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The landscape and evolution of urban planning science

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ABSTRACT

The science of urban planning has drawn on a wide range of disciplines and research perspectives. This makes it challenging to define the boundaries and directions of the field. Here, nearly 100,000 articles on urban planning are analysed to objectively determine divisions, temporal trends and influential references and actors of urban planning. In terms of the structural composition, four broad divisions are identified: (1) governance and policy, (2) economics and markets, (3) housing and (4) built and natural environment. In terms of the temporal evolution, the earliest trends were related to "welfare economics", "agglomeration economies", "urban economics", and "urban growth machine". During the 1980s and 1990s, the focus moved towards "regional policy and development", "social welfare", and "urban renaissance". This trend continued during the 2000s and 2010s, heading to "urban morphology", "participatory planning", "urban sociology", "global cities", and "political economy". The field has recently headed towards areas of "resilience", "smart cities" and "urban green space". These transitions have been derivative, and the paradigm shifts have been very gradual. Another key observation is a notable increase in author connectivity and international collaboration. The results provide objective insights into how the science of urban planning has historically transitioned and where it is headed.

1. Introduction

Urban planning, also referred to as town planning, city planning, regional planning or rural planning, is a political and technical profession that is involved with planning, regulating and managing the economic, social, and environmental significances of defined spatial boundaries (e.g., metropolitan area, cities, towns and rural areas) and the distribution of resources within it. Hippodamus, the Greek philosopher in the 5th century BCE, has been named the "father of city planning" and the pioneer of urban planning (Aristotle, Book 2, section 1267b). Despite discovering early evidence of urban planning in several ancient cities such as Egypt, China, India, and the Mediterranean world, it only appeared as a scholarly discipline in the 1900s. The first academic program on urban planning commenced at the University of Liverpool in 1909, and in 1924 it was taught at Harvard University (Fainstein, 2021). Conventionally, urban planning has been considered a top-down approach, however, over time urban planning has been focusing on social and environmental issues to help improve quality of life and wellbeing following a sustainability framework.

Urban planning is a multi-disciplinary technical profession, an endeavour that aims to create better places and public spaces for people by balancing the built and natural environment. Urban planners address community needs, respect cultural significance and consider sustainable prosperity of urban and regional areas. Urban planning theories and professional conduct have been evolving from a mixture of physical surveys, design, mapping, and infrastructure engineering to consider broader social, environmental and economic issues ((Taylor, 1998), (Frenchman, 2017)).

The evolution of urban planning theory and practice has been studied in different jurisdictions worldwide. In his seminal book "*Urban*

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Planning Theory Since 1945" (Taylor, 1998) highlighted the paradigm shifts in urban planning theory in Britain. The book outlines that the initial production of urban planning was "master" plans or "blueprints", demonstrating the land uses and urban forms and their spatial configurations. Moreover, Frenchman (2017) established that urban planning in the United States evolved from surveying engineering and real estate development activities mixed with civil engineering skills to address challenges about transportation and other infrastructure developments.

During the late 20th and early 21st century, the modern and post-modern schools of thought changed the landscape of urban planning theories, research and practice. However, in the last two to three decades, the body of knowledge emphasised greater diversification in the urban planning domain. The underpinning reasons for the recent divisions in urban planning research and practice are associated with political transformations, climate change, rapid urbanisation, and technological developments. New urban paradigms including smart growth, compact city, just city, resilient city, and smart city are some examples. However, little is known about the trend of change in urban planning research and practice during the time. Furthermore, most of the past and current literature used subjective methods to map out the changing patterns of urban planning research. It is also unclear which divisions remained alive, which ones disappeared or shrank, and which areas of urban planning research and practice are emerging.

This study aims to objectively determine divisions of urban planning research and the topics within each division. Furthermore, this study seeks to determine the temporal variations in research activities on major topics and establish fundamental references within major topics based on a multitude of indicators.

In addition to these objectives, this study looks into the patterns of production of urban planning research across various geographical regions as well as the variation of this geographical distribution over time. Moreover, patterns of international collaboration and domestic production of research within the field are analysed. This is to identify major actors and contributors to urban planning research and their relationship with one another. The overall contribution of the work is provision of novel insight into the intellectual structure and temporal progression of urban planning research at a macroscopic scale and the directions in which the field is headed currently. The knowledge about these trends can be instrumental for researchers of the field to have a more accurate and objective understanding of the field and its temporal transformation. In the remaining sections, we first introduce the method of data collection by which the underlying articles of urban planing (estimated at N ≈ 98,000 items) have been sourced. This includes the search strategy as well as the nature and composition of the dataset. Subsequently, major sub-divisions of the field are determined through analysis of the terminologies of titles and abstracts of urban planning papers and the patterns of term co-occurrence in their titles and abstracts. This is followed by a temporal analysis where emerging, trending and shrinking areas of the field are objectively determined through analysis of the reference lists of urban planning papers and by identifying patterns of document co-citation in their reference lists. Finally, analyses are conducted on the patterns of connectivity in the field at both macro (country-level) and micro (author-level) scales. The results of these multiple layers of analyses are summarized and integrated in the discussion and conclusions section.

2. Methods and data

To analyse the landscape of urban planning research in its broadest scope, collective publications in urban and regional planning journals were considered and their full bibliometric information was exported and analysed. In composing the search query, all journals that are indexed by the Web of Science (WoS) as "Urban Studies – SSCI" or "Regional & Urban Planning – SSCI" were considered and their indexation was examined individually. Journals can be indexed in multiple categories in the WOS, and those that have that characteristic often cover a diversity of topics. In order to obtain a dataset with maximum specificity (i.e., minimum false positives), journals that were indexed in another category in addition to the above categories were excluded. This filtering produced what we refer to as "specialty journals" of urban and regional planning. The filtering process identified the following list of journals and resulted in the search query below, where "SO" is the search tag for "journals" and "OR" is a boolean operator. The first paragraph in the search query lists journals in the category of Urban Studies, while the second paragraph lists those in the category of Regional & Urban Planning. There are some journals that are indexed in both categories (whose repetition in the query string would clearly not have made any difference in the results). No limit was set on the type of documents nor was any other exclusion criteria imposed. The search was conducted at the end of 2021 and the query string resulted in N = 97,550 research items. The query can be easily used (i.e., copied into the WoS Advanced Search engine) and replicated by readers as a standard way to obtain and track the literature of urban planning. It can similarly be modified in order to obtain certain subsets of the field.

So = ("Journal of Planning Education and Research" OR "Landscape and Urban Planning" OR "Cities" OR "Journal of Urban Technology" OR "Habitat International" OR "Urban Geography" OR "Urban Studies" OR "Journal of Planning Literature" OR "Urban Forestry & Urban Greening" OR "European Urban and Regional Studies" OR "Urban Education" OR "International Journal of Urban and Regional Research" OR "Planning Theory & Practice" OR "Housing Theory & Society" OR "Journal of Urban Economics" OR "Environment and Planning B-Urban Analytics and City Science" OR "International Journal of Housing Policy" OR "Housing Studies" OR "Journal of Urban Affairs" OR "European Planning Studies" OR "Environment and Urbanization" OR "Urban Affairs Review" OR "Journal of the American Planning Association" OR "Regional Science and Urban Economics" OR "Local Environment" OR "International Regional Science Review" OR "Urban Policy and Research" OR "Journal of Housing and the Built Environment" OR "Urban Research & Practice" OR "Housing Policy Debate" OR "International Journal of Urban Sciences" OR "Journal of Urban Planning and Development" OR "City & Community" OR "Journal of Housing Economics" OR "Economic Development Quarterly" OR "Urban Design International" OR "Education and Urban Society" OR "Journal of Urban History") OR

("Sustainable Development" OR "Progress in Planning" OR "Habitat International" OR "Computers Environment and Urban Systems" OR "Journal of Rural Studies" OR "Regional Studies" OR "Journal of Environmental Policy & Planning" OR "Environment and Planning C-Politics And Space" OR "Futures" OR "Papers in Regional Science" OR "Journal of the American Planning Association" OR "Journal of Environmental Planning and Management" OR "Journal of Regional Science" OR "Annals of Regional Science" OR "International Regional Science Review" OR "Urban Design International")

Full bibliometric data of this set of documents were exported in the form of text files for analysis. This included their title, date of publication, author names and affiliations, citation count, list of keywords, abstract text and list of references. In addition to statistical analysis of this bibliometric data, the structure and composition of the field was analysed using the methodology of Visualisation of Similarities (VOS) proposed by Eck and Waltman (2007), while temporal trends were identified using the Document Co-citation Analysis (DCA) methodology of Chen (2004).

3. Structural composition and major divisions of urban planning research

The composition of the field can be analysed at multiple levels and using a range of indicators. At the highest level of aggregation, however, one can make this determination based on the terminologies used in the titles and abstracts of studies and their patterns of co-occurrence. This will result in the identification of major divisions within the field. The VOS method was applied to make this determination using the $N =$

97,550 papers that were identified.

The VOS method considers n objects (1, …, n) for which we aim to determine similarities. In the case of this study, the objects could be individual terms or term combinations obtained from titles and abstracts of urban planning articles or the urban planning articles themselves. In the former case, the criterion of similarity between the objects is co-occurrence of the terms in titles or abstracts of articles (i.e., term co-occurrence analysis), and in the latter, the criterion is the degree of overlap between references lists of articles (i.e., article bibliographic coupling analysis).

We assume $T = (\tau_{ij})$ $(\tau_{ij} \geq 0, \tau_{ii} = 0, \tau_{ij} = \tau_{ji}\ \forall\ i,j \in \{1,\ldots,n\})$ as a symmetric $n \times n$ matrix labelled the *similarity matrix*. The elements of this matrix τ_{ij} are non-negative and denote the similarity between objects i and j. In the visualised output, the Euclidean distance between each pair of objects i and j are optimised in a way that it reflects their similarity τ_{ij}. The measure of similarity, referred to as *association strength* or *proximity index* (Eck & Waltman, 2007) follows Eq. (1), wherein σ_{ij} signifies the number of co-occurrences of objects i and j while δ_i and δ_j denotate their respective number of total occurrences.

$$\tau_{ij} = \frac{\sigma_{ij}}{\delta_i \delta_j} \tag{1}$$

In the visualised output, a weighted sum of the squared Euclidean distances between all pairs of items is minimised (Eq. (2)), subject to the constraint that the mean distance between pairs of items must equal unity (Eq. (3)). In this notation, $\boldsymbol{P}_i = (x_i, y_i)$ represents the position vector for item i in a two-dimensional plane and $\|\bullet\|$ is the Euclidean norm. The solution is calculated numerically using a majorization algorithm ((Borg & Groenen, 2005), (Haghani et al., 2021)).

$$Min\ V(\boldsymbol{P}_1, \ldots, \boldsymbol{P}_n) = \sum_{i<j} \tau_{ij} \left\|\boldsymbol{P}_i - \boldsymbol{P}_j\right\|^2 \tag{2}$$

$$s.t. \frac{\sum_{i<j} \tau_{ij} \left\|\boldsymbol{P}_i - \boldsymbol{P}_j\right\|}{n(n-1)/2} = 1 \tag{3}$$

The outcome of this method, once applied to the titles and abstracts of the 97,550 studies within our dataset, points to the existence of four divisions in urban planning (determined objectively by the clustering algorithm), as indicated by four clusters of co-occurred terms (Fig. 1). An examination of the content of the language and terminologies represented by these clusters suggests that these clusters reflect the presence of the following major clusters within the field: cluster (i) *governance and policy* (shown blue), cluster (ii) *built and natural environment* (shown green), cluster (iii) *economics and markets* (shown orange), cluster (iv) *housing* (shown brown). Clusters (iii) and (iv) are conceptually close to one another and also share a great deal of semantic similarities in their respective research. Readers can further explore this network of term co-occurrence using the link to the online interactive version in the caption of Fig. 1. An overarching centric term that connects clusters (i) and (ii) is "climate change".

To gain insight into the relative age of these divisions, the terms of each cluster were visualised such that each node (representing a term) was colour-coded based on the average year of publications in which the term appeared in abstracts. This overlay visualisation (Fig. 1, bottom left) shows that the division of *built and natural environment* is relatively younger than other divisions, as it contains many terms whose average year of publication are 2014 and onwards. Terms such as "land use", "tree", "ecosystem service", "connectivity" and "green space" are among those younger terms. Within cluster (i), terms such as "stakeholder" and "engagement" are among the youngest. Clusters (iii) and (iv) do not present any prominent young terms, other than "Chinese city". Despite being younger, cluster (ii) also seems to be the most cited division of urban planning research, compared to the three other major divisions. Once the network is overlaid with the average citation to the publications of origins of the terms (Fig. 1, bottom right), this effect becomes clearer. Cluster (ii) contains many more highly cited terms compared to the three other clusters. Terms "green space" (with an average citation of 39.86) and "urban green space" (with an average citation of 46.55) are the most cited terms of this cluster and the network of term co-occurrence overall.

Divisions of the field can also be determined by applying the VOS methodology to the reference lists of urban planning articles, as the indicator of similarity. This is based on the premise that articles with an overlap in their reference lists (i.e., bibliographically coupled articles) are likely to be thematically similar, and hence, a cluster of such bibliographically coupled articles can represent a division of the field. This, however, provides a segmentation of the field at a lower level of aggregation (i.e., higher resolution) since this method maintains individuality of articles (as opposed to the term co-occurrence indicator that does not maintain article individuality). This method, applied to the dataset of N = 97,550 urban planning articles, resulted in the five major divisions/clusters (Fig. 2). In the network, each node represents an individual article. Node sizes and their variations have been reduced to a minimum for the sake of visibility of the clusters and their borders. Through the files provided in the Online.

Supplementary Material, readers will be able to reconstruct an interactive version of this network. Examining the content of these clusters of bibliographically coupled articles determines that there are associations with the previously established clusters through term co-occurrence analysis. The colours assigned to these clusters are reflective of this association (compare Figs. 1 and 2). The only exception is that two different variations of the *economics and markets* research division are identifiable through bibliographic coupling patterns, hence the two clusters are shown in two different shades of orange on the right side of the bibliographic coupling network. This dissociation occurs because bibliographic coupling provides a higher level of detail and is a less aggregate form of analysis compared to term co-occurrence, as it maintains individuality of articles. The two clusters that can be differentiated in relation to *economics and markets* (at the level of bibliographic coupling) might share similar terminologies and are, therefore, not differentiable at the term-level analysis. However, the two subdivisions, despite having common terminologies, might use different sets of references, and hence, split to two different clusters at the bibliographic coupling level. The top left corner of the network represents a cluster associated with the *built and natural environment* division. An overlay of the average publication year confirms concentration of a large number of relatively newer articles in this division (Fig. 2, bottom left). The very end corner of this cluster also contains a high concentration of highly cited articles, namely on topics such as "human dimensions of urban greenways" (Gobster & Westphal, 2004), urban greening to cool cities, towns and islands ((Bowler et al., 2010), (Hamada & Ohta, 2010), (Chen et al., 2014), (Norton et al., 2015), (Park et al., 2021), (Rakoto et al., 2021)).

The text files labelled "map file" and "network file", provided in the Online Supplementary material, contain the full information of this network and can be used to re-produce the network independent of the underlying data that was used to generate the network.

The keywords provided in the urban planning articles (N = 97,550) were also analysed based on their frequency. In doing so, and to gain insight into the shift in topics within the field over time, the data was divided into three times periods – 1999 and earlier, 2000–2009 and 2010–2021 – representing the historic, intermediate, and contemporary segment of the literature respectively. The top 10 keywords of each time period were determined (Fig. 3) along with their percentage of occurrence among all keywords. Most prominent is the shift in the ranking of "China" as a keyword over these time periods – absent in the top 10 keywords of 1999 and earlier, appearing as the 7th top keyword in the first decade of the current century (2000–2009), and currently (2010−2021) the most frequent (1st) keyword in urban planning research. Despite this shift, "China" currently accounts for only a little >1 % of all keywords. Another common keyword of urban planning

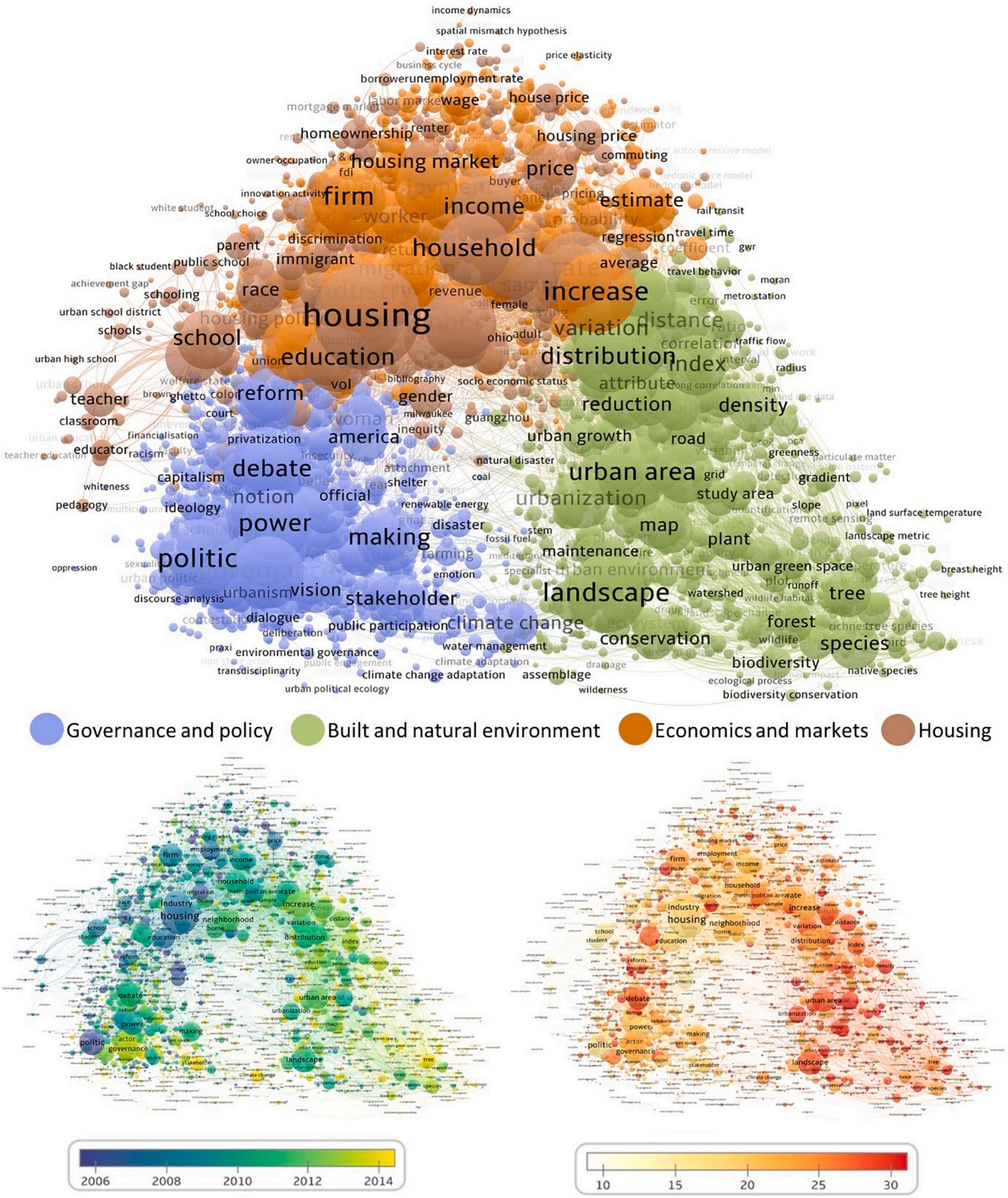

Fig. 1. The network of term co-occurrence of urban planning papers, based on the text of their titles and abstracts. This determines major divisions of the field (i.e., its structural composition) at the highest level of aggregation. Also shown are overlays of average publication year of terms (bottom left) and average citation to the articles mentioning the terms (bottom right). An interactive version of the network can be accessed through this: https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1D7VRO36RFXns5dQTBH1lnMG4juqmiQsX.

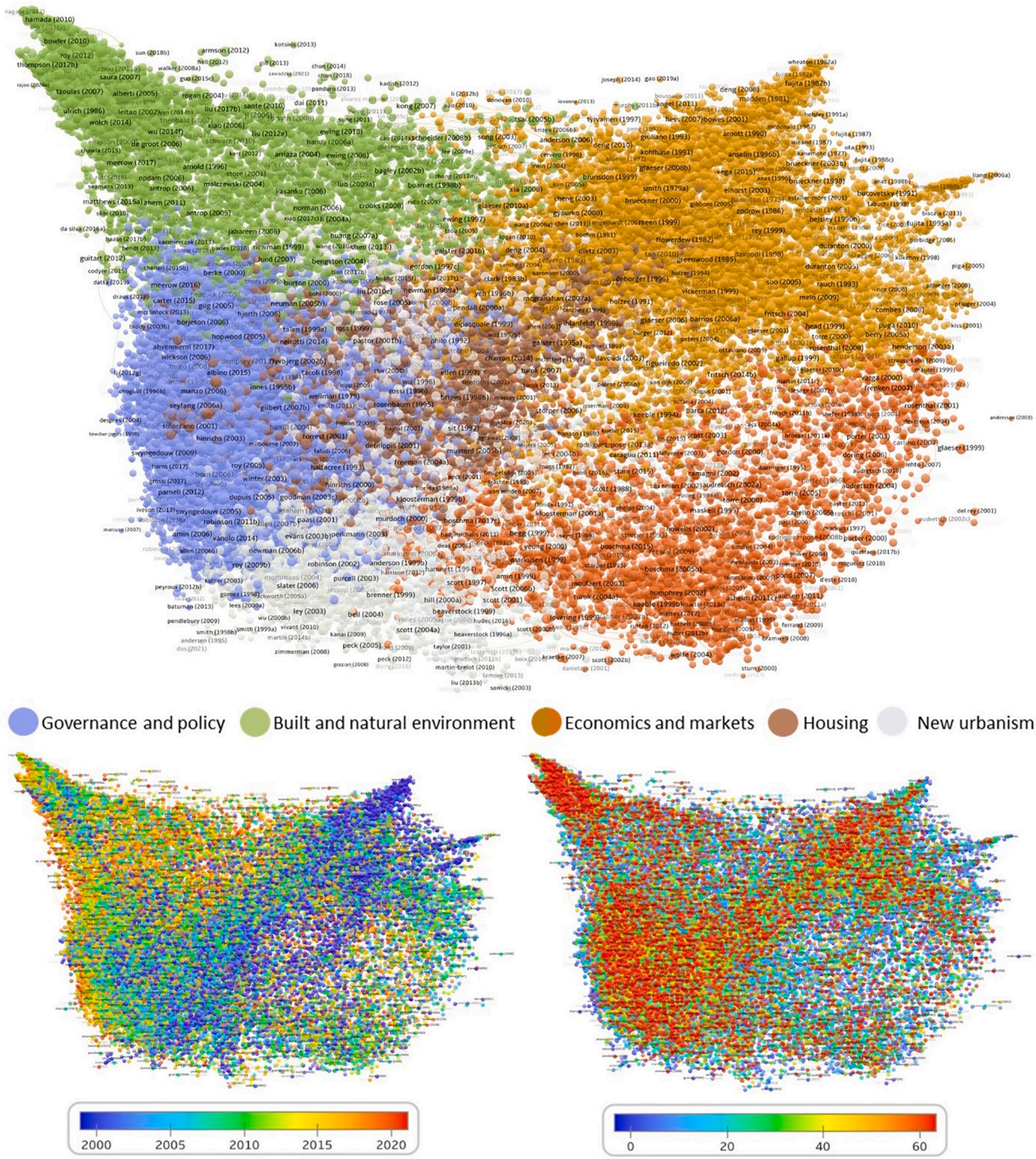

Fig. 2. The network of article bibliographic coupling of urban planning papers, based on the similarity of their reference lists. The colour coding represents associations with the divisions of the field as determined by term co-occurrence analysis. Also shown is the overlay of publication year (bottom left) and citation count (bottom right). A high-resolution zoomable image can be accessed through this link: https://unsw-my.sharepoint.com/:i:/g/personal/z3534847_ad_unsw_edu_au/EerLDj-4UINJkzrRuh5ZvL4BuM9cxVNd9YxJQbigGcW12Q?e=h4dHkc.

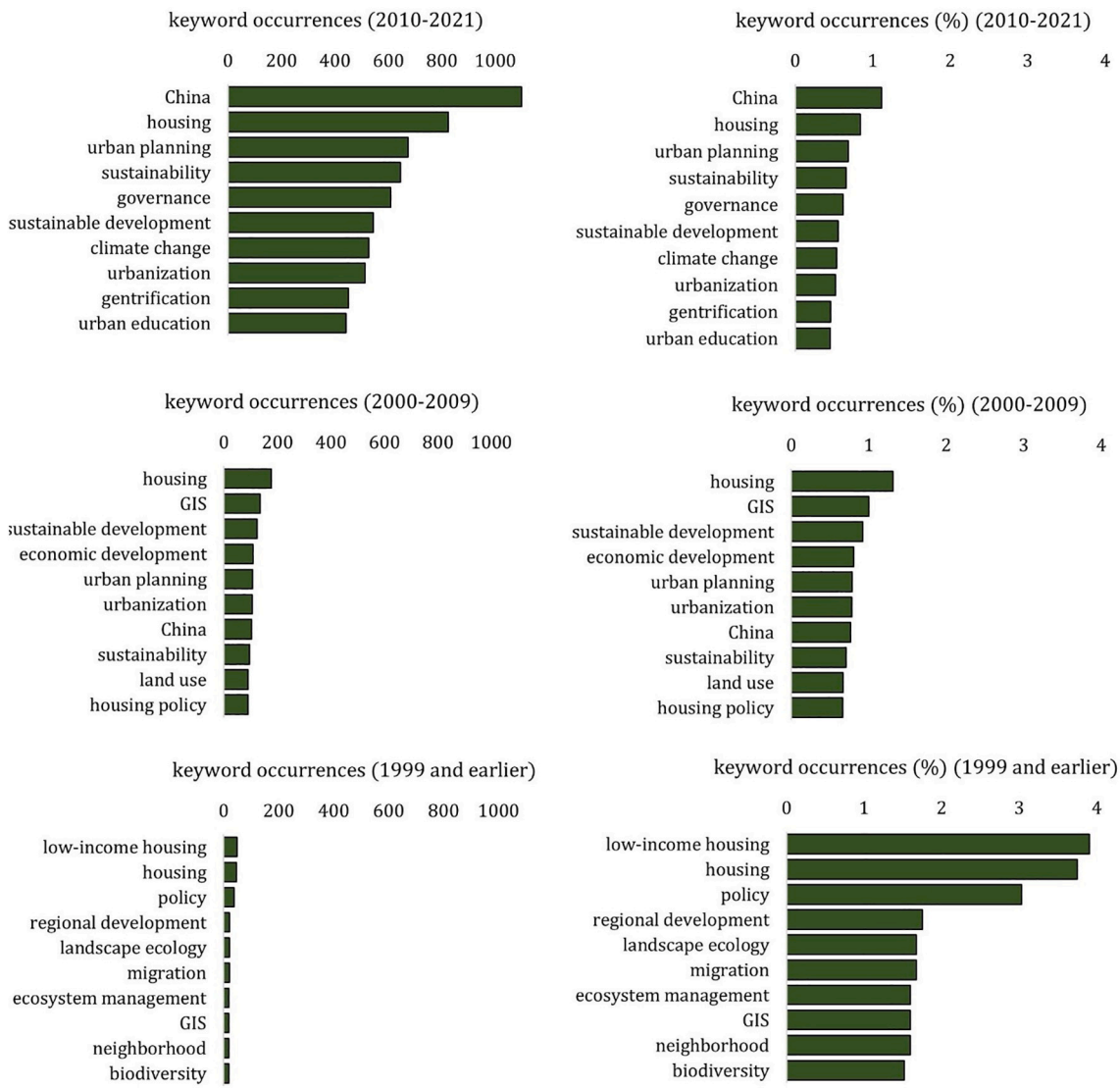

Fig. 3. Most frequent keywords in urban planning papers (left) and their relative percentage of frequency (right) over three different time periods.

articles is "housing", which was the top keyword in 2000–2009 (1st) and the 2nd most common keyword in the other time periods (2010–2021, 1999 and earlier). "Sustainable development" and "Sustainability" have also been relatively common in the last two decades (2000−2021) ranging from 3rd to 8th most common, despite not appearing in the top 10 last century (1999 and earlier). Finally, a number of other keywords – "Governance", "Climate change", "Urbanisation" and "Gentrification" – appear in the top 10 keywords currently (2010–2021) despite their absence in earlier time periods, denoting a shift towards these topics among urban planning researchers.

4. Major topics, temporal trends, and fundamental references of urban planning

At a more detailed level, compared to the previous analyses, major topics of the field can be analysed, along with temporal variations in their activities, through patterns of document co-citation. The method rests on the assumption that references that are frequently cited together in the same papers (i.e., references that are frequently co-cited) are likely to represent the *knowledge foundation* for a specific stream of research. Therefore, by identifying clusters of references in urban planning that are frequently co-cited, one determines these streams, and by examining the referencing patterns of the citing articles associated with these streams/clusters, one can gain insight into how activities of these streams have varied over time. In this method, a *citing article* could be any of the N = 97,550 articles of urban planning in our dataset and a *cited reference* could be any document (e.g., article, book, report) that frequently appeared in the reference lists of urban planning articles (see Fig. 4 for an abstract illustration of the concept).

This method was applied to the dataset of urban planning articles and produced 18 major clusters, each representing a major stream of urban planning. A set of $N = 3765$ references were identified, through a g-index algorithm, as frequently cited references of urban planning. These references are each represented by a node in the document co-citation outcome (Fig. 5). The visualisation on top lines up these nodes based on the year of the publication of the reference that they represent while the node size is proportional to the number of *local citations* to the reference (the notion of *local* citation is here used in contrast to *global* citation, meaning that this analysis only considers the number of instances of referencing to a document exclusively from the urban planning field and not anywhere else). An alternative visualisation in the bottom part of Fig. 5 presents these clusters in a network view mode, where clusters that are conceptually more similar are situated closer to one another. Nodes with a red ring represent references to which a *burst* of local citation has been detected, meaning a sudden surge of local citations to a reference from urban planning articles over a

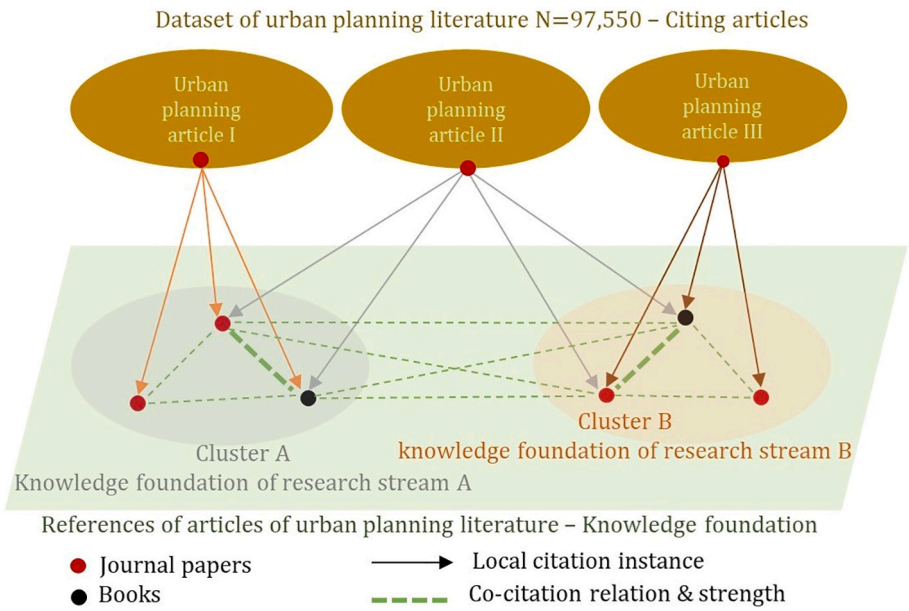

Fig. 4. The notion of document co-citation analysis.

certain period of time. A burst is characterised by its onset (i.e., begin year), end year and its intensity/strength. In both visualisations, links are representative of co-citation instances.

The extent of activities within each cluster can be determined over time by calculating the citation and co-citation instances from the citing articles of each cluster during each year. A dynamic visualisation of these activities during 1970–2021 can be accessed in the Online Supplementary Material, as well as the link provided in the caption of Fig. 5. Alternatively, the state of activities of the network at the end of each decade since 1970 has been visualised in Fig. 6, where it is apparent how activities have gradually shifted from *urban economics* at the top right corner of the network in earlier years to *urban resilience*, *urban shrinkage* and *smart cities* in the bottom left in recent years. These changes reflect the impact of recent environmental concerns and technological developments in research and practice of urban planning. These activities are also further quantified based on the number of urban planning articles that have cited references of each cluster as well as their total *coverage* (i.e., the number of references that they have cited from each cluster) during each year from 1970 to 2021. This outcome is provided in Fig. 7 and Fig. 8.

Each cluster was initially assigned a label or descriptor that was determined algorithmically through the analysis of titles of the citing articles of the clusters. The algorithm extracts noun phrases from the titles of the citing articles of each cluster and assigns a log-likelihood ratio score to each noun phrase based on their frequency of mention as well as the *coverage* of the citing article from which the noun phrase has been obtained (the coverage of a citing article refers to the number of references of each cluster that have been detected in the reference list of that citing article). The noun phrase with the highest score is visualised as the algorithmically determined label. While labels obtained from this method have the advantage of being objective, they also have the downside of not being an adequate descriptor of the cluster content in some cases. To compensate for this issue, alternative labels were determined manually by studying the content of each cluster (and also, informed by the algorithmic labels) and have been used in place of the algorithmically determined labels.

The table provided in the Appendix summarises the content of the document co-citation network as well as the most fundamental references determined by the analysis. Note that the table does not list all cited and citing references of each cluster, as the entire network contains nearly 3750 (frequently cited) references, which is impossible to list. Of this list, only a subset of the most locally cited references of each cluster have been mentioned in the table. Similarly, only citing articles with the highest coverage of each cluster have been listed in the table and not all of them, for a similar reason to that mentioned earlier.

The table provides a list of the top algorithmic descriptors as well as the author-specified descriptor, the statistics of each cluster (including the average year of the cited references and citing articles of each cluster as well as their year range, the size of each cluster (i.e., the number of references within each cluster) as well as a measure of cluster homogeneity, known as *Silhouette Score*. The Table lists fundamental/influential references of each cluster based on three metrics of significance: (i) *local citation count*, (ii) *bursts in local citation count* and (iii) *centrality*. The first metric measures the impact that references have had exclusively on urban planning research, by counting the number of times documents have appeared in the reference list of urban planning articles. The second metric considers sudden spikes in the counts of such local citations, indicative of heightened attention to a reference (and by association, to its associated topic) over a certain period of time. The last item refers to the extent to which a reference is co-cited with the references of other clusters and determines the references that have influence across a variety of topics in urban planning research. A sample of the citing articles with highest coverage are also listed for each cluster. Below we provide a short description of each cluster.

Cluster 1, *urban economics*, represents a broad stream of urban planning research using economics to analyse urban related matters such as housing, public transport and local government finance with more specific focus on the location and structure of households and firms. This cluster is associated with the major division of "housing" and "economics and markets" (Fig. 1). This cluster is one of the oldest areas of study in urban planning with citation dating back to *Principles of Economics* by Alfred Marshall in 1920, with most highly cited works occurring during the 1950s through to the 1980s (Fig. 5). Tiebout (1956) article "A Pure Theory of Local Expenditures" is the most fundamental reference in urban economic studies where he discusses the free-rider problem and argues that by asking people to reveal their preferences for public expenditure, the free-rider problem can be reduced. In the 1960s, the monocentric city model pioneered by William Alonso, Richard Muth, and Edwin Mills became the basis for many urban economic analyses. Alonso (1964) article disc-shaped Central Business District monocentric city model became popular as a starting point for urban economic analysis, however, the monocentric city concept has

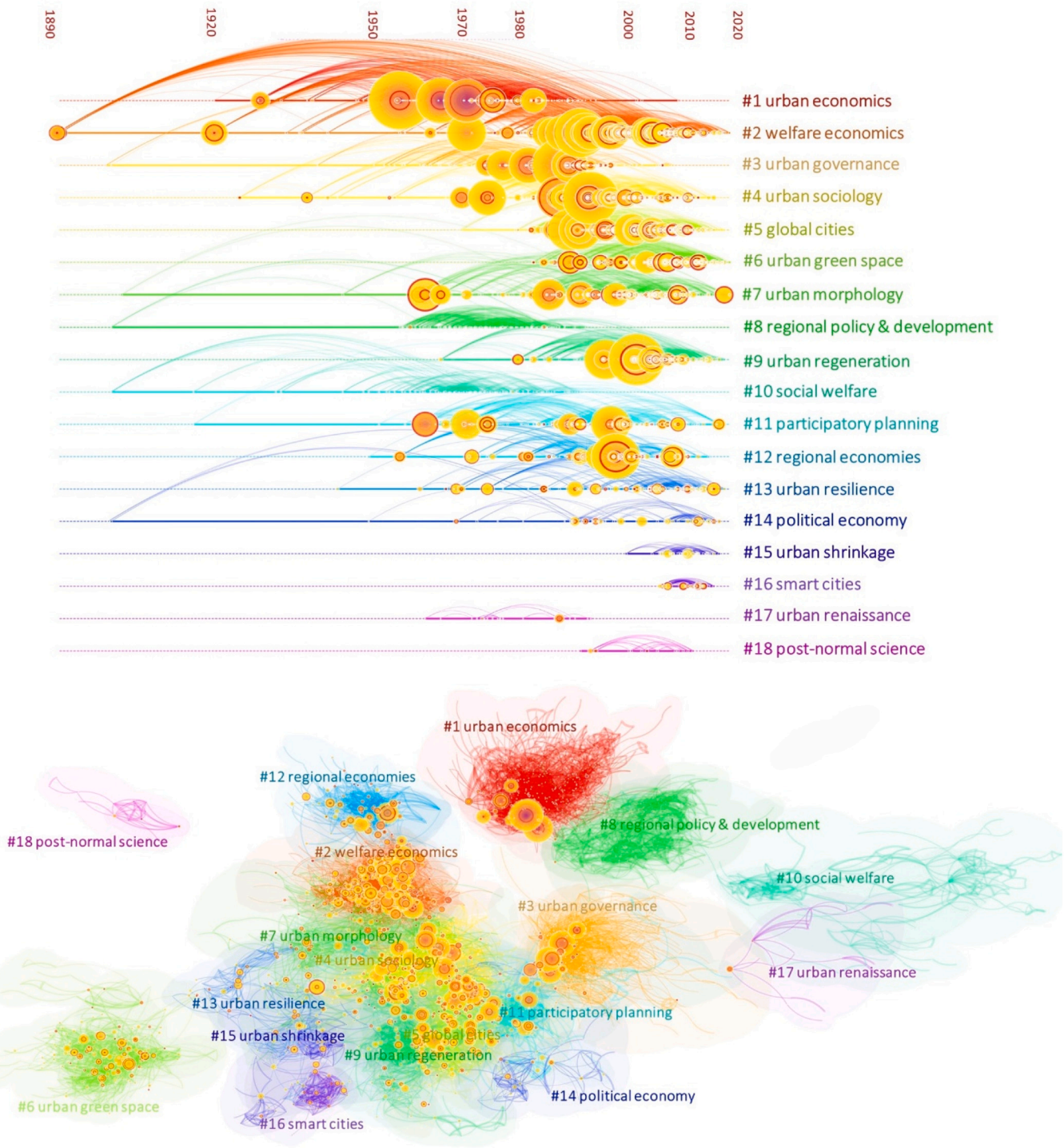

Fig. 5. The network of document co-citation of urban planning in timeline view (top) and network view (bottom). A dynamic year-by-year visualisation of activities within the network can be viewed in the Online Supplementary Material or downloaded from this link.: https://unsw-my.sharepoint.com/:v:/g/personal/z3534847_ad_unsw_edu_au/ESd0Fw36PbFEhBVYrHIg9UkBsUjfH7XzuslE2kw1ynfohg?e=QzfAfM.

become less popular with changes in cheaper and faster transportation and significant improvements in technology and communications. Lancaster (1966) consumer theory and Rosen (1974a, 1974b) model are other highly cited studies particularly in housing economics which extended this neoclassical approach by introducing hedonic models which allows heterogeneity in the model to be captured. They assume that a good is described by a number of attributes which forms bundles of utility-affecting attributes that the consumer values. Activity in urban economics was the highest in the early 1980s (see Fig. 7), with activity in this cluster declining in the last two decades.

Cluster 2, *welfare economics*, represents a stream of urban planning research on *agglomeration economies*. Its activities begin with the investigation of spatial distribution of firms and creativity as the economic growth engine of cities. The industrial evolutions including industry 4.0 and their impact on urban and regional productivity are also explored in this cluster. References in this cluster date back to 1890. However, this cluster (re)emerged in the early 21st century and remained a trending topic (based on Fig. 7). It has a relatively new set of knowledge

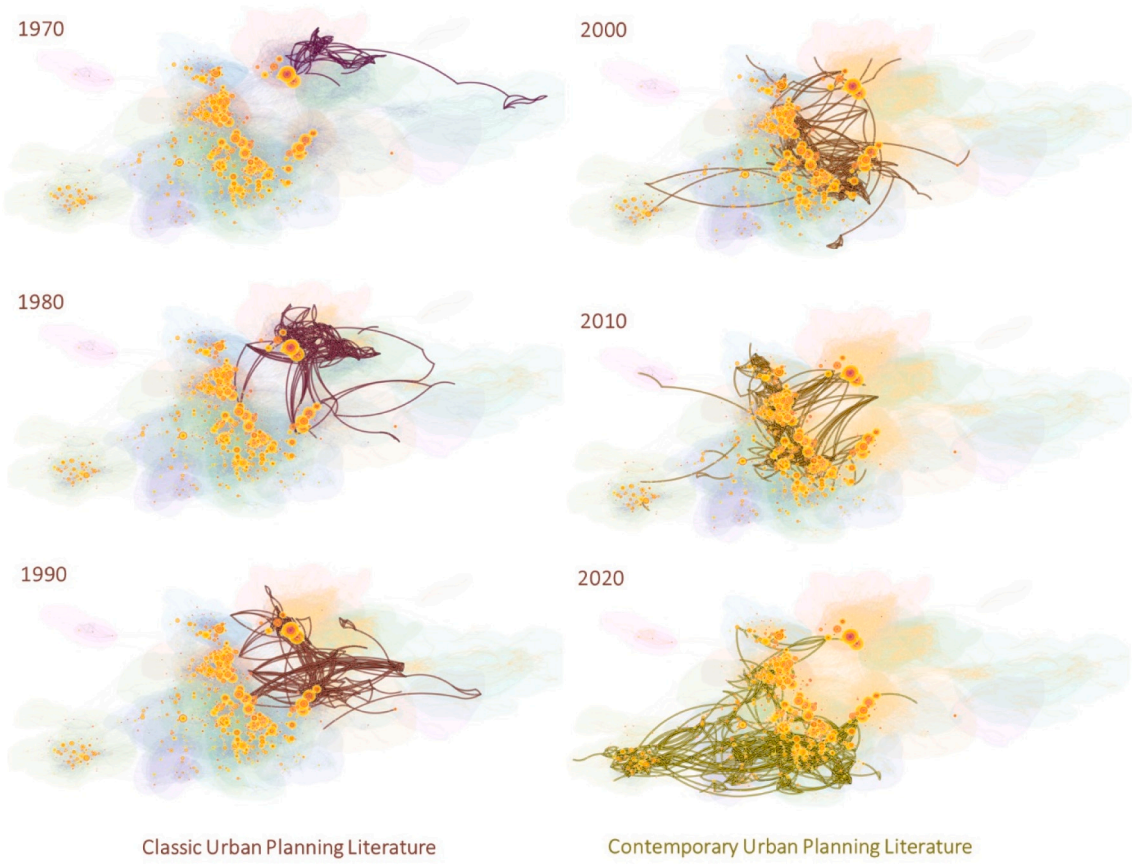

Fig. 6. The state of activities in urban planning research at various cross sections of time since 1970.

foundation (Fig. 5, top), with the most fundamental references being Krugman (1991a, 1991b) and Jacobs (1969) (Appendix Table). Specifically, the book about "Geography and Trade" by Krugman (1991a, 1991b) has been influential as it draws the attention of urban planners to the significant value of economic geography for productivity planning. Later, Andersson et al. (2005) conducted an empirical analysis of the relationships between commercial patents, localisation, and urbanisation, with the industrial composition and size distribution of firms. Their work highlighted the productivity value of the creative knowledge economy and clusters in the productivity of the local and national levels. This cluster is associated with the major division of "economics and markets" (Figs. 1 and 8).

Cluster 3, *urban governance*, relates to the *governance and politics* research areas in urban planning and urban studies more generally (including geography, sociology and political science). Its emphasis is on the relationships between urban politics and economic development. This cluster started in the early 1970s and remained as a relatively trending topic until the beginning of 21st century (based on Fig. 7). It has a relatively new set of knowledge foundation (Fig. 5, top), with the most fundamental references being Molotch (1976) and Stone (1989) (Appendix Table), but also work by Harvey (1989a, 1989b) on entrepreneurial urban governance. Logan & Molotch's book *"Urban Fortunes, The Political Economy of Place"* has been influential because it consolidated debates around the implications of the commodification of the built environment (Logan et al., 2007), emphasising the relationships between the materiality of land and buildings and broader economic circuits. This cluster is associated with the major divisions of "economics and markets" and "governance and policy" (Fig. 1).

Cluster 4, *urban sociology*, represents a stream of urban planning research on *urban gentrification* and the study of life and human interaction in urban areas. This cluster examines the urban socio-economic manifestation of urban policies, revitalisation, and redevelopment processes. The urban social phenomena, including poverty, segregation, gentrification, and community social cohesion are important attributes of this cluster. This topic started in the early 1990s in developed countries and remained alive with recent extension to the developing world (based on Fig. 7). It has a relatively new set of knowledge foundation (Fig. 5, top), with the most fundamental references being Massey and Denton (1993) and Wilson (1987) (Appendix Table). The book "American Apartheid: Segregation and the Making of the Underclass" has been influential because it emphasised the creation of ghettos and segregations through individual actions, institutional practices, and government policies. The book highlights a systematic process of urban cultural, racial, and economic segregation, which limits a part of community from mainstream society growth. This cluster is associated with the major divisions of "housing" and "governance and policy" (Figs. 1 and 8).

Cluster 5, *global cities*, represents a stream of work in urban studies and geography focusing on cities' financial markets and advanced infrastructure. This is a relatively new cluster, with activity noticeably growing since the mid-1990s, increasing mostly over the past decade (Figs. 7 and 8). This cluster is associated with the major division of "economics and markets" (Fig. 1). Influential references include Harvey (1989a, 1989b) and Sassen (1991) (Appendix Table). In particular, the work of Sassen (1991) spurred an emphasis on the formation of cross-border dynamics through which global cities – such as New York, London and Tokyo – form strategic transnational networks, with work by Taylor (1998) and others in the Globalization and World Cities Network (GaWC), now a well-established presence internationally in this strand of urban research (Taylor & Derudder, 2015).

Cluster 6, *urban green space*, is a relatively new cluster which started in the early 21st century (Fig. 5). It represents a stream of work related to urban greening in land-use planning for four basic purposes: ecology, recreation, aesthetic value, and positive health impacts. The book "The experience of nature" by Kaplan and Kaplan (1989), which looked at the

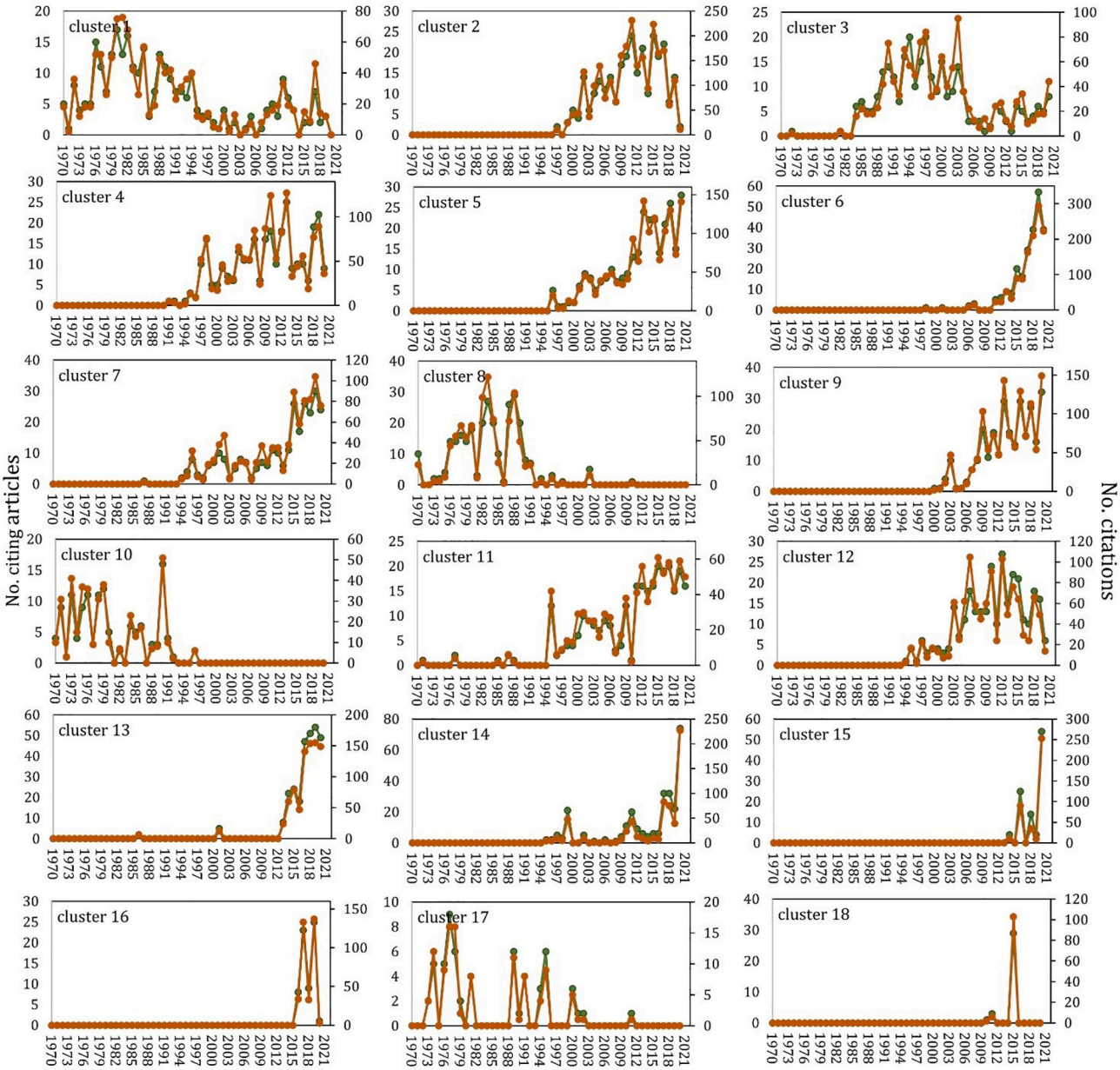

Fig. 7. Quantification of activities of various major streams of urban planning research (as determined by clusters of document co-citation network) since 1970. Activities are quantified based on the number of citing articles (left vertical axis, green lines) and the number of citations to each cluster (right vertical axis, orange lines). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

effect of the environment on humans under different circumstances, is one of the fundamental references in this cluster. Other recent established references are Wolch et al. (2014a, 2014b), Chiesura (2004), Grimm et al. (2008) and Tzoulas, Korpela, Venn, Yli-Pelkonen, Kazmierczak, et al. (2007). Since 2012, activity in this area increased significantly, resulting in both the number of citing articles and the number of citations in this cluster to be the highest among all clusters in 2018 (see Fig. 7). This cluster is associated with the major division of "built and natural environment" (see Fig. 1).

Cluster 7, *urban morphology*, is a branch of research in urban planning which looks at the urban spatial form and the agents and processes of the assembly of buildings and public spaces that encompass the city over time. Influential references on urban form date back to studies from late 19th century in central Europe with the work of Fritz (1894) who studied German cities' forms and plans. The first three decades of the 20th century was the golden era in urban form studies with the most noticeable work by Howard (1902), "Garden cities of tomorrow" book, where he offered a vision of a town where residents could benefit from high wages, amusements, opportunities, fresh air and beauty. Other noticeable references are Leighly (1928) and Giovannoni (1931). Urban form lost its momentum as other matters became important for urban geographers such as *"urban functions"* and *"urban structures"*. In the second half of the 20th century, there were again innovative contributions to the study of urban form. For example, one of the most influential works was the book titled "The Death and Life of Great American Cities" by Jacobs (1961) and the emergence of "sustainability" proposed in the World Commission on Environment and development's report "*Our Common Future*" (1987), also known as the 'Brundtland Report', which triggered studies associated with urban form and compact cities (see Fig. 7). Ewing and Cervero (2010) is a more recent study which is considered as one of the highly cited works in this cluster. Similar to cluster 5, this cluster is also associated with the major division of "built

ID	Authors descriptors	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	urban economics	•	•	•	•	•	•	••	••	•	••	••	••	••	••	••	••	•	•	••	••	•	•	•	•	••	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
2	welfare economics																												•		•	•	•	••	•	••	••	••	••	•	••	••	••	••	••	••	••	••	•	••	•	••
3	urban governance			•									•			•	•	•	•	•	••	••	•	•	••	••	••	••	••	•	••	•	•	••	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4	urban sociology																						•	•		•	•	•	••	••	•	•	•	•	•	••	••	••	•	•	••	••	••	••	••	•	••	••	•	••	••	•	•
5	global cities																											•	•	•	•	•	•	•	•	•	•	•	••	•	•	•	••	••	••	••	••	••	••	••	••	••	••
6	urban green space																													•			•					•	•				•	•	•	•	••	••	••	••	••	••	••
7	urban morphology																			•							•	•	•	•	•	•	••	•	•	•	•	•	•	•	•	•	••	••	•	••	••	••	••	••	••	••	••
8	regional policy & development	••			•	•	•	••	••	••	••	••	•	••	••	••	••	•	••	••	••	•	•		•		•		•					•									•											
9	urban regeneration																															•	•	•	••	•	•	•	•	••	••	••	••	••	••	••	••	••	••	••	••	••	••
10	social welfare	•	•	•	••	•	•	••	•	••	••	•		•		•	•	•		•	•	••	•	•				•																									
11	participatory planning		•						•								•		•	•							••	•	•	•	•	•	••	•	•	•	•	•	•	•	••	•	••	••	••	••	••	••	••	••	••	••
12	regional economies																									•	•	•	•	•	•	•	•	•	••	•	••	••	••	••	••	••	••	••	••	••	••	••	••	••	••	•	•
13	urban resilience																																•												•	••	••	••	••	••	••	••	••
14	political economy																										•	•	•	•	••			•		•		•		•	•	••	•	•	•	•	•	••	••	••	••	••	••
15	urban shrinkage																																													•		••		••	•	••	•
16	smart cities																																															•	••	•	••	•	••
17	urban renaissance				•	•		•	•	•	•		•								•	•	•			•	•					•	•	•									•										
18	post-normal science																																									•	•				••						

Fig. 8. Qualitative representation of the extent of activities in various clusters of document co-citation network based on the number of citing articles within the network citing references of each cluster during each year. The cut off point for mild (•) versus high (••) degree of activity is the presence of at least 10 citing articles during each year.

and natural environment" (see Fig. 1).

Cluster 8 represents a stream of urban planning research on *regional policy and development*. This is an older cluster, with most activity occurring throughout the 1970s and 1980s (Figs. 7 and 8), associated with the major division of "governance and policy" (Fig. 1). The most influential reference in this cluster is the book by Hirschman (1988) (Appendix Table), recognised as one of the most important contributions to development economics with its theory of 'unbalanced growth' proposed for underdeveloped countries.

Cluster 9, *urban regeneration*, represents a stream of urban planning research on *land redevelopment* to replace dilapidated urban areas and slums with high class housing, business and other developments. Its research agenda outlines the impact of new urban policies on developing creative cities, their opportunities, and implications such as urban displacement or gentrification. This cluster started in the early 2000s and maintained its trend in urban studies scholarship (based on Fig. 7). It has a new set of knowledge foundation (Fig. 5, top), the most fundamental references being Florida (2002) and Smith (1996) (Appendix Table). The book written by Smith (1996), "The New Urban Frontier, Gentrification and the Revanchist City" highlighted the new frontiers of urban gentrification and challenged the traditional view of urban displacement due to the new middle-class. Smith (1996) argued that the interconnection of private markets and new liberal urban policy are against minorities, working sectors, urban poor, and homelessness. Furthermore, Florida's (2002) book "The Rise of the Creative Class" has been influential because creativity is considered a vital urban economic resource. The book highlights the role of same sex orientation and arts (music) as the emerging creative classes that stimulate urban economic development. This cluster is associated with the major divisions of "governance and policy", "economics and markets" and "housing" (Fig. 1).

Cluster 10 represents a stream of urban planning research on *social welfare*. It is a traditional cluster that is declining (based on Fig. 7). It has an old set of knowledge foundation (Fig. 5, top), with the most fundamental references being Coleman et al. (1966) and Taeuber and Taeuber (1965) (Appendix Table). The report on "Equality of Educational Opportunity" has been influential because it highlighted the availability of equal education opportunities among non-white and white American students across public schools. Lack of opportunity was attributed to geographical, racial, and available amenities (such as libraries) in American cities. This cluster is associated with the major divisions of "housing" and "economics and markets" (Fig. 1).

Cluster 11 represents a stream of urban planning theory and research on *participatory planning*. It emphasises new theory of urban planning, citizens' power and engagement in the planning and design process. This cluster re-emerged from the late 1990s and it is still alive and trending (based on Fig. 7). It has a relatively old set of knowledge foundation (Fig. 5, top), associated with the major cluster "governance and policy" and the most fundamental references are Healey (1997) and Arnstein (1969) (Appendix Table). The article "A Ladder of Citizen Participation" (Arnstein, 1969) has been influential because it initiated the conversation about the role of participatory planning and its advantages, used to challenge the planning traditions by Healey (1997) in the book "Collaborative Planning".

Cluster 12, *regional economies*, represents a stream of urban planning research on the *economic benefits of geographical regions and human activities* leading to prosperity and growth of regions. While activity in this cluster originated in the 1950s, most activity has occurred in the last 20 years (Figs. 7 and 8). This cluster is associated with the major division of "economics and markets" (Fig. 1). Key references in this cluster include the guidelines by Allen et al. (1998) on crop water requirements and the textbook by LeSage et al. (2009) on spatial econometrics.

Cluster 13, *urban resilience*, represents a stream of urban planning research on *resilience and sustainable cities*. Its emphasis expands from population dynamics and school closures to climate adaptation and economic resilience. It is a trending topic as shown in Fig. 7, gaining

further attraction from mid-2010. It has an old set of knowledge foundation (Fig. 5, top), with the most fundamental references being Ostrom (1990) and Holling (1973) (Appendix Table). In particular, the book "Resilience and Stability of Ecological Systems" (Holling, 1973) influenced the topic of urban resilience studies because it introduced the impact of ecological systems on built and natural environments. This cluster is associated with the major divisions of "governance and policy" and "built and natural environment" (Fig. 1).

Cluster 14, *political economy* is associated with the major division of "economics and markets" (Fig. 1) and is a branch of social science that explores the connection between society and individuals and between markets and the state using a various methods and tools drawn mostly from sociology, political science and economics. The most influential references in this cluster are Esping-Andersen (1990) book titled "The Three Worlds of Welfare Capitalism" outlining the three main types of welfare states in western Europe and other advanced capitalist economies, and Piketty et al. (2014) who address how wealth-income and capital-output ratios evolve in the long run and why. This cluster is associated with the major division of "governance and policy" (Fig. 1).

Cluster 15 represents a stream of urban planning research on *urban shrinkage*. This cluster is relatively new, originating in the year 2000 (Appendix Table). It is associated with the major division of "governance and policy" (Fig. 1) and has a predominant focus on rural and older industrial areas. The most influential references in this cluster are Long et al. (2012), who examine land use restructuring in rural China, and Schilling and Logan (2008a, 2008b) who addresses the challenges that vacant and abandoned properties create in America's older industrial cities.

Cluster 16, *smart cities,* is one of the most recent concepts in urban planning (Fig. 5). This cluster is associated with the rapid development of Information and Communication Technology (ICT) and the ways it can be utilised to address urban growth and associated issues related to modern cities. The term "smart city" first emerged in the early 1990s in a book by Gibson et al. (1992). With the launch of IBM's Smarter Planet project in 2008, smart cities attracted great attention (Palmisano, 2008). Influential studies in this cluster include Caragliu et al. (2011), Kitchin (2013) and Hollands (2008), who have provided insightful commentary and critiques of the concept of smart cities. This cluster is associated with the major division of "governance and policy" (Fig. 1).

Cluster 17, *urban renaissance* refers to a branch of studies in urban planning which use scenario planning to navigate the uncertainty of the future and help planners with their decision making specifically related to population increase and the regeneration of cities. Activities in this cluster started in the early 1970s with *The Limits to Growth* report in 1972 looking at the exponential economic and population growth and its impact on our finite supply of resources. The most fundamental reference in this cluster is *Our Common Future*, also known as the *Brundtland Report* (1987). Since the beginning of the 21st century, no significant activity has taken place in this cluster with the exception of the Shucksmith et al. (2011) study which looks at the sustainability of rural communities (Fig. 7). This cluster is associated with the major division of "governance and policy" (Fig. 1).

Cluster 18, *post-normal science,* also known as *science policy,* is a novel concept in urban planning developed in the 1990s by Funtowicz and Ravetz (1993) which concentrates on aspects related to the complex relation between science and policy to address issues where urgent decisions needs to be made with uncertain facts. Most activities in this cluster took place in 2015 (Fig. 7). This cluster is associated with the major division of "governance and policy" (Fig. 1).

5. Patterns of collaboration in urban planning research

To investigate patterns of connectedness and globalization and its variation over time in urban planning research, collaborations of authors were analysed at various levels of aggregation. Similar to the previous analyses, three time periods of 1999 and earlier, 2000–2009 and 2010–2021 were considered, in addition to all years combined.

The results are presented in Fig. 9. Each part provides the network of co-authorship in urban planning research based on the publications in the specified period of time. Links to interactive versions of each network can be accessed in the figure caption. In each network, nodes represent authors and links between them represent instances of co-authorship in urban planning (within the specified time period). We call the number of co-authorship instances between a pair of authors the *link strength* between them. The aggregation of the strength of all links originating from a node is referred to as *total link strength* (TLS) for an author, which is an aggregate metric that shows the overall extent of collaborations of an author with other major authors of the field. Groups of authors that have frequently collaborated form clusters of collaboration. Each network consists of a part that is internally connected (shown towards the centre of the network) as well as isolated nodes (in the periphery). Note that each network consists only of authors that have frequently contributed to urban planning research, with a minimum of 10 items within their respective time period. We refer to these as recurring authors. Overall, an excess of 1600 recurring authors were identified in the urban planning field. The variation of this number as well as the number of connected recurring authors are shown in the bottom left of Fig. 9. Overall, a sharp increase is observed in 2010–2021 in the number of recurring authors, number of connected authors as well as the number of major clusters of co-authorship (clusters bigger than 3 authors), compared to previous time periods (see the bottom middle part of Fig. 9). The three biggest cluster sizes in the contemporary segments of the data are 46, 39 and 28, whereas these numbers for the intermediate part are 12, 10, 10. In the historic, intermediate and contemporary segment of the data, the highest TLS are respectively observed for W Lever (TLS = 57), R Olshansky (TLS = 21), B Derudder (TLS = 65). In the overall network, P Nijkamp displays the largest TLS of 85, indicative of having 85 collaborators within the pool of recurring authors of urban planning. The strongest pairs of collaborations over the time periods respectively are C Abbot & S Adler (LS = 15), L Heumann & R Olshansky (LS = 9), and P Nijkamp & K Kourtit (LS = 19). In the overall network, P Nijkamp & P Rietveld with a LS of 20 display the strongest link of collaboration.

As an overall measure of connectivity and co-authorship, the average of TLS was calculated for each period of time (Fig. 9, bottom right). These averages are respectively 2.42, 1.92 and 7.42. While the difference between the first two time periods is statistically insignificant, the difference between the intermediate and contemporary network appears to be statistically significant at any conventional level of confidence ($t = 14.34$, $p < 0.001$). In other words, the degree of connectedness has become nearly four times larger since 2010 compared to the first decade of the 21st century. This is an unambiguous indication of increase in author collaborations in the field of urban planning. A question that may arise is whether this increase is equally reflected in instances of domestic collaboration and international collaboration.

To investigate this question, the overall instances of domestic and international collaborations were calculated within the dataset. A paper is counted as international collaboration if at least two authors with affiliations with institutes of two different countries are listed on the paper. Fig. 10 provides the number of domestic and international papers in urban planning along with the overall number of production and the production from different geographical regions. A few observations are particularly noteworthy. First is the increase in the annual growth rate of publications since 2010 (Fig. 10). While the average annual growth rate during 2000–2009 is 2.76 %, this figure has increased to 8.28 % during 2010–2020, followed by an unprecedented drop of −6.1 % in 2021. In fact, the annual relative growth in the number of papers during 2019, 2020 and 2021 are respectively 37.6 % (the highest on the record), 0.9 % and −6.1 % (the second-lowest on the record). While identification of the reason for this observation is unclear, the occurrence of the global COVID-19 pandemic in 2019 appears to be the most obvious justification that comes to mind. The majority of urban planning research

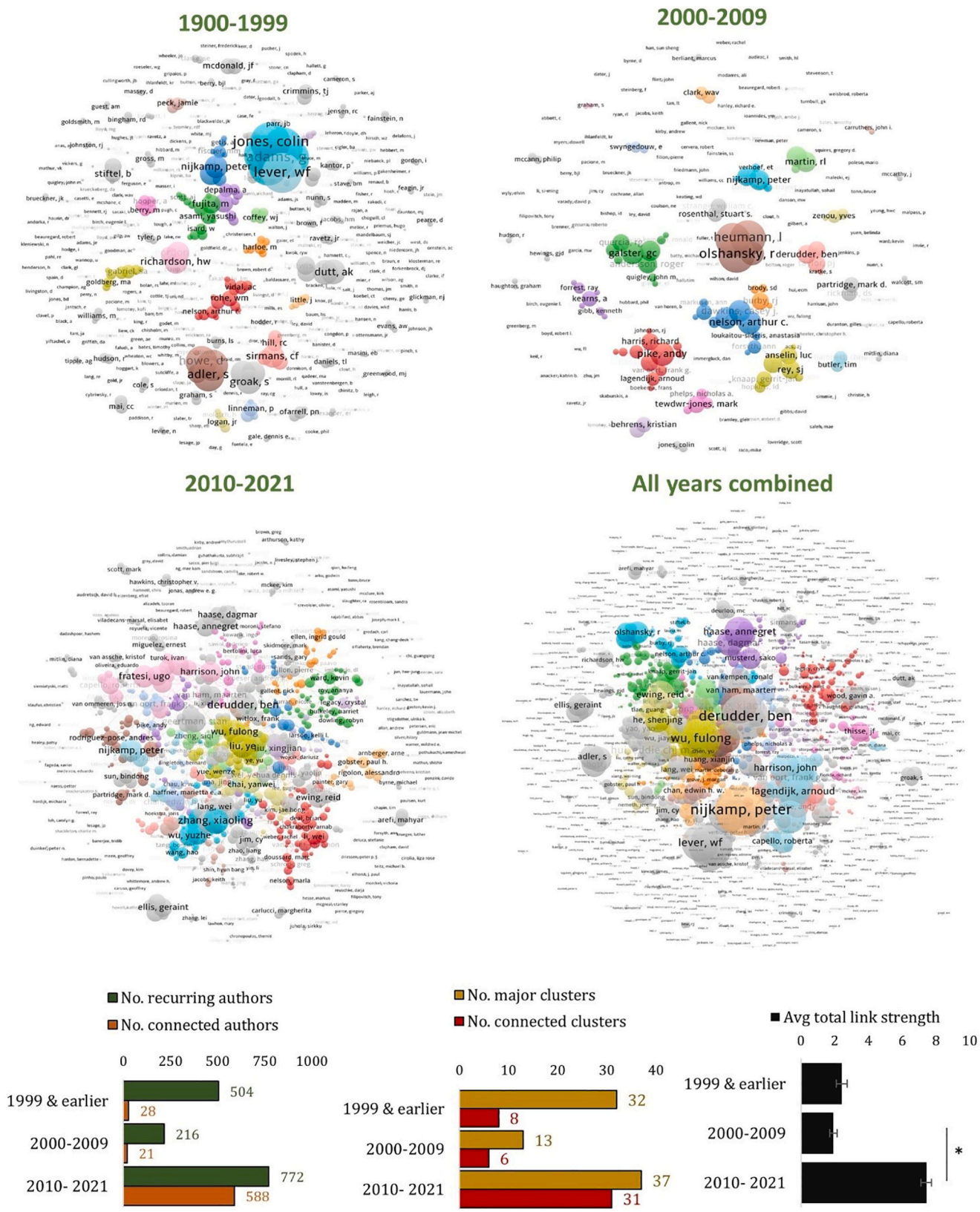

Fig. 9. Networks of author collaboration in urban planning for the periods of 1999 and earlier (https://app.vosviewer.com/?json=https://drive.google.com/uc?id=15qPoDdImBDNpy5FfybMX8oPIutt5qoB8), 2000–2009 (https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1P8lsGwDWutYsC93a2C0TJewnFEEjcT1F), and 2010–2021 (https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1hGh5r75qddsEHfXiVtvEBAFJi7zeeFDr) as well as all years combined, (https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1OP34CqYnLHA_d9uN6YVOh-HJRYwcrvDH) along with aggregate metrics of connectivity for each time period. The * sign indicates statistical significance.

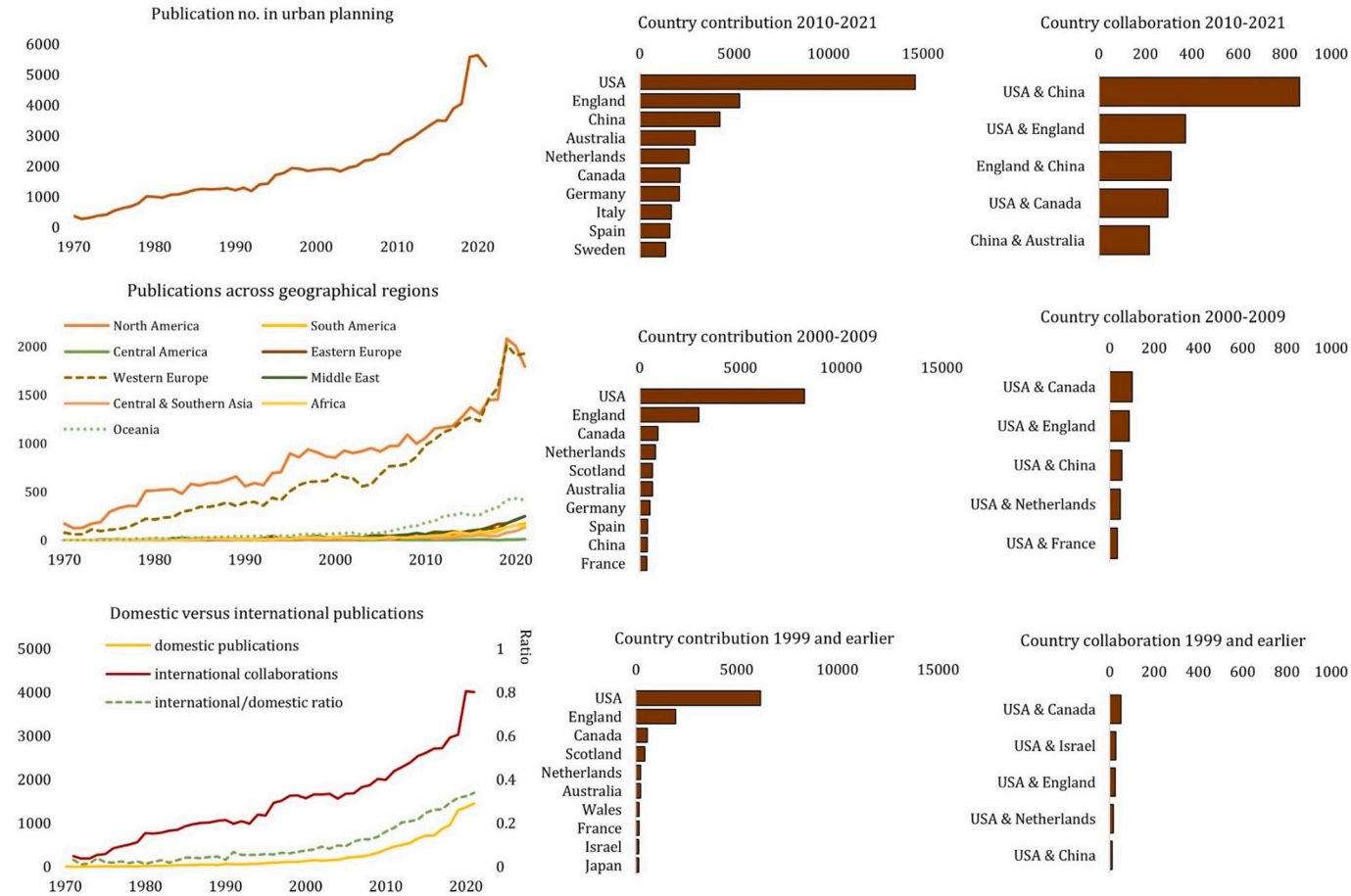

Fig. 10. Annual number of overall publications in urban planning, along with contribution of countries and geographical regions and the ratio of international and domestic publications, as well as top links of collaboration at the level of countries.

originates from the USA, followed by the Western European countries, although the rise in the share of authors from China during the recent decade is noteworthy (Fig. 10). Currently, the strongest link of country collaboration exists, by far, between authors of China and the USA (Fig. 10).

International collaborations in urban planning made up an insignificant portion of the literature in the early years (<4 % of the literature developed prior to 1999). The share of international papers has increased over time (to 9.5 % of the 2000–2009 literature and to 21.4 % of the 2010–2021 studies). In other words, slightly more than one fifth of the contemporary urban planning studies that are disseminated have been international collaborations. The latest figure has been 27.4 % in 2021. The cohort of international papers are currently increasing at a faster pace (in terms of relative annual growth) than that of domestic papers or the overall urban planning literature. A key observation is that the drop observed in the annual number of publications in 2021 is mostly attributable to the domestic cohort of papers. While the number of domestic papers in 2021 showed a 6 % decrease relative to 2020, the growth in the number of international papers continued its momentum (+4.6 % in 2020 compared to 2019, and +6.4 % in 2021 compared to 2020).

In other words, if one accepts the assumption that the occurrence of the COVID-19 pandemic has interrupted the growth of urban planning research, this interruption has been mostly levelled at domestic papers, while the international cohort of papers has maintained its momentum.

6. Discussion and conclusions

6.1. Overview and contributions

This paper set out to investigate trends in urban planning science from 1970 to 2021. The paper offers three major contributions to the field. First, an objective approach was adopted to determine trends and influential studies in the urban research and practice landscape. This is new in the field of urban planning as most previous studies adopted subjective methods and their findings are based on individual perceptions. For example, while global cities scholars believe that the seminal work of Taylor (1998) influenced this sector in urban planning research, our findings suggest the significant impact of Harvey (1989a, 1989b) and Sassen (1991). Second, most previous studies focused on a specific jurisdiction like the USA (Sanchez & Afzalan, 2017) or planning division, such as urban planning for health (Kent & Thompson, 2014) and smart cities (Wu et al., 2021). However, the scope of this paper is broader and expands previous findings through consideration of the entire urban planning field. With the consideration of almost one hundred thousand articles, this paper offers high confidence in robustness and accuracy of the determination of trends in urban planning science. Third, this paper provides a multiple level analysis in resolution and aggregation scales, from overall trends in the field (e.g., international collaborations) to major topics and individual references.

6.2. Main findings

Our findings revealed four major clusters titled governance and policy, built and natural environment, economics and markets, and

housing. Our analysis demonstrates that the division of built and natural environment is relatively younger, while divisions of economics and markets and housing are older. Despite being young, the division of built and natural environment is currently the most cited/active in urban planning in comparison to other divisions. Furthermore, our temporal analysis of fundamental references revealed that the earliest trend of work relates to welfare economics and research on agglomeration economies, urban economics, and urban growth machine dating back to the late 19th and early 20th centuries (Clusters 1 to 3). Among these earlier clusters, only welfare economics recently re-emerged in early 21st century and remained a trending topic. As can be observed in Figs. 5 and 6, during the 1980s and 1990s, the focus of urban planning research moved towards regional policy and development, social welfare, and urban renaissance. This trend continued during the 2000s and 2010s, heading to urban morphology, participatory planning, urban sociology, global cities, and political economy.

These transitions have been gradual and derivative, meaning that new research areas have been derived and paradigm shifts have happened very smoothly and gradually. This is a unique characteristic of the urban planning field which is not very common in other domains. It shows characteristics of a fluid research field and interconnectivity of social, economic, political, and environmental aspects in urban planning science. It is very clear that the field of urban planning has eventually headed towards areas of resilience, smart cities and urban green space. This shows direct parallels to global concerns about climate change, natural disasters, and the influence of technological developments in smart urban planning and management. However, we found that some aspects of emerging technologies have not been reflected quite visibly in urban research. An example is the application of Internet of Things, Machine Learning, Artificial Intelligence, and Digital Twins in urban research which appears essentially absent. An explanation for this is that the application of these technologies remained in the conceptual levels and there remains a gap on multi-disciplinary publications across digital engineering and urban planning scholars.

Another key finding was the significant growth in urban planning publications since 2010. The analysis revealed that the majority of urban planning research originated in the USA, followed by England. The number of publications originating in China increased significantly in the 2010–2021 period compared to 2000–2009, resulting in China being the third top country contributing to recent urban planning literature.

A clear finding that emerges from the analysis is that urban planning research has been visibly globalised and is transitioning from country specific case studies and concepts to studies with global implications. As a result, and in parallel, the rise in international collaborations has been very distinct in recent years. Specifically, during 2010–2021, the strongest link of country collaboration was found between authors of China and the USA. We see significantly more connectedness between urban planning scholars in the last decade compared to the previous ones. Again, another sign that urban planning science is becoming more global. The rise of new hubs/origins for urban planning research is also noted, especially China.

6.3. Implications for practice and scholarly research

The objective determination of trends provided by this paper can help urban planners to level their efforts and attention to various topics in an informed way. In the absence of such work, a broad understanding of the field and its characteristics will remain elusive. The fact that we identified distinct periods in urban planning research (classic, intermediate and contemporary) means that urban planners were educated in different periods of time that have had quite different perspectives and knowledge sources. The field shows paradigm shifts and moves on from topics every few years, and unless one is at the forefront of research, their education may become outdated. This has implications for practitioners as well as curriculum developers.

Our results (the dynamic visualisation of the document co-citation map) show how quickly the field has evolved, providing an indication of how often urban planning programs may need a revisit of their curriculum. This has implications for urban planning professional associations as well. With the changing landscape of urban planning, capacity building and training programs will need further consideration to upskill planning professionals to address new paradigm requirements. For example, urban resilience and smart cities are very specific and distinct domains that need a multi-disciplinary training approach to prepare urban planners and policy makers in addressing climate change issues and leveraging emerging technologies for sustainable, productive, and liveable cities.

6.4. Limitations and directions for further research

There are still many unanswered questions about the underpinning reasons for the observed trends in urban planning science. Further research should be undertaken to specifically investigate each cluster's dynamics, their interrelation with other clusters and the stimulating factors in the gradual transition. The current study, covering the entirety of the field at the scale of nearly a hundred thousand articles, did not allow a higher level of granularity in the analyses. In future studies, it might be possible to extract the urban planning research published in non-planning journals and identify the trend of multi-disciplinary collaborations in the field. This will answer the question of how urban planning is influenced from other disciplines and how this field influenced other sciences. Further studies on the current topic are therefore recommended.

CRediT authorship contribution statement

Milad Haghani: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Validation; Visualisation; Roles/Writing - original draft; Writing - review & editing. **Soheil Sabri**: Conceptualization; Investigation; Validation; Roles/Writing - original draft; Writing - review & editing. **Chris De Gruyter**: Conceptualization; Investigation; Validation; Roles/Writing - original draft; Writing - review & editing. **Ali Ardeshiri**: Conceptualization; Investigation; Validation; Roles/Writing - original draft; Writing - review & editing. **Zahra Shahhoseini**: Conceptualization; Investigation; Data curation; review & editing. **Thomas W. Sanchez**: Conceptualization; Investigation; Roles/Writing - original draft; Writing - review & editing. **Michele Acuto**: Investigation; Roles/Writing - original draft; Writing - review & editing.

Declaration of competing interest

The authors have no conflict of interest to declare.

Data availability

Data will be made available on request.

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Appendix A. Clusters of document do-citation network of urban planning field along with influential references of each cluster

Cluster ID Author descriptor Top terms	Cluster statistics - size - silhouette score - mean year (ref) - year range (ref) - mean year (citing) - year range (citing)		Influential references Highest local citation count		Strongest citation burst (strength, duration)			Highest centrality		Highest coverage citing articles	
Cluster #1	S	533	Tiebout (1956)	865	Muth (1969)	180.44	1971–1999	Tiebout (1956)	0.1	Bovaird (2016)	15
urban economics	SS	0.878	Alonso (1964)	596	Alonso (1964)	99.74	1971–1994	Alonso (1964)	0.08	Behrens et al. (2017)	13
	MY(ref)	1972	Muth (1969)	477	Mills et al. (1972)	83.59	1974–1998	Muth (1969)	0.07	Ahrend et al. (2017)	11
- housing demand	YR(ref)	1920–2010	Roback (1982)	361	Isard (1956)	54.19	1978–2002	Isard (1960)	0.05	Capello (2002)	11
- residential choice	MY (citing)	1988	Rosen (1974a, 1974b)	338	Isard (1960)	42.48	1978–1997	Mills et al. (1972)	0.03	Dessemontet et al. (2010)	11
- residential location	YR (citing)	1970–2019	Hotelling (1929)	241	Mills et al. (1972)	41.51	1970–1989	Isard (1956)	0.03	Charney (1993)	10
- urban housing			Mills (1967)	234	Maddala (1983)	36.61	1978–1992	Mills (1967)	0.03	Chauvin et al. (2017)	10
- housing characteristics			Mills et al. (1972)	181	Wilson (1970)	36.42	1988–2005	Rosen (1974a, 1974b)	0.03	Diamond (2016)	10
			Heckman (1979)	125	Kain and Quigley (1975)	34.26	1972–1994	Roback (1982)	0.03		
			Isard (1956)	118	Wheaton (1974)	34.12	1978–1996	Christaller and Baskin (1966)	0.02		
							1978–1997	Sjaastad (1962)	0.02		
								Hotelling (1929)	0.02		
Cluster #2	S	389	Krugman (1991a, 1991b)	740	Krugman (1991a, 1991b)	126.74	1994–2011	Granovetter (1985)	0.05	Andersson et al. (2005)	20
welfare economics	SS	0.847	Jacobs (1969)	630	Porter (1990)	117.48	2000–2009	Glaeser et al. (1992)	0.03	Andersson et al. (2009)	20
- regional innovation	MY(ref)	1997	Glaeser et al. (1992)	609	Fujita et al. (1999)	95.28	2000–2009	Jacobs (1969)	0.03	Andersson et al. (2009)	19
- agglomeration	YR(ref)	1890–2020	Boschma (2005)	485	Storper (1997)	75.81	1999–2011	Storper and Walker (1989)	0.02	Balland et al. (2014)	19
- externalities	MY (citing)	2011	Bathelt et al. (2004)	458	Marshall (1890)	67.16	2002–2012			Behrens and Robert-Nicoud (2009)	19
	YR (citing)	1997–2021	Lucas (1988)	447	Morgan (1997)	60.21	1999–2012			Bugge and Øiestad (2014)	18
			Jaffe et al. (1993)	411	Piore and Sabel (1984)	53.99	1989–2004			Acs and Varga (2016)	18
			Romer (1986)	408	Porter (1990)	53.53	1993–1999			Boschma (2014)	18
			Krugman (1991a, 1991b)	403	North (1990)	46.66	2000–2011			Asheim et al. (2011)	17
			Storper (1997)	392			2001–2009			Backman (2014)	17
			Granovetter (1985)	391						Barrios et al. (2009)	17
										Bontje et al. (2013)	17
Cluster #3	S	345	Logan and Molotch (1987)	679	Harvey (1989a, 1989b)	84.74	1991–2008	Harvey (1973)	0.16	Clarke and Kirby (1990)	17
urban governance	SS	0.822	Stone (1989)	415	Peterson (1981)	78.99	1987–2002	Logan and Molotch (1987)	0.07	Eder and Öz (2015)	16
- growth machine	MY(ref)	1984	Molotch (1976)	409	Bluestone and Harrison (1982)	72.96	1983–2001	Harvey (1982)	0.05	Brenner (2002)	15
- urban America - tourism urbanisation	YR(ref)	1899–2009	Peterson (1981)	407	Lefebvre (1991)	65.39	1986–1999	Bluestone and Harrison (1982)	0.04	Chaskin et al. (2009)	14
Urban Governance & Politics	MY (citing)	1999	Harvey (1973)	352	Mollenkopf (1983)	61.19	2000–2009	Dahl (1961)	0.03	Centner (2008)	14
	YR (citing)	1972–2020	Harvey (1989a, 1989b)	274	Elkin (1987)	54.12	1984–2002	Harvey (1989a, 1989b)	0.02	Brenner (2003)	14
			Bourdieu (1984)	189	Logan and Molotch (1987)	47	1990–2004	Peterson (1981)	0.02	Bovaird (1993)	12
			Bluestone and Harrison (1982)	147	Castells (1983)	46.77	1990–2001	Castells (1977)	0.02	Fraser et al. (2003)	12
			Lefebvre (1991)	136			1987–2003	Gans (1962)	0.02	Berglund (2020)	11
			Harvey (1985)	133				Stone (1989)	0.02	Blumenberg and Manville (2004)	11
								Molotch (1976)	0.02		
								Harvey (1985)	0.02		
Cluster #4	S	295	Massey and Denton (1993)	697	Wilson (1987)	185.53	1989–2010	Wilson (1987)	0.04	Blanco et al. (2009)	15
urban sociology	SS	0.859	Wilson (1987)	612	Putnam et al. (1994)	119.92	1996–2009	Massey and Denton (1993)	0.03	Curley (2010a, 2010b)	14
- social capital	MY(ref)	1994	Granovetter (1973)	446	Putnam (2000)	93.23	2001–2012	Kain (1968)	0.02	Anderson and Sternberg (2012)	14
- residential segregation	YR(ref)	1925–2017	Coleman (1988)	351	Wilson (1987)	59.91	2012–2019	Wilson (1996)	0.02	Curley (2010a, 2010b)	13
- spatial mismatch - public housing	MY (citing)	2009	Wilson (1987)	323	Putnam (2000)	53.27	2012–2019	Granovetter (1973)	0.02	Chaskin and Joseph (2013)	13
	YR (citing)	1991–2021	Putnam (2000)	306	Kain (1992)	44.04	1995–2006	Sampson et al. (1997)	0.02	Chaskin and Joseph (2009)	12
			Putnam et al. (1994)	278	Rusk (1993)	43.82	1994–2001			Andersson et al. (2007)	12

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Cluster ID Author descriptor Top terms	Cluster statistics - size - silhouette score - mean year (ref) - year range (ref) - mean year (citing) - year range (citing)		Influential references Highest local citation count		Strongest citation burst (strength, duration)			Highest centrality		Highest coverage citing articles	
			Kain (1968)	270	Sampson (2012)	42.82	2016–2021			Baumont (2009)	11
			Sampson et al. (1997)	254	Putnam et al. (1994)	42.02	2014–2019			Baum (2004)	11
			Putnam (2000)	241						Blasius and Friedrichs (2007)	11
										August (2016)	11
Cluster #5 global cities	S	262	Harvey (1989a, 1989b)	683	Sassen (1991)	70.79	1993–2005	Harvey (1989a, 1989b)	0.03	Acuto (2011)	19
	SS	0.845	Sassen (1991)	530	Sassen (1994)	64.76	1996–2006	Sassen (1991)	0.02	Ancien (2011)	16
- gated communities	MY(ref)	2002	Graham and Marvin (2001)	443	Sassen (1991)	55.95	1997–2010	Roy (2009)	0.02	Borén and Young (2013)	16
- global city - world cities	YR(ref)	1968–2019	Lefebvre (1991)	418	Castells (1996)	55.09	1999–2006	Graham and Marvin (2001)	0.02	Bunnell (2013)	15
	MY (citing)	2013	Peck et al. (2002)	325	Roy (2005)	49.8	2016–2021			Alexandri (2018)	14
	YR (citing)	1996–2021	Harvey (2005)	322	Graham and Marvin (1996)	48.61	1997–2006			Bierbaum (2020)	14
			Brenner and Theodore (2002)	283	Lovering (2002)	47.1	2000–2009			Boland et al. (2017)	13
			Castells (1996)	265	Taylor (2004)	44.86	2007–2014			Allegra et al. (2013)	13
			Friedmann (1986)	257	Brenner (2004)	44.29	2006–2012			Arundel and Hochstenbach (2019)	13
			Brenner (2004)	232	Flyvbjerg (2006)	43.03	2015–2021				
Cluster #6 urban green space	S	259	Kaplan and Kaplan (1989)	322	Hartig et al. (2014)	41.86	2016–2021	Grimm et al. (2008)	0.02	Calderón-Argelich et al. (2021)	17
- urban green space	SS	0.929	Wolch et al. (2014a, 2014b)	299	Kaplan (1995)	36.86	2016–2021	Kuo and Sullivan (2001)	0.02	Chen et al. (2021)	15
- urban park - ecosystem service	MY(ref)	2008	Chiesura (2004)	273	Roy et al. (2012)	34.34	2015–2021	Kaplan and Kaplan (1989)	0.02	Collins et al. (2020)	14
- urban forest	YR(ref)	1982–2020	Grimm et al. (2008)	250	Forman and Godron (1986)	33.45	2000–2007			Du et al. (2021)	13
	MY (citing)	2018	Tzoulas, Korpela, Venn, Yli-Pelkonen, Kazmierczak, et al. (2007)	233	Bolund and Hunhammar (1999)	31.14	2013–2019			Anguelovski et al. (2017)	13
	YR (citing)	1998–2021	Bolund and Hunhammar (1999)	196	Bowler et al. (2010)	30.78	2014–2021			Ferguson et al. (2018)	13
			Kaplan (1995)	187	Forman (1995)	28.63	2000–2008			Dennis and James (2017)	12
			McKinney (2002)	179	Grimm et al. (2008)	27.55	2013–2021			Alkon and Cadji (2018)	12
			Ulrich et al. (1991)	171	Tzoulas, Korpela, Venn, Yli-Pelkonen, Kazmierczak, et al. (2007)	27.55	2014–2021			Dennis and James (2016)	11
			Bowler et al. (2010)	170	Heynen et al. (2016)	25.55	2016–2021			Badura et al. (2021)	11
										Fan et al. (2021)	10
Cluster #7 urban morphology	S	238	Jacobs (1961)	775	Jacobs (1961)	68.18	2014–2021	Garreau (1991)	0.03	Blanco et al. (2009)	12
	SS	0.83	Jackson (1985)	367	Garreau (1991)	62.59	2019–2021	Jackson (1985)	0.03	Alidadi and Dadashpoor (2017)	9
- urban form - urban sprawl	MY(ref)	1997	Ewing and Cervero (2010)	315	Downs (1994)	58.21	1993–2009	Galster et al. (2001)	0.03	Baumont (2009)	9
- Chinese cities - Seoul Korea	YR(ref)	1902–2020	Garreau (1991)	299	Lynch (1960)	56.49	1995–2006	Lynch (1960)	0.02	Burgalassi and Luzzati (2015)	9
	MY (citing)	2012	Anas et al. (1998)	292	Ewing and Cervero (2010)	55.4	2015–2021	Calthorpe (1993)	0.02	Carruthers and Úlfarsson (2008)	9
	YR (citing)	1987–2021	Cervero and Kockelman (1997)	263	Lynch (1960)	43.25	2014–2021	Anas et al. (1998)	0.02		
			Lynch (1960)	238	Orfield (1997)	38.81	2000–2009				
			Alonso (1964)	222			1998–2008				
Cluster #8 regional policy and development	S	218	Hirschman (1988)	95	Fothergill and Gudgin (1982)	37.82	1983–1996	Pred (1977)	0.02	Malecki (1983)	18
	SS	0.916	Fothergill and Gudgin (1982)	62	Hirschman (1988)	30.48	1989–2008			Elias and Keogh (1982)	13
- regional policy - industrial decline	MY(ref)	1975	Jacobs (1984)	57	Keeble (1976)	24.11	1978–1983			Taylor and Thrift (1983)	13
- regional employment - multi-plant enterprise - large cities	YR(ref)	1900–1992	Pred (1977)	53	Jacobs (1984)	20.44	1997–2006			Suarez-Villa (1988)	12
	MY (citing)	1983	Ben-Akiva and Lerman (1985)	40	Borts and Stein (1964)	20.32	1980–1996			Thwaites (1978)	11
	YR (citing)	1970–2010	Keeble (1976)	36	Miller and Blair (1985)	20.17	1986–1997			Bartels et al. (1982)	10

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Cluster ID Author descriptor Top terms	Cluster statistics - size - silhouette score - mean year (ref) - year range (ref) - mean year (citing) - year range (citing)		Influential references: Highest local citation count		Strongest citation burst (strength, duration)			Highest centrality		Highest coverage citing articles	
			Borts and Stein (1964)	34	Massey and Meegan (1982)	20.17	1983–1991			Hansen (1988)	10
			Miller and Blair (1985)	33	Schmenner (1982)	19.88	1983–1995			Scott (1982)	10
			Segal (1976)	32	Richardson (1973)	19.7	1974–1988				
			Schmenner (1982)	32							
Cluster #9 urban regeneration	S	184	Florida (2002)	1025	Florida (2005)	68.27	2008–2014	Smith (1996)	0.02	Borén and Young (2013)	11
	SS	0.9	Smith (1996)	598	Glaeser et al. (2001)	48.31	2015–2021			Gospodini (2009)	11
- creative class	MY(ref)	2004	Peck (2005)	344	Smith (1979)	38.98	2016–2021			Grodach (2013)	10
- creative city	YR(ref)	1964–2019	Smith (2002)	285	Peck (2005)	37.44	2008–2017			Delgadillo (2016)	10
- creative economy - cultural economy	MY (citing)	2014	Zukin (1995)	236	Lees (2008)	30.33	2011–2018			Butler and Robson (2003)	10
	YR (citing)	2000–2021	Florida (2005)	226	Freeman (2005)	29.01	2015–2021				
			Glaeser et al. (2001)	210	Hsing (2010)	28.77	2014–2021				
			Ley (1996)	197	Slater (2006)	27.27	2007–2016				
			Lees (2008)	172							
Cluster #10 social welfare	S	167	Coleman et al. (1966)	46	Coleman et al. (1966)	30.89	1970–1978	Coleman et al. (1966)	0.03	Lucy (1975)	10
	SS	0.961	Taeuber and Taeuber (1965)	36	Taeuber and Taeuber (1965)	21.32	1985–1997	Lowi (1969)	0.03	Ornstein (1971)	7
- data envelopment - black representation	MY(ref)	1970	Charnes et al. (1978)	30	Jencks (1972)	16.89	1975–1995	Taeuber and Taeuber (1965)	0.02	Newton (1975)	6
- high-school reform	YR(ref)	1900–1991	Jencks (1972)	25	Coleman et al. (1966)	13.89	1973–1978			Lee and Hodge (1984)	6
- cross-national framework	MY (citing)	1980	Coleman et al. (1966)	22	Hunter (1974)	9.25	1978–1991			Galster (1990)	6
	YR (citing)	1970–1996	Ostrom et al. (2014)	16			1979–1986			Gale (1979)	6
			Hunter (1974)	14							
			Suttles (1972)	14							
Cluster #11 participatory planning	S	164	Healey (1997)	461	Jacobs (1961)	117.68	1993–2009	Jacobs (1961)	0.03	Fainstein (2016a, 2016b)	10
	SS	0.896	Arnstein (1969)	442	Forester (1989)	40.58	1995–2003	McHarg et al. (1969)	0.03	Afzalan et al. (2017)	9
- Planning theory - collaborative planning	MY(ref)	1990	Jacobs (1961)	337	Forman and Godron (1986)	40.11	1991–1999	Harvey (1996)	0.03	Alexander (2016)	9
- urban planning - public participation	YR(ref)	1916–2018	Forester (1989)	287	World Commission on Environment and Development. (1987)	38.41	2013–2018	Forester (1989)	0.02	Dadashpoor and Alvandipour (2020)	8
	MY (citing)	2011	Rittel and Webber (1973)	248	McHarg et al. (1969)	36.32	1987–2005	Young (1990)	0.02	Fainstein (2016a, 2016b)	8
	YR (citing)	1971–2021	Harvey (1996)	233	Ajzen (1991)	35.08	2015–2021	Friedmann (1987)	0.02	Campbell (2012)	8
			Forester (1999)	190	Flyvbjerg (1998)	30	2014–2019	Davidoff (1965)	0.02		
			Fainstein (2010)	187	Innes and Booher (2018)	28.74	2018–2021				
			Campbell (1996)	174	Harvey (2000)	27.05	2001–2009				
			Young (1990)	170	Harvey (1996)	27.04	1998–2008				
Cluster #12 regional economies	S	123	Allen et al. (1998)	717	Allen et al. (1998)	55.52	2006–2014	Allen et al. (1998)	0.03	Ertur et al. (2016)	24
	SS	0.923	LeSage and Pace (2009)	383	Barro et al. (1995)	55.32	1998–2008			Ezcurra et al. (2006)	12
	MY(ref)	1995	Anselin (2010)	321	LeSage and Pace (2009)	44.66	2012–2019			Ezcurra et al. (2006)	11
- European Union - regional governance	YR(ref)	1950–2016	Arellano and Bond (1991)	212	Barro and Sala-i-Martin (1991)	39.9	1998–2010			Celbis and de Crombrugghe (2018)	10
- spatial econometrics	MY (citing)	2010	Wooldridge (2002)	177	Wooldridge (2002)	34.1	2010–2016			Debarsy and Ertur (2010)	10
- spatial dependence	YR (citing)	1994–2021	Tobler (1970)	172	Barro (1992)	33.24	1995–2010			Ezcurra et al. (2005)	10
			Bartik (1991)	164	Fujita et al. (1999)	30.64	2002–2010				
			Angrist and Pischke (2009)	148	Rey and Montouri (1999)	29.81	2003–2009				
			Solow (1956)	142	Bartik (1991)	29.05	1994–1999				
			Blundell and Bond (1998)	137							
Cluster #13 urban resilience	S	102	Ostrom (1990)	174	Holling (1973)	35.72	2014–2021	Folke (2006)	0.03	Bierbaum (2020)	11
	SS	0.949	Yin (2018)	173	Miles and Huberman (1994)	31.94	2014–2021				
- urban resilience	MY(ref)	2002	Holling (1973)	161	Davoudi et al. (2012)	31.67	2015–2021				

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Cluster ID Author descriptor Top terms	Cluster statistics - size - silhouette score - mean year (ref) - year range (ref) - mean year (citing) - year range (citing)		Influential references Highest local citation count		Strongest citation burst (strength, duration)			Highest centrality		Highest coverage citing articles	
- economic resilience	YR(ref)	1944–2019	Glaser and Strauss (1967)	159	Yin (2018)	30.75	2017–2021				
- regional resilience	MY (citing)	2017	Miles and Huberman (1994)	144	Ostrom (1990)	28.07	2014–2021				
- developing countries	YR (citing)	1986–2021	Folke (2006)	129	Martin (2011)	25.81	2014–2019				
			Davoudi et al. (2012)	119	Geels and Schot (2007)	23.6	2014–2018				
			Milner (2012)	103	United Nations Centre for Human Settlements. (1996)	22.38	1997–2001				
			Geels (2002)	102	Bulkeley and Betsill (2005)	20.35	2013–2019				
			Giddens (1984)	95	Simmie and Martin (2010)	20.23	2014–2019				
Cluster #14 political economy	S	54	Piketty and Goldhammer (2014)	126	Piketty and Goldhammer (2014)	33.54	2015–2021			Hochstenbach et al. (2020)	9
	SS	0.958	Esping-Andersen (1990)	118	Yin (2003)	33.33	2014–2021			Byrne (2019)	9
- multiple property ownership	MY(ref)	1996	Yin (2003)	117	Miles and Huberman (1994)	31.69	2005–2012			Norris and Byrne (2020)	9
- intergenerational transfer	YR(ref)	1900–2018	Sen (1999)	78	Ronald (2008)	21.39	2015–2021				
- asset-based welfare	MY (citing)	2015	Miles and Huberman (1994)	77	Patton and Patton (1990)	10.37	2010–2014				
- private rental sector	YR (citing)	1995–2021	Beck (1992)	67	Kemeny (1995)	10.26	1998–2002				
			Rolnik (2013)	65	Delpit (1995)	10.1	2004–2011				
			Ronald (2008)	65	Esping-Andersen (1990)	8.06	1996–2002				
Cluster #15 urban shrinkage	S	33	Long et al. (2012)	107	Long et al. (2012)	30.48	2014–2021	Schilling and Logan (2008a, 2008b)	0.02	Lang et al. (2020)	11
- shrinking city - rural China	SS	0.991	Schilling and Logan (2008a, 2008b))	105						Du et al. (2020)	11
- rural restructuring	MY(ref)	2011	Martinez-Fernandez et al. (2012)	70						Wu and Wang (2020)	10
	YR(ref)	2000–2018	Turok and Mykhnenko (2007)	43							
	MY (citing)	2019	Wiechmann and Pallagst (2012)	35							
	YR (citing)	2014–2021	Woods (2016)	30							
Cluster #16 smart cities	S	24	Caragliu et al. (2011)	101	Caragliu et al. (2011)	32.26	2016–2021			Csukás and Szabó (2021)	11
	SS	0.99	Kitchin (2013)	95	Hollands (2008)	30.02	2016–2021			Marek et al. (2017)	11
- smart city	MY(ref)	2013	Hollands (2008)	94	Goodchild (2007)	24.38	2015–2019			Masik et al. (2021)	10
- smart governance	YR(ref)	2007–2017	Vanolo (2013)	74							
	MY (citing)	2019	Albino et al. (2015)	73							
	YR (citing)	2016–2021	Söderström et al. (2014)	62							
			Goodchild (2007)	62							
Cluster #17 urban renaissance	S	20	World Commission on Environment and Development. (1987)	121	World Commission on Environment and Development. (1987)	45.99	1988–2002			Cole et al. (1978)	4
- West African urbanisation	SS	0.996	Meadows et al. (1972)	74	Meadows et al. (1972)	32.56	1974–2000				
- scenario generation	MY(ref)	1977	Forrester (1971)	17	Forrester (1971)	11.26	1972–1981				
- Tolley model	YR(ref)	1961–1993			Toffler (1970)	4.75	1973–1977				
	MY (citing)	1985									
	YR (citing)	1973–2011									
Cluster #18 post-normal science	S	13	Funtowicz and Ravetz (1993)	51	Thompson Klein (2004)	8.37	2010–2015			Zscheischler and Rogga (2015)	8
	SS	1	Gibbons (1994)	36						Popa et al. (2015)	7
- land use science	MY(ref)	2003	Thompson Klein (2004)	19						Serrao-Neumann et al. (2015)	6
- empirical finding	YR(ref)	1991–2013	Sardar (2010)	15						Mitchell et al. (2015)	6
- pragmatist approach	MY (citing)	2014	Cash et al. (2003)	13						Schauppenlehner-Kloyber and Penker (2015)	5

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Cluster ID Author descriptor Top terms	Cluster statistics - size - silhouette score - mean year (ref) - year range (ref) - mean year (citing) - year range (citing)	Influential references				Highest coverage citing articles	
		Highest local citation count		Strongest citation burst (strength, duration)	Highest centrality		
	YR (citing) 2010–2015	Mobjörk (2010)	13			Rosendahl et al. (2015)	5
		Lang et al. (2012)	12				
		Helga Nowotny and Michael (2001)	11				

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cities.2023.104261.

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