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Review

Biomass Potential and Utilization in Worldwide Research Trends—A Bibliometric Analysis

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Abstract: Biomass, as a part of renewables, is a resource found in large quantities and is a basis for many different industries. This paper presents the most important trends and characteristics of research in biomass potential and biomass utilization on a world scale. The main objective of this work is to analyze the state of research and trends in biomass potential and biomass utilization from 1974 to 2021, including 7117 relevant documents. The methodology part comprised two main stages: obtaining data from Scopus and then exporting the data into Excel. The VOSviewer bibliometric tool was used to analyze clusters of countries and groups of keywords. Research on this topic experienced significant development after 2000; moreover, the global trend of publications marked a significant increase after 2012. China and India have shown exponential growth, followed by USA, Germany, and UK. An important trend globally is that energy topics are gaining more importance and percentage annually, especially in photovoltaics and new generations of biofuels in terms of keywords. The paper aims to provide a tool for the scientific community by introducing the current state and potential tendencies in this special field, including the various sides of biomass use.

Keywords: publication; cluster; energy; food; bioeconomy; biofuels

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1. Introduction

Climate change is one of the greatest challenges faced by humanity today. An important step to mitigate climate change is to replace fossil fuels (which represent 81% of the total primary energy supply according to World Bioenergy Association [1]) with renewable energy sources (RESs), while boosting energy efficiency. Among RESs, biomass is expected to continue to play the most prominent role in meeting human energy needs. Renewable energy adaptation is important not only because of the ever-increasing demand for energy [2], but also because of the even more pressing energy self-sufficiency ambitions of today. In addition, the issue of biomass potential and utilization is also of paramount importance for the supply of food and feed. Thus, feeding a growing population is one of the challenges identified in the United Nations (UN) Sustainable Development Goals (SDGs), which should be addressed to conserve the Earth's biological and physical resources [3]. There is widespread agreement that there is intense competition among food, feed, and energy production for limited resources such as land, nutrients, water, labor, and capital [4]. In order to mitigate this competition and avoid significant pressure on natural resources and ecosystems, different strategies are needed to organize and coordinate biomass use more efficiently [5–8]. In the following sections, the most essential global features and trends related to the topics of biomass potential and utilization are presented in connection with the appearance and characteristics of these topics in international publications.

Biomass Potential

The amount of globally available organic materials with biological origin is nearly endless, and they can be used for many purposes (mainly food, feedstock, fiber, and energy). The annual global primary production of biomass is equivalent to the 4500 EJ of solar energy captured and stored each year. Through this process, plants convert approximately 125 gigatons of carbon from the atmosphere into biomass, which is equal to almost 300 million tons of oil per day [9]. However, according to a Hungarian survey with a choice experiment methodology, GHG emission has a lower weight in sustainability attributes than land demand and local income do [10].

The total annual primary biomass production on the surface of the Earth is estimated to be about 1260 EJ/year, including biomass used for food, fodder, fiber, and other industrial products of 219 EJ/year. However, estimations taking into account sustainability constraints show a yearly potential of 200–500 EJ/year of the current global energy use. The share of bioenergy by 2050 was estimated in the range of 100–300 EJ/year, contributing between a quarter and a third of the future global energy mix [11]. However, according to the International Energy Agency estimation [12], the most significant capacity growth in RESs in the near future is expected in the field of solar energy, followed by wind and hydropower. The largest growth is forecasted in China, followed by the European Union (EU) and India. As Brodny and Tutak [13] mentioned, it seems reasonable to conclude that countries with large areas have easier access to RESs, especially wind and solar. Balat and Ayar [14] estimated the annual world biomass production at 146 Bt, which covered about 14% of the world's energy demand and 35% of the energy demand of the developing world.

The United States (US) biomass production—at 60 USD per dry ton cost—is projected by the US Department of Energy [15] to fall from the current 991 million to 117 million dry tons by 2030, mainly from energy crops (380 million dry tons) and agricultural by-products (174 million dry tons). Furthermore, according to the World Bioenergy Association [1] estimation, 53.6 million tons of wood charcoal were produced worldwide in 2019, of which 65% was produced in Africa. Biomass is the most widespread form of renewable energy, and demand is expected to continue to grow [12]. Globally, the largest share of biomass for energy purposes has come from forests. The land is the basis for biomass production, with a strong emphasis on sustainable use and protection of agricultural land, including protection against desertification, degradation and other negative changes. Regarding yields of major crop species, there is significant potential to increase yields in different regions to the global average, which will allow both food and fuel production to increase [1]. Innovations in agriculture and growing yields play a major role in increasing the potential for food and fuel production and in helping to resolve the conflict between the use of agricultural products for food or energy [16]. For example, increased maize yields saved 50 million hectares of land between 2000 and 2012. The World Bioenergy Association estimates that, with the right policies in place, around 5% of agricultural land (240 million hectares) will be available for energy crops for biofuels and solid biomass by 2035. According to Lin and Lu [17], the EU and the US are considered to be the most active and successful zones for biofuel production and application, primarily due to their intensive government policies supporting the rise of biofuels. However, it should be noted that in the case of biofuels, the current conventional production cannot provide a long-term solution [18,19]. A conservative estimate of the energy potential of biomass from agriculture, forestry, and the waste sector will be about 150 EJ in the next 20 years. Biomass is therefore expected to play a crucial role in the development and operation of a new energy system based primarily on RESs [20].

The gross final energy consumption of all energy sources worldwide in 2019 was 379 EJ, of which renewables accounted for 17%. The global domestic supply of biomass was 56.9 EJ. Eighty-five percent of the domestic supply was from solid biomass sources, including conventional biomass sources, wood chips, and wood pellets. Liquid biofuels accounted for 8%, while the municipal and industrial waste sector accounted for 5% and biogas for 2%. In 2020, 1.93 billion m^3 of woodfuel was produced globally. In terms of share, woodfuel production was highest in Africa and Asia, at 36% and 37%, respectively. In addition, wood pellets represent one of the fastest-growing bioenergy sectors worldwide. The transport sector is dominated by crude oil and oil products, which accounted for 92% of total energy demand. Liquid biofuels of different generations and biogas are increasingly being identified as a sustainable option for the sector. The share of biofuels is currently 3.3%, but is increasing year by year [1]. The above-mentioned details, as well as the present energy supply issues and the growing need to reduce energy dependence, underline the importance of local energy use and the role of newer-generation fuels [21]. In addition to the predominant heat production, biomass-based electricity generation (226 TWh) and transportation fuel production (160 billion litres) are also significant for energy recovery [1].

The potential for bioenergy production is largely determined by the amount of land available to produce food and feed to meet growing population demands. Governments in industrialized countries advocate energy policies that emphasize reducing global warming by lowering greenhouse gas emissions. The area sown for energy crops (25 million hectares) occupies only 0.19% of the global land area and about 0.7%–1.5% of agricultural land [22]. Looking at several scenarios [23], the amount of energy potential is estimated at 273–1470 EJ by 2050, of which Africa is expected to provide the largest share (around 20%–25%) among the continents. The situation seems to be interesting from country to country; nonetheless, below are some interesting aspects of three of the top five countries in terms of the number of publications in the field of biomass publications. In China, biomass potential is increasing continuously; however, the ratio is not the same and balanced in all regions equally. For example, South China reports a higher growth ratio than that of North China, due to climate and natural resources, especially water resources, temperature conditions, and woodland [24]. According to the same document, the future of energy supply in China can rely 10% on bioenergy derived from the residues and energy crops. Considering land use, irrigation conditions, and climate change, the expectations for bioenergy potential of energy crops and residues are forecasted to reach 4.19–6.61 EJ in 2030 and 5.11–11.01 EJ in 2100. These targets are quite promising in the case of China. Due to its large territory and differences between regions, biomass can also play a prominent role in India. Socio-economic, cultural, and environmental factors, education level, level of incomes, family size, and religious orientation appear to be some of the key determinants for biomass use [25,26]. It is evident that most rural areas in India still use biomass for cooking if they do not have access to modern LPG cooking stoves [27]. Concerning Germany, the total biomass capacity for energy supplies from agriculture, forest, and resulting residues or waste is approximately 64 MM tDM [28]. From this quantity, 34% is attributed to energetic purposes from residues/waste and agriculture with renewables, whereas the forest share remains at a slightly lower percentage of 31%. Other critical information to consider is that by the end of 2015, Germany had approximately 8900 biogas plants, which could produce 4410 MW and 27.9 terawatt-hours (TWh) possible electricity production.

The potential forecast can be divided into several differential categories. The theoretical potential is the total amount of biomass that can be produced (or formed) within physical and biological constraints, the technical potential is the amount that can be produced with the current technologies, the economic potential is the amount that can be produced economically, and the ecological potential is that amount that can be produced taking into account natural conservation aspects (biodiversity and soil erosion) [23]. As the latter three categories are highly fluctuating, global estimates usually attempt to predict the theoretical potential. According to Ladanai and Vinterbäck [22], half of all scientific publications on renewable energy in 2008 (4911 records of 9724) discussed bioenergy research. The distribution of biomass feedstocks (agriculture, forest, waste, and others) published in scientific papers was almost the same. According to Mao et al. (2015) [29], of the 33,072 scientific articles on biomass energy in 129 categories in the SCI database between 1998 and 2013, the largest share was in the Energy and Fuels category (31%), followed by Engineering (27%) and Biotechnology and Applied Microbiology (23%), and the others were lower.

Today, however, research on photovoltaic energy and energy crops can be considered a more relevant topic regarding renewable energy; they could be the most significant competitors of biomass energy use. In addition to the above, it is necessary to mention the emergence of new concepts that have only come to the fore in recent years, such as the bioeconomy or the circular economy. According to Ranjbari et al. [30], over the past decade, the increasingly intense professional discourse on sustainability and the various efforts focused primarily on environmental and economic challenges have brought the bioeconomy and circular economy to the fore. At the same time, research and publications linking biomass potential and utilization with the bioeconomy and the circular economy (or circular bioeconomy) have increased in numbers. Within each of these concepts, the area of bio-resources is also highlighted, focusing on the role of research, development, and demonstration on bio-resources in sectors such as agriculture, marine, forestry, and bioenergy, and the creation of new value chains [31]. Furthermore, to increase biomass production's volume and added value, another important target is to strive for the full utilization of biomass and organic waste [32].

As a renewable energy source, biomass is considered to have a growth potential as a result of its availability on a world scale. Moreover, biomass can be obtained as a by-product of various agricultural and industrial processes [33]. One of the essential aspects of biomass that makes it appropriate as an energy source is that biomass substances may be burned directly in waste conversion plants to generate electricity [34] or in boilers to generate heat at industrial and domestic levels [35]. One worrying element is the ongoing debate between food and fuel needs. A recent study suggested that four biofuel crops, including wheat, maize, sugarcane, and sorghum, could have possibly fed upwards of 200 million people [4]. Biomass utilization has been evolving annually, and now great attention is attributed to identifying new generations of biofuels. Based on this article [36], due to the raised demand for biofuels, the first two generations of biofuels will be inadequate for satisfying all the related needs. This regard has increased support for the development of third and fourth generations of biofuels, emphasizing the engineered microorganism. In addition, the utilization of bioethanol has received significant attention and importance in recent decades, and an important advantage could be that bioethanol can help to lower CO_2 levels by reducing reliance on and consumption of fossil fuels [37]. A unified definition of biomass includes any organic matter that derives either directly or indirectly from the process of photosynthesis of plants and algae and organic matter originating from animals, but not fossilized materials. The scope of materials that fit this definition is very wide, so their use is huge in real life [38]. Recently, the use of biomass has gained more importance in the field of energy production, while in this aspect, priority is given to having lignocellulosic materials from forests and agriculture [39]. However, some of the most common types of biomass are as follows: wood, sawdust, straw, seed waste, manure, paper waste, household waste, and wastewater [40]. Some materials can be used as fuels directly due to their properties; however, some other materials require a sequence of pretreatments that need different technologies in order to use them.

Biomass has several advantages depending on what aspects are considered, starting from the aspect of the environment where biomass has the role of an energy source for natural biomass, the transition to a low-carbon economy, the use of non-edible biomass, and the benefits of neutral CO_2 conversion and climate change benefits [41]. However, in the environmental assessment of firewood (which has great importance in heat production), it was considered a highly polluting fuel, in fact, a nonrenewable energy source, especially by the less well informed (older, poorer, less educated) in the US [42] and in Hungary [43]. A survey with a choice experiment methodology showed that GHG emission has a lower weight in sustainability attributes compared to land demand and local income [10]. Moreover, the advantages of biomass can not only be highlighted in terms of rural development through revitalization and income generation, creation of new jobs, restoration of contaminated and degraded lands [44], but also in the technological aspect, providing large and affordable sources of biofuels, fertilizers, building materials, synthesis of some materials, as well as the recovery of certain elements and compounds. The extraction of raw materials from the countryside [45] is one of the opportunities for job creation that biomass generates. Another vital aspect of biomass is the storage of solar energy; especially in recent years, special emphasis has been given to the gasification process, which is estimated to improve the use of biomass feedstocks and energy efficiency by up to 30% and 40%, thus effectively conserving solar energy in the gas producer. Another document evaluates the thermodynamic and economic performance of a solar–biomass gasification polygeneration system, which is also favorable [46,47]. This system reduces CO_2 emissions and offers alternatives to the use of renewable energies of solar and biomass resources.

Biomass as a biofuel is currently an interesting topic for scientific researchers. The number of scientific articles in many fields has increased exponentially in recent years, directly affecting the changing behavior of scientific research [48]. Moreover, a possible conclusion is that the increase of documents reveals the change in terms of scientific knowledge in a particular field. Moreover, the rising number of publications is indicative of the rise in the level of importance of a specific area.

Even though many articles are pointing out the biomass resources on a world scale, this article aims to give information about the publication of articles regarding biomass production globally. Its utilization by country, especially its use in the energy field, focuses on the importance of the future generations of biofuels. On the other side, tables and figures categorizing different periods give an added value to the article and the field. Moreover, statistics, citations, and collaborative work between countries enrich the outcome of this article.

2. Materials and Methods

One of the purposes of the literature review is undoubtedly the planning and evaluation of the subject or topic being analyzed to find research gaps and highlight new knowledge in that field [49]. Existing literature is often summarized and categorized into keywords and titles in order to easily identify the areas and trends for which research will be conducted [50]. The idea behind this paper is to look at the systematic aspect of the work of publications at a global level in terms of the biomass potential and its utilization. Therefore, two keywords, “biomass potential” and “biomass utilization”, were chosen for further analysis, and search fields included titles, abstracts, and keywords. In this way, through the Scopus database, it was possible to obtain a sufficient number of publications through which the analysis, interpretations, and conclusions were conducted.

Bibliometric studies provide an intriguing overview of a country’s scientific activity and its position in the international aspect, providing essential information to aid those in charge of scientific policy to take the most appropriate actions. A thorough search of Elsevier’s Scopus database was undertaken in this study by using the subfields (TITLE-ABS-KEY (biomass AND potential) AND TITLE-ABS-KEY (biomass AND utilization)) to locate papers addressing the issue from 1974 to 2021. The reason for starting the search in 1974 is that the first seminal document on the two keywords was published in that year.

As a scientific journal bibliographic database with the widest selection of scientific articles owned by Elsevier [51], Scopus was chosen for this bibliometric analysis as it is one of the most important scientific bibliographic databases. As of 2019, over 80 million records were contained within Scopus [52]. Scopus is one of the most important archives of literature that employ peer review as a method of study validation [53]. Several studies [54,55] show that Clarivate Analytics Web of Science (WoS) and Elsevier Scopus provide the best-quality bibliographic data for longitudinal analyses. Therefore, the WoS and Scopus databases were checked for the analysis scope. It was found that Scopus roughly provides a superset of the bibliographic records given by WoS, including some additional documents published in conference proceedings. It should be noted that the number of citations varies significantly from database to database, so mixing records from different databases results in inconsistent numbers [56]. Scopus was therefore chosen as the sole data source for the study sample.

Scopus features a user-friendly interface that aids in the visualization of data using applications like VOSviewer [57]. VOSviewer is a free program that allows the user to create and analyze bibliometric networks using data from bibliometric searches in major databases such as Scopus [58]. The analysis was performed by conducting the three main stages, as shown in Figure 1.

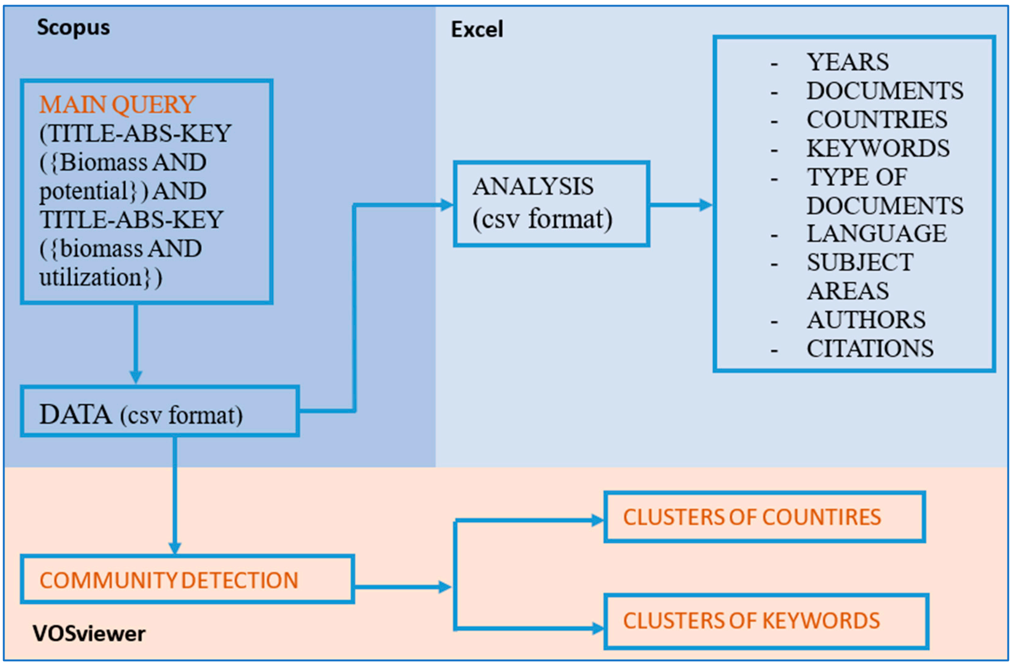

Figure 1. Methodology scheme. Source: created by the authors.

The first stage presents a general search based on the keywords selected. From 1974 to the end of 2021, a total number of 7117 documents were obtained. The second stage involves the export of the metadata of the documents to a .csv file, which was analyzed with Excel software. Then tables and figures were created and described focusing on the biomass potential and its utilization topics on the world scale. The third stage reflects on the bibliographic analysis through the performance of descriptive data by using the VOSviewer bibliometric tool to analyze co-occurrences of keywords and collaborations between countries in terms of publication documents, where the different clusters were analyzed. Once the results of the Scopus search related to biomass potential and utilization were obtained, this study executed an analysis of the scientific production and its trend, the number of publications based on countries on a world map, the evolution in the use of keywords, the publication types of documents, the language of the documents, the main subject areas in this field, the main authors in the subject, and their number of citations.

The methodology used in this study is detailed in the following steps: (1) Global search for information. (2) Then, the Scopus database was used to search for information using the following search fields: (TITLE-ABS-KEY (biomass AND potential) AND TITLE-ABS-KEY (biomass AND utilization)). (3) Each search result was a .csv file containing the following Citation information: Authors, Author IDs, Year, EID, Source title, Volume, Issue, Pages, Citation count, Source and document type, Publication Stage, DOI, Open access. Bibliometric information: Affiliations, Serial identifiers (e.g., ISSN), PubMed ID, Publisher, Editor(s), Language of the original document, Correspondence address, Abbreviated source title. Abstract and keywords: Abstract, Author keywords, Index keywords were also included. (4) Each aspect of the above data was analyzed and studied separately. (5) Finally, the main authors were identified from those who have published on this subject, and the types of documents that have been published were identified (articles and reviews).

The clustering analysis method represents a grouping of keywords in specific categories, which are mostly independent compared to other categories. Linlog modularity was applied to design the clusters based on different (bottom-up) parameters using agglomerative hierarchical clustering. Using Ward's methods, data were grouped based on the nearest distance measure. Keywords within a category represent a certain similarity or a close relationship between themselves. Furthermore, the clustering analysis method analyzes the frequency of keywords using statistical methods in terms of grouping keywords that are closely related to each other [59].

3. Results and Discussion

The number of publications produced by a country or an area is a helpful indicator of these units' scientific activity. In particular, studying the different trends and activities of countries or areas concerning a certain field of study is of significant interest. Using this approach, the research process reveals and highlights the latest models of the evolution of the given topic while localizing the results. Moreover, it is interesting to track how the scientific progress of specific topics has changed over the years and identify the advantages and priorities that are expected to take place in the future.

3.1. Trend Publications

Only a few documents on biomass potential and biomass utilization were written each year from 1974 to 2000; even though the trend was improving, it did not exceed 50 publications per year. The number of publications has been steadily increasing since 2000, as shown in Figure 2. A leap can be seen in 2011, but from 2012 onwards, a significant increase begins. The quantity of scientific papers in the field of biomass potential and utilization has increased significantly, as shown in Figure 2, by the R^2 = 0.989 fit curve. In accordance with this upward trend, which was also highlighted in the review article of [60], both graphs also show a rising trend in the last two decades. What is worth noting is that both for biomass in general and for biomass potential and its utilization, 2011 produced more documents than did the following year. However, one change between Figure 2 and the trend in the study of Perea-Moreno (2019) [60] worth noting is that the year 2008 produced a much larger number of publications in terms of biomass in general compared to biomass potential and its utilization field. The increase in the topic of biomass in general is probably due to the Kyoto Protocol's entry into force in 2008, which set a target of a 5.2% reduction in greenhouse gas emissions between 2008 and 2012 (compared to 1990 levels) [60]. In contrast, the biomass potential and its utilization field did not come to the fore.

3.2. Worldwide Distribution of Publications

Figure 3 shows world scientific production by country of origin. According to the number of publications, each country has an assigned color that goes from dark blue, which indicates a greater number of publications, to light blue, which indicates a lower number of publications. In contrast, the non-existence of publications is marked with light brown. China stands as the country with the highest number of publications (1441) in this field, followed by the United States (1124), India (763), Germany (416), and the United Kingdom (350). From this, significantly, it can be concluded that biomass potential and utilization in developed countries is a crucial component of attaining sustainable development, especially for energy use, while in developing countries, food and feed production has higher significance. The number of documents is in line with the biomass potential of these countries, as was mentioned in the literature review [24–26,28], and is also related to the promising targets set for the future and a very diverse utilization of biomass, especially in India. In this country, biogas production is very popular, not environmentally but especially from the sludge management point of view.

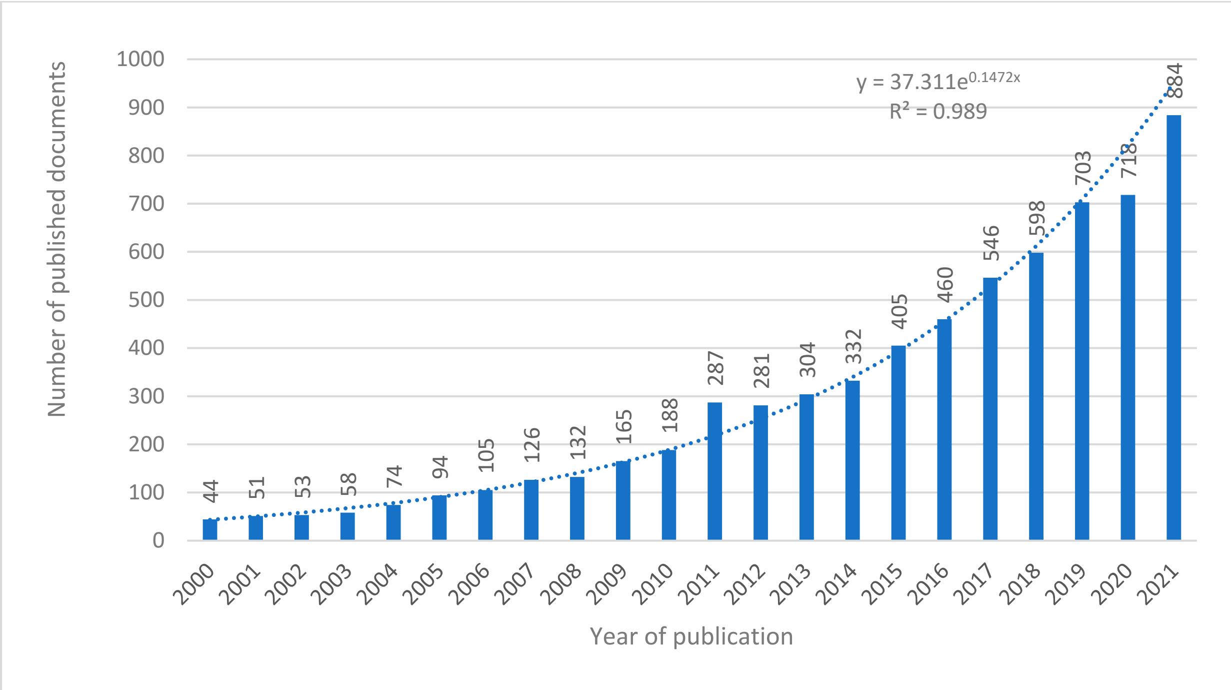

Figure 2. Publication trends of Scopus-based search literature on biomass potential and utilization. Source: created by the authors.

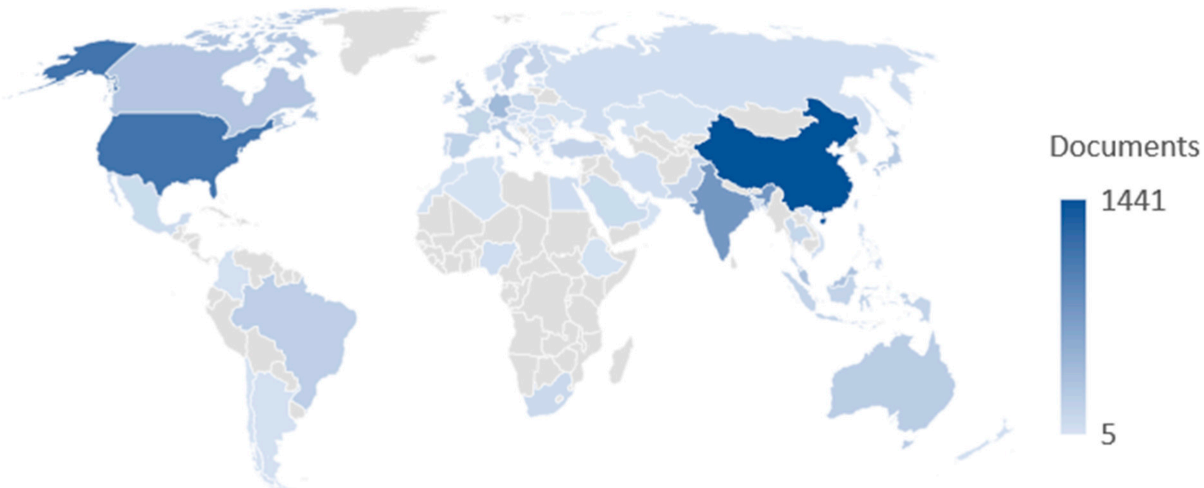

Figure 3. World scientific production in biomass potential and its utilization by country of origin. Source: created by the authors.

For biomass use, the five main consumers are the same countries that are the leading net importers, countries such as the United States, mainland China, South Korea, Japan, and the United Kingdom. At the same time, the top countries in terms of net exporters are the same as the main exploiters of biomass resources, including countries such as Brazil, India, Indonesia, Cyprus, and Latvia [61]. As is shown in Figure 3, the interest of researchers in biomass potential and its utilization on a world scale is quite high, since 195 countries have published at least one document related to the given topic. At the same time, 90 countries have published more than five documents, followed by 58 countries that have published more than 20 documents on the related topic, and more than 100 articles related to biomass topics were published from 24 countries each. Figure 4 presents the 50 most important countries, which have published at least 26 documents, out of 195 total countries. These countries form a network of co-authors in which authors are indirectly linked through their participation in one or more publications. The 50 items are categorized within four clusters. The red cluster includes most European countries, followed by the green cluster, which includes countries from Southeast Asia, including China and India, as the most important ones in this cluster. In the blue cluster, the main countries are Malaysia and Australia, including a few countries from West and South Asia and two countries from Africa. Most of the countries in the yellow cluster are from North and South America, including also UK and Russian Federation. The central actors of the clusters are also the countries that mainly provide the connection between the clusters.

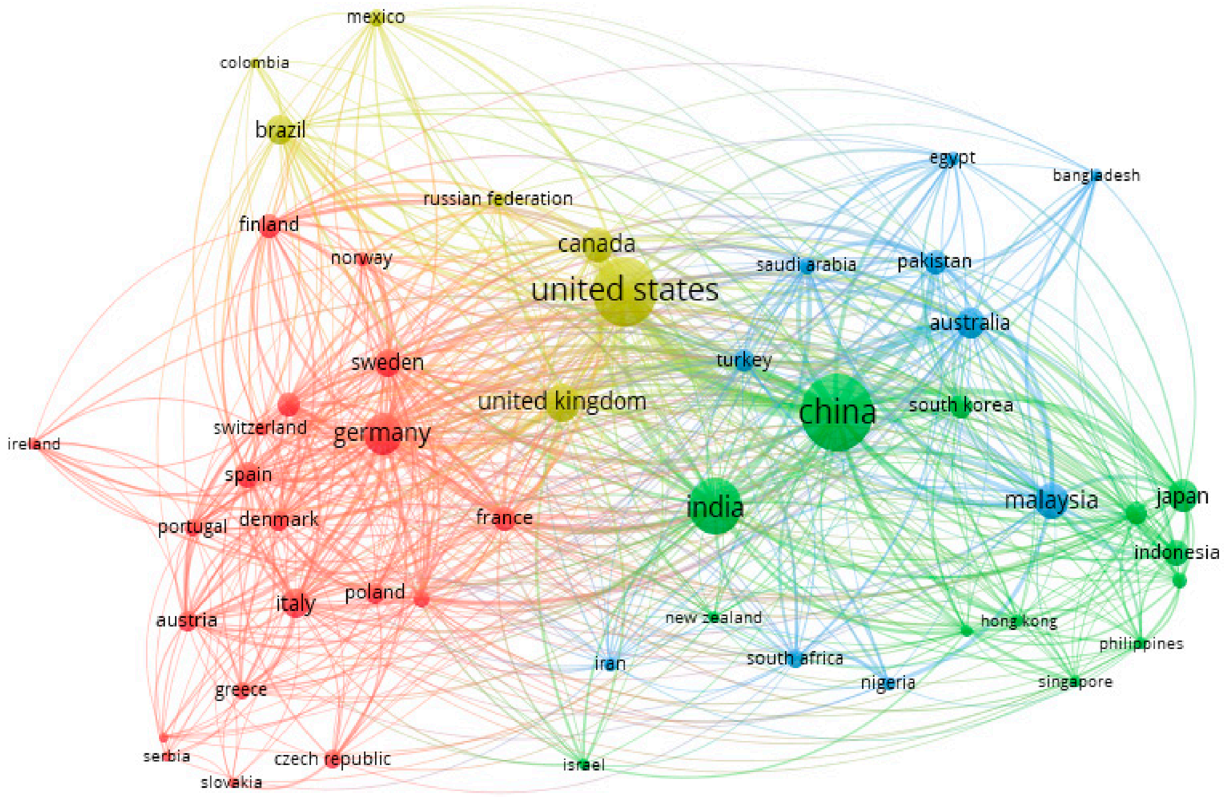

Figure 4. Collaborative work between countries. Source: created by the authors. Clusters name: red: Europe; green: South Asia and India; blue: Australia, Malaysia, and West Asia; yellow: North and South America, UK, and Russia.

Figure 5 represents the evolution of the number of documents from the five countries with the highest scientific production for biomass potential and its utilization for the last 21 years. As mentioned before, the growth trend of publications marks a significant increase after 2012 globally. However, the upward growth in these countries in terms of publication of documents on the potential and utilization of biomass is observed after 2014. While 2021 is when the peak was reached for China and India, and the upward trend is more emphasized for these two countries due to the potential to provide employment and its widely available resources. Other countries have had a more stable stance regarding the number of publications in recent years.

3.3. Keywords

Keywords reflect a general overview of the literature and are commonly used to provide guidance on the content of the whole document [59]. Table 1 presents the total link strength, which indicates the number of links between an item with another item. This score indicates the keyword's relevance in the field, as a greater value indicates that it has been associated with others several times. The number of occurrences indicates how many documents the keyword appeared in. Only the relevant and most important terms to this study are listed in the table.

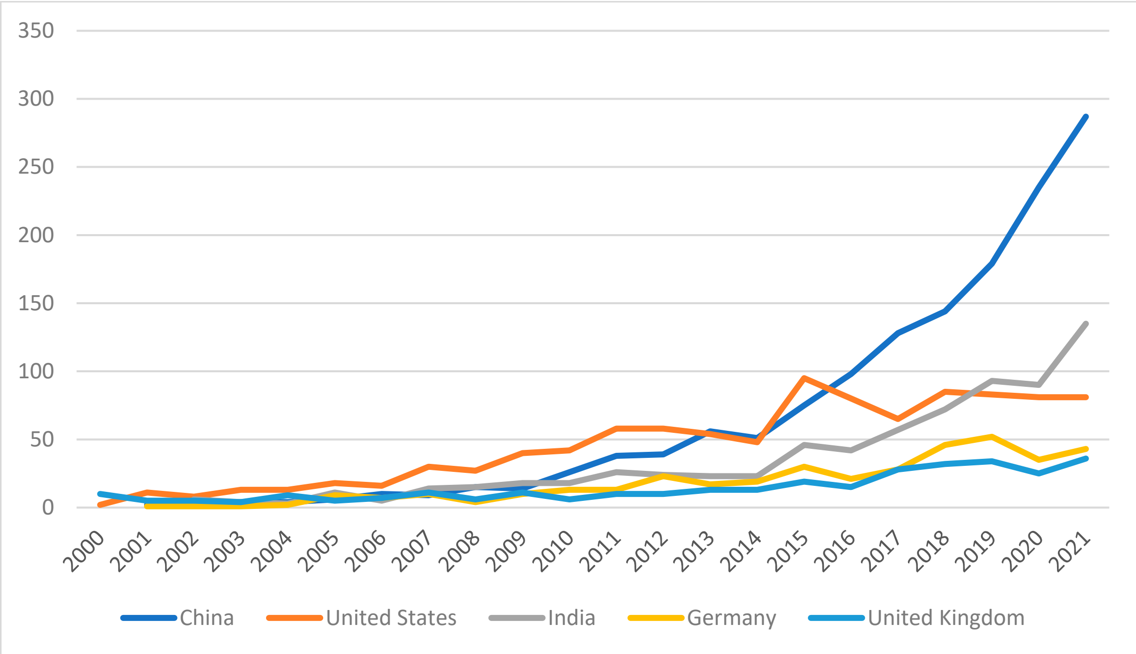

Figure 5. Trends in publications on biomass potential and its utilization in the last 22 years for top five countries. Source: created by the authors.

Table 1. Most used keywords in the period 1974–2021.

Keywords	Total Link Strength	Occurrences	%
biomass	44,545	3629	24.4
biofuel	21,639	1253	8.4
fermentation & biogas & anaerobic digestion	18,676	1146	7.7
carbon dioxide & greenhouse gases	14,647	1012	6.8
energy utilization	11,631	976	6.6
nonhuman	17,525	864	5.8
algae & microalgae	10,505	660	4.4
carbon	9130	561	3.8
metabolism	10,161	539	3.6
lignin	6817	466	3.1
cellulose	6933	466	3.1
sustainable development	5910	452	3
bioenergy	6052	419	2.8
fossil fuels	5503	407	2.7
lignocellulosic biomass	4643	350	2.4
feedstocks	4436	309	2.1
microorganisms	4589	293	2
pyrolysis	3731	292	2
bioethanol	4071	272	1.8
wastewater treatment	4386	265	1.8
life cycle	4522	255	1.7

Source: created by the authors.

3.4. Figures with VOSviewer

One of the functions of the VOSviewer is to analyze the keywords of many documents, grouping them into categories that absorb the keywords under the same community and providing them with a visual format in the best way possible. The co-occurrence network for keywords is shown in Figure 6. The former contains 60 of the 13,123 keywords that appeared in publications between 1974 and 2011; each keyword was used at least 51 times. In Figure 6, three clusters are presented. The red cluster is the main one and covers more than 50% of the entire database (including energy, its feedstock, and environment), followed by the green, which is positioned on the right side (including microbiological, technological, publication, and general expressions), the remaining blue one includes only two keywords out of 60, these are biofuels and feedstocks (overlapping with the green cluster).

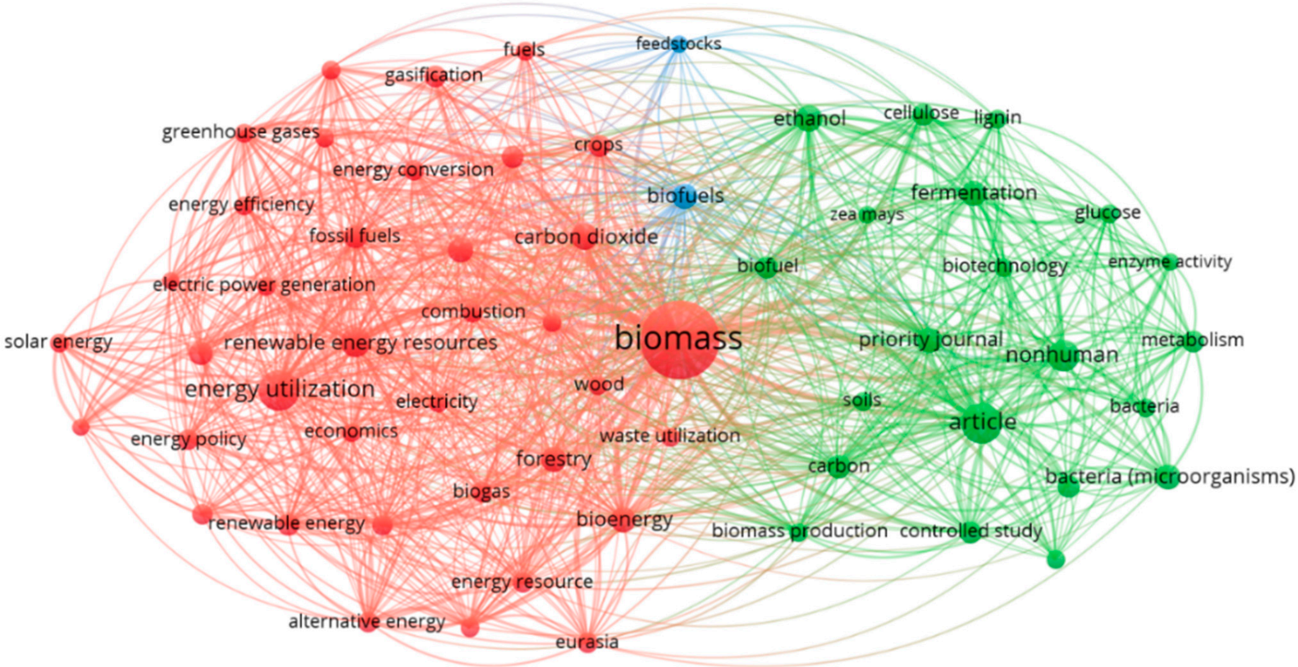

Figure 6. Keyword co-occurrence network regarding biomass potential and its utilization from 1974 to 2011. Source: created by the authors. Clusters name: red: energy use, its feedstock, and environment, green: microbiological, technological, publication, and general items, blue: next-generation transportation fuels.

Figure 7 shows 60 of the 30,883 keywords that appeared between 2012 and 2021; each keyword was used at least 176 times. The figure reveals which areas have become more significant or have developed the most since 2012. For example, the third cluster with blue color gains more importance in Figure 7. The red cluster has the majority of the keywords in the previous figure. The number of keywords within the red cluster has decreased significantly, while the number of keywords with green has increased. As shown in Figure 7, the blue cluster has seen considerable growth in popularity over the previous decade, resulting in advancement in research on keywords for third- and fourth-generation biofuel, such as biofuel, algae, microorganisms, microalgae, biodiesel, and microalgae. Furthermore, bibliometric mapping of research outputs revealed that third- and fourth-generation biofuels are now under development and will soon reach the point where they can be produced at an industrial scale [36]. The occurrence of biomass is not directly connected to human nutrition or energy production (expression of "nonhuman" in Figures 6 and 7), and it remains stable with moderate significance.

Figure 7 presents the 60 most used keywords in the period of 2012–2021, categorized into three clusters.

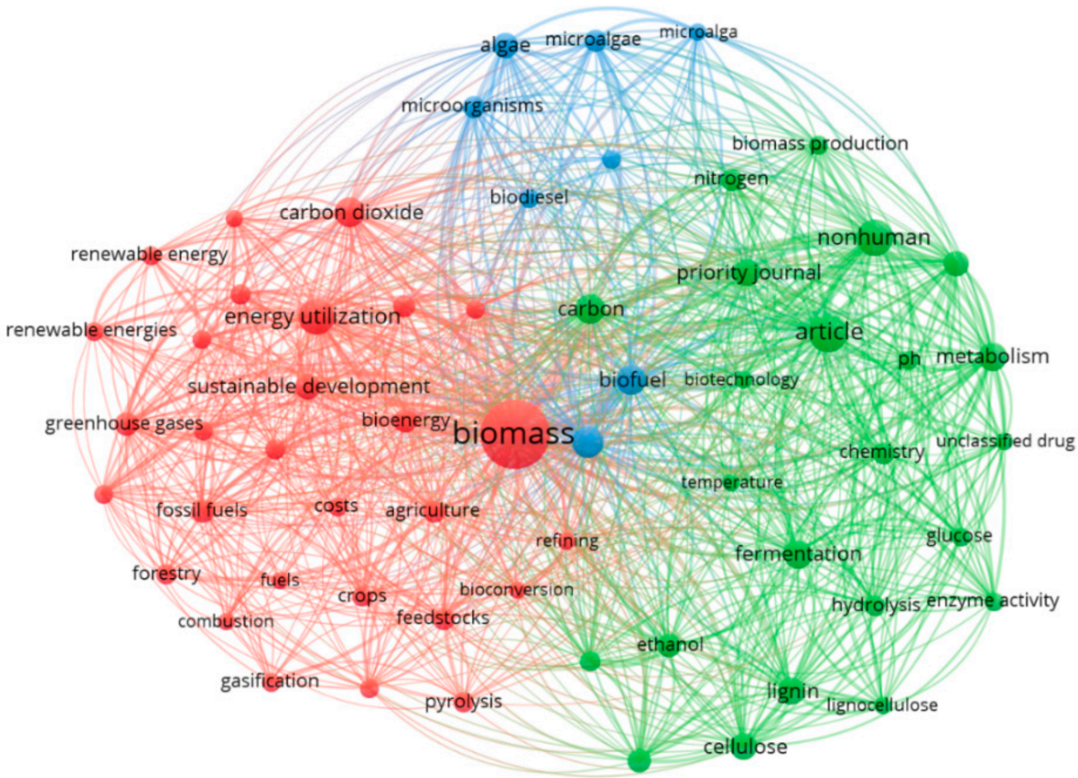

Figure 7. Keyword co-occurrence network regarding biomass potential and its utilization from 2012 to 2021. Source: created by the authors. Clusters name: red: energy use, its feedstock, and environment, green: microbiological, technological, publication, and general items, blue: next-generation transportation fuels.

The study of [30] showed that in the last few years (especially from 2019 onwards), the concepts of circular economy, bioeconomy, and circular bioeconomy have been increasingly studied in connection with biomass resources and different utilization methods. However, in the analysis carried out in this article, which covers the period 2012–2021, this trend is not yet apparent due to the time span. As a result, this study's most frequently used keywords remain the same as those in the previous results of [30,62,63], such as biogas/anaerobic digestion, sustainability/sustainable development bioenergy, biorefinery, and biofuel.

3.5. Type and Language of Publications

A number of 7117 documents were obtained from the search carried out considering various fields and types of documents for the period 1974–2021. Articles accounted for the majority of the different types of publications (68.67%), followed by Reviews (13.38%) and Conference Papers (12.42%). The low number of other documents can be attributed to the fact that conference proceedings cannot be accessed in Scopus. Figure 8 shows the various categories of papers relating to biomass potential and utilization from 1974 to 2021.

In terms of the languages used in the publications, English comprised 95% of the papers, whereas more minor national languages are not typical (well under 1%). Figure 9 shows the percentage of different languages in which the various bibliometric analysis materials have been published.

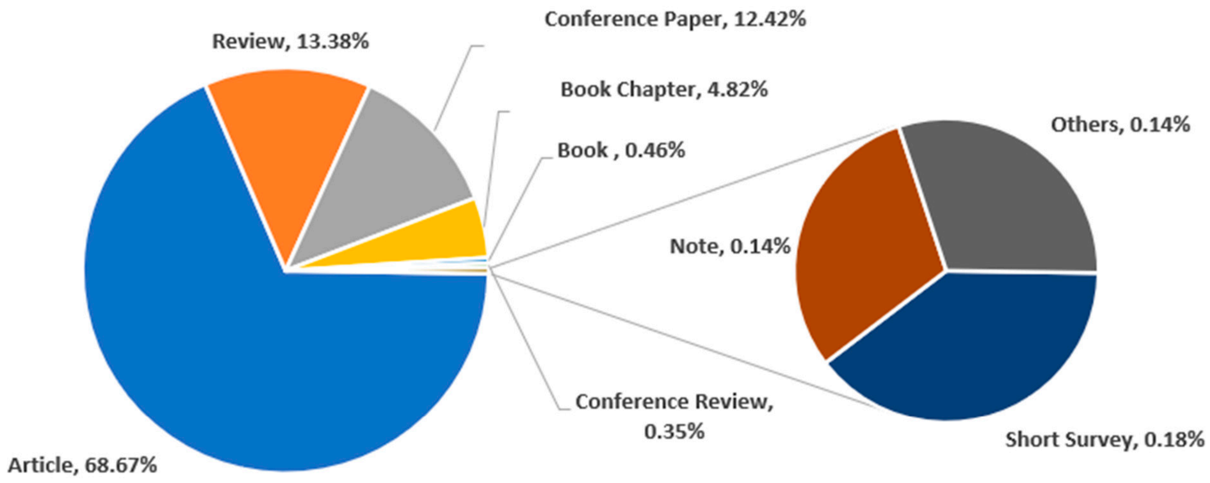

Figure 8. Distribution of different types of publications for the period 1974–2021. Source: created by the authors.

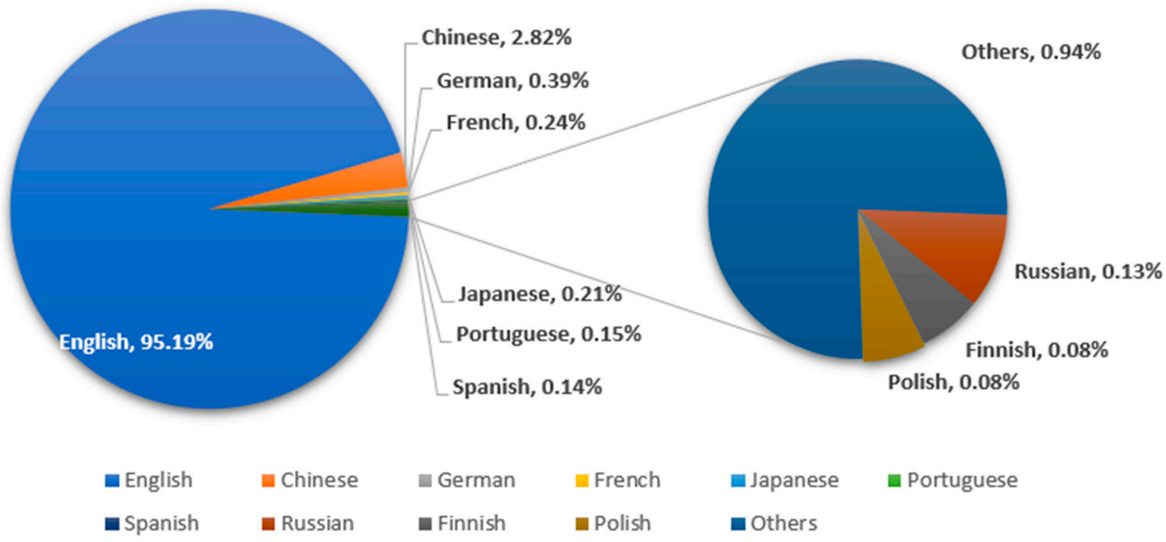

Figure 9. Distribution of publications by language for the period 1974–2021. Source: created by the authors.

3.6. Subject Categories

The distribution of publications by thematic areas was also obtained from the Scopus database's bibliometric analysis. After comparing trends over the years, interestingly, subject categories have changed over the years in terms of their percentages. For instance, Energy as a subject category during the period of 1974–2000 was listed as the fourth category with a rate of 14.07% after Environmental Science, Engineering, and Agricultural and Biological Science. However, by the year 2010, Energy as a subject category went upward to third place (16.4%), while Environmental Science remained the first category with an unchanged percentage of 19%. Figure 10 shows that the highest percentage of documents for the period of 1974–2021 was in the area of Environmental Sciences, followed by Energy and Agricultural and Biological Science. Engineering is listed as the fourth one. Areas such as Earth and Planetary Sciences, Materials Science, or Chemistry were found to a lesser extent. The "Others" area includes unspecified subject areas and covers 9.56%.

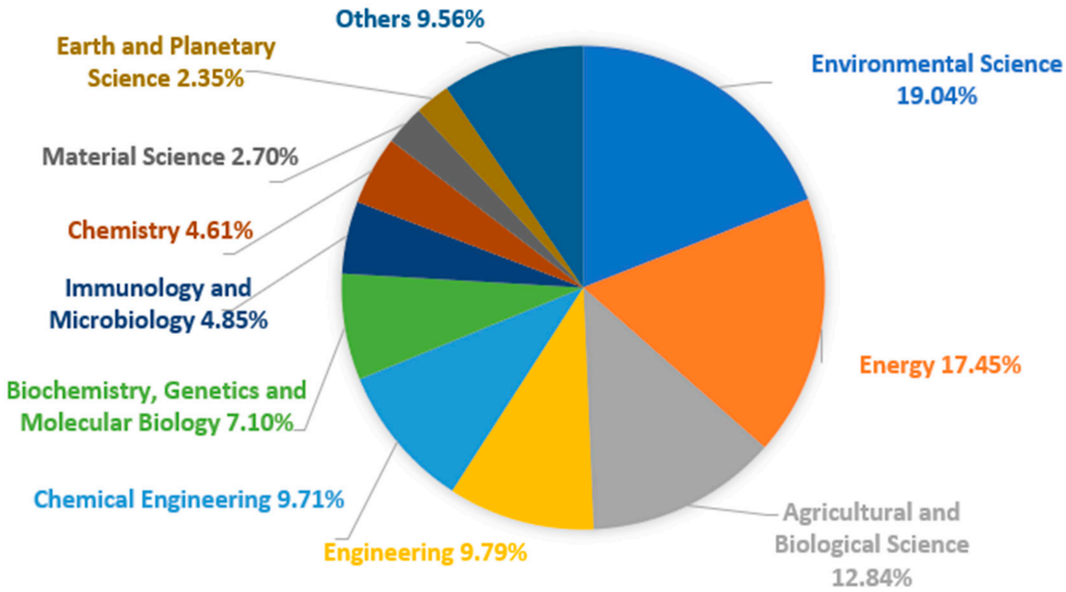

Figure 10. Subject categories of publications for the period 1974–2021. Source: created by the authors.

If only the last decade is analyzed, the percentage of Environmental Sciences decreases to 18.93%, whereas the percentage of Energy as a subject category constantly increases to 17.64%. A conclusion can be that the Energy subject category is gaining more importance in terms of biomass potential and its utilization. An increasing number of articles are being published for this subject category annually. On the other side, Engineering was listed as the second category based on the documents published by the year 2000. At the same time, based on the last decade's trend, this subject category goes down to fifth place.

In order to examine the trends in subjects of biomass use, the 27,795 articles for biomass energy analysis from the Scopus database were divided into 27 subject categories. The contribution of the top 10 subjects in biomass energy research from 1974 to 2021 is shown in Table 2. The period was divided into three parts to see the growing role of the Energy subject in the publications.

Table 2. The 10 most productive subjects during the three periods.

1974–1999			2000–2009			2010–2021		
Subject	**TP**	**%**	**Subject**	**TP**	**%**	**Subject**	**TP**	**%**
Environment	433	39.2	Environment	1570	38.9	**Energy**	**9645**	**42.6**
Agriculture	324	29.3	**Energy**	**1277**	**31.6**	Environment	9589	42.3
Engineering	322	29.1	Agriculture	961	23.8	Engineering	4879	21.5
Energy	**271**	**24.5**	Chemical Eng.	882	21.8	Chemical Eng.	4667	20.6
Earth Sciences	169	15.3	Engineering	720	17.8	Agriculture	4389	19.4
Chemical Eng.	145	13.1	Biochemistry	590	14.6	Chemistry	2342	10.3
Biochemistry	140	12.7	Chemistry	456	11.3	Biochemistry	2171	9.6
Microbiology	121	10.9	Microbiology	423	10.5	Materials Science	1162	5.1
Chemistry	41	3.7	Earth Sciences	311	7.7	Physics	1103	4.9
Physics	31	2.8	Physics	215	5.3	Microbiology	1100	4.9

TP: the number of total publications. Source: created by the authors.

Table 2 shows that the total number of the relevant publications from the first period (from the first oil crisis to the millennium) was relatively low with 42 publications per year. In the first decade of the 2000s, it had an increase in magnitude (404 articles/year), and the trend continued after the Kyoto Protocol's entry into force (1887 pieces/year).

Another typical tendency is that research on biomass utilization has increasingly focused on energy, the role of environmental protection has remained dominant, while the importance of agricultural utilization has declined. In the authors' view, this trend can be clearly explained by the growing importance of biomass-based energy production and of rural development aspects as opposed to conventional food production and research.

3.7. Relevant Journals

The rank of journals based on the number of relevant publications is shown in Table 3. All journals belong to the "Renewable Energy, Sustainability and the Environment" subject area, in accordance with Figure 11 and Table 2 (previous). Most articles can be found in Q1 and D1 categories in Elsevier journals. The journal Sustainability (MDPI) published only 39 articles on the subject. The energy subject is very popular in the Sustainability journal, but biomass potential and its methods of utilization have not been among the most popular research topics; however, they might be interesting for researchers and readers.

Table 3. Journals with the most significant number of publications (reference period: 1974–2021).

Journal	Year of Launch *	TP	Publisher	Country	H Index	SJR
Renewable and Sustainable Energy Reviews	1997–	249	Elsevier	United Kingdom	249	3.52 (Q1)
Bioresource Technology	1990–	208	Elsevier	United Kingdom	294	2.49 (Q1)
Journal of Cleaner Production	1993–	166	Elsevier	United Kingdom	200	1.94 (Q1)
Biomass and Bioenergy	1991–	153	Elsevier	United Kingdom	180	1.04 (Q1)
Renewable Energy	1991–	97	Elsevier	United Kingdom	191	1.83 (Q1)
Biotechnology for Biofuels	2008–	83	BMC	United Kingdom	93	1.44 (Q1)
Energy	1976–	83	Elsevier	United Kingdom	193	1.96 (Q1)
Science of the Total Environment	1970, 1972–	77	Elsevier	Netherlands	244	1.80 (Q1)
Fuel	1922, 1970–	71	Elsevier	Netherlands	213	1.56 (Q1)
Energies	1975–1976, 2009–	66	MDPI	Switzerland	93	0.60 (Q2)

Legend: *: the "Year of Launch" column contains the launch years and operation period(s) for each journal based on SCImago Lab and the Scopus database; TP: the number of total publications. Source: created by the authors.

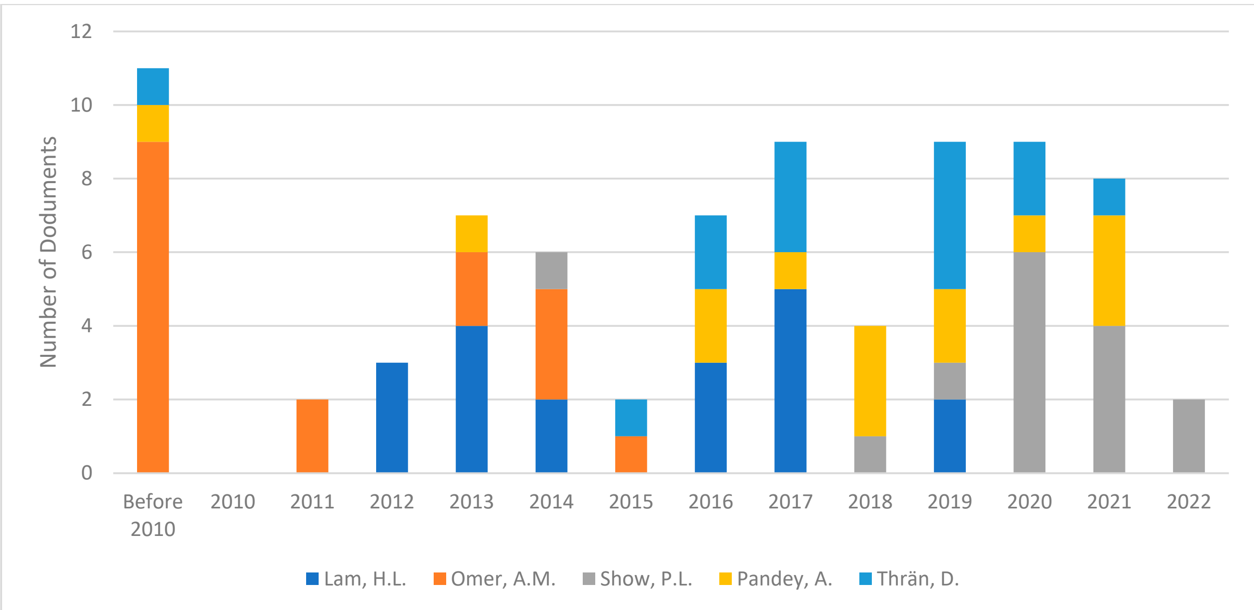

Figure 11. Bar chart of the five main authors' publications. Source: created by the authors.

The ranking in Table 3 applies not only to the number of total relevant publications but also to publications per year (1–10 pieces per year), with two notable exceptions. "Biotechnology for Biofuels" (BMC) and "Energies" (MDPI) are ranked third and fifth based on the number of publications per year, due to their much shorter lifespan, with increasing significance, especially in the last few years. As regards the overall scientific performance, "Renewable and Sustainable Energy Reviews" and "Bioresource Technology" are impressive, while "Science of the Total Environment" and "Fuel" have the longest history when considering the launch years and operating periods.

3.8. Main Authors

This study also carried out an analysis of the most prominent authors in the field of biomass potential and its utilization. Figure 11 presents the scientific output of the five main authors on this subject. Lam, H.L. stands out in this field with 19 publications, followed by Omer, A.M. (17) and Show, P.L. (15), whereas Pandey, A. and Thrän, D. have 14 publications.

In terms of the number of citations, Pandey, A. has the most citations with 1172, with most of them coming from the article titled Biotechnological potential of agro-industrial residues. I: Sugarcane bagasse [64] alone accumulated 828 citations. The second most cited author in this field is Show, P.L. (568). Whereas, Lam, H.L. is ranked as the third one with 267 citations. Thrän, D. and Omer, A.M. are ranked fourth and fifth with 229 and 131 citations, respectively (Figure 12).

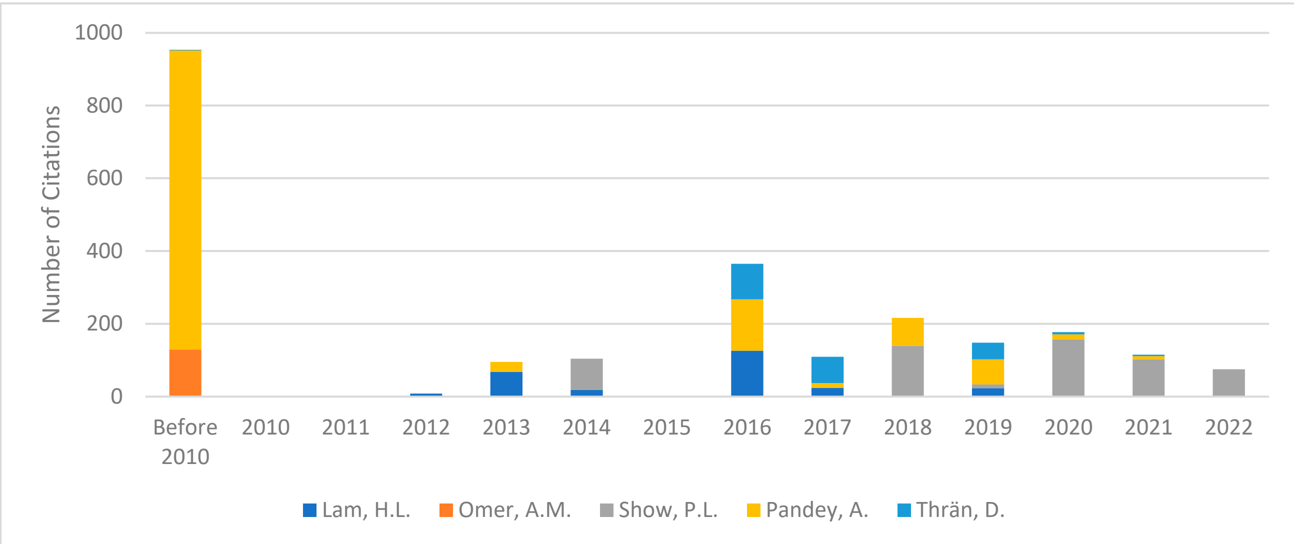

Figure 12. Bar chart of the number of citations for the five main authors' publications. Source: created by the authors.

If we exclude these five authors who have published the most, then other articles that have accumulated the most citations are as follows: the first most cited paper, published in 2010, is entitled Biofuels from microalgae—A review of technologies for production, processing, and extractions of biofuels and co-products [65], with a total of 3029 citations. The article of Naik et al. [66] can be mentioned in second place, entitled 'Production of first- and second-generation biofuels: A comprehensive review' with 1899 citations, while the third most cited scientific article is the work of Weiland [67], titled 'Biogas production: Current state and perspectives', with 1720 citations.

4. Conclusions

The biomass potential is enormous, and intensive research is essential to identify the most feasible and efficient combination or portfolio of biomass utilization options that are tailored to the specific conditions of a given region or area. Because of the fast-growing energy demand and novel value, energy use of biomass and special energy plants and plantations have higher and higher importance in scientific publications. Bioenergy methods are limited by other forms of utilization of biomass and by the importance of other renewable energy sources; therefore, their effective utilization highlights the importance of bioeconomic aspects. Regarding biomass utilization research, algae-orientated papers have the highest growth rate and interest, and the most cited article is also from this category. This high growth rate can be explained by the fact that algae as basic materials have the highest theoretical potential in next-generation fuel production and in anaerobic digestion.

The significance of energy use of biomass is dominant among RESs and mainly in heat production. However, solar energy has become a more important competitor both in research and in use, especially in electricity production, including transportation use. While, the environmental aspects of biomass use for any purpose can be considered increasingly important, simultaneously with energy use. This may be because energy plays the most significant role in greenhouse gas emissions, so biomass makes a good substitute for fossil energy sources from an environmental side, too. Scientific outputs of China and India show an exponential trend, while the role of developed countries is much moderate, or stagnant. Taking into consideration the potential yields of biomass, the rapidly growing economic potential, and the high environmental risks in these developing countries, this is not surprising. In these countries, food, direct burning, and biogas production have priority. In the US, the first- and next-generation transportation fuels are more prevalent in research, while in the EU, other RESs (especially wind and solar energy) dominate.

Regarding scientific journals, the highest number of publications are available especially in Elsevier journals (with more than 100 relevant publications), and the MDPI journals of Energies and Sustainability have published numerous articles. It is recommended to take steps towards greater research on biomass use and potential because of the expected interest from readers. Extreme situations (in the last years: COVID-19, Russian–Ukrainian war) have resulted in high volatility in energy supply and prices on both the European and World markets, which has meant extra demand for biomass as a potential energy source. Considering the constantly rising global food demand, the effective use of biomass may be the largest reserve to stabilize food and energy prices, the state of the environment, and maintain living standards.

Within the concepts of bioeconomy, the well-coordinated planning of biomass production and its loss-minimizing use are of paramount importance. As regards future trends in publications such as systematic reviews and bibliographic analyses, the following areas are the most important: (1) the utilization of the differential biomass resources, (2) the importance of sustainability criteria in biomass utilization, (3) the relocation of research centers, and (4) the classic food, feed, or energy debate.

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References

1. World Bioenergy Association. Global Bioenergy Statistics 2021. 2021. Available online: https://www.worldbioenergy.org/uploads/211214WBAGBS2021.pdf (accessed on 5 January 2022).
2. Zsiborács, H.; Baranyai, N.H.; Pintér, G. Aspects of Determining the Energy Storage System Size Linked to Household-Sized Power Plants in Hungary in Accordance with the Regulatory Needs of the Electric Energy System. *Sustainability* **2022**, *14*, 2622.
3. United Nations. *A/RES/70/1 Transforming Our World: The 2030 Agenda for Sustainable Development*; Seventieth United Nations General Assembly: New York, NY, USA, 2015; Volume 16301, pp. 1–35.
4. Rulli, M.C.; Bellomi, D.; Cazzoli, A.; De Carolis, G.; D'Odorico, P. The water-land-food nexus of first-generation biofuels. *Sci. Rep.* **2016**, *6*, 22521. [CrossRef] [PubMed]
5. Smith, P.; Gregory, P.J.; van Vuuren, D.; Obersteiner, M.; Havlík, P.; Rounsevell, M.; Woods, J.; Stehfest, E.; Bellarby, J. Competition for land. *Philos. Trans. R. Soc. B Biol. Sci.* **2010**, *365*, 2941–2957. [CrossRef] [PubMed]
6. Birkner, Z.; Németh, K.; Péter, E.; Weisz, M. Regional Development With Renewable Energy Utilization. *Acta Sci. Pol. Oeconomia* **2011**, *103*, 5–12. Available online: http://acta_oeconomia.sggw.pl/pdf/Acta_Oeconomia_10_3_2011.pdf#page=7 (accessed on 15 December 2021).
7. Haberl, H.; Erb, K.-H.; Krausmann, F. Human Appropriation of Net Primary Production: Patterns, Trends, and Planetary Boundaries. *Annu. Rev. Environ. Resour.* **2014**, *39*, 363–391. [CrossRef]
8. Muscat, A.; de Olde, E.M.; de Boer, I.; Ripoll-Bosch, R. The battle for biomass: A systematic review of food-feed-fuel competition. *Glob. Food Secur.* **2020**, *25*, 100330. [CrossRef]
9. Kopetz, H. Renewable resources: Build a biomass energy market. *Nature* **2013**, *494*, 29–31. [CrossRef]
10. Dombi, M.; Kuti, I.; Balogh, P. Aspects of the sustainable utilization of renewable energy sources. *Appl. Stud. Agribus. Commer.* **2012**, *6*, 91–94. [CrossRef]
11. Popp, J.; Harangi-Rákos, M.; Pető, K.; Nagy, A. Bioenergy: Risks to food-, energy- and environmental security. *Appl. Stud. Agribus. Commer.* **2013**, *7*, 121–130. [CrossRef]
12. International Energy Agency. Market Analysis and Forecast from 2019 to 2024. 2019. Available online: https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf (accessed on 10 January 2022).
13. Brodny, J.; Tutak, M. Analyzing Similarities between the European Union Countries in Terms of the Structure and Volume of Energy Production from Renewable Energy Sources. *Energies* **2020**, *13*, 913. [CrossRef]
14. Balat, M.; Ayar, G. Biomass Energy in the World, Use of Biomass and Potential Trends. *Energy Sources* **2005**, *27*, 931–940. [CrossRef]
15. U.S. Department of Energy. 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy. In *Economic Availability of Feedstocks*; Langholtz, M.H., Stokes, B.J., Eaton, L.M., Eds.; Oak Ridge National Laboratory: Oak Ridge, TN, USA, 2016; Volume 1.
16. Szőllősi, L.; Béres, E.; Szűcs, I. Effects of modern technology on broiler chicken performance and economic indicators–A Hungarian case study. *Ital. J. Anim. Sci.* **2021**, *20*, 188–194. [CrossRef]
17. Lin, C.-Y.; Lu, C. Development perspectives of promising lignocellulose feedstocks for production of advanced generation biofuels: A review. *Renew. Sustain. Energy Rev.* **2021**, *136*, 110445. [CrossRef]
18. Mizik, T. Economic Aspects and Sustainability of Ethanol Production—A Systematic Literature Review. *Energies* **2021**, *14*, 6137. [CrossRef]
19. Mizik, T.; Gyarmati, G. Clean Technologies Economic and Sustainability of Biodiesel Production—A Systematic Literature Review. *Econ. Sustain. Biodiesel Prod. Syst. Lit. Rev.* **2021**, *3*, 19–36.
20. World Bioenergy Association. Global Biomass Potential towards 2035. 2016. Available online: http://www.worldbioenergy.org/uploads/Factsheet_Biomasspotential.pdf (accessed on 10 January 2022).
21. EERE. Bioenergy Frequently Asked Questions | Department of Energy. Office of Energy Efficiency & Renewable Energy. Available online: https://www.energy.gov/eere/bioenergy/bioenergy-frequently-asked-questions#3 (accessed on 12 January 2022).
22. Ladanai, S.; Vinterbäck, J. Global Potential of Sustainable Biomass for Energy. 2009. Available online: http://pub.epsilon.slu.se/4523/1/ladanai_et_al_100211.pdf (accessed on 13 January 2022).
23. EUBIA. Bioenergy Production Potential—European Biomass Industry Association. European Biomass Industry Association. Available online: https://www.eubia.org/cms/wiki-biomass/bioenergy-production-potential/ (accessed on 13 January 2022).
24. Nie, Y.; Li, J.; Wang, C.; Huang, G.; Fu, J.; Chang, S.; Li, H.; Ma, S.; Yu, L.; Cui, X.; et al. A fine-resolution estimation of the biomass resource potential across China from 2020 to 2100. *Resour. Conserv. Recycl.* **2021**, *176*, 105944. [CrossRef]
25. Hiloidhari, M.; Das, D.; Baruah, D.C. Bioenergy potential from crop residue biomass in India. *Renew. Sustain. Energy Rev.* **2014**, *32*, 504–512. [CrossRef]
26. Gregory, J.; Stern, D.I. Fuel choices in rural Maharashtra. *Biomass Bioenergy* **2014**, *70*, 302–314. [CrossRef]

27. Natarajan, K.; Latva-Käyrä, P.; Zyadin, A.; Chauhan, S.; Singh, H.; Pappinen, A.; Pelkonen, P. Biomass Resource Assessment and Existing Biomass Use in the Madhya Pradesh, Maharashtra, and Tamil Nadu States of India. *Challenges* **2015**, *6*, 158–172. [CrossRef]
28. Szarka, N.; Haufe, H.; Lange, N.; Schier, F.; Weimar, H.; Banse, M.; Sturm, V.; Dammer, L.; Piotrowski, S.; Thrän, D. Biomass flow in bioeconomy: Overview for Germany. *Renew. Sustain. Energy Rev.* **2021**, *150*, 111449. [CrossRef]
29. Mao, G.; Zou, H.; Chen, G.; Du, H.; Zuo, J. Past, current and future of biomass energy research: A bibliometric analysis. *Renew. Sustain. Energy Rev.* **2015**, *52*, 1823–1833. [CrossRef]
30. Ranjbari, M.; Esfandabadi, Z.S.; Quatraro, F.; Vatanparast, H.; Lam, S.S.; Aghbashlo, M.; Tabatabaei, M. Biomass and organic waste potentials towards implementing circular bioeconomy platforms: A systematic bibliometric analysis. *Fuel* **2022**, *318*, 123585. [CrossRef]
31. Bugge, M.M.; Hansen, T.; Klitkou, A. What Is the Bioeconomy? A Review of the Literature. *Sustainability* **2016**, *8*, 691. [CrossRef]
32. Stegmann, P.; Londo, M.; Junginger, M. The circular bioeconomy: Its elements and role in European bioeconomy clusters. *Resour. Conserv. Recycl. X* **2020**, *6*, 100029. [CrossRef]
33. Li, Y.; Rezgui, Y.; Zhu, H. District heating and cooling optimization and enhancement–Towards integration of renewables, storage and smart grid. *Renew. Sustain. Energy Rev.* **2017**, *72*, 281–294. [CrossRef]
34. Kumar, A.; Kumar, N.; Baredar, P.; Shukla, A. A review on biomass energy resources, potential, conversion and policy in India. *Renew. Sustain. Energy Rev.* **2015**, *45*, 530–539. [CrossRef]
35. Perea-Moreno, M.-A.; Manzano-Agugliaro, F.; Perea-Moreno, A.-J. Sustainable Energy Based on Sunflower Seed Husk Boiler for Residential Buildings. *Sustainability* **2018**, *10*, 3407. [CrossRef]
36. Osman, A.I.; Qasim, U.; Jamil, F.; Al-Muhtaseb, A.H.; Abu Jrai, A.; Al-Riyami, M.; Al-Maawali, S.; Al-Haj, L.; Al-Hinai, A.; Al-Abri, M.; et al. Bioethanol and biodiesel: Bibliometric mapping, policies and future needs. *Renew. Sustain. Energy Rev.* **2021**, *152*, 111677. [CrossRef]
37. Alalwan, H.A.; Alminshid, A.; Aljaafari, H.A. Promising evolution of biofuel generations. Subject review. *Renew. Energy Focus* **2019**, *28*, 127–139. [CrossRef]
38. Peng, F.; Peng, P.; Xu, F.; Sun, R.-C. Fractional purification and bioconversion of hemicelluloses. *Biotechnol. Adv.* **2012**, *30*, 879–903. [CrossRef]
39. Arteaga-Pérez, L.E.; Segura, C.; Espinoza, D.; Radovic, L.R.; Jiménez, R. Torrefaction of Pinus radiata and Eucalyptus globulus: A combined experimental and modeling approach to process synthesis. *Energy Sustain. Dev.* **2015**, *29*, 13–23. [CrossRef]
40. Soltero, V.; Chacartegui, R.; Ortiz, C.; Velázquez, R. Potential of biomass district heating systems in rural areas. *Energy* **2018**, *156*, 132–143. [CrossRef]
41. Vassilev, S.V.; Vassileva, C.G.; Vassilev, V.S. Advantages and disadvantages of composition and properties of biomass in comparison with coal: An overview. *Fuel* **2015**, *158*, 330–350. [CrossRef]
42. Plate, R.R.; Monroe, M.C.; Oxarart, A. June 2010 Article Number 3FEA7 Public Perceptions of Using Woody Biomass as a Renewable Energy Source. *J. Ext.* **2010**, *48*, 1–15.
43. Szakály, Z.; Balogh, P.; Kontor, E.; Gabnai, Z.; Bai, A. Attitude toward and Awareness of Renewable Energy Sources: Hungarian Experience and Special Features. *Energies* **2020**, *14*, 22. [CrossRef]
44. Vassilev, S.V.; Baxter, D.; Andersen, L.K.; Vassileva, C.G. An overview of the composition and application of biomass ash. *Fuel* **2013**, *105*, 19–39. [CrossRef]
45. Perea-Moreno, A.J.; Perea-Moreno, M.Á.; Hernandez-Escobedo, Q.; Manzano-Agugliaro, F. Towards forest sustainability in Mediterranean countries using biomass as fuel for heating. *J. Clean. Prod.* **2017**, *156*, 624–634. [CrossRef]
46. Fang, Y.; Paul, M.C.; Varjani, S.; Li, X.; Park, Y.-K.; You, S. Concentrated solar thermochemical gasification of biomass: Principles, applications, and development. *Renew. Sustain. Energy Rev.* **2021**, *150*, 111484. [CrossRef]
47. Bai, Z.; Liu, Q.; Gong, L.; Lei, J. Thermodynamic and economic analysis of a solar-biomass gasification system with the production of methanol and electricity. *Energy Procedia* **2018**, *152*, 1045–1050. [CrossRef]
48. Popp, J.; Balogh, P.; Oláh, J.; Kot, S.; Rákos, M.H.; Lengyel, P. Social Network Analysis of Scientific Articles Published by Food Policy. *Sustainability* **2018**, *10*, 577. [CrossRef]
49. Tranfield, D.; Denyer, D.; Smart, P. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *Br. J. Manag.* **2003**, *14*, 207–222. [CrossRef]
50. Seuring, P.D.S.; Müller, P.D.M.; Westhaus, M.; Morana, R. Conducting a Literature Review—The Example of Sustainability in Supply Chains. In *Research Methodologies in Supply Chain Management*; Springer: Berlin, Germany, 2005; pp. 91–106. [CrossRef]
51. Lancho-Barrantes, B.S.; Cantu-Ortiz, F.J. Quantifying the publication preferences of leading research universities. *Science* **2021**, *126*, 2269–2310. [CrossRef] [PubMed]
52. Niñerola, A.; Sánchez-Rebull, M.V.; Hernández-Lara, A.B. Tourism research on sustainability: A bibliometric analysis. *Sustainability* **2019**, *11*, 1377. [CrossRef]
53. Salmerón-Manzano, E.; Manzano-Agugliaro, F. The Higher Education Sustainability through Virtual Laboratories: The Spanish University as Case of Study. *Sustainability* **2018**, *10*, 4040. [CrossRef]
54. Gomez-Jauregui, V.; Gomez-Jauregui, C.; Manchado, C.; Otero, C. Information management and improvement of citation indices. *Int. J. Inf. Manag.* **2014**, *34*, 257–271. [CrossRef]

55. Sugimoto, C.R.; Larivière, V. *Measuring Research: What Everyone Needs to Know*; Oxford University Press: Oxford, UK, 2018; p. 168. ISBN 9780190640125.
56. Heradio, R.; de la Torre, L.; Galan, D.; Cabrerizo, F.J.; Herrera-Viedma, E.; Dormido, S. Virtual and remote labs in education: A bibliometric analysis. *Comput. Educ.* **2016**, *98*, 14–38. [CrossRef]
57. Duque-Acevedo, M.; Belmonte-Ureña, L.J.; Yakovleva, N.; Camacho-Ferre, F. Analysis of the Circular Economic Production Models and Their Approach in Agriculture and Agricultural Waste Biomass Management. *Int. J. Environ. Res. Public Heal.* **2020**, *17*, 9549. [CrossRef]
58. De La Cruz-Lovera, C.; Perea-Moreno, A.-J.; De La Cruz-Fernández, J.-L.; Alvarez-Bermejo, J.A.; Manzano-Agugliaro, F. Worldwide Research on Energy Efficiency and Sustainability in Public Buildings. *Sustainability* **2017**, *9*, 1294. [CrossRef]
59. Gong, R.; Xue, J.; Zhao, L.; Zolotova, O.; Ji, X.; Xu, Y. A Bibliometric Analysis of Green Supply Chain Management Based on the Web of Science (WOS) Platform. *Sustainability* **2019**, *11*, 3459. [CrossRef]
60. Perea-Moreno, M.-A.; Samerón-Manzano, E.; Perea-Moreno, A.-J. Biomass as Renewable Energy: Worldwide Research Trends. *Sustainability* **2019**, *11*, 863. [CrossRef]
61. Ji, X.; Liu, Y.; Meng, J.; Wu, X. Global supply chain of biomass use and the shift of environmental welfare from primary exploiters to final consumers. *Appl. Energy* **2020**, *276*, 115484. [CrossRef]
62. Luis, E.C.; Celma, D. Circular Economy. A Review and Bibliometric Analysis. *Sustainability* **2020**, *12*, 6381. [CrossRef]
63. Duquenne, M.; Prost, H.; Schöpfel, J.; Dumeignil, F. Open Bioeconomy—A Bibliometric Study on the Accessibility of Articles in the Field of Bioeconomy. *Publications* **2020**, *8*, 55. [CrossRef]
64. Pandey, A.; Soccol, C.R.; Nigam, P.; Soccol, V.T. Biotechnological potential of agro-industrial residues. I: Sugarcane bagasse. *Bioresour. Technol.* **2000**, *74*, 69–80. [CrossRef]
65. Brennan, L.; Owende, P. Biofuels from microalgae—A review of technologies for production, processing, and extractions of biofuels and co-products. *Renew. Sustain. Energy Rev.* **2010**, *14*, 557–577. [CrossRef]
66. Naik, S.N.N.; Goud, V.V.; Rout, P.K.; Dalai, A.K. Production of first and second generation biofuels: A comprehensive review. *Renew. Sustain. Energy Rev.* **2010**, *14*, 578–597. [CrossRef]
67. Weiland, P. Biogas production: Current state and perspectives. *Appl. Microbiol. Biotechnol.* **2010**, *85*, 849–860. [CrossRef]