Journal of Energy Systems

2023, 7(1)

2602-2052

DOI: 10.30521/jes.1252122

Research Article

A bibliometric analysis on renewable energy's public health benefits

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Submitted: 11.01.2022
Accepted: 27.01.2023
Published: 31.03.2023

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Abstract: Renewable energy (RE) is a field in which an increasing number of academic studies are being conducted on multiple dimensions, including technical, economic, political, and social. Wide and varied disciplines conduct research on the processes of making an investment decision in renewable energy, developing, and adopting policies for this purpose, selecting RE suitable for the location, establishing it by taking economic and environmental factors into account, developing energy distribution and storage systems, and supporting regional development. To accurately calculate the installation costs, which are viewed as one of the barriers to a greater use of renewable energy, the co-benefits of RE must be analyzed and transferred to this calculation, and thus to the decision-making processes. Understanding these co-benefits will also facilitate consumer adoption of sustainable energy sources. In addition to economic growth, financial development, employment growth, and regional development, it is crucial to understand the public health benefits of renewable energy. Through bibliometric analysis, which permits the quantification and visualization of qualitative data, the status and development of the literature on the health benefits of RE are examined in this study. That is determined the most researched topics, current issues and trends, and prominent issues in academic studies, too. Thus, the transition to environmentally friendly energies can be accelerated by increasing public awareness of health co-benefits from a more holistic perspective.

Keywords: *Bibliometric analysis, Co-benefit, Public health, Renewable energy*

Cite this paper as: Durmuş Şenyapar, H.N., A bibliometric analysis study of renewable energy's public health benefits. *Journal of Energy Systems* 2023; *7*(1): 132-157, DOI: 10.30521/jes.1252122

1. INTRODUCTION

Sustainability has become one of the priority issues for activities at all levels, the deterioration of the ecosystem has increased the importance of sustainability in all areas. Environmental degradation and the deterioration of environmental quality have garnered substantial attention from development cooperation on a worldwide scale [1]. After industrialization, imprudent use of all resources has resulted in the destruction of the environment to a degree that prevents it from repairing itself, and consequently, global warming. Global warming resulting from the greenhouse effect, which can be explained as the retention of the sun's reflected rays by the gases released into the atmosphere, causes numerous political, economic, and social issues. Ecosystems and human societies are in great danger because of circumstances such as the increased frequency and effect of severe weather conditions including drought, floods, and strong hurricanes, rising seas and saltwater levels, and the melting of glaciers. Human activity is the most significant causer of the climate change over the world. However, human will be the most effective force for reducing and reversing environmental damage. The easiest manifestation of this desire will be the formation of production and consumption practices within the framework of methods that do not harm the environment or cause less harm. Utilizing renewable energy sources (RESs) is without a doubt the first of the most crucial initiatives that can be taken to minimize the production of carbon and other greenhouse gases (GHGs), which are substantial contributors to global warming.

Renewable energy is becoming more and more preferred due to meeting the increasing energy demand of countries, reducing foreign dependency, accelerating sustainable development, increasing regional employment, and being less harmful to the environment. Environmental benefits are among the numerous advantages of renewable energy sources, which means that, unlike fossil fuels, RES do not emit greenhouse gases. Once RESs infrastructure is established, the ongoing cost of producing electricity from renewable energy sources is frequently significantly less than that from fossil fuel-based energy sources [2]. Energy security, which allows countries to become independent of foreign oil and gas, is another added benefit of renewable energy sources [3]. Renewable energy plants have the potential to create a significant number of new jobs for the regions where they are established, thereby supporting regional development [4]. RES can improve public health by reducing air and water pollution that can lead to heart disease, bronchioles and similar diseases [5]. However, RES have advantages as well as disadvantages, one of which is that renewable energy is intermittent. The fact that the energy supply can be unpredictable and variable, and not always available when needed, are important points of hesitation [6]. Initial installation costs of RES infrastructure may be more costly than conventional fuels [7]. Even if investments are made for RES to overcome continuity and storage issues in energy supply and for high installation costs, RES may require a large amount of land in order to establish energy plants [8]. There are also concerns that RES infrastructure may affect wildlife and cause environmental or sound pollution [9]. However, the transition to RE is not at the expected pace due to the relatively high initial installation costs, low storage capacity, and usage habits. By considering other drivers of RE investments such as income, energy reliance, and pollution emissions, it has been discovered that more democratic nations are inclined to invest more in environmentally friendly energies [10]. Indeed, the benefits and co-benefits of RE in many areas make it the most reasonable option for the energy transition. In this context, the benefits and the co-benefits can be listed such as reduction of carbon emissions and the use of electric vehicles (EV) for air pollution; the health and economic benefits of RE use and climate policies are greater in regions that are more dependent on coal production, the savings from health co-benefits from improved air quality may offset the costs of implementing climate policy, and the co-benefits of RE exceed the leveled cost of electricity (LCOE) [11]. To politically promote environmentally friendly RE, different subsidy policies have been implemented to accelerate the development of local RE industries [12]. Although countries provide partial incentives to accelerate this transition, since they are signatories of agreements on the prevention of climate change, different incentives should be introduced, especially in the adoption of the use of RE resources by the end consumer.

As health is currently one of the primary concerns of individuals, it has been determined that highlighting the co-benefits of RES use within the context of health can accelerate this transformation. While scientific studies have demonstrated that air and other forms of pollution from fossil fuels cause a variety of diseases, including respiratory diseases, cardiovascular diseases, and even depression, it is evident that the use of renewable energy and even electric vehicles is an important step that individuals can take, not only for the environment but also for human health [13]. RES does not cause harmful emissions or has fewer emissions than conventional fossil fuels when considering the entire life cycle. Therefore, the use of RES can contribute to a significant reduction in emissions and ultimately a significant reduction in pollution-related health damage. Recognizing the health benefits of replacing fossil fuels with RES is therefore important [14]. However, the health benefits of RE are not well known and emphasized enough. It is observed that the subject is not adequately addressed in academia. While various studies are performed on the co-benefits of RE [15], and the research on the health co-benefits of renewables is limited [16]. Critics assert that academic studies focusing on the significant, near-term, local health co-benefits that drive policy formulation and net cost savings are better suited to describing the interaction between environmental policies and health and the amplitude of possible consequences than to presenting precise and accurate projections of health co-benefits [17].

Various bibliometric analysis studies have been carried out on academic studies on RE. While some of them examine the issue of RE in general [18], some of them deal with issues such as environmental policy [19,20], employment, sustainability [21], economic development [22], different types of RE [23], [24], RE finance [25], commercialization [26], agriculture [27], green buildings [28], and supply chain management [29]. Although various studies perform bibliometric analysis by addressing the issue of RE technically, economically, and politically, there is no bibliometric analysis directly via an analyzing research on the health co-benefits of RE.

The academic community has been captivated by the issue of RE for decades, and research on the technical aspects of the issue is continuing to expand. In addition, there exist also publications on co-benefits, and these findings are crucial for evaluating the total cost of these energy sources and making more rational investment choices. Co-benefits of RE are evaluated, calculated, and disclosed using a variety of models, instruments, metrics, and analyses [30,31,32,33]. However, the number of direct studies on the health co-benefits of RE is relatively small. While publications in which many diseases such as respiratory diseases, cardiovascular, neurological, and psychological disorders are associated with global climate change are studied intensively, especially in the field of medicine, studies on the health co-benefit of RE use as one of the most effective ways of mitigating the emission of greenhouse gases have been limited [34,35,36,37]. In a systematic review of databases such as Medline, Web of Science, PubMed, and EMBASE, it was determined that the majority of the identified studies were based on modeling scenarios, with a primary focus on alternative power scenario modeling, wind energy, biofuels, photovoltaic cells, transportation, and building energy efficiency [38].

In this study, answers to the following research questions (RQ) are sought to present the status and trends of academic studies on the health co-benefits of RE and to offer suggestions to researchers about new fields of scientific study:

1. *What issues does research on the health co-benefits of RE focus on?*
2. *What are the most researched and current topics in the literature?*
3. *What are the promising current issues and perspectives in the literature?*

Using VOSviewer software and analytical methods, this study analyzes the academic studies on health co-benefits of renewable energy. Using bibliometric parameters such as authors, citations, keywords, and publication countries, bibliometric analysis, providing a holistic perspective by bringing together pieces of information in the literature using an objective methodology, can reveal thematic analyses for selected studies. Inferences will be made regarding future research directions based on the bibliometric analysis of academic studies examining the relationship between RE and health performed in this study. This study's findings are intended to provide a potential roadmap for future researchers wishing to conduct researches in the field. Sec. 2 provides the required background on the bibliometric mapping exercise for the systematic analysis. In Sec. 3, the analyses on the publications in the journals scanned in WoS on the health co-benefits of RE is performed. In Sec. 4, the methodology is explained while the research questions are answered by using the results of the analysis in Sec. 5. In Sec. 6, the findings are evaluated in comparison with the previous studies, and the study is concluded with a conclusion part.

2. GLOBAL CLIMATE CHANGE AND PUBLIC HEALTH NEXUS

Global climate change refers to the long-term warming of the planet and the long-observed changes in global weather patterns [39]. Human activity, notably the combustion of fossil fuels like coal, petroleum, and natural gas, is the primary driver of this warming [40]. These activities release greenhouse gases, primarily carbon dioxide, into the atmosphere. These gases trap solar heat, thereby contributing to the warming of the planet [41]. Global climate change does indeed have and potentially disastrous repercussions. Rising temperatures can lead to more severe heat waves, droughts, and storms [42]. Warmer oceans can lead to more intense hurricanes and typhoons [43]. Melting ice in the Arctic and Antarctic can cause sea levels to rise, flooding coastal areas and small islands [44]. Climate change can also lead to changes in precipitation patterns, causing some regions to become drier while others become wetter [45]. Climate change also affects ecosystems and wildlife [46]. Rising temperatures and changing precipitation patterns can disrupt the timing of seasonal events, such as the flowering of plants and the migration of birds. Warmer oceans can lead to coral bleaching and the death of marine organisms [47]. Changes in weather patterns can also affect the distribution of pests and diseases, putting additional stress on crops and wildlife [48]. Many scientists believe that the Earth's climate is approaching a tipping point beyond which the effects of global warming could become irreversible [49]. This is why, it is important to take immediate action to reduce Green House Gas (GHG) emissions and mitigate the effects of climate change. One of the main solutions, to reduce GHG emissions, is to transition to clean and RESs for illustrate solar and wind power [50]. The development of electric cars and more efficient public transportation can also help in order to reduce emissions from the transportation [51]. Planting trees, and protecting wetlands and other natural carbon sinks can also help absorb carbon dioxide from the atmosphere. Adaptation is also important, such as building sea walls to protect coastal areas from sea level rise [52], and finding ways to make crops and infrastructure more resilient to changing weather patterns [53]. The Paris Agreement, which was signed in 2015, aims to prevent climate change by limiting the increase in global temperatures to a minimum of 2 °C beyond pre-industrial levels and pursuing efforts to limit the increase to 1.5 °C [54]. It is essential to note that the effects of climate change will not be distributed evenly across the globe. Developing nations and low-income communities are frequently the most susceptible to the effects of climate change because they have fewer resources to adapt and are more reliant on agriculture and natural resources.

The emission of GHG is one of the primary causes of climate change. Carbon dioxide, methane, nitrous oxide, and water vapor are an example of greenhouse gases, naturally occurring gases that trap heat from the sun in the Earth's atmosphere, keeping the planet warm enough for life to exist [55]. Human activities including the combustion of petroleum and coal, deforestation, and agricultural activities have considerably increased the amount of these gases in the atmosphere, causing the greenhouse effect, which is the excessive trapping of heat [56].

Deforestation and land use change are major factors that contribute to global climate change [57]. Through photosynthesis, trees and other vegetation absorb carbon dioxide from the atmosphere. When they are cut down or burned, they release greenhouse gases back into the atmosphere [58]. Other effects of deforestation and land use change on the Earth's capacity to absorb carbon dioxide include the loss of carbon sequestration in soils and the reduction of evapotranspiration. Deforestation is the removal of natural forests for a variety of purposes, such as agriculture, urban development, mining, and logging. When woodlands are cleared, the carbon that has been sequestered in the trees and other plants is released into the air, which contributes to an increase in the amount of pollution in the atmosphere.

Industrial processes such as cement production [59], fertilizer manufacturing [60], and waste disposal [61] contribute to global climate change by releasing greenhouse gases into the atmosphere. The fertilizer manufacturing process primarily contributes to GHG emissions by producing nitrous oxide [62]. As a by-product of the chemical reactions that occur during the production of nitrogen fertilizers, which are utilized to increase crop yields, nitrous oxide is released into the atmosphere. Another industrial process that contributes to GHG emissions is waste disposal [63]. Methane, a powerful greenhouse gas, is emitted into the atmosphere by landfills and waste incineration. In the absence of oxygen, decomposition of organic matter such as food waste and yard waste produces methane [64].

Agriculture is another significant activity that contributes to global climate change through GHG emissions, the conversion of natural habitats to agricultural areas, and the excessive use of pesticides. As a result of their digestion, livestock, particularly cows, sheep, and goats, produce methane, a GHG [65]. The use of synthetic fertilizers releases nitrous oxide, another potent greenhouse gas, into the atmosphere [66]. Agriculture also contributes to climate change by altering the albedo of the Earth’s surface, also known as the reflection of solar radiation [67]. Converting natural habitats such as forests and wetlands to croplands alters the reflectivity of the Earth’s surface, which can result in global warming. In addition, agricultural practices such as monoculture, intensive tillage, and the heavy use of pesticides and herbicides can lead to soil degradation, biodiversity loss, and a reduction in carbon sequestration, which can further contribute to climate change [68].

The emission of greenhouse gases, primarily carbon dioxide, from transportation is a significant contributor to global climate change [69]. The combustion of fossil fuels such as gasoline and diesel, which are utilized by internal combustion engines, buses, trains, and airplanes, is the primary source of transportation sector emissions. On-road transportation, including cars, trucks, and buses, is responsible for the majority of GHG emissions associated with transportation. Due to the altitude at which emissions are released, air travel has a much greater impact per unit of emissions than other modes of transportation [70].

Through the use of energy for heating, cooling, lighting, and to power appliances and electronics, buildings are a major contributor to global climate change [71]. The largest energy demands of buildings are for heating and cooling, which are also a significant contributor to building-related GHG emissions. In addition to the direct emissions from the energy used to power buildings, the building’s construction and materials also have an impact on the environment. Furthermore, building materials, such as cement, steel, and others, release greenhouse gases into the atmosphere, and the clearing of natural habitats for construction sites can contribute to deforestation and land-use change [72].

In general waste, specifically the disposal of solid waste in landfills and its incineration, is a major contributor to global climate change through the emission of greenhouse gases such as methane and carbon dioxide [73]. Typically, waste placed in a landfill is buried and covered with soil. In the absence of oxygen, the waste’s organic matter decomposes and produces methane, a potent greenhouse gas. The United States’ landfills are the third-largest source of methane emissions, after the oil and gas industry and agriculture [74]. The waste incineration process, the method of burning waste to generate energy, also emits carbon dioxide and other pollutants into the atmosphere, leading directly to air pollution [75]. Although waste incineration can reduce the amount of waste sent to landfills, it is not considered a sustainable waste management method because it still contributes to GHG emissions.

Climate change poses a significant threat to public health, both in the short-term and long-term [76]. Extreme weather events such as heat waves, floods, and droughts can cause injury, illness, and death in the short term. Heat waves can cause heat stroke and dehydration, whereas floods can cause water-borne diseases like cholera. In addition, natural disasters can result in displacement and a lack of access to basic services such as healthcare and clean water, which can exacerbate the negative health effects [77]. Changes in the distribution of disease-carrying organisms, such as mosquitoes and ticks, can increase the risk of infectious diseases like malaria and Lyme disease [78]. Air pollution, which is also affected by climate change, can lead to respiratory illnesses such as asthma and heart disease [79]. The generation of electricity, in particular, has been the segment of the energy industry that has been directly responsible for the greatest amount of global pollution caused by the combustion of fossil fuels, lowering the quality of the air for breathing and is directly responsible for major issues affecting human health [80]. Coal-fired power plants are responsible for more than 200,000 deaths worldwide each year, and reducing such deaths is an important health co-benefit of actions to reduce greenhouse gases that support RE or energy efficiency (EE) [81].

Climate change also has an impact on food availability and quality, which can lead to malnutrition and other health issues [82]. Climate change also disproportionately affects vulnerable populations such as children, the elderly, and low-income communities [83]. Due to factors such as inadequate housing, lack of access to healthcare, and limited adaptability to extreme weather events, these groups are often more vulnerable to the health impacts of climate change. Adaptation measures, including early warning systems and emergency preparedness, can mitigate the short-term health effects of climate change. Long-term solutions, such as reducing GHG emissions and expanding access to clean energy, can aid in preventing further climate change and its associated health consequences. Overall, climate change is a significant threat to public health that requires prompt and decisive action. The World Health Organization, which is an organization affiliated with the United Nations that conducts international studies on public health, estimates that climate change is already responsible for 150,000 deaths per year, and this number is expected to grow 250,000 [84] in the future without significant action to reduce the GHG emissions and adapt to the impacts of climate change. Table 1 lists some of the disease states that can be caused by the climate change.

Table 1. List of diseases which can be caused by climate change [85,86,87,88,89,90,91,92].

Heat-related illnesses	The risk of heat stroke, heat exhaustion, and other heat-related disorders increases in direct proportion to the rise in temperature. Those who are elderly or who already have one or more medical disorders are at a heightened risk when exposed to them.
Air pollution	The effects of climate change could have a negative impact on air quality by contributing to an increase in ground-level ozone and particle matter. This can lead to complications with the respiratory system such as asthma and bronchitis, in addition to problems with the heart.
Vector-borne diseases	It is possible that climate change will result in an expansion of the range and distribution of disease-carrying organisms such as mosquitoes and ticks, which are both species of insects that are considered to be a nuisance. Malaria, dengue fever, and Lyme disease are just some of the illnesses that could become more widespread as a result of this.
Water-borne diseases	Alterations in the patterns of precipitation and the level of the sea can lead to flooding and contamination of the water supply, which in turn raises the danger of water-borne diseases such as cholera and typhoid.
Food security	Both the quantity of crop yields and the quality of food in terms of its nutritional value could be affected by climate change. This can lead to malnutrition as well as other health difficulties, particularly in nations that are still developing.
Mental health	The effects of climate change on mental health might be compounded by the fact that climate change can lead to the loss of jobs and other sources of stress.
Vulnerable populations	The effects of climate change are felt disproportionately by vulnerable people, including children, the elderly, and communities with lower incomes. These individuals usually lack access to the resources that would have enabled them to adjust to the consequences of shifting environmental conditions, which leaves them more susceptible to the dangers posed to their health.
Natural disasters	As a result of climate change, it is possible that natural catastrophes such as tornadoes, flooding, and wildfires could become more common and destructive. These incidents can result in a variety of negative outcomes, including emotional stress, physical injuries, being displaced from one's home, and a loss of access to essential resources.

To put it briefly, events such as extreme weather events, increased disease transmission, food and freshwater shortages, sea level rise and the resulting economic and administrative disruptions are the health effects of climate change. Energy efficiency (EE) and RE offer significant public health benefits by reducing the emissions of fossil-fueled electricity generating units and also achieving the net-zero target [93]. Preventing or reducing emissions from pollution from fossil fuel power plants, particularly coal, not only mitigates climate change but is a significant co-benefit through reducing high health costs [94].

3. RENEWABLE ENERGY AND HEALTH CO-BENEFITS

Many different sectors and activities have an impact on global climate change, both directly and indirectly. There is no doubt that the use of renewable energy is extremely beneficial in terms of preventing global destruction and reducing the effects of climate change on both humans and the environment. Renewable energy sources, which are crucial to environmental problem mitigation, notably air pollution-related health issues, can reduce pollutants and thereby improve air quality and human health [95]. With the transition to RE, millions of tons of toxic gases are stopped from being discharged, and deaths, non-fatal heart attacks, chronic bronchitis, asthma, and other hospital admission-related disorders can be prevented [96]. Reducing emissions of greenhouse gases can provide ancillary benefits and slow climate change through the improved air quality [97]. It is conceivable to employ RE as a tool in health-related regulations to enhance air quality due to the substantial savings that can be realized from reduced healthcare costs [98].

Renewable energy is derived from renewable and naturally replenishing sources such as sunshine, wind, rain, ocean tides, and geothermal heat. It is appealing since it is derived from the Earth's natural resources and is typically regarded as more environmentally friendly than conventional energy sources, which contribute to the depletion of the environment [99].

Renewable energy is often abundant, thus it may frequently be utilized to supplement conventional energy sources and lessen dependency on fossil fuels [100]. Utilizing RESs offers many benefits. RE is clean energy, meaning it does not emit greenhouse gases like fossil fuels or other pollutants that directly contribute to climate change on our planet. In addition, renewable energy sources are often abundant and frequently available for free, making them far more affordable than conventional energy sources. Furthermore, unlike conventional energy sources, RE is renewable and will never run out. In addition to their environmental and economic benefits, these sources also have technological pros and cons [101]. RES are typically easier to use and maintain than conventional energy sources and can be implemented in a range of situations. In addition, these sources are frequently modular, meaning they may be quickly scaled to meet the needs of the users. Despite these benefits, there are also disadvantages linked with renewable energy sources. Investing in a RE system demands an up-front expenditure that some consumers may not be able to afford [102]. In addition, some RESs need a considerable deal of room, thus they may not be suitable [103]. In addition, some of them require particular weather or environmental conditions to function, meaning they may not be trustworthy in all regions [104]. Overall, renewable energy, also known as green energy, is gaining popularity due to its environmental, economic, and technological benefits. The sources will likely continue to be produced and utilized in the future, aiding in the reduction of dependency on fossil fuels and the climate change caused by nonrenewable sources. While there are obstacles associated with green sources, they are manageable, and the benefits of utilizing them are considerable. Following are descriptions of the renewable energy sources utilized in our planet.

Solar energy is a plentiful, renewable, and clean energy source with the potential to meet a significant portion of the world's energy requirements. This energy is generated by the sun's radiation and is measured per square meter. It is captured in a variety of ways, including solar photovoltaic cells, concentrating solar power systems, and solar thermal energy systems [105]. Via a series of chemical reactions, solar photovoltaic cells are able to directly convert the sunlight into energy. These cells are composed of semiconductor materials such as silicon. Concentrating solar power systems focus sunlight on a receiver, generating heat that is then used to generate electricity [106]. Solar thermal energy systems use the heat of the sun to heat a fluid, which then powers a turbine, which generates electricity [107]. These energy systems offer numerous advantages, including their accessibility, affordability, and environmental friendliness. It is accessible practically everywhere, as the sun is a steady and dependable energy source, and it is also cost-effective, as the cost of solar energy continues to decline as technology advances [108]. Overall, solar energy is clean and perpetual, meaning that it does not release pollutants such as greenhouse gases into the atmosphere and cannot be exhausted. It can also be utilized in many industries, including agriculture, to power pumps, lighting, and other equipment. To reap the benefits of this energy, it is necessary to comprehend its right application. It is essential to choose the proper technology for the intended application and to size the system correctly. The local temperature and meteorological conditions should also be considered, as some regions may be more appropriate for solar energy than others. Additionally, it is necessary to comprehend the many types of solar energy systems, as well as the potential benefits and drawbacks associated with each system. With the proper knowledge and resources, solar energy may be a dependable and cost-effective source of energy for many homes, businesses, and the entire globe.

Wind energy is one of the most promising and viable RESs. It is a clean, sustainable, and abundant source of energy that can be harnessed to generate electricity [109]. It has been employed in various machines since ancient times, but it did not become a practical source of energy until the late 20th century [110]. It can be used to generate electricity through turbines which are prompted by using the kinetic energy of wind and it is related to the cube of wind speed [111]. Wind turbines have been used to generate electricity for many years, but recent technology advancements have made wind energy generation on a commercial scale practical. This energy is currently one of the most cost-competitive electricity sources. In many regions, wind-generated electricity is less expensive than electricity derived from fossil fuels. In addition, as technology advances and more turbines are constructed, it is anticipated that the price of wind energy will continue to decrease. In the coming decades, the quantity of electricity generated by wind could more than double its current levels [112]. Wind energy plants do not pollute the air or water like fossil fuel plants, and the process of generating power from wind is entirely renewable. Consequently, it can be a significant component in reducing GHG emissions and addressing climate change. It is a dependable energy source that can generate electricity even when the wind is not blowing. Modern wind turbines are built to run even in conditions with little wind, and they can store energy for later use. Consequently, wind energy is a reliable and resilient source of electricity.

Hydropower energy is a renewable and sustainable energy source derived from water. Utilizing the potential energy of water flowing in rivers, streams, dams, and other bodies of water, hydroelectricity is generated. The energy is generated by redirecting water via a turbine and transforming it into electricity. In addition to being clean and renewable, hydropower energy is also cost-effective, sustainable, and dependable. It can be utilized as a primary or secondary source of energy [113]. This form of energy is commonly utilized in numerous locations worldwide. It is one of the oldest methods of producing energy and has been utilized for decades. On September 30, 1882, the world’s first hydroelectric facility, also known as the dam spanning Fox River in Appleton, Wisconsin, went into service [114]. Hydropower energy is widely used for producing electricity for homes, businesses, and industries. It is a very efficient method of producing electricity and can produce a large amount of electricity for a relatively low cost. This makes it an appealing option for many nations attempting to lessen their reliance on conventional energy sources.

Geothermal energy is a source of renewable energy derived from the internal heat of the Earth. This energy can be used for a multitude of purposes, including heating, and cooling buildings, producing electricity, and heating water. The energy source is far less expensive than solar and wind power. Geothermal energy has a comparatively low impact on the environment [115]. It does not emit greenhouse emissions or contaminants. Certain regions of the world, such as Iceland and New Zealand, have utilized it for millennia [116]. Geothermal energy has recently become a popular form of RE in the United States, with the number of geothermal power plants rapidly increasing [117]. Geothermal energy is most frequently used for heating and cooling buildings. Geothermal systems can provide a consistent supply of energy to heat and cool a home or structure by exploiting the natural heat of the Earth’s interior. Using geothermal systems, it is possible to heat swimming pools and provide hot water for showers and other uses. Additionally, geothermal energy can be utilized to generate power. This is achieved by drilling deeply into the Earth’s crust and tapping into natural stores of steam or hot water.

The steam or hot water is then used to generate power by driving turbines. Geothermal power facilities often generate less electricity compared to other types.

Biomass energy is the production of energy from organic matter, such as plant and animal waste. It is one of the most adaptable RESs accessible and may be utilized for a multitude of purposes. This form of energy can be used to produce power, heat, and even fuel for transportation systems [118]. In addition, it is significantly more efficient and environmentally friendly, emitting fewer hazardous emissions into the atmosphere. This energy is an excellent option for reducing carbon dioxide emissions that are directly released into the atmosphere and have significant environmental effects such as air pollution. Additionally, biomass energy helps lessen the amount of garbage sent to landfills [119]. Organic material, such as food waste, can be converted into energy instead of being thrown away.

Tidal energy, also known as ebb and tide, has been growing in popularity among renewable energy sources in recent years. It is a type of renewable energy that is derived from the rise and fall of the ocean's tides. As the tide ebbs and flows, it generates kinetic energy that can be captured and converted into electricity [120]. Tidal energy is a clean energy source that is not directly dependent on the sun, wind, or other weather-dependent sources. The use of tidal energy dates to ancient civilizations, who used the tides' energy to help move boats and other vessels by harnessing the power of the water. In the modern era, tidal energy is used to generate electricity in many countries around the world. The most common and efficient method of generating electricity from tidal energy is to use tidal turbines, which are placed in the water and spin as the tide moves in and out. The turbines are linked to a generator, which produces electricity [121]. Tidal energy does not necessitate the construction of dams or other large infrastructure projects, so it can be easily installed in areas lacking large bodies of water. Despite these benefits, it has a number of drawbacks. This type of energy technology is still in its early stages of development, making it relatively expensive to build and maintain. Finally, it is only available in specific areas near the sea or ocean, indicating that it is not a viable source of energy in all parts of the world [122].

Reducing GHG emissions can help to reduce air pollution and protect public health. Energy industries based on traditional fossil fuels such as natural gas, oil, and coal are being replaced by renewable energy industries in order to improve air quality. Because the hidden costs of energy production based on fossil fuels, namely energy externalities, are not reflected in prices, the use of these traditional energy sources is considered to be relatively cheaper. However, one of the most significant externalities of the energy sector is its negative impact on human health. Taking into account all of the benefits of RES, including health co-benefits, can help to reduce cost disadvantages [123].

The concept of "co-benefit", which can be defined as the additional positive impact of a policy, program, or project with the primary desired objective, may relate to human health and well-being, the environment, the economy, and social aspects. A study was carried out that revealed the results of the transition of the entire energy sector to 100% wind, water, and sunlight (WWS) energy by 2050 at the latest in 74 metropolitan cities, including 30 megacities around the world, and the transition to 100% clean, RE and storage in metropolitan areas, it has been demonstrated that it can provide significant economic, health, climate, and business advantages. Accordingly, it has been determined that energy costs can be reduced by 61.1% and social costs (energy, air pollution, climate costs) by 89.6%. The cost of energy per unit decreases, the cost caused by air pollution decreases, the reduction in deaths provides savings, the costs caused by global climate change decrease, and it can create many long-term full-time jobs [124]. To reach zero fossil fuel use by 2050, RE production would need to be increased 6-fold or 8-fold (if world energy demand increases by 50%)[125], and all eight ways to replace fossil fuels with RE (renewable energy development; improving energy efficiency; increasing energy savings; carbon taxes; a fairer balance between human well-being and per capita energy use; border and trade systems; carbon sequestration, use, and storage; and nuclear energy development) need to be applied aggressively, ensuring major lifestyle changes in developed countries, and close cooperation across all countries was underlined. Public support is required for the promotion of RESs to enable financial support for the government [126,127].

4. MATERIALS AND METHODS

Bibliometric analysis, which is used to analyze the quality and impact of scientific production and the evolution of research in relation to its intellectual, conceptual, and social structures, is a statistical analysis technique designed to explain and map how disciplines and research areas are structured and evolve. In establishing a complete view of the research that has been done to reveal the connection among RE and health in the published works , the WoS database was combed for scholarly articles on the health advantages of RE. Web of Science, which indexes the blind peer-reviewed journals published in many scientific domains and brings together recognized publications of the academic world, is the go-to resource for scholars seeking trustworthy academic discoveries. Analysis performed with the logical operator includes "health benefit*" + "renewable energy" OR "co-benefit*" + "renewable energy" OR "health expend*" + "renewable energy" in WoS database. In the search carried out in February 2023, 374 publications were reached. The data set of all the publications accessed without any year, language, country, index, or document type restrictions were taken from WoS and transferred to the VOSviewer program to perform bibliometric analysis. By using bibliometric analysis, topics such as trends in research, contributions of authors, and distribution of studies by country were transformed into visualized forms based on data. A wide variety of bibliometric information such as article title, language, author keywords, keywords plus, abstract, address, and affiliation obtained from the WoS search was analyzed with the VOSviewer program, and the qualitative data were quantified, thus ensuring the objectivity of the analysis, and the findings of the study are given in the next chapter.

5. RESULTS

5.1. Pre-processing of the Documents

A search was performed in the Web of Science (WoS) database, where many prominent and accepted peer-reviewed journals in the literature are indexed. The search keywords were determined in such a way that only the studies dealing with the health co-benefits dimension of RE could be examined. The word groups "health co-benefits", "co-benefit" and "health expenditure" were scanned together with the word group "renewable energy" in the WoS Core Collection index without any year or database limitation. The data containing detailed bibliographic information about the studies determined in this way have been archived for use in the Biblioshiny program. A total of 373 articles on the health co-benefits of REs were identified in the literature. All details of these articles (information such as responsible author, keywords, abstract, references, keyword plus, titles, publication year, all author names, publisher, printing house, and publication language) were analyzed in the R programming language and the mapping process was carried out. General information about the publications used in the analysis process is shown in Table 2.

Table 2. Main information about the data

MAIN INFORMATION ABOUT THE DATA	
Timespan	2002:2023
Sources (Journals, Books, etc.)	178
Documents	373
Annual Growth Rate %	7.97
Document Average Age	4.69
Average citations per doc	24.09
References	22321
DOCUMENT CONTENTS	
Keywords Plus (ID)	1114
Author's Keywords (DE)	1191
AUTHORS	
Authors	1407
Authors of single-authored docs	27

AUTHORS COLLABORATION	
Single-authored docs	27
Co-Authors per Doc	4.44
International co-authorships %	39.68
DOCUMENT TYPES	
Article	278
Article; book chapter	3
Article; early access	7
Article; proceedings paper	1
Article; retracted publication	1
Editorial material	5
Proceedings paper	22
Review	51
Review; book chapter	3
Review; early access	2

In the WoS search conducted between 2002 and 2023, 373 papers from 178 sources were located. There are more than 22,000 references utilized in these articles. The number of Keywords Plus and author-determined keywords for articles is comparable. Developed with a specific algorithm, KeyWords Plus are words and phrases that are not included in the title of the article itself but are frequently found in the titles of the article's references. Examining the annual productions of articles depicted in Fig. 1., it is evident that RE has begun to be evaluated within the context of health co-benefits, particularly after 2010, and that there has been a rapid increase in the number of scientific publications through 2022.

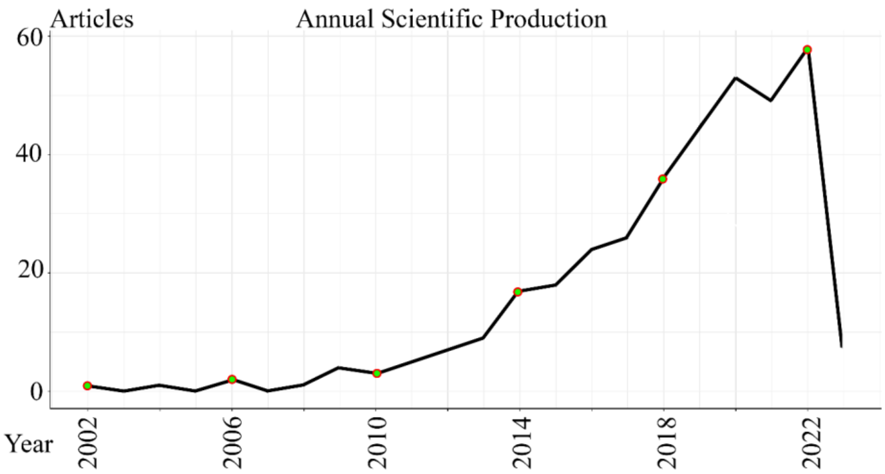

Figure 1. Annual scientific production. The data is eligible till 2022.

The complete publication data collected from the WoS database as a result of the research-specific keyword search were exported for bibliometric analysis and processed in the VOSviewer application. The VOSviewer program, which is used to visualize bibliometric data, processes a large number of data loaded into the software and presents the results, such as the frequency of words used in academic studies, trending concepts, prominent topics, and academic collaborations based on individuals and institutions, in graphics that are both comprehensible and visually striking. The program, which generates a scientific map from database data, is capable of visualizing numerous bibliometric network analyses, including co-citation and co-occurrence network analysis, trend themes and word frequency analysis, and thematic map.

5.2. Co-occurrence Network

In academic papers, the conceptual structure is examined to assess the significance and relevance of the research by disclosing the issues addressed by the researchers. One of these is co-occurrence networks, which reveal the conceptual relationships between phrases. The co-occurrence analysis of the keywords of the examined academic papers depicts a visual representation of the articles' similarities. In this section of the research, the answer to 1 was sought, and as seen in Fig. 2, Co-occurrence Network Analysis revealed that climate change is the most prevalent term. Greenhouse gases are related to the health benefits of RE. As shown by the blue label representing the greatest cluster, air pollution generated by greenhouse gases, particularly from the production of electricity, has been related with health, and the co-benefits created by the usage of RE in terms of air quality are emphasized. While the economic development and health expenditures of RE use are bundled in the red cluster, life cycle assessments have been used to highlight sustainable energy and energy security in the endeavors to cut emissions of greenhouse gases with energy transition within the realm of energy policy. The green cluster, which combines climate change with energy efficiency and sustainable development, aims to supply the energy demand using renewable sources rather than fossil fuels.

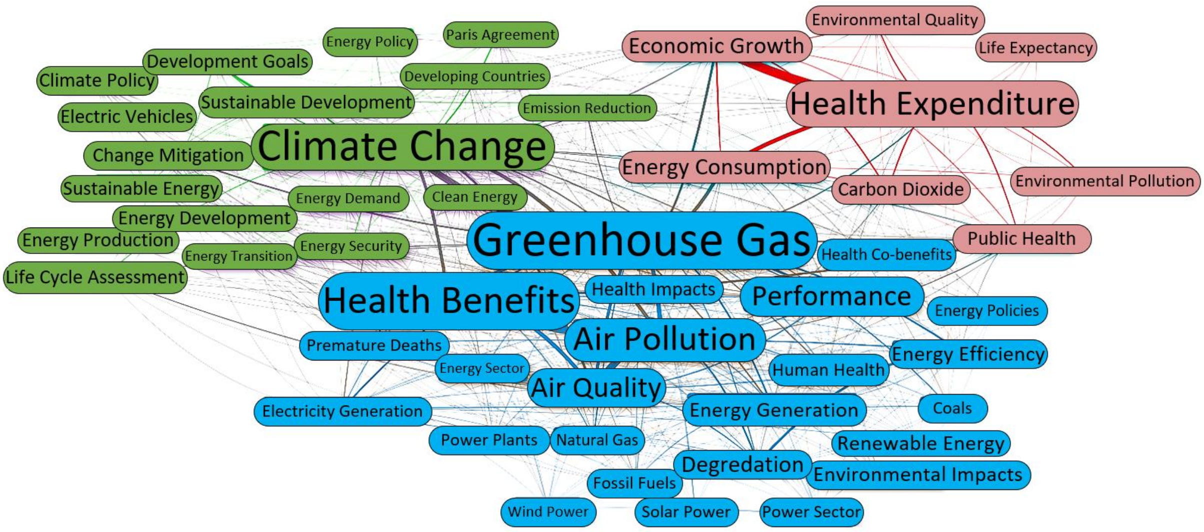

Figure 2. Co-occurrence network analysis.

5.3. Common Citation Network Analysis

Using the reference inputs of the data, the joint reference analysis, which shows the structure of a particular area as connections between nodes, examines the specified publications and reveals meaningful networks between the researchers. This bibliometric technique is used to map the structure of academic studies carried out in the literature in the specified period. The most striking situation in the joint citation analysis findings is that academic studies are mostly conducted by international organizations such as the United Nations, World Health Organization, OECD, European Commission, the International Energy Agency, and U.S. Environmental Protection Agency (US EPA) as seen in Fig.3. Although the subject is handled by some researchers, the fact that public health is an important point of attention of the international public is an indication that the health co-benefits of RE are handled by these organizations. In events such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC), solutions were sought for global climate change on international platforms, and the publications that emerged as a result of these studies tried to raise awareness in the society and policy makers to take the necessary precautions, and academics mostly referenced these reports [128,129]. When the WoS search data is examined, it is seen that many studies are supported by international organizations, ministries, public institutions, foundations, and initiatives.

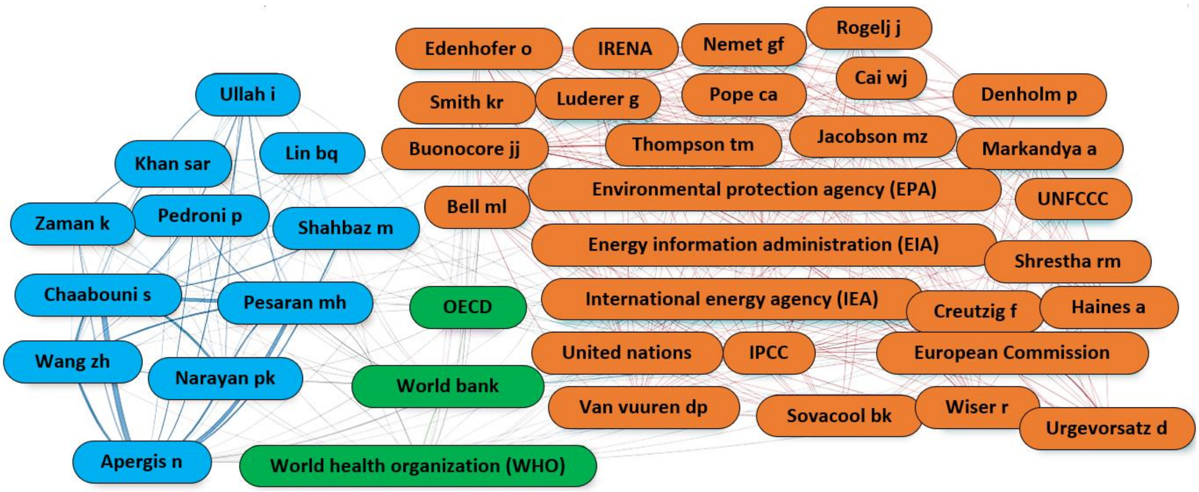

Figure 3. Co-citation network analysis.

5.4. Thematic Analysis

The thematic analysis performed on written texts and utilized in text mining based on artificial intelligence enables the literature to be objectively assessed and organized. The thematic map is an informative graph that enables topics to be analyzed based on the quarter in which they are placed. Each area in the theme analysis represents a distinct study circumstance, and the size of the clustered circles indicates the subject's density. Within the framework of measurements relating to their proximity and density to the center, this analysis divides the topics covered in the research into four categories based on their thematic analysis. Each field represents a distinct study situation, and the size of the grouped circles indicates the strength of the theme. The quadrant at the top right is described as "*Motor Themes*" and is the part where the studies are carried out intensively, and there are important issues in terms of the orientation of the research. The upper left quadrant is called "*Niche Themes*". It is possible to say that the themes here are specialized and the development in clusters is high. However, since the external relations of niche themes with other themes are weak, their effects on the field of study are weak. "*Basic Themes*" at the bottom right quadrant are basic themes that play an important role in the field but are still not well developed enough. "*Emerging or Declining Themes"* at the bottom left quadrant show marginal themes that are newly developing or disappear.

As evidenced in Fig. 4 "Thematic Map" generated based on the Author's Keywords and responding to the research question 2, the motor themes of the area are strongly developed in over ten clusters. Climate change, air pollution, and co-benefits form one cluster, while sustainability, public health, and electric vehicles form another important cluster. While energy transformation, energy justice, and sustainability develop together, willingness to share, choice modeling, and biomass energy have formed a cluster. Environmental pollution, biodiversity, and bioenergy such as leap model and energy systems, and bioenergy with carbon capture and storage (BECCS) are clustered together. It is observed that morbidity and mortality are handled within the framework of risk management. Carbon footprint and mercury emissions were studied by atmospheric dispersion. Studies have been carried out to solve the environmental effects of solar energy obtained by floating solar panels. Floating photovoltaic panels stand out as an environmentally friendly option for countries with limited land. Floating solar energy systems with very high co-benefits because they do not require the use of land for solar energy facilities, provide high energy efficiency with the natural cooling effect of the water on the solar modules, protect water resources as it reduces evaporation, and allow the development of natural fish farms under the platform[130]. Life cycle assessment methods, industrial ecology, and hydrogen terms used to calculate the total cost of RE are found in the Basic Themes quadrant, while CO_2 emissions and health expenditures are the most common basic concepts. Carbon tax and climate mitigation are other issues in this area.

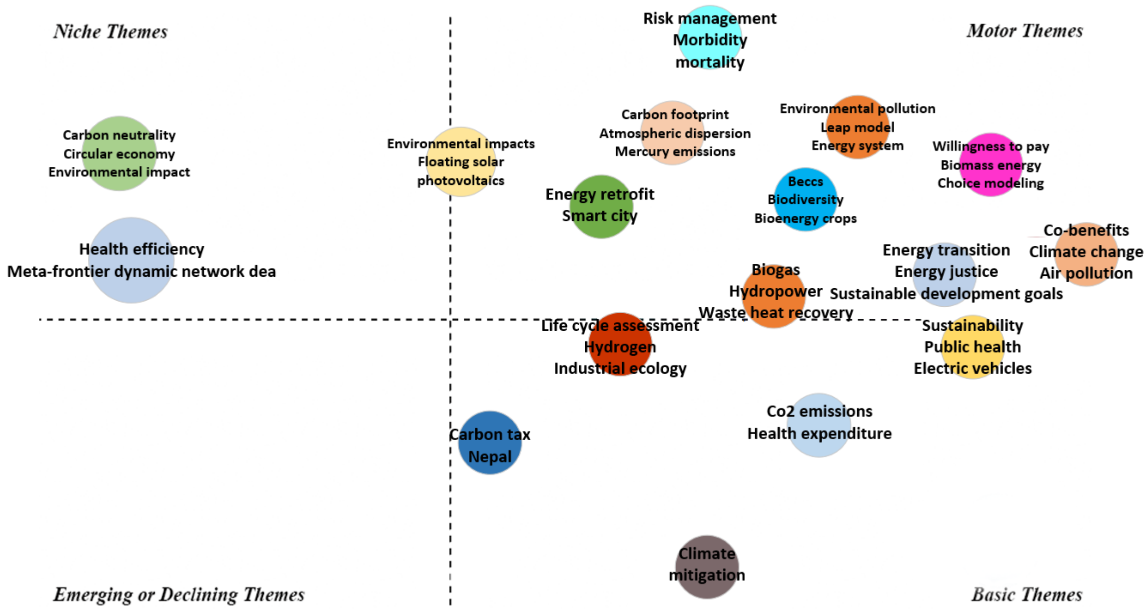

Figure 4. Thematic map.

5.5. Keyword Analysis

In this part of the study, responses to the research question 3 is visualized in Trend Topic graphic prepared according to the keywords plus. Fig. 5 which shows the tendency of the concepts to be used over the years Figures out that for many years, subjects such as Greenhouse gases, bioenergy, biomass, and human health, air pollution have been mainly discussed. It is seen that the co-benefits of RE were discussed the most especially in 2018. The words “co-benefits”, “climate change”, and China were used the most in 2018, while the words “air pollution” and “sustainability” were trending in 2020. In recent years, academic studies have mainly focused on environmental sustainability, health expenditures and costs, and carbon emissions. The words biomass and bioenergy have maintained their trend from 2011 to 2022. It is seen that the country where the effects of RE on health are mostly studied is China. It was found that approximately 17,137 and 24,220 premature deaths could be avoided in China in 2030 if fuel power were entirely replaced by alternative energy. This was determined by taking into account more rigorous non - conventional energy targets as well as the expenditures of cutting emissions from coal-fired energy plants. The elimination of the cost of fossil energy results in a savings of $32 billion, indicating that tighter renewable power targets in China are beneficial from a health perspective. If China were to reduce its reliance on coal energy in a scenario that was analogous to the Climate Action Plan (CAP), this would result in $9.4 billion being made available in the annual energy budget for spending on alternatives. [131].

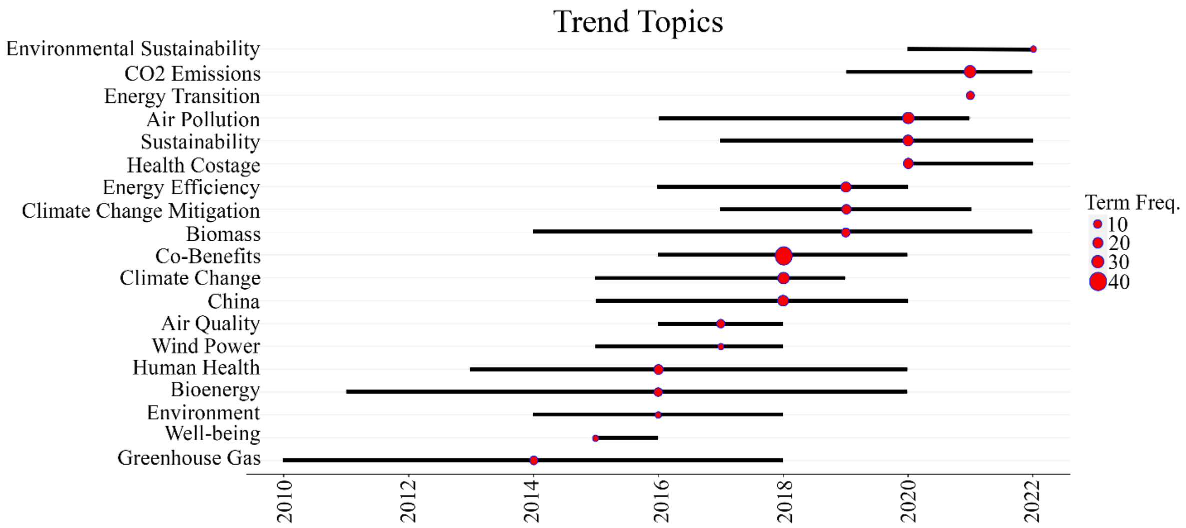

Figure 5. Trend topics.

Word Cloud in Fig. 6 presents a visualization in which groups of words are represented by different colors and the size of the tags is determined according to their frequency. As more meaningful results can be achieved while performing the keyword analysis, visualization was made with binary word groups instead of single words. Accordingly, the most frequently used word groups are determined as greenhouse gas (186), health expenditure (154), climate change (151), air pollution (125), health benefits (110), air quality (95), energy consumption (91), economic growth (87), energy efficiency (64), public health (59), and sustainable development (50). It is noteworthy that one of the most important health advantages that the use of RESs can offer is the prevention of premature deaths (20), and that only this subject is included in the word cloud analysis together with life expectancy (27) and no other disease is mentioned.

Figure 6. Word cloud.

In Fig. 7, which shows the change in the frequency of use of word groups used in the abstracts over the years, it is seen that “Climate Change” has always been the leader after 2010, and the concept of “Health Benefits” has taken the second place with the momentum gained recently. While Air Pollution and Air Quality are in third and fourth places, it is seen that the concepts of Energy Consumption, Economic Growth, Health Expenditures, Greenhouse Gas, and Energy Efficiency follow them respectively.

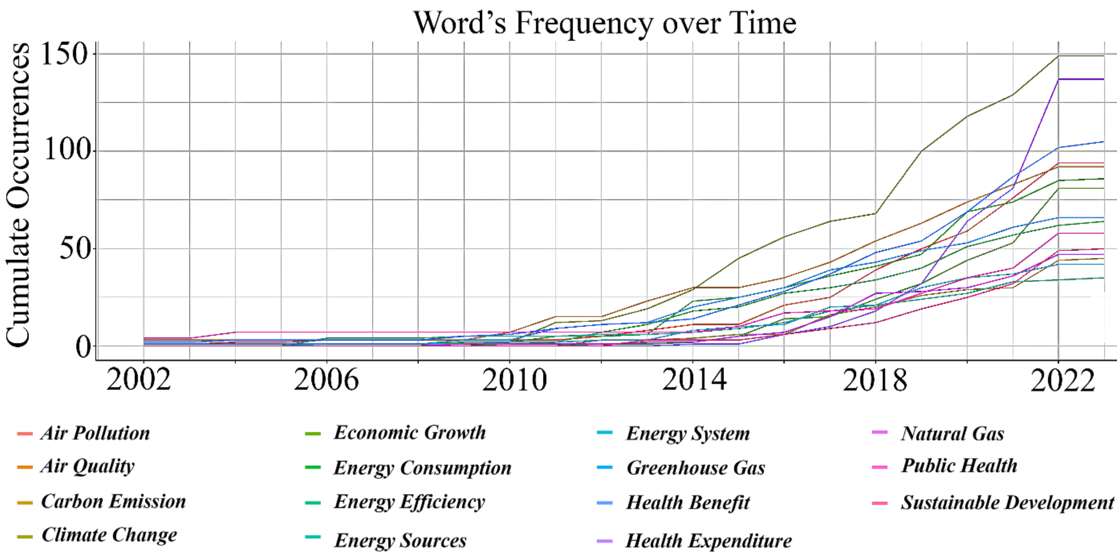

Figure 7. Word's frequency over time.

5.6. Geographical Analysis

The geographical analysis performed as part of bibliometric analysis reveals the geographical relationship between those who contribute to the growth of literature in a certain academic subject. Examining the contributions of authors and nations to the scholarly accumulation in the field and feeding the geography. Examining the production of academic research by country, as shown in Table 3, reveals that the United States produces the most publications in the subject. China follows closely behind. It is trailed by nations such as the United Kingdom, Australia, Pakistan, Germany, and Italy. Fig. 8 is a map illustrating the contributions of various geographies to literary production.

Table 3. Number of publications by country

Country	Freq.
USA	248
CHINA	233
UK	77
AUSTRALIA	74
PAKISTAN	48
GERMANY	42
ITALY	39
JAPAN	34
INDIA	32
CANADA	27
NETHERLANDS	26
TÜRKİYE	22
SPAIN	18
AUSTRIA	16
THAILAND	15

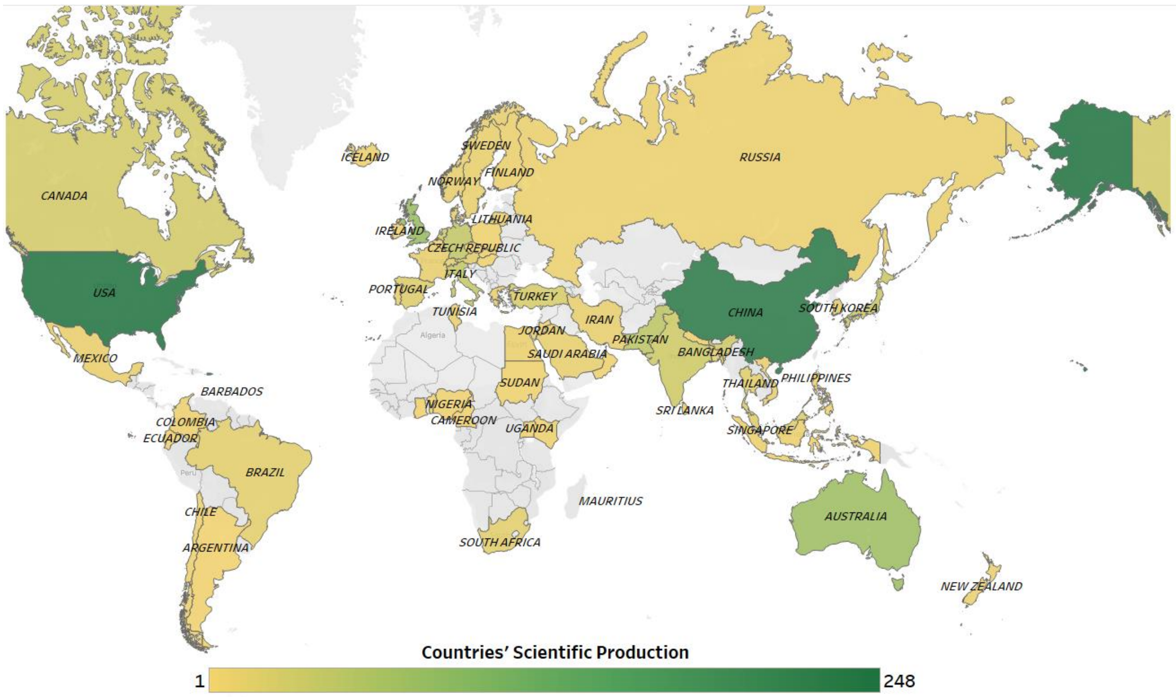

Figure 8. Countries' scientific production.

6. DISCUSSIONS

While it is evident that immediate and decisive climate action is essential to prevent the catastrophic effects of climate change and its associated health effects, it is also evident that the political will required for this action has not been adequately established [132]. Since the use of nonrenewable energy is one of the largest causes of damage to the environment and climate, it is crucial to achieve a rapid, well-planned, and sustainable transition to RE. Although there are initial setup costs, transportation and storage issues, social acceptance, and other impediments to this transition, it would be advantageous to compute the costs with co-benefits and stress the health co-benefits as a strategy for expediting social acceptance. To cover the cost of the transition to RE, it is necessary to develop social awareness through a variety of channels and effect a shift in behavior. The impact of academic research on society's understanding of this transformation as an immediate health crisis, as opposed to a distant environmental issue, is undeniably significant.

There are academic researches in a vast array of areas that study the positive and negative ecological effects of RE both directly and indirectly [133]. In medical, nursing, and other health periodicals, such as The Lancet and the American Journal of Preventive Medicine, the negative health implications of climate change have been studied. Additionally, there are studies on the health co-benefits of RE, such as co-benefits in other domains. Although the number of academic studies in this area is relatively low compared to other scientific endeavors in the field of energy, both the quantity and quality of academic studies are rising. By revealing the mentioned topics, a collective appraisal of publications in a promising field might enable the identification of knowledge gaps.

The bibliometric analysis conducted in this study to disclose the structure of academic studies on the health co-benefits of RE revealed that the number of publications in this sector has increased significantly since 2021. Existing studies demonstrate significant health co-benefits associated with the use of RES, which must be taken into account in cost-benefit analyses for these projects. However, only a small number of articles have quantified health co-benefits individually, making the field relatively new and in need of expansion [134].

It is seen that academic studies have been carried out for more than ten years on biomass and bioenergy among RE types. In a study examining scientific production on renewable energies from 1979 to 2009[135], it was also determined that the most publications were on biomass (56%), solar energy (26%), and wind (11%) like the findings of this study. Wind and photovoltaic energy and natural gas are also frequently studied energy types according to the findings of this study. In a literature review on the health-related co-benefits of RES use, it is found that (1) wind and solar energy are the most studied RES sources [136]. The environmental co-benefits offered by all emissions reductions mechanisms mainly rely on the selection of technology, as demonstrated by a comparison of alternative technology choices in decarbonization pathways in the energy sector using integrated and holistic models in terms of non-climatic environmental impacts and combined with a forward-looking life cycle assessment. Wind and solar-powered mitigation scenarios are superior to low RE ones in terms of minimizing negative effects on human health. [137]. The results of the geographic analysis performed in this study confirm the findings of similar studies, according to which most of the academic studies in the field were conducted in the United States and China [138].

It is a fact that can only be expressed by looking at the word cloud analysis to say that the air pollution caused by greenhouse gases has a pollution effect in the harm to people's health brought on by climate change and that the reduction of health expenditures will support economic growth and sustainable development. In line with the findings of this study, according to the results of the study carried out to determine the causality relationship between RE consumption, economic growth, and health expenditures in Türkiye between 1995-2015, a one-way causality relationship from RE consumption to health expenditures has been determined, that is, a change in RE consumption has been found to cause a change in health expenditures. It has been concluded that developing projects and providing incentives in the field of RE resources in Türkiye can contribute to reducing health expenditures by having a sustainable environment and healthy individuals [139].

In the thematic analysis carried out, the issue of health co-benefits was discussed in various dimensions such as economic, political, social, environmental, and technical, covering themes such as climate change, air pollution, sustainability, public health, energy justice, risk management, willingness to pay and floating solar photovoltaics. Co-benefits have become an important topic of climate change and energy discourse, and when deciding on a climate- or energy-related investment or policy, all costs and benefits must be considered. This is challenging in part because the methodologies that include common impacts, such as cost-benefit analysis, into conventional decision-making frameworks are either insufficient or immature [140]. A study carried out on the publications in the ISI Web database to reveal the development trends of scientific studies in the field of RE in Türkiye, although the number of publications on biomass and conversion systems (39.1%) and solar energy systems (20.0%) is high, the weakest area among all the parameters examined was policy development studies (3.3%) [141], [142]. But considering the issue at the level of government and including it in decision-making processes is an important initiative in terms of public health.

While determining the economic sustainability of RES, it is imperative that legislative, legal, and financial decisions take into account the positive effects that RES have on public health [143]. Policymakers should consider all positive externalities of renewable resources when assessing the options of promoting these resources, and governments should be supported by the most recent research when determining on the most adequate power mix for the country. This is due to the fact that not all RESs have equivalent positive effects [144].

Due to differences in electricity generation or savings by location, characteristics of the electrical system and relocated power plants, as well as population trends, the benefits of energy efficiency (EE)/renewable energy (RE) installations might vary dramatically according to installation type and location [145]. In addition to the feasibility of different types of energy in different areas, the regional effect of the co-benefits of RE types also differs and the health benefits of RE use vary greatly with region-specific conditions [146]. Site-specific information is important in accurately estimating the public health and climate benefits of EE/RE efforts [147]. The need for rigorous co-benefit research and modeling for reliable and useful information on the co-benefits and co-harms of mitigation strategies becomes increasingly urgent as many important mitigation policy decisions will be made so that policies to mitigate global climate change can be taken and adopted worldwide over the next decade [148].

According to the results of the co-citation analysis, academic studies typically cite publications published by international organizations and public agencies. The confidence in these resources, the study of RE, and its implications on health are regarded as a public health priority and are prioritized by governments. These analysis and evaluations are factored into the establishment of energy policy and energy distribution, and incentives and similar applications are used to direct investments. Evaluation of health benefits may be incorporated into the evaluation of RE distribution and other climate initiatives. Information on health advantages is frequently extremely helpful for the public, discussion, and decision-making, and can be used to create political support for climate policies and ensure their soundness and fairness [149]. The possibility for increased collaboration between environmental educators/researchers and healthcare practitioners is highlighted by the importance of reframing climate change as a health concern for environmental movements, environmental education, and environmental research.

7. CONCLUSION

Energy is the main impetus of all industries, a crucial component of development, and a necessity in every aspect of existence. The usage of fossil fuels to satisfy the growing energy demand created by industrialization, without understanding or possibly caring about the damage to the environment, has wreaked havoc on our globe. Realizing that an energy policy conducted at the expense of the environment is unsustainable, alternative energy sources have been explored, and renewable energy sources have been promoted as a means for man to restore the harm he has caused to nature. Despite the fact that renewable energy (RE) brings benefits and co-benefits to its consumers and the country as a whole, the transition to this sort of energy has not occurred swiftly or decisively enough. The health co-benefits of RES can serve as a catalyst for this transition. Energy justice and equity, social welfare, economic growth, biodiversity, and a sustainable ecosystem should be considered when choosing the most effective energy policy and mitigation strategies. The health co-benefit is unquestionably one of the most significant and possibly most directly experienced side effects, and the significance of these impacts must be stressed.

Using bibliometric analysis of scientific papers, this study provides an objective overview of the existing literature regarding the health benefits of renewable energy. Based on a review of 373 academic papers published between 2002 and 2023, it was determined that the number of publications in the subject increased significantly after 2010. It has been observed that a greater emphasis has been placed on diseases induced by environmental contamination. It has been discovered that the majority of academic research in the topic is conducted by multinational organizations with a significant involvement in climate action. Greenhouse gas, health expenditure, and climate change are the most used terms in published works. From this perspective, it can be stated that academic studies on the increase of health expenses owing to GHG-induced climate change are conducted often. Under the context of these findings, it is possible to conclude that the good impacts of RES on public health may encourage the switch to renewable energy. Through boosting academic publications, the good health impacts of RES can be highlighted, making it easier for stakeholders and the public to implement policies that can support a sustainable future by raising awareness. Energy requirements and demand will continue to increase in the years to come. It is essential to meet this demand with renewable energy sources in order to mitigate the negative health impacts of air and environmental pollution, reduce the economic burden of health care costs, and redirect the savings to economic growth efforts. Appropriate RE transition will surely contribute to the reduction of illness and mortality, the lightening of the strain on the health system, the transfer of savings from health expenses to economic development, and the creation of a peaceful and happy society. Academic studies that emphasize the positive side effects of RE on health will be crucial for increasing public understanding in this area.

In this regard, it is crucial that academics communicate the benefits and co-benefits of renewable energy from a comprehensive standpoint. Understanding the positive benefits of RE use on health may be useful for prioritizing public health and making it more equitable, as well as for garnering political support for climate policy.

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