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ORIGINAL ARTICLE

Intellectual property and sustainable development goals (SDGs): Driver of innovation or obstacle to progress? An analysis of recent global literature

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ABSTRACT

Objective. The objective is to analyze the relationship between intellectual property and the Sustainable Development Goals (SDGs) from the academic, scientific, and business perspectives indexed in Scopus to assess how intellectual property can boost or limit the achievement of the SDGs.

Design/Methodology/Approach. The first research stage analyzes their performance and impact, while the second stage involves scientific mapping of the publications identified for both. This allows for studying the initial state of the topics from a common perspective to identify the relevant agents and issues in a given period.

Results/Discussion. They show hierarchical and cross-cutting relationships between the clusters and highlight the centrality of the economic and regulatory approach, the relevance of environmental management and governance, and the growing role of digitization and the green economy. The thematic mapping offers a structured view of current knowledge and provides a strategic framework to guide future research and policy in the intersection between intellectual property and sustainable development.

Conclusions. The analysis of the groups or clusters identified in recent literature reveals that this field of study is configured as an interdisciplinary, complex, and dynamic system, where intellectual property acts as an articulating axis of structural debates, practical applications, and emerging challenges.

Originality/Value. The holistic approach to the intersection between the two concepts in various fields shows that while intellectual property can drive innovation, it can also hinder access to key technologies for developing countries. The analysis offers a crucial perspective for rethinking public policy and proposes aligning intellectual property protection with sustainability and social inclusion principles.

Keywords: intellectual property, sustainable development goals (SDGs), public policies, strategic intelligence, foresight, bibliometric analysis.

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INTRODUCTION

In 2015, world leaders outlined an ambitious plan: the 2030 Agenda for Sustainable Development, which contains the 17 Sustainable Development Goals (SDGs). These goals promise to eradicate poverty, improve education, reduce inequalities, and foster economic growth, all while tackling climate change and protecting the planet (United Nations, "Sustainable Development Goals"). The idea is clear: development and sustainability go hand in hand. The SDGs have become the new playing field where academics, businesspeople, and politicians want to make their mark. It's not just about theory; it's about strategy: sustainability sells, and whoever dominates the narrative dictates the market rules. Katanalp and Sağlık (2024) point out that the conversation focuses on a few key fronts: SDG 9 (industry, innovation, and infrastructure), SDG 12 (responsible production and consumption), SDG 11 (sustainable cities and communities), and SDG 8 (decent work and economic growth).

In the corporate sector, implementing the SDGs has generated debates on regulations, investment strategies, and sustainable business models. Radu, Dragomir, and Ionescu-Feleagă (2023) warn that, although companies are increasingly discussing their role in the SDGs, the actual connection between their performance on environmental, social, and governance (ESG) factors and these goals remains an underexplored territory. Corporate sustainability cannot be limited to a mere public relations exercise; to have a tangible impact, it must be strategically aligned with the SDGs, allowing real progress to be measured and more effective solutions to be designed.

Companies have learned to speak the language of sustainability and have adopted a new mantra: corporate social responsibility (CSR). According to Durán Acosta (2024), this approach is not just a question of corporate ethics but a strategy designed to address global challenges with a veneer of commitment. According to Roffé and Gonzalez (2024), the debate is set: on one hand, sustainability is the new calling card for any company that wants to survive in today's market. However, implementing responsible practices is not inexpensive, and profitability is always a concern.

Intellectual property is the safeguard that turns ideas into assets and the mechanism that transforms a spark of creativity into a temporary monopoly. Patents, copyrights, trademarks, industrial designs, geographical indications, and trade secrets; each of these instruments protects innovation and goes even further by defining who can benefit from it and on what terms (WIPO, n.d.). In theory, this balance between the creator's exclusive right and the public interest should foster a dynamic ecosystem of creativity and progress. It represents a battleground where innovation, competition, and profitability are intertwined in a game of power and access.

In the context of the SDGs, intellectual property faces a dilemma: it can act as the impetus that fosters sustainable technological innovation or become a barrier that prevents access to essential technologies in developing countries. It is a game of extremes, where exclusive rights can unleash creative potential or reinforce inequality. Boldrin and Levine (2009) dismantle the almost sacred idea that intellectual property rights are a "necessary evil" to incentivize innovation. Instead, they point out that tightening these rules has served more to fatten the pockets of large corporations than to drive progress. The result is a system where the concentration of economic power dilutes the promise of social benefit, and where there is less competition and more monopolies.

More recently, Rikap and Lundvall (2020) warn that technology giants such as Google, Amazon, and Microsoft have become veritable "data-driven intellectual monopolies," where knowledge and information are accumulated and transformed into strategic assets. This absolute dominance over innovation raises serious questions about who benefits from progress and how this affects the SDGs. Far from being simple players in the innovation ecosystem, these corporations have perfected the art of "knowledge predation": they absorb and monetize ideas generated by other organizations, from universities to start-ups, leaving little room for real competition. This hoarding distorts corporate innovation systems and can slow development and increase inequalities, reducing opportunities for other participants to join the game.

The irruption of artificial intelligence in climate governance further intensifies the clash between intellectual property and sustainable development. Li *et al.* (2023) delve into this turbulent terrain and explore how patents and open source coexist or conflict in the development of green artificial intelligence. Their analysis focuses on TinyML, a technology that brings machine learning to low-power devices, and demonstrates that innovation protection and open access are key to creating sustainable solutions. Turning to perhaps the most sensitive issue, public health and intellectual property, the debate becomes a battleground where corporate interests and human rights collide, and the World Trade Organization (WTO), with its Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), is at the center of the dispute. Rahmani *et al.* (2020) analyze this tension, particularly about pharmaceutical patents and their impact on developing countries. In theory, these patents seek to encourage innovation and the creation of new drugs, but they can become an insurmountable obstacle for those who need them most.

The requirement to recognize pharmaceutical patent protection under TRIPS has triggered a heated debate: how can we balance rewarding innovation and ensuring access to essential medicines? The 2001 Doha Declaration tried to appease tempers, clarifying that the agreement should not hold back measures needed to protect public health (WTO). However, the reality remains stark: many nations still struggle to implement policies that encourage medical research and prevent access to healthcare from becoming an unaffordable luxury.

However, the relationship between intellectual property and the SDGs is slippery, filled with contradictions and difficult decisions. The need arises to rethink Intellectual Property, not as a set of isolated rights, such as patents, trademarks, or copyrights, but as a "global governance of knowledge." This approach, which Chon (2019) considers, expands the traditional vision and proposes a more inclusive system of knowledge management that promotes innovation, the capacity to innovate, technology transfer, and the circulation of knowledge across borders. This paradigm shift requires a deeper understanding of Intellectual Property: it is not an end but a tool at the service of the SDGs. Intellectual property regulation must be guided by social justice and equity principles and direct its use to foster more inclusive development.

Abdel-Latif and Roffe (2018) note that while intellectual property can drive innovation and strengthen economies, it can also create barriers to access to essential goods and services, particularly in developing countries. The struggle between protecting intellectual property rights and ensuring sustainable development is fought on multiple fronts, including public health, technology transfer, and environmental protection.

Academia in Jordan presents an intriguing case when seeking a solution to this dilemma. According to Barqawi and Al-Arasi (2024), universities in this country have become key bastions for intellectual property protection, playing a vital role in promoting innovation and technological development. Some of these educational institutions have established specialized innovation centers that protect intellectual property and foster its creation. These centers operate as incubators of ideas, where academic research becomes a tangible force capable of transforming entire sectors.

The challenge is not a minor one: it is a matter of finding a balance that allows creativity to be fostered without excluding anyone from the benefits of progress. In this power game, it is crucial to question whether the current intellectual property system is paving the way for fairer development or whether, on the contrary, it is raising ever-higher barriers.

2. MATERIAL AND METHODS

Bibliometric tools, techniques, and methodologies have established themselves as fundamental resources for the academic community and for strategic knowledge management. Their application makes it possible to analyze an area of study's impact, relevance, and evolution over time, as in this case with the intersection between intellectual property and the SDGs. Thanks to these methodologies, it is possible to identify the main knowledge agents, the dominant trends and their thematic development, which facilitates the creation of knowledge maps that serve as a structural reference for future research (Cobo, 2012; Cobo *et al.,* 2011; van Raan, 1996, 2003, 2014).

Bibliometrics allows two main types of analysis to be carried out: performance analysis and scientific co-occurrence maps. The former focuses on quantifying the impact of publications through the number of citations and their evolution over time, while making visible the most influential authors, institutions, or countries in the field. The latter makes it possible to spatially represent the relationships between concepts, authors, or documents using elements such as keywords, which facilitates the discovery of thematic links that are not obvious to the naked eye. These maps have proven to be especially useful for understanding complex knowledge structures, identifying gaps, emerging axes, and connections between areas that would otherwise remain fragmented (Casas-Valadez *et al.,* 2020; López-Robles, 2019; López-Robles *et al.,* 2020).

This study has chosen to work with publications indexed in Scopus, one of the most complete and widely recognized international scientific databases. A corpus of relevant documents published in recent years focused on the joint analysis of Intellectual Property and the SDGs has been compiled and refined. From this database, key terms have been extracted, and co-occurrence maps have been constructed using the VOSviewer tool. This has made it possible to identify and visually represent the main topics addressed by the literature, as well as their level of relationship.

Only the terms that appear most frequently in the analyzed corpus (more than five publications) were included to ensure thematic relevance. Subsequently, VOSviewer automatically grouped the concepts by their linking strength, generating five thematic clusters distinguished by color. This grouping was manually reviewed and labeled based on the semantic content of the terms, facilitating the identification of consolidated lines of research and emerging areas.

It is important to note that the relationships between topics occur both internally, within each group, and externally, between different groups, reflecting the multidimensionality of the field. Some concepts act as intermediate nodes between multiple lines, as thematic catalysts or epistemological bridges. The interpretation of these relationships has been conducted by simultaneously considering their number of occurrences and the strength of their connections, understanding that the relevance of a theme in the development of a research area lies both in its frequency and its capacity to link.

Overall, the bibliometric methodology not only describes the current state of research on Intellectual Property and sustainability but also provides a solid empirical basis for structuring new scientific agendas, informing the design of public policies, and promoting convergence between innovation, regulation, and sustainable development.

3. RESULTS

3.1. Performance analysis

Figure 1 shows a steady growth in the number of publications and citations related to intellectual property and the SDGs from 2015 to 2024. This increase reflects the growing importance of these issues on the global agenda and has significant practical implications for academia, science, government, and business. First, the rise in publications and citations indicates that companies must be prepared to adapt to an ever-changing regulatory environment. Governments and businesses must anticipate these changes and develop flexible intellectual property strategies aligned with the SDGs. This includes implementing open access policies for key technologies, adopting circular economy practices, and integrating sustainability criteria into intellectual property management.

Second, the peak in publications between 2021 and 2023 can be attributed to the COVID-19 pandemic, which highlighted the importance of health innovation and equitable access to medical technologies. For government institutions and companies in the pharmaceutical or biotechnology sector, this means they must be prepared to address the challenges related to patent protection and access to essential medicines. The negotiation of voluntary licenses and the implementation of tiered pricing policies that guarantee access to critical technologies without compromising profitability are issues of interest that the economic entities involved should consider.

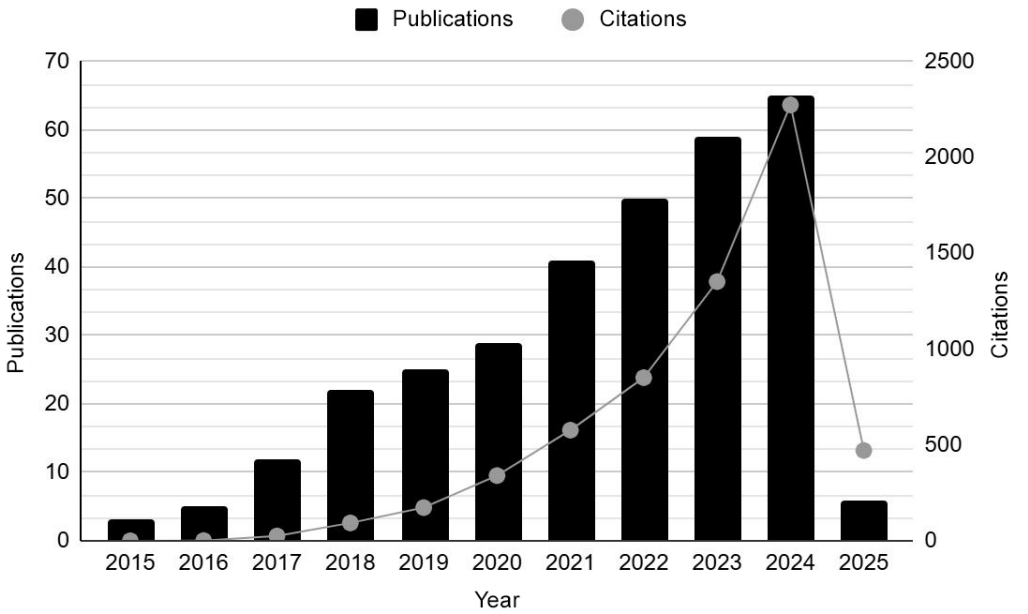

Figure 1. Distribution of citations and publications related to intellectual property production and the SDGs according to Scopus.

Table 1 provides a detailed analysis of the scientific production related to the intersection between intellectual property and the SDGs. The data reveal that the most productive authors in this field are Abbas, J.; Armas, K. L.; Bogere, P.; Di Pippo, S.; Di Vaio, A.; Klingenberg, B.; Quintella, C. M.; Rothberg, H. N.; Temmen, K.; Tseng, M. L., who have contributed significantly with multiple publications.

Regarding the most productive countries, China leads the list with 64 publications, followed by the United States and the United Kingdom, each with 50 publications. India and Australia also have a notable presence, with 38 and 33 publications, respectively. This indicates that these countries are at the forefront of research on the relationship between intellectual property and the SDGs, likely due to their innovative and sustainable development policies, as well as their commitment to the global challenges posed by the 2030 Agenda.

It is crucial to emphasize China, as the Asian giant is not satisfied with small achievements; its dedication to research and development in key sectors for the SDGs is ambitious. With the *Made in China* 2025 plan, the country has committed to renewable energy, clean technology, and electric mobility (Institute for Security and Development Policy, 2018), making it clear that sustainability is not just a political slogan but also a growth driver. However, the key lies in artificial intelligence and automation, which promise industrial efficiency and more innovative and strategic resource consumption.

In terms of intellectual property, China dominates the sector globally. In 2021, it surpassed the United States with 3.6 million active patents and 37.2 million trademarks in force. Likewise, with 2.6 million design registrations, the country consolidated its position as the global epicenter of registered innovation. The pandemic did not slow down its machinery: the China National Intellectual Property Administration (CNIPA) processed 9.5 million applications (China National Intellectual Property Administration, 2022), showing that, in terms of patents, China not only follows the global trend but also defines it.

The Far Eastern powerhouse does not stop there: the 14th Five-Year Plan (2021-2025) is the roadmap to a more technological, self-sufficient, and digital China. It emphasizes innovation as the cornerstone of development, industrial modernization, and the need for a robust domestic market (China National Intellectual Property Administration, 2022). The message is clear: China wants to lead the future of innovation and sustainability and write the game's rules.

Regarding the most productive organizations, the University of South Africa and Xi'an Jiaotong University stand out with six publications each, followed by institutions such as INRAE and the World Health Organization, with five publications. This indicates that these institutions play a key role in generating knowledge for the academic community in this field.

The main publication sources include journals such as *Sustainability-Switzerland,* with 24 publications, and *Journal of Cleaner Production,* with 13 publications, reflecting the relevance of these journals in disseminating research on intellectual property and the SDGs. The most prominent areas of knowledge are social sciences (185 publications) and environmental sciences (138 publications), underlining the importance of approaching intellectual property from an interdisciplinary perspective that integrates social, economic, and environmental aspects. This approach is crucial for understanding how intellectual property policies can be aligned with the principles of the SDGs, ensuring that innovations are not only technologically advanced but also socially inclusive and environmentally responsible.

Indicator	(Publications) Description
Most productive authors	(3) Abbas, J.; Armas, K.L.; Bogere, P.; Di Pippo, S.; Di Vaio, A.; Klingenberg, B.; Quintella, C.M.; Rothberg, H.N.; Temmen, K.; Tseng, M.L.
	(2) Adam, N.A.; Almada Santos, F.C.; Alyusuf, A.; Anand, U.; Aslanyan, G.; Asmi, F.; Bannerman, S.; Barsanti, S.G.; Bode, H.; Chin, T.; Chon, M.; Denoncourt, J.; Dent, J.; Failler, P.; Fombad, M.C.; Graef, K.M.; Hajikhani, A.; Hanna, S.A.; Hassan, R.; Haugen,; H.M.; Işık, C.; Jose, K.R.Y.; Kopishynska, K.; Kravchenko, M.; La Diega, G.N.: Levula, A.; Mangla, S.K.; Metternicht, G.; Palladino, R.; Papa, A.; Pata, S.K.; Pata, U.K.; Patil, P.; Pyshnograiev, I.; Rossi, A.; Sanin, C.; Sarma, P.R.S.; Suominen, A.; Szczerbicki, E.; Thakur, R.; Trofymenko, O.; Umer, Q.; Uniyal, S.; Yadav, S.; de Castro, R.O.
Most productive countries	(64) China
	(50) United States of America; United Kingdom
	(38) India
	(33) Australia
	(30) Brazil
More productive organizations	(6) University of South Africa; Xi'an Jiaotong University
	(5) INRAE; Organisation Mondiale de la Santé; Universitas Indonesia; Università degli Studi di Salerno; University of Melbourne
	(4) CIRAD; Fundacao Oswaldo Cruz; Parthenope University of Naples; Seoul National University; The University of Queensland; UNSW Sydney; United Nations; Universidade de São Paulo; Universidade Federal de Santa Catarina; Universiti Sains Malaysia; University of Plymouth
Main sources	(24) Sustainability Switzerland
	(13) Journal Of Cleaner Production
	(12) Proceedings of the European Conference on Knowledge Management ECKM
	(11) Journal Of Lifestyle and SDG S Review; Proceedings of the International Association of Hydrological Sciences; Sustainable Development
	(8) Plos One
Main areas of knowledge	(185) Social Sciences
	(138) Environmental Science
	(106) Business, Management and Accounting
	(94) Engineering
	(91) Computer Science
Type of Document	(272) Article
	(80) Paper
	(60) Book Chapter
	(41) Review

Table 1. Bibliometric performance on Intellectual Property and the SDGs according to Scopus.

3.2. Content analysis

Based on the bibliometric analysis conducted on recent scientific literature linking intellectual property and the SDGs, five distinct thematic groups were identified, and their quantitative structure provides a preliminary approximation of the positioning and intensity of the research lines developed in this field. This study concentrates on the numerical values of links. These connection strengths and occurrences create an objective basis for establishing research priorities, highlighting predominant areas of focus, and addressing existing imbalances regarding this critical intersection between innovation, regulation, and sustainability.

The first group, called "Development economics and global sustainability" (red color), represents the most consolidated and dense line of the thematic map. It brings together nine terms that accumulate 195 links, a total link strength of 375, and 190 occurrences. Its intensity in connections and recurrence in publications positions it as a space of theoretical and practical consensus on how intellectual property affects the dynamics of sustainable development. From a strategic perspective, this group reflects the scientific community's interest in addressing the structural role of intellectual property in global development models.

The second cluster, identified as "Environmental management and decision making" (green color), groups eight terms, totaling 151 links, a total strength of 241, and 109 occurrences. This is a cluster of intermediate size, but it has a fairly cohesive linkage structure, focusing on applied and operational approaches. These lines explore institutional and management mechanisms that connect Intellectual Property instruments with decision-making processes, impact assessments, and organizational sustainability. Although less prominent in total volume, it demonstrates a concentration of efforts around practical solutions that are especially relevant for effectively implementing the SDGs.

The third group, called "Human development, health and governance" (blue color), consists of 7 terms and exhibits a high level of connection with 150 links, 344 total link strength, and 141 occurrences. This thematic line aligns with the more social and human dimensions of development, exploring the impact of intellectual property on structural variables linked to equity, well-being, and access to essential services. Its relative weight in the overall analysis underscores the academic concern for understanding intellectual property not only as a tool for protecting rights but also as a potential catalyst or barrier to social justice and human progress.

The fourth cluster, named "Energy, mitigation and knowledge transfer" (yellow color), includes six terms, with 115 links, a total link strength of 197, and 74 occurrences. This cluster presents a specialized technical and environmental focus, characterized by lower but sustained connectivity over time. It is emerging as a notable line that is beginning to consolidate around energy sustainability, climate change, and the dissemination of technological knowledge, which is key to the ecological transition and current debates on equity and open access in regulatory contexts.

Finally, the purple cluster, named "Digital transformation and green economy," includes six terms and represents an emerging strand with 107 links, a total link strength of 176, and 70 occurrences. Although it is smaller in quantity, its structure demonstrates signs of specialization and growth. This line focuses on digitalization, automation, and sustainable industrial innovation, reinforcing its relevance as a future trend and its potential impact on intellectual property regulatory frameworks.

Overall, the results show that recent academic production on intellectual property and the SDGs is not only expanding, but also presents a broad thematic structure that is interconnected and in the process of specialization. The predominance of the red cluster highlights the centrality of the innovation-sustainability binomial in recent literature, while the other clusters allow us to observe complementary approaches from governance, environmental management, energy transition, and digital transformation. The preliminary quantitative analysis provides a solid basis for deepening the understanding of current scientific discourses and strategic orientations that could guide future research and public policies in this field.

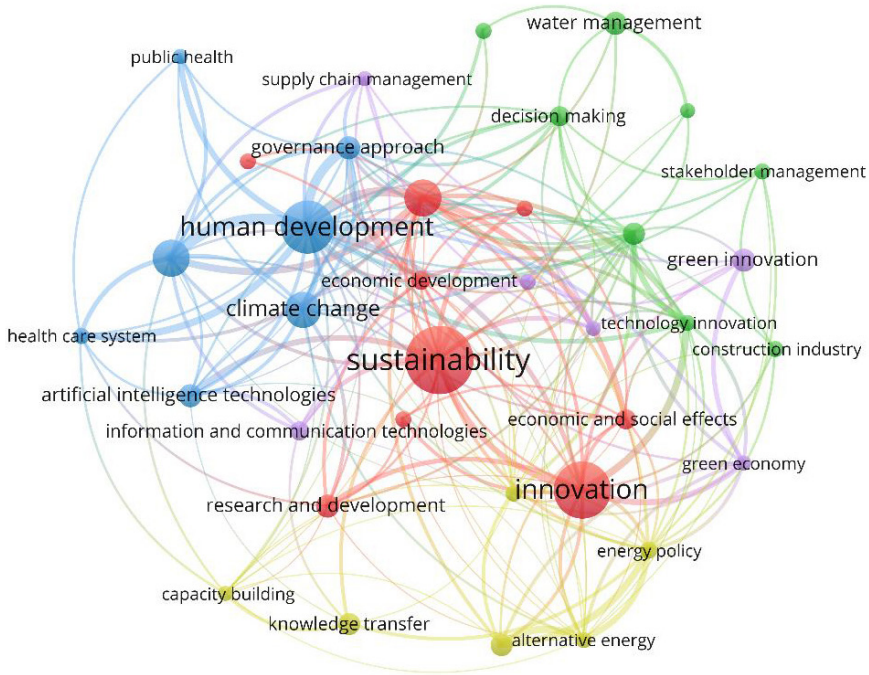

Figure 2. Thematic clusters in the field of intellectual property and the SDGs.

Term	Cluster color	Link weight	Weight of the total binding force	Weight of occurrences
circular economy	rojo	7	9	11
economic and social effects	rojo	24	37	14
economic aspect	rojo	32	76	26
economic development	rojo	26	48	13
economic growth	rojo	14	19	11
environmental economics	rojo	18	25	11
innovation	rojo	27	65	40
research and development	rojo	17	29	16
sustainability	rojo	30	67	48
construction industry	verde	16	20	11
decision making	verde	22	36	14
environmental management	verde	11	15	10
environmental protection	verde	29	57	15
poverty alleviation	verde	16	20	11
stakeholder management	verde	17	22	11
technology innovation	verde	25	50	11
water management	verde	15	21	16
artificial intelligence technologies	azul	13	27	16
climate change	azul	24	46	25
developing countries	azul	23	56	26
governance approach	azul	29	55	16
health care system	azul	11	26	11
human development	azul	29	94	37
public health	azul	11	20	10
alternative energy	amarillo	20	34	11
capacity building	amarillo	13	18	10

Term	Cluster color	Link weight	Weight of the total binding force	Weight of occurrences
carbon dioxide emission	amarillo	24	34	11
energy policy	amarillo	23	49	12
knowledge transfer	amarillo	13	20	15
renewable energy technologies	amarillo	22	41	15
digitalization	morado	16	25	11
green economy	morado	22	43	10
green innovation	morado	13	21	16
industrialization	morado	20	31	10
information and communication technologies	morado	20	30	13
supply chain management	morado	16	26	10

Table 2. Occurrence of terms per cluster.

As one delves deeper into the thematic structure of the scientific literature on intellectual property and the SDGs, the first group that stands out for its centrality and volume is the one identified as "Development economics and global sustainability" (corresponding to the red cluster in the co-occurrence map). This cluster articulates a set of fundamental concepts related to development economics, sustainability, innovation, and economic growth, analyzed from a strategic and institutional perspective closely linked to intellectual property regulatory frameworks.

The terms included in this group reflect a clear orientation towards the structural analysis of intellectual property as a vector of development. The most recurrent term in the group is *sustainability,* with 48 occurrences, 30 links, and a total link strength of 67, evidencing its central role both as a normative objective and as a cross-cutting dimension. It is followed by *innovation,* which has 40 occurrences and a total link strength of 65, and *economic aspect,* with 26 occurrences and a link strength of 76 —the highest value within the group for this indicator— highlighting its high level of thematic interconnectivity. Other relevant terms include research and development (16 occurrences, 29 strength), economic and social effects (14 occurrences, 37 strength), and *economic development* (13 occurrences, 48 strength).

These concepts form a core in which intellectual property is addressed not only as an incentive mechanism for innovation but also as an economic governance tool that has profound implications for achieving several of the SDGs. For example, the relationship with SDG 9 (industry, innovation, and infrastructure) is direct, as intellectual property is seen as a catalyst for R&D activities. Likewise, its link with SDG 8 (decent work and economic growth) is manifested in concerns over the impact of intellectual property on productivity, the formalization of knowledge-intensive sectors, and access to markets. The inclusion of environmental and circular economy issues also connects this group with SDGs 12 (Responsible production and consumption) and 13 (Climate action), as sustainable innovation models and economic strategies with low environmental impact are explored.

Quantitatively, this group is the most robust in the analysis: it consists of 9 terms, accumulating 195 links, with a total link strength of 375 and 190 occurrences. These figures reflect a high frequency of occurrence and demonstrate significant internal cohesion, positioning it as the gravitational center of the current scientific literature on intellectual property and sustainability. The analysis of this group suggests that academic discussions on intellectual property concerning the SDGs are largely structured from a macroeconomic perspective, viewing intellectual property as a key economic institution in shaping sustainable, inclusive, and resilient development models. Through this approach, both its potential benefits and structural limitations are acknowledged, particularly regarding its ability to foster equitable and accessible innovation.

After examining the central group of the literature - the "Development economics and global sustainability" cluster - it is necessary to explore the second major thematic axis identified: the "Environmental management and decision-making" cluster (corresponding to the

green cluster). This cluster presents a more operational and applied approach, analyzing the impact of Intellectual Property on the management, environmental governance, and strategic planning of organizations and sectors linked to the SDGs. This group is composed of eight key terms that together add up to 151 links, 241 total link strength, and 109 occurrences. Although these values are lower than those of the previous group, they stand out for their cohesion and density, suggesting a consolidated thematic line with a strong capacity for integration between concepts. The structure of the group reflects a practical orientation towards the implementation of tools, decision-making strategies, and participatory approaches, in which Intellectual Property acts as an enabling or conditioning element.

Among the most representative terms is *environmental protection* (15 occurrences, 29 links, 57 strength), which occupies a prominent position as an articulating axis among sustainability, environmental regulations, and innovation systems. It is followed by *technology innovation* (11 occurrences, 25 links, 50 strength), which introduces the dimension of technological transformation in organizational and sectoral processes, as well as decision making (14 occurrences, 22 links, 36 strength), which alludes to the need to incorporate intellectual property into strategic planning and evaluation processes. Other terms, such as *stakeholder management* (11 occurrences, 17 links, 22 strength) and *water management* (16 occurrences, 15 links, 21 strength), broaden the focus to multi-stakeholder involvement and critical resource management.

This cluster is closely linked to the SDGs, such as SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), and especially SDG 12 (Responsible Production and Consumption), by addressing tools and strategies that enable the application of intellectual property to optimize production processes and environmental systems. The presence of poverty (11 occurrences) also connects this group with SDG 1 (End poverty) by introducing a dimension of justice and equity in the distribution of applied knowledge.

Overall, the "Environmental Management and Decision Making" cluster offers a more instrumental view of intellectual property, emphasizing its potential as a tool to support informed, sustainable decision-making aligned with global challenges. Its focus on management, stakeholder participation, and efficient resource use complements the structural vision of the previous cluster and provides insight into how IP principles can be concretely applied to the design and implementation of responsible policies, technologies, and business models.

Continuing with the analysis of the main thematic axes identified in the scientific literature on intellectual property and the SDGs, the next most relevant group is the "Human development, health and governance" cluster (corresponding to the blue cluster). This cluster represents a line of research with a strong social and institutional orientation, focusing on the impact of intellectual property on human welfare, access to essential services, equity in development contexts, and the creation of inclusive governance frameworks.

This group, composed of seven key terms, presents a solid structure with 150 links, a total link strength of 344, and 141 occurrences. These figures reflect a significant presence in the literature and a high interconnection between the concepts that comprise it. In this sense, it comprises a cluster that combines thematic density and critical orientation in addressing both the benefits and barriers that intellectual property may represent in human development processes. The most prominent term in the group is *human development,* which registers 37 occurrences, 29 links, and a link strength of 94 —the highest among all the terms analyzed. This centrality reveals a clear academic concern for the implications of intellectual property in improving living conditions and access to opportunities. The term *developing countries*, with 26 occurrences and a strength of 56, places the focus on the asymmetries between institutional contexts and the need to adapt IP frameworks to local realities. *Climate change* (25 occurrences, 24 links, and a strength of 46) and *governance approach* (16 occurrences, 29 links, and a strength of 55) also stand out, reflecting a growing interest in integrating intellectual property into institutional, climate, and global sustainability agendas.

In addition, terms such as *public health* (10 occurrences) and *health care system* (11 occurrences) consolidate the connection of this

cluster with SDG 3 (Health and well-being) and SDG 10 (Reducing inequalities) by exploring how intellectual property regimes can affect access to medicines, health technologies, and basic infrastructure. The emergence of *artificial intelligence technologies* (16 occurrences, 13 links, 27 strength) also introduces a technological frontier dimension that raises new ethical and regulatory challenges within the SDG framework. As a whole, the "Human development, health and governance" cluster offers a critical and profoundly humane view of the debate on intellectual property. It highlights its role as a potential enabler of social progress but also as a tool that, if not properly managed, can perpetuate structural inequalities and hinder equitable access to knowledge and the benefits of innovation. This group thus introduces a normative and ethical axis that runs through recent literature and should be taken into account when formulating public policies consistent with the principles of the 2030 Agenda.

Going deeper into the thematic dynamics that structure the recent scientific literature on Intellectual Property and the SDGs, the next group to be analyzed is the "Energy, mitigation and knowledge transfer" cluster (corresponding to the yellow cluster). This cluster introduces a more technical and specialized approach, focused on the intersection of energy innovation, climate sustainability, and technology diffusion mechanisms, with regulatory and strategic implications of intellectual property. Composed of six terms, this cluster accumulates 115 links, 197 total link strength, and 74 occurrences. Although these values are lower compared to the previous clusters, the quantitative analysis reveals remarkable internal cohesion, as well as clear thematic specialization. This cluster represents an emerging area in the literature that responds to interest in understanding how intellectual property can facilitate - or condition - the transition to low-carbon economies and the adoption of clean technologies.

Among the most relevant terms are *energy policy* (12 occurrences, 23 links, 49 strength) and *renewable energy technologies* (15 occurrences, 22 links, 41 strength), which highlight the growing concern for integrating Intellectual Property into regulatory frameworks that promote sustainable energy. Similarly, *carbon dioxide emission* (11 occurrences, 24 links, 34 strength) directly connects this cluster to SDG 13 (Climate action) by addressing the role of innovation and knowledge protection in climate change mitigation. The inclusion of *knowledge transfer* (15 occurrences, 13 links, 20 strength) underscores the importance of mechanisms that enable technology and capacity sharing across regions, a key issue in advancing SDG 17 (Partnerships for achieving the goals).

Other concepts such as *alternative energy* (11 occurrences) and *capacity building* (10 occurrences) reinforce the instrumental nature of this cluster, as public policies and governance models aimed at institutional strengthening, local capacity building, and equitable access to innovative energy solutions are examined. In this context, Intellectual Property is discussed both for its role as an incentive for technological investment and for the necessity of making its frameworks more flexible in situations of climate urgency and global inequality.

Overall, the "Energy, Mitigation and Knowledge Transfer" cluster represents a thematic line of great strategic importance for fulfilling the 2030 Agenda. It addresses one of the most complex intellectual property dilemmas: how to ensure a competitive innovation environment without restricting access to technologies essential for environmental sustainability and climate justice? This panel highlights the need for more adaptive intellectual property regimes that favor international collaboration, open innovation, and technological equity.

Finally, the analysis of the "Digital transformation and green economy" cluster (corresponding to the purple cluster) concludes the tour of the five major thematic axes that constitute the scientific literature on Intellectual Property and the SDGs. This cluster represents an emerging and growing trend that addresses how the processes of digitization, automation, and industrial innovation are redefining sustainable development strategies and regulatory frameworks for intellectual property. The cluster comprises six key terms, totaling 107 links, with an overall link strength of 176 and 70 occurrences. Although it is quantitatively the smallest group in the set, its occurrence reflects a clear trend toward incorporating digital technologies and sustainable economic models as a priority object of analysis in the debate between intellectual property and the SDGs. The

level of connection among its components indicates that this is a field still in consolidation, but with strong potential for expansion.

Among the most representative terms are digitalization (11 occurrences, 16 links, 25 of strength) and *information and communication technologies* (13 occurrences, 20 links, 30 of strength), which reflect the interest in understanding how digital technologies interact with Intellectual Property regimes, both as means to generate innovation and as platforms for distributing it. In turn, *green innovation* (16 occurrences, 13 links, 21 strength) and *green economy* (10 occurrences, 22 links, 43 strength) articulate the link between digital transformation processes and new economic models oriented toward environmental sustainability.

This cluster is directly connected to SDG 9 (Industry, innovation and infrastructure) and SDG 12 (Responsible production and consumption) by addressing issues such as clean industrial innovation, energy efficiency, and the creation of circular value chains. Likewise, concepts such as *supply chain management* (10 occurrences) and industrialization (10 occurrences) complete the approach from a systemic logic, aiming at the reconfiguration of global production processes through sustainable technological solutions that integrate aspects of Intellectual Property, automation, and resilience.

Despite its smaller size, the "Digital transformation and green economy" cluster stands out for its strategic projection. It addresses some of the most contemporary and disruptive issues at the intersection of intellectual property and sustainability, such as the data-driven economy, open digital platforms, green innovation, and the governance of global supply chains. Its consolidation in the literature reflects the transition of intellectual property studies to more dynamic, decentralized, and digitized contexts that demand new ways of protecting knowledge and fostering international collaboration.

On the other hand, Figure 3 illustrates the thematic evolution in the field of intellectual property and the SDGs, highlighting the main thematic clusters identified in the literature. This map is quite interesting, as it shows how the topics have evolved from a perspective focused on human rights and sustainability to a more specific focus on innovation policies, energy, and the green economy. In its early days,

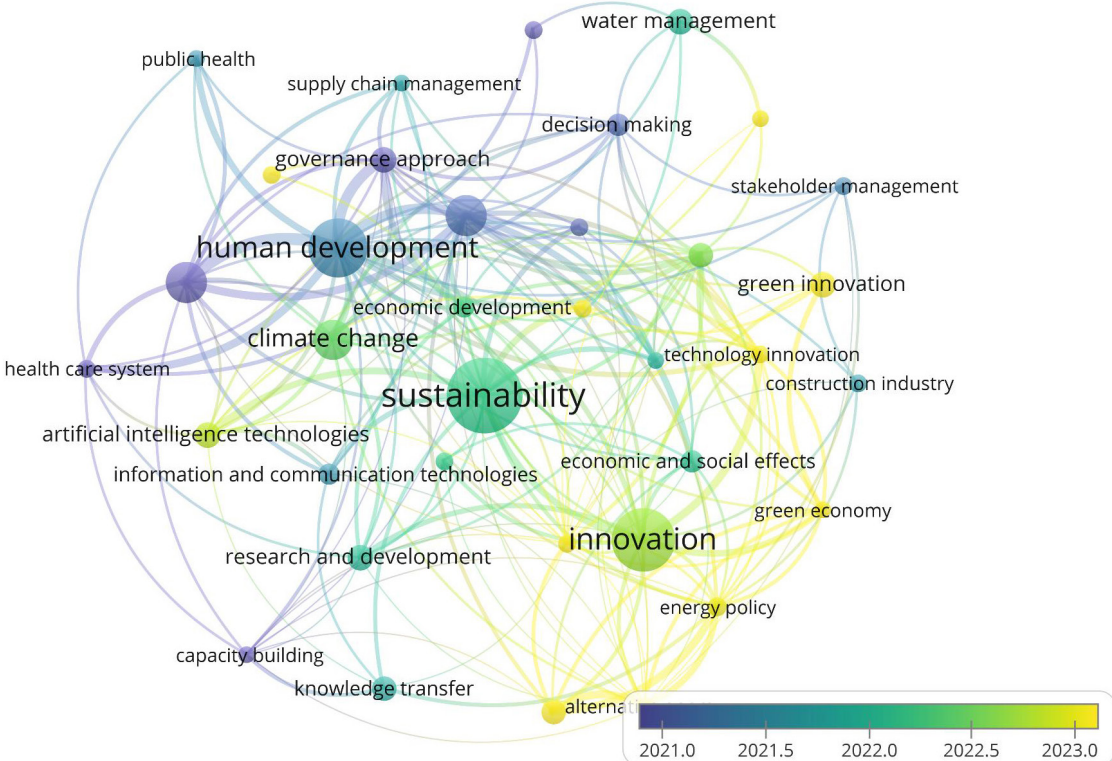

Figure 3. Thematic developments in the field of Intellectual Property and the SDGs.

research on intellectual property and the SDGs emphasized human rights, recognizing that access to innovation and knowledge is fundamental to ensuring social and economic well-being. This initial focus reflected concerns about how intellectual property policies might affect access to essential medicines, educational technologies, and other resources critical to human development.

Subsequently, the focus shifted to sustainability, understood as a balance among economic, social, and environmental development. This thematic shift reflected the growing awareness of the need to address environmental challenges, such as climate change and ecosystem degradation, from a holistic perspective that includes technological innovation and resource management.

In recent years, research has focused on more specific topics, such as innovation policy, renewable energy, and the green economy. This shift reflects the growing importance of these issues on the global agenda, especially in the context of energy transition and decarbonization of the economy. However, it also raises an important criticism: the "green component" seems to have become an add-on to policies and actions, rather than an intrinsic element of any initiative.

This reductionist view of sustainability as something external or an "added value" is problematic because it fails to address the root causes of environmental and social problems. Sustainability should not be treated as an option or an add-on, but as a fundamental principle guiding all actions and decisions. This is the only way to move toward a truly sustainable and equitable future.

The bibliometric analysis presented in Tables 1 and 2, as well as in Figures 1 to 3, reveals that the convergence between intellectual property and the SDGs is not a passing trend but a strategic necessity for achieving a more balanced future. China, with its disruptive approach to patents and sustainable technologies, stands out as a leader transforming the global IP landscape. However, this field must address not only the technical aspects but also the social and environmental implications of innovation. Sustainability must be integrated as a fundamental principle, not as an add-on. IP practice must adapt to this new reality and guide companies in a complex and ever-changing regulatory environment. Ultimately, success lies in a strategic and interdisciplinary approach that fosters innovation and ensures alignment with the principles of sustainability and equity.

This analysis establishes a framework for future research and public policy, highlighting the need to align intellectual property policies with the principles of sustainable development. It aims to ensure that innovation is accessible and beneficial to all, specifically through the implementation of open access policies for key technologies, the adoption of circular economy practices, and the integration of sustainability criteria in managing intellectual property.

4. CONCLUSIONS

The conclusions drawn from the analysis of the five thematic clusters identified in the recent scientific literature on intellectual property and the SDGs provide us with a structured and relational view of this expanding field of study. The distribution, density, and connectivity of the clusters reveal the predominant research foci, as well as the hierarchical and cross-cutting relationships among them. Together, the thematic clusters outline a complex, interdependent, and evolving system that articulates structural debates, practical applications, societal demands, technological challenges, and emerging trends.

The "Development economics and global sustainability" cluster serves as the structural core of the literature. Its high volume and connectivity position it as the overarching framework within which the effects of intellectual property on economic growth, innovation, and sustainability are discussed. This cluster articulates the macroeconomic and normative principles underlying all the other clusters, establishing it as the field's starting point and conceptual reference.

The "Environmental management and decision making" cluster focuses on operational and practical aspects and explores how intellectual property interacts with environmental management, planning, and governance instruments. It closely relates to the core cluster, as it translates general principles into institutional mechanisms, analytical tools, and organizational models, especially in corporate sustainability and natural resource management contexts.

The "Human development, health and governance" cluster introduces a fundamental social, ethical, and institutional dimension. It focuses on access to knowledge, equity, and well-being, raising potential tensions between exclusive intellectual property rights and the universality of certain social goods. This cluster connects with the economic core and the practical aspects of management while adding a critical perspective on the distributional impact of Intellectual Property, especially in developing countries.

The "Energy, mitigation, and knowledge transfer" cluster is presented as a space for technical specialization. It connects intellectual property with strategic sectors such as clean energy and climate change. It underlines the need to adapt regulatory frameworks to environmental requirements and the challenges of global access to sustainable technologies. This group establishes clear links with the central regulatory cluster and the social and institutional dimensions, especially regarding international cooperation and local capacities.

Finally, the "Digital transformation and green economy" cluster represents an emerging frontier focused on digitization processes, automation, and sustainable industrial innovation. Although it is the most recent cluster with the lowest density, it has significant strategic potential. It is interconnected with all the other clusters: from the regulatory (due to new regulatory challenges in the digital environment) to the social (due to the impact of technology on inclusion) to the environmental (due to its link with the circular economy and energy efficiency).

The five clusters form an interdisciplinary field combining macro and micro, normative and technical, critical and prospective approaches. Intellectual Property, far from being an isolated concept, is revealed as an articulating axis of multiple dimensions of sustainable development, whose implications transcend sectors, scales, and disciplines. This thematic mapping not only allows us to understand the structure of current knowledge, but also provides a strategic framework to guide future research, public policies, and multilateral actions in the intersection between intellectual property and the SDGs.

Conflict of interest

The authors declare that there are no conflicts of interest.

Contribution statement

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Statement of data consent

The data generated during the development of this study have been included in the manuscript. Contribution statement.

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