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# Discovering emerging trends and interdisciplinary mechanisms in urban studies and planning research using topic modelling 1991–2021

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This study empirically maps interdisciplinary evolution in urban studies and planning through latent Dirichlet allocation analysis of 44,147 articles from 30 leading journals (1991–2021). We identify 12 research topics organised into three clusters and reveal three distinct interdisciplinary mechanisms: asymmetric knowledge flow where socio-political geography influences planning policy 2.3 times more than reciprocally, unexpected bridge topics with urban-rural development facilitating 54.2% of cross-topic engagement, and methodological integration through spatial analysis tools enabling collaboration across traditionally distinct domains. Temporal analysis reveals rising prominence of environmental sustainability and neighbourhood planning, whilst traditional spatial econometric approaches decline significantly. Co-occurrence network analysis quantifies increasing interconnectedness, with cross-topic authorship rising from 1.6 to 3.2 authors per publication, demonstrating collaborative mechanisms transcending disciplinary boundaries. These findings advance interdisciplinary theory by providing empirical evidence for knowledge synthesis frameworks, revealing how computational methods and collaborative networks serve as practical vehicles for disciplinary integration. The prominence of environmental management and urban-rural development provides data-driven support for contemporary planning paradigms including 15-min cities and Nature-based Solutions. This research contributes novel quantitative methods for mapping knowledge integration mechanisms, offering a replicable framework for understanding interdisciplinary evolution in response to complex societal challenges.

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## Introduction

Urban-themed research has been rapidly flourishing, with academic knowledge about cities spanning across multiple disciplines. Despite this expansion, a comprehensive understanding of the broader urban research landscape remains elusive. While bibliometric analyses have shed light on specific areas or topics within urban studies (Li and Zhao, 2015; Liu et al., 2012; Liu, 2005; Wang et al., 2012; Wu et al., 2015; Zhuang et al., 2013), they often fail to capture the full spectrum of the discipline. This gap underscores the need for a more holistic perspective that spans the entirety of urban research, aiming to uncover themes, trends, limitations and evolutionary patterns across urban studies and planning.

Bibliometric methods, systematic reviews and topic modelling have been instrumental in evaluating the patterns of urban-themed research. These tools help in identifying emerging trends and potential gaps within the field (Derudder et al., 2019; Pendlebury, 2009, 2010; Sun and Yin, 2017). However, the focus has predominantly been on isolated sub-fields or specific topics, limiting the understanding of the interconnections and interdisciplinary influences that shape urban studies as a whole.

Research by Fang and Ewing (2020) and Sanchez (2020) has highlighted that bibliometric analyses often restrict themselves to particular journals or are limited to geographic regions such as North America. This narrow focus fails to provide an overarching view of urban planning and its evolution. Recent works by Haghani et al. (2023) and Sharifi et al. (2023) advocate for a broader perspective that encompasses global trends and interdisciplinary research dynamics. Urban studies and planning, as an inherently interdisciplinary field, draw on diverse disciplines to address complex urban challenges, necessitating both theoretical and practical engagement with interdisciplinarity (Klein, 1990). Theoretically, interdisciplinarity fosters synthesis across socio-political, environmental, and technical domains, while practically, it requires mechanisms like collaborative research networks to overcome disciplinary silos (Keynejad et al., 2021). The interdisciplinary approach is crucial for gaining a more comprehensive understanding of urban research and its challenges.

Terzano et al. (2020) provide valuable insights into the process of navigating the publication landscape in urban planning, emphasising the importance of selecting appropriate journals based on topic and ranking, and offering guidance for both researchers and practitioners. To further expand on the notion of topic understanding, this study aims to provide a comprehensive analysis of the field of urban studies and planning by utilising topic modelling to map these interdisciplinary dynamics and explore emerging trends and the intellectual base of research from the past three decades. By examining analysing publication metadata from 30 prominent academic journals, this research seeks to reveal how urban scholarship integrates diverse perspectives to inform sustainable urban futures and offer a valuable reference point for a diverse group of stakeholders in the urban studies and planning community.

Our primary contribution lies in revealing quantifiable mechanisms of interdisciplinary knowledge integration through systematic analysis of cross-topic engagement patterns. We demonstrate three previously unidentified integration pathways: asymmetric knowledge flow where socio-political geography influences planning policy 2.3 times more than reciprocally, unexpected bridge topics with urban-rural development facilitating 54.2% of cross-topic engagement, and methodological integration through spatial analysis tools enabling collaboration across traditionally distinct domains. These quantitative insights into interdisciplinary mechanisms represent a methodological advancement in understanding how knowledge synthesis occurs

in practice, moving beyond descriptive bibliometric analysis to reveal the operational pathways through which academic fields integrate to address complex societal challenges.

Moreover, compared to previous studies that focused on select journals or US-centric contexts, our analysis of leading journals over three decades provides more comprehensive empirical coverage of urban studies and planning research. Our term frequency analysis across topic clusters identifies emerging research frontiers, particularly the rising emphasis on environmental sustainability and climate-responsive urban policies, providing clear directions for future research development. Our use of latent Dirichlet allocation (LDA) on this comprehensive dataset enables a nuanced exploration of emerging trends beyond regional or sub-disciplinary foci, addressing a critical gap in understanding the field's interdisciplinary evolution whilst informing urban planning practice by identifying research trends that align with pressing real-world challenges.

By providing a detailed and structured analysis of the intellectual landscape of urban studies and planning, the insights gained from this study are intended to support the academic community and practitioners in navigating the complexities of urban research and in making strategic decisions that reflect the current and future states of the field.

The remainder of this paper is organised as follows: it first reviews urban studies research themes and their evolution, along with topic modelling methodologies, particularly LDA. It then details the data collection from Web of Science (WoS) and the systematic LDA implementation process. The 'Results' section presents bibliometric trends, topic discovery and classification, temporal evolution patterns, authorship and citation analysis, and co-occurrence network mapping. The 'Discussion' section examines theoretical implications of knowledge integration mechanisms, environmental paradigm shifts, practical collaboration pathways and institutional barriers, and study limitations. Finally, the paper synthesises key findings regarding interdisciplinary evolution and suggests directions for future urban studies research.

## Literature review

**Urban studies and planning research themes and their transition.** Urban studies and planning research examines the dynamic structures of cities, shaped by interconnected subsystems such as land development policy, demographics, market trends and transportation networks (Allam, 2018). To understand these dynamics, scholars have identified diverse research areas. For instance, Hutchison (2010) highlighted topics like advocacy planning, growth management, housing, tourism and urban design, while Liu (2005) emphasised the field's multidisciplinary nature. Forsyth (2012) noted the evolution of distinct research streams, including scientific inquiry, practical concerns, and theoretical reflection. In addition, Sanchez and Afzalan (2017) categorised urban planning into 11 domains, such as community, housing and economic development; public policy and finance; transportation; land-use management and growth; sustainable design, theory, history and space; environmental sustainability and spatial analysis; methods; social and health studies; real estate; citizen participation; and environment and urbanisation.

More recently, Sanchez (2020) and Fang and Ewing (2020) adopted quantitative approaches to analyse urban research themes. Sanchez (2020) utilised the Support Vector Machine (SVM) labelling method to classify publication titles, whereas Fang and Ewing (2020) employed the LDA text mining method to generate research themes from word clusters of full-text documents. Although the results of both studies differ

significantly due to variations in analysis scale, scope of research, data and method, Fang and Ewing (2020) were able to observe changing patterns of research themes and interests over time and space, based on three North American-based journals, namely the *Journal of American Planning Association* (JAPA), *Journal of Planning Education and Research* (JPER) and *Journal of Planning Literature* (JPL). They noted increasing interest in themes such as planning process, planning methods and growth management, while scholarly interest in planning theory and education appeared to diminish. New themes such as food systems and historical preservation were observed as emerging in the field (Fang and Ewing, 2020).

Furthermore, Haghani et al. (2023) and Sharifi et al. (2023) applied the VOS clustering method to identify the thematic clusters of about 100,000 articles from the 'Urban Studies' and 'Regional & Urban Planning' categories of the WoS database. Haghani et al. (2023) identified four general thematic clusters: governance and policy, built and natural environment, economics and markets, and housing. They further divided these clusters into 18 thematic networks, discovering an increase in topics such as urban shrinkage and smart cities since the 2000s. Sharifi et al. (2023), while not further sub-diving topics quantitatively, identified similar emerging urban themes such as smart cities, big data analytics and urban resilience. In alignment with Haghani et al. (2023), Fu (2024) highlighted the growing role of natural language processing in urban planning research, identifying a fragmented landscape dominated by exploratory studies.

Interdisciplinarity is pivotal to urban studies and planning, enabling the integration of diverse methodologies to tackle multifaceted urban issues (Klein, 1990). Klein (1990) frames interdisciplinarity as a synthesis of knowledge, uniting social, environmental, and policy perspectives to address complex challenges. Practically, this involves navigating barriers like disciplinary silos through mechanisms such as international collaborations and transdisciplinary frameworks, which transcend traditional boundaries (Petts et al., 2008; Keynejad et al., 2021). Unlike multidisciplinary, which juxtaposes disciplines, transdisciplinarity fosters co-produced knowledge, as seen in urban environmental research (Petts et al., 2008). These studies exemplify such integration, combining computational and urban scholarship, to be essential in mapping interdisciplinary trends.

In addition to individual urban scholars, a number of planning research themes have been identified by academic institutions across continents. The Association of Collegiate Schools of Planning (ACSP) has identified themes mainly relevant to the North American context; the Association of European Schools of Planning (AESOP) has identified themes mainly relevant to the European context; the Asian Planning Schools Association (APSA) which previously hosted the World Planning Schools Congress has identified themes concerning global and Asian context; and the International Society of City and Regional Planners (ISOCARP) has identified themes based on international context (see Tables B1 & B2 in Supplementary Material).

While these institutions would host academic conferences and congresses almost each year based on a specific research theme concerning the research context of the host countries, such as global village and health, they often select the most general and heated research themes in the field as research track for paper submissions.

**Topic modelling.** Beyond traditional bibliometric tools like performance analysis, science mapping and network analysis, machine learning techniques such as LDA and SVM have advanced topic modelling and research theme categorisation (Fang and Ewing, 2020; Fu, 2024; Jelodar et al., 2019; Sanchez,

2020; Sanchez et al., 2024; Sun and Yin, 2017). LDA, a probabilistic model for discrete data proposed by Blei et al. (2003), clusters words based on co-occurrence, enabling the identification of topics from predefined clusters (Marvuglia et al., 2020). In bibliometric analysis, it calculates topics probabilities from keywords, titles, or abstracts, repenetrating relevant documents. Further theoretical and mathematical explanations of the application of LDA for text modelling on bibliographic data, particularly regarding topic variations and topic coherence across journals, countries/regions and years, can be found in Blei et al. (2003) and Röder et al. (2015).

LDA is an unsupervised learning algorithm that eliminates the need for pre-classification and labelled training data, offering greater efficiency and accuracy for large datasets compared to manual labelling or traditional clustering method like K-means (Clements et al., 2023; Fang and Ewing, 2020; Lore et al., 2024). Its key advantages include flexibility, interpretability and scalability, and its generative probability-based approach. LDA provides detailed and objective topic representations, analyses diverse datasets (e.g. text, music, imagery, social networks), and generate interpretable topics as probabilistic word distributions. Finally, its scalability further enables efficient processing of large datasets through distributed computing.

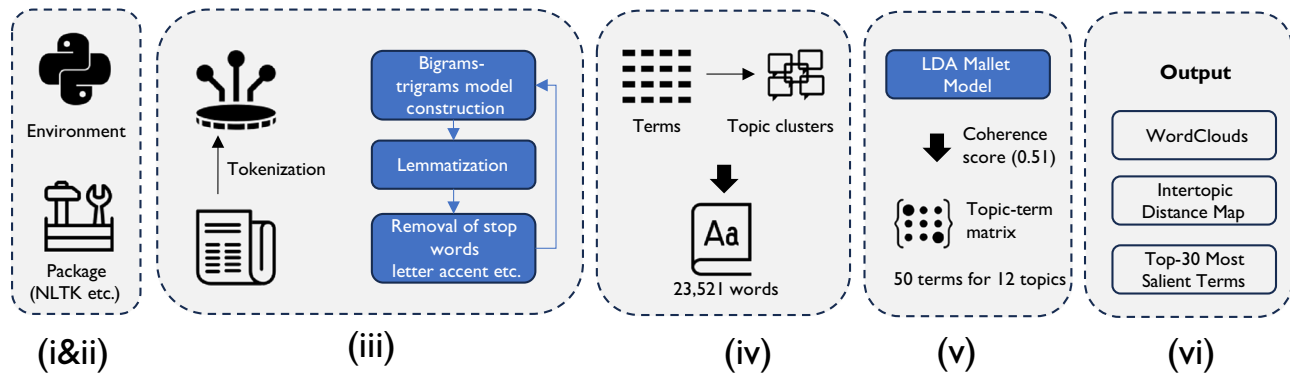
Expanding on the benefits of LDA, Lore et al. (2024) argued that combining human expertise with automated deep learning models can improve accuracy without sacrificing scalability in urban planning research. They emphasise using LDA alongside count vectors to identify topic distributions across large text datasets, showcasing its utility in diverse urban contexts. Recent applications namely Kwon and Nguyen (2024) utilised LDA with qualitative text coding to investigate racial equity in urban planning literature, revealing a significant underrepresentation of this theme in high-impact journals, as well as Sanchez et al. (2024) applied LDA and ChatGPT to analyse artificial intelligence (AI)'s role in urban planning, identifying 16 key themes, including urban design, transportation, and smart cities.

The integration of machine learning in urban studies, particularly through topic modelling, has proven to be a valuable tool for identifying thematic clusters and shifts in planning research, enabling scholars to navigate the vast and interdisciplinary landscape of urban planning.

## Data and methods

This research aims to explore the evolution of research themes in urban studies and planning over more than three decades, from 1991 to 2021. The 1991–2021 timeframe reflects both practical and theoretical considerations. The start date represents when comprehensive abstract data became consistently available in WoS for our journal selection, ensuring analytical consistency across the dataset. The endpoint provides a natural conclusion before the COVID-19 pandemic's substantial disruption to academic publishing patterns, which would introduce confounding variables into our longitudinal analysis.

The analysis is segmented into six distinct time periods: 1991 to 2000 (10 years), 2001 to 2005 (5 years), 2006 to 2010 (5 years), 2011 to 2015 (5 years), 2016 to 2018 (3 years), and 2019 to 2021 (3 years). This segmentation strategy balances analytical granularity with statistical robustness across changing publication volumes. The varying durations reflect the field's publication growth trajectory: the initial 10-year period corresponds to limited publication volumes in early digital databases requiring longer intervals for meaningful analysis, subsequent 5-year intervals capture the field's steady expansion phase, whilst final 3-year intervals reflect exponential growth in publications enabling finer temporal granularity whilst maintaining statistical



**Fig. 1 Systematic process of developing the LDA model.** This figure outlines the systematic process of developing the LDA model, detailing steps from data preprocessing to topic identification for analysing 44,147 articles in urban studies and planning research.

significance within each interval. This approach follows established bibliometric practice of adjusting temporal windows to publication density rather than maintaining uniform intervals that might obscure important patterns in rapidly evolving fields.

For a focused and relevant analysis, a list of urban-themed journals was carefully compiled. Selection was based on the categories of 'Urban Studies & Planning' as indexed in Google Scholar (GS) and 'Urban Studies' and 'Regional & Urban Planning' as categorised in Journal Citation Reports (JCR). The most influential 30 journals were identified using JCR impact factors and GS h5-indexes. This scoping review approach taken in this study builds on the need, discussed in the literature, to expand the scope of analysis from a limited number of journals to a larger and more comprehensive dataset. For example, Fang and Ewing (2020) examined trends in urban studies research but focused on only three North American journals, potentially limiting the breadth of their findings. Similarly, while Sanchez (2020) provided broader coverage by analysing more than 30 journals and incorporating full-text data, our analysis narrows down to the top 30 leading journals in the field and uses attributes data such as abstracts, titles, journals, and author keywords to provide a more focused and detailed examination.

These journals were selected based on their influence and high impact factor in the field, as indexed by GS and JCR. This selection ensures that the study focuses on the most impactful and widely recognised outputs in urban studies and planning research. Future studies could expand the dataset to include non-English journals and examine regional diversity more comprehensively, providing a broader representation of research trends in the field.

Based on the identified journal list, a total of 46,640 records were initially collected from the WoS Core Collection database, a well-regarded source for high-quality and comprehensive bibliometric data. After a meticulous cleansing process to ensure data quality and relevance, 44,147 records were retained, including attributes such as abstracts, titles, journals, and author keywords to examine the evolution of research themes. This approach enables us to reveal more nuanced insights into the changing themes and trends of the urban studies and planning research field over the past three decades and ensures that the study encompasses leading scholarly outputs, thereby providing a comprehensive view of the field's academic impact and evolution.

This research utilised LDA, a probabilistic model for uncovering latent topic structures in text data, following a systematic process illustrated in Fig. 1. The key steps involved (i) setting up the Python environment; (ii) importing required packages, especially the NLTK for stopwords; (iii) the dataset's articles were processed using bigram, trigram models and lemmatisation techniques with Gensim and SpaCy; (iv) Stopwords, short tokens,

and letter accents were removed for improved accuracy, and a dictionary was constructed to monitor term frequency, which resulted in a refined dictionary with 23,521 words; (v) using this, an LDA Mallet-based topic model was created (Supplementary Material C), achieving a coherence score of 0.51, exceeding the acceptance benchmark of 0.45; and (vi) WordClouds were generated to visually represent the weight of topic terms, and further visual interpretations were conducted using Python, including the Intertopic Distance Map and Top-50 Most Salient Terms (see Table C2 in Supplementary Material). The detailed methodology, including model settings, preprocessing steps, and visualisation techniques, is provided in Supplementary Material (Appendix A) to ensure full transparency and reproducibility. It is important to note that the topic order does not signify their importance in the dataset but rather reflects the statistical structure of the results.

## Results

This section presents empirical findings from our analysis of 44,147 articles from 30 leading urban studies and planning journals spanning 1991–2021, utilising bibliometric indicators and LDA topic modelling to examine research theme evolution and interdisciplinary patterns.

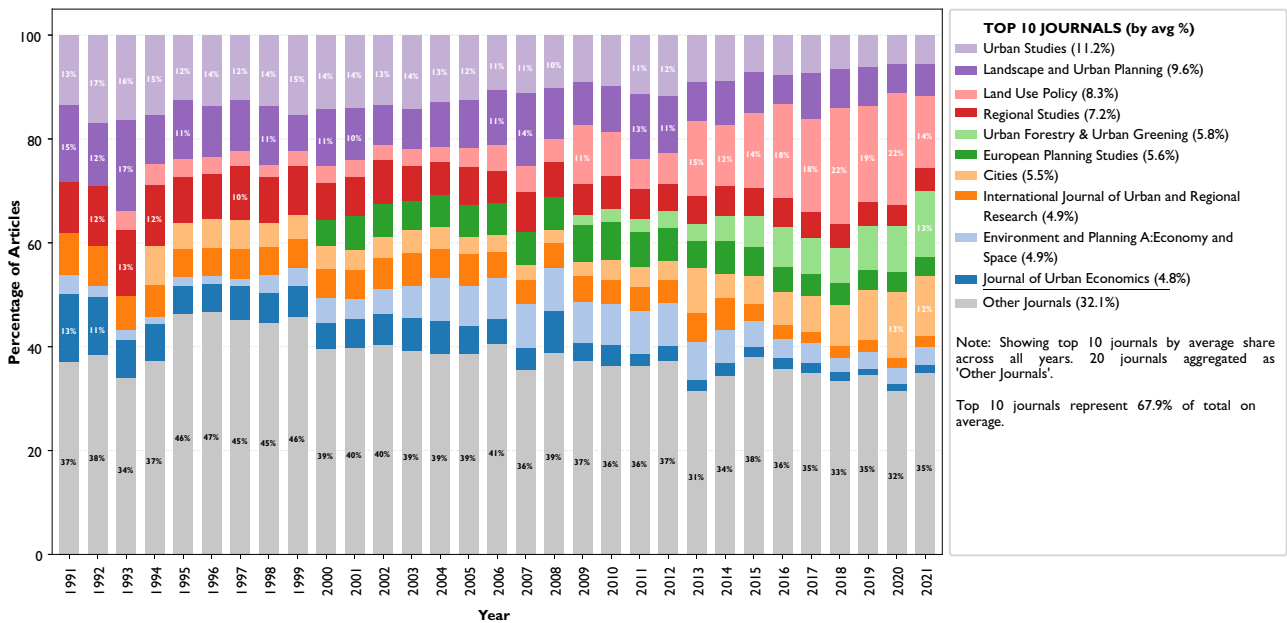
**Bibliometric overview and journal distribution.** Analysis reveals a significant growth in scholarly output within urban studies and planning as shown in Table 1. Key metrics demonstrate consistent increases, reflecting the expanding scope of this research field. Publications grew from 403 in 1991 to 3210 in 2021, representing an eightfold increase. The average number of authors per paper doubled from 1.6 to 3.2, indicating more collaborative and interdisciplinary research efforts (Cai et al., 2023). The number of references per article grew from 28 in 1991 to 64 in 2021, pointing to deeper engagement with existing literature.

Figure 2 illustrates distribution shifts across journals. *Urban Studies* has consistently been the single largest outlet by average share across 1991–2021, though its share has gradually declined since the early 1990s as the field diversified. *Landscape and Urban Planning* maintained a strong presence from the late 1990s onward, but its relative share has also decreased in recent years. *Land Use Policy* increased markedly after 2010 and has been a leading journal since 2013. *Regional Studies* was a dominant contributor from the 1990s, but both experienced proportional decline after 2010, reflecting the rise of alternative publication venues. *European Planning Studies* became more prominent from the 2000s, then moderated after 2010. In contrast, *Urban Forestry & Urban Greening* expanded rapidly, especially after 2016, mirroring the growing prominence of sustainability and green space research. *Cities* showed a brief uptick around 2013, a

**Table 1 Major bibliometric indicators for urban studies and planning research, 1991–2021.**

PY	TP	AU	AU/TP	NR	NR/TP	TC	TC/TP
1991	403	636	1.6	11,248	27.9	8656	21.5
1992	432	643	1.5	12,758	29.5	11,555	26.7
1993	563	887	1.6	16,372	29.1	12,042	21.4
1994	541	828	1.5	18,178	33.6	13,243	24.5
1995	674	1084	1.6	21,826	32.4	17,852	26.5
1996	680	1107	1.6	23,951	35.2	23,029	33.9
1997	720	1160	1.6	26,881	37.3	23,778	33.0
1998	797	1394	1.7	28,932	36.3	25,395	31.9
1999	785	1297	1.7	28,741	36.6	34,083	43.4
2000	871	1520	1.7	33,229	38.2	39,696	45.6
2001	874	1513	1.7	35,458	40.6	38,267	43.8
2002	927	1612	1.7	36274	39.1	46,477	50.1
2003	897	1670	1.9	39,247	43.8	47,919	53.4
2004	959	1757	1.8	42,418	44.2	51,412	53.6
2005	954	1877	2.0	42,801	44.9	53,369	55.9
2006	1103	2182	2.0	49,607	45.0	60,265	54.6
2007	1114	2318	2.1	53,288	47.8	58,632	52.6
2008	1149	2355	2.0	56,407	49.1	54,183	47.2
2009	1350	2950	2.2	68,183	50.5	64,076	47.5
2010	1385	3046	2.2	70,694	51.0	66,921	48.3
2011	1485	3437	2.3	76,121	51.3	58,156	39.2
2012	1568	3740	2.4	83,281	53.1	59,683	38.1
2013	2030	4912	2.4	108,004	53.2	66,544	32.8
2014	2074	5210	2.5	111,092	53.6	69,100	33.3
2015	2262	6032	2.7	123,816	54.7	71,614	31.7
2016	2420	6434	2.7	133,438	55.1	60,106	24.8
2017	2685	7758	2.9	155,175	57.8	62,239	23.2
2018	2909	8782	3.0	172,058	59.1	55,352	19.0
2019	3096	9485	3.1	188,744	61.0	43,850	14.2
2020	3230	10,163	3.1	201,049	62.2	32,312	10.0
2021	3210	10,285	3.2	205,699	64.1	15,163	4.7
Average	1424	3486	2	73,386	46	43,386	35
Total	44,147	108,074	-	2,274,970	-	1,344,969	-

Key trends include eightfold growth in publications (403 to 3,210), doubling of collaborative authorship (1.6 to 3.2 authors per paper), and increased engagement with existing literature (28 to 64 references per article), reflecting the field's expansion and growing interdisciplinary collaboration. PY publication year, TP total publication, AU number of authors, NR number of cited references, TC total citation count.



**Fig. 2 Percentage distribution of articles across journals over time (1991–2021).** This figure shows the percentage distribution of 44,147 articles across 30 urban studies and planning journals from 1991 to 2021, highlighting shifts in journal influence.



‘spatial’, ‘level’, ‘factor’, and ‘employment’. This topic features traditional spatial econometric approaches examining basic neighbourhood effects, spatial spillovers, and locational determinants.

- *T7: Landscape and forestry* (8.6%) addresses urban green-space, ecological systems, and landscape management through terms including ‘landscape’, ‘forest’, ‘tree’, ‘green’, and ‘park’. This topic has gained significant prominence, reflecting increasing environmental awareness and the integration of nature-based solutions into urban planning practice.
- *T8: Environmental management* (8.4%) encompasses broader environmental sustainability concerns, climate change adaptation, and ecological planning approaches. Prominent terms include ‘environmental’, ‘management’, ‘change’, ‘water’, and ‘climate’, representing the field’s response to global environmental challenges and the mainstreaming of sustainability considerations.
- *T9: Urban-rural development* (6.2%) bridges urban and rural planning concerns through territorial development approaches, featuring terms ‘development’, ‘growth’, ‘rural’, and ‘economic’. This topic serves as a crucial connector between traditionally separate research domains, addressing peri-urban development, land-use transitions, and territorial governance challenges.
- *T10: Neighbourhood planning* (8.2%) focuses on local-scale planning processes, community development, and participatory governance, characterised by ‘social’, ‘residential’, ‘household’, and ‘neighbourhood’. This topic reflects planning’s increasingly participatory and community-focused approaches, emphasising bottom-up planning processes and local empowerment.
- *T11: Public space and urban design* (5.2%) addresses the design, management, and social functions of urban public spaces through terms including ‘public’, ‘place’, ‘design’, and ‘building’. The relatively lower prominence reflects this topic’s practice-oriented nature, where professionals often prioritise project implementation over academic publication.
- *T12: Planning policy and community governance* (10.6%) encompasses planning institutions, policy processes, governance mechanisms, and institutional frameworks, characterised by ‘policy’, ‘local’, ‘community’, and ‘government’. This topic captures the regulatory, institutional, and procedural dimensions of urban planning practice and policy implementation.

Four dominant topics (T3, T4, T12, T2) each account for over 10% of research output, suggesting core thematic areas that have sustained scholarly attention across three decades.

**Topics distribution over time.** Temporal analysis reveals significant shifts in research priorities (Fig. 4). ‘T3: Socio-political geography’ maintained strong presence throughout, peaking during 2011–15 and 2019–21. ‘T4: Housing and property market’ experienced fluctuations whilst maintaining relevance, dropping from top rank to rank 6 by 2019–21.

‘T7: Landscape and forestry’ and ‘T8: Environmental management’ showed remarkable growth, rising from ranks 9 and 11 (1991–2000) to ranks 2 and 3 (2019–2021). This dramatic ascent reflects environmental concerns’ integration into mainstream planning discourse. ‘T6: Spatial spillovers and locational effects’ declined notably from top 5 to rank 11, indicating shifts from conventional spatial analyses toward more sophisticated approaches captured in ‘T1: Spatial analysis and modelling’.

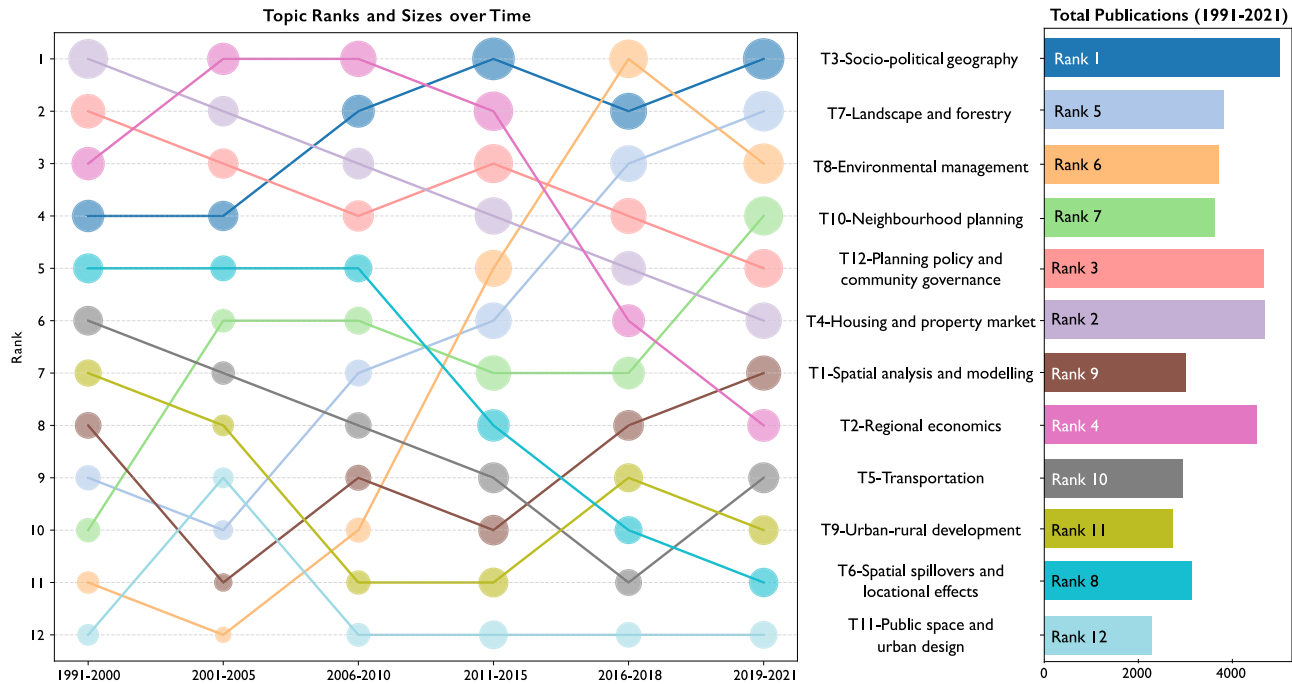
‘T10: Neighbourhood planning’ improved from rank 10 to rank 6 in the early 2000s and then rose further to rank 4 in 2019–2021, reflecting planning’s increasing emphasis on participatory governance. The complete temporal ranking changes across six intervals are detailed in Supplementary Material Table D2.

**Authorship and citation patterns.** Analysis of authorship and citation metrics reveals topic-specific collaboration and impact patterns across the 30-year study period (Table 2). Topics such as ‘T7: Landscape and forestry’ and ‘T8: Environmental management’ demonstrated higher authorship averages, with T7 expanding from 2.0 to 4.4 authors per publication, reflecting diverse expertise requirements for addressing environmental challenges. Conversely, the popular topic, ‘T3: Socio-political geography’ maintaining the lowest authorship average throughout, with fewer than 2.0 authors per publication, consistent with qualitative research traditions and single-author scholarly practices common in critical geography and political theory.

Citation impact patterns reflect both topic-specific influence and the natural citation life cycle, where publications from earlier periods have had more time to accumulate citations but mid-period works often peak before later decline. ‘T7: Landscape and forestry’ consistently shows relatively high citation counts, indicating strong and enduring influence in the field. Meanwhile, the drop in citations for ‘T1: Spatial analysis and modelling’ and ‘T2: Regional economics’ showed strong citation levels up to the mid-2000s, after which their influence diminished. This decline may reflect changes in academic or policy priorities, technological advancements that alter research methods, or a natural evolution of the fields that may have moved interest towards more contemporary issues such as climate change or urban resilience. The increased attention on ‘T8: Environmental management’ and ‘T9: Urban-rural development’ between 2006 and 2010 reflects a growing recognition of the importance of these areas, further supported by citation trends. Supplementary Material Tables D6–D8 provide detailed citation and journal analysis.

**Co-occurrence networks between topics.** Network analysis reveals complex interdisciplinary exchange patterns (Fig. 5). Using the Louvain Community Detection method (methodology detailed in Supplementary Material Appendix E), three primary clusters emerged, centred on socio-political/governance community, comprising socio-political geography (T3), planning policy and community governance (T12), and environmental management (T8). Analysis revealed three key patterns:

- (1) *Asymmetric knowledge flow:* ‘T3: Socio-political geography’ and ‘T11: Public space and urban design’ share 166 authors with notable asymmetry. Authors primarily in T3 are 2.0 times more likely to publish in T11 than vice versa. This suggests socio-political insights more strongly influence public space and urban design than the reverse. Supplementary Material Fig. E2 provided detailed heatmap diagrams showing the temporal evolution of the detailed normalised bilateral co-occurrence pattern between topics.
- (2) *Unexpected bridge topics:* Contrary to expectations that environmental management might bridge clusters, ‘T9: Urban-rural development’ demonstrates the highest cross-topic engagement at 54.2% of authors publishing across multiple topics. This reveals T9’s crucial role integrating diverse research domains, particularly connecting environmental concerns with socio-economic issues.
- (3) *Evolution of methodological integration:* ‘T1: Spatial analysis and modelling’ increasingly serves as methodological



**Fig. 4 Research topic rank changes over time (1991–2021).** This figure tracks the ranking changes of 12 research topics from 1991 to 2021, showing the rise of environmental management and decline of spatial effect.

**Table 2 Authorship intensity and citation impact patterns by research topic across temporal intervals, 1991–2021.**

	1991-2000		2001-2005		2006-2010		2011-2015		2016-2018		2019-2021	
Topic	Auth/P	Cite/P	Auth/P	Cite/P	Auth/P	Cite/P	Auth/P	Cite/P	Auth/P	Cite/P	Auth/P	Cite/P
T1	1.76	25.49	2.14	60.89	2.72	48.32	3.26	42.53	3.56	25.40	3.72	10.84
T2	1.64	40.20	1.75	59.40	1.94	39.50	2.20	32.74	2.50	19.99	2.72	9.29
T3	1.33	36.18	1.40	56.48	1.55	56.84	1.63	35.81	1.83	22.37	1.97	9.68
T4	1.65	24.67	1.86	32.86	1.93	37.92	2.17	24.52	2.32	17.43	2.49	7.43
T5	1.69	30.27	1.95	46.88	2.10	51.34	2.58	31.34	2.85	20.25	3.18	9.13
T6	1.68	42.81	1.83	41.91	2.01	44.15	2.20	22.61	2.42	15.80	2.51	6.98
T7	<u>2.02</u>	<u>39.82</u>	<u>2.59</u>	<u>74.14</u>	<u>3.03</u>	<u>70.68</u>	<u>3.55</u>	<u>47.53</u>	<u>4.10</u>	<u>27.25</u>	<u>4.40</u>	9.94
T8	1.87	27.71	2.52	53.95	2.58	60.92	3.29	39.63	3.72	24.00	4.02	12.09
T9	1.54	32.88	1.84	61.34	2.25	66.66	2.58	46.95	2.86	<u>30.48</u>	3.28	<u>13.19</u>
T10	1.65	36.98	1.93	64.36	2.21	57.99	2.43	34.61	2.86	<u>25.17</u>	3.24	<u>9.81</u>
T11	1.45	31.08	1.51	54.84	1.79	47.10	2.00	29.46	2.35	16.90	2.80	7.83
T12	1.53	25.77	1.70	38.86	1.85	35.93	2.28	28.73	2.52	18.01	2.85	7.68

This table illustrates variation in collaborative practices (measured by authors per publication) and scholarly impact (measured by citations per publication) across 12 topics, revealing environmental topics' higher collaborative requirements and shifting citation patterns reflecting evolving research priorities and methodological transitions. Note: Auth/P = authors per publication; Cite/P = citations per publication. The highest value in each column is blue and underlined.

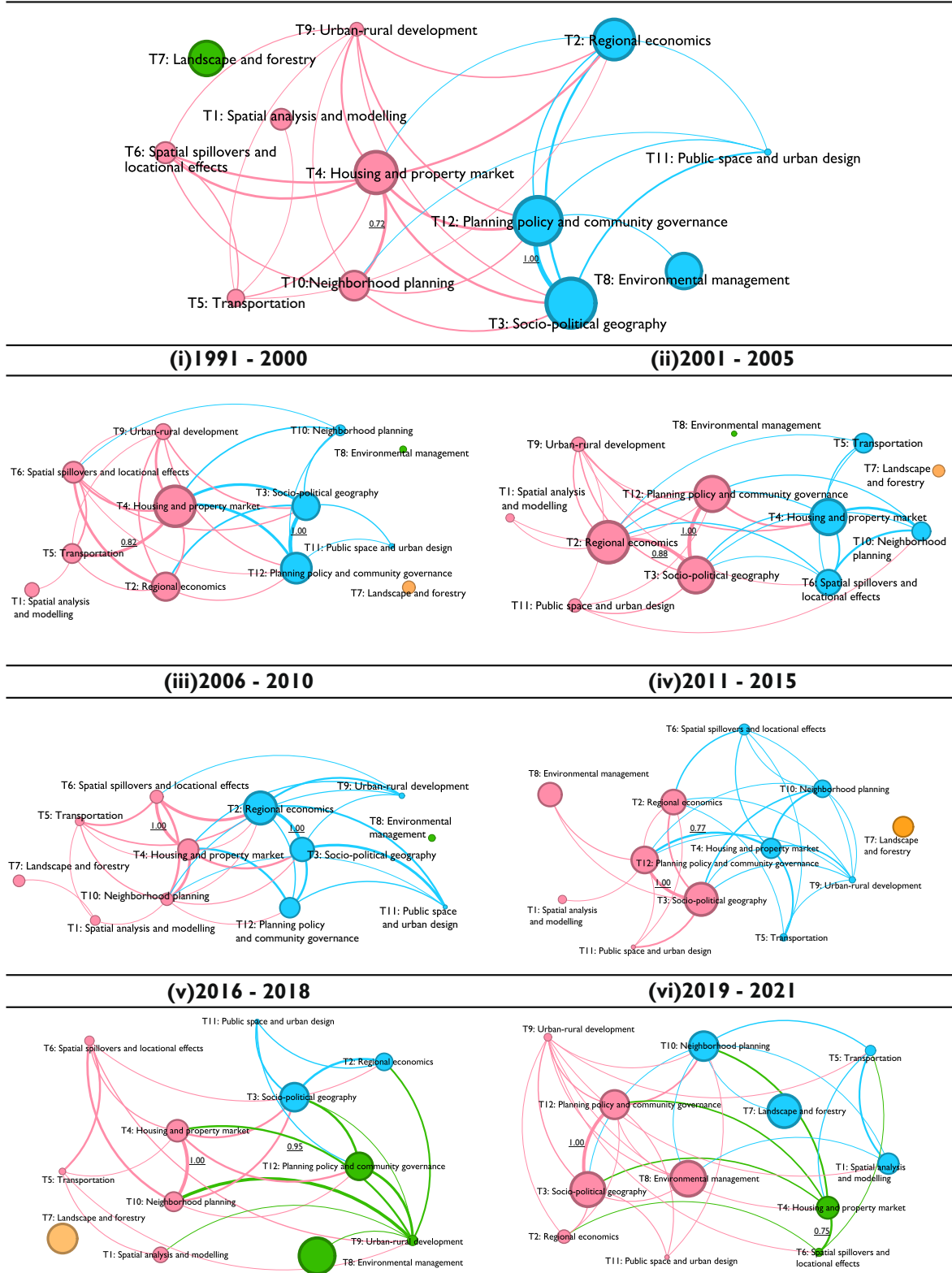
bridge, with connections to other topics growing significantly since 2016. Notable links emerge with transportation (T5, 4.6% overlap) and environmental management (T8, 3.2% overlap), suggesting spatial analysis enables integration across traditionally distinct domains.

The environmental cluster initially maintained limited exchange (11.6% cumulative cross-topic connections during 1991–2000) but developed substantial connections through T9 since 2016. Direct T8-T9 linkages increased approximately twofold (from 1.7% in 1991–2000 to 3.1% in 2019–2021), contributing to overall cross-topic connections rising to 15% by 2021. Supplementary Material Fig. E3 provides detailed Sankey diagrams showing temporal evolution of these network patterns.

**Emerging research frontiers.** Term frequency analysis across topic clusters reveals emerging directions (Supplementary Material Figs. E4–E7 show comprehensive word frequency analysis). Environmental integration appears as dominant trend, with 'urban green', 'green space', and 'ecosystem services' appearing across multiple clusters including T7, T10, T1, and T5. This indicates environmental sustainability's integration into mainstream planning rather than remaining specialised.

Climate change and policy integration emerges through 'policy' and 'climate change' prominence within T3 and T8, suggesting recognition that climate challenges require institutional innovation beyond technical solutions. The temporal evolution shows increasing frequency of terms related to participatory planning, computational methods, and nature-based solutions, indicating

Overall: 1991 - 2021



**Fig. 5 Co-occurrence networks mapping of the topics (1991-2021).** This figure maps co-occurrence networks of 12 topics, revealing urban-rural development's bridging role (54.2% engagement) from 1991 to 2021.

the field's methodological sophistication and environmental integration.

The integration of AI and advanced computational methods in urban planning represents another significant research frontier, though this may be underestimated in our metadata-based analysis as such technologies are often embedded within broader methodological approaches captured in 'T1: Spatial analysis and modelling'. The growing sophistication of computational approaches suggests that AI applications are increasingly shaping both research methodologies and practical approaches to urban challenges, warranting focused investigation within the analytical frameworks our topic analysis has identified, echoing Peng et al. (2024), Sanchez et al. (2024), and Choi and Zhang (2024).

## Discussions

Our empirical analysis reveals three fundamental mechanisms through which interdisciplinary knowledge integration occurs in urban studies scholarship, advancing theoretical understanding of how academic fields evolve to address complex societal challenges whilst providing practical insights for fostering cross-disciplinary collaboration.

**Theoretical implications of knowledge integration mechanisms.** The identification of three distinct interdisciplinary mechanisms challenges conventional assumptions about knowledge exchange in academic fields. Our finding of *asymmetric knowledge flow* between socio-political geography and planning policy provides empirical evidence for Klein's (1990) conceptualisation of 'directional synthesis', where critical geographical theory serves as a knowledge producer whilst planning practice functions primarily as knowledge application. This hierarchical relationship suggests that interdisciplinary collaboration does not operate through equal exchange but rather through specific directional pathways that reflect disciplinary power structures and theoretical foundations.

The *unexpected bridging role* of urban-rural development fundamentally challenges assumptions about thematic similarity driving interdisciplinary synthesis. Rather than environmental management serving as the primary bridge between social and technical domains, territorial development facilitates the highest cross-topic engagement through spatial continuity, scalar integration, and temporal bridging mechanisms. This finding supports Camagni's (1998) territorial approach to sustainable development, suggesting that spatial relationships, rather than thematic content, drive interdisciplinary synthesis. The bridging function operates by spanning traditional analytical boundaries between urban and regional studies, requiring methodological integration across multiple spatial scales and connecting historical urbanisation processes with contemporary sustainability challenges.

The *evolution of methodological integration* through spatial analysis represents the emergence of computational methods (e.g. spatial behavioural analytics and modelling) as enabling technologies for interdisciplinary collaboration. Advanced analytical methods serve as interdisciplinary methodological commons, providing shared languages that enable researchers from different theoretical backgrounds to collaborate around quantitative approaches. This reflects broader developments in computational social science and urban big data availability, where technical sophistication becomes a vehicle for transcending disciplinary boundaries.

These mechanisms operate simultaneously to create knowledge exchange patterns that transcend simple disciplinary boundaries, providing empirical grounding for theoretical discussions about interdisciplinarity whilst demonstrating that knowledge

integration occurs through multiple pathways rather than uniform processes.

**Environmental integration and contemporary planning paradigms.** The dramatic rise of landscape/forestry and environmental management topics from peripheral (ranks 9–11 in 1991–2000) to central positions (ranks 2–3 in 2019–2021) represents more than topical expansion; it indicates fundamental restructuring of planning theory and practice. Environmental considerations have achieved paradigmatic status within planning, moving from external constraints to foundational principles that alter how planners approach problems across all domains.

This paradigm shift provides empirical validation for contemporary planning concepts gaining international traction. The integration of neighbourhood planning (T10) with environmental management (T8) offers data-driven evidence supporting the 15-min city concept, which requires precisely this synthesis of local-scale accessibility with environmental considerations. The consistent appearance of terms such as 'urban green', 'green space', and 'ecosystem services' across multiple clusters—including spatial analysis (T1), transportation (T5), and neighbourhood planning (T10)—demonstrates that environmental sustainability has transcended specialised domains to become integral to mainstream planning practice.

Similarly, the increasing interconnection between spatial analysis tools and environmental topics supports Nature-based Solutions approaches, which depend on sophisticated spatial modelling to optimise ecological interventions in urban contexts. Our finding that urban-rural development (T9) serves as the primary interdisciplinary bridge provides quantitative support for territorial approaches within frameworks such as the European Green Deal, recognising that sustainable urban development requires integrated governance spanning metropolitan regions rather than confined administrative boundaries.

The prominence of 'policy' and 'climate change' related terms within socio-political geography (T3) and environmental management (T8) suggests recognition that climate challenges require institutional innovation beyond technical solutions. This evolution reflects planning's response to global environmental challenges and the mainstreaming of sustainability considerations, indicating a field-wide transformation rather than merely adding environmental topics to existing frameworks.

For policy implementation, these patterns suggest that effective climate adaptation strategies must integrate across spatial scales and disciplinary domains, echoing the emergence of urban systems science (see, e.g. Xu et al. 2025, Yang and Zhang 2025). The prominence of cross-topic engagement (54.2% in urban-rural development) indicates that successful contemporary planning requires collaborative frameworks spanning multiple expertise areas rather than siloed approaches.

**Practical pathways and institutional barriers to interdisciplinary collaboration.** Our analysis reveals specific mechanisms enabling interdisciplinary collaboration alongside persistent structural barriers limiting cross-disciplinary knowledge production.

*Collaboration pathways in practice.* The doubling of average authors per publication from 1.6 to 3.2 demonstrates expanding collaborative networks, but growth varies significantly across topics. Environmental topics require diverse expertise ('T7: Landscape and forestry' expanding from 2.0 to 4.5 authors), whilst socio-political geography maintains lower collaborative

intensity (1.5 authors), reflecting qualitative methodological traditions.

Urban-rural development's exceptional bridging capacity (54.2% cross-topic engagement) operates through territorial governance requirements necessitating expertise spanning multiple domains, scalar integration demanding both local and metropolitan coordination, and temporal complexity connecting historical patterns with future sustainability planning. These multi-dimensional requirements create natural collaboration incentives transcending disciplinary boundaries.

Spatial analysis tools serve as methodological facilitators, enabling researchers from different backgrounds to collaborate around shared analytical frameworks. The threefold increase in connections between spatial analysis and environmental topics since 2016 reflects practical utility: environmental researchers gain analytical capabilities whilst spatial analysts access application domains.

*Institutional barriers and systemic constraints.* Fundamental structural barriers persist despite growing collaborative activity (Siedlok and Hibbert, 2014). Disciplinary funding mechanisms favour single-department applications, creating financial disincentives for interdisciplinary research. University promotion criteria emphasise disciplinary recognition over interdisciplinary impact, discouraging cross-disciplinary work (Shanableh et al., 2022). Journal publication systems reinforce boundaries through specialist review processes, creating publication challenges for synthetic knowledge that may not fit established editorial categories.

The concentration on English-language and Western journals reveals broader inclusivity limitations. Interdisciplinary collaboration mechanisms may operate differently across institutional contexts and linguistic communities, suggesting that global interdisciplinary dialogue requires more inclusive knowledge production systems incorporating diverse theoretical traditions.

*Fostering effective collaboration.* Effective interdisciplinary collaboration requires institutional reforms addressing these barriers. Universities could implement cross-departmental funding pools, create interdisciplinary promotion pathways, and develop collaborative spaces facilitating sustained interaction. The success of urban-rural development in bridging diverse domains suggests that effective interdisciplinarity emerges around shared practical challenges rather than abstract commitments, implying that fostering collaboration requires creating contexts where problem-solving necessitates cross-disciplinary engagement.

**Study limitations and methodological constraints.** Our analysis faces several methodological and scope limitations that inform interpretation of findings. The reliance on abstracts, titles, and keywords rather than full-text analysis may underestimate interdisciplinary integration occurring within detailed methodological discussions. Our focus on 30 leading journals, whilst providing quality control, potentially excludes relevant research published in regional, practitioner-oriented, or emerging digital venues.

The dataset's concentration on English-language and predominantly Western journals limits global representation of urban studies scholarship, potentially missing important theoretical developments from the Global South or non-English speaking research communities. The temporal endpoint of 2021 excludes recent developments, particularly post-COVID urban research and rapidly evolving applications of AI in planning (Meng et al., 2026; Sanchez et al., 2024; Sharifi et al., 2023; Zhou et al., 2026).

LDA methodology introduces specific constraints including random initialisation variability and subjective interpretation in topic labelling. While our systematic validation process addresses some concerns, alternative computational approaches might reveal different thematic structures. The gap between academic research focus and professional planning practice suggests our findings may not fully represent applied knowledge development in the field.

## Conclusion

This analysis of 44,147 articles across 30 leading journals (1991–2021) reveals significant emerging trends and interdisciplinary mechanisms transforming urban studies and planning research.

Emerging trends demonstrate paradigmatic shifts within the field. Environmental topics (i.e. landscape/forestry and environmental management) ascended dramatically from peripheral positions (ranks 9–11 in 1991–2000) to central prominence (ranks 2–3 in 2019–2021), indicating sustainability's transformation from external constraint to foundational planning principle. Neighbourhood planning gained prominence whilst traditional spatial econometric approaches declined, reflecting the field's evolution toward participatory governance and methodological sophistication. Collaborative intensity doubled from 1.6 to 3.2 authors per publication, with environmental topics requiring particularly diverse expertise.

Three interdisciplinary mechanisms drive knowledge integration across domains. Asymmetric knowledge flow demonstrates that socio-political geography influences planning policy 2.3 times more than reciprocally, challenging assumptions about equal disciplinary exchange. Urban-rural development's unexpected role as primary bridge topic (54.2% cross-topic engagement) reveals that spatial continuity, not thematic similarity, drives interdisciplinary synthesis. The emergence of spatial analysis as methodological bridge shows how computational tools enable collaboration across traditionally distinct domains.<sup>1</sup>

These patterns provide empirical validation for contemporary planning paradigms. The integration of neighbourhood planning with environmental management supports 15-min city concepts, whilst urban-rural development's bridging function validates territorial approaches within frameworks such as the European Green Deal.

Future research directions emerge from these interdisciplinary patterns. The consistent emphasis on environmental sustainability across multiple topic clusters suggests promising avenues for investigating how ecological considerations are reshaping planning methodologies beyond traditional environmental planning domains. The prominence of climate change and policy integration terms indicates growing research potential in developing resilient institutional frameworks capable of responding to environmental challenges whilst addressing social equity concerns. The territorial bridging function of urban-rural development, combined with increasing methodological sophistication, suggests potential for investigating how planning innovations emerge and diffuse across different spatial contexts through the interdisciplinary networks our analysis reveals.<sup>2</sup>

The study advances interdisciplinary theory by revealing concrete mechanisms through which disciplinary boundaries dissolve around shared practical challenges. Urban studies emerges as a model for interdisciplinary scholarship, demonstrating how computational methods and collaborative networks enable knowledge synthesis addressing complex societal problems. The analytical framework developed offers replicable methodology for

examining interdisciplinary evolution across academic fields confronting global challenges including climate adaptation and sustainable development.

### Data availability

The datasets generated and/or analysed during the current study are available in the Figshare repository, <https://doi.org/10.6084/m9.figshare.30880133>.

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### Notes

- 1 Fig. 3 – The number in parentheses represents the contribution of each topic to the entire landscape of urban studies and planning by publication number.
- 2 Fig. 5 – (1) The nodes (representing topics) have been organised into groups and coloured using the Louvain Community Detection method based on their closeness; (2) Size of the nodes indicates the number of authors associated with each topic. Note that this sizing does not serve as a measure of the topic's significance over time. Instead, it helps us to understand the relationships and closeness of topics; (3) The links between nodes are filtered, only those top 50% (33) were showed to avoid overly complexity; and (4) Heatmaps and Sankey in Supplementary Material (Fig. E1 – E3) specified a more detailed changes of the topic trend.

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### Author contributions

Research design: SH and TY. Data collection and analysis: SH and WD. Visualisation: SH and WD. Network analysis: WD and TY. Writing and editing: SH, WD, and TY. Research supervision and validation: TY.

### Competing interests

TY is an Editorial Board Member of this journal. The authors declare no conflicts of interest related to the research article.

### Ethical approval

The ethics approval was not obtained/applicable because the study does not involve human participants or their data.

**Informed consent**

Informed consent was not obtained/applicable because the study does not involve human participants or their data.

**Additional information**

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