

# EXPLORING CONTEMPORARY TRENDS IN THE BUILT ENVIRONMENT TOWARD UN SUSTAINABLE DEVELOPMENT GOALS: A GLOBAL BIBLIOMETRIC ANALYSIS

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## Abstract

The built environment continues to play an important role in the United Nations Sustainable Development Goals (SDGs) achievement, namely sustainable city development, infrastructure resilience, and climate action. The purpose of this research was to identify global trends in studies within the subject of concern over ten years from 2015 to 2025. For this research to carry out its study, articles for use were obtained through the Scopus database and were designed to measure trends over time in relation to practice in the built environment towards sustainability. The research reflected that the earlier research was mainly oriented towards green buildings and energy efficiency. Nowadays, more integrated and innovative approaches have been used. These include using artificial intelligence, circular economy principles, and nature-based solutions to assist in improving sustainable urban development. It also found that inter-disciplinary collaboration is more common and that digital technologies and government policy have a greater role to play in determining the planning and building of cities. Most of the research reviewed, however, comes from high-income economies. Contributions from low- and middle-income countries are still few, which hints at a lack of global balance in sustainability studies. This divide mirrors the need for increased representative research encompassing under-served regions. Research in the future needs to give more attention to countries in the Global South, especially through bibliometric studies that bring into focus local concerns and enable the development of tailor-made solutions befitting the needs of respective regions. Also, there is a good argument for additional long-term case studies. These would allow researchers and policymakers to learn about how sustainability policies and projects fare in the long term and their effects in practice. This research can inform improved planning and more pragmatic outcomes for subsequent sustainable development initiatives.

**Keywords:** Built Environment, Sustainable Development Goals, Bibliometric Analysis, Green Building, Circular Economy, Digital Innovation, Urban Sustainability, Life Cycle Assessment, Nature-Based Solutions, Decarbonization, Sustainability Trends, Resilience Strategies.

## 1. SDGs AND THE BUILT ENVIRONMENT

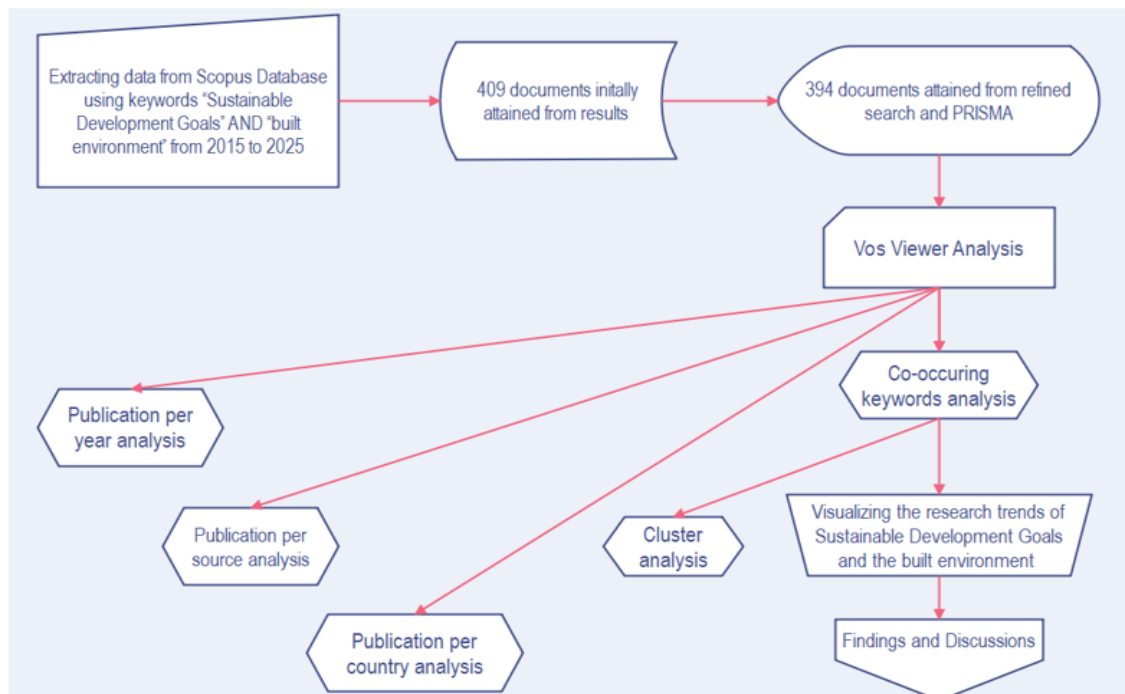
The UN's Sustainable Development Goals (SDGs) have ignited a global movement to tackle deep-rooted environmental, social, and economic challenges since their adoption in 2015. The 17 interlinked goals look toward the future of the world as sustainable, highlighting the imperative of radical change for the people and the planet. Achievement of these goals necessitates collaborative, multi-disciplinary action, with the built environment leading the charge because of its profound implications on resource use, energy, and environmental sustainability (Aghimien et al., 2020). The built environment, or all human environments created to enable human activity, is a primary driver of global energy use and environmental footprint. Yet technological innovation, policy innovation, and integrative practice present a great opportunity for the industry to scale-up action towards the Sustainable Development Goals (SDGs). Emerging technologies like green building methods and sustainable materials have maximized resource efficiency and reduced environmental impacts (Otasowie et al., 2024). An encouraging trend connecting the built environment and the SDGs is Construction 4.0, a trend aligning with Industry 4.0 philosophies. It leverages automation, data-driven solutions, and real-time monitoring to improve efficiency, productivity, and sustainability. These technologies improve project management, reduce waste, and make it easier to construct smart buildings that evolve with new requirements and reduce their environmental footprint (Hussien & Adewumi, 2024). Being large consumers of energy and producers of greenhouse gases, building construction has a significant influence on climate change mitigation. Buildings emit plenty of carbon dioxide from heating, cooling, lighting, and appliances which represent a huge share of worldwide energy consumption and greenhouse gas emissions. Utilization of energy-saving design, green buildings, and renewable energy sources is a practicable solution for reducing emissions and achieving climate-related SDGs, i.e., affordable and clean energy (SDG 7) and cities and communities that are sustainable (SDG 11) (Olaniyan, 2023). Despite these benefits, the use of green buildings and sustainable construction is still a colossal challenge, especially among developing economies. Most of the stakeholders view sustainable building practices as costly, with most of the cost being high upfront investment in green materials and technology. The cost normally has long-term economic gain in addition to environmental gain. International bodies and the government play a significant role in enabling access to finance, education, and training, and policy enforcement offering a more sustainable built environment (Ekung et al., 2024). Achievement of Sustainable Development Goals (SDGs) requires inter-disciplinary and inter-sectoral cooperation. Built environment professionals such as construction managers, quantity surveyors, and sustainability consultants also have a role to play. The authors suggest formalization of lifecycle analysis as a mechanism for incorporating sustainability in all stages of the building's lifecycle, namely design, construction, use, and deconstruction. The use of sustainable materials like recycled material and ecologically low-impact materials reduces ecological footprints along with promoting responsible consumption and production patterns (Opoku, 2024). Furthermore, innovative energy technologies like solar panels, green roofs, and passive design principles reverse energy efficiency and clean energy needs. A comprehensive bibliometric and literature review is provided through this study since it examines the alignment of the built environment

with SDGs. It is concerned with policy-shaping research, practice, and technological innovation, providing informative knowledge to construction stakeholders.

## 2. METHODOLOGY

This study aimed to conduct a detailed analysis of recent trends in the built environment concerning the United Nations SDGs. Through the application of a systematic bibliometric method, this research attempted to uncover and map significant knowledge domains and hot topics in the built environment's alignment with the SDGs. Bibliometric methods have been widely embraced as an efficient means of conducting comprehensive and systematic reviews of large literature, with more revealing outcomes compared to traditional manual reviews, as demonstrated by Ametepey et al. (2024) and Saputra & Suartika (2023). This study looked at research from 2015 to January 2025, covering nearly ten years of work and trends in the relevant fields. We followed a simple four-step process: collecting data, cleaning it up, making visual representations, and then interpreting what the results meant. These processes are aligned with typical bibliometric research protocols, as previously designed by Ametepey et al. (2024) and Walker et al. (2023). Scopus database served as the primary source of data due to its extensive coverage of peer-reviewed scholarly material, efficient indexing capability, and broad disciplinary scope (Ametepey et al., 2024). Scopus is renowned for having an extensive database of scholarly publications, including journals, books, and conference proceedings, supported by advanced tools for tracking and visualizing research trends. To enable robust data retrieval, Scopus was utilized exclusively, augmented by additional manual filtering to reduce the dataset by removing non-relevant items and retaining only the most pertinent literature (Walker et al., 2023). The search terms used were the keywords "Sustainable Development Goals" AND "built environment" in the title, abstract, and keyword fields of relevant journal papers, conference papers, book chapters, books, and reviews that qualify as scientific literature. We found 409 documents published from 2015 to 2025. The dataset covers a broad range of topics, languages, sources, and locations to include various writers (Pachouri et al., 2024). We followed the PRISMA guidelines to sort and select these documents. To further restrict the dataset, only the last published articles were included. Publications that were in press but had not been published were excluded to maintain the stability and credibility of citation tracking. High scholarly credibility was maintained in the research through this selection process to ensure that only validated, and peer-reviewed research products were included. This yielded a final selection of 394 documents. The output dataset was in CSV format and contained metadata such as titles, years of publication, author affiliations, abstracts, keywords, citation information, and DOIs. The data were analyzed using VOSviewer, a text-mining tool for bibliometric studies. The analysis was focused on the following primary fields: (1) geographical spread of publications, (2) publication trends over time and the most highly cited publications, (3) keyword co-occurrence, and (4) thematic evolution based on publication years. The bibliometric analysis provided an overview of how research on the built environment has evolved to address the SDGs, both showing opportunities and challenges associated with mainstreaming sectoral practices into global sustainability agendas.

The methodology is visualized in the figure 1 below:



**Figure 1: Summary of Document Collection from SCOPUS database for Bibliometric Analysis**

### 3. RESULTS

#### 3.1. Network of Publications per year

This article employed a cut-off of at least 10 publications and 10 citations per nation to identify the front-runner nations to emerging built environment research aligned with the SDGs. Based on these cut-offs, 21 nations were front-runner nations, a reflection of global interest and participation in this stream of research. As indicated in Table 1/Figure 2, the top ranking is the United Kingdom (61 documents, 804 citations), followed by the United States (40 documents, 1082 citations), Australia (41 documents, 601 citations), and Italy (40 documents, 239 citations). Although the United States has fewer papers than the United Kingdom and Australia, it has the highest number of citations, revealing its significant global influence and research impact. China ranks within the top five producers on 32 papers and 511 citations, reflecting the high profile of Asian built environment research. South Africa is the African continent leader with 25 papers and 270 citations, followed by Nigeria (17 papers, 90 citations), Egypt (17 papers, 62 citations), and Ghana (12 papers, 125 citations). While such publications demonstrate a growing body of information, overall research output by African nations lags considerably behind those of North America, Europe, and parts of Asia. The difference implies the likely underrepresentation of research from Africa within sustainable built environment

literature. Overall link strength measure, measuring the intensity of collaboration and connection, and the volume of research connectedness, are among the measures central to this research. United Kingdom (50) and United States (41) have extremely high link strengths, reflecting widespread worldwide co-authorship networks and intensively focused collaborative research efforts in sustainable built environment research. Ghana (10) and Norway (9) reflect lower link strengths, illustrating the need for broader international collaboration to realize enhanced research visibility and citation impact. The outcomes confirm the intensification of globally internationalized study in sustainable built environment, as evidenced by developed world leadership both in terms of published output and contribution. Alternatively, the outcomes suggest possibilities of improved scholarship comprehensiveness and representation, notably from Africa and the rest of the developing nations. Global research networking and global collaboration will be instrumental in bridging the research gap as well as facilitating global sustainable development efforts.

**Table 1: The publications per country**

Country	Documents	Citations	Total Link Strength
United Kingdom	61	804	50
Australia	41	601	30
Italy	40	239	27
United States of America	40	1082	41
China	32	511	24
India	28	278	20
South Africa	25	270	30
Spain	19	124	27
Egypt	17	62	19
Germany	17	115	28
Nigeria	17	90	27
Japan	15	343	12
Malaysia	15	48	13
Denmark	14	363	16
Canada	13	311	17
Ghana	12	125	10
Belgium	11	199	15
Netherlands	11	365	8
Norway	11	104	9
Austria	10	307	14
Greece	10	142	17

**\*Total link strength-** Total link strength (TLS) is an important bibliometric metric used to measure the intensity of co-authorship research depths by authors, institutions, and nations. TLS measurements quantify the intensity and number of co-authorship connections and reflect the level of international or institutional co-authorship research collaboration in the built environment and Sustainable Development Goals (SDGs). Higher cumulative link strength means more vigorous research communities, where institutions and researchers are engaged in collaborative studies, co-authored publications, and interdisciplinarity. Highly ranked TLS nations or institutions show greatly linked science cooperation centers, regularly engaged in

multi-institutional research projects and international knowledge exchange.



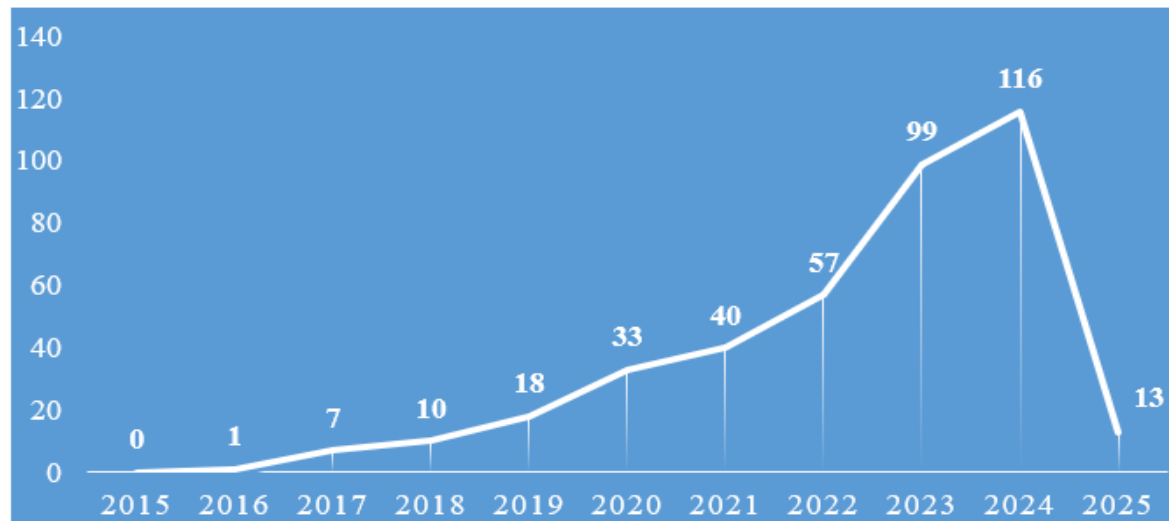
**Figure 2: Visualization of the Publication per Country**

### 3.2. Publication Trends Over Time

A total of 394 articles were being compared within this bibliometric analysis capturing increasing scholarship interest in the built environment in accordance with United Nations Sustainable Development Goals (SDGs). In Figure 3, the trend of increasing each year from 2015 up to 2025 is depicted, although the trend is quite slow to take shape in 2015 when it had no publication. The output of research increased from one paper in 2016 to 40 papers in 2021 only to record humongous spikes in subsequent years to a high of 116 papers in 2024. The dip to 13 papers in 2025 is due to the first half of 2025 being indexed and not a decrease in academic interest. This long-term growth is evidence of growing international recognition of the paramount importance of the built environment in sustainability issues. Past research has primarily been focused on local-scale issues such as sustainable materials for building and energy-efficient building (Jakhar & Jain, 2024). Subsequent studies, however, have gone back to examining this topic on a combined, interdisciplinary platform involving areas such as climatic resilience, application of ICT technologies such as Building Information Modelling (BIM) and smart sensors, and policy framework design for promoting resilient urban development (Singla, 2024). The expansion of the research base and increasing scholarly



interest are proof of the built environment's ability to be a leader in driving the UN SDGs. This evolving research environment is state-of-the-art and holistic in approach, and it is a precursor to a trend towards more advanced, interdisciplinary research. Through incessant innovation, international collaboration, and inter-disciplinary research, the field of the built environment is better positioned to lead the development of global sustainability targets.



**Figure 3: Publication trends from 2015 to 2025**

### 3.3. The Publications per Document Source

Source title analysis above the minimum requirement of five documents and five citations determines eight major sources of publication engaged in influencing a wide range in this study. From Table 2, Sustainability (Switzerland) occupies the highest document source position with 35 documents and 522 citations since it holds an excellent position as a bearer of research information in the nexus between environmental, social, and economic sustainability. The second most productive source is the IOP Conference Series: Earth and Environmental Science, a series of 34 papers and 162 citations, which testifies to the continuing relevance of conference proceedings in delivering timely knowledge transfer within this rapidly advancing field. The Sustainable Development Goals Series (Book Series) with 23 papers but 24 citations proves its novelty as well as expert status, which one can understand as the cause of its relatively limited citation span. Other journals with impacts like the Journal of Cleaner Production (10 articles, 148 citations) and Sustainable Cities and Society (7 articles, 311 citations) also have high citation rates that indicate studies in these journals receive significant scholarly interest and influence. Other major contributors, including Buildings (9 articles, 72 references) and Building and Environment (5 articles, 70 references), remain powerful voices when it comes to matters of energy efficiency, green building, and the health of building occupants. Their moderate to high impact factors, in addition to healthy H-indices (63 and 205, respectively), further make them central discussion forums in the construction and architectural subfields.

**Table 2: Publications per document source**

Source	Documents	Citations	Journal Impact factor	h-index
Sustainability (Switzerland)	35	522	4.39	169
IOP Conference Series: Earth and Environmental Science	34	162	0.55	48
Sustainable Development Goals Series (Book Series)	23	24	N/A	15
Journal of Cleaner Production	10	148	9.8	309
Buildings	9	72	3.1	63
Cities	7	47	6	127
Sustainable Cities and Society	7	311	10.5	130
Building and Environment	5	70	7.1	205

### 3.4. Analysis of co-occurrence of keywords

A careful analysis of the keyword co-occurrence data resulted in a dense network of 128 suitable terms, narrowed down from an original 140 by the exclusion of geographic pointers (e.g., China and Ghana) and publication type pointers (e.g., reviews and articles). Using a cut-off of five or more appearances for all of the keywords, Figure 4's co-occurrence map presents a graphical representation of the thematic relationship in built environment research that aligns with the United Nations Sustainable Development Goals (SDGs). The frequently appearing words incorporate key nodes such as sustainable development, built environment, sustainability, and sustainable development goals, showing their application in the literature. The visual map identifies several distinct clusters, each representing a specific field of sustainability in the built environment. The clusters represent construction industry fields, city relationships, and human concerns like green building, circular economy, waste, resilient cities, and social welfare in determining sustainability agendas. The clustering is classified as given in Table 3, divided by their respective colors. This article brings to perspective the expansive range and interconnectedness of subjects of research in this discipline (Ametepey et al., 2024). It not only discusses trends that are current but also provides the foundation upon which further studies are to identify solutions that integrate technological innovation with policy structures.

**Table 3: List of Clusters and Co-occurring Keywords**

Cluster Label	Keywords	Number of Occurrence	Total Link Strength
Cluster 1(red)	adolescent	5	66
	adult	5	73
	aged	5	31
	child	6	82
	environment design	5	65
	environmental planning	5	71
	female	10	136
	geographic information systems	5	52
	gis	6	51
	health	8	51
	housing	14	105



	human	28	335
	human experiment	5	72
	humans	18	232
	land use	10	87
	male	9	126
	neighborhood	10	98
	pedestrian	6	87
	perception	9	61
	physical activity	6	71
	population density	7	73
	poverty	5	45
	public health	9	79
	public transport	5	49
	quality of life	9	90
	traffic and transport	5	76
	transportation	5	59
	urban area	15	134
	urban population	7	74
Cluster 2 (green)	air quality	8	44
	artificial intelligence	6	39
	bibliometrics	5	49
	bibliometrics analysis	5	49
	building	13	114
	building construction	9	56
	circular economy	22	100
	construction	5	29
	construction industry	31	193
	covid-19	7	46
	environmental impact	13	71
	environmental management	9	55
	gas emissions	8	59
	greenhouse gases	9	72
	intelligent buildings	9	56
	life cycle	12	75
	life cycle analysis	7	56
	life cycle assessment	8	67
	machine learning	8	42
	particulate matter	5	31
	recycling	5	33
	sustainable development	172	1018
	sustainable development goals (sdgs)	74	403
	visualization	5	40
	waste management	11	69
Cluster 3 (blue)	buildings	15	106
	built environment	147	944
	construction projects	5	40
	decision making	20	140
	developing countries	8	69
	developing world	5	44

	economic and social effects	13	95
	environmental protection	7	58
	environmental sustainability	10	58
	planning	28	211
	population statistics	6	48
	project management	8	44
	sdgs	10	41
	smart city	6	40
	social aspects	5	25
	sustainability	77	434
	sustainable cities	10	64
	sustainable construction	8	51
	urban growth	6	41
	well being	5	38
Cluster 4 (yellow)	benchmarking	5	47
	cities	10	98
	city	6	91
	city planning	6	75
	economics	10	75
	energy efficiency	10	74
	energy use	5	43
	energy utilization	11	77
	environmental assessment	5	40
	environmental economics	5	41
	indicators	5	30
	new urban agenda	7	28
	stakeholder	12	85
	urban	6	39
	urban sustainability	9	55
	urbanization	11	90
	wellbeing	8	85
Cluster 5 (purple)	accessibility	6	23
	adaptation	6	46
	adaptive management	7	49
	biodiversity	5	45
	climate change	42	267
	mobility	5	36
	nature-based solutions	6	26
	resilience	8	32
	risk management	5	23
	sustainable development goal	76	527
	case-studies	5	47
	urban design	12	97
	urban development	18	103
	urban planning	30	184
	urban regeneration	5	19
	vulnerability	5	31
Cluster 6 (aqua)	architectural design	10	48
	architecture	14	55

	design	10	61
	education	8	39
	higher education	7	33
	innovation	8	49
	quantitative analysis	5	40
	social impact	5	35
	student	5	22
Cluster 7 (orange)	energy	10	64
	green building	5	15
	green buildings	13	74
	green development	5	24
	sustainable building	19	124
	sustainable city	11	55
	sustainable development goals	74	382
	zero-carbon	6	41
	energy	10	64
Cluster 8 (brown)	concrete	5	19
	infrastructure	7	40
	un sustainable development goals	5	17
	united nations	23	155

**Cluster 1 (red) - Human-Centric Planning, Health, and Urban Dynamics:** This category contains 28 associated keywords such as adolescent, adult, environment design, environmental planning, public health, urban area, and transportation, and they indicate the interlink between human health and the built environment for various population groups. Indicators of population density, housing, and poverty are examples that show the interlink between socio-spatial environments and health consequences. Research shows that walkable neighborhoods with affordable transportation promote higher rates of physical activity, and this mitigates the health consequences of physical inactivity. Geographic Information Systems (GIS) is an application to be used in more advanced spatial analysis that yields socioeconomic inequalities and directs focused interventions to augment equitable access to essential services. Human subject experiments in which environmental interventions such as sidewalk construction or green corridor creation are undertaken and their impact on behavior is determined are proof of real-world effectiveness for these interventions. Integrating public health objectives such as air quality, pedestrian safety, and accessibility to individuals of all ages with urban planning significantly enhances residents' quality of life, particularly in highly urbanized city environments. Urban planners and policymakers who respond to natural environments and transport systems to various human needs can break free from health disparities and assist in developing equitable, healthy communities.

**Cluster 2 (green) - Data-Driven Innovations and Environmental Sustainability in Construction:** There are 25 terms like artificial intelligence, machine learning, circular economy, life cycle assessment, greenhouse gases, and waste management that reflect the growing intersection of emerging technology with environmental sustainability in construction. Focus on gas emissions, environmental management, and life cycle analysis is an indication of the direction of the industry towards quantification and minimization of environmental

footprint. At the same time, machine learning and artificial intelligence are revolutionizing the building sector using data-based optimization, predictive models of energy consumption, greenhouse gas emissions, and air quality. The technologies are supporting green development projects and contribute to the Sustainable Development Goals (SDGs) by integrating cleaner and wiser processes throughout every phase of the building project. The circular economy model is also affecting waste management and recycling activities, changing the sector from linear consumption patterns to recirculation of resources. The COVID-19 pandemic also brought into focus the need for resilient and smart buildings with real-time monitoring systems, further propelling the application of AI and automation to prevent health risks during periods of disruptive events. Besides, increasing academic interest in such matters can be observed through bibliometric analysis and visualization tools, which are capable of tracking, evaluating, and informing research into transformational construction practice. The circular economy model is also influencing waste management and recycling activities, changing the sector from linear consumption to material recirculation. The COVID-19 pandemic also showed the world the need for intelligent and resilient buildings with real-time monitoring systems, further pushing the adoption of AI and automation to prevent health risks during periods of disruptive events.

**Cluster 3 (blue) - Sustainability Integration in Construction, Urban Growth, and Social Aspects:** This cluster, as explained by keywords; built environment, sustainability, sustainable construction, and SDGs, sees the interplay of the social, economic, and environmental elements in construction projects, particularly in the developing world. Economic and social impacts, environmental conservation, and happiness illustrate the broad field of sustainability extending beyond environmental conservation efforts to inclusive society development. Urbanization trends, oftentimes analyzed through population data, emphasize the need for strategic planning and evidence-informed decision-making to ensure that urban expansion is synergistic with environmental sustainability and social well-being. Smart city initiatives apply technology, data analysis, and project management strategies to enhance environmental sustainability while enhancing the quality of life in urbanizing areas. These programs strive towards optimizing the utilization of resources, reducing greenhouse gas emissions, and achieving equitable access to basic services that has a particular confluence with the SDGs agenda. Some particular problems in the developing countries include inefficient infrastructure, lack of availability of finance, as well as poor institutional capacity. Their overcoming is required in terms of alternate means of financing in combination with inclusive governments to ensure sustainable urban development. The emphasis on sustainable construction and cities in the cluster shows the presence of a live strategic vision with an orientation towards the integration of green processes, social justice, and financial sustainability at each phase of the life cycle of construction activities.

**Cluster 4 (yellow) - Urban Benchmarking, Methodologies, and Policy for Sustainable Development:** This cluster contains 18 terms such as cities, energy efficiency, environmental economics, new urban agenda, and urban sustainability, which highlight the importance of systematic approaches and methodologies in urban development and policymaking. Greater use of benchmarking and indicators is due to greater demands for robust frameworks to assess the performance of cities, track progress, and make evidence-based decisions. Such a priority

is articulated in the New Urban Agenda, which gives precedence to inclusive, resilient, and sustainable urbanization through the co-integration of energy efficiency, economic sustainability, and environmental stewardship in planning solutions. Research on energy consumption, energy efficiency, and energy consumption establishes the bittersweet role of cities as both large energy consumers and hubs of innovation due to their highly concentrated resources, infrastructure, and population. The convergence of city planning, environmental assessment, and urbanization determines policies that respond to the objective of minimizing environmental effects while securing social and economic well-being. Environmental economic instruments provide a platform for comparative cost and benefit interventional analysis and for enabling a sustainable urban scheme that addresses varied constituencies. These words as a whole point towards a multi-dimensional strategy for the promotion of evidence-based signs of environmental influence reduction along with the improvement in the living standard of citizens. Urban policy may enable resilience and sustainable development through reflective city planning, adopting cutting-edge technologies, and stakeholder participation in decision-making.

**Cluster 5 (purple) - Adaptive Strategies, Nature-Based Solutions, and Climate Resilience:**

This cluster includes 16 terms like adaptation, biodiversity, nature-based solutions, resilience, and vulnerability, reflecting heightened sensitivity to ecological and adaptive responses to climate change and accelerated urbanization. That risk management, mobility, and accessibility concepts are present reflects urban planning and design efforts to balance human needs, infrastructure needs, and the need to conserve and restore natural systems. Nature-based solutions are instituted in flood risk reduction, heat island mitigation, and local ecosystem enhancement strategies where biodiversity conservation and sustainable urban redevelopment are enabled. Adaptive management as a concept integrates the adaptive, iterative process wherein stakeholders can modify policies and strategies to suit new data and evolving environmental conditions. Case studies of various contexts provide evidence-based solutions that can be replicated or scaled up based on the respective requirements of the various urban areas. The integration of the Sustainable Development Goals (SDGs) into resilience action ensures that the response is not just to proximate climate risks but also to more universal socioeconomic challenges, such as poverty reduction, equity, and health equity. This cluster responds to the need for multi-scale, cross-disciplinary solutions in urban policy, social science, and environmental science. Knowledge solutions need to be set in place in order to bring about urban regeneration, maintain ecological well-being, and ensure the well-being of vulnerable groups against the ever-changing urban environment.

**Cluster 6 (aqua) - Architecture, Design Education, and Social Impact:** Architectural education is also increasingly innovative through quantitative analysis via computational methodology and data metrics for form, functionality, and environmental performance analysis. Instructors introduce these design thinking methods through coursework and design studios, sparking data-inspired creativity and integrating aesthetic goals associated with measurable social, economic, and environmental objectives. Social effect as theory provides the balance for everything regarding the notion that architecture outcomes extend the built form beyond it to have implications on individuals' health, the feeling of a shared sense of place, and the

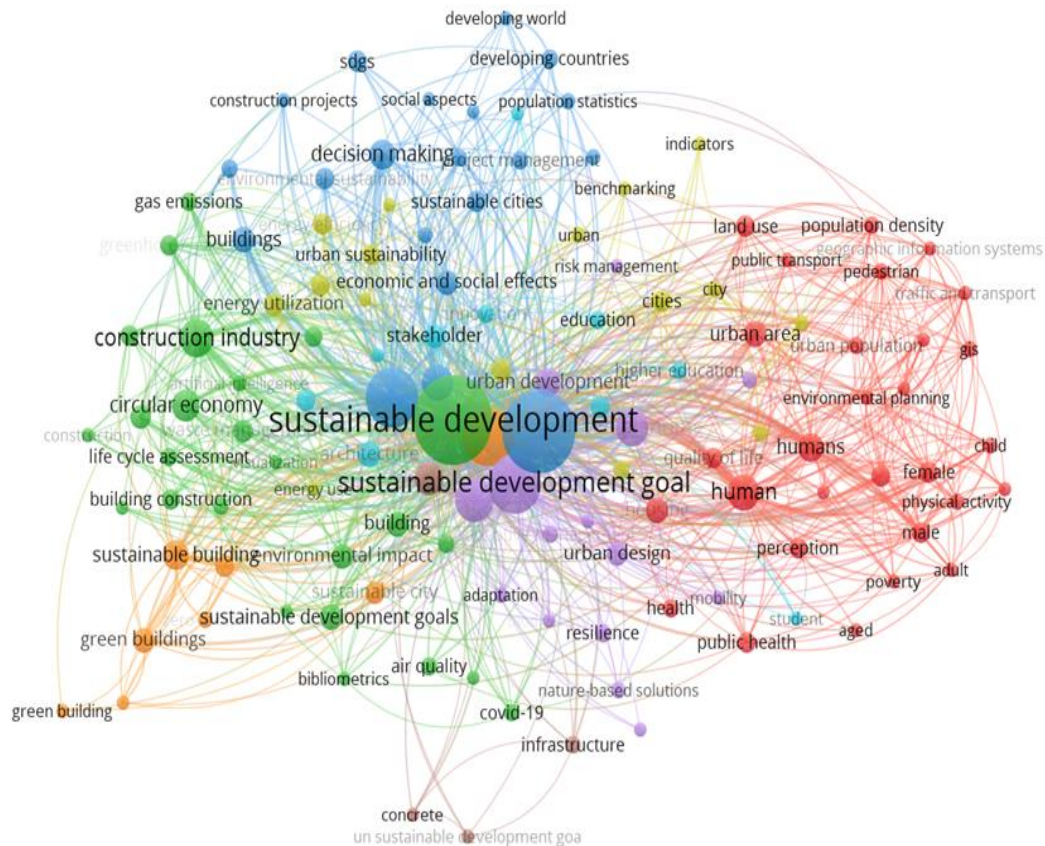
shaping of culture. This larger worldview places architecture in the position of an agent for change, rising pedagogic importance to global agendas, such as equitable access to quality urban, and sustainable living. Cumulatively, this collective authorship traces the way that the convergence of pedagogy, innovation, and design yields architects responsible not just for creating the built environment but addressing social and ecologic concerns.

**Cluster 7 (orange) - Green Building, Zero-Carbon, and Sustainable Energy Approaches:**

This cluster, with keywords such as energy, green building, zero-carbon, and sustainable development goals is evidence of the urgency of rewiring building activity and urban planning onto low-carbon, resource-aware paths. The use of terms such as sustainable city and green development is a sign of a rapidly moving world transition towards green infrastructure, taking into account a greater emphasis on lowering greenhouse gas emissions and achieving net-zero positions. The prevalence of green buildings and sustainable buildings in this cluster implies a lifecycle approach, wherein design, material choices, and operational strategies are aligned to minimize ecological impacts. At the hub of these efforts are renewable power technologies, passive design strategies, and cutting-edge technologies such as solar photovoltaics and high-efficiency HVAC equipment, which facilitate healthier indoor spaces, lower life cycle costs, and greater resilience in the built environment. Apart from addressing the challenges of climate change, these practices support a number of Sustainable Development Goals (SDGs), but particularly SDG 7 (Affordable and Clean Energy) and SDG 11 (Sustainable Cities and Communities). This session positions the central contribution of the built environment to decarbonization worldwide, as well as how policy, design innovation, and stakeholder participation can converge to accelerate the shift to cleaner, more sustainable cities. Employing sustainable practices not only minimizes the environmental impacts but also contributes to promoting greater socioeconomic goals, towards a more equitable and sustainable future.

**Cluster 8 (brown) - Sustainable Concrete Infrastructure for Achieving the UN SDGs:** This group, referencing terms such as concrete, infrastructure, UN Sustainable Development Goals, and United Nations, highlights the central role that heavy building material and bulk project play in enhancing global sustainability efforts. Concrete is one of the most frequent used building materials yet is central in infrastructure development yet has very alarming environmental challenges that arise due to its carbon debt and consumption rate. Mitigation of such effects involves synchronization of infrastructure development with the UN Sustainable Development Goals (SDGs), SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities). The development of new low-carbon binders, recycled aggregates, and green construction practices should be carried out in an effort to reduce the environmental footprint of concrete without undermining its durability and economic value. Policy-level, the United Nations promotes economic development, climate resilience, and sustainable development through its 2030 Agenda to align with requirements for sustainable solutions in infrastructure. This group brings together concrete technology advancements and worldwide goals so that we can prioritize environmental sustainability as well as economic development through construction. Incorporating green principles into our concrete systems is a tactical move towards developing strong, resource-efficient, and climate-resilient systems alongside worldwide efforts towards sustainability.





**Figure 4: Network visualization map for co-occurring Keywords**

### 3.5. Research Trends Based on Year of Publication

The overlay visualization in Figure 5 illustrates the evolution of academic interest in sustainability in the built environment during the past decade. It charts the trajectory from the pioneering research topics in 2015 through to the forefront subjects envisioned in 2025.

The color gradation, from cooler tones (blue-green) in the initial years to warmer tones (yellow-orange) in the subsequent years, mirrors the changing thematic priority and developing research themes.

The initial years comprised studies that were predominantly on broad ideas of sustainability, as evident in terms such as sustainable development, sustainability, and green building. The initial studies explored environmental protection, life cycle, and resource management, with emphasis on how to reduce the environmental impact of the construction sector. Initial studies tended to invoke the UN's 2030 Agenda, concentrating on the role of international frameworks of sustainability.

Policy coordination and initial discourse on sustainable construction methods marked this phase, laying the groundwork for subsequent cross-disciplinary studies. The research scope increased manifold after 2018. Circular economy, energy efficiency, urban planning, and public health were a few of the buzzwords that occupied the limelight.

Green building studies were more applied in nature, echoing efforts to put sustainability into practice with more materials, design solutions, and occupant health measures. Urban sustainability studies shifted toward socio-economic concerns like housing shortages, health inequalities, and climate change resilience.

This decade also saw more interdisciplinary engagement among policymakers, environmental scientists, and architects, who applied life cycle assessment (LCA) tools for quantifying the long-term impacts of construction activities. In the most recent era (2022–2025), the prevailing research topics are sustainable construction, green building, sustainable city, and zero-carbon, reflecting growing concern with decarbonizing the built environment and net-zero ambitions.

The research path in built environment sustainability demonstrates rising sophistication as scientists, practitioners, and policymakers seek to balance urbanism and construction with global environmental limits and social justice goals.

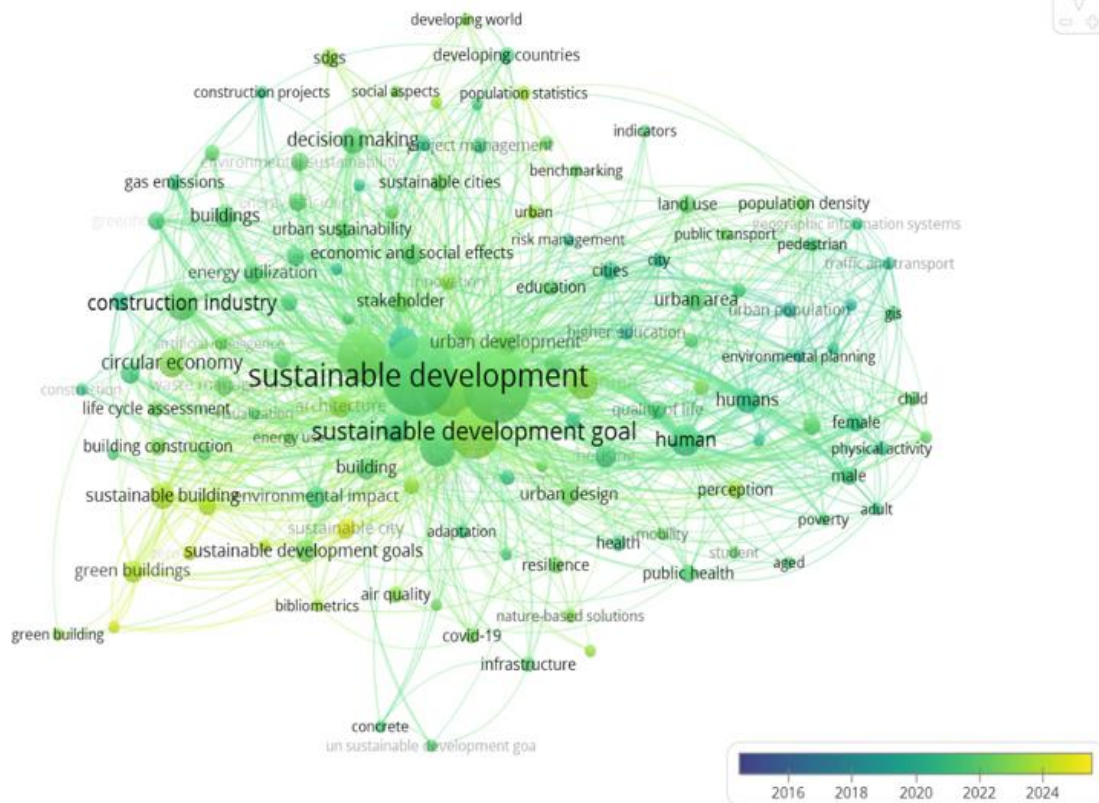
The timeline reflects an unshakable commitment to sustainability, marrying academic research with practice application in the pursuit of meeting the 2030 SDG agenda requirements. Practical applications such as the integration of renewable energy systems into building designs are afforded greater attention.

Green building is now examined based on a more systemized approach in meeting occupant wellness, economic viability, and climate change mitigation interventions. Technological innovation, including smart monitoring systems and high-efficiency HVAC systems, is being explored as a key enabler of zero-carbon ambitions without compromising comfort or profitability.

Urban research has also accelerated rapidly, with an emphasis on walkability, cyclical material flows, and community resilience, particularly for quickly urbanizing areas or those with enhanced climate vulnerabilities.

Evolution from early sustainability principles to integrated solutions indicates an expanding field maturation. Early research established the theory foundation, and subsequent phases involved technological and policy developments in urban sustainability solutions. Present and potential research focuses on decarbonisation, embodied energy, and solutions based on life cycles, in a convergence of environmental, social, and economic agendas.

The research pathway in built environment sustainability increases in sophistication as scholars, practitioners, and policymakers seek to balance urbanism and building with global environmental limits and social justice goals. The timeline indicates a consistent emphasis on sustainability, bridging scholarly research with practice application towards meeting the demands of the 2030 SDG agenda.



**Figure 5: Overlay visualization for co-occurring keywords**

## 4. DISCUSSIONS

### 4.1. The impact of future trends on policy practice and technological innovation

The thematic clustering and bibliometric analysis of sustainability studies in the built environment (2015–2025) point towards a shift to technology-driven, holistic strategies with far-reaching implications for practice, policy, and innovation. The shift pinpoints four dominant new trends: digital transformation, decarbonization strategy, circular resource flows, and human-centered design, all setting the agenda for the future of the industry. Application of advanced digital technologies, such as AI-supported simulations, Building Information Modeling (BIM), and Internet of Things (IoT) sensors, is reflective of a move towards data-intensive, real-time project management (Ghaffarianhoseini et al., 2013; Scrivener et al., 2018). These technologies are being increasingly implemented by governments to enable project approvals, enhance compliance monitoring, and enable predictive maintenance of infrastructure (Li et al., 2024). The introduction of blockchain-supported smart contracts, AI-based compliance systems, and cloud storage necessitates policy interventions that address cybersecurity threats, data security, and interoperability requirements (Feng et al., 2020; Ani et

al., 2017). These developments place emphasis on the need for regulation of digital ethics, data governance, and technology integration in the construction sector (Yi & Nie, 2024; Krychevs'ka et al., 2024). The success of e-government systems depends on the development of regulatory environments in which new technologies are experimented with test environments prior to large-scale use. Policymakers need to develop well-crafted regulatory environments such that cybersecurity threats are mitigated, intellectual property is protected, and AI and blockchain-based applications are brought under legal and ethical compliance (Dubinin, 2024). Regulatory sandboxes allow governments to experiment with policy settings for encouraging innovation without sacrificing compliance with sustainability requirements (Krychevs'ka et al., 2024). Leverage of digital technologies such as Building Information Modeling (BIM) and Project Management Information Systems (PMIS) enhances the efficiency of governance through real-time monitoring, predictive analysis, and automated risk assessment (Yi & Nie, 2024). Additionally, data-driven governance frameworks are essential in construction enterprises to optimize decision-making and enforce regulatory compliance in multi-project environments (Dubinin, 2024). Decarbonization efforts are gaining momentum as net-zero and ultra-low energy building codes become central to climate change mitigation. Research shows increasing interest in high-efficiency HVAC systems, low-carbon cement, and renewable energy integration, which governments are supporting through subsidies, tax benefits, and certification programs such as LEED and BREEAM (Habert et al., 2020; Scrivener et al., 2018). Enforcement of energy performance requirements, such as embodied carbon reporting, keeps material supply and construction procedures transparent. Life cycle control is fast becoming an indispensable tool, which calls for open reporting of embodied carbon and material use, thereby encouraging green buying, circular uptake of products, and resource-saving design strategies (Khasreen et al., 2009; Ghaffarianhoseini et al., 2013). Resource circular management policies are also gaining traction, which encourages resource-smart configurations, calling for construction and demolition debris recycling, in order to stem linear consumption practices. Grants for development and tax credits for new materials such as recycled aggregates, low-carbon cement and binders, and bio-based materials will accelerate the market transition and lower raw material extraction pressures (Hellweg & Milà i Canals, 2014; Ghaffar et al., 2020). Previous bibliometric studies have examined sustainability in the built environment, but most have primarily focused on urban planning and green building policies (Chen, Liu, & Xu, 2024; Moises & de Carvalho, 2024). This study builds on past research by introducing a greater emphasis on the integration of AI, blockchain, and predictive modeling into governance frameworks. Compared to the literature that has predominantly addressed sustainability indicators and policy recommendations, the current research focuses on how digital innovations are transforming enforcement, compliance testing, and financial incentives for sustainability (Kaur, Arora, & Goyal, 2024). The combination of decarbonization planning with circular economy thinking also separates the current study from earlier works, with an emphasis on the ways in which fiscal tools, digital technologies, and evidence-informed policy can accelerate sustainability transitions (Alshdaifat et al., 2024). Human-centered planning is also incorporated in sustainability planning, where technological performance, public health, occupant comfort, and accessibility are being taken into account in the context of high-density urban life (Frumkin et al., 2004; Giles-Corti et al., 2009). Public participation



will become part of future policymaking in planning, as building management through AI will be planned according to cultural, socio-economic, and demographic needs (Khorrami et al., 2021). Incorporating real-time AI-based monitoring systems into platforms for compliance boosts the transparency level in sustainability checking and minimizes dependency on audit manuals. Governments can compel construction contractors to apply real-time performance measurement to their projects such that environmental impacts are monitored and controlled in real-time (Chen et al., 2024). There is also international cooperation propelling policymaking that is sustainable in which governments, institutions, and the private sector are working more together in an attempt to merge national strategies toward sustainability with the best global practices. The exchange of information through open real-time interaction across border is bridging international cooperation to coordinate sustainability policies among nations (Alshdaifat et al., 2024). This approach permits SDG-consistent strategies to be jointly developed instead of separately and thus exploits the combined experience of different stakeholders. These trends are reflected directly to the United Nations Sustainable Development Goals (SDGs) by green buildings, zero-carbon option, and community health (United Nations, 2015). The findings ground the dual role of policy and technology in shaping the built environment of the future. Governments must put in place enabling regulation and financial incentives to guide sustainable construction, as the private sector and research base continue to drive digital innovation, develop more sustainable materials, and apply data-driven best practices. Ensuring that these innovations make things stronger, reduce inequalities, and create long-term value is a prime challenge for industry leaders and policymakers.

#### **4.2. Insights for stakeholders in integrating SDGs in the built environment**

The bibliometric results show that sustainability in the built environment is closely linked to the United Nations Sustainable Development Goals (SDGs), particularly Goal 9 (Industry, Innovation, and Infrastructure), Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action). As research increasingly adopts holistic and interdisciplinary approaches, stakeholders including policymakers, urban planners, private-sector organizations, NGOs, and local communities must implement innovative strategies to integrate the SDGs into practical applications. Public-Private Partnerships (PPPs) provide a platform for collaboration to act on sustainability issues, e.g., the establishment of green infrastructure, implementation of building codes for sustainability, and funding mechanisms for the adoption of renewable energy in social housing. Research has proved that well-structured PPPs increase public and private resource mobilization, constraining economic limitations to the incorporation of sustainability (Akomea-Frimpong et al., 2023). The success of such partnerships, however, depends on regulatory clarity, risk-sharing arrangements, and incentive structures that ensure long-term private-sector engagement in sustainable construction. Governments need to adopt governance structures that establish clear sustainability performance goals, thus PPPs are synchronized with SDG-related objectives such as climate resilience, carbon neutrality, and resource efficiency. Increased industry-academia collaboration is also necessary to bring SDGs mainstream into the built environment. Universities and research centers play a vital role in low-carbon material testing and validation, smart energy systems, and circular building techniques before commercial application. University knowledge transfer policies that promote

cross-linkages of higher institutions and private sector companies enable research on sustainability by linking-up with industry standards. Cross-linkages are even able to support labor expansion through combining integration of digital building management, ESG reporting, and sustainability governance in technical capacity-building programs for imparting skills in rendering SDG-amicable practice (Khorrami et al., 2021). Social justice and equality need to be embedded at the core of SDG action plans. Poor people need to be among the largest agendas of sustainable urban development so that climate change adaptation strategies and infrastructure investments cut across poor groups. Evidence suggests that higher levels of urban regeneration programs that involve active citizen participation result in better acceptance levels of green infrastructure, energy-efficient programs, and waste reduction initiatives (Frumkin et al., 2004; Giles-Corti et al., 2009). Socio-economic effects taken into consideration for the study of environmental impact assures the incorporation of the voice of marginalized sections of society while determining sustainability policies. These policies can be complemented with equity-based building policies such as low-income family subsidized green homes, incentives on people-centered sustainable development projects, and the employment of local workers in green infrastructure. Institutional framework is essential in driving SDG-related objectives. Governments must enforce and implement green building codes, waste prevention acts, and low-emission zoning regulations that convert the commitments into actions. Incentivized policy such as sustainable materials preferential procurement schemes, tax incentives to companies that invest in energy-efficient buildings, and carbon emissions taxes on high levels of emissions can create a regulatory environment that encourages the use of sustainability in the built environment (Aigbavboa et al., 2024). Best practice lessons for the international arena are that obligatory reporting sustainability requirements, in combination with disclosure policies by government, enhance corporate accountability and ESG compliance transparency. Technology plays a pivotal role in advancing sustainability actions in the built environment. Building Information Modeling (BIM), Internet of Things (IoT) sensors, and Artificial Intelligence (AI) analytics are data technologies that can be utilized to track energy efficiency, emissions savings, and equity measures in real-time (Li et al., 2024). Governments and private investors are able to utilize these technologies to construct automated sustainability tracking platforms with real-time monitoring and data-driven decision-making. The application of blockchain-based governance models can similarly otherwise improve green finance, carbon offsetting market, and sustainable procurement policy transparency, staying compliant with SDG goals without resorting to greenwashing (Feng et al., 2020). Nature-based solutions complement the application of high-tech mechanisms of sustainability by offering low-cost climate resilience options. The implementation of green roofs, urban wetlands, and tree-lined corridors enhances biodiversity, improves urban air quality, and reduces heat island effects in urban metacentres. Research shows that integrating ecological restoration into urban planning strategies boosts climate resilience and social health, supporting SDG goals directly (Hellweg & Milà i Canals, 2014). Robust monitoring and evaluation systems are necessary to track SDG progress in the built environment. Governments and urban planners should utilize Geographic Information Systems (GIS), remote sensing technologies, and open data platforms to monitor carbon emissions, green space availability, and air quality metrics in real time (Scrivener et al., 2018). These technological instruments render policies more transparent so that stakeholders



can identify sustainability gaps and make evidence-based amendments to city development plans. Both city governments and private developers must publish annual sustainability performance reports to ascertain that project-level interventions achieve national and international sustainability thresholds. Successful implementation of SDG-driven sustainability strategies also involves translating international frameworks into local realities. Whereas low-income housing and fundamental infrastructure would be developing economies' areas of concentration, advanced economies will target emission reduction, energy efficiency, and AI-optimized cities. Adaptive management policy, whereby the policies get developed according to pilot project results, stakeholders' views, and emerging evidence, constitutes an adaptive and responsive governance framework that continues to be attuned to emerging sustainability imperatives. These approaches underline the fact that SDG-based sustainability interventions need to be reconciled with prevailing economic, environmental, and social conditions in a manner that fosters long-term resilience within the built environment.

## 5. CONCLUSION

Bibliometric evidence indicates a changing research scholarship of sustainable practice in the built environment, in particular where these intersect with the United Nations Sustainable Development Goals (SDGs). Research agendas from 2015 to 2025 moved away from core sustainability basics of green building, energy efficiency, and environmental protection towards more holistic and technology-facilitated strategies embracing principles of circular economy, digital innovation, and human-centered design.

The recognized clusters outline a constantly evolving and multi-disciplinary profession more interested in aligning the practice of construction with environmental necessities, social welfare, and strong policy frameworks. Scholars, experts, and policy makers are seeking new horizons, such as AI-aided building design, smart urban development, and locally driven regeneration strategies, to develop climate change-resilient built environments together with socio-economic issues.

The ongoing return of SDG-based themes in the literature speaks of a shared universal hope for harnessing innovative construction technologies and economy-enabling design philosophy in constructing equitable, adaptable, and sustainable urban spaces. The progress in the discipline portends an optimistic union of scholarship research, sector innovation, and governing systems to become an exemplary paradigm of revolution in construction and city planning.

### 5.1. Limitations

This study presents an image of the overall global trend of constructing sustainability, albeit with some limitations. Depending on Scopus as the principal source of information does not capture literature indexed elsewhere in other databases such as Web of Science and Google Scholar. Therefore, there is a limited scope to the study. The exclusion of in-press articles can also lead to the fact that the latest trends in sustainability governance are not well-covered. While the study can effectively identify international bibliometric trends, its general nature

may not effectively reflect regional-level sustainability concerns. Lack of local bibliometric studies, particularly for Africa, Latin America, and Southeast Asia, limits knowledge on context-specific policy modifications and governance structures. Furthermore, quantitative keyword and citation counts employed here, while useful to track trends of research, fall short of accessing the qualitative dimensions of policy influence, industry adoption, or stakeholder engagement. Future research based on expert interviews, case studies, and policy analyses would provide a more nuanced and functional explanation of sustainability initiative implementation in practice. The results of this study will be more applicable, and the success of implementing SDG-informed sustainability practices in the built environment will be guaranteed if these constraints are addressed through cross-disciplinary, methodologically diverse, and region-specific research.

## 5.2. Future Research

There are several themes that require examination based on accessible bibliometric information to develop knowledge on sustainability in the built environment. National bibliometrics and regional bibliometrics, particularly the Global South, are required to offer the argument for regionalized issues, policy gaps, and localized innovations in sustainable construction.

Looking at the research in Africa, Latin America, and Southeast Asia can really give things some perspective regarding the trends, how governments are coping, and what the socio-economic problems they are facing. This can help develop more effective strategies for sustainability that are appropriate for each region's needs. Future works should consider diving into some long-term case studies of SDG-friendly building projects to see their performances and long-term impacts are. Tracking these projects over a few years enables us to measure the success of policies, stakeholder collaboration, and whether winning strategies can be scaled up. Some research questions to ask are:

- In what manner are issues related to regulations and finance affecting the implementation of sustainability practices in developing countries?
- What are the best governance models for imposing SDG-conformant construction practices in different regions?
- What is the contribution of digital technologies, such as AI-driven sustainability appraisal and blockchain governance, to compliance and transparency within the built environment?

Future research could use mixed-method designs, with expert interviews and case studies, to get the details of policy take-up and technological embedding. Follow-up bibliometric studies should also track thematic developments of sustainability language, observing how ideas such as circular economy, smart cities, and climate resilience evolve. Closing the gaps would yield rich, locally grounded knowledge of sustainable development in the built environment.

## Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work the authors used ChatGPT 4 in order to check and refine grammar and language. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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