

Emerging Trends and New Developments on Urban Resilience: A Bibliometric Perspective

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Abstract

Urban resilience is concerned by the scholars in the world, especially in light of new uncertainty challenges for cities such as natural disasters and man-made disasters. We performed a bibliometric analysis on urban resilience research based on the 1296 articles in the SCI, SCIE, SSCI and A&HCI database from 1986 to 2015. Publication trends were discussed in HistCite to reveal the publication outputs, subject categories and publication pattern, most prolific authors and international productivity. The document co-citation analysis was made in CiteSpace III to explore the research basements and research trajectories, emerging trends and new developments. Growth of article output has emerged since 2003. Environmental studies and environmental sciences came out the most urban resilience articles. *Ecology and Society* was the most productive journal in this area. Barthel was the most prolific author. USA and UK were the most productive countries, and Arizona State University was the most high-productive institution, but the cooperation is lacking in the worldwide. Two streams were detected from the co-cited papers. "Governance", "climate-change" and "city" are research hotspots of urban resilience according to the strongest citation bursts of keywords, and Folke's paper published in 2006 has the strongest bursts. Future research will focus on ecosystem service, adaptive capacity and human-dominated ecosystem.

Keywords

Urban Resilience, Bibliometric Analysis, Research Fronts, Burst Analysis, CiteSpace

1. Introduction

Urbanization is a vital social development in the 21st century, as the global proportion of urban population has

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increased from 28.3% to 50% in 2010. While man is facing all sorts of emerging uncertainty challenges in social progress, such as natural disasters (e.g. earthquake, flood, drought, climate change, etc.) and man-made disasters (e.g. environmental pollution, war, terrorism, etc.). Urban resilience is a significant capacity to adjust to stress from hazards and to recover quickly from their impacts from catastrophe. Indeed, urban resilience can be seen in the context of risk and vulnerability assessments, institutional and social governance structures, resilience in (or of) different sectors (e.g. ecosystem, economy, etc.), and transformations of urban areas. In other words, to strengthen urban resilience is beneficial to reduce the influence of urban disaster.

To develop opportunities for the sustainable development of cities, researchers from multiple disciplines are studying the feedback, dynamics, and behavior of urban vulnerability and urban resilience in the face of urban crisis, such as the axioms and mean of urban resilience (Campanella, 2006; Surjan et al., 2011; Wilkinson, 2012; Childers et al., 2014), climate change and urban resilience (Grimm et al., 2008; Leichenko, 2011; Tyler & Moench, 2012), spatial planning and urban resilience in the flood risk (Deppisch & Schaerffer, 2011; Cruz et al., 2013; Lu, 2014), urban resilience and human-dominated ecosystems (Ernstson et al., 2010), urban infrastructure systems (Wilbanks et al., 2012; Ouyang & Wang, 2015), urban resilience index (Attoh-Okine et al., 2009; Sellberg et al., 2015), urban social resilience (Cutter et al., 2010; Tate, 2012) and resilient cities (Godschalk, 2003; Pickett et al., 2004; Desouza & Flanery, 2013; Vale, 2014). Further, topics on urban resilience and its related domain have become hot-debated focus (Beilin & Wilkinson, 2015). It is necessary to describe the status qua on urban resilience studies for exploring the research basements and research fronts.

Some scholars have made some reviews on urban resilience or resilient cities (Lang, 2011; Müller, 2011; Chelleri, 2012; Jha et al., 2013; Cartalis, 2014), and bibliometric analysis could display the research performance and trajectories, emerging trends and new developments (Chen, 2006; Chen et al., 2014; Wang & Liu, 2014; Kim & Chen, 2015), but a review used bibliometric analysis has been not much. However some researchers focused on resilience research (Xu et al., 2015; Meerow & Newell, 2015) with bibliometric analysis. These studies could not get the map of the urban resilience research.

In this article, we will provide a comprehensive survey of the advance of urban resilience. More specifically, it aims to 1) present mainly publication outputs, subject categories and publication pattern, most-prolific authors and international productivity; 2) emerge the research basements and research trajectories by visualizing the citation network using CiteSpace III; 3) identify the research trends and new developments according to the keywords and cited references with strongest citation bursts.

2. Data and Methods

We established an analysis database of urban resilience from the Science Citation Index (SCI), Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI) and Arts and Humanities Citation Index (A&HCI) supported by Web of Science. “Urban resilience” or “resilient city” or “resilient cities” were used as keywords to search from 1st January, 1986 to 5th August, 2015. Then we removed duplicate articles and got 1296 related articles.

Many available tools are used by bibliometric research, such as HistCite, CiteSpace, VOSviewer and Sci² etc. HistCite is a flexible tool to provide research perspectives and information in our analysis database (Garfield, 2009) through GCS, LCS, LCR, LCS/t and GCS/t indicators, such as to analyze the classical literatures, to look for the productivity authors and institutions. Meanwhile, CiteSpace is popular to study the knowledge domain in a scientific field (Chen et al., 2014), can be used to analyze the knowledge basement and development track, to detect emerging trends and new developments.

3. Empirical Results

3.1. Publication Outputs

There has become a rapid increase on urban resilience work since 2003, as showed in **Figure 1**. According to the curve of publication number on urban resilience research, two stages can be notified. Before 2003: The articles number kept a low level. In this period, many workers paid great attention to the high-risk and resilient children, psychosocial resilience, urban children with stress resilient and stress affect outcomes, talked about that how to improve the human development in the city. After 2003: With the climate change and disasters increasing in the world, how to promote the orderly development of the city had attracted the attention of scholars.

Pursuers of diverse disciplines to conduct researches on the resilient city and urban resilience from different angles. And the publication number grew from 12 in 2003 to 215 in 2014 steeply.

Regarding publishing language, eight languages were discovered among 1296 articles. 1275, or 98.4%, of the articles were submitted in English. A few articles were published in Spanish (8), French (5), Portuguese (3), Slovenian (2), German (1), Polish (1) and Russian (1).

3.2. Subject Categories and Publication Pattern

Several ISI-defined subject categories were included, such as environmental studies, environmental sciences, urban studies, ecology, geography etc. We presented the uppermost 10 subject categories in **Table 1**. The most common categories were environmental studies (260; 20.06%), environmental sciences (203; 15.66%), urban studies (176; 13.58%), ecology (141; 10.88). Meanwhile, we find out the urban resilience research has the nature of multidisciplinary, involves the environmental science, ecology, geography, psychology and social work etc.

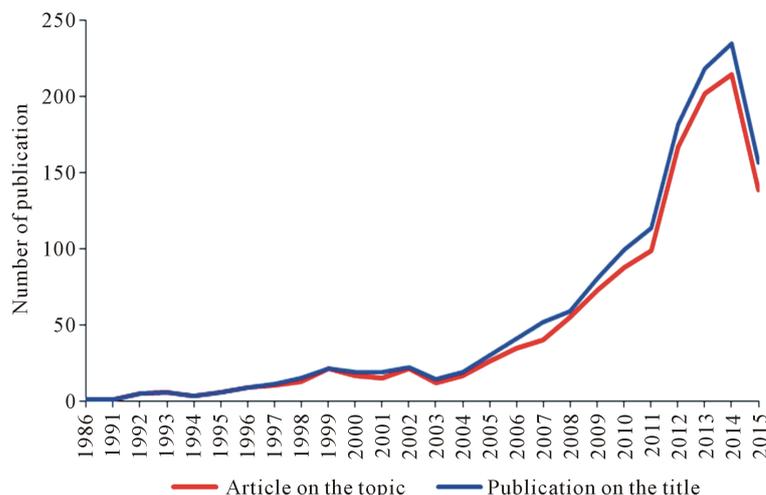


Figure 1. Growth of urban resilience study publications from 1986 to 2015.

Table 1. Distribution of the subject categories: the top 10.

Web of science subject category	TA	%
Environmental studies	260	20.06
Environmental sciences	203	15.66
Urban studies	176	13.58
Ecology	141	10.88
Geography	128	9.88
Public environmental occupational health	109	8.41
Water resources	101	7.79
Geosciences multidisciplinary	69	5.32
Psychology developmental	69	5.32
Planning development	65	5.02

TA, the number of articles on one subject category.

These 1296 urban resilience articles were issued in 604 ISI-indexed journals. Maximum 18 active journals (2.98% of the 604 journals) published 741 papers (21.84%) out of a total of 1296 articles, while 388 journals (64.24%) published only one paper. **Table 2** showed the 18 most common journals on urban resilience research, along with the number of articles, the number of the LCS, LCS/t, GCS, GCS/t and LCR received. The main publication journal for urban resilience research included *Ecology and Society*, *Environment and Urbanization*, *Landscape and Urban Planning*, *Sustainability*, *Urban Studies* and *Cities*. In *Ecology and Society*, 34 articles, or 2.62% out of the 1296 journals articles, were published, and received 543 GCS, 77.76 GCS/t and 22 LCR. *Environment and Urbanization* ranked second in terms of published numbers, with 28 articles, 43 LCS, 11.91 LCS/t, 218 GCS, 39.14 GCS/t and 20 LCR.

3.3. Most-Prolific Authors and International Productivity

3624 authors concentrated on the urban resilience and published related articles. However, only 67 scholars produced more than 4 papers, accounting for 1.85% of the total scholars, 3267 authors only had one article. **Table 3** lists the 18 most productive authors, each with more than 5 published articles on related study. The most prolific author, Stephan Barthel and Rajib Shaw, had published 10 papers. Stephan Barthel work at Stockholm University in Sweden, with 47 LCS and 245 GCS. Rajib Shaw service for Kyoto University in Japan, with 4 LCS and 18 GCS. Other prolific authors included Kylie Bail, Emory L. Cowen, Peter A. Wyman, and so on. It is useful to mention that all the 18 most prolific scholars in **Table 3**, who come from developed countries.

Table 2. Most active scholarly journals in urban resilience research.

#	Journal name	TA	TA%	LCS	LCS/t	GCS	GCS/t	LCR
1	Ecology and Society	34	2.62	0	0	543	77.76	22
2	Environment and Urbanization	28	2.16	43	11.91	218	39.14	20
3	Landscape and Urban Planning	25	1.93	60	10.10	300	54.46	33
4	Sustainability	19	1.47	0	0	26	8.33	18
5	Urban Studies	18	1.39	12	5.10	147	30.44	20
6	Cities	17	1.31	12	4.75	62	22.95	33
7	Global Environmental Change-Human and Policy Dimensions	15	1.16	38	8.08	192	44.21	20
8	Natural Hazards	14	1.08	9	1.86	92	17.45	1
9	Natural Hazards and Earth System Sciences	14	1.08	8	2.33	39	8.88	14
10	Building Research And Information	13	1.00	5	1.72	47	11.21	11
11	Habitat International	12	0.93	0	0	34	6.55	13
12	Water Science and Technology	12	0.93	8	1.67	77	11.23	3
13	PLoS ONE	11	0.85	0	0	45	16.00	1
14	Urban Education	11	0.85	5	0.79	149	15.70	6
15	American Journal of Community Psychology	10	0.77	33	2.51	251	23.15	15
16	Development and Psychopathology	10	0.77	44	2.31	780	52.23	3
17	Environmental Hazards-Human and Policy Dimensions	10	0.77	4	0.62	34	6.04	7
18	Urban Ecosystems	10	0.77	2	0.67	36	10.60	2

TA, total number of articles; TA%, the percentage in the 3085 articles; LCS, local citation scores; LCS/t, local citation scores per year; GCS, global citation scores; GCS/t, global citation scores per year; LCR, local cited references.

Table 3. The 18 most-productive authors.

#	Author name	Full name	TA	LCS	LCS/t	GCS	GCS/t	Institute
1	Barthel S	Stephan Barthel	10	47	11.67	245	48.70	Stockholm University
2	Shaw R	Rajib Shaw	10	4	0.79	18	4.36	Kyoto University
3	Bail K	Kylie Bail	9	8	1.83	69	15.75	Deakin University
4	Cowen EL	Emory L. Cowen	9	70	3.28	342	16.02	University of Rochester
5	Wyman PA	Peter A. Wyman	9	70	3.28	342	16.02	University of Rochester
6	Colding J	Johan Colding	8	39	7.67	218	32.53	Stockholm University
7	Elmqvist T	Thomas Elmqvist	8	33	6.00	168	23.57	Stockholm University
8	Work WC	William C. Work	8	68	3.15	336	15.62	University of Rochester
9	Brown RR	Rebekah R. Brown	7	7	2.14	36	10.10	Monash University
10	Ernstson H	Henrik Ernstson	7	33	6.83	183	34.38	Stockholm University
11	Masten AS	Ann S. Mastern	7	18	1.21	458	36.64	University of Minnesota Twin Cities
12	Bradley B	Bekh Bradley	6	2	0.40	37	7.97	Emory University School of Medicine
13	Broto VC	Vanesa Castan Broto	6	5	2.00	44	16.5	University College London
14	Crawford D	David Crawford	6	7	1.58	59	12.58	Deakin University
15	Pickett STA	Steward T.A. Pickett	6	36	4.58	131	20.00	Cary Institution of Ecosystem Studies
16	Ressler KJ	Kerry J. Ressler	6	3	0.54	63	10.82	Emory University School of Medicine
17	Wallace R	Rodrick Wallace	6	9	0.68	51	4.41	New York State Psychiatric Institution
18	Zevenbergen C	Chris Zevenbergen	6	11	1.86	47	8.13	UNESCO-IHE

TA, total number of articles; LCS, local citation score; LCS/t, local citation scores per year; GCS, global citation score; GCS/t, global citation scores per year.

The 1296 urban resilience research articles were scattered geographic distribution in the world, and gathered mainly in the developed country. Five countries or regions contribute to the urban resilience research articles more than 50 papers, most of the countries or territories published less than 10 articles. United State was the most industrious country with 510 articles, and got the largest LCS (452) and GCS (8391), and had the largest average citation rate of LCS (0.89) and GCS (16.45). UK was the succeeding productive country with 203 articles, and received the second LCS (134) and GCS (1987). Australia was the third productive country (125), followed Canada (80) and Netherlands (52). Other prolific countries included Sweden (46), Germany (43), China (39), South Africa (39), and so on. More interestingly, the result confirmed that most of developed countries with post-urbanization paid attention to the urban resilience specially, and just a few developing countries with rapid urbanization has begun to emphasize the related research, such as China, South Africa, Brazil, India (see [Table 4](#)).

Institution distribution of urban resilience research was gathered, and mainly concentrated in several developed countries, such as USA, UK and Australia. [Table 5](#) displayed the 21 most fruitful research institutions, each with more than 13 articles. Arizona State University was the most high-producing institution with 27 articles (2.08% of the 1296 articles), followed closely by Stockholm University (24), University of Maryland (21), Yale University (21). About the urban resilience research, there are several sub-institutions in Arizona State

University, such as school of sustainability, school of social work, school of geography science and urban planning et al. It is necessary to say that Stockholm Resilience Centre was established on 1st January 2007, to advance research on the governance of social-ecological systems with a special emphasis on resilience.

3.4. Research Basement and Research Trajectories

According to the **Figure 2** and **Table 6**, two research streams have been formed. A big stream (A) as **Figure 2** on the right, which paid more attention to urban resilience in the ecology perspective. It was started by **Holling's (1973)** paper called "resilience and stability of ecological systems" in *Annual review of ecology and systematics*. These studies focused on resilience theory (**Gunderson & Holling, 2002; Adger, 2006; Smit & Wandel, 2006**), the resilience of ecological system (**Holling, 1973; Grimm et al., 2000**), the resilience of social-ecological system (**Adger, 2000; Folke et al., 2005; Folke, 2006**), resilient city (**Pelling, 2003; Pickett et al., 2004; Grimm et al., 2008**), disaster and resilience (**Carpenter et al., 2001; Berkes et al., 2003; Wisner et al., 2004**). Another stream (B) concentrated on the psychology and resilience (**Rutter, 1987; Masten et al., 1990; Luthar et al., 2000**), high-risk children and resilience (**Werner & Smit, 1982; Werner & Smith, 1992**).

Table 4. Top 20 productive country of urban resilience research.

#	Country	TA	TA%	LCS	LCS/TA	GCS	GCS/TA
1	USA	510	39.35	452	0.89	8391	16.45
2	UK	203	15.66	134	0.66	1987	9.79
3	Australia	125	9.65	47	0.38	773	6.18
4	Canada	80	6.17	11	0.14	535	6.69
5	Netherlands	52	4.01	34	0.65	288	5.54
6	Sweden	46	3.55	90	1.96	573	12.46
7	Germany	43	3.32	16	0.37	219	5.09
8	China	39	3.01	19	0.49	303	7.77
9	South Africa	39	3.01	47	1.21	261	6.69
10	Italy	38	2.93	11	0.29	233	6.13
11	Spain	36	2.78	6	0.17	272	7.56
12	France	31	2.39	26	0.84	195	6.29
13	Japan	23	1.77	5	0.22	38	1.65
14	Brazil	19	1.47	0	0.00	171	9.00
15	New Zealand	19	1.47	9	0.47	296	15.58
16	Belgium	16	1.23	4	0.25	86	5.38
17	India	16	1.23	4	0.25	68	4.25
18	Switzerland	16	1.23	4	0.25	173	10.81
19	Israel	14	1.08	5	0.36	129	9.21
20	Portugal	11	0.85	2	0.18	44	4.00

TA, total number of articles; TA%, the percentage of the 3085 article; LCS, local citation score; GCS, global citation score.

Table 5. Top 21 productive research institutions of urban resilience research.

#	Institution	TA	TA%	LCS	GCS
1	Arizona State University	27	2.08	47	727
2	Stockholm University	24	1.85	83	501
3	University of Maryland	21	1.62	9	484
4	Yale University	21	1.62	27	443
5	University College London	20	1.54	20	180
6	Columbia University	19	1.47	30	439
7	Monash University	19	1.47	16	110
8	University Melbourne	18	1.39	4	122
9	Harvard University	16	1.23	4	176
10	US Forest Service	16	1.23	7	130
11	University Birmingham	15	1.16	16	85
12	University N Carolina	15	1.16	22	351
13	University Wisconsin	15	1.16	10	339
14	Emory University	14	1.08	10	255
15	University Colorado	14	1.08	13	675
16	University Manchester	14	1.08	30	154
17	Deakin University	13	1.00	8	86
18	Kings College London	13	1.00	5	187
19	Kyoto University	13	1.00	5	28
20	University British Columbia	13	1.00	3	127
21	University California Berkeley	13	1.00	11	198

TA, total number of articles; TA%, the percentage in the 3085 article; LCS, local citation score; GCS, global citation score.

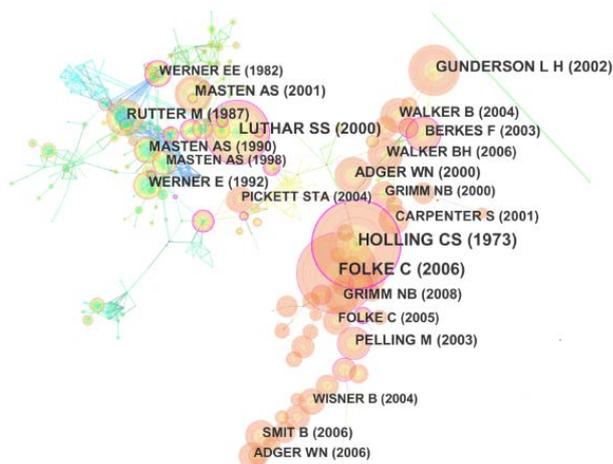


Figure 2. Co-cited of paper on the urban resilience.

Table 6. Research basements and research streams.

#	Article information	Frequence	Stream
1	Holling, 1973, Annual Rev Ecol Syst, V4, P1	97	A
2	Folke, 2006, GLOBAL ENVIRON CHANG, V16, P253	85	A
3	Luthar et al., 2000, CHILD DEV, V71, P543	69	B
4	Gunderson & Holling, 2002, PANARCHY UNDERSTANDI	58	A
5	Rutter, 1987, AM J ORTHOPSYCHIAT, V57, P316	48	B
6	Walker et al., 2004, ECOL SOC, V9	46	A
7	Masten, 2001, AM PSYCHOL, V56, P227	44	B
8	Adger, 2000, PROG HUM GEOG, V24, P347	42	A
9	Walker et al., 2006, RESILIENCE THINKING	40	A
10	Berkes et al., 2003, NAVIGATING SOCIAL EC	38	A
11	Grimm et al., 2008, SCIENCE, V319, P756	37	A
12	Pelling, 2003, VULNERABILITY CITIES	37	A
13	Werner & Smith, 1992, OVERCOMING ODDS HIGH	37	B
14	Masten et al., 1990, DEV PSYCHOPATHOL, V2, P425	36	B
15	Smit & Wandel, 2006, GLOBAL ENVIRON CHANG, V16, P282	35	A
16	Carpenter et al., 2001, ECOSYSTEMS, V4, P765	34	A
17	Werner & Smit, 1982, VULNERABLE INVINCIBL	33	B
18	Folke et al., 2005, ANNU REV ENV RESOUR, V30, P441	32	A
19	Adger, 2006, GLOBAL ENVIRON CHANG, V16, P268	31	A
20	Grimm et al., 2000, BIOSCIENCE, V50, P571	31	A
21	Masten & Coatsworth, 1998, AM PSYCHOL, V53, P205	31	B
22	Pickett et al., 2004, LANDSCAPE URBAN PLAN, V69, P369	31	A
23	Wisner et al., 2004, RISK NATURAL HAZARDS, V2nd	30	A

4. Emerging Trends and New Developments

4.1. Temporal Evolution of Keywords

Keywords are vital components of the article, and it will show the research focus to analyze the keywords frequency and keywords centrality. As **Table 7** showed, in the past study, according to frequency the top 10 keywords were resilience, vulnerability, management, cities, risk, adaptation, systems, children, climate change and urban. However, the top six keywords were biodiversity, adolescents, youth, resilience, ecosystem services and vulnerability, looking from the keywords centrality. United-states as a keyword, had been mentioned 43 times with 0.01 centrality. There are limited reasons, firstly many scholars are interested in urban resilience in USA, and secondly USA is the representative of the developed country.

Similarly, keywords will identify research fronts to explore the burstness of keywords. Some fast growing topics will be detected by analyzing bursts. As **Table 8** showed, competence has the strongest bursts among

Table 7. Top 24 keywords frequency and centrality.

#	Keywords	Frequency	Centrality	Year	#	Keywords	Frequency	Centrality	Year
1	Resilience	484	0.15	1993	13	Health	62	0.01	2002
2	Climate-change	155	0.07	2007	14	Biodiversity	56	0.42	2004
3	Vulnerability	128	0.09	1995	15	Adolescents	55	0.30	1993
4	Management	116	0.08	2004	16	City	53	0.01	2004
5	Cities	106	0.05	2004	17	Ecosystem services	52	0.13	2005
6	Risk	92	0.03	1996	18	Governance	47	0.01	2013
7	Adaptation	90	0.07	2010	19	Youth	46	0.19	1994
8	Systems	84	0.01	2008	20	Framework	46	0.01	2010
9	Children	80	0.04	1993	21	Stress	43	0.08	1993
10	Urban	71	0.01	2001	22	United-states	43	0.01	1993
11	Sustainability	69	0.04	2004	23	Impact	42	0.01	2005
12	Social-ecological systems	62	0.05	2010	24	Urbanization	42	0.01	2007

Table 8. Top 20 keywords with strongest citation bursts.

Keywords	Year	Strength	Begin	End	1986-2015
Competence	1986	12.0149	1986	2007	
Childhood	1986	5.3831	1992	2008	
Family	1986	5.4281	1993	2004	
Children	1986	8.1744	1994	2005	
Youth	1986	5.3045	1994	2006	
Adolescents	1986	6.1366	1995	2003	
Behavior	1986	6.4017	1996	2003	
Urban children	1986	5.4304	1996	2004	
Prevention	1986	4.5489	1996	2009	
Protective factors	1986	4.4138	1996	2005	
Delinquency	1986	4.1046	1996	2003	
Outcomes	1986	3.5142	1996	2005	
Social support	1986	3.7974	1998	2007	
Adjustment	1986	11.0837	1999	2008	
Community violence	1986	3.6593	2003	2007	
New York city	1986	4.7616	2006	2008	
Posttraumatic-stress-disorder	1986	3.8927	2006	2011	
Governance	1986	6.9628	2013	2015	
Climate-change	1986	5.7883	2013	2015	
City	1986	4.1326	2013	2015	

keywords, with 12.0149 burst strength and burst duration from 1986 to 2007. Adjustment was the second strongest citation burst (10.9996) in the period of 1999 and 2008, followed children (8.1744), government (6.9628) and behavior (6.4017). It meant nothing worth that three keywords (“governance”, “climate-change”, “city”) are research focus in the future from the time.

4.2. Burstness of the References

Burst detection and visualization can be implemented to different types of nodes for finding out the research basement of future research. **Table 9** displays the top 20 high citation bursts of articles about urban resilience. From the list, [Folke \(2006\)](#) has the strongest bursts among articles published in *Global Environmental Change*, with 14.1352 burst value and burst duration from 2013 to 2015. It is further curious to note that [Luther et al. \(2000\)](#) has the second strongest citation burst in the period of 2005 and 2011. However, some papers will be research basements for future research, such as [Folke \(2006\)](#), [Cutter et al. \(2008\)](#) and [Barthel et al. \(2010\)](#) in the field of environmental change, [Walker et al. \(2006\)](#) in the theory of resilience, [Davoudi et al. \(2012\)](#) in planning areas, [Walker et al. \(2004\)](#) and [Folke et al. \(2010\)](#) in the ecological society areas.

Table 9. Top 20 references with strongest citation bursts.

References	Year	Strength	Begin	End	1986-2015
Werner, 1989, Am J Orthopsychiat, V59, P72	1989	5.3538	1986	2001	
Rutter, 1987, Am J Orthopsychiat, V57, P316	1987	7.1107	1993	2000	
Werner & Smith, 1992, Overcoming Odds High, V, P	1992	6.6177	1993	2008	
Masten et al., 1990, Dev Psychopathol, V2, P425	1990	6.3382	1993	2004	
Wyman et al., 1991, Am J Commun Psychol, V19, P405	1991	5.5104	1993	2002	
Wyman et al., 1992, J Am Acad Child Psy, V31, P904	1992	5.4153	1993	2001	
Masten & Coatsworth, 1998, Am Psychol, V53, P205	1998	8.5880	1999	2008	
Mcloyd, 1998, Am Psychol, V53, P185	1998	5.4108	2000	2009	
Luthar et al., 2000, Child Dev, V71, P543	2000	8.7105	2005	2011	
Godschalk, 2003, Nat Hazards Rev, V4, P136	2003	6.9447	2012	2015	
Cutter et al., 2003, Soc Sci Quart, V84, P242	2003	6.5584	2012	2013	
Cutter et al., 2008, Global Environ Chang, V18, P598	2008	5.9203	2012	2015	
Wisner et al., 2004, Risk Natural Hazards, V2nd, P	2004	5.4874	2012	2015	
Folke, 2006, Global Environ Chang, V16, P253	2006	14.1352	2013	2015	
Walker et al., 2006, Resilience Thinking, V, P	2006	7.0720	2013	2015	
Davoudi et al., 2012, Planning Theory Prac, V13, P299	2012	6.9824	2013	2015	
Ernstson et al., 2010, Ambio, V39, P531	2010	6.0370	2013	2015	
Walker et al., 2004, Ecol Soc, V9, P	2004	5.9948	2013	2015	
Folke et al., 2010, Ecol Soc, V15, P	2010	5.7072	2013	2015	
Barthel, 2010, Global Environ Chang, V20, P255	2010	5.3367	2013	2015	

4.3. Clusters of Co-Cited References from 1986 to 2015

To identify further development clearly, we showed a timeline visualization based on the dataset which we gathered. Visualized clusters are defined based on citation instances made by the top 50 most-cited articles per three years from 1986 to 2015. Timeline visualizations can be revealed the newly emerged threads. Timeline visualization for $T_{1986-2015}$ is showed in **Figure 3**, animatedly. The largest cluster is cluster #0 on ecosystem services, and the largest circles with red rings depict the references to [Holling \(1973\)](#). Some recent developments since 2010 are presented in **Figure 3** as the clusters' labels. New clusters include #2 on adaptive capacity and #11 on human-dominated ecosystem.

A more detailed visualization was obtained to further investigate new developments about urban resilience as showed **Table 10**. The largest cluster #0 ecosystem service has over 30 references as its members with an average year of publication of 1999. It was high silhouette value of 0.932 indicates a high homogeneity of the cluster.

The largest cluster was formed by more recently published articles, which was #11 and labeled as human-dominated ecosystem. This cluster had ten members and an average year of publication of 2007. And **Table 11** showed seven articles in cluster #11 with the strongest citation bursts. Folke is undoubtedly the major contributors of social-ecological system on urban resilience. Meanwhile, [Folke's \(2006\)](#) paper held the strongest citation bursts in this cluster. **Table 12** showed three most-representative articles of cluster #11. [Ernstson et al.'s \(2010\)](#) work had combined urban resilience and human-dominated ecosystem. This is a mainstream of the present study on urban resilience.

The other cluster included cluster #2, which was labeled as disaster resilience indicator and adaptive capacity. **Table 13** lists nine articles in cluster #2 with the strongest citation bursts. Tilte terms include Resilience, vulnerability, hazards and adaptability. Cutter has been focused on the social vulnerability and social resilience, and published a large number of articles. [Davoudi et al. \(2012\)](#) has the strongest citation bursts in this cluster.



Figure 3. A timeline visualization for $T_{1986-2015}$ is shown. New developments since 2010 are included in the visualization, notably in association with clusters #2 and #11.

Table 10. Largest clusters of co-cited references among the 43 clusters.

Cluster ID	Size	Silhouette	Average year	Label by TF*IDF	Label by log-likelihood ratio	Label by mutual information
0	31	0.932	1999	Ecosystem service	Management	India
1	30	0.842	1992	Exposure	Community violence	Homeless urban adolescent mother
2	28	0.951	2004	Adaptive capacity	Disaster resilience indicator	Year
3	27	0.816	1986	Differentiating young at-risk urban children	Differentiating young at-risk urban children	Turnaround process
4	26	0.800	1989	Stress-affected adolescent	Stress-affected adolescent	Year
5	26	0.854	1993	High school student	High school student	Community
6	20	1.00	1983	Base-isolated structure	Base-isolated structure	Earthquake
7	20	0.853	1984	Major life stress	Major life stress	Promotion
8	20	0.947	1990	Motivation	Motivation	Turnaround process
9	20	0.900	1996	PTSD	Disaster	Community
10	12	0.978	1986	Urban black-adolescent	Urban black-adolescent	School psychologist
11	10	0.977	2007	Human-dominated ecosystem	Human-dominated ecosystem	Case study
12	8	0.991	1988	Psychosocial risk	Protective factor	Moderator effect

Table 11. Articles with strongest citation busts in cluster #11.

Citation	Burst	Author	Year	Title	Source
85	14.14	Folke	2006	Resilience: The emergence of a perspective for social-ecological systems analyses	GLOBAL ENVIRON CHANG
24	6.04	Ernstson et al.	2010	Scale-crossing brokers and network governance of urban ecosystem services: the case of stockholm	AMBIO
25	5.71	Folke et al.	2010	Resilience thinking: integrating resilience, adaptability and transformability	ECOL SOC
14	4.44	Evans	2011	Resilience, ecology and adaptation in the experimental city	T I BRIT GEOGR
31	4.43	Pickett et al.	2004	Resilient cities: meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms	LANDSCAPE URBAN PLAN
32	3.94	Folke et al.	2005	Adaptive governance of social-ecological systems	ANNU REV ENV RESOUR
13	3.57	Ahern	2011	From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world	LANDSCAPE URBAN PLAN

Table 12. Articles that cite over 20% members of cluster #11.

Coverage (%)	Articles citing cluster #11
50	Ernstson, Henrik et al. (2010) urban transitions: on urban resilience and human-dominated ecosystems
40	Ernstson, Henrik et al. (2010) scale-crossing brokers and network governance of urban ecosystem services: the case of stockholm
20	Wilkinson, Cathy (2012) social-ecological resilience: insights and issues for planning theory

Table 13. Articles with strongest citation bursts in cluster #2.

Citation	Burst	Author	Year	Title	Source
19	6.98	Davoudi et al.	2012	Resilience: A Bridging Concept or a Dead End?	PLANNING THEORY PRAC
26	6.94	Godschalk	2003	Urban hazard mitigation: creating resilient cities	NAT HAZARDS REV
26	6.56	Cutter et al.	2003	Social vulnerability to environmental hazards	SOC SCI QUART
39	5.99	Walker et al.	2004	Resilience, adaptability and transformability in social-ecological systems	ECOL SOC
24	5.92	Cutter et al.	2008	A place-based model for understanding community resilience to natural disasters	GLOBAL ENVIRON CHANG
30	5.49	Wisner et al.	2004	At Risk: Natural hazards, people's vulnerability and disasters	BOOK
28	4.93	Norris et al.	2008	Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness	AM J COMMUN PSYCHOL
21	4.52	Folke et al.	2002	Resilience and sustainable development: building adaptive capacity in a world of transformations	AMBIO
18	4.52	Newman et al.	2009	Resilient cities: responding to peak oil and climate change	BOOK

5. Conclusions

In this paper, we have provided bibliometric techniques on research trends in the urban resilience research, based on the 1296 articles, which were downloaded in the Web of Science during the period from 1986 to 2015. The paper presented publication outputs, subject categories and publication pattern, most prolific authors and international productivity, research basements and research trajectories, emerging trends and new developments. Works show that the article number on urban resilience has increased since 2003. Environmental studies and environmental sciences came out the most related papers. Meanwhile, *Ecology and Society* and *Environment and Urbanizations* were the most-prolific journal; Barthel was the most-prolific author. In addition, most research of urban resilience was dominated by USA and UK, and Arizona State University was the most high-productive institution.

Two streams were identified. One stream paid attention to social-ecological system of urban, others focused on psychology and resilience. According to the bursts of the node, these keywords were research hotspots, such as “government”, “climate-change” and “city”; the articles were the research basement of future research, such as Cutter et al. (2008), Folke (2006), Davoudi et al. (2012) and Walker et al. (2006). Future research will focus on three areas mainly, such as ecosystem service, adaptive capacity and human-dominated ecosystem. With the development of global city, more topics will be concerned, such as the metrics of urban resilience, the relationship between leisure city and resilient city, urban vulnerability and urban resilience.

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