into the 2020-2024 RPJMN. In the future, more greenhouse gases will be produced yearly, so low-carbon development is needed to minimize greenhouse gases. In this research, a literature study was conducted on the barriers for the government towards low carbon development so that it can run according to plan in implementing the plan (Sambodo et al., 2022).

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CONCLUSION

In this study, 2022 has the most research publications on low carbon development for industrial activities from 2012 to 2022, as indexed by Scopus. Indonesia is one of the countries that issued a publication document in this study. Then, Meine van Noordwijk became the author who contributed to the research on the theme of low-carbon development for industrial activities from 2012 to 2022, indexed by Scopus. The University of Indonesia is the most contributing institution with the keyword Low Carbon in Indonesia. The review results with VOSviewer show that 4 clusters form a network based on the keywords selected through Scopus. Low carbon development and carbon emission reduction are the words that appear most often.

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