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## Article

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## Environmental Accounting: A Scientometric using Biblioshiny

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### ABSTRACT

This study aims to determine the development of research trends on environmental accounting published by national and international journals. The data analyzed consists of 500 indexed research publications during the period 1981-2020. The data is then processed and analyzed using the R Bibliometric application to determine the bibliometric map of environmental accounting developments. The results showed that the number of publications on the development of the role of research related to environmental accounting has increased significantly. Then, the most common type of document that analyzes environmental accounting is journal articles. The most popular writer was Wood R, who during the research period he consistently conducted research on this theme, and the most popular keywords were energy, environmental and assessment.

**Keywords:** Environmental Accounting, Energy, Bibliometrics R

**JEL Classifications:** Q56, Q50, M41

## 1. INTRODUCTION

National development is currently being directed at sustainable development, namely development that balances ecological/environmental, economic and social aspects (Herath, 2005). This principle is in accordance with the triple bottom line concept consisting of profit, planet and people or 3P, which means that national development aims to gain profit while protecting the earth and people (Elkington, 1999).

In modern industry, many companies apply the concept of maximizing profit, but violating the principles of profit maximization itself. The principles that were violated included the principles of economic costs, accounting costs and opportunity costs. The implications for violating these principles include neglecting environmental management.

The environmental aspect is one of the important aspects, considering the impact of good and bad environmental

management has an impact on human life both in the short and long term (Sambharakreshna, 2009). Concern for the environment in the industrial world can be created with encouragement from government, consumers, stakeholders and competition (Berry and Rondinelli, 1998; Jafar and Arifah, 2006). According to Pflieger et al. (2005), environmental conservation efforts carried out by the company bring several benefits such as being able to create interest from shareholders and stakeholders towards company profits as a result of environmental management. In addition, environmental management can improve the quality of a product, thereby increasing economic benefits.

Information related to company performance in environmental management is a necessity for stakeholders, where disclosure of the company's environmental performance is one of the factors determining the company's success in achieving the success of the company's financial performance and economic performance (Sambharakreshna, 2009). Companies with good environmental performance will be responded positively by investors through

fluctuations in company shares which reflect the company's economic performance achievement.

As for environmental accounting, there has been much literature discussing it, although there are still few attempts to include such accounts in the standard national accounts framework (Muller et al., 2011). Environmental accounting itself is a useful tool for assessing the biophysical and economic value of natural capital and ecosystem services in terrestrial and marine ecosystems (Buonocore et al., 2020). Research with this theme examines how companies calculate and disclose environmental impacts (Marrone et al., 2020).

The concept of environmental accounting aims to evaluate the environmental performance at the global scale of the biosphere, taking into account free environmental inputs (for example, solar radiation, wind, rain, and geothermal flows), human-driven flows of energy and materials, and environmental support directly embodied in human labor and services (Buonocore et al., 2020).

There are more than 500 published scientific research papers that are the object of research both nationally and internationally in the time span of writing this paper, namely December 2020. The paper that is the object of this research is a paper that discusses environmental accounting. Research with this theme is interesting to do considering that environmental accounting is currently being used as scientific research to produce ideas and innovations that can answer problems in the industrial world.

## 2. LITERATURE REVIEW

Environmental Accounting is a term to classify the financing made by companies and the government in carrying out environmental conservation into company practices. According to Lindrianasari (2007), environmental accounting is an activity carried out in connection with environmental conservation, such as: (1) conservation of living things; (2) conservation of conditions that affect as a whole, such as global warming, depletion of the ozone layer, and sea water pollution; and (3) conservation of resources. Meanwhile, according to the United States Environmental Protection Agency (US EPA), environmental accounting is a function that describes environmental costs that must be considered by companies in identifying ways to reduce or avoid costs at a time which coincides with efforts to improve environmental quality.

According to Burnett and Hansen (2008), if a company wants to improve its environmental performance, it requires accounting in carrying out the functions of collecting, calculating, analyzing and reporting costs to manage environmental aspects. The purpose of environmental accounting is to correct information gaps that arise because costs and environmental damage are not identified in support of business decisions (Dourala et al., 2003). In an effort to improve environmental accounting, the branch used is management accounting or environmental management accounting/EMA (Xiaomei, 2004). Environmental Management Accounting/EMA is the analysis and use of financial and non-financial information to support management in running its business (Berkaoui, 2000).

There are several factors that encourage a company to carry out environmental management, including regulatory demand, cost factors, stakeholder forces, and competitive requirements (Berry and Rondinelly, 1998; Ja'far and Arifah, 2006). In making efforts to improve environmental accounting, the company has the concept of Triple Bottom Line Accounting/TBLA. TBLA consists of three pillars, namely people, profit and the company environment. People are related to the touch of humanism that is managed by the company, profit reflects the company's ability to earn profits and the environment reflects the company's relationship with the company's environment such as air quality, water and biodiversity.

## 3. METHODOLOGY

Bibliometric mapping is a research topic in the bibliometric field (Borner et al., 2003). Two bibliometric aspects that can be distinguished are the construction of the bibliometric map and the graphical representation of the map. In the bibliometric literature, the greatest concern has been with the construction of bibliometric maps. Research on the effect of differences on size similarity (Ahlgren et al., 2003), and they were tested by different mapping techniques (Boyack et al., 2005). Several bibliometric applications can be found in research conducted by Antonio et al. (2020) and Rusydiana (2021).

The graphical representation of the bibliometric received less attention. Although there are some researchers who seriously study problems related to graphic representation (Chen, 2003). Most of the articles published in the bibliometric literature rely on simple graphical representations provided by computer programs. This study uses publication data in the form of papers sourced from various scientific journals and other sources with the theme of environmental accounting research on accounting, energy and environmental research in general. From the search results obtained 500 published articles.

## 4. RESULTS AND DISCUSSION

### 4.1. Source

The Table 1 showing a collection of documents used in research with the theme of environmental accounting. The number of documents used is 500 which are divided into 4 types of documents, including journal articles (492 documents), book chapters (5 documents), proceedings (2 documents), and preprint design (1 document).

Based on the results of the grouping of document types above, the type of document that is most widely used as the subject of research on the theme of environmental accounting is a document

**Table 1: Document types**

| No | Document types  | Number of articles |
|----|-----------------|--------------------|
| 1  | Journal article | 492                |
| 2  | Book chapter    | 5                  |
| 3  | Proceedings     | 2                  |
| 4  | Preprint        | 1                  |
|    | Total           | 500                |

in the form of a journal article with a percentage of 98.4% or as many as 492 documents. Meanwhile, the least document used was in the form of a preprint document of 0.2% or as much as 1 document. This shows that the references used are quite valid because most of them come from documents in the form of scientific articles.

#### 4.2. Average Citation Per Year

Next, the research was also carried out based on the average citations/citations in the paper related to the theme of environmental accounting, both in average per year and per article. The time span of research carried out under this theme was published from 1981 to 2020. From the Table 2, it is known that the most published papers related to the theme of environmental accounting were published in 2015 with a total of 47 documents.

Then, based on the average total citation for each article the highest occurred in 2006 with an average of 273.33 citations. Whereas for the average annual citation, the research with the highest citation occurred in 2019 at 47.67. This shows that papers published in 2006 and 2010 are cited more than any other year in the environmental accounting theme.

The Three Fields Plot in Figure 1 is a picture consisting of 3 elements in it, namely, the name of the publication journal, a list of authors' names and the themes/topics used. The three elements are connected by a gray plot which is related to one another. Starting from the name of the journal, then each journal shows the author who often contributes to its publication, then each writer shows the topic they often use for research conducted with the theme of environmental accounting. The size of the rectangle illustrates the large quantity of publications associated with each of these elements.

From the picture above, it is known that in the first element, there are 17 journals indexed in the Three Fields Plot which publish the paper on the theme of environmental accounting. The top journals that publish the most number of papers with the theme of environmental accounting are Waste Management and Research which is depicted with a green rectangle connected to several authors, namely Christensen TH and Larsen AW.

Next, on the second element in the middle of the image, which shows the author's name. Where there are several authors who are linked to the journal. In addition, the author will also be associated with topic keywords that are often used on the right of the image. Where in this study there were 20 top researchers enrolled in this plot. The size of the rectangle indicates the respective quantity of research publications from each author. The authors of this study mostly publish environmental accounting themes, namely Christensen TH and Ulgiati S, which are depicted by light purple and brown rectangles.

Finally, the third element that describes the research topic which is on the right side of the picture. Each topic is connected with writers who write a lot on related topics. From the results of the image, there are 20 keyword topics listed. Of all the topics that appear, the word accounting is the most frequent word marked

**Table 2: Average citation per year**

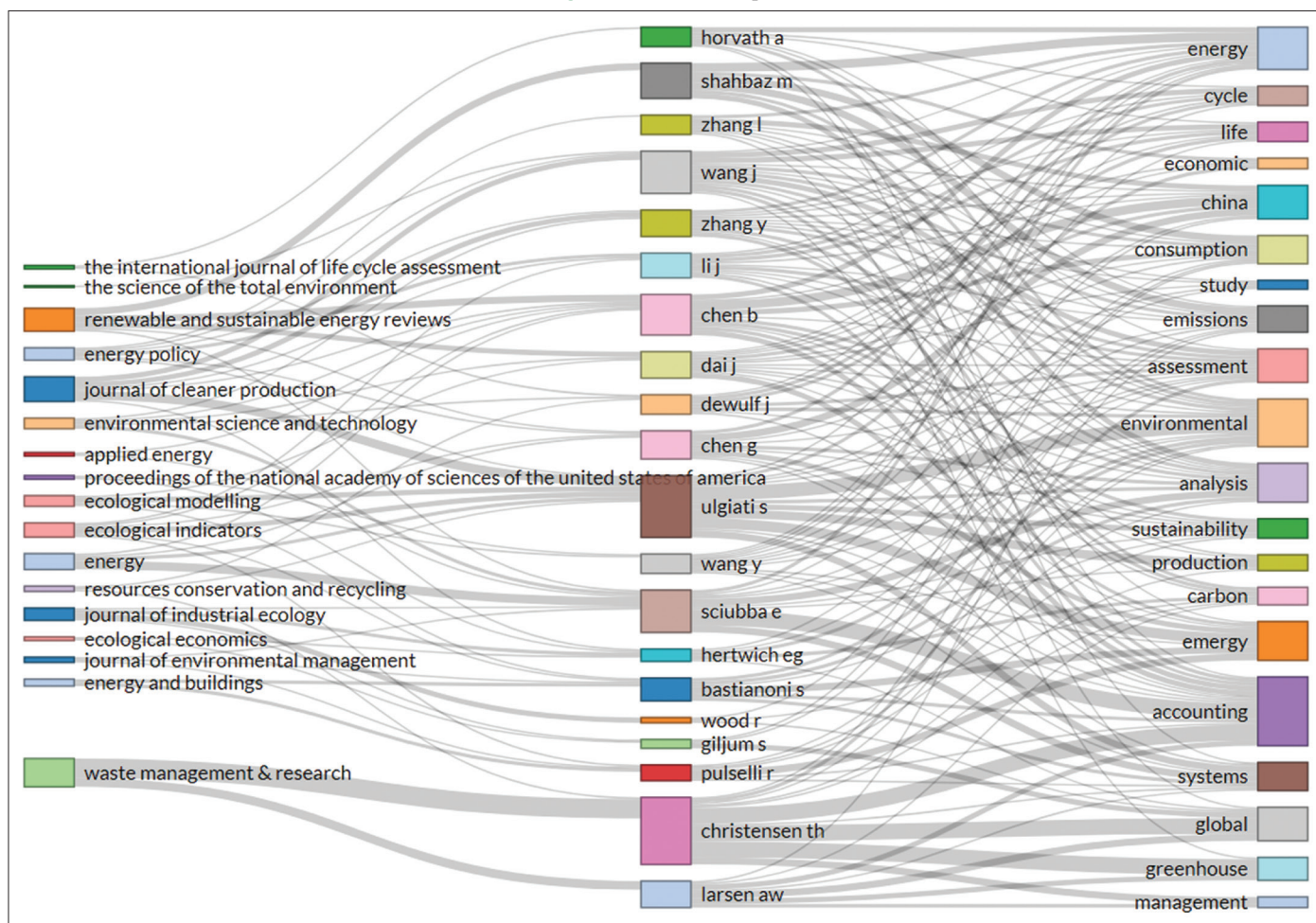
| Year  | n   | Mean TC per Article | Mean TC per Year | Citable Years |
|-------|-----|---------------------|------------------|---------------|
| 1981  | 1   | 39.00               | 1.00             | 39            |
| 1983  | 2   | 79.00               | 2.14             | 37            |
| 1985  | 1   | 75.00               | 2.14             | 35            |
| 1990  | 1   | 163.00              | 5.43             | 30            |
| 1991  | 1   | 108.00              | 3.72             | 29            |
| 1992  | 3   | 99.67               | 3.56             | 28            |
| 1995  | 4   | 57.50               | 2.30             | 25            |
| 1996  | 7   | 66.14               | 2.76             | 24            |
| 1997  | 3   | 257.67              | 11.20            | 23            |
| 1998  | 6   | 88.83               | 4.04             | 22            |
| 1999  | 2   | 53.50               | 2.55             | 21            |
| 2000  | 8   | 72.88               | 3.64             | 20            |
| 2001  | 6   | 93.67               | 4.93             | 19            |
| 2002  | 5   | 144.80              | 8.04             | 18            |
| 2003  | 14  | 86.79               | 5.11             | 17            |
| 2004  | 8   | 103.25              | 6.45             | 16            |
| 2005  | 15  | 88.40               | 5.89             | 15            |
| 2006  | 18  | 273.33              | 19.52            | 14            |
| 2007  | 24  | 149.50              | 11.50            | 13            |
| 2008  | 30  | 94.07               | 7.84             | 12            |
| 2009  | 40  | 102.03              | 9.28             | 11            |
| 2010  | 29  | 79.34               | 7.93             | 10            |
| 2011  | 38  | 97.34               | 10.82            | 9             |
| 2012  | 42  | 73.38               | 9.17             | 8             |
| 2013  | 27  | 85.11               | 12.16            | 7             |
| 2014  | 32  | 61.03               | 10.17            | 6             |
| 2015  | 47  | 56.98               | 11.40            | 5             |
| 2016  | 42  | 60.71               | 15.18            | 4             |
| 2017  | 23  | 54.61               | 18.20            | 3             |
| 2018  | 16  | 63.75               | 31.88            | 2             |
| 2019  | 3   | 47.67               | 47.67            | 1             |
| 2020  | 2   | 39.00               |                  | 0             |
| Total | 500 |                     |                  |               |

with a dark purple rectangle. Meanwhile, the word environmental in the second position which is often used by almost all authors is marked with a rectangle in orange color. This illustrates that the words accounting and environmental are closely related to research on the theme of environmental accounting.

Then, the Figure 2 shows the number of research documents published by each journal based on the level of relevance to the environmental accounting theme. The data shows a list of the names of the top journals published and the interval for the number of documents published with a blue bar chart. The darker the blue color shows the more quantity and relevance to the research theme,



Figure 1: Three fields plot



the number of documents published by all journals ranges from 0 to more than 40 documents.

Journal of Cleaner Production is a journal that is in the top position with the number of published documents of more than 40 documents shown in a dark blue bar chart compared to the bars of other journals. This is because the journal is relevant to the theme discussed. Meanwhile, for the journals that are in the lowest position with the number of publications <5, there are 8 journals marked in bright blue. This means that in terms of quantity and relevance the environmental accounting theme is lacking. Apart from that, in total there are 30 journals listed in the most relevant data sources.

This study also discusses the development of journals that become sources in research on environmental accounting themes. The curve in Figure 3 shows the development of the annual occurrence of each journal from 1981 to 2020. Where the curve illustrates that research with the theme of environmental accounting tends to fluctuate in its publication. From the curve above, it also shows that some journals have started to develop since 2003 and continue to increase even though in several years they have decreased, such as Energy Policy and Energy. Meanwhile, other papers that have decreased drastically in 2020 at 0 are The International

Journal of Life Cycle Assessment and Environmental Science and Technology.

In addition to that, productivity can not only be measured in journals, but also for the author in particular. Where in the Figure 4 shows the productivity of some of the top authors during the study period, namely from 1995 to 2019. This productivity is shown by a red line from the time the author published his research until the last year the author published his research. In addition, the circle in red line shows the quantity of papers issued according to the applicable year.

The picture above presents an overview of authors who have written research related to environmental accounting for a long time or have recently written. The author who has long published research related to environmental accounting, namely Wood R, from 1995 to 2019 has been productively writing which has increased every year. In addition to that, the writer who has a long track record is also occupied by Ulgiati S who wrote from 1998 to 2018.

Authors who have published their papers can also be sorted based on the resulting impact based on the h-Index. The authors' h-Index values range from 0 to 15. The magnitude of my impact is marked in dark blue in the bar chart above. Where from the Figure 5

Figure 2: Article sources

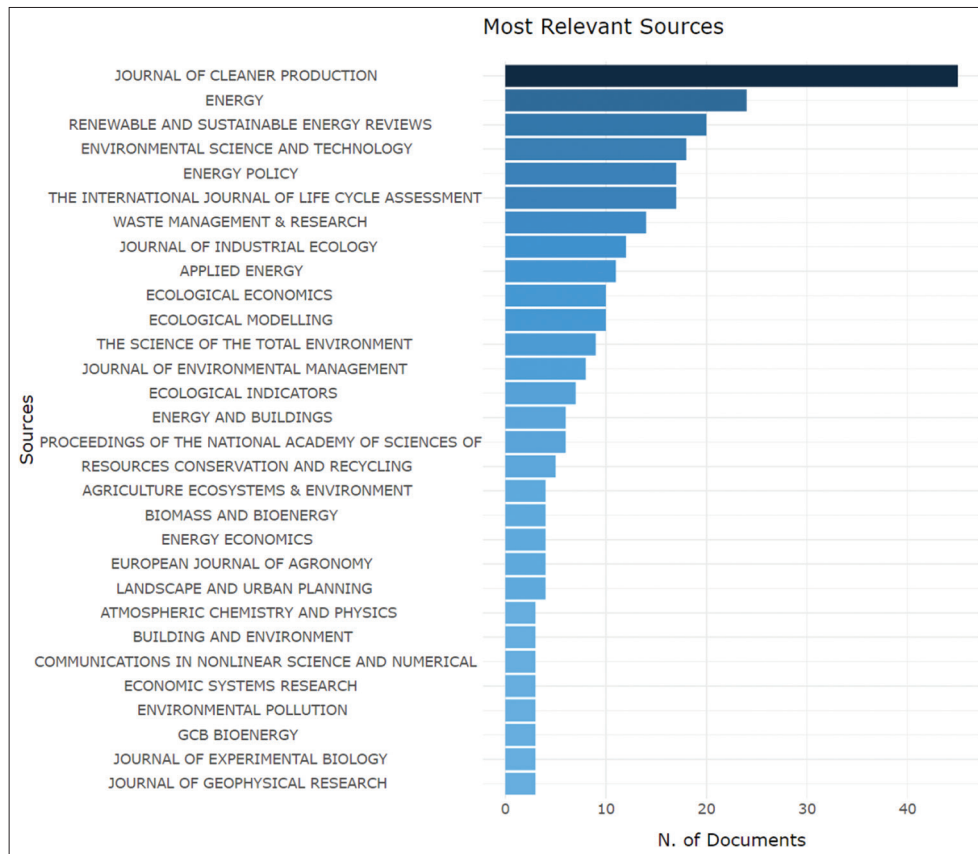
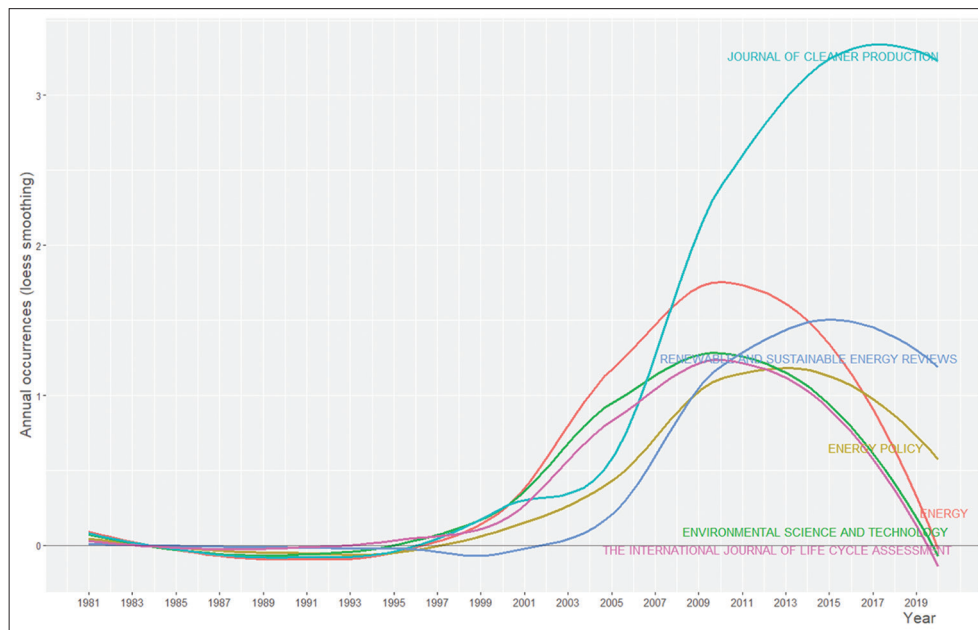


Figure 3: Sources growth



shows that the authors with the highest h-Index obtained Ulgiati S with an achievement of number 15 marked with a dark blue bar chart color that describes the maximum impact. Then followed by three other authors with a value of h-Index 12 with a fairly good impact, namely Chen B, Christensen TH, and Sciubba E. T, Gang Y and Giljum S.

The Figure 6 shows the authors' correspondence countries contained in each article with the calculation of the total form of collaboration between SCP (single country collaboration) or one country collaboration, not MCP (multiple country collaboration) or collaboration between several countries. There are 13 top countries included in this data and the document quantity interval is between

Figure 4: Top authors production over the time

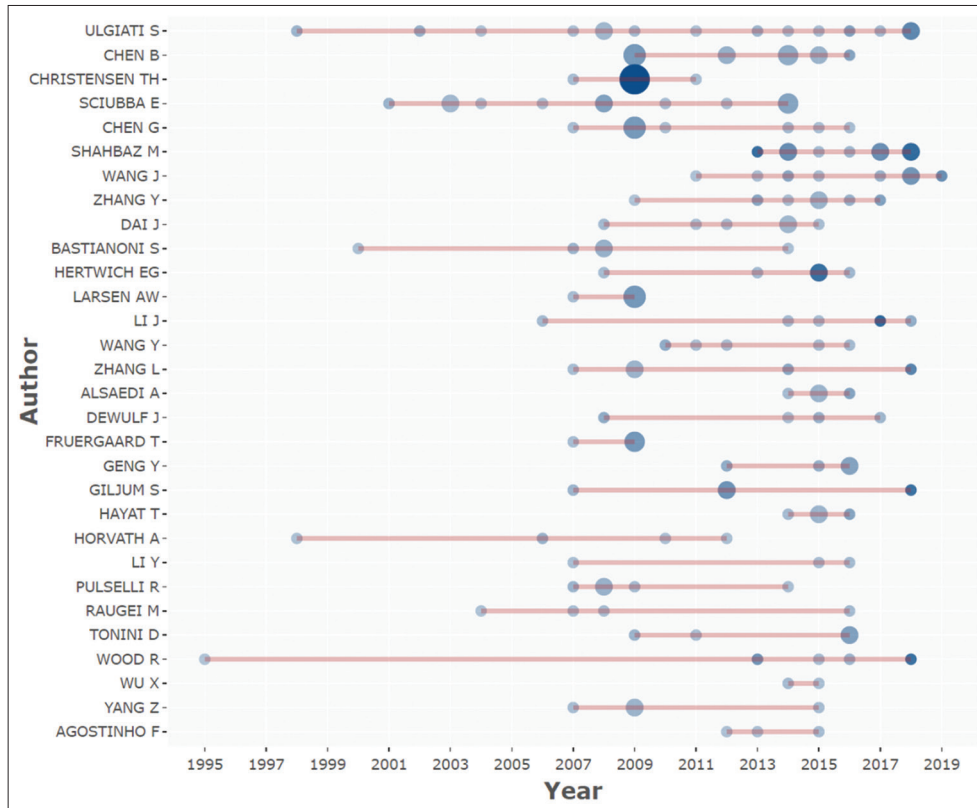
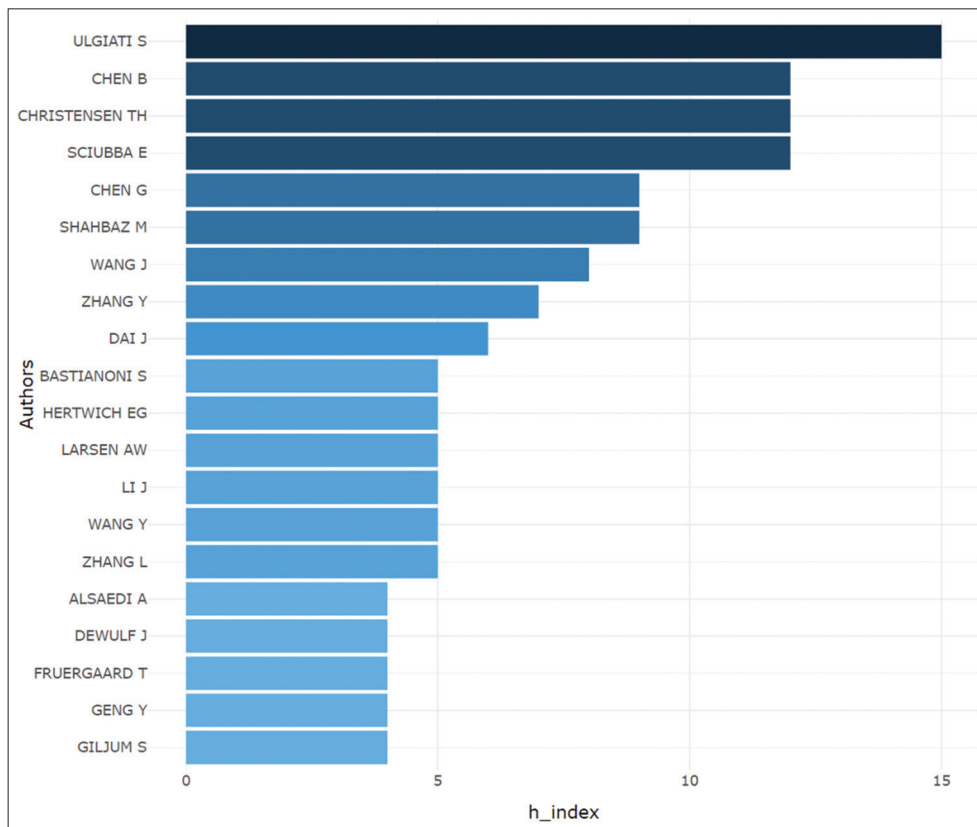


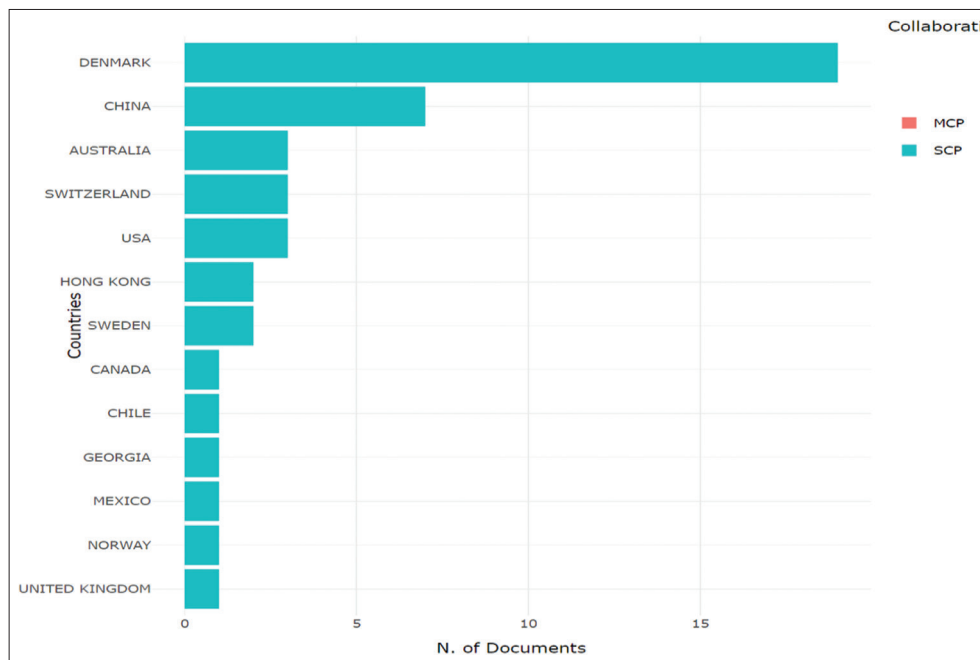
Figure 5: Author impact



0 and more than 15 published paper documents with the theme of environmental accounting.

The results obtained are that Denmark is in the first rank as a country with the highest quantity of author correspondence with

Figure 6: Country of corresponding author



more than 15 published papers. Furthermore, the second rank is China with more than 5 published papers. Finally, namely Canada, Chile, Georgia, Mexico, Norway and the United Kingdom with the number of published papers 1.

These data indicate the need for an increase in the number of published papers on the theme of environmental accounting in other countries in order to research new and better ideas and innovations for the development of environmental accounting management so that the hope is that they can produce better output.

This study also counts the words that are relevant to be used in the collection of documents that are the object of the study, where there are several words with a number of occurrences between 0 and more than 110 times. The top 50 listed words marked with the diagram in blue show the comparison of the number of occurrences of each word usage and their relevance to the environmental accounting theme.

The top word with the highest number of occurrences and the most relevant to the research theme is the word energy with a total usage of 113 times and which is indicated in blue. This illustrates that the theme of environmental accounting research is closely related to the word energy which often appears in research with this theme. Furthermore, in second place is the word environmental with an occurrence quantity of 110 times. Then in the third place, namely the word assessment with an appearance quantity of 65 times.

The Word Tree Map in Figure 7 displays words that often appear in boxes similar to regions on the map, where the more words appear, the larger the square area.

Topic trends are also part of this research, where the Figure 8 shows an overview of the development of the topic from time to time with the division per year. So that it is known what

topics have been used for a long time and what topics have been used recently. The appearance of the topic is also adjusted to the frequency of the quantity of the word appear in research on environmental accounting themes. The higher the more the word is used and the more to the right the more recent the word is used. The development of the topic began to experience a significant increase since 2005.

Based on the description of the data above, the topic that has been used since 2002 is modeling, especially those related to the theme of environmental accounting. Then in 2005 the topic of changes began to appear. Although it has been a long time, the quantity of topics that have emerged under 2005 is still small. The topics that are widely used in 2016 include evidence, generation, renewable, growth, countries and pollution with different quantities.

In this study, an analysis of thematic maps was also carried out based on density and centrality which were divided into 4 theme quadrants as in the Figure 9. This result is obtained from a semi-automatic algorithm by reviewing the titles of all references to the research object with the addition of relevant keywords other than the author's keywords, so that the results are able to capture deeper variations.

The upper right quadrant is a driving theme characterized by high density and centrality, so it needs to be developed and it is important to be studied in further research. In this quadrant there are themes of assessment, energy and environmental. Furthermore, the upper left quadrant shows a specific and rare theme but has a high development, which is indicated by high density but low centrality. The themes in this quadrant include global and water.

Furthermore, in the lower left quadrant are themes that have been used for a long time but have experienced a downward trend with marked low centrality, but in this quadrant no themes



Figure 7: Tree map

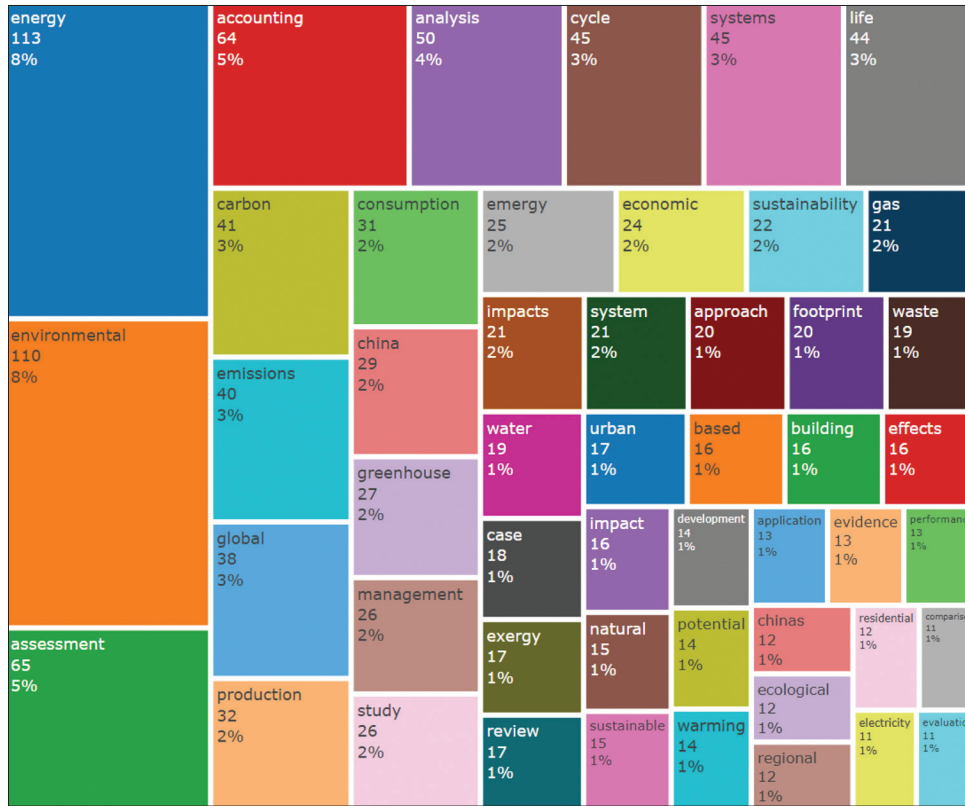
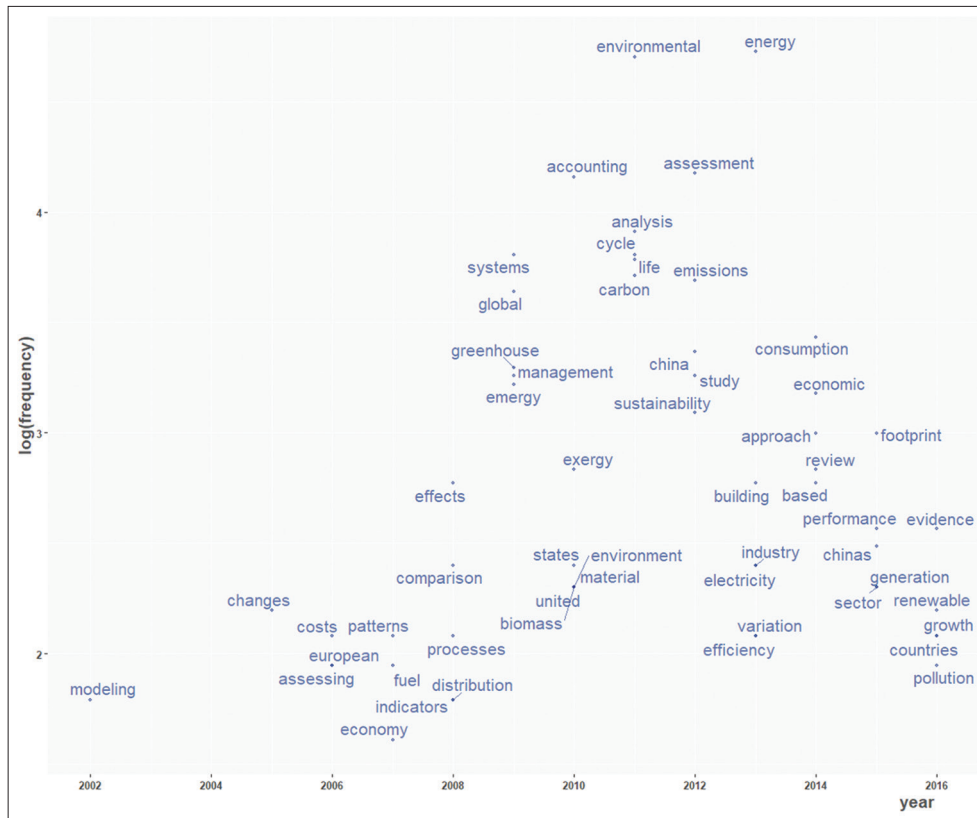


Figure 8: Trend topics of environmental accounting



were detected. Finally, the lower right quadrant is a basic theme characterized by high centrality but low density. These themes

are important to be included in research because they are general topics that are commonly used, including sustainable themes.

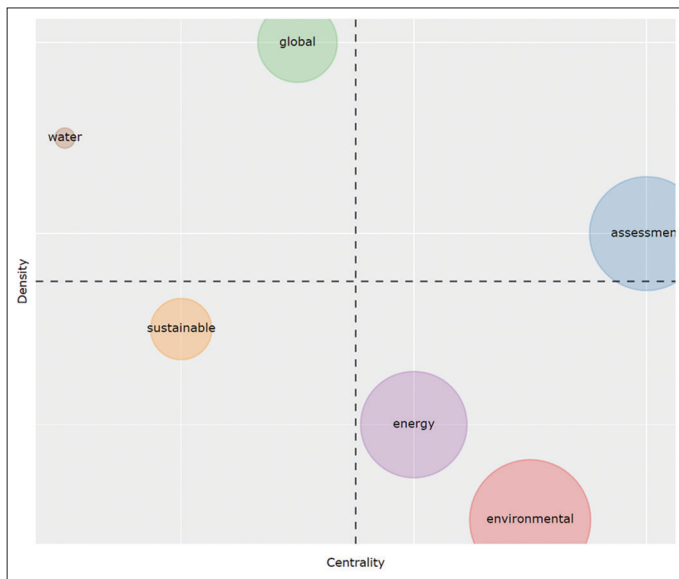
The themes used in papers that are the object of research continue to change, especially from papers that have recently been published when compared to papers that have been published for a long time. The evolution of the theme is shown in the Figure 10. Although the theme of this study is environmental accounting, these data indicate several sub-themes that are widely used. The left side shows some of the themes that are widely used from 1981 to 2009, there are 9 themes listed with different sizes depending on the quantity of use of the theme. The assessment theme took the first position, followed by the energy theme.

The second or middle part shows some of the themes that are widely used from 2010 to 2013. Some of the themes that have

emerged during this period are an evolution of the previously used themes and have a connection in their content, for example the theme “carbon” emerged as a form of revolution from the theme. These “effects,” “energy,” and “accounting” show that the research using the extension theme is an extension of the research on the effects, energy and accounting themes in previous studies. In this section, the most widely used themes are environmental and energy.

The third or right section shows the most recently used themes in the period between 2014 and 2020. There are 8 listed themes, of which 8 themes are evolutionary themes that appeared in the previous period.

Figure 9: Thematic map



This study also describes a conceptual structure map or map of the contextual structure of each word that often appears in research papers on the theme of environmental accounting by dividing it based on mapping the relationship between one word and another through area mapping. Each word is placed according to the values of Dim 1 and Dim 2 so as to produce a mapping between words whose values do not differ much.

In this data, there are 2 parts of the area which are divided, namely the red area and the blue area, each area contains words that are related to each other. Based on the Figure 11, the red area shows more and more various words included in it, this shows that there are many research papers that link between the words listed in this area.

### 5. FINDINGS

The implementation of financial accounting has a positive and significant impact on environmental performance. This is in

Figure 10: Thematic evolution

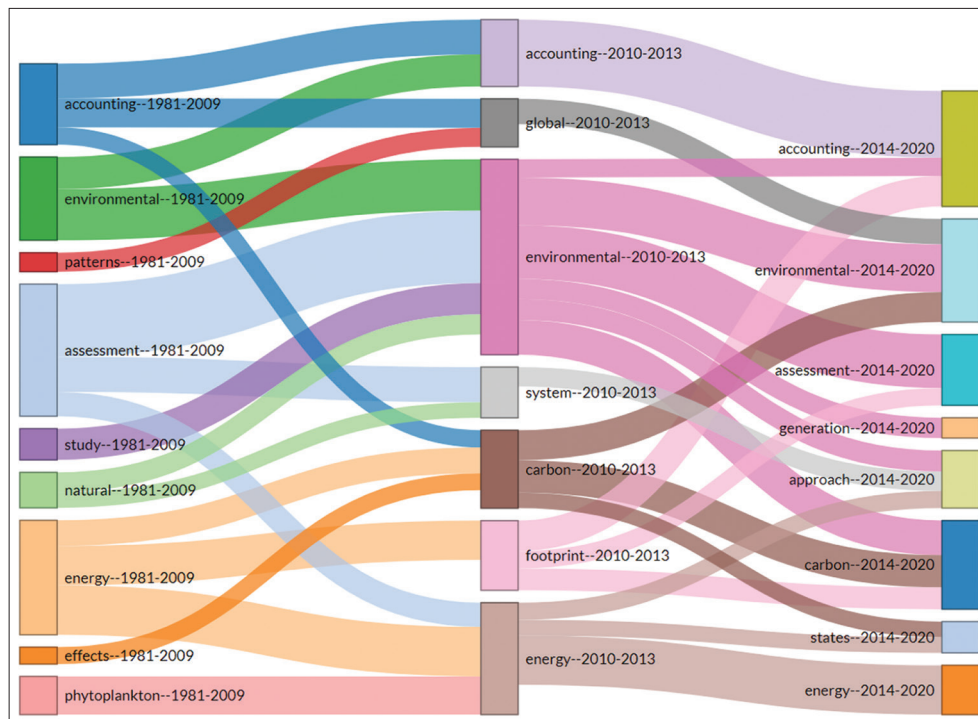
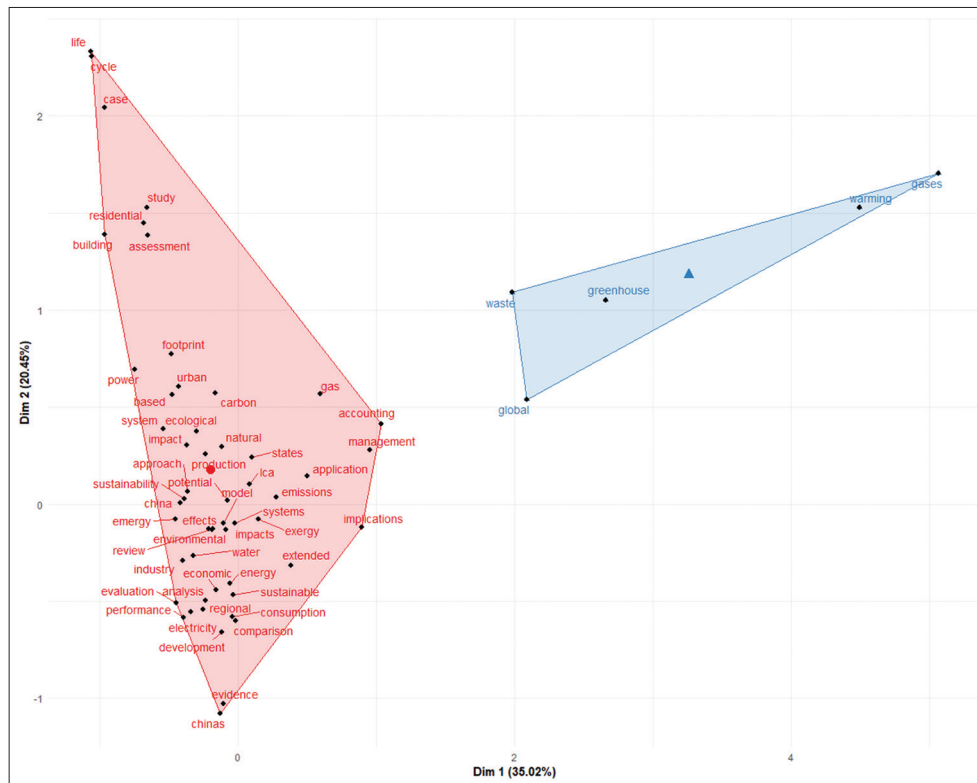


Figure 11: Conceptual structure map



accordance with research conducted by Burhany (2014). In addition to that, environmental accounting is able to present information related to the environment both to internal and external parties, where the presentation is voluntary as a form of corporate responsibility which is usually presented in the form of annual reports, sustainability reports, websites, or other forms of voluntary disclosure (Nortcut, 1999; Li and McConomy, 1999). Verrecchia (1983) stated that in presenting this data, companies tend to convey good news and tend to hide bad news.

Environmental accounting with the concept of triple bottom line accounting/TBLA is now implemented through CSR (Corporate Social Responsibility) or known as corporate responsibility (Suartana, 2010). This CSR is implemented through social, economic and environmental domains to get a good image in the eyes of company stakeholders. Darwin (2006) states that companies that are successful in implementing CSR have economic resilience, social responsibility, and social accountability which are reflected in a sustainability report.

Accounting has adopted environmental costs in its reporting system. Environmental accounting will make the financial statements of an organization or company more complete and comprehensive (Suartana, 2010). Comprehensive financial reports will make it easier for stakeholders to assess the performance of an organization. Meanwhile, corporate responsibility is not a mere management impression tool, but is more than a long-term investment for the company.

Environmental accounting also has an essential role in implementing good corporate governance (GCG), which is very important to convey

the urgency of environmental protection in corporate governance oriented towards conserving natural capital and delivering sustainable ecosystem services (Buonocore et al., 2020). Every company is expected to develop a comprehensive environmental accounting system and report it to their stakeholders (Jones, 2010).

This is done to avoid environmental losses such as pollution and emissions generated by the company (Muller et al., 2011) because companies also have an essential role in achieving local, regional and global nature conservation targets (Buonocore et al., 2020). Environmental accounting is essential in implementing good corporate governance (Kuasirikun, 2005) because it affects its business continuity.

The existence of environmental accounting is also essential if we see that countries that can apply the concept of environmental accounting correctly show that they tend to control the negative impact of economic development. For example, the United States applies environmental accounting to be able to estimate the external costs of air pollution in the framework of the national economic balance (Muller et al., 2011), as well as China which seeks to carry out low-carbon development with environmental accounting (Marrone et al., 2020).

Environmental accounting is also proposed to be implemented in the South African industry with a framework for corporate evaluation of investment alternatives, projects and processes and to estimate current and especially future economic and environmental performance (de Beer and Friend, 2006), as well as Thailand which have a concern for applying accounting concerning social and environmental problems (Kuasirikun, 2005).

Besides, environmental accounting is also in line with a shift to a low-carbon economy consistent with the achievement of the sustainable development goals (SDGs) set by the United Nations General Assembly in 2015 under the 2030 Agenda (Marrone et al., 2020). The achievement of the SDGs, especially from the energy and environmental aspects, is currently important (Rusydia et al., 2021), including OIC countries (Laila et al., 2021). With environmental accounting, there have been efforts in calculating the human contribution to the welfare of nature and the environment (Boyd and Banzhaf, 2007).

Today, more and more companies are starting to publish reports on “sustainable development” (Brown and Fraser, 2006). Even governments, public policy makers, private sector organizations and professional bodies have formed working groups on various aspects of environmental accounting (Thomson, 2020). Thus, many accounting experts suggest that environmental accounting is a solution to environmental problems (Lohmann, 2009).

## 6. CONCLUSIONS

The research was conducted to determine the development of research on environmental accounting during the period 1981 to 2020. Of the 500 documents used in this study, it shows that research with the theme of environmental accounting has increased every year. As for the author who often conducts research with the theme of environmental accounting, Wood R, during the research period, he consistently conducted research on this theme. While the keywords that are often used in this research are the words accounting and environmental. Overall, the development of research with the theme of environmental accounting is growing. Therefore, research with this theme needs to continue to be developed considering the limited research that addresses this environmental accounting theme extensively.

This research has important implications that environmental accounting is an inseparable part of the company’s annual financial statements so that a high level of awareness is needed for company management. This is supported by regulations from the government regarding the obligation to pay environmental costs to companies that have the potential to have a negative impact on the environment. Thus, companies are required to disclose all of their activities not only related to financial performance but also environmental performance through disclosures in annual reports. This is closely related to the Sustainable Development Goals (SDGs) program that companies must take part in protecting nature as well as important information for all stakeholders in assessing overall performance, including investors who want to invest in the company.

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