Cities 72 (2018) 141–148

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

Urban resilience and urban sustainability: What we know and what do not know?

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ARTICLE INFO

Keywords:
Urban resilience
Urban sustainability
CiteSpace

ABSTRACT

The past literatures have studied both 'urban resilience (UR)' and 'urban sustainability (US)' in terms of the dual character - vulnerability and pertinacity - of cities. However, there is a large overlap between the meaning of resilience and sustainability, which threatens to weaken both concepts. In this study, we discuss the difference between urban resilience (UR) and urban sustainability (US) from three aspects of research trends, research scale and research clusters. CiteSpace 4.0.R5 is used for co-citation analysis, visualizing co-citation networks and research clusters. UR and US studies contrast in not only their different theoretical bases, but also even more in their empirical work. A conceptual framework is proposed to define the difference between UR and US, and four kinds of urban development are examined based on the framework. We indicate that rational urban development can be achieved only when it is both resilient and sustainable, and conclude that urban planners, policymakers and researchers should pay equal attention to both UR and US before decision-making.

1. Introduction

Cities are increasingly becoming complex systems of social, economic and ecological factors (Liu et al., 2007). However, they are very vulnerable when any of their subsystems are destroyed or fail to adapt to new challenges (Coaffee, 2010). Such a situation may lead to a fatal crisis or even destruction (Rao & Summers, 2016). Uncertain factors, such as natural disasters, climate change, energy crises, political instability, financial crises, food security and terrorist attacks play an important role in threatening urban development (Spaans & Waterhout, 2017). Although these threats have already existed worldwide for a long time, few big cities have been permanently destroyed or abandoned since the 19th century (Campanella, 2006). Such famous cities in the world as Hiroshima, Tokyo, Warsaw, Dresden, Berlin and Beirut, for example, although destroyed by wars or natural disasters, continue to exist even more vibrantly than before.

Urban resilience (UR) and urban sustainability (US) are studied here in terms of the dual character - vulnerability and pertinacity - of cities. In the urban research field, UR has gradually changed from an emerging research topic direction into mainstream one. The International Local Governments for Sustainability (ICLEI), for instance, hosted its "1st Global Forum on Urban Resilience and Adaptation" in 2009. The concept of "Planning for Resilient Cities and Regions" was developed by the Association of Collegiate Schools of Planning (ACSP, US) and Association of European Schools of Planning (AESOP) together in 2013 and has been widely recognized by urban academia in both the U.S. and the EU. In May 2014, the Resilience Alliance Resilience 2014, was hosted in Montpellier, France. Increasing numbers of government administrators, research scholars and urban planners participate in UR study and many academic organizations (*e.g.* Resilience Alliance, Resilience Organization, Resilient City Organization) have been founded worldwide.

However, resilience has been closely associated with sustainability for more than a decade, although without precise meaning and often as an additional label attached to pre-existing research (Timon, 2014). In current studies, some scholars hold the view that UR has already replaced US as the mainstreaming concept in the discipline of urban studies. A large overlap between the meaning of resilience and sustainability threatens to weaken both concepts. It is an urgent matter, therefore, to break this confusing status quo by clarifying their relationship. In order to meet this need, this study aims to answer the following question: what is the difference between UR and US? Firstly, a large sample of articles from the Web of Science are reviewed to identify the difference in research trends and research clusters between

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http://dx.doi.org/10.1016/j.cities.2017.08.009
Received 16 December 2016; Received in revised form 28 July 2017; Accepted 11 August 2017
Available online 30 August 2017

UR and US and the differences in research priorities from the different scale of research involved. The New York Sea Gate project is then used as an example to demonstrate the contradictory nature between UR and US. Finally, a new conceptual framework is developed to capture the essential differences between UR and US and from which new and inclusive definitions are offered.

2. Research method and materials

In this study, CiteSpace 4.0.R5 is used to do co-citation analysis, and applied for visualizing co-citation networks and research clusters. CiteSpace is an open-source Java application that must be run on a computer that supports Java (Chen, Hu, Liu, & Tseng, 2012) and can download input data from the Web of Science (WoS) (Madani & Weber, 2016). Applying CiteSpace, researchers can do temporal and structural analyses of various networks derived from academic publications, including document co-citation networks, author co-citation networks and collaboration networks (Mustafee, Bessis, Taylor, & Sotiriadis, 2013). The bibliometric tool focuses on identifying the critical points in the development of a field or domain, especially intellectual turning points and pivotal points (Chen, 2004). It also provides a variety of functions to promote the simulation, understanding and interpretation of literature network patterns and historical patterns, including decomposing a network into clusters, automatically labeling clusters with terms from citing publications and geospatial patterns of collaboration (Chen, Ibekwe-Sanjuan, & Hou, 2010).

The Science Citation Index and Social Sciences Citation Index contained in Database of Web of Science™ Core Collection are used to identify the literature relating to urban/city UR and US. The search terms “urban resilience” or “city resilience” contained in title yield 272 results, while the search terms “urban sustainability” or “city sustainability” yield 679 results. These data are used for trend analysis by ranking all the literature for both UR and US by their frequency of citation. The 200 most cited articles in the SCI and SSCI are therefore imported into CiteSpace to visualize and analyze the co-citation network, aiming to reveal the research clusters. These 400 papers are then reviewed to find the primary differences in UR and US research priorities according to the different scale of research.

3. Differences between UR and US

Temporal evolution, spatial scale and the space-time carrier are recognized as the three main devices for estimating the difference between different objects of study in geography research. These three devices are also often applied in urban studies research. In this section, research trends, scale and clusters are used to represent temporal evolution, spatial scale and the space-time carrier respectively to examine the difference between UR and US studies.

3.1. Difference in research trends

Although there are far fewer papers relevant to UR than US, the momentum (increased rate of articles) of UR studies is much stronger (Fig. 1). The earliest US paper appeared in 1968 (Cain, 1968). This was

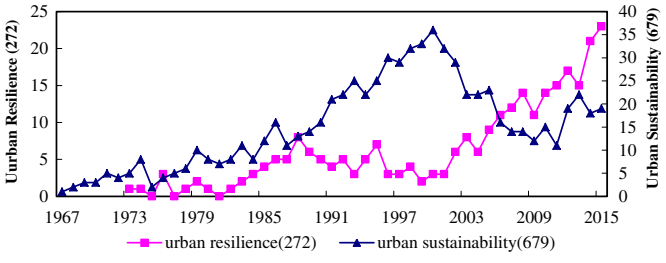


Fig. 1. Publication comparison between UR and US.

concerned with the contribution of land use & planning to urban sustainable development and first recognized the importance of ecological studies as a basis for land use & planning. The first UR article was published five years later (Holling, 1973) and is often cited as the origin of modern UR theory. This is echoed with the fact that the UR and US viewpoints can yield different approaches to the management of multiple kinds of resources from the ecological systems' behaviors. The US research focuses on socioeconomic equilibrium, the maintenance of ecological balance and the harvesting of nature's excessive production with least destabilization. In contrast, the resilience view emphasizes domains of attraction and the need for persistence (Holling, 1973).

Although the first US article was published only 5 year earlier than the first UR study, these two kinds of research are substantially different in their volume and trend of research papers published over the past 50 years. In terms of volume, there were 679 US papers over the period compared with 272 UR papers, suggesting US research to be the most dominating keyword over the period. The trends of the two are quite different, however, as Fig. 1 illustrates, with US peaking at around the year 2000 and UR becoming increasingly popular since that time. This suggests that many US researchers may have chosen to switch their allegiance to UR since the new millennium.

3.2. Difference in research scale

Relatively speaking, US is an old but evolving concept, while UR is new, but inconsistently defined. This section examines the trajectories of the difference in research priorities across global, regional, city, community and facilities levels.

As Table 1 shows, there are many studies involving UR and US from the global to facilities scale, with each having different priorities.

1) On the *global scale*, both UR and US studies involve collective measures for the management and protection of ecological systems. The difference is that UR studies place more emphasis on the self-protection and restoration of ecological systems to cope with crises, while US studies pay more attention to the utilization and protection of ecological resources.
2) On the *regional scale*, US studies place additional emphasis on the self-sufficiency of the local economy and environmental benefits of economic activities, while UR studies keep a watchful eye on the stability and diversification of urban economic structures to cope with unknown risks and pressures.
3) On the *city scale*, UR studies place more prominence on policy management and propose strengthening the institutional arrangement of elastic urban structure to guarantee the adoption of elastic city measures. Moreover, UR studies are more concerned with the influence of terrorism on sound urban development, while US studies always take into account administrative issues, such as urban and land use planning, needed to realize sustainable urban development.
4) On the *community scale*, although both UR and US studies propose providing basic material conditions for residents, such as sufficient water, healthcare and dwellings, the resilient city attaches more importance to diversification and the insurance benefits of employment.
5) On the *facilities scale*, UR studies stress the guarantee of traffic and communication infrastructure to ensure their immediate availability in emergencies and with much greater emphasis on the design of green buildings at the micro level and aseismic requirements of construction. In contrast, US studies always place more emphasis on infrastructure, architectural planning and layout.

3.3. Difference in research clusters

In this section, the 200 most cited UR and US articles are imported into CiteSpace to visualize and analyze the co-citation network, and

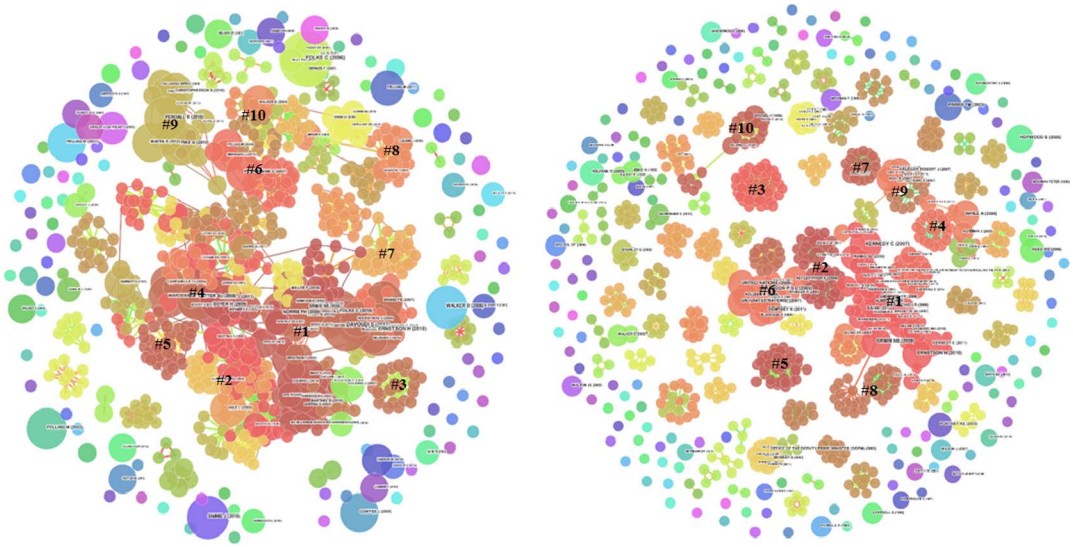
Table 1
Research priorities at different scales.

Scale	Items	UR		US	
Global scale	Ecological environment protection	Ecological environment crises (Woolhouse, Rambaut, & Kellam, 2015)	P	Ecological environment monitoring (Rees & Wackernagel, 1996)	A
		Landscapes and ecosystems for human welfare (Kareiva, Watts, McDonald, & Boucher, 2007)	P	Ecological infrastructure construction (Passarini, Pereira, Farias, Calarge, & Santana, 2014)	A
	Resource protection and utilization	Climate change (Leichenko, 2011)	P	Non-renewable resource protection (Wang, 2011)	A
		Resource inventory (Campanella, 2006)	A	Renewable resource utilization (Banai, 2005)	A
	Population and health	Emergency equipment and personnel (Sui, 2010)	P	Aging (Buffel & Phillipson, 2016)	P
		Space allocation of medical resources (Asprone & Manfredi, 2015)	P	Health service facilities (Chelimsky, 1993)	A
Regional scale	Regional economic structure	Emergency funds for individuals and the public (Stone, 2008)	P	Regional economic vitality improvements (Chan & Lee, 2008)	A
		Regional economic structure update (Barata-Salgueiro & Erkip, 2014)	P	Local economic circulation system (Fung & Kennedy, 2005)	A
	Regional resource flow	Water management (Balsells et al., 2013)	A	Cyclic utilization of natural resources (Tidball & Stedman, 2013)	A
		Resource allocation across regions (Toubin, Laganier, Diab, & Serre, 2015)	P	Optimal allocation of social resources (Wang, 2011)	P
	Regional resource carrying capacity	Factors influencing regional carrying capacity (Davoudi, 2009)	P	Carrying capacity management (Wei, Huang, Li, & Xie, 2016)	A
		Carrying capacity calculations (Wei et al., 2016)	A	Intensive use of resources (Shi & Yu, 2014)	A
Urban/city scale	Urban governance	Diversified employment opportunities (Beilin & Wilkinson, 2015)	P	Land use/urban planning (Foley et al., 2005)	A
		Social insurance and welfare (Wagenaar & Wilkinson, 2015)	P	Urban management system (Moussiopoulos, Achillas, Vlachokostas, Spyridi, & Nikolaou, 2010)	A
	Urban system	Urban spatial structure (Barthel, Parker, & Ernstson, 2015)	A	Urban metabolism (Khan & Uddin, 2015)	A
		Urban flood control and drainage systems (Aerts et al., 2014)	P	Social and economic system (Moussiopoulos et al., 2010)	A
	Urban Security	Corruption (Server, 1996)	P	Safety risk monitoring and warning (Zhang & Guindon, 2006)	P
		Terrorism (Githens-Mazer, 2012)	P	Public awareness of risk (Bagaeen, 2006)	P
Community scale	Residents demand	Emergency needs of residents (Vallance, 2015)	P	Residents' healthy living needs (Marsden & Sonnino, 2012)	A
		Basic security needs of residents (Mehmood, 2016)	P	Residents' quality of life demands (Smith & Levermore, 2008)	A
	Neighborhood	New neighborhood relationships (Chelleri, Schuetze, & Salvati, 2015)	P	Neighborhood effect (Chelleri et al., 2015)	A
		Community exchange platform (Brand & Nicholson, 2016)	A	Community cohesion (Eames & Egmose, 2011)	A
	Community management	Community emergency response (Braun-Lewensohn & Sagy, 2014)	P	Diversity of community income groups (Molnar, Ritz, Heller, & Solecki, 2011)	A
		Community network development (Pauwelussen, 2016)	A	Diversity of age groups (Saadatian, Bin Sopian, & Salleh, 2013)	A
Facilities scale	Infrastructure management	Critical infrastructure planning (Chang, McDaniels, Fox, Dhariwal, & Longstaff, 2014)	A	Infrastructure capital investment (Chester, Pincetl, Elizabeth, Eisenstein, & Matute, 2013)	A
		Continuity of key services (Toubin et al., 2015)	P	Infrastructure selection (Muller, Biswas, Martin-Hurtado, & Tortajada, 2015)	A
	Transportation	Traffic emergency management (Testa, Furtado, & Alipour, 2015)	P	Integrated transport networks (Sinha, 2003)	A
		Transportation security (Cox, Prager, & Rose, 2011)	P	Reliable and compatible communication networks (Pandolfini, Bemposta, Sbardella, Simonetta, & Toschi, 2016)	A
	Building	Green buildings (Zaidi & Pelling, 2015)	P	Buildings plot ratios (Smith & Levermore, 2008)	A
		Earthquake resistant buildings (Takewaki, Fujita, Yamamoto, & Takabatake, 2011)	P	Architectural composition (Specht et al., 2014)	A

Note: "P" indicates that the research aim is the passive measure and response taken in case of influences of external factors. "A" indicates that the research aim is the active selection and behavior generated spontaneously based on its own needs.

further to reveal the research clusters of both UR and US. Cluster labels, cluster members and cluster silhouettes are discussed to identify the specific research field, hotspots and homogeneity of UR and US studies in which:

1) the *cluster label* represents the nature of an identified cluster from phrases in the titles, key words or abstracts of articles citing a particular cluster
2) the *cluster members* indicate the total number articles included in the cluster
3) the *cluster silhouette* indicates the homogeneity of a large-enough-size cluster (Chen & Leydesdorff, 2014), with higher silhouette scores indicating more consistent cluster members when the clusters are of a similar size.



Urban Resilience Studies Urban Sustainability Studies

Fig. 2. Comparison of clusters.

The UR research network is divided into 21 research clusters, although many overlap. These research clusters are labeled by index terms from their own citers. Fig. 2 provides a visual comparison of the UR and US clusters. The different colors represent different clusters. The node size represents the number of times cited. Two nodes with a cited relationship are connected by a line. CiteSpace highlights nodes with highly cited relationship in red, the thickness of which indicates the strength of their connection to other relevant studies. The clusters with more members and higher silhouette values usually appear at the center of the network. The clusters of UR, for example, are more concentrated in the middle of the network with a large area of overlap and there is a close relationship among different clusters. The specific contents of UR studies are relatively concentrated, while those for the US studies are relatively dispersed. However, the US clusters are less connected, with relatively small correlations between specific research fields.

The largest five clusters for the UR and US studies are shown in Table 2a and b, indicating Ecological Systems and Infrastructure Systems to be common for both UR and US studies, with the former being particularly prominent.

The most actively cited of the *Ecological Systems cluster* in UR studies is "*Resilience and stability of ecological systems*" (Holling, 1973). As mentioned earlier, this paper was the first to find that the UR and US viewpoints can yield different approaches to manage multiple kinds of resources from the ecological systems' behavior. In contrast with US studies, the UR view emphasizes the domains of attraction and the need for persistence. The most actively cited in US studies is "*Urban ecological footprints: Why cities cannot be sustainable - And why they are a key to sustainability*" (Rees & Wackernagel, 1996). Hence, a creative approach for assessing the ecological role of cities is introduced in this article. The authors conclude that as nodes of energy, material and natural resources consumption, cities are causally linked to accelerating global ecological decline and are not by themselves sustainable.

Table 2
Largest five clusters.

Cluster ID	Cluster members	Cluster silhouette	Cluster label
a. UR studies			
#1	54	0.86	Ecological Systems
#2	34	0.73	Climate Change
#3	28	0.81	Infrastructure Systems
#4	25	0.63	Emergency Operations
#5	21	0.77	Urban Recovery
b. US studies			
#1	31	0.82	Ecological Systems
#2	27	0.93	Sustainability Indicators
#3	22	0.73	Infrastructure Systems
#4	18	0.83	Urban Metabolism
#5	16	0.68	Urban Land

For the *Infrastructure Systems cluster*, the most actively cited in UR studies is "*A three-stage resilience analysis framework for urban infrastructure systems*" (Ouyang, Duenas-Osorio, & Min, 2012). A new multi-stage framework is proposed to analyze infrastructure resilience in this paper. A series of UR-based improvement strategies are highlighted and appropriate correlations identified. They are combined to establish an expected annual UR metric that is adequate for both single hazards and concurrent multiple hazard types. The most actively cited in this cluster in US studies is "*Developing sustainability criteria for urban infrastructure systems*" (Sahely, Kennedy, & Adams, 2005). In order to assess the sustainability of urban infrastructure systems, a research framework that focuses on key interactions and feedback mechanisms between infrastructure and the economic-social systems, is developed in this paper. As Fig. 2 illustrates, the Infrastructure Systems clusters in both UR and US are very different. The UR cluster in has 28 members and the cluster silhouette is 0.81, which is the second highest in UR studies, while the US cluster silhouette is only 0.73, which is the second lowest in US studies.

The *Emergency Operation cluster* is mainly concentrated in the UR studies. In particular, terrorism, as a new factor influencing UR, has attracted increasing research attention, the most actively cited being "*Elements of resilience after the World Trade Center disaster: Reconstituting New York City's Emergency Operations Centre*" (Kendra & Wachtendorf, 2003). This research identified the factors contributing to UR following the attack as the availability of resources. For a city to be truly resilient, it should have enhanced its capability being substituted for redundancy of 'personnel', 'equipment' and 'space'. This may help generate inner-driving support structured relationships that will help address communication challenges when emergency occurred. After that, proactive engagement activities within the organizational patterns of response integration and role assignments are also needed. This cluster very much overlaps with clusters #1 and #5 (Fig. 2).

Fig. 3. The "Passive - Active" dimension.

Fig. 4. The "Rational - Irrational" dimension.

4. Connections between UR and US

Although urban orders are normally generated from the top-down hierarchy, they may sometimes be generated from bottom-up spontaneity. Top-down hierarchy is a passive way and will be more objective, while bottom-up spontaneity is active and more subjective (Fig. 3).

In addition, urban development can be distinguished on a "Rational - Irrational" dimension (Fig. 4), as it has both a rational side that makes it more formal and an irrational side make it more informal.

Therefore, the two axes can be combined into a matrix with four quadrants (Fig. 5). UR can not only reinforce sustainability, but also leading to unsustainable developmental pathways. Taking advantage of UR to reinforce the urban system dynamics that promote US is a key to achieving desired future US states (Timon, 2014). In addition, it can be seen from Table 1 that the majority of UR and US studies are primarily passive (P) and active (A).

Fig. 5 presents a conceptual framework to encapsulate these differences between UR and US based on their rationality. This indicates four quadrants divided by two dimensions, where the abscissa represents passive-active dimensionality and the ordinate represents rational-irrational dimensionality, the active-rational quadrant represents sustainable, the active-irrational quadrant represents unsustainable, the passive-rational quadrant represents resilient and the passive-irrational quadrant represents rigescent. Both UR and US are considered rational, while urban rigidity and urban unsustainability are deemed irrational. Based on the descriptions and the theoretical and empirical studies analyzed beforehand, we can offer the following definitions:

Urban Resilience is the passive process of monitoring, facilitating, maintaining and recovering a virtual cycle between ecosystem services and human wellbeing through concerted effort under external influencing factors; while.

Urban Sustainability is the active process of synergetic integration and co-evolution between the subsystems making up a city without compromising the possibilities for development of surrounding areas and contributing by this means towards reducing the harmful effects of development on the biosphere.

Understanding UR and US as two different concepts promotes a diversity of solutions to social-ecological problems. This implies that urban planning needs to adopt new metaphors and paradigms to further transform cities (Wilkinson, 2012). Based on the conceptual framework in Fig. 5, therefore, we conclude with four kinds of urban development - RU, SU, URU and USU - representing resilient urban, sustainable urban, un-resilient urban and unsustainable development respectively. Rational urban development, it is argued, can be achieved only when it is both resilient and sustainable. Rational urban development is non-convergent, which means there is no better form of development. If the development is unsustainable and un-resilient, it is considered irrational urban development. Irrational urban development is convergent, which means the eventual destruction of the urban environment. Between these two extremes of rational and irrational urban development, there exist two types of sub-rational urban development, which are sustainable but un-resilient and resilient but unsustainable.

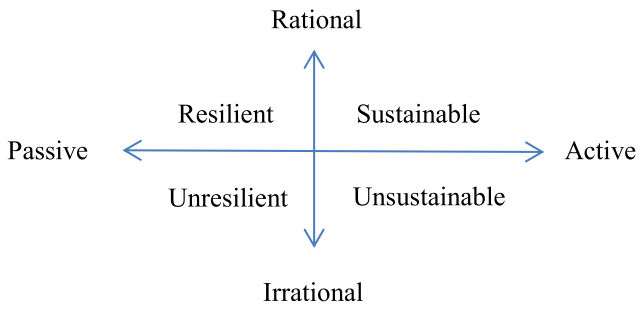


Fig. 5. Difference between UR and US.

5. UR and US may compete with each other

UR and US studies can be compared not only in their different theoretical bases, but also in their empirical work. The differences and connections between UR and US have been discussed in Sections 3 and 4 respectively. In order to apply the theory into real practice, the Sea Gate project used to be proposed by New York City is selected to prove that UR and US are different and they may compete with each other in practice. New York City usually faces significant risks from natural disasters. As a city with more than 520 miles of coastline (one of the most in North America), the potential for more frequent and intense coastal storms (with increased impacts due to a rise in sea level) is a serious threat. This threat, in various forms, touches every part of the city and not just waterfront areas. For instance, in 2012, the Superstorm Sandy hit New York City and the New Jersey coastline. This natural calamity caused 43 deaths, 6500 patients were evacuated from hospitals and nearly 90,000 buildings were submerged. What is worse, about 1.1 million children were unable to attend school for a whole week, and nearly 2 million people could not get access to power and the damage caused was estimated as USD 19 billion.

Therefore, the City believes that it must bulk up its defenses, improving the coastline with protective measures. This will not eliminate all flooding from all conceivable storms - an impossible goal - but mitigate the effects of a rise in sea level, where the risk is greatest, and significantly reduce the effects of storm waves and storm flooding. Although Sandy's presence generally devastated areas that it touched, some coastal features and strategies - such as beaches nourished with sand, dunes, wetlands, new and elevated drainage systems, site elevation and bulkheads - did offer some protection. For example, many nourished beaches and dunes absorbed the destructive energy of waves and floodwaters, buffering adjacent neighborhoods in many cases. As a result, a large technical infrastructure, Sea Gate, was proposed for dealing with any possible storm surges and flooding. In order to enhance New York's UR, this closeable sea gate was to be built at the narrow section of the entrance to New York harbor (Fig. 6). However, the proposal, if implemented, would have serious ecological negative effects and locking the city into economically unsustainable long-term maintenance costs (Timon, 2014). It was therefore a resilient but unsustainable project, in which the UR may not meet the requirements of US, while the US might not achieve the aim of UR.

UR is more relevant to emergency recovery capabilities. As defined in Section 4, it is the passive process of monitoring, facilitating, maintaining and recovering a virtual cycle between ecosystem services and human wellbeing through concerted effort under external influencing factors. Compared with UR, US is an active process of synergetic integration and co-evolution between the subsystems making up a city without compromising the possibilities for development of surrounding areas and contributing by this means towards reducing the harmful effects of development on the biosphere. Thus US is more relevant to the core concept of sustainable development. The modern concept of

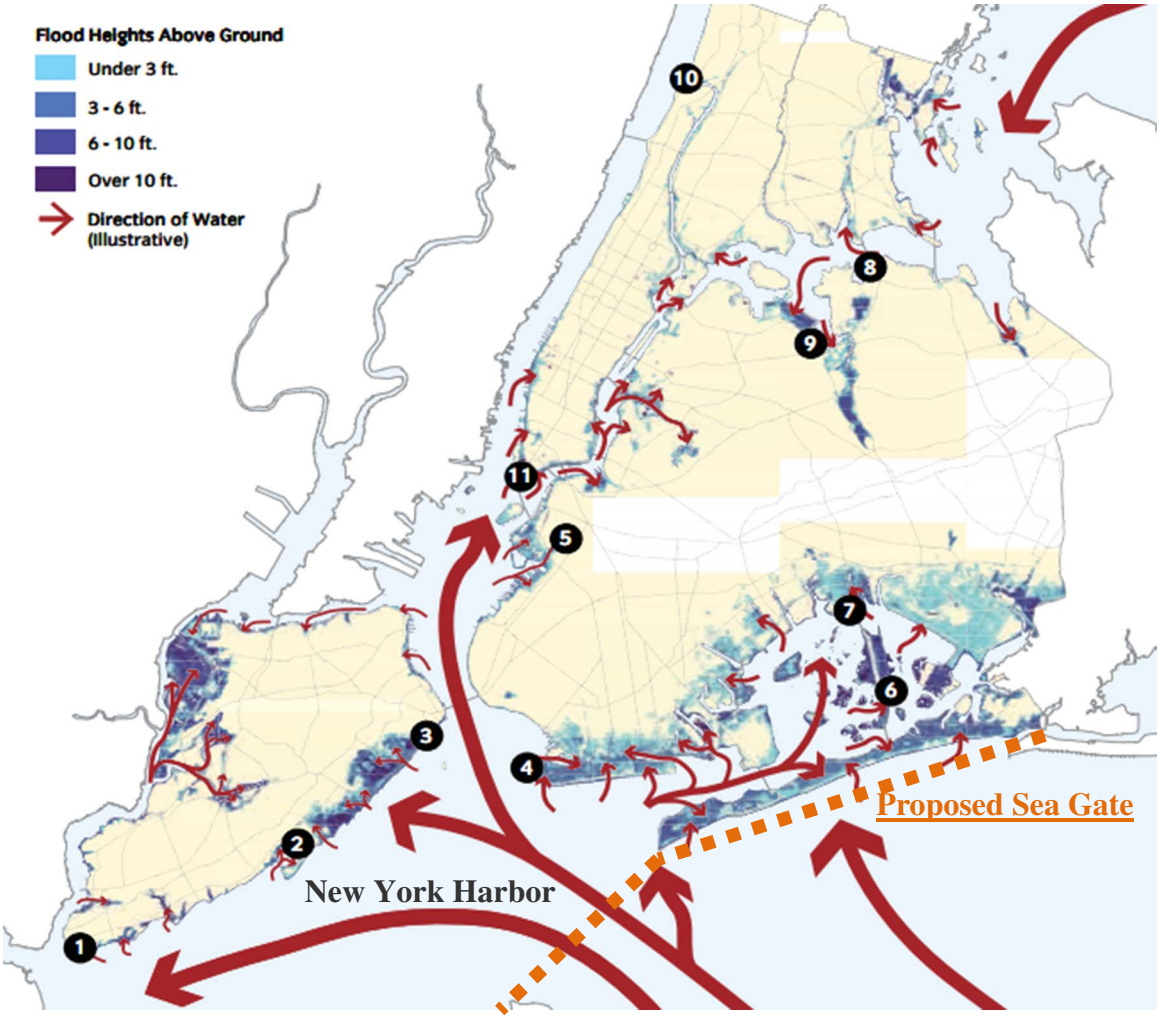


Fig. 6. Sea gate proposed in the report, "A Stronger, More Resilient New York" from the NYC Special Initiative for Rebuilding and Resiliency (http://s-media.nyc.gov/agencies/sirr/SIRR_singles_Hi_res.pdf).

sustainable development is derived from the 1987 Brundtland Report: *Our Common Future*, which defines sustainable development as one "*that meets the needs of the present without compromising the ability of future generations to meet their own needs*". The concept of "needs" in this definition, in particular, represents the essential needs of the poor in the world, to whom overriding priority should be given, and the idea of limitations imposed by the state of technology and social organization on the ability of environment to meet present and future needs. In US studies, this concept is often described in terms of economic, environmental and social dimensions (Zinatizadeh, Azmi, Monavari, & Sobhanardakani, 2017). US pays more attention to time duration, focusing on an active process of sustainable development over a long period, while UR is problem-solving-oriented development, a passive process after being faced with various threats. A self-organizing capability is established in this process to recover urban areas from damage. Hence, it is concluded that US may not lead to UR and *vice versa*.

In order to meet both UR and US needs, New York City has carried out several coastal protection strategies for future possible risks by

(1) *Increasing coastal edge elevations*. A rise in sea level threatens to inundate some neighborhoods with daily or weekly tidal flooding by the 2050s. To address this risk, the City will increase the height of vulnerable coastal edges with bulkheads, beach nourishment and other measures over time. This adaptive strategy allows the ongoing monitoring of increased sea levels. Although further investment is required, much less cost than the Sea Gate project would be paying. It is therefore become economically sustainable than the Sea Gate project in order to keep up the resilience of the city.

(2) *Protecting against storm surges*. To address the risk of storm flooding, the City works to keep water from storm surges out of vulnerable neighborhoods and away from critical infrastructure. To do this, the New York City uses flood protection structures, such as floodwalls, levees and local storm surge barriers. Where possible, these will be erected to the 100-year flood elevation, with an additional allowance for future rises in sea level. Obviously, such kind of long term planning is economically sustainable for the city and do not need put huge sums of money in one project in one time. Although storm flooding still cause some damage, the city now have enough resilient capability for recovery. Generally speaking, the City will seek for measures that can minimize damage if overtopped.

(3) *Improving coastal design and governance*. This is a top-down rational activity to meet both resilient and sustainable requirements. To ensure the successful implementation of these above strategies, the City will make improvements to the design and governance of coastal areas. In particular, they would study how natural areas and open spaces can be used to protect adjacent neighborhoods and maintain the quality of life in the neighborhood, and will work to manage its own waterfront assets more effectively, while also developing partnerships to improve the authorization and study of innovative coastal protection.

6. Conclusion and suggestions

The city is the most complex and typical social-ecological system shaped by human beings. As urban planners, policymakers and researchers navigate into the new urban world, the key stresses of government and governance will be urban in nature. This, in part, reflects the global interest in urban resilience and urban sustainability. Currently, however, the vulnerability of city is often criticized for the frequent occurrence of a variety of uncertain perturbation factors, which have caused tremendous economic, social and cultural losses. In this context, the concept of rational urban development is developed based on discussing urban resilience and urban sustainability. Based on recognizing environmental uncertainty and limited urban capacity, rational urban development respects the basic laws of social-ecological systems in a way that combines both resilience and sustainability. However, UR and US contrast in not only their different theoretical bases, but also even more in their empirical work. CiteSpace 4.0.R5 is used for co-citation analysis, visualizing co-citation networks and research clusters of UR and US studies. The Sea Gate project of New York harbor is selected as a case study to demonstrate that UR and US can be contradictory. Further, a conceptual framework is proposed to define the difference between UR and US, and four kinds of urban development are then examined based on the framework. We indicate that rational urban development can be achieved only when it is both resilient and sustainable, and conclude that urban planners, policymakers and researchers should pay equal attention to both UR and US before decision-making.

In the process of realizing the goal of both sustainable and resilient development, we should see the dominant role of social factors such as urban governance in the process of urban adjustment and adaptation. Thus, compared with the simple investment of manpower and materials, the establishment of an urban rational development mechanism could help improve the urban capability more effectively to cope with the various crises involved. Urban rational development should be seen as process-oriented action, rather than an outcome-oriented. As it were discussed in this paper, UR and US may compete with each other, and rational urban development only occurs when it is both resilient and sustainable. Urban managers, planners and researchers should therefore pay equal attention to both UR and US in the decision-making process.

Acknowledgment

The research reported in this paper is supported by the State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University; National Natural Science Foundation of China (71673232), Tongji University Sustainable Development and New-Type Urbanization Think Tank and CityU Internal Funds for PRC Grants (MFPRC) (9680195). The work described in this paper was partially supported by a grant from the Research Grant Council of the Hong Kong Special Administrative region, China (Project No: CityU 11271716 and CityU 21209715). In addition, the authors are indebted to the Junior Fellowships for CAST Advanced Innovation Think-Tank Program (Project No: DXB-ZKQN-2016-009) and Special Grade of the Financial Support from the China Postdoctoral Science Foundation (2017T100434).

References

Aerts, J. C. J. H., Botzen, W. J. W., Emanuel, K., Lin, N., de Moel, H., & Michel-Kerjan, E. O. (2014). Evaluating flood resilience strategies for coastal megacities. *Science*, *344*(6183), 473–475.

Asprone, D., & Manfredi, G. (2015). Linking disaster resilience and urban sustainability: A glocal approach for future cities. *Disasters*, *39*, S96–S111.

Bagaeen, S. G. (2006). Redeveloping former military sites: Competitiveness, urban sustainability and public participation. *Cities*, *23*(5), 339–352.

Balsells, M., Barroca, B., Amdal, J. R., Diab, Y., Becue, V., & Serre, D. (2013). Analysing urban resilience through alternative stormwater management options: Application of the conceptual spatial decision support system model at the neighbourhood scale. *Water Science and Technology*, *68*(11), 2448–2457.

Banai, R. (2005). Land resource sustainability for urban development: Spatial decision support system prototype. *Environmental Management*, *36*(2), 282–296.

Barata-Salgueiro, T., & Erkip, F. (2014). Retail planning and urban resilience - An introduction to the special issue. *Cities*, *36*, 107–111.

Barthel, S., Parker, J., & Ernstson, H. (2015). Food and green space in cities: A resilience lens on gardens and urban environmental movements. *Urban Studies*, *52*(7), 1321–1338.

Beilin, R., & Wilkinson, C. (2015). Introduction: Governing for urban resilience. *Urban Studies*, *52*(7), 1205–1217.

Brand, D., & Nicholson, H. (2016). Public space and recovery: Learning from post-earthquake Christchurch. *Journal of Urban Design*, *21*(2), 159–176.

Braun-Lewensohn, O., & Sagy, S. (2014). Community resilience and sense of coherence as protective factors in explaining stress reactions: Comparing cities and rural communities during missiles attacks. *Community Mental Health Journal*, *50*(2), 229–234.

Buffel, T., & Phillipson, C. (2016). Can global cities be 'age-friendly cities'? Urban development and ageing populations. *Cities*, *55*, 94–100.

Cain, S. A. (1968). The importance of ecological studies as a basis for land-use planning. *Biological Conservation*, *1*(1), 33–36.

Campanella, T. J. (2006). Urban resilience and the recovery of New Orleans. *Journal of the American Planning Association*, *72*(2), 141–146.

Chan, E. H. W., & Lee, G. K. L. (2008). Contribution of urban design to economic sustainability of urban renewal projects in Hong Kong. *Sustainable Development*, *16*(6), 353–364.

Chang, S. E., McDaniels, T., Fox, J., Dhariwal, R., & Longstaff, H. (2014). Toward disaster-resilient cities: Characterizing resilience of infrastructure systems with expert judgments. *Risk Analysis*, *34*(3), 416–434.

Chelimsky, E. (1993). The political debate about health care: Are we losing sight of quality? *Science*, *262*(5133), 525–528.

Chelleri, L., Schuetze, T., & Salvati, L. (2015). Integrating resilience with urban sustainability in neglected neighborhoods: Challenges and opportunities of transitioning to decentralized water management in Mexico City. *Habitat International*, *48*, 122–130.

Chen, C. M. (2004). Searching for intellectual turning points: Progressive knowledge domain visualization. *Proceedings of the National Academy of Sciences of the United States of America*, *101*, 5303–5310.

Chen, C. M., Hu, Z. G., Liu, S. B., & Tseng, H. (2012). Emerging trends in regenerative medicine: A scientometric analysis in CiteSpace. *Expert Opinion on Biological Therapy*, *12*(5), 593–608.

Chen, C., Ibekwe-Sanjuan, F., & Hou, J. (2010). The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. *Journal of the American Society for Information Science and Technology*, *61*(7), 1386–1409.

Chen, C. M., & Leydesdorff, L. (2014). Patterns of connections and movements in dual-map overlays: A new method of publication portfolio analysis. *Journal of the Association for Information Science and Technology*, *65*(2), 334–351.

Chester, M., Pincetl, S., Elizabeth, Z., Eisenstein, W., & Matute, J. (2013). Infrastructure and automobile shifts: Positioning transit to reduce life-cycle environmental impacts for urban sustainability goals. *Environmental Research Letters*, *8*(1).

Coaffee, J. (2010). Protecting vulnerable cities: The UK's resilience response to defending everyday urban infrastructure. *International Affairs*, *86*(4), 939.

Cox, A., Prager, F., & Rose, A. (2011). Transportation security and the role of resilience: A foundation for operational metrics. *Transport Policy*, *18*(2), 307–317.

Davoudi, S. (2009). Scalar tensions in the governance of waste: The resilience of state spatial Keynesianism. *Journal of Environmental Planning and Management*, *52*(2), 137–156.

Eames, M., & Egmose, J. (2011). Community foresight for urban sustainability: Insights from the citizens science for sustainability (SuScit) project. *Technological Forecasting and Social Change*, *78*(5), 769–784.

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... Snyder, P. K. (2005). Global consequences of land use. *Science*, *309*(5734), 570–574.

Fung, M., & Kennedy, C. A. (2005). An integrated macroeconomic model for assessing urban sustainability. *Environment and Planning. B, Planning & Design*, *32*(5), 639–656.

Githens-Mazer, J. (2012). Terrorism, risk and the global city: Towards urban resilience. *Parliamentary Affairs*, *65*(4), 896–898.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, *4*, 1–23.

Kareiva, P., Watts, S., McDonald, R., & Boucher, T. (2007). Domesticated nature: Shaping landscapes and ecosystems for human welfare. *Science*, *316*(5833), 1866–1869.

Kendra, J. M., & Wachtendorf, T. (2003). Elements of resilience after the world trade center disaster: Reconstituting New York City's emergency operations centre. *Disasters*, *27*(1), 37–53.

Khan, S., & Uddin, M. S. (2015). Sustainable urban metabolism practices an understanding. *Proceedings of 10th global engineering, science and technology conference, Bangladesh*.

Leichenko, R. (2011). Climate change and urban resilience. *Current Opinion in Environmental Sustainability*, *3*(3), 164–168.

Liu, J., Dietz, T., Carpenter, S. R., Alberti, M., Folke, C., Moran, E., ... Taylor, W. W. (2007). Complexity of coupled human and natural systems. *Science*, *317*(5844), 1513–1516.

Madani, F., & Weber, C. (2016). The evolution of patent mining: Applying bibliometrics analysis and keyword network analysis. *World Patent Information*, *46*, 32–48.

Marsden, T., & Sonnino, R. (2012). Human health and wellbeing and the sustainability of urban-regional food systems. *Current Opinion in Environmental Sustainability*, *4*(4), 427–430.

Mehmood, A. (2016). Of resilient places: Planning for urban resilience. *European Planning Studies*, *24*(2), 407–419.

Molnar, C., Ritz, T., Heller, B., & Solecki, W. (2011). Using higher education-community

partnerships to promote urban sustainability. *Environment*, *53*(1), 18–28.
Moussiopoulos, N., Achillas, C., Vlachokostas, C., Spyridi, D., & Nikolaou, K. (2010). Environmental, social and economic information management for the evaluation of sustainability in urban areas: A system of indicators for Thessaloniki, Greece. *Cities*, *27*(5), 377–384.
Muller, M., Biswas, A., Martin-Hurtado, R., & Tortajada, C. (2015). Built infrastructure is essential. *Science*, *349*(6248), 585–586.
Mustafee, N., Bessis, N., Taylor, S. J. E., & Sotiriadis, S. (2013). Exploring the E-science knowledge base through co-citation analysis. *Procedia Computer Science*, *19*, 586–593.
Ouyang, M., Duenas-Osorio, L., & Min, X. (2012). A three-stage resilience analysis framework for urban infrastructure systems. *Structural Safety*, *36-37*, 23–31.
Pandolfini, E., Bemposta, A. C., Sbardella, M., Simonetta, G., & Toschi, L. (2016). Well-being, landscape and sustainability of communication. *Agriculture and Agricultural Science Procedia*, *8*, 602–608.
Passarini, K. C., Pereira, M. A., Farias, T. M. D., Calarge, F. A., & Santana, C. C. (2014). Assessment of the viability and sustainability of an integrated waste management system for the city of Campinas (Brazil), by means of ecological cost accounting. *Journal of Cleaner Production*, *65*, 479–488.
Pauwelussen, A. (2016). Community as network: Exploring a relational approach to social resilience in coastal Indonesia. *Maritime Studies*, *15*.
Rao, F., & Summers, R. J. (2016). Planning for retail resilience: Comparing Edmonton and Portland. *Cities*, *58*, 97–106.
Rees, W., & Wackernagel, M. (1996). Urban ecological footprints: Why cities cannot be sustainable - And why they are a key to sustainability. *Environmental Impact Assessment Review*, *16*(4–6), 223–248.
Saadatian, O., Bin Sopian, K., & Salleh, E. (2013). Adaptation of sustainability community indicators for Malaysian campuses as small cities. *Sustainable Cities and Society*, *6*, 40–50.
Sahely, H. R., Kennedy, C. A., & Adams, B. J. (2005). Developing sustainability criteria for urban infrastructure systems. *Canadian Journal of Civil Engineering*, *32*(1), 72–85.
Server, O. B. (1996). Corruption: A major problem for urban management: Some evidence from Indonesia. *Habitat International*, *20*(1), 23–41.
Shi, P., & Yu, D. (2014). Assessing urban environmental resources and services of Shenzhen, China: A landscape-based approach for urban planning and sustainability. *Landscape and Urban Planning*, *125*, 290–297.
Sinha, K. C. (2003). Sustainability and urban public transportation. *Journal of Transportation Engineering-ASCE*, *129*(4), 331–341.
Smith, C., & Levermore, G. (2008). Designing urban spaces and buildings to improve sustainability and quality of life in a warmer world. *Energy Policy*, *36*(12), 4558–4562.
Spaans, M., & Waterhout, B. (2017). Building up resilience in cities worldwide – Rotterdam as participant in the 100 resilient cities programme. *Cities*, *61*, 109–116.
Specht, K., Siebert, R., Hartmann, I., Freisinger, U. B., Sawicka, M., Werner, A., ... Dierich, A. (2014). Urban agriculture of the future: An overview of sustainability aspects of food production in and on buildings. *Agriculture and Human Values*, *31*(1), 33–51.
Stone, R. (2008). Lessons of disasters past could guide Sichuan's revival. *Science*, *321*(5888), 476.
Sui, D. (2010). Terrorism, risk, and the global city: Toward urban resilience, 2nd edition. *Environment and Planning. B, Planning & Design*, *37*(3), 568–569.
Takewaki, I., Fujita, K., Yamamoto, K., & Takabatake, H. (2011). Smart passive damper control for greater building earthquake resilience in sustainable cities. *Sustainable Cities and Society*, *1*(1), 3–15.
Testa, A. C., Furtado, M. N., & Alipour, A. (2015). Resilience of coastal transportation networks faced with extreme climatic events. *Transportation Research Record*, *2532*, 29–36.
Tidball, K., & Stedman, R. (2013). Positive dependency and virtuous cycles: From resource dependence to resilience in urban social-ecological systems. *Ecological Economics*, *86*, 292–299.
Timon, M. (2014). The rise of resilience: Linking resilience and sustainability in city planning. *Urban ecology at The New School in New York City, New York*.
Toubin, M., Laganier, R., Diab, Y., & Serre, D. (2015). Improving the conditions for urban resilience through collaborative learning of Parisian urban services. *Journal of Urban Planning and Development*, *141*(4).
Vallance, S. (2015). An evaluation of the Waimakariri district council's integrated and community-based recovery framework following the Canterbury earthquakes: Implications for urban resilience. *Urban Policy and Research*, *33*(4), 433–451.
Wagenaar, H., & Wilkinson, C. (2015). Enacting resilience: A performative account of governing for urban resilience. *Urban Studies*, *52*(7), 1265–1284.
Wang, R. (2011). Environmental and resource sustainability of Chinese cities: A review of issues, policies, practices and effects. *Natural Resources Forum*, *35*(2), 112–121.
Wei, Y., Huang, C., Li, J., & Xie, L. (2016). An evaluation model for urban carrying capacity: A case study of China's mega-cities. *Habitat International*, *53*, 87–96.
Wilkinson, C. (2012). Social-ecological resilience: Insights and issues for planning theory. *Planning Theory*, *11*(2), 148–169.
Woolhouse, M. E. J., Rambaut, A., & Kellam, P. (2015). Lessons from Ebola: Improving infectious disease surveillance to inform outbreak management. *Science Translational Medicine*, *7*(307), 307rv5.
Zaidi, R. Z., & Pelling, M. (2015). Institutionally configured risk: Assessing urban resilience and disaster risk reduction to heat wave risk in London. *Urban Studies*, *52*(7), 1218–1233.
Zhang, Y., & Guindon, B. (2006). Using satellite remote sensing to survey transport-related urban sustainability part 1: Methodologies for indicator quantification. *International Journal of Applied Earth Observation and Geoinformation*, *8*(3), 149–164.
Zinatizadeh, S., Azmi, A., Monavari, S. M., & Sobhanardakani, S. (2017). Evaluation and prediction of sustainability of urban areas: A case study for Kermanshah city, Iran. *Cities*, *66*, 1–9.