The methodology therefore provides a new way of drawing the GI, which is generally based on the specific ability to favour biotic and abiotic flows. In this case, we try to optimize this pattern by also maintaining and raising other ES, starting from the regulation of the soil disruption.

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ID 1409 | LIVING THE CLIMATE RESILIENT CITY—HANGZHOU'S 'FIVE WATER CO-LEAD' STRATEGY

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1 INTRODUCTION

Climate awareness in urban planning has increased from 2011 due to more frequent occurrences of extreme-weather disturbances in Chinese cities. To deal with climate-related disturbances, the notions of urban resilience and resilient planning have gained increasing attention and interest over recent years in the field of water management and urban planning. A simple definition of resilience is the ability of a city to

absorb disturbance while maintaining its functions and structures (Holling, 1987, 2001; White, 2010). With the challenges of climate change, planners and decision-makers in China realize that it is possible that resilient strategies provide more adaptive and flexible approaches in decision-making. In planning practice, however the concept of resilience features in many policy documents, the implications for planning policy officials remain unclear in the case of Hangzhou, China.

Drawing on information from a review of policy documents supplemented by interviews with policy officials, this paper aims to understand key issues in transitioning to climate resilience in Chinese cities through a study of Hangzhou. The main body of the paper is structured in three parts. The first section presents a review of the notion of resilience and examines its relevance for urban planning and climate change. The second part provided the assessment of planning strategies related to climate change in the city. Specific attention is paid to how planning processes in the city consider or deal with the climate risks that it presents. The third part explored the challenging areas – spatial data infrastructures, climate planning, green infrastructure planning, limiting urban sprawl –as viable facets for sustaining urban transition strategies.

2 RESILIENCE THINKING AS THE BASIS OF A NEW PARADIGM IN PLANNING PRACTICE

The amount of literature on resilience and uncertain disturbances in urban systems has increased greatly over the last decade. Broadly speaking, a resilient system is defined by its two main features: its ability to absorb change and disturbance, and the persistence of systems while retaining its basic functions and structure (Walker et al. 2006); together with the ability to survive, adapt and transform itself (Ludwig et al. 1997).

2.1 REFRAMING THE NOTION OF RESILIENCE

The simple understanding of resilience is the capacity of a system to undergo change and still retain its basic function and structure after facing an external disturbance (Holling, 1973, 1987, 2001; Tasan-Ko and, Stead et al., 2013; White, 2010). Some of the early resilience literature originates from studies of ecological equilibrium in the 1970s (e.g., Holling, 1973).The studies of ecological resilience around this time focused on self-(re)organising ability and the speed of return to a new stable or fully functional state(Ludwig et al., 1978; Pimm, 1991). In the social sciences, the growing interest in the notion of resilience can be seen as a consequence of increasing complexity, uncertainty and insecurity in the search for new approaches for adaptation and transformation (Christopherson and Michie et al., 2010). The notion of social resilience is often associated with the ability to learn, primarily in order to become more robust to change (Newman, 2009; Newman et al., 2009).

The notion of resilience appeared in urban systems and urban planning in the 1990s (Mileti, 1999). In particular, resilience has emerged as an attractive perspective with respect to urban systems, often theorized as highly complex, adaptive systems. Urban resilience refers to the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity.

The literature on resilience in planning has often put the emphasis on preparation, mitigation and adaptation actions. It is widely acknowledged that spatial planning has an important role in promoting urban resilience. There is widespread recognition that the spatial configuration of cities and towns, and the way in which land is used and developed, has significant implications for both adaptation to the adverse impacts of climate change and the reduction of emissions that cause the change (i.e. mitigation).

2.2 THE ATTRIBUTES OF CLIMATE RESILIENT CITY

Climate change is an increasingly important issue for urban planning. Scholars highlight that, from a resilience perspective, climate change is not only associated with disruptive events (e.g., storms or

heatwaves) but also with gradual trends (e.g. rises in sea level or average global temperatures) that can still give rise to large disturbances if left unchecked (Wardekker and de Jong et al., 2010).

In addition to robustness (or mitigation) and rapidity (or flexibility or adaptation), scholars have also discussed the notion of resilience in terms of characteristics such as redundancy, diversity, efficiency, autonomy, strength, interdependence, adaptability and collaboration (Godschalk, 2003), or attributes of decision-making processes such as fluidity, reflexivity, contingency, connectivity, multiplicity and polyvocality (Davoudi and Strange, 2009).

Some studies of resilience also highlight the importance of Robustness, Social capital, Reflexivity ,Contingency, Connectivity, Multiplicity, Learning capacity and so on (Linnenluecke and Griffiths, 2010 , Wardekker et al., 2010, Walker and Salt, 2006, Davoudi and Strange, 2009, van den Brink et al., 2011 and Gupta et al., 2010).

Table 1 provides a summary of resilience characteristics from a range of different studies. On the basis of existing studies of resilience attributes, we identify six characteristics of resilience in relation to planning for climate disturbances and flood risks: (i) Recovery; (ii) Connectivity; (iii) Social capital; (iv) Adaptability; (v) Robustness; and (vi) Transformability (Tables 2 and 3).

Literature debates	Characterising the notion of resilience
Linnenluecke and Griffiths, 2010 and Wardekker et al., 2010	– Robustness (or strengths, mitigation) – Rapidity (or flexibility)
Walker and Salt, 2006	– Diversity – Ecological variability – Modularity – Acknowledging slow variables – Tight feedbacks – Social capital – Innovation – Overlap in governance and ecosystem services
Godschalk, 2003	– Redundancy – Diversity – Efficiency – Autonomy – Strength – Interdependence – Adaptability – Collaboration
Davoudi and Strange, 2009	– Fluidity – Reflexivity – Contingency – Connectivity – Multiplicity – Polyvocality
van den Brink et al., 2011 and Gupta et al., 2010	– Variety – Learning capacity – Room for autonomous change – Leadership – Resources – Fair governance

Table 1 -Summary of studies characterising the notion of resilience.

Resilience characteristics addressed by planning system						
Proposed characteristic in this paper	Recovery	Connectivity	Social capital	Adaptability	Robustness	Transformability
Linnenluecke and Griffiths, 2010 and Wardekker et al., 2010				-Rapidity; -Flexibility	-Robustness; -strengths; -mitigation	
Walker and Salt, 2006	-Tight feedbacks		-Social capital	-Diversity; -Ecological ; -Variability; -Modularity		-Innovation

Godschalk, 2003	-Strength	- Interdependence	-Antonomy; - Collaboration	Diversity; Adaptability; -Efficiency	- Redundancy	
Davoudi and Strange, 2009	- Reflexivity	-Connectivity	-Polyvocality	- Multiplicity; -Fluidity		
van den Brink et al., 2011 and Gupta et al., 2010			-Learning capacity; -Leadership; -Resources; -Fair governance	-Variety; -Room for autonomous change		

Table 2 - Summary of characteristics describing the notion of resilience.

Characteristic	Description
Recovery	the ability of the system to recover from a disturbance and refers to the ability of a system to respond to an event
Connectivity	the degree to which the nodes of a network are directly linked with each other. In terms of resilience, connectivity embraces more than just the physical dimension, as it includes also the relationships between people and organisations
Social capital	the quality and quantity of a society's social interactions that are shaped by institutions, relationships, and societal norms
Adaptability	the ability of society in a social-ecological system to cope and respond to novel situations and change without losing options for the future
Robustness	the ability to withstand a given level of stress without suffering degradation or loss of function
Transformability	the capacity to learn and create a fundamentally new and different socio-ecological system , one that hopefully would possess the attributes of adaptability and resilience

Table 3 - Six characteristics of urban resilience.

2.3 A FRAMEWORK FOR ASSESSING RESILIENCE

The issue of change is a central dimension of resilience, both in terms of resistance to change and recovery from it. Resilience is therefore related to both preparations to minimize disturbances (or change) and actions to deal with disturbances once they have occurred. As such, resilience represents an on-going process, a time-scale of reshaping, reorganizing and developing new strategies (Lu and Stead, 2013).

The empirical analysis of Hangzhou is based on a review of policy literature from 2010 on-wards (summarized in Table 5 and discussed later in the paper), supplemented by interviews with policy officials from the city of Hangzhou. All the planning policies and documents analyzed in this paper address urban planning and climate change issues.

Resilience characteristics addressed by planning system	Overarching question	Measures/indicators: (the capacity to)
Recovery	Are the policies, programmes, plans and projects promoting capacity in the territory to respond to and recover from distrubance?	A1:Evalnate and maintain the conditions of urban lifeline A2:Establish the system for preventing and reducing flood disasters.
Connectivity	Are the policies, programmes, plans and projects enabling an interrelated territory, in which the nodes of the network are effectively linked?	A3:Develop ecological network A4:Develop soft mobility (pedestrian and bicycle routes) and public transportation networks A5:Coordinate readiness actions
Capital building	Are the policies, programmes, plans and projects under analysis contributing to the build-up of capital (stock), reinforcing in this way the stability and cohesion of the territory?	A6:Collaborate decision-making between different levels of governance A7:Communicate findings (concepts, skills, actions) about water management A8:Raise public awareness and preparation education

Adaptability	Are the policies, programmes, plans and projects enhancing the adaptability of the territory and its capacity to adjust to change in a reactive way?	A9:Identify and assess the probability of risks and disturbances A10: Forecast A11:Promote Low Impact Development technology
Robustness	Are the policies, programmes, plans and projects increasing the robustness of the territory to unforeseen shocks and disturbances?	A12:Evaluate and maintain the conditions of flood-protective facilities
Transformability	Are the policies, programmes, plans and projects contributing to the transformability of the territory and to its ability to innovate and create a new system should the previous become no longer viable?	A13: Setting goals and propose new standards A14:Innovate and propose actions

Table 4 - An assessable framework of resilience in planning decision-making.
Source: based on Eraydin and Tasan-Kok (2013).

3 EMPIRICAL STUDY: RESILIENCE ASSESSMENT OF HANGZHOU

Although water-related spatial strategies for flood risk management have been embedded in the planning system in east China's Zhejiang province throughout history, climate change is a relatively new issue for urban planning. In 2013 two events occurred which affected the city of Hangzhou. Both events led to institutional changes and a reframing of the system of decision-making.

The first event was that some directors of the Municipal Environmental Protection Bureau in Zhejiang province were "invited" to swim in rivers in the beginning of 2013, which showed Public dissatisfaction with water pollution. Then the second event was that Typhoon Fitow triggered heavy rain in Zhejiang province in October, inundating roads and houses, and causing river breaches and power failures. Figs. 1 and 2 indicate the vulnerable position of the city of Hangzhou.

Figure 1 - Water sources in Hang-Jia-Hu Region. Source: Water resources planning for Hang-jia-hu Region (2015).

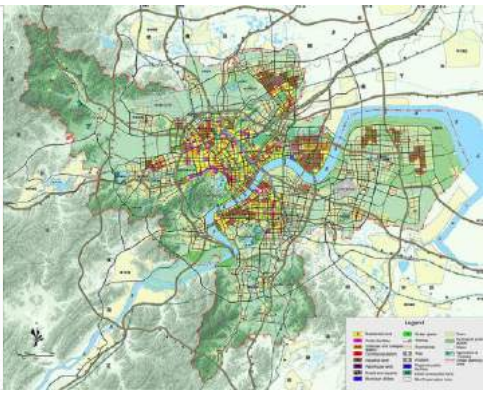

Figure 2 - Water sources in Hang-Jia-Hu Region. Source: Water resources planning for Hang-jia-hu Region (2015).

The shock of the events prompted heated debates about urban planning, climate change and the traditional water management. Decision-makers proposed new strategies such as ‘Sponge city’ and ‘Five water co-lead’. A ‘Sponge city’ refers to a city where its urban underground water system operates like a sponge to absorb, store, leak and purify rainwater, and release it for reuse when necessary. ‘Five water co-lead’ integrate these strategies addressing to polluted water, water-logging, flood, water supply and water saving. Briefly, these planning strategies were established to offer better water environment by changing current river conditions, engineering infrastructure and land-use strategies.

3.1 NEW DEMANDS OF PLANNING TO COPE WITH CLIMATE-RELATED FLOODS

Planning documents in Hangzhou began to demonstrate an awareness of the impacts of climate-related floods from 2010, including the national, regional and local levels. Based on policy reviews and semi-structured interviews with planning officials, the analysis below assesses the use and significance of the notion of resilience in a wide variety of planning documents from the national, regional and local levels (Table 5). The analytical framework presented in Table 3 was used to structure the analysis.

Year	Title	Level of governance	Focus on	Produced by	In collaboration with
2016	Action plan for urban adaptation to climate change	National	Proposing practices for climate change	the National Development and Reform Commission (NDRC)	-Urban-Rural Development of the People's Republic of China
2014	China's National Climate Change Program	National	Establishing a comprehensive framework for climate adaptive strategy-making	The National Development and Reform Commission (NDRC)	-Ministry of Finance of P.R. China; -Ministry of Urban-Rural Development; -Ministry of Transport ; -Ministry of Water; -Ministry of Agriculture; -State Forestry Administration -State Meteorological Administration; -State Oceanic Administration
2013	National Strategy of Climate Change Adaptation	National	Proposing strategies for climate change	the National Development and Reform Commission (NDRC)	- Ministry of Finance of the People's Republic of China; -Ministry of Urban-Rural Development; -Ministry of Transport ; -Ministry of Water; -Ministry of Agriculture; -State Forestry Administration -State Meteorological Administration; -State Oceanic Administration
2015	Water resources planning for Hang-jia-hu Region	Regional	Spatial plan for the Hang-Jia-Hu region	The Development and Reform Commission of Zhejiang Province	-Department of Water Resources of Zhejiang Province;
2010	Zhejiang province's programme to address climate change	Regional	Proposing climate-adaptive strategies for the Zhejiang province	Province of Zhejiang	
2016	The master plan for Hangzhou city 2001-2020 (2016)	local		City of Hangzhou	-Hangzhou Planning Bureau
2016	The subject plan of sponge	local	Proposing new strategies for water management	City of Hangzhou	-Hangzhou municipal leading group office for sponge city

Table 5 - List of documents reviewed.

3.2 CHARACTERISTIC 1: RECOVERY

Various planning documents indicate that the ability of recovery has been addressed in planning policies in Hangzhou (A1 and A2 Table 4). At the national level, Action plan for urban adaptation to climate change 2016 and China's National Climate Change Program 2014-2020 both mention new requirements for improve after-disaster reconstruction speed, and reduce the negative influences to the lowest level. Recovery issues in Zhejiang province's programme to address climate change 2010 focus on establish the system for preventing and reducing flood disasters. Attention to the ability of recovery is addressed in local documents like the master plan for Hangzhou city 2001-2020 (2016) and Urban drainage plan for Hangzhou city 2014 at different aspects. For instance, the master plan for Hangzhou city 2001-2020 (2016) focuses on evaluate and maintain the conditions of urban lifeline, while Urban drainage plan for Hangzhou city 2014 and Action plan of 'five water co-lead' for Hangzhou city 2014-2016 emphasises the establishment of the system for preventing and reducing flood disasters.

3.3 CHARACTERISTIC 2: CONNECTIVITY

Three indicators (A3, A4, A5) address the connectivity of ecological network, transportation networks and social network respectively. Regarding the connectivity of ecological network (A3), national, regional and local documents are mainly focused on optimizing ecological network to achieve a better quality of life in the city. Examples are actions for a robust and resilient water system (e.g., Action plan for urban adaptation to climate change 2016, the subject plan of sponge city for Hangzhou 2016, Action plan of 'five water co-lead' for Hangzhou city 2014-2016), water environment and quality (e.g., Water resources planning for Hang-jia-hu Region 2015, Action plan of 'five water co-lead' for Hangzhou city 2014-2016), and water landscapes in the spatial framework (e.g., the master plan for Hangzhou city 2001-2020, Action plan of 'five water co-lead' for Hangzhou city 2014-2016).

In addition, national documents address two different aspects of transportation networks: China's National Climate Change Program 2014-2020 emphasise soft mobility (pedestrian and bicycle routes) and Action plan for urban adaptation to climate change 2016 consider public transportation networks.

Coordinative capacity (A5) is another indicator of the connectivity. In Action plan for urban adaptation to climate change 2016 and Action plan of 'five water co-lead' for Hangzhou city 2014-2016, the importance of inter-sectoral collaboration between politicians and scientists is highlighted.

3.4 CHARACTERISTIC 3: SOCIAL CAPITAL

In regard to the capacity of multi-level collaborative decision-making (A6), national documents in many cases give the directions for provincial and local policies to follow, especially in relation to water (flooding) issues which have been the primary task. Local policies indicate the active attitudes of multi-level collaborations with national policy-making for managing climate disturbances and relevant floods. Zhejiang province's programme to address climate change 2010, Water resources planning for Hang-jia-hu Region 2015, the master plan for Hangzhou city 2001-2020 (2016), Urban drainage plan for Hangzhou city 2014 and Action plan of 'five water co-lead' for Hangzhou city 2014-2016 are all influenced by Action plan for urban adaptation to climate change 2016, China's National Climate Change Program 2014-2020 and National Strategy of Climate Change Adaptation 2013.

The second social capital characteristic relates to the capacity to communicate, build public awareness and educate. Regarding the capacity to communicate findings (concepts, skills, actions) about water management (A7), various national, provincial and local documents (e.g., Action plan for urban adaptation to climate change 2016; Zhejiang province's programme to address climate change 2010; the subject plan of sponge city for Hangzhou 2016; and Action plan of 'five water co-lead' for Hangzhou city 2014-2016) refer to public education about climate risk, Sponge City and five water co-lead Strategy.

Evidence of public awareness and preparation education (A8), can be seen in the online citizens' panel in Action plan of 'five water co-lead' for Hangzhou city 2014-2016, climate-related flood knowledge promotion in Action plan for urban adaptation to climate change 2016.

3.5 CHARACTERISTIC 4: ADAPTABILITY

In relation to the capacity to identify and assess the probability of risk and disturbances (A9), Action plan for urban adaptation to climate change 2016, China's National Climate Change Program 2014-2020, National Strategy of Climate Change Adaptation 2013, Zhejiang province's programme to address climate change 2010, and Urban drainage plan for Hangzhou city 2014 all have relevant strategies to define and assess climate risk probability and potential disturbances. Action plan of 'five water co-lead' for Hangzhou city 2014-2016 proposes practical strategies for rivers (water and flooding issues) which have been implemented since 2014 to ensure enough space for water discharge by 2016.

Regarding the capacity to forecast (A10), national documents like Action plan for urban adaptation to climate change 2016, China's National Climate Change Program 2014-2020, and National Strategy of Climate Change Adaptation 2013 mention strategies for risk forecasting, mainly in relation to flood risks.

Low Impact Development technology (A11) are emphasised in local policies. The subject plan of sponge city for Hangzhou 2016 identify and propose relevant studies that focus on the topic of sponge city, including rain garden, low elevation greenbelt, green roof, permeable pavement and so on.

3.6 CHARACTERISTIC 5: ROBUSTNESS

Regarding the capacity to evaluate and maintain flood-protective facilities (A12), national documents like Action plan for urban adaptation to climate change 2016, China's National Climate Change Program 2014-2020, and National Strategy of Climate Change Adaptation 2013 all implement strategies to maintain and improve flood-protective facilities closely related to the requirements of setting new goals of water safety.

At the provincial and local level, Zhejiang province's programme to address climate change 2010 and Action plan of 'five water co-lead' for Hangzhou city 2014-2016 address the 'integrated' approach of creating a safe environment.

3.7 CHARACTERISTIC 6: TRANSFORMABILITY

The policy documents reviewed indicate a wide range of approaches regarding setting goals and creating new standards (A13). National documents highlight priorities and new standards in terms of resilience capacity and sustainability for comprehensive developments between water safety and quality of life.

Local policies, such as the subject plan of sponge city for Hangzhou 2016 and Action plan of 'five water co-lead' for Hangzhou city 2014-2016 focuses on technical strategies (new required standards) not only for flood risk management (such as water safety, a robust and resilient water system) but also for issues like fresh water supply and water landscapes.

Regarding the capacity to propose and elaborate innovational actions (A14), local documents like the subject plan of sponge city for Hangzhou 2016 and Action plan of 'five water co-lead' for Hangzhou city 2014-2016 propose practical strategies for spatial implementation. Interviews suggest that various innovative proposals for 'five water co-lead' strategy were developed and seen as an opportunity for the city's resilient development.

Overall, the review suggests, firstly, that recent planning initiatives show that the main focus of urban planning has shifted from promoting hard infrastructure to green infrastructure (in terms of sponge city). Secondly, the uncertainty of climate change has increased the importance of scientific studies in planning decision-making. Thirdly, the case study of Hangzhou indicates that the city itself is a key driver in developing an integrated adaptive strategy for climate change and water manage. Planners and decision-makers in the municipality are keen to transform climate threats into opportunities for urban resilient transformation.

4 TRANSITIONING TO CLIMATE RESILIENT CITY

Hangzhou's vulnerability to floods and climate uncertainty has motivated the city to become a pioneer in the fields of urban planning and climate change. Interviews suggest that various challenging areas for transitioning to climate resilient city should be explored, such as spatial data infrastructures, climate planning, green infrastructure planning, limiting urban sprawl.

4.1 SPATIAL DATA INFRASTRUCTURES

The demand to plan for urban resilience presents additional infrastructural and technological requirements, especially spatial data infrastructures. Geographic information systems (GIS) technology, in particular, offers a wide range of analytic tools and methods such as feature, grid and network analyses, as well as change, impact and decision modelling (Nyerges and Jankowski, 2009). These additional functionalities also carry the potential to enhance the visualisation of planning issues and solutions. Interactive GIS-based scenario analysis tools, Geoweb tools and 3D visualizations can present spatial characteristics and help demonstrate consequences of environmental and urban change (Sheppard, 2005). A geospatial database at urban level can both enable e-planning and enhance the planning process. Hangzhou 'five water co-lead' Integrated information management platform is established through the Infrastructure for Spatial Information. Though still in its implementation phase, this development has been motivated by the need to harmonize data for environmental planning and management across Hangzhou Region, and clearly carries some relevance for urban sustainability and resilience.

4.2 CLIMATE PLANNING

Planning for climate resilient cities faces challenges in terms of water management. Adaptation measures may lower the probability of flooding, reduce the potential damage; or transfer risks (Treby and Clark et al., 2006). However, water-related infrastructure measures need to be implemented through urban planning and land use management. These measures involve a different use of space, which is often limited in urban environments. Hence, requirements for flood protection, water storage, green areas or different building strategies are competing, and priorities for the use of space have to be made. To support Climate planning, improved methods for linking urban land use modelling and assessment of urban functions are required.

4.3 GREEN INFRASTRUCTURE PLANNINGLIMATE PLANNING

Urban green space policy is increasingly being used as a tool to build sponge city in china. Augmenting the economic models, novel field-based research trials and landscape-scale case studies may consolidate an understanding of the potential of green infrastructure. For example, innovation in green roof technology may show that green infrastructure can be designed to maximise the biodiversity, ecosystem services and carbon storage value of green spaces, if designed towards specific goals (Simmons et al., 2008). Next to green roofs, other ways of enhancing green infrastructure in the urban context should be considered such as the role of rain gardens, and urban agriculture and innovative urban landscape design in conserving regionally important biodiversity and providing food security (Collier et al., 2013). Green infrastructure can be optimized by combining new technologies, public and private initiatives in a coherent 'five water co-lead' strategy.

4.4 LIMITING URBAN SPRAWL

The urban dimension of climate challenges faced by Chinese cities is highlighted in the need to promote a smarter, more sustainable and socially inclusive urban development. This call for a new urbanisation, striving for complexity, compactness, functional diversity plurality and social integration, recognizes wide geographical and contextual diversity across Chinese cities and towns, and rejects the application of 'one-size-fits-all' solutions in integrated urban regeneration plans and programmes, but points towards a more resilient urban destiny.

5 CONCLUSIONS

This paper has examined the awareness and understanding of the concept of resilience in the planning policy arena in Hangzhou. Planning strategies address the notion of resilience not only in relation to tackling external changes and shocks but also in responding actively and positively to risks.

Local authorities have been taking measures as preparation for climate change and flood risks since 2010. As one of Hangzhou's areas of expertise, Sponge city and 'five water co-lead' strategies are communicated widely. Local resilience actions are crucial for developing new, more adaptive approaches to coping with the uncertainty of flood risks. In addition, various challenging areas, such as spatial data infrastructures, climate planning, green infrastructure planning, limiting urban sprawl, should be explored for transitioning to climate resilient city.

The study of Hangzhou illustrates that the assessment framework for resilience is applicable for examining planning strategy-making. What is clear is that urban resilience is a broad concept that can easily become blurred and abstracted. From this study it is clear that the notion can be helpful from a planning perspective in the understanding and analysis of contemporary urban systems, defining a new approach and setting new principles (or priorities) in policy-making. It also suggests that the concept of resilience in

Hangzhou is frequently used as a synonym for adaptation, whereas in more water-specific documents it is understood as a soft form of resistance. And for many stakeholders remains quite abstract.

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