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Green Jobs: The Present and Future of the Building Industry. Evolution Analysis

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Abstract: In the recent context of environmental sustainability awareness, a new trend has emerged in the construction industry: the use of green energy and green jobs. Such practices are particularly frequent in the mentioned sector, precisely because it is amongst those with the greatest energy use and workforce demand. Such a trend characterizes the green building phenomenon, on which the present work aims at achieving a deeper understanding of by analyzing its evolution, examining the most studied topics, and verifying whether they are related to current studies. To this end, a literature review of the most recent works, as well as a bibliometric analysis of papers published in the Scopus database, have been carried out. Next, the collected material was subjected to a deductive content analysis, followed by an Intraclass Correlation Analysis. Findings point to a convergence of the most studied topics within the three analyzed fields (green building, green jobs, and renewable energy), which are also strongly correlated.

Keywords: green building; green jobs; renewable energy; Scopus; correlation

1. Introduction

Green jobs are defined as jobs that contribute to the preservation and restoration of the environment, whether in traditional sectors, such as agriculture or construction, or in new emerging sectors, such as renewable energy and energy efficiency. According to Consoli et al. (2018), the concept can be defined either as an activity aiming at reducing the negative consequences of contamination and resource exploitation, or as the design of new solutions to avoid such contamination.

From the business point of view, green jobs can produce goods or provide services that benefit the environment. However, they are not always based on production and green technologies. In sum, green jobs contribute to the use of production processes that are more respectful to the environment, which is achieved through measures such as lower water consumption or improved recycling (Renner et al. 2008).

As the idea of sustainability evolves, the concept of circular economy (CE) development also attracts attention in the academic, entrepreneurial, and political contexts (Burger et al. 2019). The idea implies changes in the competencies required for workers in the area and in the environmental regulations. Both affect jobs. In general, work in the context of the CE show a greater demand for competencies (Burger et al. 2019). In the United States, for instance, regulation changes have led to a significant, although modest, increase in the demand for certain ecological competencies, especially in technical jobs, such as in engineering (Vona et al. 2018). Moreover, the transition to greener ways of production, distribution and consumption is generally associated with long-term benefits that result from the reduction of environmental damage (Consoli et al. 2016).

In this context, green jobs help preserve the environment for present and future generations, and therefore, should include workers from all countries. The goal of companies employing green jobs is to contribute to sustainable economies, while conserving the environment for present and future generations (Cai et al. 2011). According to a report by the United Nations Environment Program (ONU 2016), under the Green Jobs initiative with the International Labor Organization (ILO 2018), as we move towards a more sustainable and low carbon economy, more green jobs will appear.

Additionally, green jobs lead to a series of environmental advantages, such as: increasing the efficiency of energy consumption and raw materials; limit greenhouse gas emissions; minimize waste and contamination; contribute to climate change adaptation; protect and restore the ecosystems. However, some implications of the green growth in the workforce must also be considered. Green jobs imply, for instance, a reconfiguration of work methods that must be carefully examined (Vona et al. 2018).

There are more than 24 million new jobs that could be created in 2030 (ILO 2018). The industry's participation on job generation currently oscillates between 2% and 3% (Consoli et al. 2018). This characterizes what has been referred to as the "green economy", a wide concept perceived by many countries as an opportunity to preserve the environment, boost the economy, and create new jobs, while focusing on human well-being and avoiding ecological scarcity and environmental risks.

Renewable energies is also particularly relevant within the construction industry. The World Employment and Social Outlook report 2018: Greening with Jobs (ILO 2018) emphasizes, for instance, the emergence of more than 2 million jobs in the energy sector from electricity generation through renewable sources, which will offset the loss of almost 400,000 jobs in electricity generation based on fossil fuels.

Even considering the less optimistic perspectives regarding job creation, green jobs are a reality. This requires a restructuring of the economy and stresses the need to take action on this type of employment, both new and emerging. For instance, the international demand of renewable energy increases job creation and employment (Cecere and Mazzanti 2017). However, there is also some ambiguity in this sector. Sometimes, jobs that a priori should be green are effectively not, as they cause environmental damage due to inadequate practices. Therefore, the definition of green employment is not absolute, as there are "shades" of green as the concept evolves over time. In addition, evidence shows that green jobs do not automatically consist of ethical work. Many of these jobs are "dirty, dangerous and difficult" (ILO 2018), hence the importance of Occupational Risk Prevention. In sectors such as recycling, waste management, biomass energy, and construction, employment is often precarious, and the income is low. However, the concept of green jobs must include ethical work, as stated in the ILO definition. Green ethical jobs effectively link with the Millennium Development Goals (poverty reduction and protection of the environment) and contribute to their mutual support by reducing the onset of conflict (United Nations 2015).

The world is currently in a transition towards sustainable development economies, which implies the need for some specific competencies. Vona et al. (2018) identify two sets of so-called ecological competencies: engineering abilities for technology design and production, and managerial skills for implementing and monitoring environmental organizational practices.

Considering the described situation, the present work aims at achieving a deeper understanding on the concept of green jobs, as well as on its relationship with green building. To this end, first, a theoretical review on topics related to green jobs was carried out. Such topics encompass green building, including the benefits and risks; renewable energies, and waste management in green building. In a second moment, an analysis of the evolution of scientific research on those fields was performed through a bibliometric analysis of works published on the Scopus database, including a deductive content analysis of their tittles, abstracts, and keywords. Finally, possible relationships between them have been highlighted through an Interclass correlation analysis. Results show that research on those topics is relatively recent. Findings, also highlight that the topics are indeed linked to each other, and that current studies are consistent with the trends noticed within the last two decades.

2. Green Building

Construction was the first specific sector addressed in the ILO's Green Jobs initiative. The sector concentrates 25% to 40% of the world's energy and uses 30% to 40% of total greenhouse gas emissions.

In this context, some examples of actions and postures that aim at turning the economy greener are: reducing the emission of harmful gases through the development of renewable energy sources, increasing energy efficiency in transportation, construction and industrial production; and recycling or reusing materials (Vona et al. 2018). All are often found in green buildings.

It is, therefore, one of the human activities that most impact the environment and people's health. Although work-related accidents in the construction sector have declined significantly in recent years, the sector's rates remain among the highest. In addition, the number of occupational diseases represents a very significant percentage. In this context, green building has also been described as a risky activity. This does not mean, however, that green building is more dangerous to the worker than other less green models, but it is important to know that it encompasses different risks (Haslam et al. 2005).

All construction-related jobs can fall into the "green jobs" category. Turning construction jobs green requires training, as managers and supervisors must select which materials to use and how to use them in order to build "green", considering the goals of reducing energy and water consumption, minimizing waste and toxic emissions, and prioritizing workers' safety (Sorvig and Thompson 2018). The study carried out by Vona et al. (2018) shows that the content of work in green jobs is generally less routine oriented than in non-green jobs.

In response to this, one of the betting options in this sector is the development of a new model based on innovation that adapts to the social, economic, and environmental needs. Innovation in this sector can be achieved through improvements in different technical areas, such as using sustainable and better-quality materials, as well as new green technologies and work equipment, improving processes, increasing buildings' energy efficiency, providing more environmentally sustainable structures designs, etc. (Kibert 2016).

The trend of improving energy efficiency through new building designs and the willingness to adapt older structures for a more efficient use of natural resources (especially sunlight through large glazed areas or skylights) can lead to an increase in job creation. Those initiatives are carried aiming at improving energy efficiency, but they may also lead to an increase in the number of workers exposed to the risks associated with these operations (Thormark 2006).

Waste management is also a key word in this sector. The production of waste through both construction and demolition is indissociable from the construction sector.

The boom in this sector has generated significant amounts of waste, which, due to a lack of planning and adequate management, was deposited in landfills, which are frequently uncontrolled. This leads to a waste of energy and reusable material, which negatively affects the environment. Therefore, responsible waste management is necessary to avoid pollution and environmental impacts (US Green Building Council 2011).

3. The Use of Renewable Energy in Green Building

The Current global energy model is environmentally, economically, and socially unsustainable. The main challenges for reverting this scenario are: reducing energy use, reducing fossil fuel consumption, reducing greenhouse gas emissions, securing energy supply, and providing access to energy services to more than 2 billion people who lack them. It is particularly important to consider greenhouse gas emissions, as it is closely related to global warming, and might be the main factor responsible for climate change in the next decades if not reduced (Guile and Pandya 2018).

Currently, most countries depend on coal, oil, and natural gas, that is, fossil (non-renewable) fuels, for energy production. To get ahead in Green Jobs and Green construction, it is imperative to incorporate the use of renewable energy (Lehr et al. 2012). Germany, for instance, recognized the importance of renewable energy and developed a long-term strategy. The German government seeks to

get rid of all nuclear power plants until 2022, and produce 80% of the energy consumed in the country from renewable sources by 2050. Renewable energies provide several environmental benefits and improvements (Destek and Aslan 2017), such as the reduction of surface and groundwater pollution (the extraction of oil, for example, pollutes groundwater), reduction of impact on soil and wildlife, and avoidance of oil spills in transport (an example of an oil spill caused by non-renewable energy production methods is the case of Prestige, an oil tanker that sank in Galicia in 2002, affecting 2000 km of Spanish, French, and Portuguese coasts). Other advantages are: positive economic impact and job generation, since economic gains remain in the country, which creates jobs; and the surplus production is sold abroad, contributing to avoid economic dependence on foreign countries.

Another concept that must be applied in a green and sustainable building model is energy efficiency, i.e., the ability to consume less energy to produce or build, which also helps reduce greenhouse gas emissions. In this context, the current energy-efficient housing policy, which is of critical importance in fighting climate change and minimizing energy costs. Benefits associated with an energy efficient model include: saving money, which is a solid argument in the construction sector; minimizing environmental impacts, improving national security, and improving the quality of life (greater comfort, higher productivity, and better transportation). Moreover, uncertainty about the future enhances the need for adaptation. Therefore, although the implementation of renewable energies is challenging, it is a viable way to help adapt the electricity market to such environmental changes (Jayamaha 2007).

The most used types of energy worldwide are solar, hydro, wind, tidal, and thermal. However, due to the need and the consequent trend to develop different alternatives to fossil energy, new energy generation methods have emerged. One of those new renewable energy sources is underwater currents, which is particularly promising, as two-thirds of the Earth's surface is covered by water, many marine currents are constantly operating at high speeds (Boyle 2004), and currently, only sea waves are actually used to generate kinetic energy.

As using fossil fuels as energy sources is non-sustainable in the long run, efforts should be made to minimize the environmental costs. This is a key factor in green building, concerning both the construction process and energy consumption in new houses and buildings.

4. New Technologies in Green Construction and Their Benefits

The top of green areas is mostly high-tech (Consoli et al. 2018). The benefits associated with green jobs in the construction industry are mainly related to environmental improvements, in which advances in new technologies play a key role (Attmann 2010; Bryde et al. 2013; Kats 2003; Ries et al. 2006).

Moreover, from a theoretical stance, product innovation is expected to have a positive effect on demand for green jobs. In this context, Vona et al. (2018) distinguish the effect on work demand for each technological advance.

Technological changes are particularly important to the construction sector, and must be incorporated in a wide range of procedures within the activity. This includes both procedures that already exist and those in the implementation phase, as well as both medium term and long term procedures (Komnitsas 2011). The list of new technologies that lead to environmental improvement in construction includes:

- 3D printing. It has been used in order to produce complex forms in less time. However, the technique's potential to make construction more sustainable is yet to be fully explored. Potential measures to increase sustainability include substituting the currently used polymers, which are derived from petroleum, with biodegradable and renewable alternatives, such as vegetable cellulose (Rifkin 2012).
- Kinetic Roads. In an increasingly ecologically aware world, many organizations have sought ways to create sustainable, green energy. For instance, the Italian company Underground Power has developed a way to capture the kinetic energy from braking cars to generate electric current (Bjegović and Štirmer 2018).

- Solar Roads. Since 2009, Scott and Julie Brusaw have developed a solar roofing system to be use on the road. The system is made of tiles that produce electricity from sunlight and support weights up to 125 tons (Vijayaraghavan 2016).
- Small house style. In 1997, Sarah Susanka created the movement called "small house". It consists of building houses in a very limited scape, incorporating all kinds of architectural elements to maximize each square meter. These houses have minimal impact on the environment and are considerably smaller than traditional ones. Usually, miniature houses are built from recycled materials and designed for low energy consumption. Less artificial light is used, and the heating system is simpler and cheaper (Pandey and Pandey 2018).
- Recycled materials. Houses made out of containers, for example, are a relatively inexpensive and fast option. They have been tested for many years in different countries, and proved to be a valid construction alternative. Container houses are viable even in place with extreme climates, such as northern European countries (Schrader et al. 2015).
- Low-energy buildings. The trend towards "low-energy" or "zero-energy" stems from the search to minimize energy consumption in the construction and demolition processes. Therefore, the construction of "low-energy" buildings must prioritize materials that require less energy throughout their life cycle, including the extraction of natural resources, demolition, and transportation to the landfill. A building generates various types of costs during its life cycle: the direct cost of materials and construction, running costs (maintenance and repair), demolition costs, etc.; but also indirect costs related to the environment (pollution) and the costs of use (e.g., water, gas, and electricity) (Fouquet et al. 2015).
- Green buildings and urbanism. A building is always part of the environment with which it interacts, and in which it is integrated. All buildings are connected through water and energy networks, as well as through transportation and communications networks. This raises several challenges related to environmental, social, and waste management regulations.

Some of these technologies are used simultaneously to improve the prevention of occupational risks (Fernandez et al. 2017). In short, it is necessary to consider some questions when operating in green construction:

- Consider the climatic conditions, hydrography, and ecosystems in order to maximize their performance and minimize their impact.
- Make moderate and efficient use of building materials, prioritizing those with a low energy content versus those high energy content.
- Reduce the energy consumption in all activities, including the rest of the demand with renewable energy sources.
- Reduce the overall energy consumption throughout the building's life-cycle, including the design, construction, use, and end-of-life phases.

5. Risks of Green Building

Along with the technological advances, there has also been a development of legislation to protect the environment through green jobs. However, workers are still exposed to other risks. For instance, waste sent to landfills has increased the accident and work-related disease rates of construction workers. Installing a solar water heater involves combining the qualities of a carpenter, a plumber, and an electrician, all of whom are usually grouped into a single worker. Moreover, some epoxy resins used in the manufacture of wind turbines are associated with certain allergies, and workers are not always prepared for these situations. According to the second research phase of the Occupational Safety and Health Administration (OSHA), the Foresight report, which identifies new or emerging hazards in green jobs, issues such as waste management, recycling, production technology, and nanotechnologies are the sectors related to the green economy with the greatest potential risks to workers' health. On the other hand, the energy sector has the lowest risk (Yang and Zou 2014).

In addition, EU security officials warn that given the fast pace of the green economy growth, it could create gaps in skills that affect inexperienced or unskilled workers, raising issues such as safety and health. It should also be considered that individuals with low level of qualification might have no choice but to accept subpar working conditions, and that economic and political pressure might lead to those problems being ignored by the Occupational Safety and Health (OSH).

In light of the above, it is clear that the main disadvantages of green building are the occupational risks associated with the activity. Such risks are potentialized by the increase in the active population's age, which is particularly important in an industry that includes physically demanding activities to a significant part of workers (Ghaffarianhoseini et al. 2017).

There is a progressive increase of harmful and fatal accidents, on older workers, with 47 being the age in which the rates start to ramp up in most construction jobs.

Some of the risks in this sector are new compared to traditional construction work, and are caused by the new materials and technologies employed on green projects. Other risks are common in traditional construction as well, such as work at heights, bumps, falls, etc. In this context, green constructions require special attention to minimize both traditional and new work-related risks. The main occupational hazards associated with green building are summarized below:

- Traditional occupational risks of the construction industry, which also apply to green building. The construction industry has particularly worrying occupational accident rates, due to the very dangerous nature of the activity. Over 50% of workplace accidents in the EU occur in the construction industry. They are related to architectural decisions, inadequate organization, or poor management and planning. Slips, trips, falls, blows, and run overs, for instance, are quite common in this industry. In addition, green buildings tend to be more airtight due to less ventilation, which increases exposure to volatile organic compounds from paints and varnishes. The rehabilitation of old buildings with new, low consumption heating or hot water facilities also implies conventional risks associated with construction jobs, such as tube fitters, heaters, and electricians (Azhar 2011).
- Risks arising from the use of new materials, technologies, and eco-friendly models.
    - Risks caused by the use of environmentally friendly materials. New trends include renewable and recycled materials, aqueous products, and nanomaterials. Wood, which is among the usual materials, brings about risks due to sawdust, including skin rash, eyes and respiratory tract irritation, bronchitis, asthma, and even nasal cancer. Eco-friendly materials can also imply risks of exposure to allergens based on proteins and microorganisms such as bacteria and fungi. Also, crushed recycled paper, used as an insulator, contains boric acid, which is toxic and can cause damage to the reproductive system (Armand and Tarascon 2008).
    - Risks caused by the use of new ecological technologies. These risks are related to the materials and methods employed in eco-friendly electrical and water supply, waste reduction, and mainly, emission reduction. In the case of demolition, for instance, separating waste for recycling or reusing often implies manually handling waste material in order to filter recyclables such as plastic, wood, glass, and metal. Combined with the physical workload, this increases the risk of slips, falls, and muscle strains... (Wynne 2002).
    - Risks from new ecological projects. These include skylights and atriums, which aim at providing natural light. Building such structures often exposes workers to some of the biggest risks associated to sustainable construction, since it implies a more intense use of scaffolding.

6. Waste Management as Part of Green Building

One of the problems associated with green building, including both new constructions and renovations, is waste management. An important concept in waste management is the waste hierarchy, which indicates the priority and adequate treatment of each type of waste (Kreith 1999).

When defining waste prevention and management policies and legislation, both construction companies and local administrations apply the waste hierarchy to achieve a better overall environmental result (Morrissey and Browne 2004). Such a hierarchy is summarized in the following priority list (Figure 1):

- Prevention: a set of measures taken at the creation, design, production, distribution, and consumption phases of substances, materials, or products, in order to reduce:
    - The quantity of waste, which is achieved, for instance, through the reuse of products or the maximization of their life span;
    - Adverse waste's impacts on the environment and on human health, which is achieved, for instance, through a parsimonious use of materials and energy.
- Minimization: efforts to minimize the use of materials and energy during the manufacturing stage.
- Preparation for reuse: including control, cleaning, and repair.
- Recycling: any assessment operation whereby waste is transformed back into products, materials, or substances, either for its original purpose, or for any other purpose. It includes the transformation of organic material, which does not involve the recovery of energy, as well as the transformation into materials to be used as fuel.
- Other types of recovery: any operation that turns waste useful, either for replacing other construction materials, or to generate energy.
- Exclusion: recovery, which allow, for instance, the use of substances or energy.

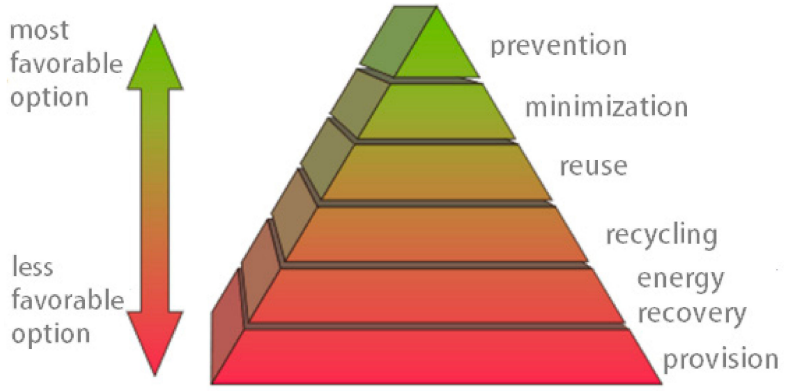

Figure 1. Waste hierarchy. Source: own elaboration.

7. Methodology

The practical component of this investigation consists in a bibliometric analysis (Bornmann and Mutz 2015; Fahimnia et al. 2015) of works containing the terms "green building", "green jobs", and "renewable energy + green building", which were also used in the search of scientific articles for the literature review. This analysis aimed at examining the evolution of scientific research in these currently popular fields. In this context, the adopted specific objectives were: to explore the most frequently used topics in research on these fields; to verify whether the most current study topics are different from those addressed in the last decades; and to discover potential relationships between different research subtopics. In light of those objectives, the Scopus database was selected as the source for the examined scientific works, as it is includes the greatest number

of works, citations, and abstracts among the available peer reviewed literature sources in the Web (Andalial et al. 2010; Bosman et al. 2006). The aforementioned terms were searched for both on tittles and on abstracts and keywords. The time interval of searched works varies according to the topics. Considering all the examined works, green buildings are addressed in 16,938, green jobs are present in 1972 address, and 1130 approach renewable energy + green building (see Table 1). Following the search procedures, a deductive content analysis of the work's tittles, abstracts, and key-words, was carried out. Next, possible correlations between the addressed subtopics were examined, to which the Pearson Correlation Coefficient was employed. In this context, the coefficient quantifies the correlation between different measurements of a numeric variable, and can also be used in cases where there are more than two observations for each subject. In sum, it is an indicator of a single measure's reliability, which is determined by the following expression (relationship between the covariance and the product of typical in each variable):

$$\rho = \frac{б xy}{б x \, б y}$$

The coefficient values range from -1 to 1, where 1 expresses the maximum possible positive correlation and -1 expresses the maximum possible negative correlation.

Table 1. Works retrieved from Scopus database.

Search Terms	Number of Works	Time Interval
Green building	16,938	1920–2019
Green Jobs	1972	1951–2019
Renewable energy + green building	1130	1983–2019

8. Results

Amongst the examined topics, green building has been studied for the longest time. Research in this area dates back to the 1920 decade, when four works have been published. Until the 1940's, however, no additional work is found. Research in the area only really starts to ramp up, however, up from the 1970's, and 69% of the published works are concentrated in the last decade (from 2011). Moreover, 26.7% of works were published in the previous decade, 2001 to 2010. In sum, 95.7% of all the research is concentrated in the las two decades (see Figure 2).

In regard to green jobs, the first work was published in 1951, and no additional paper was published until one decade later. As in the case of green building, research is concentrated in the last decade (which encompasses 63.2% of works), followed by the previous one (28.14%) (see Figure 3).

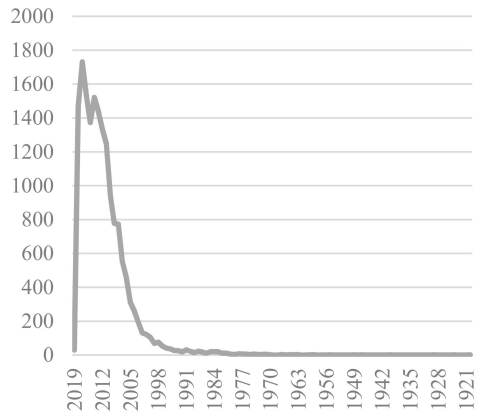

Figure 2. Evolution of scientific research on green building.

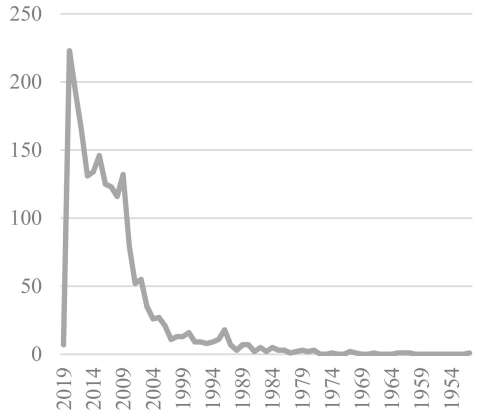

Figure 3. Evolution of scientific research on green jobs.

The third search was the most refined one, as it combined two search parameters in order to examine research in renewable energy associated to green building. In this context, it ensued the smallest amount of works, which however, follow the same evolutionary logic as the other two topics. During the 1980's, three works were published, but only in the 2000's does research begin to see regular frequency. The connection between the two topics is the most recent among the examined research fields, and 73% of the published works are from the last decade (after 2011) (see Figure 4).

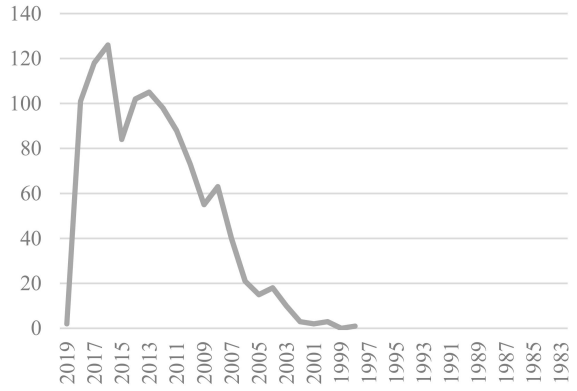

Figure 4. Evolution of scientific research on renewable energy associated to green building.

The study fields of the journals in which works have been published, as well as the type of published documents, have been analyzed. Five study fields account for the majority of studies, and amongst those, engineering occupies a significantly greater volume of research (see Table 2). Article is the most frequent document type, followed by conference paper, with a significant difference between them.

Table 2. Main subject areas and documents type (%).

	Green Building	Green Jobs	Renewable Energy + Green Building
SUBJECT AREA			
Engineering	45.65	23.38	43.45
Environmental Sciences	21.06	17.19	19.56
Social Sciences	14.93	21.30	12.21
Energy	13.73	12.47	37.08
Material Sciences	9.98	5.53	5.84
DOCUMENT TYPE			
Article	54.52	55.18	41.00
Conference paper	31.26	17.15	36.64
Review	5.16	3.56	6.72
Book Chapter	3.43	4.58	6.90
Conference review	1.83	15.15	3.63
Others	3.80	4.38	5.11

To achieve a more detailed understanding of the subtopics addressed in the literature, the frequency of keywords in works published within the three fields was also measured (Table 3). Terms like "sustainable development", "energy efficiency", and "energy utilization" are common within the three fields. The main subtopics addressed are sustainable development, energy utilization and renewable energy sources. The most proliferous authors have published more than 20 papers associated with green building, or more than five in the other two areas.

Table 3. Top ten key words and top five authors.

Green Building (n = 6763)		**Green Jobs (n = 5875)**		**Renewable Energy + Green Building (n = 6645)**	
Sustainable development	2503	Energy utilization	181	Renewable energy sources	288
Buildings	2233	Green computing	177	Energy efficiency	281
Green buildings	2075	Energy efficiency	172	Sustainable development	244
Energy efficiency	1785	Article	171	Renewable energies	216
Energy utilization	1308	Human	169	Energy utilization	194
Energy conservation	1140	Sustainable development	163	Buildings	165
Green building	1075	Employment	144	Energy policy	163
Sustainability	1037	Scheduling	128	Green buildings	151
Architectural design	1012	Humans	119	Renewable energy	147
Building materials	966	Green jobs	100	Energy conservation	145
Author	n works	Author	n works	Author	n works
Jim, C. Y.	28	Bianchini, R.	7	Omer, A. M.	10
Cabeza, L. F.	27	Nguyen, T. D.	7	Chong, W. T.	6
Cole, R. J.	27	Levine, L.	6	Levine, L.	6
Post, N. M.	26	Renner, M.	6	Arcioni, L.	5
Pérez, G.	25	Anon	5	Bianchini, R.	5

Upon the review of all works published in the Scopus database, it becomes clear that the most recent works, some of which are still "in press", are especially relevant. Those works provide a good idea of the current trends in those three fields. Considering this, in order to assess the most currently relevant themes, the 15 most recent works' abstracts and keywords were analyzed (Table 4). Such analysis points to some of the same themes shown in Table 3, including energy efficiency, sustainability, and green building, as well as others, such as quality, productivity, greenwashing, and wave energy. Therefore, it can be inferred that the current trends coincide with the dominant topics within the research developed in the last decade.

Table 4. The most recent articles.

Authors (year)	**Title**	**Topics**
Zhang et al. (2019)	Building up the soil carbon pool via the cultivation of green manure crops in the Loess Plateau of China	Green manures; quality; productivity.
Ma et al. (2019)	China Act on the Energy Efficiency of Civil Buildings (2008): A decade review	Energy efficiency project (EEP); civil building; implementation.
Gunhan (2018)	Analyzing Sustainable Building Construction Project Delivery Practices: Builders' Perspective	Sustainable building; factors affecting; green building.
Gupta et al. (2019)	All that glitters is not green: Creating trustworthy ecofriendly services at green hotels	Green practices; greenwashing; environmental policies; green service encounter (GSE).
Han et al. (2019)	Word-of-mouth, buying, and sacrifice intentions for eco-cruises: Exploring the function of norm activation and value-attitude-behavior	Impact of non-green alternatives; responsible cruise products.
Lavidas (2019)	Energy and socio-economic benefits from the development of wave energy in Greece	Wave energy; socioeconomic benefits.
Bayulgen and Benegal (2019)	Green Priorities: How economic frames affect perceptions of renewable energy in the United States	Cloud services and applications; energy efficient.
Ramos et al. (2018)	Linking sustainable tourism and electric mobility–Moveletur	Sustainable tourism; electric mobility.
Chaudhary (2018)	Can green human resource management attract young talent? An empirical analysis	Green human resource; management; talent.

Table 4. *Cont.*

Authors (year)	Title	Topics
Chang et al. (2018)	Unlocking the green opportunity for prefabricated buildings and construction in China.	Green building; construction; recycling; conservation.
Liu and Ren (2018)	Research on technology clusters and the energy efficiency of energy-saving retrofits of existing office buildings in different climatic regions	Energy demand; building energy; energy efficiency.
Pouran (2018)	From collapsed coal mines to floating solar farms, why China's new power stations matter	Renewable energies; building; energy landscape.
Mauger (2018)	The voluminous energy transition legal framework in France and the question of its recognition as a branch of law	Energy transition; green growth; renewable energy.
Oberloier and Pearce (2018)	Open source low-cost power monitoring system	Digital Universal Energy Logger (DUEL); low-cost power.
Liu et al. (2018)	Quantitative analysis of carbon emissions for new town planning based on the system dynamics approach	Building sector; renewable energies; green spaces.

In terms of the countries that produced the most volume of research, United States, China, United Kingdom, and Italy lead the three fields (see Figures 5–7). In the case of green building, those countries are followed by Australia, Germany, India, and Canada, with over 500 works each. In regard to green jobs, the four leaders are followed by Canada, Germany, France, and Australia. Finally, in the field of renewable energy associated with green building, India, Malaysia, Australia, and Germany occupy the following positions.

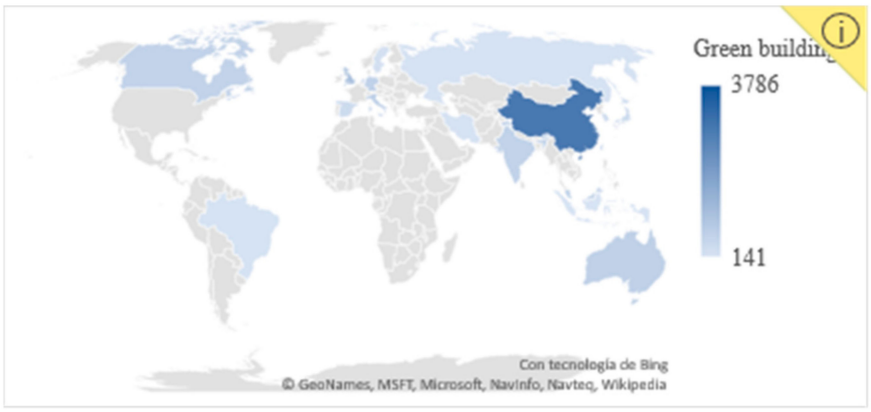

Figure 5. Countries with the biggest volume of research in green building.

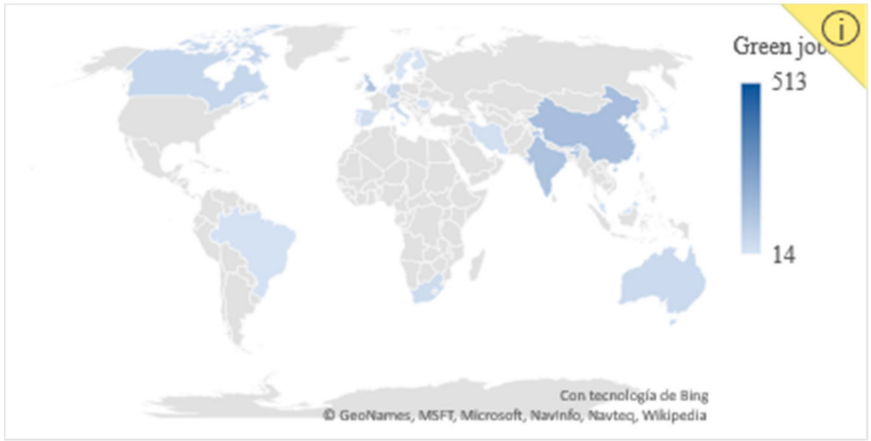

Figure 6. Countries with the biggest volume of research in green jobs.

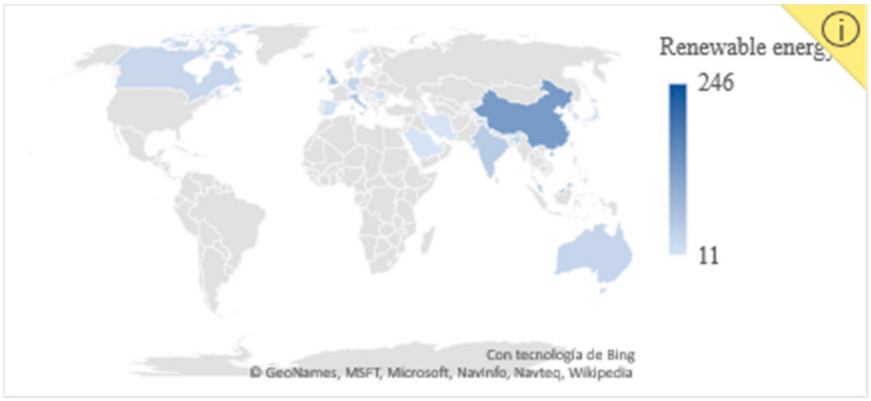

Figure 7. Countries with the biggest volume of research in renewable energy + green building.

After finding the most recurrent keywords in studies within the three fields (Table 3), possible relationships among them were examined (Table 5), which pointed to subtopics that are common to those areas. The subtopics addressed in green building, green jobs, and renewable energy present a high degree of correlation. Some even reach a ϱ value of 1, which indicates total correlation. Works on sustainable development, for instance, are totally correlated with those on energy efficient. Green buildings, green building, and architectural design are also totally correlated with buildings. Works on sustainability are totally correlated with those on energy utilization, and "building materials" is totally correlated with "energy conservation". Therefore, it can be inferred that the three areas of work are indeed related.

Table 5. Correlations between the most frequently addressed subtopics.

	SD	BS	GBS	EE	EU	EC	GB	S	AD	BM	GC	A	H	E	SC	HS	GJ	RESO	RES	EP	RE
SD	1.00	0.75	0.81	1.00	0.96	−0.92	0.75	0.98	0.75	−0.93	−0.95	−0.99	−0.99	0.19	0.19	−1.00	0.19	−0.97	0.28	−0.76	−0.19
BS	0.75	1.00	1.00	0.79	0.54	−0.43	1.00	0.59	1.00	−0.45	−0.92	−0.63	−0.83	−0.51	−0.51	−0.81	−0.51	−0.57	0.85	−0.13	0.51
GBS	0.81	1.00	1.00	0.84	0.62	−0.51	1.00	0.67	1.00	−0.54	−0.95	−0.70	−0.88	−0.42	−0.42	−0.86	−0.42	−0.65	0.79	−0.23	0.42
EE	1.00	0.79	0.84	1.00	0.94	−0.89	0.79	0.96	0.79	−0.90	−0.97	−0.97	−1.00	0.13	0.13	−1.00	0.13	−0.95	0.34	−0.71	−0.13
EU	0.96	0.54	0.62	0.94	1.00	−0.99	0.54	1.00	0.54	−0.99	−0.83	−0.99	−0.92	0.45	0.45	−0.93	0.45	−1.00	0.01	−0.91	−0.45
EC	−0.92	−0.43	−0.51	−0.89	−0.99	1.00	−0.43	−0.98	−0.43	1.00	0.75	0.97	0.86	−0.56	−0.56	0.88	−0.56	0.99	0.12	0.95	0.56
GB	0.75	1.00	1.00	0.79	0.54	−0.43	1.00	0.59	1.00	−0.45	−0.92	−0.62	−0.83	−0.51	−0.51	−0.81	−0.51	−0.57	0.85	−0.13	0.51
S	0.98	0.59	0.67	0.96	1.00	−0.98	0.59	1.00	0.59	−0.99	−0.86	−1.00	−0.94	0.39	0.39	−0.95	0.39	−1.00	0.07	−0.88	−0.39
AD	0.75	1.00	1.00	0.79	0.54	−0.43	1.00	0.59	1.00	−0.45	−0.92	−0.62	−0.83	−0.51	−0.51	−0.81	−0.51	−0.57	0.85	−0.13	0.51
BM	−0.93	−0.45	−0.54	−0.90	−0.99	1.00	−0.45	−0.99	−0.45	1.00	0.77	0.98	0.87	−0.54	−0.54	0.89	−0.54	0.99	0.09	0.94	0.54
GC	−0.95	−0.92	−0.95	−0.97	−0.83	0.75	−0.92	−0.86	−0.92	0.77	1.00	0.88	0.98	0.13	0.13	0.98	0.13	0.85	−0.56	0.52	−0.13
A	−0.99	−0.63	−0.70	−0.97	−0.99	0.97	−0.62	−1.00	−0.62	0.98	0.88	1.00	0.96	−0.35	−0.35	0.96	−0.35	1.00	−0.11	0.86	0.35
H	−0.99	−0.83	−0.88	−1.00	−0.92	0.86	−0.83	−0.94	−0.83	0.87	0.98	0.96	1.00	−0.06	−0.06	1.00	−0.06	0.93	−0.40	0.67	0.06
E	0.19	−0.51	−0.42	0.13	0.45	−0.56	−0.51	0.39	−0.51	−0.54	0.13	−0.35	−0.06	1.00	1.00	−0.09	1.00	−0.41	−0.89	−0.78	−1.00
SC	0.19	−0.51	−0.42	0.13	0.45	−0.56	−0.51	0.39	−0.51	−0.54	0.13	−0.35	−0.06	1.00	1.00	−0.09	1.00	−0.41	−0.89	−0.78	−1.00
HS	−1.00	−0.81	−0.86	−1.00	−0.93	0.88	−0.81	−0.95	−0.81	0.89	0.98	0.96	1.00	−0.09	−0.09	1.00	−0.09	0.94	−0.37	0.69	0.09
GJS	0.19	−0.51	−0.42	0.13	0.45	−0.56	−0.51	0.39	−0.51	−0.54	0.13	−0.35	−0.06	1.00	1.00	−0.09	1.00	−0.41	−0.89	−0.78	−1.00
RESO	−0.97	−0.57	−0.65	−0.95	−1.00	0.99	−0.57	−1.00	−0.57	0.99	0.85	1.00	0.93	−0.41	−0.41	0.94	−0.41	1.00	−0.05	0.89	0.41
RES	0.28	0.85	0.79	0.34	0.01	0.12	0.85	0.07	0.85	0.09	−0.56	−0.11	−0.40	−0.89	−0.89	−0.37	−0.89	−0.05	1.00	0.41	0.89
EP	−0.76	−0.13	−0.23	−0.71	−0.91	0.95	−0.13	−0.88	−0.13	0.94	0.52	0.86	0.67	−0.78	−0.78	0.69	−0.78	0.89	0.41	1.00	0.78
RE	−0.19	0.51	0.42	−0.13	−0.45	0.56	0.51	−0.39	0.51	0.54	−0.13	0.35	0.06	−1.00	−1.00	0.09	−1.00	0.41	0.89	0.78	1.00

SD: sustainable development; BS: buildings; GBS: green buildings; EE: energy efficiency; EU: energy utilization: EC: energy conservation; GB: green building; S: sustainability; AD: architectural design; BM: building materials; GC: green computing; A: article; H: human; E: employment; S: scheduling; HS: humans; GJS: green jobs; RESO: renewable energy sources; RES: renewable energies; EP: energy policy; RE: renewable energy.

9. Conclusions

Sustainability, understood as everything related to preserving resources for future generations, is one of current society's major concerns. Aspects such as climate change are discussed in summits and conferences, in order to find ways to ease the current situation. Thus, the green phenomenon enters many spheres of society, from food consumption to energy production. In this context, the concept of green building has gained relevance in the construction industry, especially within issues related to labor and energy efficiency. The emergence of such topic stems from the idea that, in order for construction to be considered or sustainable, the concept must permeate workforce issues, as well as energy use; i.e., reducing consumption and prioritizing renewable energy sources—as the industry is amongst those with the greatest energy demands. Moreover, green construction must use eco-friendly materials. The construction industry is a fertile research field, as scholars are constantly searching environmentally friendly alternatives to the materials and methods traditionally employed. The most cutting-edge eco-friendly technologies, such as new recycled or recyclable materials, more efficient machinery, and cleaner energy sources—"low-energy" or "zero-energy"—emerge in this industry. It must be observed that green building is a dangerous industry (for the workers), as it inherits risks from traditional building, and adds new ones, which result from the use of new materials, technologies, machinery, and procedures.

The present investigation corroborates that this study area is relatively recent, and coincides with the boom in the stainability phenomenon. 65% of all the research linked to green building, green jobs, and renewable energies is concentrated in the last decade, although in the case of green building, pioneer works have been published since the 1920's. Findings also point out that the most addressed research topics in each of the fields are common, and as shown by the content analysis of the most recent works, the themes addressed coincide with the trends noticed in the last decades. Moreover, results indicate a strong correlation between the main analyzed topics, which are frequently studied together in the same work.

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