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THE IMPACT OF OIL AND GAS PIPELINES ON AGRICULTURAL ACTIVITY: LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract

Natural gas infrastructure is still a hot topic for researchers and policymakers in a world where energy transition and supply security are important issues. In addition to being crucial for getting resources to consumer markets, natural gas pipelines also bring up concerns about sustainability, the economy, and the environment. The objective of this study was to investigate the development of research on natural gas infrastructure, identifying the key subjects examined in the specialized literature, the global research collaborations, and the new avenues that have the potential to influence the field's future. Applying bibliometric techniques to the Scopus database, the analysis showed that the research was fragmented in multiple directions. The first path is the technical and operational one, which aims to maximize the transportation of energy resources and increase the efficiency of gas pipelines. Studies that concentrate on energy security policies and the incorporation of natural gas into domestic and global economic strategies represent a second trend, which is represented by economic factors and market rules. A third dimension of research, which has gained momentum recently, concerns the energy transition and reducing the ecological impact of natural gas, in particular by exploring alternative solutions such as green hydrogen and integrating existing infrastructure with new energy technologies. A key result of the study is that, although the impact of gas pipelines on agriculture is significant, this topic is insufficiently explored in the specialized literature. Gas pipelines can affect soil quality, farmland fertility and value, and farmers in affected areas often face land use restrictions and additional costs for soil restoration. As the energy transition becomes a global priority, future research will need to focus not only on making gas transport more efficient and reducing emissions, but also on how this infrastructure interacts with other economic sectors, especially agriculture. Gas pipelines are not only a component of the energy system, but also a factor with significant economic and ecological implications, which must be thoroughly understood in order to be managed effectively. In conclusion, this study highlights that natural gas infrastructure remains a critical topic for the global energy future, but requires a more integrated approach that includes economic, social and environmental aspects.

Key words: *natural gas, sustainable development, economic effects, environmental effects, agriculture*

INTRODUCTION

Energy infrastructure is an essential pillar of economic development, influencing both energy security and the stability of regional markets. Natural gas pipelines play a critical role in ensuring continuous energy flows, facilitating economic integration, reducing dependence on more polluting fuels and promoting a sustainable economy. In the context of decarbonization and the global energy transition, the importance of natural gas infrastructure is analyzed both from the perspective of ensuring energy security and economic and environmental sustainability [1, 7, 28]. Studies show that the development of transnational transport pipelines contributes to price stability and the reduction of supply bottlenecks [9, 30]. Also, the interconnection of natural gas networks allows rapid redistribution of resources in the event of demand fluctuations or unexpected supply

interruptions [33, 38]. A concrete example of the importance of these infrastructures is the European Union, where the policy of creating an "energy union" was driven by the need to reduce dependence on foreign imports and increase the diversification of supply sources [2, 11, 22].

The expansion of natural gas infrastructure contributes to economic growth by attracting investment and creating jobs [3, 12, 25]. At the same time, natural gas pipelines reduce energy costs for consumers and industry, facilitating access to more efficient and less polluting energy sources compared to coal or oil [15, 23]. In order to stabilize national economies and preserve competitiveness in global markets, these infrastructures are crucial. Furthermore, in the current energy transition context, natural gas is regarded as an intermediary solution for lowering carbon emissions, enabling the integration of renewable energy sources by bolstering natural gas-based energy production during periods of wind and solar energy fluctuation [5, 8]. An important aspect is the use of existing infrastructure for the transport of renewable natural gases, such as biomethane or green hydrogen, which contributes to reducing the carbon footprint of this sector [24]. In order to create a resilient and sustainable energy system, it is imperative that the current infrastructure be modified. Despite these benefits, the infrastructure for transporting natural gas has numerous drawbacks from an economic and environmental standpoint.

The development of energy infrastructure, especially the expansion of natural gas pipeline networks, has a significant impact on agriculture and agricultural land. One of the most significant economic effects of gas pipelines on farmers is the decrease in crop yields due to physico-chemical changes in the soil. Research has shown that high pipe temperatures reduce soil moisture, thus affecting plant development and leading to significant yield losses [13]. These losses translate into lower incomes for farmers, who are forced to adopt additional measures such as additional irrigation or the use of expensive fertilizers to compensate for soil damage.

The installation of pipelines involves excavation work that destroys the soil structure, which imposes additional costs on farmers in order to restore the fertility of the affected lands. Research from Poland shows that farmers have to bear high costs for fertilization and mechanical land restoration [19]. Gas pipelines impose restrictions on the use of land, which causes a significant depreciation of its value. Farmers who want to sell affected land face difficulties, as investors avoid land subject to restrictions imposed by energy infrastructure [19, 26]. This decrease in land value is a major obstacle for farmers who want to expand their agricultural holdings or obtain financing to modernize their farms. A key aspect of the economic impact is the low level of compensation offered to farmers affected by the construction of gas pipelines. In many cases, gas transportation companies only provide compensation for temporary land use during construction, without considering long-term losses [19, 27].

In addition to direct financial losses, farmers face significant restrictions on land use after pipelines are installed, such as prohibiting the use of heavy machinery for plowing or harvesting above the pipelines or limiting the types of crops that can be planted to avoid damage to the pipeline [29].

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In this context, the paper aimed to investigate the development of research on natural gas infrastructure, identifying the key subjects examined in the specialized literature, the global research collaborations, and the new

avenues that have the potential to influence the field's future.

MATERIALS AND METHODS

To carry out the bibliometric analysis related to the impact of natural gas pipelines and energy infrastructure on agriculture, a methodology based on the consultation of the Scopus database, one of the most comprehensive sources of scientific literature, was used. The research was carried out between February 15-18, 2025, the searches being carried out using specific terms of interest, which allowed the extraction of a set of relevant articles. Thus, the expression "Natural gas pipelines" allowed the identification of 26,240 articles, reflecting the breadth of research dedicated to gas transport infrastructure. The term "sustainable development" generated 358 articles, indicating a significant concern over the relationship between energy infrastructure and the principles of sustainable development. In order to analyze the effects of this type of infrastructure on the environment and the economy, the search with the terms "environmental and economic effects" identified 26 articles, which demonstrates a need to deepen this topic in the specialized literature. Regarding the connection between gas pipelines and the agricultural sector, the term "agriculture" returned only 3 articles, which highlights the need to develop research regarding the impact of this infrastructure on agricultural land.

For the analysis and processing of the extracted data, the VOSviewer software was used, a tool specialized in visualizing co-citation networks and relationships between scientific concepts. With its help, the main research directions, the connections between different subfields and the most relevant authors in this field were identified. This method allowed us to create bibliometric maps that highlight the structure of existing research, major thematic clusters and gaps in the specialized literature, thus facilitating a deeper understanding of the subject and providing future directions for research on this important subject.

RESULTS AND DISCUSSIONS

The bibliometric analysis allowed us not only to identify trends in research regarding energy infrastructure and the impact of natural gas pipelines on agriculture, but also to outline an overview of the evolution of this field, facilitating a deeper understanding of the interconnections between energy, the economy and the environment, elements that can contribute to the foundation of coherent sustainable policies (Fig. 1).

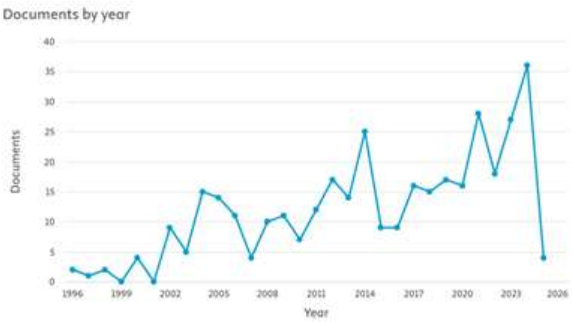

Fig. 1. Evolution of research on energy infrastructure and natural gas pipelines
Source: [32].

Analyzing the research situation in the field, it can be seen that there is a growing interest in studies on energy infrastructure and natural gas pipelines, especially in the last decade (Fig. 2).

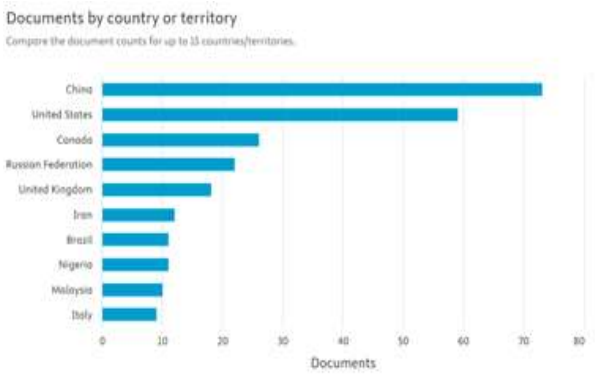

Fig. 2. Distribution of documents regarding energy infrastructure and natural gas pipelines by country
Source: [32].

This trend shows that the development of sustainable energy technologies, the impact on agriculture and the circular economy are

becoming increasingly relevant topics in global research.

Bibliometric analysis is a way of highlighting emerging research directions and the evolution of the topic in the context of the energy transition and policies to reduce carbon emissions.

According to the data presented in Figure 2, there is a growing interest in studies on energy infrastructure and natural gas pipelines, especially in the last decade. This trend shows that the development of sustainable energy technologies, the impact on agriculture and the circular economy are becoming increasingly relevant topics in global research.

Romania is on the last places in this ranking, as a result of the fact that this topic was addressed in a single scientific article.

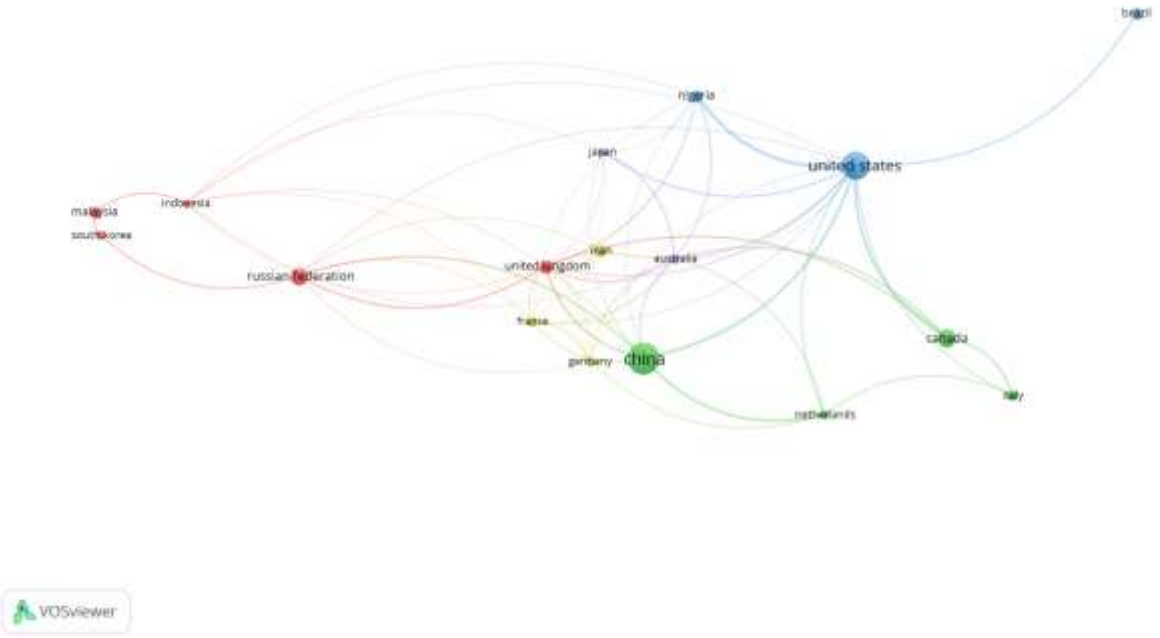

Fig. 3. Global co-authorship network in energy infrastructure research
Source: own processing [34].

The analysis of the relationship between the co-authors and the countries highlights the structure of international collaborations in the field of energy infrastructure that have an essential role in the advancement of scientific research, facilitating the exchange of knowledge, access to resources and the development of innovative technological solutions (Fig. 3).

It can be seen that the U.S. constitutes one of the most important centers of collaboration, having extensive connections with Canada, Nigeria, China and Brazil. This dominant position proves that American researchers are actively involved in international partnerships and that universities and research institutes frequently collaborate with counterparts in other regions of the world. To strengthen this position, collaborations could be expanded with emerging states in Asia and Africa, where energy infrastructure development is booming. Another central actor in this network is China, which has multiple connections with Germany, the United Kingdom, Iran and the Netherlands. This reflects not only an active presence in international research, but also a strategic interest in sustainable energy technologies. Collaborations between China and European states can be intensified through joint projects

focused on the energy transition and the development of renewable sources. The Russian Federation also occupies an important place in the co-authorship network, having strong ties with Southeast Asian countries such as Malaysia, Indonesia and South Korea due to the interest related to the expansion of energy infrastructure in the Asian regions and for collaborations in the field of natural gas. Iran and the United Kingdom play intermediary roles in this network, connecting various regions and facilitating the transfer of knowledge between Middle Eastern states and Europe. Their position enables them to serve as intermediaries between researches projects carried out on several continents. Research in this crucial area may be further, in our opinion, by the establishment of international research consortia, which would provide access to European and worldwide funds for collaborative energy initiatives. European nations like Germany, France, and the Netherlands are well-integrated into the network because of their great interest in energy research and connected academic environment. To lessen the ecological impact of energy infrastructure, however, more cooperation with poorer nations could make it easier to transfer technologies and put creative solutions into practice.

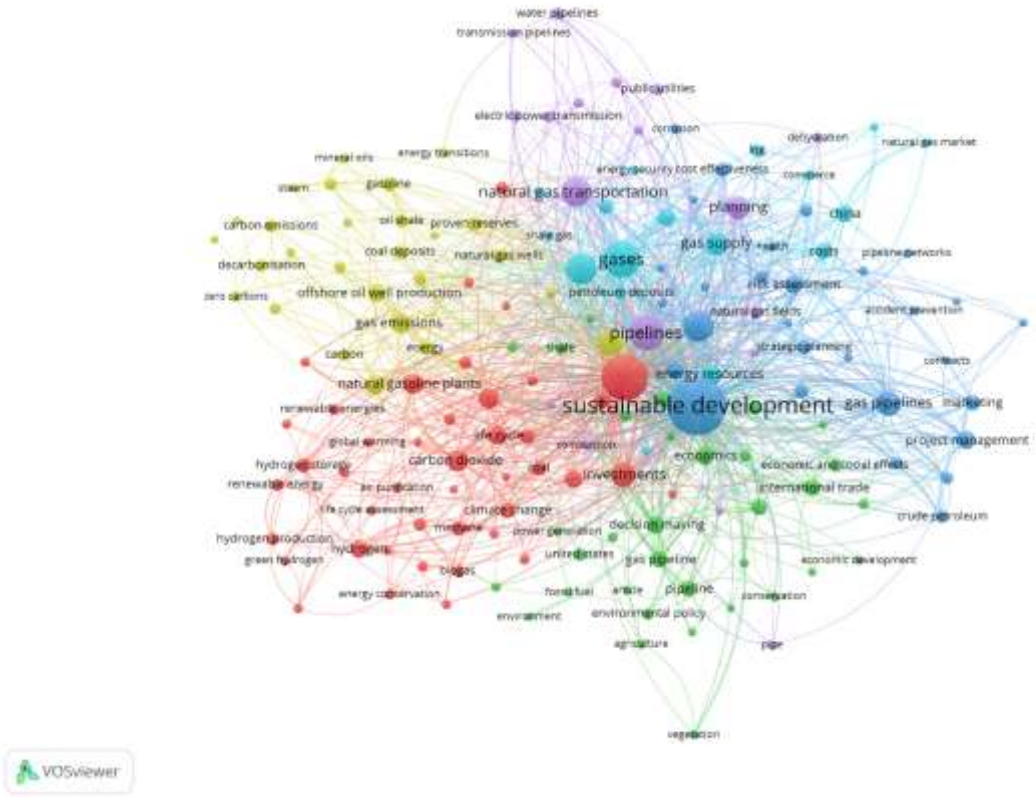

Fig. 4. An examination of the keywords that appear together in the fields of sustainable development and energy infrastructure
Source: own processing [34].

The high correlation between the terms "sustainable development," "pipelines," "energy resources," and "gas supply" suggests that the economic, social, and environmental impacts of energy infrastructure are increasingly being considered when analyzing it (Fig. 4).

The necessity of an integrated strategy to managing natural gas transmission networks is highlighted by the frequent inclusion of elements like risk assessment and strategic planning. The decarbonization and renewable energy cluster is a second significant cluster that includes phrases like "carbon dioxide," "climate change," "hydrogen production," and

"renewable energy." This demonstrates that switching to less polluting sources and lowering greenhouse gas emissions are emerging as top research priorities. Additionally, although the integration of hydrogen as a natural gas substitute is a growing topic, it is not yet fully associated with gas pipeline studies, which may suggest areas for further research. In parallel, another cluster is focused on the exploitation of fossil fuel resources, including terms such as "natural gas wells", "coal deposits" and "offshore oil well production". This aspect demonstrates that, despite energy transition efforts, natural gas continues to be an essential component of the global energy market. Researcher interest remains high on extraction efficiency, resource management and pipeline transport optimization. An important dimension of the research is represented by energy planning and infrastructure, grouped in a cluster containing terms such as "public utilities", "electric power transmission" and "pipeline networks". This highlights the strong link between natural gas transmission networks, energy security and their integration into electricity and water supply systems.

In terms of economic and environmental impact, related terms such as "economic development", "environmental policy", "agriculture" and "conservation" emphasize the importance of analyzing the effects of gas pipelines on agricultural land, ecosystems and local communities. However, the weaker connections between these concepts show that this direction of research is still insufficiently explored, which opens up opportunities for in-depth studies on the relationship between energy infrastructure and the sustainability of land used for agriculture (Fig. 5).

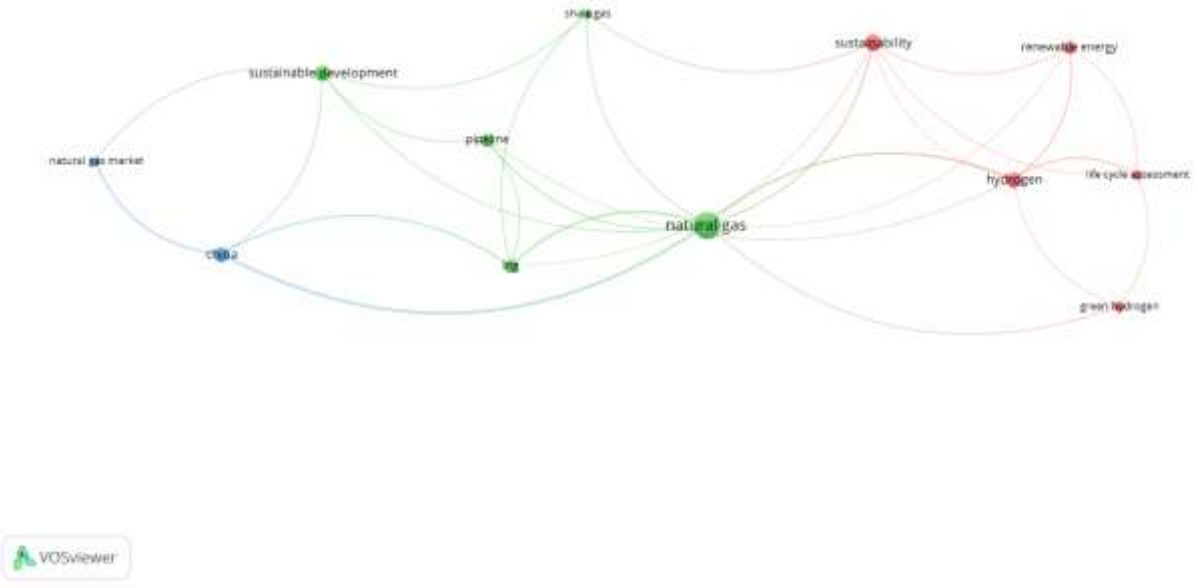

Fig. 5. Examination of key words' co-occurrences and authors in the context of sustainable development and energy infrastructure
Source: own processing [34].

From the analysis of the relationship between the co-occurrence and the authors of the keywords, it is found that a first essential aspect observed is the central position of the term "natural gas", which dominates the thematic network and is directly correlated

with fundamental concepts such as "pipelines", "LNG" (liquefied natural gas) and "shale gas". This connection indicates that the literature places particular emphasis on natural gas transport and distribution, reflecting concerns about infrastructure, energy efficiency and accessibility in global markets. Moreover, the link between "natural gas" and "sustainable development" demonstrates that recent studies analyze natural gas from a sustainability perspective, considering both economic and environmental implications. The "natural gas market" represents another significant cluster, and its strong relationship to "China" suggests that scholars are becoming more interested in the local natural gas market's development. There has been a lot of research on energy policy, infrastructure investments, and the effects of natural gas on China's energy security because the country is one of the biggest importers and consumers of natural gas.
In parallel, the report also highlights the decrease of carbon emissions and the shift to renewable energy sources as areas of attention. Thus, the terms "sustainability", "hydrogen" and "renewable energy" form a distinct cluster, reflecting the global trend to explore cleaner alternatives to fossil fuels. Interestingly, "green hydrogen" is a well-connected concept in this network, suggesting an increased interest in green hydrogen as a viable solution in the energy transition. Also, the presence of the term "life cycle assessment" in this cluster indicates that recent studies pay more attention to the life cycle assessment of natural gas and hydrogen, analyzing their environmental impact and economic feasibility.
The analysis also highlights a close connection between natural gas infrastructure and sustainable development, as a result of which current research is no longer limited to the technical and economic aspects of gas transport, but also includes dimensions related to environmental policies, resource conservation and the impact on ecosystems

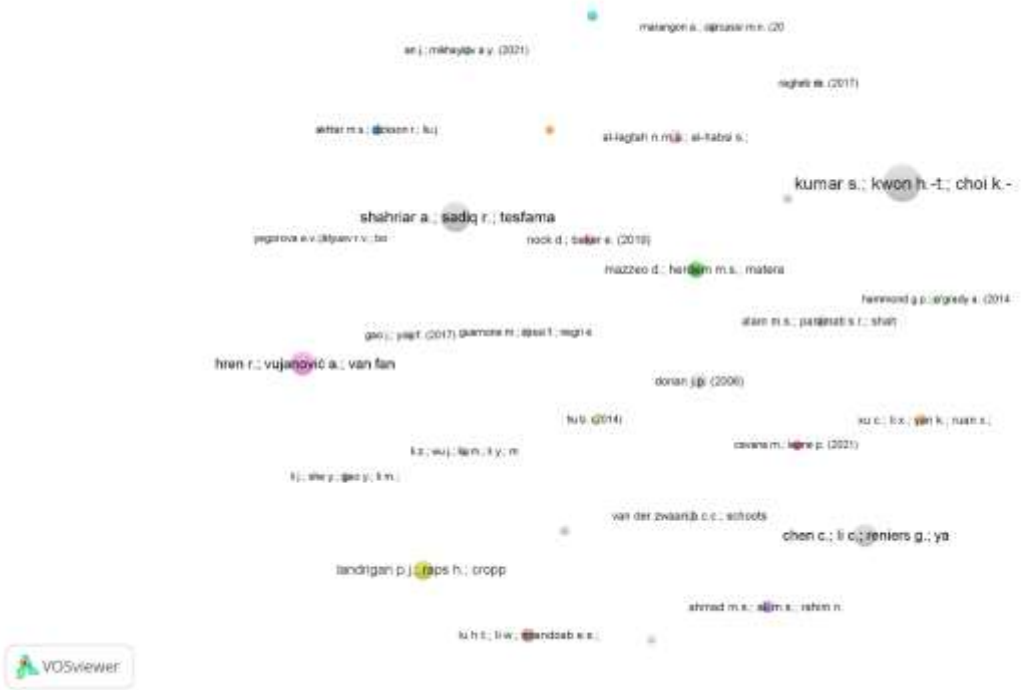

Fig. 6. Analysis of the citation network of documents from the specialized literature on energy infrastructure and sustainable development
Source: own processing [34].

A first aspect observed is the distribution of authors according to the influence of their works (Fig. 6). Names like Shahriar A., Sadiq R. [31], Kumar S. and Kwon H.-T. [20] they

have a high number of citations and, implicitly, a significant influence on the evolution of the field. Similarly, authors Hammond G.P. and O'Grady A. (2014) [14] are placed in central positions, due to the fact that their works were frequently used as references in subsequent studies. Also, the connections between the authors demonstrate the existence of complementary research directions, with authors grouped in clusters depending on the topic addressed. For example, Chen C., Li C. and Reniers G. [6] are associated with economic and management aspects of gas infrastructure, while Hren R., Vujanović A. and Van Fan [16] are related to technical analysis and sustainability. This structure shows that the literature is fragmented into distinct subfields, but which interact with each other through common citations and references.

Another important aspect of the analysis is the identification of seminal and emerging works. Older researches, such as Dorian J.P. (2006) [10] and Hu B. (2014) [17], have a high number of citations, having an essential role in establishing some key concepts and methodologies used in subsequent research. Instead, more recent works such as Cavana M. and Leone P. (2021) [4] have opened up new research directions and emerging trends.

A dynamic ecosystem is thus reflected in the citation network, where new contributions are progressively incorporated into the body of existing literature and previous research serves as the basis for current investigations.

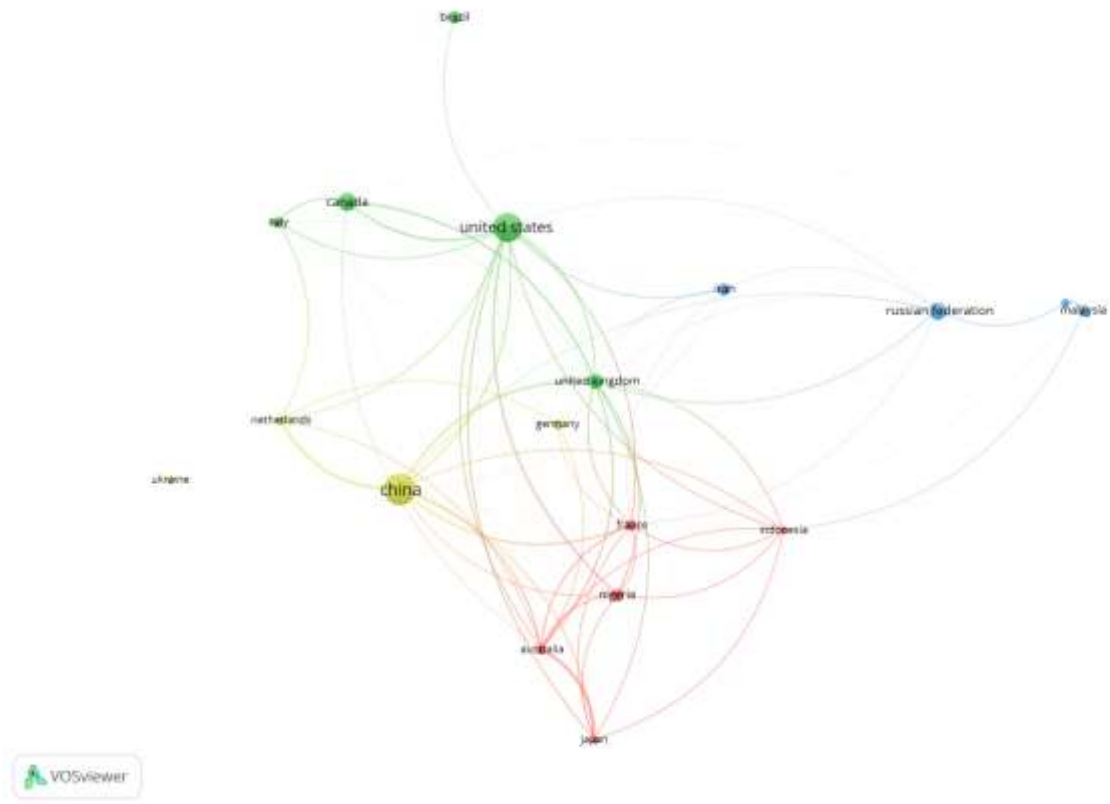

Fig. 7. An examination of the connection between countries and co-citations
Source: own processing [34].

A complex web of scholarly impact characterizes research on energy infrastructure in the context of globalization and the energy transition. The most cited writers establish their status based on how frequently their work is cited in later studies.

Figure 7 sheds light on the primary research centers by examining co-citations, identifying the nations that have the most effect on the literature and the connections between them.

The dominance of the United States and China in the co-citation network is the first

important factor. These countries are the main hubs for science and have a significant impact on the development of energy infrastructure both theoretically and practically. The United States is closely associated with Canada, the United Kingdom, and Brazil. However, China's close ties to the Netherlands, Germany, and France show a propensity for cooperation with Europe, particularly in the areas of energy laws and gas transportation technologies.

The distribution of theme clusters suggests that there are multiple separate but related lines of inquiry. Because they are concerned about managing energy resources in an economical and ecologically responsible way, the United States, Canada, and the United Kingdom are mostly focused on energy policy, economics, and sustainability. To maintain a global balance between supply and demand, China, Germany, and the Netherlands, on the other hand, are increasingly concentrated on gas transportation technologies and energy infrastructure optimization.

Another important cluster, made up of Japan, Australia, Nigeria and Indonesia, addresses the environmental impact of energy infrastructure, focusing on climate change, the energy transition and the development of renewable sources, relevant as it reflects increasing pressure on governments and industry to reduce the carbon footprint of natural gas transport. In parallel, a group of countries such as Russia, Iran and Malaysia are more focused on issues related to energy security and natural gas geopolitics, given their major role in the export of energy resources.

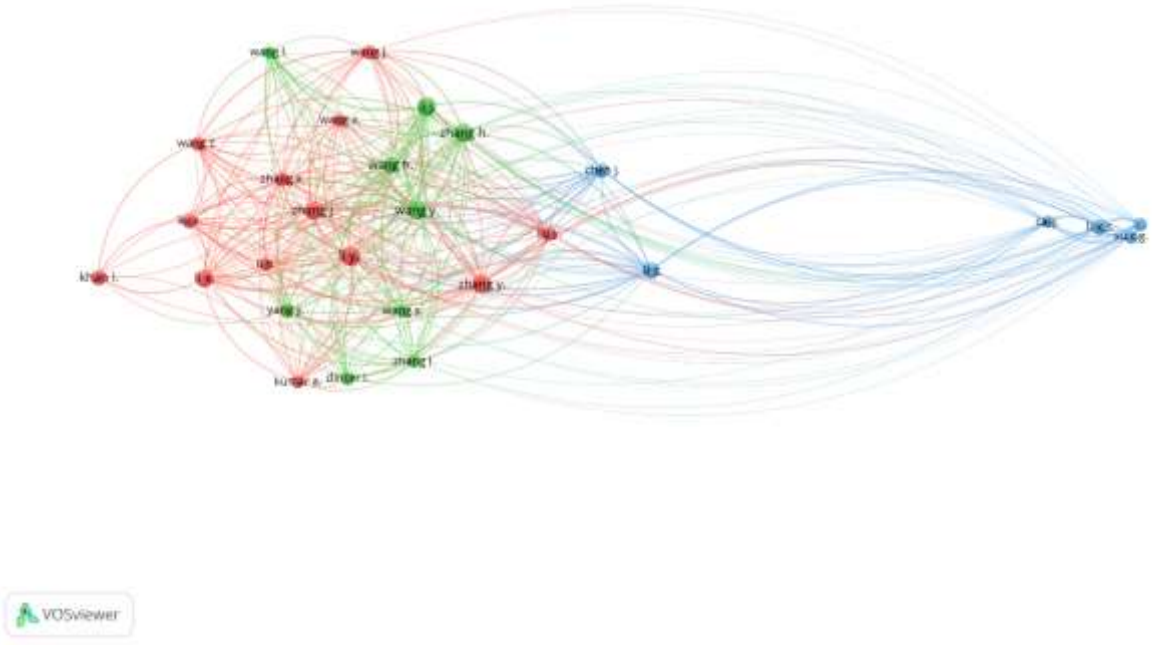

Fig. 8. Analysis of the relationship between co-citations and cited authors in the field of energy infrastructure and sustainable development
Source: own processing [34].

Figure 8 shows a well-defined structure, where authors organize themselves into three main clusters, each representing a distinct research direction. The red cluster, where we find authors such as Khan I., Liu J. and Zhang X. [18], reflects a research focus on technical

and operational aspects of natural gas infrastructure, such as optimization of transmission networks and distribution efficiency. The green cluster, dominated by names such as Zhang Y., Wang H. and Liu L. [37], is more oriented towards energy economy and sustainability, analyzing the impact of infrastructure on global development and public policies. In parallel, the blue cluster, where authors such as Xu G., Cai J. and Li Z. [36] are present, indicates an interdisciplinary approach, with research that questions the role of natural gas in the energy transition and their integration into the renewable energy mix.

A distinctive feature of this network is the existence of a dense central core, where authors from the red and green clusters are frequently cited together.

Tabelul 1. Analysis of the articles regarding the impact of the natural gas pipelines on agriculture

Authors and year of publication	Title	Purpose	Results obtained
Landrigan, P. J., Raps, H., Cropper, M., Bald, C., Brunner, M., Canonizado, E. M., ... & Dunlop, S. (2023) [21]	The Minderoo-Monaco Commission on plastics and human health	The purpose of this study is to analyze the impact of natural gas transportation on agriculture, highlighting the main effects that energy infrastructure has on agricultural land and rural ecosystems. In this context, the research explores how the construction and operation of gas pipelines influence soil fertility, access to water resources and agricultural productivity	Studiul a evidențiat că The transportation of natural gas has a significant negative impact on agriculture, affecting soil fertility, access to water and land use through soil compaction, erosion, contamination and imposing restrictions on agricultural activities. It was also found that, although these effects are obvious and relevant from an economic and ecological point of view, the specialized literature has not paid enough attention to this topic, indicating the need for further research to quantify the long-term impact and identify mitigation solutions. [21].
Walker, B. L., Neubaum, M. A., Goforth, S. R., & Flenner, M. M. (2020). [35].	Assessing habitat loss and alteration brought on by recent energy infrastructure development in a remote, outlying greater sage-grouse population	This study set out to measure the amount of habitat loss and alteration that an isolated Greater Sage-Grouse (GrSG) population in the western United States—more especially, Colorado—has experienced as a result of the development of energy infrastructure. Evaluating how highways, natural gas pipelines, and other energy infrastructure affect ecosystems and land cover was the main goal of the study	The research indicates that the growth of energy infrastructure, such as natural gas pipelines, is significantly influencing natural habitats and farms, which in turn impacts the species that rely on these ecosystems. Even while land reclamation is being done, it is not very effective, and little is known about how it will affect agriculture and biodiversity in the long run. According to these findings, more stringent energy infrastructure impact management regulations are required to stop additional habitat loss and to safeguard the environment and local economies in impacted areas [35]

Source: own processing.

This is due to the fact that their works serve as fundamental references for numerous subsequent researches, having a significant impact on the development of the field.

In contrast, the authors in the blue cluster present a more dispersed network, having a greater influence in interdisciplinary areas and in studies aimed at the integration of natural gas into new energy policies.

The analysis of this co-citation network also highlights a significant presence of researchers from Asia, especially China, which reflects the growing involvement of this region in the development and modernization of energy infrastructure.

Next, we also analyzed the articles on the impact of natural gas transport on agriculture, confirming that the number of studies is surprisingly low, although the effects on agricultural land are significant. Most existing research focuses on the technical aspects of infrastructure, energy efficiency and impact on biodiversity, and the issues of soil compaction, fertility loss and restrictions on farmers are rarely addressed in detail (Table 1).

Studies on energy infrastructure prioritize grid optimization and emissions reduction over the impact on agriculture. Also, the effects on agricultural land are difficult to quantify in the long term, requiring long monitoring and interdisciplinary studies, which discourages extensive research in this field.

In this regard, it is imperative that future research focus more on the long-term effects of gas pipelines on agriculture, incorporating multidisciplinary studies that examine both the economic impacts on farmers and the physico-chemical changes to the soil, so that decisions regarding the expansion of energy infrastructure are founded on a thorough evaluation of the costs and benefits.

CONCLUSIONS

As the world's energy revolution accelerates, natural gas pipelines play an increasingly complicated role by tying together sustainability, energy security, and economic factors. These infrastructures are much more than just ways to move resources; they also serve to maintain delicate economic equilibrium, impact geopolitical relations, and determine the direction of energy on a global scale.

The examination of scientific studies showed that natural gas infrastructure is a complex area with entwined technical, financial, and sustainability elements. Despite the fact that a great deal of research has been done on the effectiveness of transportation networks, energy flow optimization, and natural gas integration in the energy transition, the effects on agriculture have not received enough attention. Despite the fact that the effects on agricultural land are significant – including soil compaction, erosion, restrictions on farmers and decreased land values – the number of studies analyzing these issues is few. This gap in research can be explained both by the difficulty of quantifying long-term impact and by the prioritization of other topics of interest by research funders.

This bibliometric analysis was not just a theoretical exercise, but a research that aimed to provide essential insight for governments, investors and researchers. The results obtained can contribute to the shaping of energy policies, providing a sound scientific basis for decisions on infrastructure investments. At the same time, identifying the most influential research directions facilitates the understanding of technologies and strategies with the greatest development potential. Last but not least, this report helps policymakers and academics create new academic and industrial relationships by giving them a comprehensive picture of the key trends and potential for international collaboration.

In this context, future research must focus not only on optimizing gas transport and reducing ecological impact, but also on how this infrastructure influences agricultural land and the rural economy. Given the interdependence between energy infrastructure and other economic sectors, a more integrated and interdisciplinary approach is essential so that infrastructure development is compatible with sustainability goals and the protection of natural resources.

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