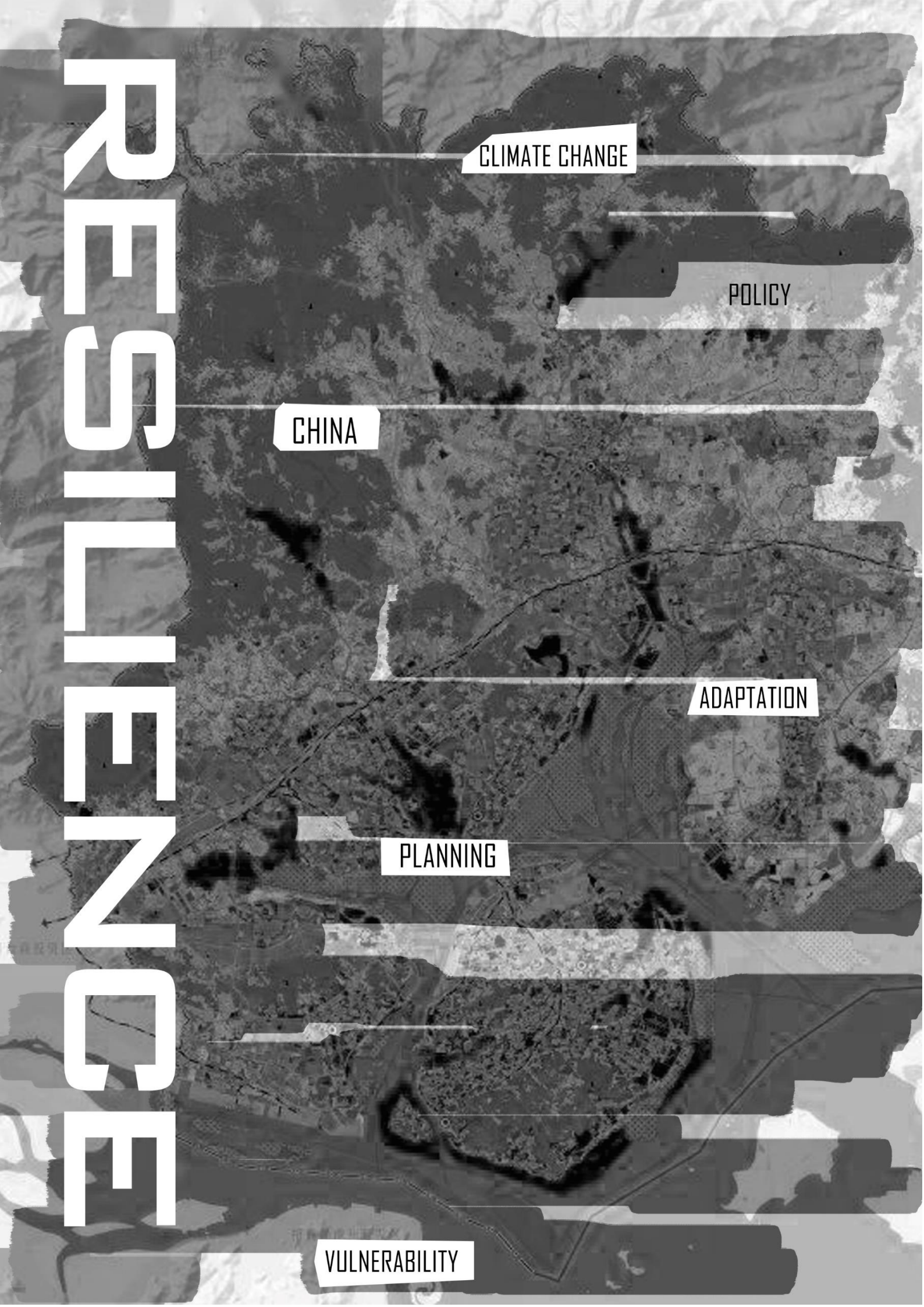
RESILIENCE
CLIMATE CHANGE
POLICY
CHINA
ADAPTATION
PLANNING
VULNERABILITY

Politecnico di Torino

Architecture for the Sustainability Design

MASTER THESIS

Urban policies for urban resilience in China - the case study of coastal city Xiamen

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Content

Urban policies for urban resilience in China - the case study of coastal city Xiamen

Abstract

Global climate change has led to a high incidence of extreme climate disaster events and cities have been subject to natural disasters and extreme weather since ancient times strongly influenced by their own high population and economic density bringing higher exposure and high intensity of man-made environmental modifications, which induce pregnancy and disaster environmental sensitivity, making them more vulnerable to extreme weather disasters when they occur the impact.
Due to the uncertainties and potential crises that global climate change brings to urban development, the construction of resilient cities is becoming a hot topic of urban planning. The construction of resilient cities is a comprehensive action involving political, economic, cultural, social and ecological fields. This thesis provides a detailed review of the development of the concept of resilience and research related to resilient urban planning. The development of resilience theoretical frameworks in some regions has been quite mature, and the practice and application of resilience theory has also accumulated a lot of experience.
The purpose of this paper is to analyze China's policies and strategies for interpreting the concept of resilience in the context of current cutting-edge resilience theory and practice. A resilience assessment and policy analysis is conducted for the city of Xiamen, which is typical of China and at the forefront of resilient city development. The paper explores the development of resilience theory in urban planning from a Chinese perspective. The paper uses a literature review, expert interviews and case studies.

Key words: Resilience Urban Planning Adaptation Disaster prevention Xiamen policy flooding sponge city

1 Introduction

1.1 Research Background

Climate change has caused many negative impacts on normal human production and life and poses a threat to sustainable urban development. Climate change and the resulting natural disasters, such as heavy precipitation, urban flooding, and extreme weather, have caused unavoidable casualties and economic losses to cities. Coping with the uncertainties and potential crises brought by climate change to urban development has gradually become a hot topic of concern for cities, which also highlights the need for resilient city construction. Resilient planning is widely recognized as one of the effective strategies to adapt to climate change and prepare for urban safety problems caused by extreme weather events.

With the rapid progress of urbanization in China, the urban space and population distribution of the majority of cities are becoming more and more dense, the social organization and functions of cities are becoming more and more complex, and the economic structure of cities are becoming more and more diversified, which also makes the uncertainty and unknown risk disasters faced by urban development more and more complex, and the impact and consequences caused by them are increasingly difficult to be measured. 2012 Beijing 7.21 flooding event, 2013 Yangtze River Delta Region Large Area Haze Time, 2021 7.20 Extraordinary Heavy Rainfall Flooding Event ..... The current research on resilient cities in China is still at the stage of introducing foreign theories and methods mainly, with less local research. Although the demand of resilient city planning practice is

increasing, the planning theory, planning method and planning technology are seriously lagging behind the demand of planning practice. China's cities are becoming resilient without delay.

1.2 Research Approach and main questions

Under the blow of a series of events caused by global warming and climate extremes, the idea of resilience to cope with the persistence of natural disasters is beginning to be applied to the field of urban climate change research . How to adapt to changes in natural climatic conditions through urban planning means and improve the ability of cities to cope with natural disasters under the premise of dense population and buildings, complex functions and limited land use. Among them, urban climate adaptation planning has become one of the most important means to improve urban resilience by adopting appropriate planning strategies to mitigate and adapt to climate change and improve the resilience and response capacity of cities, which can help reduce the occurrence of natural disasters caused by extreme weather.

In this context, the Chinese government constructed a new type of comprehensive disaster prevention plan in 2010, launched the "Sponge City" project in 2014, and jointly issued the "Action Plan for Urban Adaptation to Climate Change" by the National Development and Reform Commission and the Ministry of Housing and Construction in 2016 to address the impact of extreme weather on cities and guide them to become more resilient. more resilient responses. However, climate extremes in the relative pilot cities continue to have serious consequences for local communities and human casualties. The relatively short period of time since the programs were initiated and implemented is one factor, as are the relatively independent plans and the often problematic interface between them. How should resilient cities be understood in the Chinese context,

what is the relationship between resilient cities and traditional Chinese planning, how can planning policy aspects and spatial design lead to resilience, and how can new technical tools be applied. In the face of brutal and realistic urban disaster statistics, and the vulnerability of Chinese cities, these have gradually become bottlenecks that constrain the safety and sustainable development of Chinese cities.

1.3 Aims and objectives

- Explore the current status of building and implementing resilient cities in China and find the direction of urban improvement
- Understand the Chinese government's policies on climate change and urban resilience, as well as its exploration and efforts in the context of rapid urban development in China
- To explore the relevant plans for improving urban resilience in China and their strengths and weaknesses and limitations
- Exploring the interconnectedness of ecological, spatial, functional and climate-resilient characteristics of urban form
- In-depth analysis of specific city cases and recommendations for guiding urban resilience building

1.4 Research methodology

1.4.1 Literature Research

Systematic organization of literature is a prerequisite for research. In this paper, a large number of books, books, journal articles, papers and reports related to urban planning in response to climate change were collected, read and organized extensively. Advanced foreign research on urban

resilience and related academic conference reports are collected, and the Chinese side collates the Chinese Society of Urban Planning, the national professional journal with planning as its core, Planner, and International Urban Planning sponsored by the China Academy of Urban Planning and Design. At the same time, urban policies and related government implementation documents and data reports for the Xiamen government in China were compiled, and feedback on policy implementation and policy updates were collected.

1.4.2 Case study method

The analysis of practical case studies in Xiamen, China, will deepen the theoretical research, and conversely test the feasibility and effectiveness of the theory in practical projects, and through theoretical experience in order to better guide future practical activities. The research basis of this paper involves relevant practice cases, including those in developed countries such as Singapore, the United States and the United Kingdom, which have already achieved certain results, and takes the implementation of resilience-related policies and practice pilot projects in Xiamen, China as the main object of study, with in-depth research on specific cities being an important guarantee of the operability of the research findings.

1.4.3 Interviews

Interviews with professors in the field of urban resilience and with frontline planning staff and professors at the Xiamen Planning and Design Institute in Fujian Province, China, provide a broader range of insightful perspectives and opinions on the content and findings of this paper.

The author's interviews with Professor Nicola Tollin, an expert in the field of 'resilience' research, provide the most objective and empirically based deeper knowledge of the development and application of the concept of resilience, and share the wealth of experience and strategies for advancing

resilient urban development and climate change adaptation that he has been involved in during his research work. He also shares a wealth of experience and strategies to promote resilient urban development and climate change adaptation that he has been involved in during his research work. The interviews consist of a series of questions provided by the authors related to the research content of this paper, concerning controversial views on the concept of resilience, the implementation of resilience strategies and other related issues, and avoiding a completely closed formatted question and answer session, providing the interviewees with an open opportunity to provide their own perspectives, in order to expand the limitations of their views and lead to in-depth conversations between the authors and the interviewees to think about new directions for the research of the paper.

Also in the China case study chapter, the authors interviewed local planning practitioners (Xiamen Planning and Design Institute) in Xiamen, Fujian Province, China, to gather the most up-to-date information on local resilience planning policies and implementation in Xiamen and to provide contributions and relevant urban planning information to support the case study.

2 Resilience overview

2.1 Definition of resilience

2.2 From resilience to the urban resilience

2.3 The social implication of the urban resilience

2.4 The specific outlook: climate resilience

2.5 National adaptation plans

Resilience overview

2.1 Difinition of resilience

Over the past decades, the term resilience has been influenced by the spread of the term across disciplines such as physics, applied mechanics, materials science, psychology, medicine, ecology and the field of urban planning. It has continued to drive the application, development and transformation of the term 'resilience' in various scientific fields and has been expanding its definition and meaning. The definition of the term "resilience" is still a vague concept._The simplest definition of resilience is the ability of a system to undergo change in the face of external disturbances and still maintain its basic function and structure. The cultural history of the term resilience dates back to the 17th and 18th centuries, when the concept was used in early modern British physics to mean the balance of forces in the application of elastic objects and materials. Its physical elasticity also drove the exploration of traditional terminology in applied mechanics and materials science. There has also been a trend to re-expand the meaning of the term.

In 1973 Holling defined engineering resilience as the ability of a system to recover to an equilibrium or steady state after a disturbance, with the focus being on recovery time, with faster recovery efficiency indicating greater stability and resilience. These disturbances are not limited to natural disasters but can also be social crises and cataclysmic changes or wars. Engineering resilience is a single, stable equilibrium state. After the First World War, when psychological science resumed its interest in the mental health and stability of individuals and societies, 'resilience' was also emphasised in psychological science, where it had previously been used to

describe individuals, groups of individuals below shock and emotional stability, and remained a broad psychological statement. Resilience in psychology has also experienced a shift in attention to the concept of resilience, to a retreat to the background and then a shift back to resilience in the 1950s. The concept of resilience has thus weaved and shifted within various academic fields, with influences driving it. “the impression was given in the end that all physical, biological and social systems are regulated and controlled according to similar principles” (Stamou 2012, pp. 96 ff.). It is undoubtedly a powerful and influential term, and with the increased awareness of and responses to the financial crisis, global warming, extreme disasters, including the recent global Covid-19 epidemic, the concept of resilience has become an inescapable study for researchers from many different disciplines due to its dynamic, co-evolutionary, moving on to a better state.

The concept of resilience first appeared in ecology in the 1970s when C. S. Holling, a professor of ecology at the University of Florida, namely In his book 《Resilience and Stability of Ecological Systems》, C. S. Holling introduced the concept of "ecosystem resilience" in 1973, that is, "the persistence of natural systems in response to natural or human-induced changes in ecosystems", In this seminal paper, sharp attention to the resilience of ecological, systems has strengthened so that the primary definition of “static equilibrium” of resilience (i.e., the ability of a system to return to an equilibrium state after a temporary disturbance[1]) evolves

[1] Alessandro Bonifazi ,Carlo Rega. The Rise of Resilience in Spatial Planning: A Journey through Disciplinary Boundaries and Contested Practices. *Sustainability* 2020, 12(18), 7277.

toward a “dynamic” one.[2] In Holling's 1973 IIASA research proposal, “already signalled the reorientation towards the development of a scientific, planning and management concept for a strategic linkage of the resilience of ecological and social systems” (Holling 1973b). The aim is to provide government and social decision makers with a policy design process that integrates environmental, economic and social aspects. The planned 'resilience framework' exhibits 'the characteristics of resilience and stability and the ability to survive under great uncertainty. Diversity, spatial and temporal heterogeneity, flexibility, small-scale processes" (IIASA 1973, pp. 13f.).[3]

And in 1996, further identified "ecological resilience In 1996, in《Engineering Resilience Versus Ecological Resilience》identified the special features of "ecological resilience" from the traditional concept of "engineering resilience", and pointed out that these two different definitions of resilience originated from different understandings of the concepts of "stability" and "balance". Engineering resilience" focuses on a single state of ultimate equilibrium, measured by the indicator of "the speed of the system's return to equilibrium", while "ecological resilience" focuses on the evolution and development of the system, measured by the indicator of "the speed of the system's return to equilibrium". Ecological resilience" is concerned with the evolution and development of the system, measured by the indicator "the magnitude of disturbance the system can withstand

[2] Grazia Brunetta and Ombretta Caldarice. (2020) Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. Encyclopedia of the UN Sustainable Development Goals.

[3] Hans Dieter Hellige. (2018) *The metaphorical processes in the history of the resilience notion and the rise of the ecosystem resilience theory.* The resilience concept:From its historical roots to theoretical framework for critical infrastructure design.

before transitioning to another regime (regime)"[4]. In 2001, in Holling's book：《Understanding Transformations in Human and Natural Systems》, Holling first applied the concept of ecosystem resilience to human social systems and proposed an "adaptive cycle" model to describe the interaction between disturbance and restructuring in social-ecological systems.

This model describes the interactions between disturbance and restructuring in social-ecological systems and the changes in their resilience. Four different phases of change in the structure and function of the system are involved: the growth or development phase, the conservation phase, the release or creative destruction phase and the restructuring phase. In general, the concept of resilience from an ecological perspective has gone through a process of "single equilibrium (engineering resilience) - multiple equilibria (ecological resilience) - complex adaptive systems (adaptive cycles)", from "equilibrium" to "adaptation", and from "equilibrium" to "adaptation". " to "adaptation" and from "ecosystem" to "social-ecological system". Currently, the socio-ecological system resilience theory, based on adaptive cycles, emphasizing integrated system feedback and cross-scale dynamic interactions (chaos).

Shifting perspectives on resilience theory：

Engineering resilience：

Fig1. Focus on recovery time, efficiency and stability. Approaching a single equilibrium state.

[4] Holling CS. Resilience and Stability of Ecological Systems[M]. Annual Review of Ecology and Systematics, 1973, 4(4): 1-23.

Ecosystem resilience：

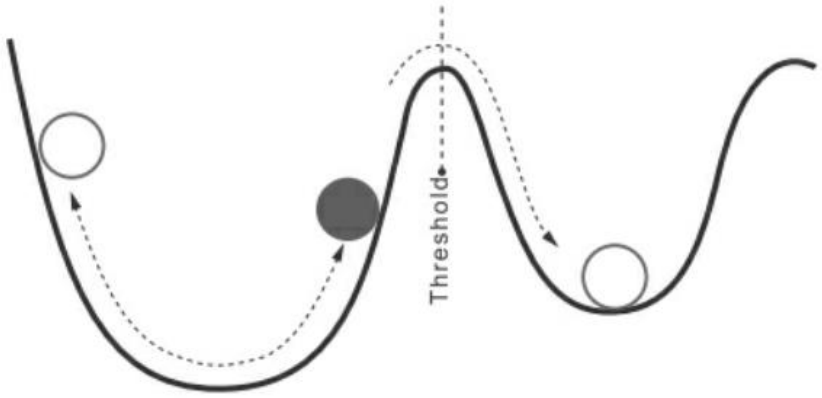


Fig2. Multiple balances. Focus on cushioning capacity, the ability to resist shocks to maintain function.

The notion of engineering resilience is concerned with whether the system can remain at the bottom of the basin; while the notion of ecological resilience is concerned with whether the system can remain within the current basin (Holling 1996).

Socio-ecological resilience:

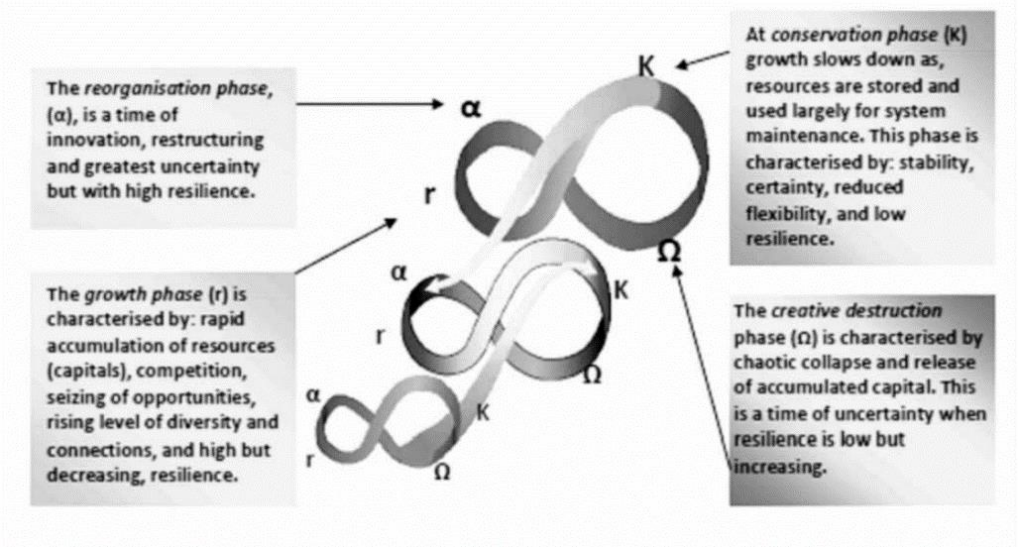


Fig.3 Panarchy, a heuristic model of nested adaptive renewal cycles emphasizing cross scale interplay. The panarchy model of adaptive cycle. Source: Davoudi, et al (forthcoming) adapted from Holling and Gunderson (2002, pp. 34 – 41) and Pendall et al (2010, p. 76).

The basic definition of 'adaptation' in the socio-ecological discipline is the process of active or passive adjustment of the internal elements of a system in response to changes in the external environment, to achieve its own continuous evolution within that environment. A complex adaptive system is a complex system with adaptive functions, consisting of an adaptive subject and an environment. The subject requires the ability to accumulate experience from interaction with other systems and the external environment in order to update better coping patterns to ensure the renewal and sustainable operation of the system.

2.2 From resilience to the urban resilience

Before 2008, urban and regional planners, ecologists, and environmentalists in the United States began to focus on the resilience of urban systems to disasters[5], and the concept of resilience began to be used in a variety of disciplines, with multiple definitions ranging from technical discourse to conceptual metaphors[6]. From ecosystem resilience to socio-

[5] Holling C S. Engineering Resilience Versus Ecological Resilience[J].Engineering Within Ecological Constraints, 1996: 31-44.

Pickett S T A, Cadenasso M L, Grove J M. Resilient Cities: Meaning,Models, and Metaphor for Integrating the Ecological, Socio-economic, and Planning Realms[J]. Landscape and Urban Planning, 2004, 69(4): 369-384.

Clout H. Lawrence J. Vale, Thomas J. Campanella, eds. The Resilient City: How Modern Cities Recover from Disaster[J]. Journal of Historical Geography, 2007, 33(2): 458-459.

[6] Adger W N. Social and Ecological Resilience: Are They Related?[J]. Progress in Human Geography, 2000, 24(3): 347-364.

ecological system resilience (defined as "the ability of a system to absorb disturbances, reorganize, and maintain essentially the same structure, identity, and feedback when subjected to change")[7], resilient socio-ecological systems are characterized by the following:

---The ability of the system to withstand a large number of changes and still be able to control functions and structures

---The ability of the system to self-organize in response to external changes

---The system is able to build and increase its capacity to learn and adapt.[8]

Cities are typical social-ecological systems, and the concept of resilience is also applicable to urban research. “Within this definition, socio-ecological resilience is not conceived as a return to the previous status but as the ability of a complex socio-ecological system to change, adapt, and transform in response to stresses and strains[9]. In this perspective, socio-ecological systems are conceived as complex, nonlinear, self-organized, and permeated by uncertainty and discontinuities (Folke et al. 2004).”[10] Chinese scholars interpret "urban resilience" as the ability to buffer and respond to uncertain disturbances in urban systems and regional scales through reasonable preparations to ensure the normal operation of public safety, social order, and economic construction. Resilient cities emphasize the ability to absorb external shocks and disturbances, to restore the

Carpenter S, Walker B, Anderies J M, et al. From Metaphor to Measurement: Resilience of What to What? [J]. Ecosystems, 2001, 4(8): 765-781.

[7] Walker B, Holling C S, Carpenter S R, et al. Resilience, Adaptability and Transformability in Social-ecological Systems[J]. Ecology and Society, 2004,9(2): 5.

Resilience Alliance, Resilience[EB/OL]. http://www.resalliance.org/576. php

[8] Li Tongyue, New Progress in Study on Resilient Cities.(2017)

[9] Donghyun Kim, Up Lim. Urban Resilience in Climate Change Adaptation: A Conceptual Framework. Sustainability 2016, 8(4), 405.

[10] Grazia Brunetta and Ombretta Caldarice. (2020) Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. Encyclopedia of the UN Sustainable Development Goals.

original state or reach a new equilibrium state through learning and in the organization.[11] With the expansion of the concept of resilience, urban resilience research has gradually broken through the fields of engineering construction and ecosystem research, extending to climate change adaptability, disaster risk management, and economic recession response. Among them, disaster risk management research includes response measures to man-made or natural shocks and secondary disasters such as earthquakes, floods, epidemics, etc. Resilience city is a new way for mankind as a community of destiny to deal with risks and crises from the perspective of a comprehensive system.

In general, the innovative point of urban resilience lies in taking the potential impacts faced by the city as the problem-oriented and responding to the problems through reasonable planning and management methods. It is not limited to focusing on the single goal of physical space construction but focusing on cities in a multi-source uncertain environment, exploring the logic of coping with problems and the methods of social system construction adopted.

Since 2008, researchers from ecology, engineering, public administration, computer science, sociology, economics, and other disciplines have joined the research team of resilient cities in the world as the awareness of global warming, extreme climate disasters, and urban sprawl, whether from internal disturbances in urban systems or external disasters, has increased. In just five years, a large number of research results have been produced, mainly from the United States, the United Kingdom, Japan, and other countries and research fields such as regional planning, environmental

[11] United Nations. "Transforming Our World: The 2030 Agenda for Sustainable Development", adopted by the United Nations General Assembly in Resolution 70/1 on September 25, 2015 [R]

science, engineering, ecology, geography, public administration, and policy. The concept of resilience, with its dynamic, co-evolutionary, and "bouncing to a better state" connotations [12], has been widely applied to the study of adaptation strategies of urban systems in the face of incomplete, massive, and uncertain future climate change[13].

In the more recent Resilient Cities 2019 conference, the theme of urban environmental and social issues has also emerged recently. For example, the study of big data and smart technologies, special urban groups and informal habitats, among other topics, innovation in urban resilience building solutions is advocated to encourage nature-based solutions, smart technologies and resilience building paths from different cultural perspectives.

In the research paper "Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition" by Grazia Brunetta and Ombretta Caldarice, the origin of the term "resilience" is discussed and analyzed in detail. Transition", the origins of the term "resilience" are discussed and analyzed in detail, emphasizing that resilience "refers to the "implied instability " of a territorial system that is able to move toward a new status without losing its identity in the face of change." [14]

The term resilience has been questioned and promoted by researchers from different fields, but the real meaning of the word resilience is the active promotion of different researchers and stakeholders to come together and

[12] Wildavsky A B. Searching for safety[M]. Transaction Publishers, 1988.
Barnett J. Adapting to Climate Change in Pacific Island Countries: the Problem of Uncertainty[J]. World Development, 2001, 29(6): 977-993.

[13] Thomalla F, Downing T, Spanger-Siegfried E, et al. Reducing Hazard Vulnerability: Towards a Common Approach Between Disaster Risk Reduction and Climate Adaptation[J]. Disasters, 2006, 30(1): 39-48

[14] Grazia Brunetta and Ombretta Caldarice. (2020)Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. Encyclopedia of the UN Sustainable Development Goals. *Sustainability* 2021, 13(3), 1113.

promote attention to urban risks and disasters, and interdisciplinary communication in the context of increased attention to the crisis of urban uncertainty and public concern about disasters and risks. “resilience thinking has been characterized as the “science of surprise” (Kates and Clark 1996) in which multidisciplinary scientific collaboration is fostered (Star and Griesemer 1989).”

In an interview session with Professor Nicola Tollin (University of Southern Denmark) on the concept of resilience and its application in the city, Professor Tollin made the following observations on the pillars of resilience policy and its application without the city dimension:

Regarding what to define our resilience before understanding what is fundamental to domestic policies, is this specific understanding that the use for other(all the) resilience. most of the United Nation processes in the policy, use resilience in a rather than limited manner.

They refer to resilience as synonym of climate adaptation, or a synonym of disaster risk reduction, which is a rather limited type of understanding of it.And the definition that tried to use is that resilience shall respond to urban challenges and urbanism challenges and among this challenge is the most urgent and it's the one of climate change. Urban resilience Is shall not only be intended as substitute of climate adaptation was at about the level but shall consider both causes and effects of climate change as an entry point, but not limiting the concept to climate.

This is also to stress another important factor, which is the fact that I'm a resilience in practice. And in policy, is having three different types of Geneses. one that's coming from climate science studies and the second one that is coming from not studies but policies. The second one that is coming out from disaster risk reduction type of policies.

And the third one that broadly considering it humanitarian development

work. For that reason, that's a fundamental premises to or regarding the effectiveness of the policy.Because it's again, a broader type of understanding, the effectiveness of the policy is the main pillar, it's about integration. the integration is having three fundamental aspects.

The first one, it's the cross-sector reality.Meaning that so far and also for understandable reason, intervention in the urban space, are mostly sectarian or specific story issues that can be regarding transport could be looked at in wastewater etc. Or to consider for example, a very specific type of risk or assets. Versus heatwave some.Resilience policies tend to be translated into planning, require to have a cross sectorial title of approach. Particularly in order to avoid replication of Walker rebound effects for considering the fact that we are acting in terms of urgency, in terms of very high stake that we're taking, in terms of very high level of uncertainty, and in terms of very limited financial and human resources. We don't have resources and time available in order to work for one side into transport and other ways to look only at floods, Without considering droughts, we seek to make some examples.

The other level of integration that is needed the one more specifically regarding policies in terms of multilevel governance. and this is a subcomponent that one from one side, related about vertical integration, meaning the level of collaboration between the national level and sub national levels. particularly, of trying to understand which way in national policies can be achieved through the operationalization of local level, and in which way local plans and actions actually aligned with national policies and then and this is also related to a location of resources.

The other subcomponent of the multi level governance it's the horizontal component and this horizontal integration that happens at the different levels mentioned is collaboration among different types of ministries and national level of different types of department on local level.

the third component, as I say, my premises is the one not too limited the scope is to disaster risk reduction in humanitarian work or to climate change. That level also integrated perspective on all that. if you are intervening in particular developing contexts, only in trying to reduce the impact of a specific risk without taking into account that the priority in specific local context is actually survival because the province, most of the populations living below extreme poverty rate, then it's difficult to try to respond to that. Finally, the last pillar is the that instrument in order to reach this level in the three-folder level of integration is the participation.And then we have other components that again, instrumental that its capacity building in general, it's finance.And it's that technology, that's following it more or less socially taxonomy defined by human nation under the Paris Agreement, etc.

Urban systems have multiple, dynamic structural processes and organizational linkages that make urban resilience planning extremely complex. As resilience is supposed to be a dynamic process that is dynamically unbalanced and constantly changing. Spatial resilience in an evolutionary perspective suggests that it is not the “return to normalcy” (Pendall et al. 2010, p.76), but instead “a continually changing process” (Davoudi et al. 2012, p. 304).[15] The development of effective resilience planning depends not only on a scientific assessment of the current state of urban risk and resilience, but also requires a holistic and systematic understanding of urban system processes and mechanisms.[16]

[15] Grazia Brunetta and Ombretta Caldarice. (2020)Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. Encyclopedia of the UN Sustainable Development Goals.

[16] JABAREEN Y. Planning the resilient city: concepts and strategies for coping with climate change and environmental risk[J]. Cities,2013,31:220-229

Resilience has emerged as an attractive perspective with respect to cities, often theorized as highly complex, adaptive systems (Batty, 2008, Godschalk, 2003). 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. [17]

The evolution of the concept of toughness has gone from single homeostasis to multistability to dynamic thinking, from recovery initial to finding new states to continuous adaptation and learning, and from deterministic order to complex disorder to uncertainty and chaotic development process.

Some of the research starts with the multiple feedbacks of complex adaptive systems in cities. The framework of a resilient city is constructed from multiple feedbacks from complex adaptive systems. The identification and study of these feedbacks is key to the framing of complex systems or complex adaptive systems that create self-organising or emergent patterns through multi-directional feedback processes, including urban elements, stressors, outcomes of stressors, reinforcing effects, inhibiting effects, impacts and means of intervention. Urban systems and people interact with four types of stressors - natural, technological, economic and human - as both 'physical' and 'social' element types. The physical elements are physical resources; the social elements include people, institutions and actions; natural stressors are hurricanes, earthquakes, tsunamis and exogenous disasters associated with climate change; technological stressors are technological system failures and their spread; economic stressors are economic fluctuations and increased unemployment and

[17] Sara Meerow, Joshua P. Newell, Melissa Stults. Defining urban resilience: A review. *Landscape and Urban Planning*, Volume 147, March 2016, Pages 38-49.

poverty; and human stressors are terrorist attacks, war, crime and riots.

The most fundamental aspect of planning lies in activating and capturing the principles of self-organisation, and planning for the deployment of new elements and flexibility is an important opportunity to shape urban resilience. In the 21st century, the idea of resilience has been widely applied to urban research, especially in the field of urban disaster management. Although academics have recognized the importance of resilience in urban research, there has been no definite conclusion on how to systematically perceive urban resilience.[18] Nowadays, natural disasters and human actions are considered uncertain, unpredictable urban threats. Therefore, cities must respond more quickly and more effectively to anticipate and minimize the associated consequences and dangers. Promoting urban resilience in relation to environmental, social, economic and political domains has increasingly attracted the attention of researchers and local authorities.[19] "there is then a growing sense that spatial planning not only has an important role in addressing the causes and impacts of new and unexpected events but that it is increasingly required to do so." (Brunetta and Caldarice 2019).[20]

Spatial the aim of resilience work was to create a systematic approach and a clear view about urban resilience for building and strengthening cities

[18] 邵亦文，徐江．城市韧性： 基于国际文献综述的概念解析 [J]. 国际城市规划，2015,30(2): 48-54

[19] Paulo Jorge Gomes，Ribeiro，Luís António，Pena Jardim Gonçalves（2019） Urban resilience: A conceptual framework. *Sustainable Cities and Society* Volume 50, October 2019, 101625.

[20] Grazia Brunetta and Ombretta Caldarice. (2020)Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. Encyclopedia of the UN Sustainable Development Goals. S*ustainable Cities and Communities* pp 628–640.

against new disturbances. [21]Spatial resilience is an important influential force driving spatial planning to persist in innovative change and sustainability adaptability, especially in cities facing unpredictable disaster crises.

Also under the thesis study，Four key pillars of spatial resilience systems are examined ("Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for UrbanTransition") of Prof. Grazia Brunetta and Ombretta Caldarice of Politecnico di Torino, territorial systems in the face of uncertainty. Four pillars of spatial resilience: 1. The Type of Disturbance, "means what shocks sudden events like conflict or disasters – and/or disturbances, long-term trends like resource degradation, urbanization, or climate change, the territorial system aims to be resilient to" (Grazia Brunetta and Ombretta Caldarice,2020), In the face of rapid urban expansion, extreme climate hazards brought by climate change, and especially unpredictable severe urban disasters under global climate change, the vulnerability of cities has increased under the superposition of these aspects in the current situation of dense urban population and complex urban functions. The impact of human activities and artificial construction practices on the land and natural environment has caused the territory to lose its original natural resilience.

2.The Genius Loci, "represents how environmental context (i.e., institutions and social groups) enhances the resilience ability of a territorial system." (Grazia Brunetta and Ombretta Caldarice,2020) "The 'genius loci' are understood in the context of spatial resilience, which emphasises the intervention of people rather than merely relying on and focusing on spatial

[21] Paulo Jorge Gomes， Ribeiro，Luís António， Pena Jardim Gonçalves（2019） Urban resilience: A conceptual framework. *Sustainable Cities and Society.* Volume 50, October 2019, 101625

issues. Communities and institutions are able to act positively and innovatively in the face of external disturbances to their territory, through the group's understanding and experience of their own environment, in a top-down openness to resilience.

3. The Ability to Respond, Means the ability to react when the urban system faces and suffers blows and unpredictable events. Absorbing and buffering the negative impacts triggered by disturbances in an appropriate manner and suppressing them through optimisation, coordination and reorganisation between the components of the entire urban system, allowing the system to function properly and being able to learn and reflect from each shock in order to continuously advance its ability to respond to crises. 4. The Pathway of Response. “represents the range of possible responses to shocks and disturbances of territorial systems – i.e., collapse, conservation, adaptation, and evolution.”

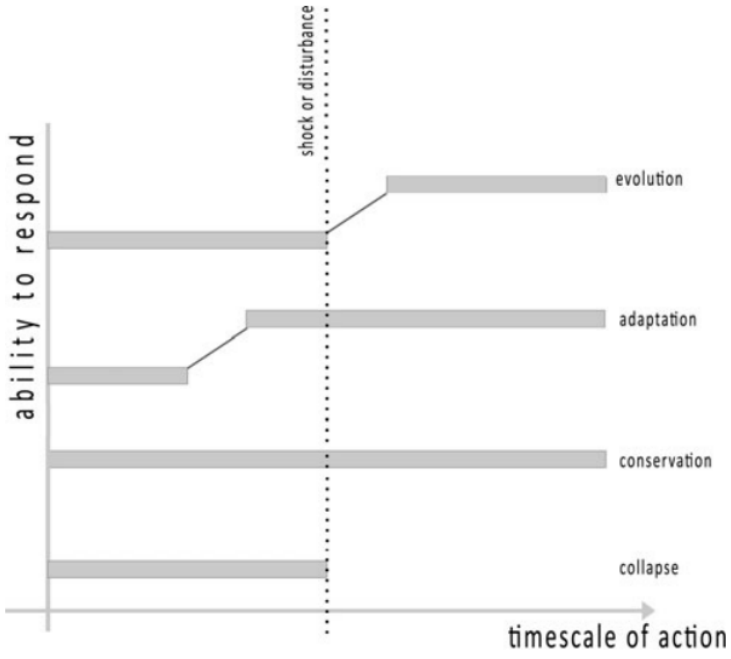


Fig. 4 The pathway of response in relation to the ability to respond of territorial systems. (Source: Grazia Brunetta and Ombretta Caldarice, “Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition”)

Urban resilience is the ability to buffer and respond to imperfectly predictable perturbations and ensure the stable development of public safety, social order and economic construction. Its connotation refers mainly to the logical relationship between the interaction between urban systems and the risks they face, and the measures that cities should take to deal with unpredictable perturbations.

The resilience of cities is supposed to be universally adaptive and its conceptual ambiguity and plasticity have made resilience an increasingly popular concept in the research of global scholars as a response to crises of complex interwoven vast systems and unexpected uncertainties. As cities continue to grow and grapple with uncertainties and challenges like climate change, urban resilience has become an increasingly favoured concept (Carmin et al., 2012, Leichenko, 2011). Urban resilience has become an increasingly popular concept as cities continue to grow and respond to uncertainties and challenges such as climate change (Carmin et al., 2012; Leichenko, 2011).[22]

However, while there are currently many studies and implementation examples of urban resilience evaluation and assessment, the problem is that there is still a lack of methodological frameworks and implementation systems for assessing resilience, which provides a major challenge and opportunity for the future development of holistic research on enhancing urban resilience, where a systematic standard framework that can be formulated into problems can identify the most effective measures to improve the resilience of different urban systems and provide urban planners with a more precise understanding of the specific problems of urban resilience.

[22] Sara Meerow, Joshua P.Newell, Melissa Stults. Landscape and Urban Planning, Volume 147, March 2016, Pages 38-49. Defining urban resilience: A review.

According to Godschalk D.R in his article "Urban hazard mitigation: creating resilient cities" in 2003, "the concept of resilient cities has been developed primarily as a response to urban The concept of the resilient city was originally conceived as a consideration of urban risk response. "International scholars have proposed a range of integrated approaches to assessing urban risk resilience for different types of cities and for different risks such as floods and earthquakes; for different spatial scales such as communities and cities; and for different urban functions.

In relation to the study published by Professor Nicola Tollin in article: 《Building Resilient Cities: Climate Change and Health Interlinkages in the Planning of Public Spaces》2022. Several tools developed by UN-Habitat to analyse and assess urban vulnerability and climate change are also mentioned in the 'Assessment Process' of the article. Including "Climate Change Vulnerability and Risk" , "The City Resilience Profiling Tool (CRPT)", The "Health Impact Assessment (HIA)"… etc.

In response to the content of the Assessment tools analysis, the interviews were equally interested in whether the results in Copenhagen, the specific analysis methods and data in the decision-making process and supporting design phase could be shared or replicated in other regions. In response to the question about the formulaic nature of assessment, Professor Tollin made the following comments:

The couple of levels of consideration this matter,

First, the analytical part of that specific article trying to look at the interlinkages as any type of scientific level, it's replicable, because the methodology should be always clearly described transparent and that should give you a possibility to be replicated just to test, the conclusion but also for further development of the world. So on that level, yes, it's replicable. As a matter of fact, I don't know if you had the possibility to look

at it. But that work also was instrumental in order to develop that project in collaboration. With CDP and the World Health Organization, to which we've been developing profile, herbal profiles for six cities, looking at health and climate interlinkages.

Then another factor for replicability. It's very much and that's limiting the applicability.

That's related to the specific context.

When I speak about the specific context, I'm speaking about a number of different variable, the most obvious one is the physical one, physical and which we can put also question regarding specific climatic methodological conditions etc. But most importantly, we have a legislative and normative frame. And we have also social, cultural one.

Meanings on that and this define also specificity of the case in Copenhagen. I will point out specifically to the social cultural work because eventually is the one that it's a little bit more oversighted. Meaning that in Copenhagen, the relation with public open spaces, and the use of means of mobility that are not based on a motorized vehicle is much broader and open with respect many the context, not only global level that's evident but also within same Europe. meaning it's more much more natural, culturally for citizens in Copenhagen, to use, for example, bike as a means of transport or working instead to use cars or motorized transport.

This is something that has been also supported by policy, policy decision. And these reflect also on the way in which citizens are understanding and living public spaces, particularly green public spaces.

To give you a couple of practical examples. within the project to construct the new Metro underground stations. It was mandated for the project implementation that we're consideration regarding public spaces that were consideration regarding climate change adaptation. That we're going beyond the simple provisional of the station for the port.

And it's again, it's an example of a cross sectoral integration as we are speaking about before. So they're out of the case of Copenhagen. We can then summarize that these interlinkages shall be based on a clearer understanding in terms of planning of the about the inclusion of else considering it.

we need more that information that we need clear policy and planning guidelines. And then we also need some level of capacity building both among the professionals and the policymakers.

Working from Europe, we implicitly think that cities are responsible for the planning process here locally.

Local authorities are responsible for local planning and cities. That's not the case in in all countries. Many countries around the world the responsibility for urban planning and reciting within the national government.

Already that paragraph graphical but it's just a different in context that already that a single one issue changed completely the way in which planning understood. what was said before regarding social cultural background, and those difficult one.

2.3 The social implication of urban resilience

Early academic understanding of social resilience focused on reducing the vulnerability of social systems to external hazards[23], but not enough attention was paid to internal changes in society (e.g, social change) or long-term chronic stress changes (e.g, climate change).

[23] ADGER W N. Social and ecological resilience: are they related? [J].Progress in human geography,2000,24:347-364.

International research on resilience theory has mainly covered the fields of ecological resilience, engineering resilience, economic resilience, and social resilience. Compared with the concept first proposed by Holling, social-ecological resilience shows a more complete understanding of the system's operating mechanism. Socio-ecological resilience describes an adaptive cycle of chaotic equilibrium, i.e., the ability of a system to absorb shocks, recover its state and continue to develop when disturbed by uncertainties, i.e., the amount of disturbance and system that can be absorbed while remaining in equilibrium. The ability to self-organize is superimposed on the ability to improve learning and adaptation.

In recent years, research has considered "social resilience as the structural nature of society, the connectivity of its parts, and the strengths and qualities that sustain the social structure and facilitate its effective functioning and development" [24], and "the ability of social systems to restore equilibrium in the face of external uncertainties or perturbations"[25]. It is the ability of a social system to restore equilibrium in the face of external uncertainties or perturbations", and emphasizes the interconnectedness and consensual behavior of individuals, groups, and organizations (e.g., social participation), the internal factors and processes of social systems such as rights and competition systems[26], and the equality of different age and income groups in climate change adaptation[27]. Markus

[24] 王思斌 . 社会韧性与经济韧性的关系及建构 [J]. 探索与争鸣 ,2016(3):4-8,2

[25] 赵 方 杜 , 石 阳 阳 . 社会韧性与风险治理 [J]. 华东理工大学学报 (社会科学版),2018,33(2):17-24.

[26] COTE M, NIGHTINGALE A J. Resilience thinking meets social theory: situating social change in socio-ecological systems (ses)research[J]. Progress in human geography, 2012,36:475-489.

[27] DUY P N, CHAPMAN L, TIGHT M.etal. Urban resilience to floods in coastal cities: challenges and opportunities for ho chi minh city and other emerging cities in southeast Asia[J].Journal of urban planning and development, 2018,144:05017018.

et al. reviewed the development of the concept of social resilience as the ability of all aspects of society to cope with disasters, the ability of social agents to learn from experience and adapt to future challenges in their daily lives, and the ability of society to undergo structural transformation, emphasizing better individual welfare and overall robustness to face future crises[28].

Most cities' definitions and priorities for resilience focus on recovery and adaptation, with limited engagement with systemic inequality and the uneven politics of urban development. Some cities do emphasise equity in their plans, suggesting that resilience efforts can advance social justice, but even they tend to focus on the equal distribution of material resources and opportunities. Applied to planning and development in the context of climate adaptation and resilience, allocating resources evenly may flatten identities and misrecognise the different needs of individuals, especially those whose identities are politically underrepresented.[29]

At present, Numerous studies have shown that hazards disproportionately impact low-income and minority communities, that they receive fewer resources to recover, and that disruptions often exacerbate inequalities. Definitions of social equity and justice have evolved over time, generally expanding from a narrower focus on distributional equity to include participation and recognition as critical components of justice. Several recent studies (Chelleri et al. 2015; Meerow and Newell 2019; Fainstein 2018) [30] have raised concerns about the distributional inequities of

[28] KECK M, SAKDAPOLRAK P. What is social resilience? Lessons learned and ways forward[J]. Erdkunde, 2013,67:5-19.

[29] Sara Meerow, Pani pajouhesh&Thaddeus R.Miller. (2019) Social equity in urban resilience planning

[30] Judy Bush, Andreanne Doyon (2019),《Cities》*Building urban resilience with nature-based solutions: How can urban planning contribute? ,*Volume 95.

resilience-building efforts, pointing out that there are inevitable trade-offs in the beneficiaries of resilience initiatives, and they are often not the most vulnerable.

The formulation of resilience policies and the fairness of the specific devolved distribution are crucial when dealing with social groups of different densities, incomes and statuses, and policies that are uniformly distributed across the board and do not take into account the specific needs of regional groups often exacerbate urban vulnerability and inequality. The implementation of resilience under resilient urban planning requires those in power to have a reasonable understanding of and respect for different groups of people in different areas, to pay attention to who is more vulnerable in actual policy making, and to understand the historical context in which social vulnerability is formed. There is a need for more scientific distribution, more inclusiveness and forms of collaboration between different social groups and their participation and understanding of policy designations.

The situation of Chinese society is characterised by social resilience and related social problems with Chinese characteristics in the context of China's development history.

The situation in Chinese society is characterised by social resilience and related social problems with Chinese characteristics in the context of China's current development. From the perspective of urban planning and construction in China, Chinese planners emphasise the ecology of urban space, engineering resilience And relevant pilot projects such as sponge cities, eco-cities and smart cities have been proposed. In the wake of the global public health outbreak in 2020, a series of policy responses to the outbreak in several Chinese cities have revealed the fragility of urban

society. This is also linked to China's specific political system and social governance system. In the midst of rapid urbanisation and a burgeoning urban population, China's current cities are no longer the traditional acquaintance communities of the past, nor are they truly socially autonomous, with unfamiliar community relations among residents and low community organisational capacity and responsiveness.

Chinese citizens interface directly with the market and government to realise their needs, and government services and market products reach individuals directly for their daily needs, so that the current general situation is one in which individuals have less need for and dependence on residential communities and community organisations. Residents are generally unfamiliar with the people who govern their communities and therefore have little real involvement in community governance activities. The separation of individual life and community makes social organisation and social participation more difficult. This alienation, coupled with the implementation of a 'one-size-fits-all' policy of decentralisation, therefore contributes to social vulnerability.

Social resilience requires institutional and governance flexibility, requiring the coordination of the various social groups in the main body of social governance, with enough independent flexibility to adjust the deployment of resources, to be able to respond quickly to the needs of the population and to avoid the accumulation of numerous fragmented demands and problems. Creating the strengths of the people in social resilience, normativism and avoiding pure technocracy, in order to cope with the complexity of uncertainty.

2.4 A specific outlook: Urban climate resilience

Climate change and rapid urbanisation in China are intertwining at an unprecedented pace and scale. The uncertain risks posed by climate change also pose new challenges to urban planning, and building resilient cities that respond effectively to climate change will become an important topic for urban planning research.

The application of resilience thinking to the field of urban planning has become a hot topic of extensive debate in the context of global climate change and extreme weather conditions that have led to a number of practical strikes against urban systems in response to natural disasters and adaptive strategies in the face of unpredictable, massive and uncertain future climate change.[31]

Climate-related disasters have cost the world $650 billion in the last three years, more than 0.25% of global GDP in that time; and it is projected that a 2°C rise in global temperatures by 2100 could cost up to $69 trillion. Every $1 increase in the planet's climate resilience investment saves $6 in other areas. The United Nations Environment Programme's (UNEP) Climate Adaptation Gap Report, published in 2021, states that the annual cost of climate adaptation in developing countries alone will be around US$79.6 billion in 2019; this figure will rise to US$140-300 billion by 2030 and US$280-500 billion by 2050. These astronomical figures tell us how much effort is required to build climate-resilient habitats, and how much potential there is for nature-based, nature-adapted building pathways.

It is in this context that nature-based green infrastructure and climate-resilient sponge cities have received unprecedented attention. UNEP, governments around the world and major banks are also beginning to turn

[31] Thomalla F, Downing T, Spanger-Siegfried E, et al. Reducing Hazard Vulnerability: Towards a Common Approach Between Disaster Risk Reduction and Climate Adaptation[J]. Disasters, 2006, 30(1): 39-48

their attention to climate adaptation responses and actions. It is particularly noteworthy that in recent years, the concept and practice of "sponge cities" with strong Chinese characteristics has become a hot topic, with as many as 100 million search results for "sponge city" in Google, almost as many as The number of Google searches for "sponge city" is 100 million, almost twice as many as for "Confucius". And the world's major banks - including the World Bank, the Asian Infrastructure Investment Bank and the European Bank for Reconstruction and Development - are turning their attention to nature-based investments in climate-resilient infrastructure, including sponge cities and eco-infrastructure.

The impacts of climate change on cities include the urban 'heat island effect', increased cooling demand and reduced urban air quality; heavy rainfall, significant pressure on municipal infrastructure and flood defenses, damage to urban underground spaces and facilities, increased risk of infectious diseases; longer periods of drought, threatening food and water security, increased fire risk; typhoons and sea level rise.

Climate change	The impact of climate change on cities
High temperatures	Urban "heat island effect"; increased demand for cooling; deterioration of urban air quality; increased water demand; deterioration of water quality.
Cold snap	Snow and ice causing traffic disruptions; increased heating demand; damage to municipal infrastructure; inconvenient travel for residents; deterioration of surface water quality; flooding causing temporary disruption to commerce, transport, social operations
Rain storm	Significant pressure on municipal infrastructure, flood defences; damage to underground spaces and facilities; damage to property; Increased risk of infectious disease; secondary disaster damage
Typhoon	Power and water supply disruptions; traffic disruptions due to flooding and high winds; property damage
Drought	Threats to food security; threats to water security; constraints on industrial production; increased risk of fire; impact on plant growth
Sealevel rise	Seawater intrusion, reduction of freshwater resources; erosion and inundation of land; urban and population displacement; increased cost of coastal protection; destruction of urban infrastructure; Impact on coastal zone biodiversity

Fig5. The impact of climate change on cities. (Author's summary from: Hong

Liangping , Hua Xiang , Cai Zhilei . Urban planning responses to climate change [J]. Urban Issues ,2013(7):18-25.)

Rapid dynamic urbanization brings changes in the urban spatial environment and, combined with the inherent fragility of the urban fabric, the control of urban elements in urban planning is key to climate adaptation. "The concept of 'resilience' has been accompanied by the frequent use of terms such as 'climate resilience' and 'climate-resilient cities', which emphasise the ability of cities, urban agglomerations and urban residents to recover quickly from climate-related emergencies.[32] Climate resilience is the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate.[33] In the case of urban climate adaptation, an approach based on resilience encourages practitioners to consider innovation and change to aid recovery from stresses and shocks that may or may not be predictable.[34] Resilience- building as a strategic approach has many advantages over conventional system management for complex social–ecological systems that are dynamic and facing high uncertainty (Walker et al., 2002).

Of the actions that have been implemented, some countries have aimed to increase the resilience of their cities and have successively developed their own disaster prevention or adaptation plans to deal with extreme weather strikes, mainly at the level of dealing with climate change.

Rotterdam in 2008 in its Climate Protection Plan to address the threat of sea level rise due to global warming through flood management, adaptive

[32] PELLING M. The Vulnerability of Cities: Natural Disasters and Social Resilience[M]. Earthscan,2003. BOYD E, OSBAHR H, ERICKSEN P J, et al.Resilience and ‘ Climatizing’ Development:Examples and Policy Implications[J]. Development,2008,51(3):390-396.

[33] c2es. https://www.c2es.org/content/climate-resilience-overview/.

[34] Debra Knopman, Robert J. Lempert. Urban Responses to Climate Change Framework for Decisionmaking and Supporting Indicators. *RAND Corporation.*

floating flood gates and floating houses; London in 2011 in Managing Risk and Building Resilience using rainwater-stagnant green buildings, flood management, tree planting and green roofs to tackle persistent floods, droughts and extreme heat; New York in 2013 in A Stronger, More Resilient New York addresses climate threats such as floods and storms by proposing to transform infrastructure such as communities, hospitals, power, roads, water and drainage and flood control.

Two of the perspectives to address urban disasters and urban climate change in resilient urban planning and construction are low-carbon resilient planning techniques for climate change mitigation and a planning research framework for climate change adaptation respectively. Resilient Cities Theory argues that the two strategies are not independent and emphasises that the priority trade-offs between the two should be explored both conceptually and practically, building on both for integrated climate action.[35] Planning techniques for climate change mitigation are mainly related to reducing the risk of climate hazards, which aims to reduce the frequency and intensity of regional and urban climate extremes, thus reducing the risk of cities facing extreme climate hazards such as floods, storms and high temperatures. One of the major causes of climate change is the high level of greenhouse gas emissions from urban energy, transport, buildings and other systems. Therefore, climate change mitigation is often planned and controlled through energy, transport, land, water, buildings and solid waste materials, such as through transit-oriented development techniques, multi-distribution of public services, pedestrian-friendly neighbourhood-scale control techniques, and green carbon sink networks to mitigate damage to

[35] LEICHENKO R. Climate change and urban esilience[J].Current opinion in environmental sustainability, 2011,3:164-168

the environment and reduce greenhouse gas emissions, thereby achieving the goals of climate change mitigation and abatement of extreme The aim is to mitigate climate change and reduce extreme weather events.

Climate change adaptation planning techniques are a range of technologies that allow urban systems to adjust to the effects of climate change (e.g. floods, storms, heat, etc.) in order to adapt to changes in the current state of the environment. When mitigation techniques are unable to counteract the dangers posed by extreme climate hazards, adaptive planning techniques are needed to reduce the vulnerability and exposure of cities to climate hazards, and to improve the ability of cities to adapt and transform to face the impacts of hazards such as heat, floods and storms on urban systems.

From the perspective of urban planning policy, urban resilience involves and how policy and planning tools can be adapted to ensure its detailed implementation in the face of climate change, Professor Tollin made the following observations:

It's a basic radical change. Well, resilience is a radical change in terms of planning. Process instruments. This is due to the fact that with urban resilience particularly with reference to its climate change component we are facing a high level of uncertainty. And also, in the latest definitions, at least in the latest scientific developments, the concept is clear that urban resilience requires a dynamic approach. Urban resilience is defined as an evolutionary process.

So, the uncertainty and the dynamic characteristic that are mandated in order to manage the urban resilience transition to require a change in planning. planning can still nowadays it's often intended in a more than view of it. 19 Century based type of approach where you're planning something on the base or challenges that refer are fixed, in the pre

preparation of the plan then you are implementing some works that often are resulting in some physical structure, infrastructure to be built, the work is done and is finished. in reality and nobody through all the implementation phase that can be extremely long is ever reviewing what were the promises of that.

when we are and that it's creating some monsters. Give you an example for this, please take my statement regarding this example as illustrative and not take it as granted and just making general reference, I'm not going to be very precise.

Venice, and it's problem of floods. That are further accentuated by sea level rise due to climate change. The solution that the government agree upon over almost 30 years ago, The issue was that actually the scenarios that were prepared in order to take a decision and then implemented projects were done 30 years ago. The entire project and entire Walk was basically developed. considering scenarios that have never been fully updated or that were not using through mentally in order to review and eventually upscale or eventually manage.

The project implementation better. So we are constantly and rapidly developing more knowledge regarding both climate change impact and possible solutions. Working what is not working. been able to build up a system of planning more is a process, a dynamic process that can constantly be retrofitted by base new knowledge.

Then thing up with things that are going to be at best useless. of course, having the even more negative effect and positive ones. in terms of resilience also, as we are speaking about wicked problems, problems that are very matching to tween and difficult to understand.

The planet doesn't have the possibility to be wrong and to invest resources in sensing that it's just not completely almost resolving the problem. It's creating, it's enhancing the negative impact of the phenomenon that you're trying to respond to.

2.5 National adaptation plans

The national adaptation plan (NAP) process was established under the Cancun Adaptation Framework (CAF). It enables Parties to formulate and implement national adaptation plans (NAPs) as a means of identifying medium- and long-term adaptation needs and developing and implementing strategies and programmes to address those needs. It is a continuous, progressive and iterative process that follows a country-driven, gender-sensitive, participatory and fully transparent approach.[36]

National Adaptation Plans (NAPs) are a tool and process designed to help countries assess and address their vulnerabilities to climate change and develop strategies for adaptation. NAPs are a key component of the United Nations Framework Convention on Climate Change (UNFCCC) and are supported by the United Nations Environment Programme (UNEP) and other international organizations.

The primary objective of NAPs is to enable countries to identify their current and future climate change risks and develop appropriate adaptation measures. While NAPs are not specifically focused on assessing resilient cities, they can contribute to enhancing the resilience of urban areas within a broader national context.

NAPs typically involve the following some key steps，Countries assess their vulnerability to climate change by conducting a comprehensive analysis of climate hazards, exposure, sensitivity, and adaptive capacity. This assessment includes considering the potential impacts on various sectors,

[36] Alec Crawford ,Clare Church, Christian Ledwell. Toolkit for Engaging the Private Sector in National Adaptation Plans (NAPs).2020. https://unfccc.int/.

including urban areas.Based on the risk assessment, countries develop adaptation plans that outline strategic objectives, priorities, and actions to address climate change risks. These plans can encompass multiple sectors, including urban planning, infrastructure, agriculture, water resources, and more.

NAPs include mechanisms for implementing adaptation actions, such as establishing institutional frameworks, mobilizing financial resources, and promoting stakeholder engagement. Monitoring and evaluation frameworks are established to assess the effectiveness of adaptation measures and make adjustments as needed. Aim to mainstream adaptation considerations into national policies, plans, and decision-making processes. This integration ensures that adaptation is embedded across sectors and levels of governance, including urban planning and development.

While NAPs primarily focus on national-level adaptation planning, they can indirectly support the creation of resilient cities. Cities are integral parts of national systems, and the identification and integration of climate risks and adaptation measures at the national level can inform and guide urban planning processes. NAPs provide a framework for countries to assess the vulnerabilities and adaptation needs of urban areas, enabling the development of policies, strategies, and projects that enhance urban resilience. Furthermore, NAPs often involve consultations and engagement with sub-national entities, including local governments and stakeholders. This provides opportunities for cities to contribute to the NAP process and ensure their specific adaptation needs and priorities are taken into account.

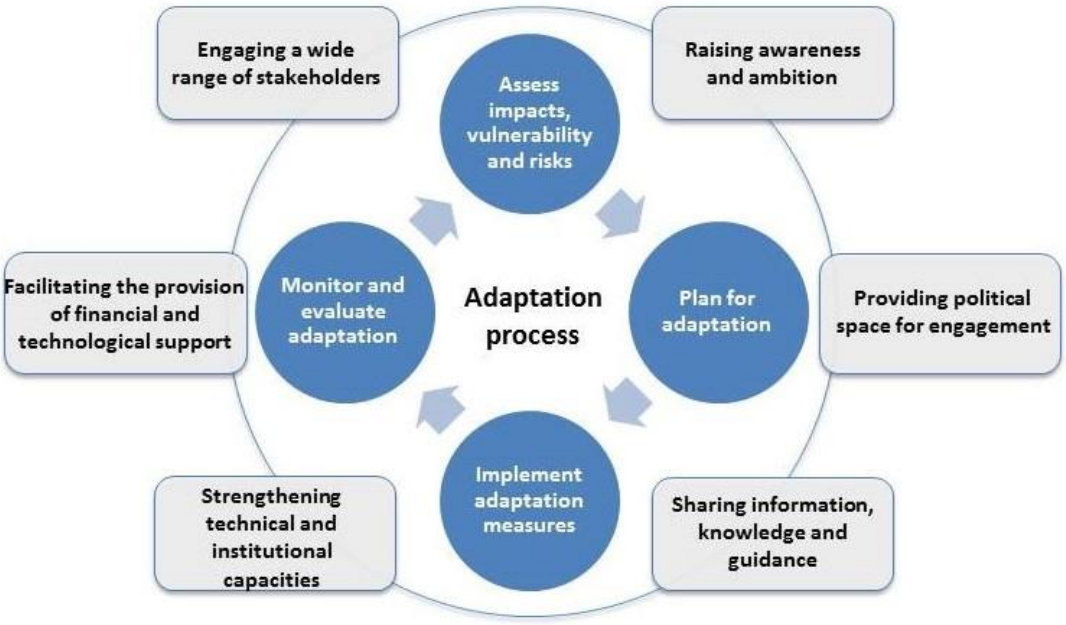


Fig.6 adaptation policy cycle and support offered under the UN Climate Change regime. Sources from: https://www.unep.org/explore-topics/climate-action/what-we-do/climate-adaptation/national-adaptation-plans

The NAP mentioned in the publication "A Methodological Framework to Assess the Urban Content in Climate Change Policies" is a very important element. China is updating its National Climate Change Plan. A number of thematic projects have also been carried out, such as the Sponge City Pilot Project, Eco-City and Low Carbon City construction.

Taking up the final sentence of publication, "…(i)…. In a nutshell, to make the NAP's urban content review a functional tool for national and local governments to implement climate actions, the methodology should be replicated across all countries that submitted NAPs up to the present. Reviewing the urban content would help Un Habitat define a stronger focus on implementing climate action within new guidelines that strengthen the urban content in NAPs. Secondly, it will allow nations to understand their

policies' limitations or strengths while also comp …(i)…"[37]

In the process of updating for the NAP, Professor Tollin made the following points during the interview session: we've been carrying out the preliminary review of the urban content of labs but was more internal exercises was published data. we've been carrying out an extensive review of the urban content on nationally determined contribution.

So for your knowledge under the Paris Agreement, the main policy that all countries are mandated to submit regularly is national determined contribution and this is having elements of mitigation adaptation, and then also include consideration of institutional capacity technology and finance.

Then we have two other documents.

type of documents one is national reputation plans, that in this case, referring to non-annex one countries, meaning countries, developing and transition countries. And then we have also that's more focusing on adaptation as we say, and then we have long term, low emission strategies that are having a predominant focus but not exclusive on the issue.

So just to clarify what is the architecture the Paris Agreement for you. So, I cannot speak specifically about the NAPS because it shall be based on an appropriate type of study that we are planning and partially already undertaking for publication but I can refer to the official component of the measurement contribution allowances, for example the content that will be published. So that report states very clearly that there is a major gap for example, in between the determination of climate hazards. So, again, for to give the climate risk. It's composed by climate hazards, that phenomena, specific meteorological phenomena, the frequency the magnitude, etc. multiplied the exposure are multiplied by the vulnerability. divided by the

[37] Pizzorni, M., Caldarice, O., & Tollin, N. (2021). A methodological framework to assess the urban content in climate change policies. Valori e Valutazioni, 27(29), 123-132. https://doi.org/10.48264/VVSIEV-20212909

action to reduce disaster risk.

So that's the out is normally understood. Now, the fact that we found that in the NDCs with urban content the urban climate action, so we're listed at different level, but these were not paid by a recognition within this policy document about the actual climate risk, and by a proper understanding of climate hazards.

So The policy define some possible actions. But these actions were not supported by information on the actual assets and the protection.

This was one of our fun things. so already to have a good baseline. It's an important factor particularly if we're considering that without that baseline, it's very difficult to monitor and evaluate the effectiveness of actions in time and to assess the future impact and the Evergreen back to the fact that planning for resilience shall be considered a process that continuously get integrated with new knowledge.

3 Resilience in China

Resilience in China

3.1 China's National Climate Change Adaptation strategy

The urgency of introducing and applying the concept of resilience in the context of global climate change stems from the increasing frequency and severity in facing climate challenges. Resilience is essential for building the resilience of cities and reducing vulnerability to the impacts of climate change. There is a close and inseparable relationship between urban resilience, national adaptation planning and climate change, with mutual coordination through consistent goals, policy integration and information sharing of data. They interact with each other to enhance the resilience and sustainability of urban areas.

Current projects where urban resilience is clearly linked to national adaptation planning strategies include the Dutch national adaptation planning approach to the challenges of sea level rise and climate change. This approach includes the Delta Plan, which develops an integrated strategy for coastal protection and water management and integrates urban resilience measures in vulnerable areas, and in the South East Asia region, Singapore, which has developed a national adaptation planning framework called the 'Singapore Blueprint for Sustainable Development'. It guides the city-state's efforts to build resilience, sustainability and climate readiness. The blueprint includes strategies for urban greening, sustainable transport, water management and smart and resilient infrastructure development.

Advancing resilience to climate change at national and local levels.

While resilience theory and national adaptation planning policies both aim to reduce urban vulnerability and enhance adaptive capacity, from regional to national overarching objectives, national adaptation policies more operationally provide the ability to identify their current and future climate change risks and specify specific measures that can be practiced, and the identification and integration of climate risks and adaptation measures at the national level can inform and guide the urban planning process. to facilitate the designation of policies and pilot projects that are appropriate to the local context.

The urgency and necessity of applying resilience strategies in practice becomes particularly evident in the context of China's cities, which have a large and rapidly urbanizing population, with huge pressures on resources, infrastructure and the environment and ecology as a result of this huge urbanization process. At the same time, with the rapid expansion of China's economy, the urban economy has become a vital part of China's national economy, with a high concentration of industrial and urban economic activities in urban spaces. The risks posed by climate change to China's economic and social development and the safety of people's production and livelihood will increase.[38]

The frequency and intensity of extreme weather and climate events in China have been on the increase, with heavy rainfall and flooding, high temperature and drought, low temperature and cold damage, tropical cyclones, strong convection, sand and dust, etc. appearing to be characterized by strong extremes, obvious regional phases and frequent occurrence of anomalous conditions. 2000-2021 saw an annual average of

[38] National Climate Change Adaptation Strategy 2035. cset.georgetown.edu. https://www.gov.cn/zhengce/zhengceku/202206/14/5695555/files/9ce4e0a942ff4000a8a68b84b2fd791b.pdf

300 million people affected by meteorological disasters and the secondary geological disasters they caused, with direct economic losses of The average annual damage caused by meteorological hazards and their secondary geological hazards is 300 million people nationwide, with direct economic losses of 289.7 billion yuan. [39]

Climate warming has led to a marked increase in water security risks, a trend towards glacier retreat and a reduction in the extent of multi-year permafrost. Vegetation phenology has been significantly affected by climate change, with reduced stability and an increase in pests and biological invasions. Coastal sea level changes are higher than the global average for the same period, and marine hazards are becoming more frequent and the intensity of impacts is increasing, resulting in huge pressures and serious threats to marine and coastal area ecosystems. It also affects the construction and operation environment of infrastructure and major projects, threatening the safety, stability and reliability and durability of infrastructure and affecting the safe operation of major projects. The impacts of climate change in the Chinese context are far-reaching, broader in scope and continuing to deepen in magnitude, with compounding extreme weather events occurring.

In the face of climate change China has issued a number of climate adaptation related policies at national and sectoral levels in line with the requirements of China's sustainable development strategy and has given high priority.

In 2007, China issued its China's National Programme to Address Climate Change, the first developing country to issue a national level to address

[39] Chao Qingduan (Director, Researcher, National Climate Centre)，2022. “Increasing climate risks, increasing urgency for adaptation action”. http://www.youth.cn/

climate change, which set out various tasks for adaptation to climate change. In 2013, China released its first National Climate Change Adaptation Strategy, which sets out the overall objectives of national climate change adaptation, including key tasks and a series of safeguard measures. Nine years later, in 2022, the《China's National Climate Change Adaptation Strategy 2035》 was proposed, with a different emphasis on "active adaptation" and "scientific adaptation", and "strengthening climate change detection, early warning and risk management". "The strategy will be implemented in the future. At the implementation level, it is particularly proposed to consider different climate regions and to focus on exploring vulnerable areas. The principle of "systemic and synergistic" requires the linkage of different levels of sectors and areas for joint governance.

The strategy clearly states that by 2035, social overall should be more climate resilient, and that a climate resilience society will be basically in place. Focusing on implementation of the strategy, China has out forward a series of enabling measures, and issued Guidelines for Compiling Provincial Action Plans for Climate Change Adaptation, (生态环境部办公厅文件) requiring all localities to formulate provincial action plans for climate change adaptation by the end of 2023, with the aim of strengthening provincial resilience.[40]

The latest China National Climate Change Adaptation Strategy 2035 has four more advanced features: First, it gives more prominence to climate change monitoring and early warning and risk management, proposing such tasks and initiatives as improving climate change observation networks,

[40] China National development and reform Commission. https://www.ndrc.gov.cn/fggz/dqjj/qt/202207/t20220701_1329875_ext.html

strengthening climate change monitoring and prediction and early warning, enhancing climate change impact and risk assessment, and strengthening comprehensive disaster prevention and mitigation; second, it divides the natural ecosystem and economic and social systems into two dimensions, and separately The third is to build a multi-level regional pattern for climate change adaptation, combining climate change adaptation with territorial spatial planning and considering regional differences in climate change and its impacts and risks, and proposing It covers adaptation tasks in eight regions across the country and major strategic regions such as Beijing-Tianjin-Hebei, the Yangtze River Economic Belt, the Guangdong-Hong Kong-Macao Greater Bay Area, the Yangtze River Delta and the Yellow River Basin[41]; fourth, it pays more attention to mechanism building and sectoral coordination, and further strengthens the organization and implementation, financial and fiscal support, scientific and technological support, capacity building, international cooperation and other safeguard measures.

In terms of enhancing the capacity of natural ecosystems to adapt to climate change, the Strategy focuses on natural ecosystems such as water resources, terrestrial ecosystems, and marine and coastal zone ecosystems.

In terms of strengthening the capacity of economic and social systems to adapt to climate change, the Strategy focuses on economic and social areas such as agriculture and food security, health and public health, infrastructure and major projects, urban and human settlements, and sensitive secondary and tertiary industries.

In terms of building a regional landscape for climate change adaptation, the Strategy points out the need to build a territorial space for climate change adaptation, strengthen regional climate change adaptation actions, and

[41] Central People's Government of the PRC.(2022). “National Adaptation Strategy 2035 issued”. https://www.gov.cn/xinwen/2022-06/14/content_5695549.htm

enhance the capacity of major strategic regions to adapt to climate change. For the implementation of the Strategy, further work needs to be carried out in terms of strengthening organization and implementation and mechanism building, enhancing financial and fiscal support, strengthening scientific and technological support, strengthening capacity building and deepening international cooperation.

Along with economic development and technological advances, China's basic capacity for climate adaptation has been strengthened, and research and assessment of climate change has been intensified. Major relevant industries and localities have started to carry out adaptation actions and have achieved positive results in coping with flood and drought disasters, agricultural drought resistance, ecological restoration, adapting to sea level rise and building adaptive cities. However, judging from the results of the evaluation of pilot climate-resilient cities, there is still much room for development in China's climate change adaptation work in terms of strengthening the concept of urban adaptation, innovating institutional mechanisms, strengthening capacity building, improving monitoring and early warning and disaster prevention capabilities, and developing international cooperation, and scientific research on climate adaptation in China needs to be further strengthened.

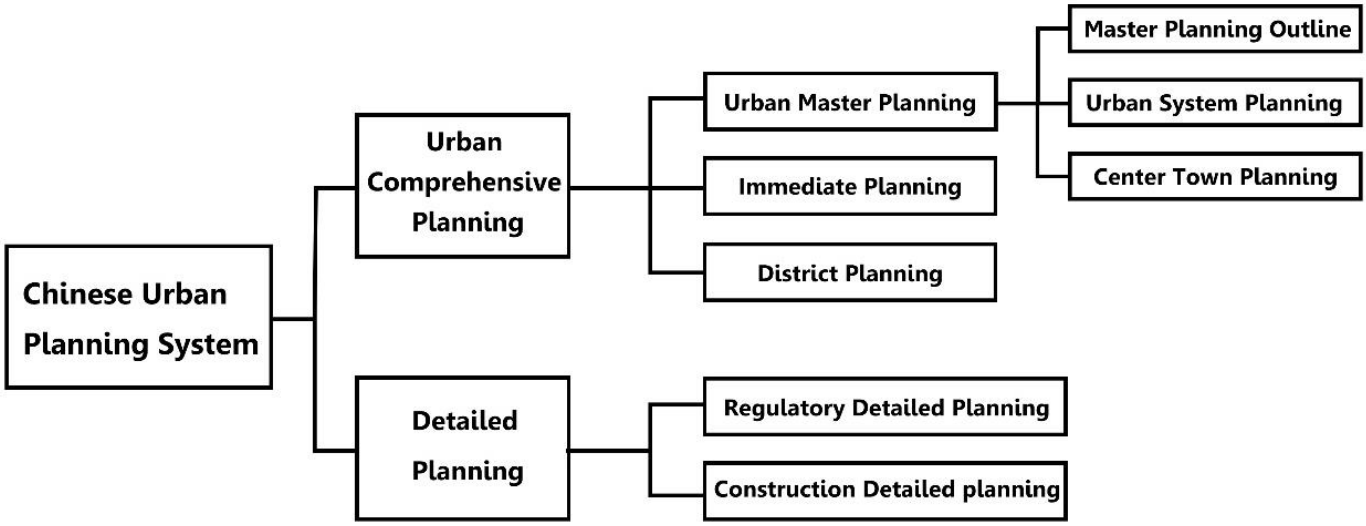
At present, it has become a global consensus to actively resist climate risks and improve adaptive capacity. China's national strategy has once again made it clear that it will strengthen the observation of the impact of global warming on vulnerable areas and enhance the capacity of urban and rural construction, agricultural production and infrastructure to adapt to climate change. The current rapid economic and technological development advances also provide favourable conditions for enhanced adaptation efforts. All of these factors will be important contributors to China's efforts to

improve its understanding of climate adaptation and enrich its means of adaptation, giving support to more mature technical means in terms of learning from external experience and accumulating experience within the country. However, on the other hand, the current focus on climate adaptation is relatively weak and fragmented compared to climate mitigation, and China's enhanced climate adaptation efforts face a number of challenges. Firstly, the analysis and assessment of climate change impacts and risks is still inadequate, and there is a lack of universal tools, and the tools and instruments have not yet formed a complete system for adaptation in China. Secondly, climate adaptation involves many areas, with multiple sectors and disciplines intersecting, making coordination difficult and management integration at all levels difficult, and the governance system for climate change adaptation needs to be further improved. In addition, it is difficult to assess the profitability of adaptation projects and measures, as they are relatively public goods, and market incentives and instruments are limited. Finally, theories, technologies, knowledge, experience and awareness in the field of climate adaptation are still relatively weak, and there is a need to further strengthen concepts and consensus.

3.2 Chinese Urban planning systems and Urban Integrated Disaster Prevention

Urban and rural planning in China is based on the Chinese national standard "Standard for Basic Urban Planning Terms", urban planning: "the comprehensive deployment, specific arrangement and practical management of the economic and social development, land use, spatial layout and various constructions of a city within a certain period of time. "
From the perspective of the social role of urban and rural planning,

according to the "Interpretation of the Law of the People's Republic of China on the Planning of Vehicles", urban and rural planning is defined as "urban and rural planning is an important basis for governments at all levels to arrange the spatial layout of urban and rural development and construction



of child worms, protect the ecological and natural environment, rational use of natural resources, and maintain social justice and equity, and has the attributes of an important public policy. "

Fig7. Chinese Urban planning systems. (Source：drawn by the author)

China's planning system covers economic, spatial, land and environmental aspects, which is very complicated. According to the different planning contents, the planning system can be mainly divided into: the national economic and social development planning system for economic development; the main functional zone planning system and urban and rural planning system for spatial development; the land use planning system for land use; and the ecological functional zone planning system for environmental protection. All kinds of planning systems are supported by corresponding laws and regulations or administrative documents, such as the Opinions of the State Council on the Preparation of National Planning of

Main Functional Zones to support the zoning of main functions, and the Urban and Rural Planning to support the Urban and Rural Planning, such as the Urban and Rural Planning Regulations and the Measures for the Preparation of Urban Planning. Therefore, statutory is the most prominent feature of China's planning system and its main development path.[42]

In recent years, Chinese internal academics have also analyzed the shortcomings of China's spatial planning system and explored the possibility of transforming the planning system from horizontal to vertical, i.e., "multi-planning". The current internal planning system in China is very complicated and difficult to coordinate. Various parallel administrative departments are responsible for planning and control of different functions, and there are more than 80 kinds of plans issued by the government. Various types of plans involving space and resources overlap with each other in terms of planning objects, objectives and tasks, causing conflicts, and there are problems of separate plans and difficulties in connection.[43] In terms of external reasons, China has entered a new stage of high-quality economic development after experiencing a phase of high-speed economic growth. In the face of climate change, higher requirements for urban quality of life, sustainable urban development, etc. have raised higher requirements for spatial strategic planning.

[42] 曹康，章怡（2020）空间战略规划与中国规划制度——制度变迁与关键节点. *«UPI: Urban Planning International» 2020/4.138*

[43] 吕悦风，项铭涛，王梦婧，吴次芳 （2021）从安全防灾到韧性建设—国土空间治理背景下韧性规划的探索与展望. *自然资源学报(Journal of Natural Resources.) 2021.36(9):2281-2293J.*

3.2.1 The Development of Integrated Urban Disaster Prevention Planning in China

The comprehensive urban disaster prevention plan in China's urban planning system is an extremely important professional plan. It is closely related to other professional plans, and its preparation organization and procedure The preparation organization and procedure should be consistent and synchronized with the urban master plan. The planning content is mainly engineering disaster prevention, focusing on the professional disaster prevention The planning content is mainly engineering disaster prevention, with emphasis on the implementation of the professional disaster prevention planning content of each disaster type in the spatial layout. The contents of the plan are mainly engineering disaster prevention, focusing on the implementation of the contents of the specialized disaster prevention plans of each disaster type in the spatial layout.[44]

The research history and planning practice of integrated urban disaster prevention planning in China has gone through three main development stages:

Traditional Disaster Prevention Planning:

[44] 赫磊 , 戴慎志 , 宋彦 . 城市综合防灾规划编制与评估的美国经验及对我国的启示 [J]. 城市规划学刊 , 2011(5): 87-94

Modern urban planning in China began in the 1950s, and it was clearly proposed that urban disaster prevention planning is an integral part of urban master planning, but no systematic and scientific preparation method has been formed.[45]

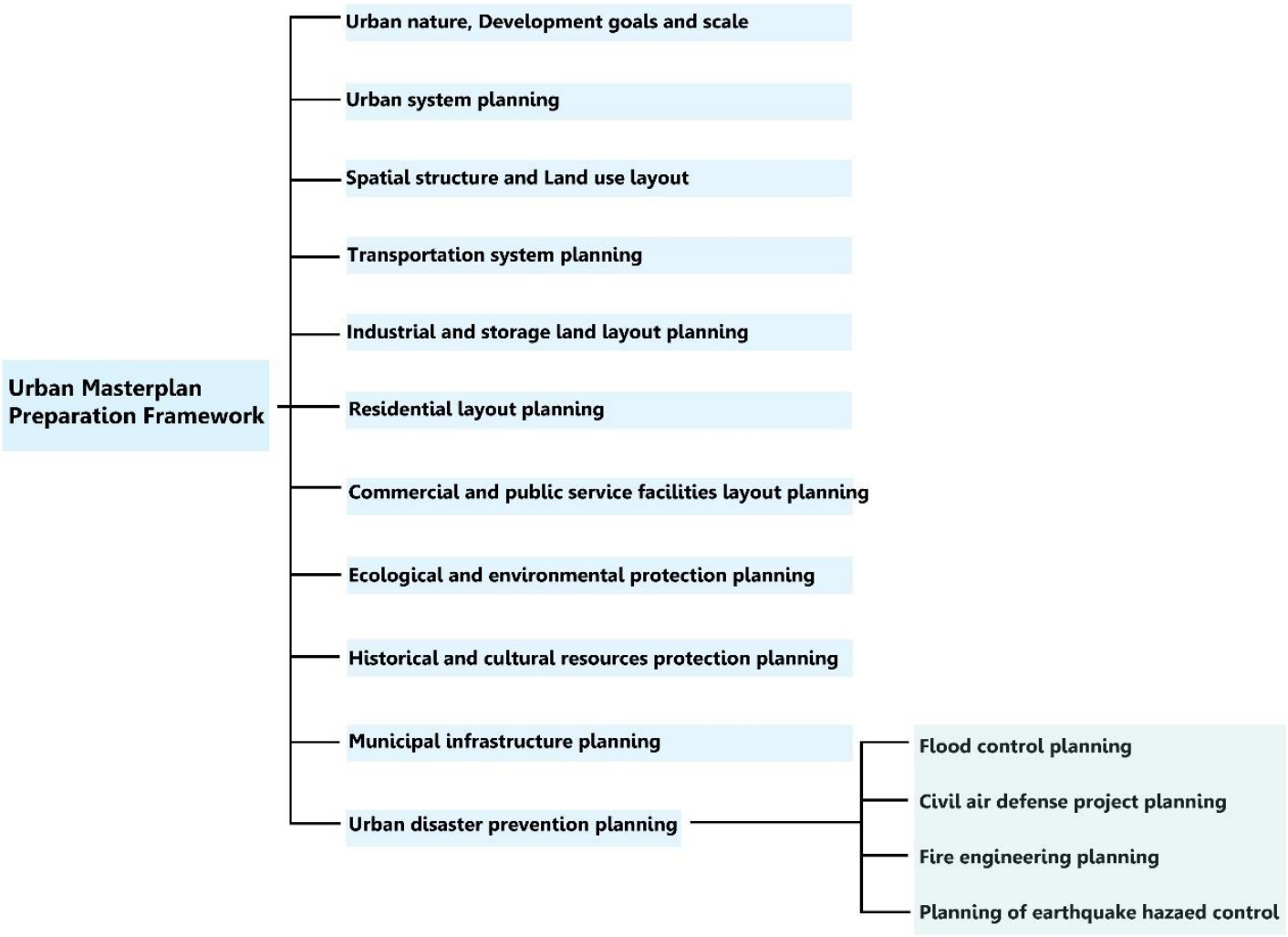


Fig8 . The framework of traditional disaster prevention planning. (Source：drawn by the author)

China's understanding of "integrated disasters" was very limited at that time, and not enough attention was paid to it due to the basic national conditions and the primary stage of urban development. The traditional type of disaster prevention planning was a separate part of the urban master

[45] 王江波 . 我国城市综合防灾规划编制方法研究： 美国经验之借鉴 [D]. 上海： 同济大学 , 2006

plan. It was biased towards engineering planning, with very little consideration given to urban space, facilities and urban systems. At the same time, the types of disasters and methods of response are fixed and limited to traditional and typical disasters such as earthquakes, floods and wars.

The planning content also emphasizes single-hazard planning strategies. The single planning systems are independent of each other, and there is no consideration of integrated response to disasters, emergency response and post-disaster reconstruction.

Traditional Integrated Disaster Prevention Planning:

Since 2000, especially after the 2008 Wenchuan Earthquake in China, there has been an in-depth understanding of integrated disaster prevention planning in China. Based on the Standard for Integrated Urban Disaster Prevention Planning (GB/T51327-2018), the preparation method is consistent with the Disaster Mitigation Act 2000 developed by the Federal Emergency Management Agency (FEMA) of the United States, which contains disaster risk analysis, planning objectives, planning strategies and measures, and planning implementation and supervision.[46]

China has gradually carried out the practice and application of large-scale integrated disaster prevention planning preparation and has initially realized the integrated consideration of multi-hazards. Due to the strong subjectivity of the multiple risk indicator system , the coupled with the historical disaster-based The multi-hazard overlay projection based on

[46] 王江波 , 戴慎志 , 苟爱萍 . 城市综合防灾规划编制体系探讨 [J]. *规划师* , 2013,29(1): 45-49

陈鸿 , 戴慎志 . 城市综合防灾规划编制体系与管理体制的新探索 [J]. *现代城市研究* , 2013, 28(7): 116-120

historical disaster probability has a large prediction risk , which cannot objectively reflect the risk of disasters. In this stage, theories, techniques, and methods of disaster prevention planning are inadequate to quantify the multi-hazard risk through the coupling of hazard-causing factors

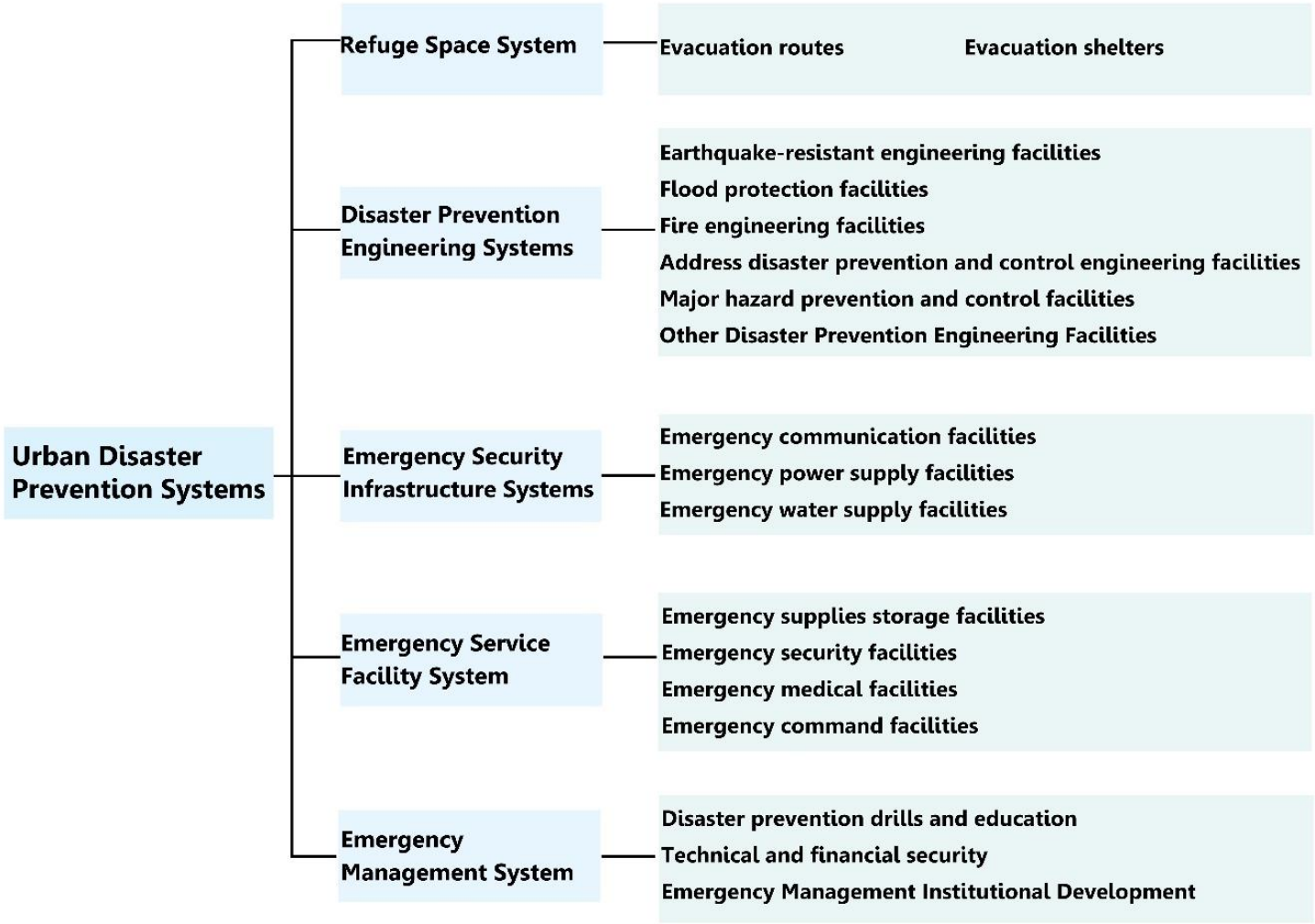


Fig 9 . Urban disaster prevention system (Source：drawn by the author. Based on Dai Shenzhi's <Comprehensive Urban Disaster Prevention Plan> and China < Approach to Urban Planning >)

New integrated disaster prevention planning:

Since 2010, with the rapid progress of climate change research, China has proposed to build resilient cities and improve their disaster prevention capacity.

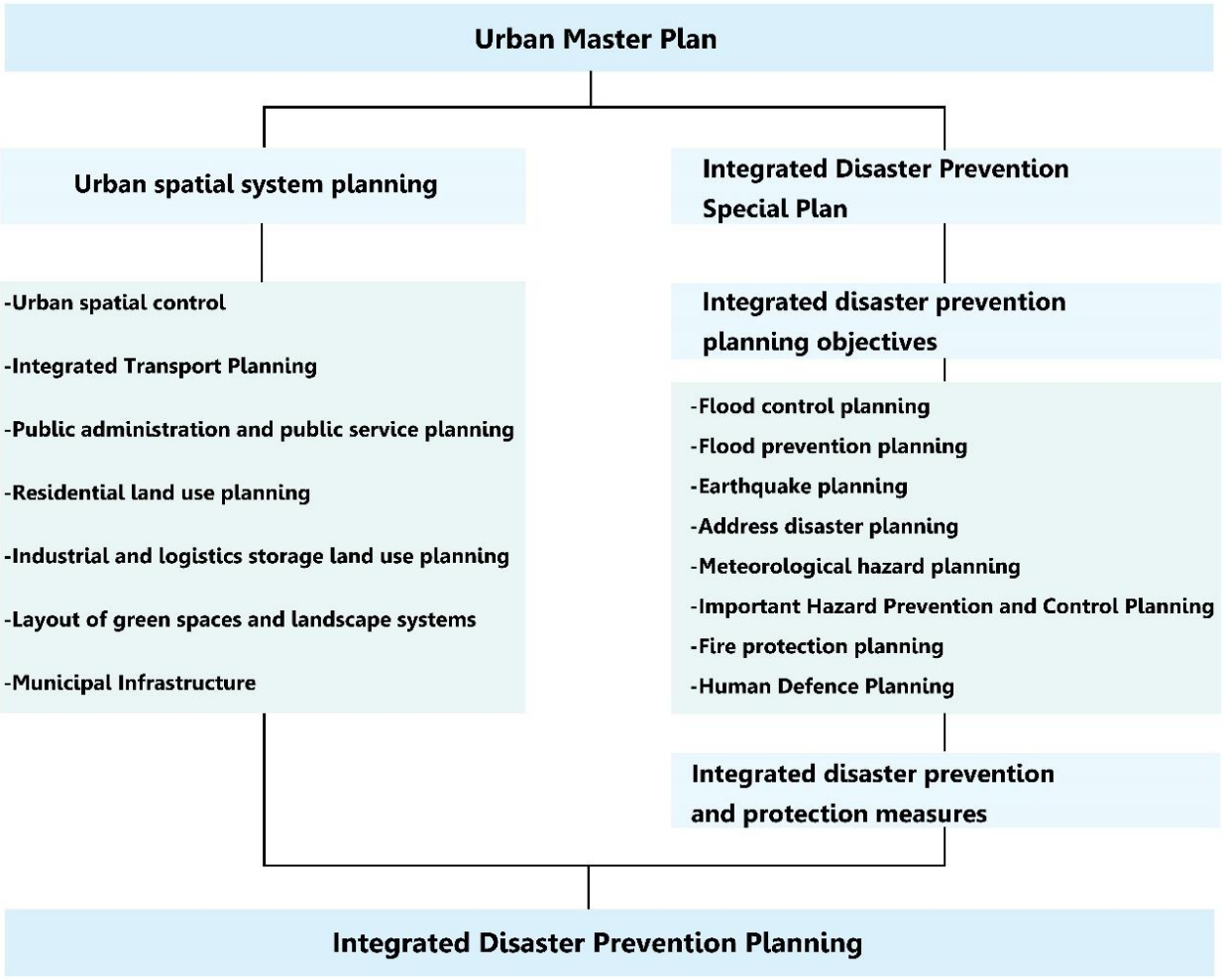


Fig10. . The new framework of comprehensive disaster prevention planning (Source：drawn by the author)

Due to the uncertainty of disaster-causing factors, it is common for large cities at home and abroad to reduce disaster risk by improving the resilience of the carrier in the current urban master plan, and to build a highly resilient urban subsystem by integrating the safety elements of comprehensive urban disaster prevention into various subsystems of the urban master plan,

including urban spatial control, land use, and municipal infrastructure, etc.[47].

The city master plan is a highly resilient urban subsystem. However, the mechanism of dependent coupling between urban multi-systems has not been focused on, and the impact of failure of key elements of a single system on the cascading effect of urban multi-system networks is not clear.[48] In the integrated multi-hazard risk assessment of cities, starting with the collection of raw data and the construction of indicator systems. The raw data is subject to duplication, intersection, and other problems due to the variety of source types. The data needs to be collated, filtered, and assigned hierarchical values. The risk is mainly determined by the combination of two aspects: the "risk assessment of the causal factors" and the "vulnerability assessment of the hazard-bearing bodies" to form a comprehensive risk assessment. ".

In China's latest National Comprehensive Disaster Prevention and Mitigation Plan for the 14th Five-Year Plan, China will basically modernise its disaster prevention and control capabilities. With meteorological disaster prevention and mitigation as the focus of natural disaster prevention and mitigation, China will build a seamless and comprehensive forecasting system during the 14th Five-Year Plan period, with the forecast accuracy rate for heavy rainfall expected to reach 90% and the warning time for severe convective weather exceeding 45 minutes in advance. In the face of sudden warnings[49], the warning time will reach those in charge of disaster prevention and

[47] 陈琦 ．国际大都市安全和防灾规划趋势研究： 对上海市城市总体规划修编的启示[D].上海：同济大学 , 2016.

[48] HE Lei； XIE Zi'ang.Towards Resilience: Review and Prospects of Urban Integrated Disaster Prevention Planning. *National Key Research and Development Program "Cross-Scale Cross-Scale Linkages and Multi-System Synergy Mechanisms" (Project No: 2020YFB2103901-2) TU984. 2096-3025（2021）03-0043-12*

[49] http://www.gov.cn/zhengce/2022-07/22/content_5702141.htm. Central People's Government of the People's Republic of China.

mitigation at all levels within five minutes. From focusing on post-disaster relief to focusing on pre-disaster prevention, from dealing with a single disaster to comprehensive disaster mitigation, from reducing disaster losses to mitigating disaster risks, and comprehensively enhancing the comprehensive prevention capacity of the whole society to resist natural disasters.[50]

3.2.2 The logical evolution of the concept of integrated disaster prevention in Chinese cities

Traditional disaster prevention and mitigation planning in China is mostly based on engineering thinking, both through engineering-based protective measures and process-based management models to ensure that cities can effectively withstand the impact of external risks in the event of a disaster.[51] The logic of the development and study of the plan is also closely tied to the updated change in the concept of disaster prevention.

The earliest human knowledge of disasters was natural disasters. The concept of disaster prevention was mainly based on engineering disaster prevention. In order to resist extreme climate disasters such as typhoons, earthquakes, tsunamis and floods, the main choice was to prepare and resist, and to protect various risks and disasters from facilities by physical measures. However, the problem with natural disasters is that the prediction of damage and impact exceeds the predicted physical

[50] Feng Kong, Yifei Wang. Better understanding of climate catastrophe insurance in China: issues and opportunities, international insights, and directions for development. *Natural Hazards* volume 114, pages2969–2990 (2022)

[51] 吕悦风，项铭涛，王梦婧，吴次芳 （2021）从安全防灾到韧性建设—国土空间治理背景下韧性规划的探索与展望．*自然资源学报(Journal of Natural Resources.) 2021.36(9):2281-2293*

construction, which leads to the failure to achieve the expected protection effect even after spending a lot of human and material resources on engineering facilities.

With the addition of foreign factors and the continuous gathering of various elements in the city, as well as the occurrence of huge disaster losses, the single engineering measure in the field of disaster prevention was also rethought, and the idea of the pillar of human-nature coexistence was put forward, firstly, to reduce the impact of human behavior on nature from the source, and at the same time, based on the importance of engineering disaster prevention, the main types of land in the city were allocated with corresponding disaster prevention land. and not only in the appearance of circled squares, green areas, underground facilities and safety works as an indicator to form a systematic disaster prevention and mitigation network. With the idea of disaster mitigation as the center, it emphasizes non-engineering spatial control, spatial resource allocation, disaster prevention management and other comprehensive measures.

As global awareness of disasters grows, especially the dramatic impact of global climate change, research and practice on extreme weather events is maturing. The concept of "adaptation" has been introduced in the concept of disaster prevention and mitigation. The concept of disaster prevention and mitigation introduces the concept of "adaptation", which is a purposeful response to climate change, arranging city plans to enhance the city's ability to cope with the potential impacts of climate change. Disaster prevention in cities is also influenced by the uncertainties within the built environment system, not only by external disasters.

The shift from deterministic planning to the use of the concept of disaster prevention against uncertainty is also due to the limitations of historical data on disasters, the continuous changes in the disaster environment, and the impact of interaction with cities. It is not possible to determine the evolutionary pattern of the development of future disaster problem

machines. Traditional disaster description, characterization, and historical quantification have lacked scientific validity and utility for effective response to urban disasters.

3.2.3 Summary of Integrated Urban Disaster Prevention Planning in Response to Climate Change

China's disaster prevention planning is guided by an in-depth understanding of the interrelationship between disaster factors and the built environment of the city, which determines the philosophy of China's disaster prevention and mitigation planning.

The initial response to urban hazards in planning was to combat them with engineering disaster prevention measures through a single-minded use of purely physical prevention and resilience in the construction of load-bearing structures. The unpredictability of natural hazards, however, placed cities in a completely reactive and high-risk situation, and the limits of human behaviour were gradually realised after many catastrophic consequences. Since then, there has been a shift from exclusively engineered disaster prevention measures to a multifaceted application of prevention, mitigation and coexistence.

As the global climate continues to change, objective factors, limited by historical statistics, overlap to make traditional planning methods uncomfortable to deal with the uncertainty of ongoing hazard change. The current trend in China is towards more resilient disaster prevention planning research, which has realised that cities are complex systems with multiple systems and dimensions, and that in cities it is often the case that a single shock moves the whole body, shifting from reactive response to shocks to proactive crisis resolution and more research into the construction of spatial

resilience.

3.3 Resilience concept in China — Relevant pilot projects

3.3.1 Interpreting Resilience in Chinese Urban Planning

The concept of resilience in China, the introduction and related conceptual exploration and concerns have largely kept pace with resilience research in developed countries. At the national level in China, in 2017, the China Earthquake Administration included "Resilient Cities and Towns" as one of four scientific programmes ("Transparent Crust", "Anatomical Earthquakes", "Resilient Cities and Towns")[52]. "Resilient Cities and Towns" and "Smart Services") into the National Earthquake Science and Technology Innovation Project. The "Resilient Cities and Towns" programme will enable China to reach an international advanced level in the fields of seismic hazard risk assessment, engineering resilience, and social resilience support, and to take the lead in building a number of model resilient towns. Since this initiative, the concept of "resilience" has been formally adopted by national policy.

In 2018, the Safety Production Committee of the State Council launched the "Model Cities for Safe Development", which is regarded as the first large-scale practice of urban resilience construction in China. In June 2020, the Ministry of Housing and Urban-Rural Development (MOHURD) of China

[52] https://www.iem.ac.cn. Institute of Engineering Mechanics, China Earthquake Administration.

selected 36 sample car stories, including Tianjin and Shanghai, to carry out a "City Health Check Project", which included "safety and resilience" as one of the core indicators for implementing and testing cities. In October 2020, China adopted the "14th Five-Year Plan", proposing to "enhance urban flood control and drainage capacity, build sponge cities and resilient cities", since then "resilient cities" was formally incorporated into China's national strategic plan for the first time. China's resilient city building is officially in its infancy.

The diverse resilient city initiatives that are gradually taking place across China are mainly divided between collaborative projects with international partners and China's own exploration. Even though there are more and more actions and demands for resilient city planning practices in China, the planning theories, methods and techniques that are suitable for the Chinese context are not quite in sync with the practical demands.

Most of the cities selected for resilient city building projects with international cooperation are cities with a population of less than 3 million and follow specific operational models with reference to the resilience framework and guidelines of international schemes. The Rockefeller Foundation's pioneered '100 Resilient Cities' project includes the Chinese cities of Deyang, Haiyan and Yiwu, for example. The UNDRR's 'making cities resilient' initiative includes seven cities in China, including Chengdu, Sanya and Luoyang.

Moreover, China's independent exploration of resilient cities has mainly selected first-tier mega-cities as the subject of action in order to introduce relevant policies to give guidance to its macro planning. Among them, Beijing is the first city in China to incorporate the task of building a resilient city into the city's overall planning, and in September 2017, the Beijing Urban Master Plan (2016-2035) was released, putting forward the requirement of improving urban resilience.2021 In November, Beijing

issued the Guidance on Accelerating the Construction of Resilient Cities, which takes emergencies as the traction, based on natural disasters, safety production, public health and other public safety areas, and plan to improve the overall resilience of Beijing's city from the whole process of urban planning, construction and management. By 2025, the resilient city evaluation index system and standard system will be basically formed, and 50 resilient communities, resilient neighbourhoods or resilient projects are expected to be built, forming a plan for replicable and replicable typical experience of resilient city construction.

For Shanghai, a highly densely populated national metropolis with a resident population of over 24 million, a total underground mileage of 700 km, a total building stock of over 1.3 billion square metres and more than 14,000 housing estates. With such a large volume of people, the city is exposed to extreme weather conditions, high rates of new and updated technologies, major infectious diseases, terrorist attacks and other uncertainties. The vulnerability of cities and their response to internal and external shocks has taken on an urgency that cannot be ignored.

The Shanghai Urban Master Plan (2017-2035) also proposes to build a more sustainable resilient eco-city. Shanghai is also relying on the strong resources and platforms of the first-tier cities in the specific urban resilience construction, while the page is gradually carrying out plans from the grassroots level of the people with the opportunity of the national digital transformation. The city's detection and early warning system has been upgraded to detect and anticipate risks and to create a "15-minute community living circle", a community garden on the doorstep of the citizens themselves, meeting their needs for ecology, culture, healthcare, retirement and fitness within a 15-minute walk. This is an organic dismantling of a mega-city like Shanghai, like the formation of a complete cellular system.

3.3.2 China “sponge city”

The "sponge city" is China's response to urban water environment problems. In December 2013, China proposed to "give priority to retaining limited rainwater when upgrading urban drainage systems, to make more use of natural forces to drain water, and to build sponge cities with natural storage, natural infiltration and natural purification" (Guiding Opinions on Promoting Sponge City Construction 2015), and has carried out pilot projects in more than 30 cities in China, focusing on solving water environment, water ecology and waterlogging problems in China's urban construction, improving urban ecosystem functions and reducing the occurrence of urban flooding.

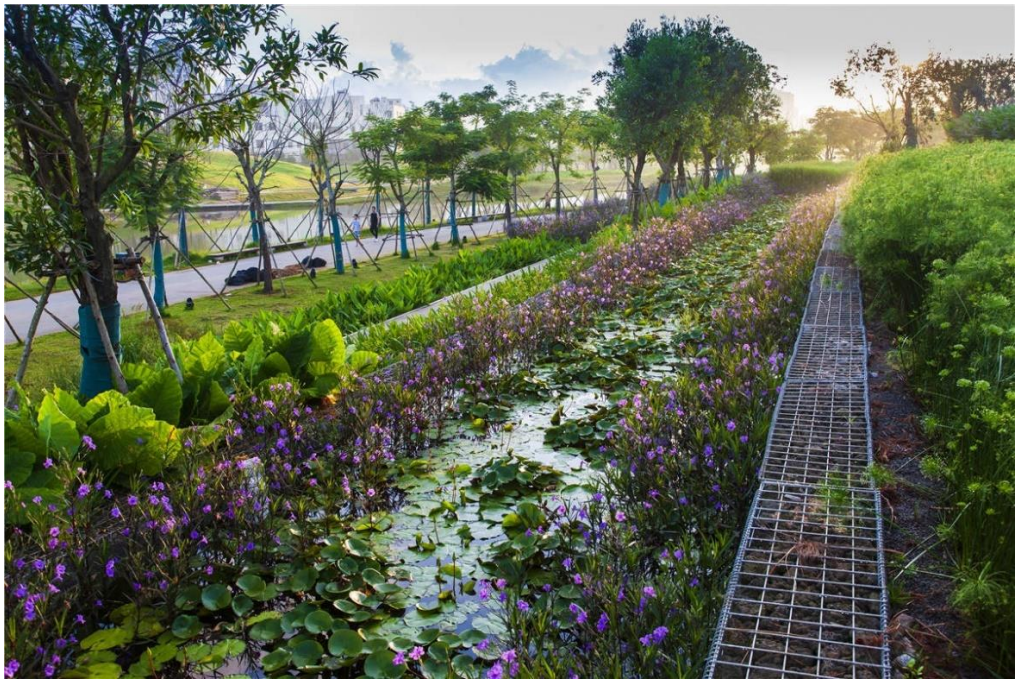


Fig.11 Ecological restoration of the Meishe River in Haikou. Source from: Baidu image

By incorporating the domestic grey sewage treatment system, the sewage network and treatment plant are used to collect and treat point source

discharges, cutting off the main sources of pollution discharged into the river, and the landscape design turns the river corridor into an integrated ecological infrastructure, systematically addressing urban stormwater and water environment issues, creating diverse habitats, restoring biodiversity and creating a place for recreation, leisure and scenic beauty.
(source:https://www.sohu.com/a/396956053_655781?_trans_=000014_bdss_dkmwzacjP3p:CP=.)

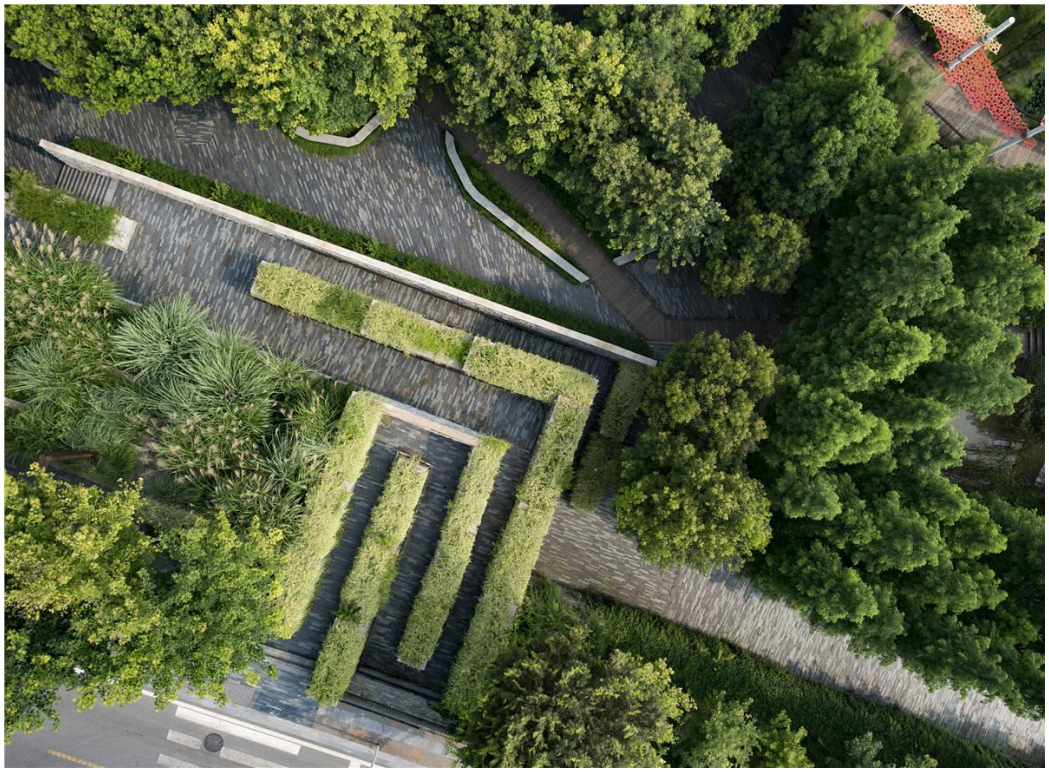


Fig.12 Canal Park, Yichang(source:https://www.sohu.com/a/396956053_655781?_trans_=000014_bdss_dkmwzacjP3p:CP=.)

The fish pond has been cleverly designed as an urban water purifier, with the introduction of groves, walkways, bridges and pavilions, making it an 'ecological sponge' for the new city through minimal intervention, purifying the polluted canals, alleviating urban flooding, preserving the memory of the site and providing a distinctive open space for the surrounding residents.
China's rapid urbanization has exposed very many urban problems, and in

the context of the whole of China's rapid economic development, cities are also expanding blindly, emphasizing above-ground works at the expense of underground facilities. The application of a crude and uniform model of urban construction, the lack of regional planning, the focus on the "face" of the city, the expansion of roads and the development of large facilities often carry with them the performance of the city manager's utilitarian agenda.

In terms of urban stormwater management, the main reliance is on traditional drains and 'grey infrastructure'. For most Chinese cities in general, the traditional infrastructure often exceeds the capacity of the facilities in the face of unpredictable high-density rainfall storms." Seeing the sea in the city" has also become the norm in the discussion of the Chinese people. Coupled with rapid land urbanization, increased artificial construction and unscientific interference with natural resources, some cities are also facing urban water problems such as water pollution, water shortage and ecological degradation. In order to effectively respond to the urban 'water problems' caused by the traditional urban construction model, this is a new urban construction concept in China - the "sponge city", an innovative local practice project.

The design concept of the sponge city is first and foremost to reverse China's traditional urban construction model, which relies only on "grey infrastructure" for urban drainage, with "quick removal" and "end-of-pipe centralization" as the main design concept. "This often results in flooding during heavy rainfall and water shortage during dry periods, i.e. the city's vulnerability is greatly increased as it transitions between dry and flooded conditions.

In contrast, sponge cities give priority to changing traditional hard curbs into grassed ditches, rain gardens, sunken green spaces and other measures that are more in tune with the natural environment to organize drainage, with the 'sponge' part encompassing the city's rivers and lakes

including green spaces. The main design concepts are "slow discharge" and "decentralization of sources". Resilience thinking emphasizes the ability to recover and maintain a stable state in the face of stress, which is very similar to the concept of sponge city development. With a broader scope of practice, the integrated choice of natural pathways and man-made facilities to build sponge cities as a whole provides a greater ability to cope with unpredictable risks and self-recovery of urban water systems, while also addressing the dilemmas and inefficiencies of traditional planning and design in dealing with environmental issues such as extreme rainstorms, typhoons and the urban heat island effect.

In summary, sponge cities are primarily about solving urban water problems, however water problems are complex in cities and therefore require urban systems thinking to view and solve a range of water problems. Moreover, urban water problems are only one of a variety of urban problems in China. Among the many urban schemes in China, such as low-carbon cities, eco-garden cities and smart cities, sponge cities are only projects for rainwater management. The current practice of sponge city construction is mainly through engineering measures to achieve these goals, but engineering measures can only effectively deal with regular high probability events[53], and in the event of an extreme low probability event such as the Zhengzhou rainstorm disaster, the urban engineering system will be in a state of near "paralysis".

In addition to considering the systemic nature of the city, the construction of a sponge city also requires long-term implementation and the cost of time cannot be ignored, requiring repeated research, constant review and validation, scientific documentation and evaluation. There is also a need to develop sound overall control indicators and technical specifications. As a

[53] 朱正威（2021）海绵城市的实践探索与韧性治理. http://www.rmlt.com.cn/2021/1129/633070.shtml.

major member of disaster prevention and mitigation, sponge cities also need to shift towards resilience. Focusing on non-engineering in practice, the construction of sponge cities should also be integrated into the relevant indicators in the preparation of urban planning, detailed control planning, to avoid isolation from the overall urban planning.

3.3.3 Low Carbon Transition in Chinese Cities

At the 75th session of the United Nations General Assembly in 2020, China stated that it would increase its national financial contribution, adopt more vigorous policies and measures, strive to reach peak CO2 emissions by 2030, work towards carbon neutrality by 2060, and promote a "green recovery" of the world economy after the epidemic. ". China is in an accelerated stage of urbanization, with an urbanization level of over 55%.

The China Urban Low Carbon Transition and Low Carbon Pilot Cities Project is a low carbon city program launched in China since 2010, which will pilot the implementation of total carbon control, low carbon living, low carbon transportation, green buildings and their technology promotion. There are currently 42 national low carbon city pilots in China, and these pilot areas account for around 40% of the country's population and 60% of the country's total GDP. In December 2022, the first "Low Carbon City Construction Level Index" was released, which is the first comprehensive analysis of the dynamic development of the low carbon construction level of cities in eight aspects: energy structure, economic development, production efficiency, urban residents, carbon sinks in waters, forests, green areas and low carbon technologies, and serves as a reference and method for building a scientific low carbon city in China. [54] The study provides a reference and methodology for building a

[54] 中国青年报.(2022)
https://baijiahao.baidu.com/s?id=1753620259186269361&wfr=spider&for=pc.

scientific low-carbon city in China.

The application of the low carbon city concept in China's urban planning emphasises the application of low carbon and energy saving technologies, the allocation of social resources, energy saving and emission reduction in all production and construction stages, the use of green and clean energy and environmentally friendly materials. It also focuses on urban greening to reduce construction costs and maximise the use of resources. In addition to this, even though China is rich in resources, the use of land resources is still limited. This is the second point that the low carbon city concept emphasises: respecting and maximising the value of ecological natural resources.

China's low carbon evaluation criteria were explored on the basis of a combination of the regional representation of these individual cities, different target types, different stages of development, different regional resources and different industries. Due to the huge size of China's territory, the differences between different regions are also very obvious. For example, first-tier developed cities such as Beijing and Shenzhen have basically completed industrialisation; but central and western regions may only be in the beginning stages of industrialisation; there are also old industrial regions in northeastern China; and resource-depleted cities that originally relied on the development of high-energy-consuming industries and needed to undergo rapid urban transformation. These are the characteristics of China's low-carbon cities, and each city is exploring the appropriate direction of green and low-carbon development. Through exploration and efforts, “these low-carbon pilot cities have generally achieved a higher rate of reduction in carbon dioxide emissions per unit of GDP than non-pilot areas, and the rate of reduction in carbon intensity is also significantly higher than the national average rate of reduction in carbon intensity,”(Development talk: Transcript of an interview with Kang Yanbing, Director of the Energy Sustainable Development Research Centre of the Energy Research Institute of the National Development and

Reform Commission) [55]indicating that these pilot cities have achieved positive results in terms of industrial transformation, energy transformation and improving the quality and efficiency of development.

The problem in the construction of low carbon cities remains the contradiction between economic development and ecological protection in the context of China's general environment. The focus of most cities is still on social production and economic efficiency, and the economic situation also has a great impact on the development of low carbon cities, as China's economy enters a new normal and the pressure to develop remains high. Regions and cities are thinking more about how to secure existing economic growth. This is coupled with the fact that low carbon development is a concept that has been introduced to China in recent years. In the meantime, developed countries have gone through a process of heavy industrialisation and have gained much experience. In contrast, China's understanding of green and low-carbon development is still poorly understood in specific regions, at the initial exploration stage, with ambiguous conceptual objectives. There are inconsistent levels of planning and construction, and insufficient support for industrial development.

3.4 The dilemma of applying the concept of resilience to disaster prevention and mitigation in China

At present, research on urban resilience in China is mainly focused on the concept of urban resilience, analysing the characteristics and components of urban resilience, and providing guidance and recommendations for planning at the macro level.

Although the concept of resilience has been proposed, it is still a traditional

[55] Development talk: http://cn.chinagate.cn/news/node_7230454.htm.

comprehensive disaster prevention study. Most of the traditional disaster prevention and mitigation studies focus on a particular aspect or process, improving the resilience of some components and processes in the city. The concept of urban resilience, however, emphasises both the holistic nature of the city as an integrated system and the process nature of resilience, and this holistic and process-oriented perspective is important for improving a city's overall disaster preparedness.

In the Shanghai Urban Master Plan (2017-2035), there are strategic objectives and targets for urban resilience, but it is not clear how the targets guided by the concept of resilience can be controlled through the targets to achieve resilience enhancement. This is essentially because the inherent complexity of urban systems and scales and the uncertainty of risk have been overlooked, and the mapping between resilience targets and indicators for controlling urban elements is unclear. Therefore, discovering and understanding the mechanisms and laws of the "hidden order" within urban systems is the root cause of the problem of urban uncertainty. [56] New integrated disaster prevention planning urgently requires the introduction of complex science, only when the intrinsic structure of complex networks is explored in depth The need for a deeper understanding of the intrinsic structure of complex networks and their impact on the network as a whole only through a deeper understanding of the intrinsic structure of complex behaviour and performance of complex systems, so that urban land use, facility layout and system planning can be adjusted in a targeted manner. This will enable us to target our land use, facility layout and system planning.

[56] 刘春成(2017) . :*城市隐秩序： 复杂适应系统理论的城市应用* [M]. 北京：社会科学文献出版社，2017

4 Resilience measures of Chinese cities to cope with climate change: A case study of coastal city Xiamen (China)

Resilience measures of Chinese cities to cope with climate change: A case study of coastal city Xiamen (China)

4.1 Selection of city: Xiamen General overview

The city of Xiamen, China, was chosen as the main subject of study firstly because it has long been an important economic centre in the southeast coastal region of China based on its geographical advantage and strong economic development. Xiamen has been an important port of commerce for China since ancient times, and today it is also the gateway to China's openness and cooperation, a hot spot for national policies and investments. Xiamen is also one of the first low-carbon cities and sponge cities in China, a key coastal city in the promotion of urban resilience, and is a major player in the promotion of China's "Yangtze River Delta" and "Guangdong-Hong Kong-Macao Greater Bay Area" due to its strong radiation influence. It is also an important platform city for promoting the linkage development and integration of high-end resources. The significance of the study of Xiamen is not only to summarise the theoretical practice of resilience within the region, but also to reflect on the more advanced policy implementation and practice of Xiamen, which can be an important reference for projecting China's urban shift towards resilience.

Xiamen is located in eastern China and southeastern Fujian Province, the lower reaches of the Min jiang River and coastal areas. between 24°23'-24°54'N and 117°53'-118°26'E. It has a southern subtropical maritime

monsoon climate with mild and rainy conditions.[57]

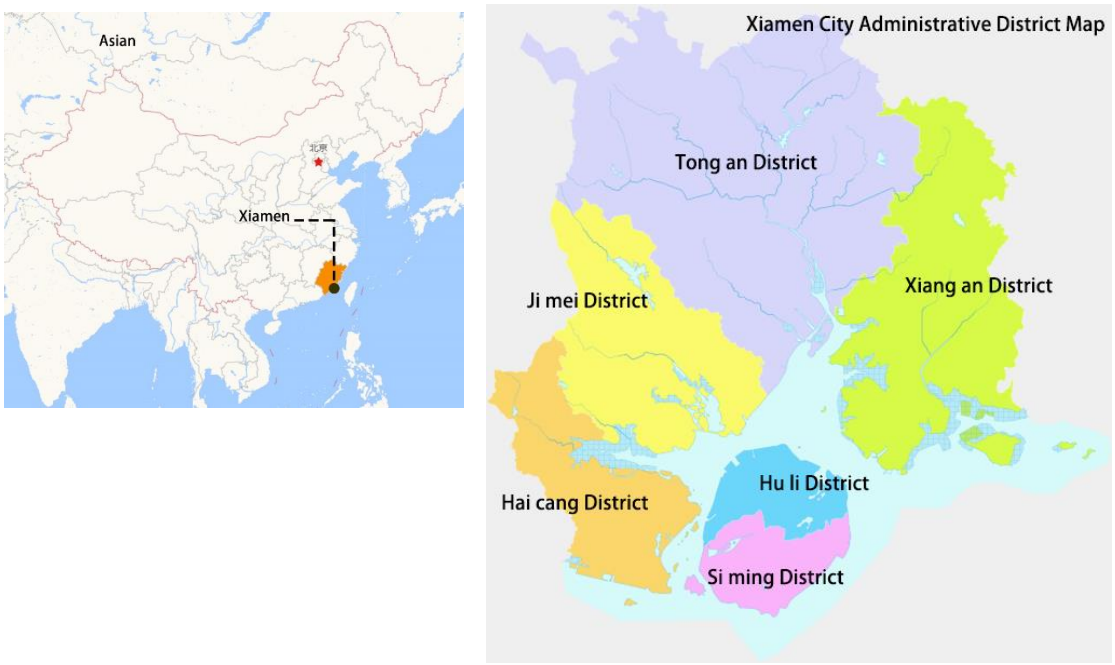


Fig.13 Xiamen city location. Drawn by author.

The city of Xiamen consists of Xiamen Island, Gulangyu Island and the inland coastal area. This topic focuses on the administrative This topic focuses on the administrative area of Xiamen, with a land area of 1699 km2 (including 981 km2 of ecological control line, 640 km2 of construction land growth boundary and 78 km2 of mudflats). The area covers 1,699 km2 of land (including 981 km2 of ecological control line, 640 km2 of land growth boundary for construction and 78 km2 of mudflats), including the main island of Xiamen and four districts outside the island.

[57] Xiamen Municipal People's Government.

Fig14. Topographical map of Xiamen city. Sources from: Territorial spatial master planning(2020-2035) http://zygh.xm.gov.cn/

The topography of Xiamen is dominated by coastal plains, terraces and hills. The topography of Xiamen slopes from north-west to south-east, with a wide variety of terrain and landform composition. Xiamen's geological formations. It falls within the coastal seismic zone of southeast China.

It is a natural shelter from the wind with the barrier of islands such as Xiamen Island and Gulangyu Island, and its coastline is winding for 234 kilometres. The harbour is surrounded by islands and mountains, and the harbour is wide and deep and freezing all year round.

Xiamen has a subtropical maritime monsoon climate, with mild and rainy weather, and an average annual temperature of about 21°C. It is free from cold in winter and heat in summer. Due to the temperature difference between the Pacific Ocean and the air currents, it is affected by an average

of 4 to 5 typhoons per year, mostly in July to September.[58]

The main types of disasters in Xiamen are natural disasters and accidents, of which the main ones are floods, typhoons and landslides. Since 1949, floods have occurred almost every year in Xiamen, and since the 1990s, floods have become more frequent[59], with an average of four to five major floods occurring each year.

4.2 Spatial analysis of the Xiamen city

In the context of global climate change and extreme weather conditions that have led to a number of practical strikes against urban systems in response to natural disasters and adaptive strategies in the face of unpredictable, massive and uncertain future climate change.[60] The impacts of climate change on cities include the urban 'heat island effect', increased cooling demand and reduced urban air quality; heavy rainfall, significant pressure on municipal infrastructure and flood defenses, damage to urban underground spaces and facilities, increased risk of infectious diseases; longer periods of drought, threatening food and water security, increased fire risk; typhoons and sea level rise.

Rapid dynamic urbanization brings changes in the urban spatial environment and, combined with the inherent fragility of the urban fabric, the control of urban elements in urban planning is key to climate adaptation. The application of resilience thinking to the field of urban planning , "The

[58] Xiamen Municipal People's Government.

[59] 唐诺亚（2018）厦门城市灾害风险与韧性评估及提升策略研究．*共享与品质——2018 中国城市规划年会论文集(01 城市安全与防灾规划)*

[60] Thomalla F, Downing T, Spanger-Siegfried E, et al. Reducing Hazard Vulnerability: Towards a Common Approach Between Disaster Risk Reduction and Climate Adaptation[J]. Disasters, 2006, 30(1): 39-48

concept of 'resilience' has been accompanied by the frequent use of terms such as 'climate resilience' and 'climate-resilient cities', which emphasise the ability of cities, urban agglomerations and urban residents to recover quickly from climate-related emergencies.[61]

Urban form has a crucial impact on the resilience of cities, their ability to prevent and mitigate disasters and to respond to unpredictable crises. “Context is important because prioritization of efforts aimed at increasing resilience of urban form may be context sensitive.”[62] The physical form of the city determines the size of the 'ecological interface', which influences the exchange of climate elements.[63] the high population density of the city, especially in China's large number of high-density cities, leads to an increase in urban heat island intensity; the high density of buildings and high floor area ratios lead to lower wind speeds in the city, (and high wind speeds between high-density high-rise buildings cause The high volume ratio of buildings leads to lower wind speeds in the city (and higher wind speeds between high-density high-rise buildings lead to increased discomfort for the city's inhabitants); the reduced visibility of the sky from the streets makes it difficult for the heat radiation received by the ground to escape and increases the temperature of the city; urban spaces, especially in China, become more dense with already complex and multifunctional systems and are at greater risk from natural hazards.

When urban form is faced with climate resilience, cities in different regions and contexts have their own unique regional development and specific

61 PELLING M. The Vulnerability of Cities: Natural Disasters and Social Resilience[M]. Earthscan,2003. BOYD E, OSBAHR H, ERICKSEN P J, et al.Resilience and ‘ Climatizing’ Development:Examples and Policy Implications[J]. Development,2008,51(3):390-396.

62 Ayyoob Sharifi Yoshiki Yamagata.(2018) Resilient Urban Form: A Conceptual Framework.

63 蔡云楠，温钊鹏，雷明洋．高密度城市绿色开敞空间的建设误区和优化策略 [J]．中国园林，2016(12)：76-80

needs, and face different risks. But urban form is, after all, a physical element, and generally speaking physical form is less likely to change, and changes are minor, but because of this these urban elements can also be analysed and measured. At the same time, urban form inevitably affects urban social and economic development, and human behaviour and interventions are inextricably linked to urban form. The analysis of urban form can be used as a basis for policy support for climate resilience in cities. Like the research from Ayyoob Sharifi and Yoshiki Yamagata said same in "Resilient Urban Form: A Conceptual Framework": "While 'resilient urban form' may seem to be an oxymoron given the seemingly rigid and inflexible physical structure of cities, it is argued that urban form can affect resilience of cities both directly and indirectly and steering urban form towards more resilient pathways is critical for enhancing the overall resilience of cities."[64] The elements of urban form are divided into two main categories according to their composition: the built environment and the urban (transport) network[65]. Based on the function and characteristics of the urban site, urban form elements are classified into five categories: density, housing/building type, transport infrastructure, layout and land use.[66] Urban morphological elements are classified into three main categories according to the different dimensions of the city: macro-scale(The overall structure of the city, its size and population distribution) , meso-scale(The structure and state of the settlement, the transport network network and the size of the green space)

[64] Ayyoob Sharifi and Yoshiki Yamagata(2018) Resilient Urban Form: A Conceptual Framework. Resilience-Oriented Urban Planning pp 167–179

[65] SILVA M C, HORTA I M, LEAL V, et al. A Spatially-explicit Methodological Framework Based on Neural Networks to Assess the Effect of Urban form on energy demand. *Applied Energy Volume 202, 15 September 2017, Pages 386-398*

[66] ZUMELZU A, BARRIENTOS-TRINANES M. Analysis of the Effects of Urban Form on Neighborhood Vitality: Five Cases in Valdivia,Southern Chile[J]. *Journal of Housing and the Built Environment,2019*

and micro-scale(The size of streets and building plots, the Site coverage.)[67].

Scale	Attributes	Sub-attributes
Macro-scale	Scale hierarchy	Regional connectivity, etc.
	City size	Population density
		City area
	Development type	Planned/unplanned; formal/informal
		Infill, sprawl, etc.
	Distribution pattern of population and employment	Degree of equal distribution
	Degree of clustering	Degree of compactness
		Centrality/uniformity/monocentricity/polycentricity
	Landscape/habitat connectivity	
Meso-scale	Structure and shape of neighborhoods/districts	Neighborhood size and shape, Sanctuary area, etc.
	Diversity/Heterogeneity	Land use mix; ratio of open and green space
	Typology of transportation network (both active and non-active transportation)	Route type (grid pattern, curvilinear, cul-de-sac, radial, organic, hybrid, etc.)
		Street width
		Street orientation (direction)
		Design and layout of streets, cycling, and pedestrian networks
		Centrality and spinally of street network segments
		Permeability/connectivity
	Access to amenities	
	Open and green space	Size, shape (design), and distribution pattern of Vacant and open spaces
		Size, shape (design), and distribution pattern of green space

Scale	Attributes	Sub-attributes
Micro-scale (building and block)	Block type	Block size, Perimeter urban block and its permutations,
	Site layout	Layout configuration (uniform/random)
		Lot size and geometry
		Site coverage
	Building configuration/layout	Dwelling size
		Dimensions and compactness (surface to volume ratio, depth)
		Orientation
		Spacing between buildings
	Roof type	
	Glazing	Size and position of windows; window to wall ratio
	Building typology	courtyard, townhouse, detached, …
	Density	Floor area ratio, etc.
	Street canyon geometry	aspect ratio,
	Design (street front/street edge)	Space between building façade and streets
		Front usage
	Design of emergency routes	

Fig.15 Constituent elements of urban form. (Source: Ayyoob Sharifi and Yoshiki Yamagata(2018) Resilient Urban Form: A Conceptual Framework.)

At the macro level of the natural urban environment factors, urban differentiation stems from natural landscapes, human landscapes and

[67] Holling CS. Resilience and Stability of Ecological Systems[M]. *Annual Review of Ecology and Systematics, 1973, 4(4): 1-23.*

human activities in different cultural and development contexts. Ecosystems, on the other hand, are somewhat flexible and adaptable. Therefore, in the construction of climate-resilient cities, urban green space and vegetation cover are important indicators of climate resilience at the macro level. [68] Urban spaces that focus on the ecological and natural environment that have a great potential to withstand natural hazards, especially The potential for resilience to natural hazards, especially floods and typhoons.

At the meso level of urban land use types and spatial distribution, the flexibility and adaptability of urban spatial distribution is reflected in the planning of spatial resilience.[69] In spaces where there is no clear and specific defined function (e.g. streets and internal green spaces in neighbourhoods), improving the adaptability and flexibility of the space can reduce the vulnerability of the city. It is because of these spaces with uncertain functions that, when extreme disasters and extreme climate risks strike, the government and the managers of the relevant departments can transform the non-functional spaces into new functional areas capable of coping with resilient risks through correct scientific guidance. This is in line with the concept of sponge city construction in China. That is, the transformation and utilisation of urban grey space. The transformation of urban neighbourhoods, spongy roads and square spaces, etc. To summarise this point i.e. the potential of urban public space is emphasised and urban land use types and functions are an important part of planning and design that can to some extent influence climate resilience. The reservation and functional adaptation of public open space provides effective strategies to

[68] LI Kexin, LI Chaosu.(2021) Exploring the Linkages of Urban Form and Climate Resilience from a Multidimensional Perspective. *URP:Urban and Rural Planning 2021/3. TU984*

[69] HABRAKEN N J. The Uses of Levels[J]. *Open House International,2002,27(2):9-20*

help cope with uncertain urban hazards.

At a micro level, i.e. in terms of architectural design, i.e. the design of the surrounding site. The flexibility of building functions, the convertibility of functions and how they can become more sustainable in light of the emerging global climate change. More consideration is given to the relationship between the building and the city, the openness of its design, the choice of building form and building materials is also particularly important for the overall urban form in combating climate change.

The current urban situation in China is one of rapid urbanisation and great urban population density. Combined with the current stage of development in China, the focus of development is still more on urban areas, with more development projects and resources decentralised to cities, which attracts more people to flock to cities. This has placed greater demands on urban planning. Although the risks posed by climate change can be predicted with the development of modern detection technologies, the diversity of risks combined with the vulnerability of cities, the complex natural environment and the continuous dynamics of human behaviour make the risks to climate resilience in urban space unpredictable and uncertain. With multiple uncertainties overlapping, it is very difficult to predict the impact of climate change on cities in the long term. Therefore, by focusing on urban elements at different scales and by enhancing spatial diversity and spatial planning at different scales, the urban resilience of existing cities and new urban areas to be developed can be effectively improved.

According to the current urban master plan of Xiamen, which was officially approved by the State Council of China in 2010 to expand the Xiamen Special Economic Zone from the main island of Xiamen to the city's administrative jurisdiction Xiamen City has undergone significant changes

in its development environment, and with the consent of the Ministry of Housing and Construction, Xiamen City has revised its reported master plan, which was approved by the State Council for implementation in February 2016.

The city of Xiamen is a special economic zone, with a resident population of 5 million in 2020. Xiamen has an urban construction land area of 440 square kilometres and a visionary urban development boundary of 640 square kilometres. Planning and layout: The city will implement the cross-island development strategy, focus on urban strategy and investment outside the island, and build a grouped bay city with "one island, one belt and many centres".

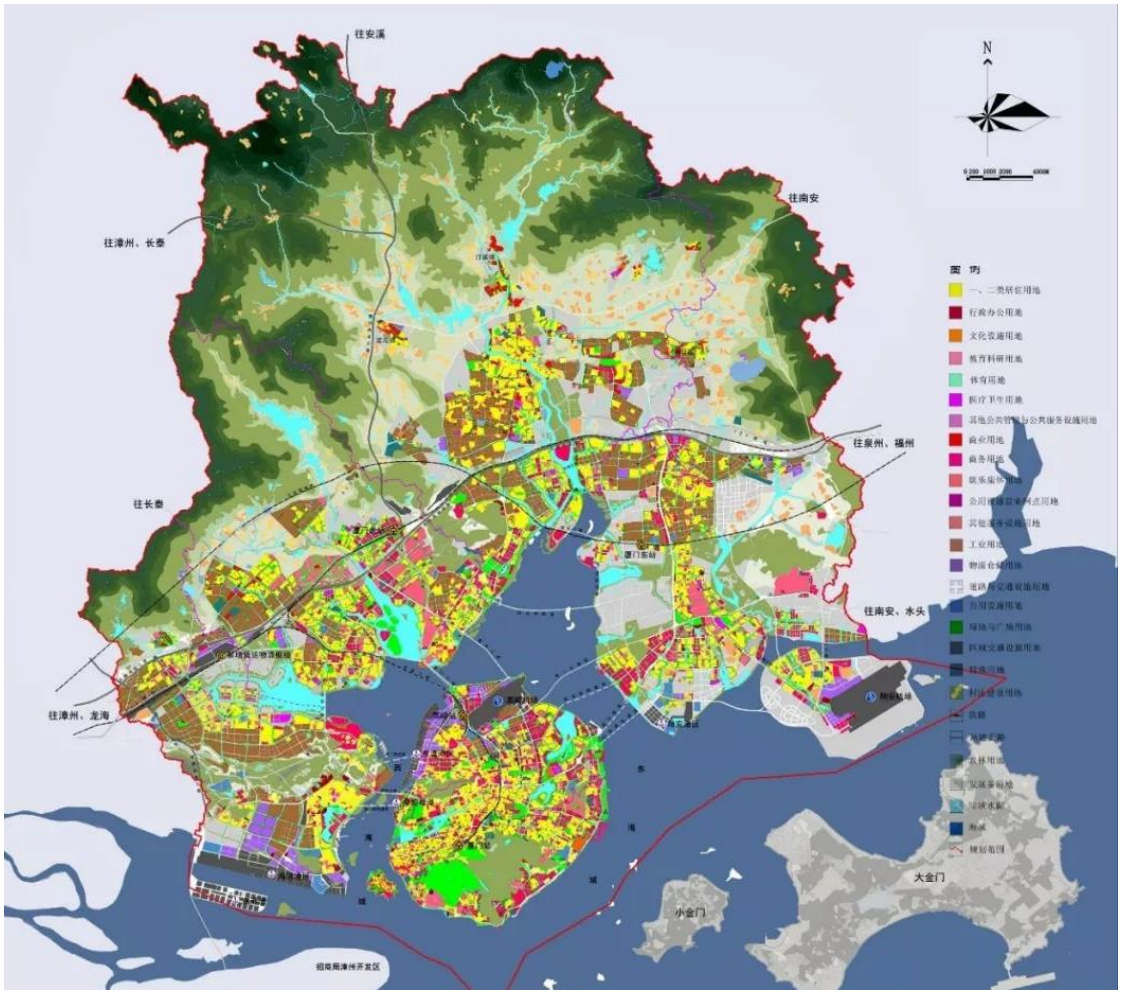


Fig.16. Current Xiamen City Land Use Plan. Source from: http://zygh.xm.gov.cn/

The Xiamen city's urban spatial form is a grouped bay city with "one island, one belt, two cores and multiple centres". The "one island" is Xiamen Island; the "one belt" is the city belt around the bay, linking Haicang, Jimei, Tong'an and Xiang'an, and radiating China Merchants Zhangzhou Development Zone, Longhai, Jiamei, Nan'an and Jinmen; the "two cores The "two cores" are the two municipal centres of Xiamen Island and the eastern part of Xiamen; the "multiple centres" are the district centres of Siming, Huli, Haicang, Jimei, Tong'an and Xiang'an; the five urban groups of Xiamen Island, Jimei, Haicang, Tong'an and Xiang'an are grouped together to promote the construction of the five urban groups, integrate urban spatial resources, and rationalise urban functions.

In addition, the city will also be able to rationalize urban functions, improve social and municipal infrastructure, and effectively divert the population from the central city. The planning of a multi-core compact city form of "one island, one belt, two cores and multiple centres" has gradually transformed several centres into a number of independent low-carbon centres, which are connected to each other by light rail, laying the foundation for a low-carbon urban planning in Xiamen.

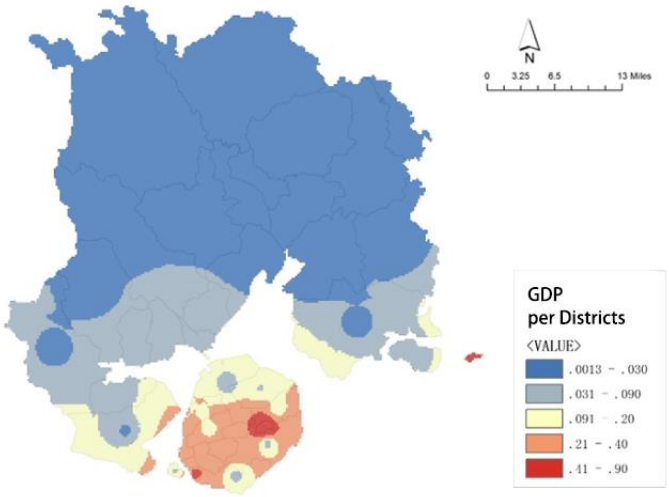


Fig.17. GDP per administrative district in Xiamen. (drawn by author, Basic Source from: http://zygh.xm.gov.cn/)

In terms of population distribution, Huli District is the most densely populated (137 persons/ha) and Siming District is more densely populated (118 persons/ha). The population density in Jimei, Haicang, Tongan and Xiangan districts is relatively low, especially in Tongan and Xiangan districts (only 8 persons/ha). The higher the GDP per capita rating, the greater the potential for damage in the event of an earthquake and the higher the risk level. The average GDP of each district is used as the average GDP of each street (town). It can be seen that Siming District has the highest average GDP of The highest GDP is in Siming District, at 12,592,700 yuan/ha, followed by Huli District, at 10,493,700 yuan/ha, and Tongan District, at 374,800 yuan/ha.Tong'an District is the smallest, at RMB 374,800/ha.

Xiamen Island is the main urban body of Xiamen and is the most concentrated and fastest urbanising area in the city. The area under the jurisdiction of Xiamen is the last among the 15 sub-provincial cities in China, and the small size of the area has become the biggest bottleneck for the development of Xiamen. Water resources are scarce in Xiamen and have become a major constraint on the city's development and population concentration. In addition, the three cities of Xiamen and Zhangzhou have their own independence and do not form a clustering effect. As a result, with the accelerated urbanisation process, Xiamen's urban space continues to grow and urban construction land has increased dramatically. A large amount of non-urban construction land has been encroached upon, and is increasingly being shown to be enclosed by the sea, adjacent to the sea and engineered.

Xiamen's urban building land is increasing year on year and the increase is increasing. The total area has increased by 193%, and has become the largest spatial type. After 2004, Xiamen's construction land has been growing rapidly, with rapid growth in construction land on the island. This is because Xiamen has been implementing a bay-type urban development

strategy since 2003. The spatial distribution of construction land tends to be concentrated due to the rapid expansion of small scattered pieces of building land.

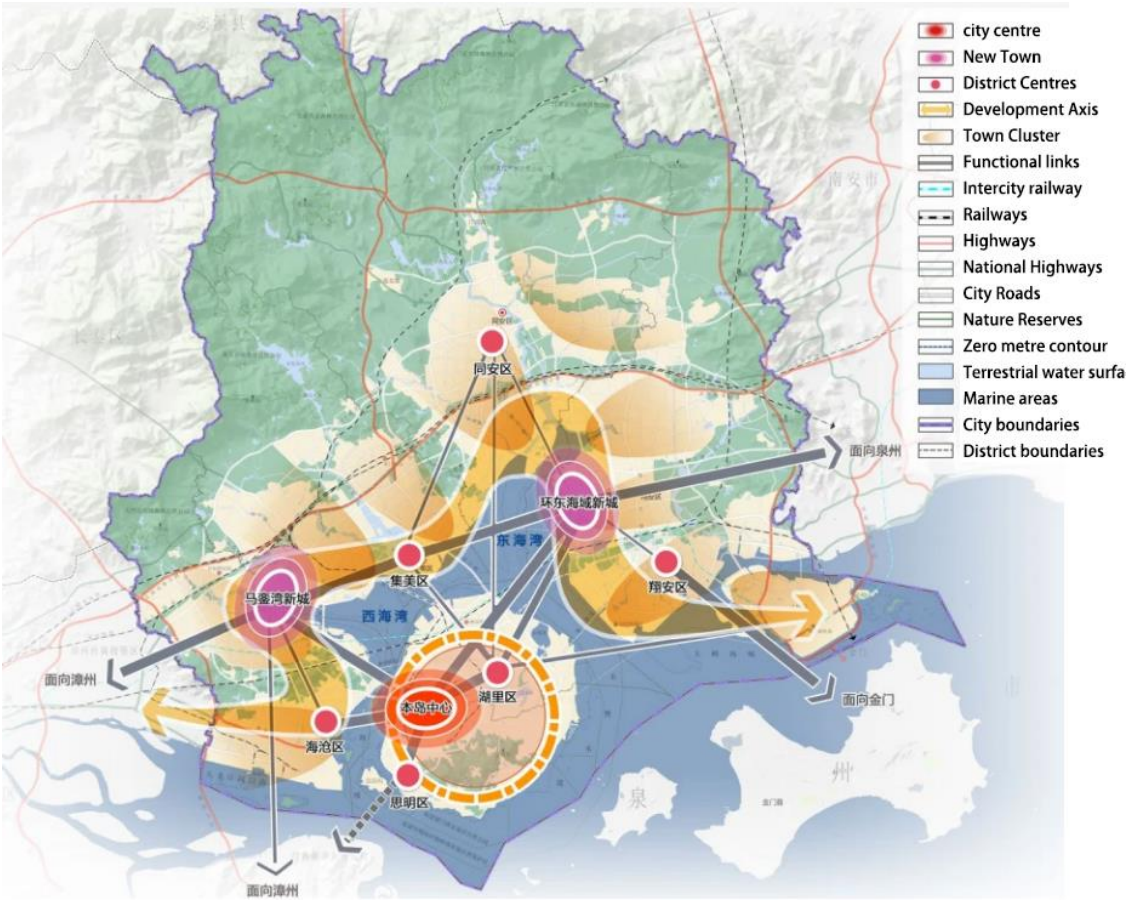


Fig. 18. Xiamen Urban Spatial Structure (Source from: http://zygh.xm.gov.cn/)

According to “Xiamen 14th Five-Year Plan for Ecological and Environmental Protection”. the concept plan of landscape pattern, spatial layout plan of woodland and special plan of green space have been compiled. The basic ecological pattern of "points, lines and surfaces" is formed by relying on the existing mountains, streams and shores, establishing strict basic ecological control lines by combing mountains and waters, leaving green axes, ventilation corridors and storage depressions, and building a natural ecological spatial pattern of "mountains, waters, forests, fields and lakes".

The natural ecological spatial pattern. The clusters are separated by sea areas, mountains and ecological green corridors, forming an ecological structure that integrates the urban and natural environments and improves the urban microclimate.

In terms of adaptive capacity, a special plan for drainage (rainwater) prevention and flooding in Xiamen has been prepared. In terms of adaptability, special plans for drainage (rainwater) prevention and flooding and special plans for sponge cities have been prepared. By increasing the number of sponge facilities, strengthen the construction of urban drainage and flood prevention infrastructure, improve the level of The city's ability to cope with climate change has been enhanced by increasing the number of sponge facilities, strengthening the construction of urban drainage and flood prevention infrastructure, improving the level of prevention and control of flooding in built-up areas, and alleviating the heat island effect. The city's ability to cope with climate change will be enhanced.

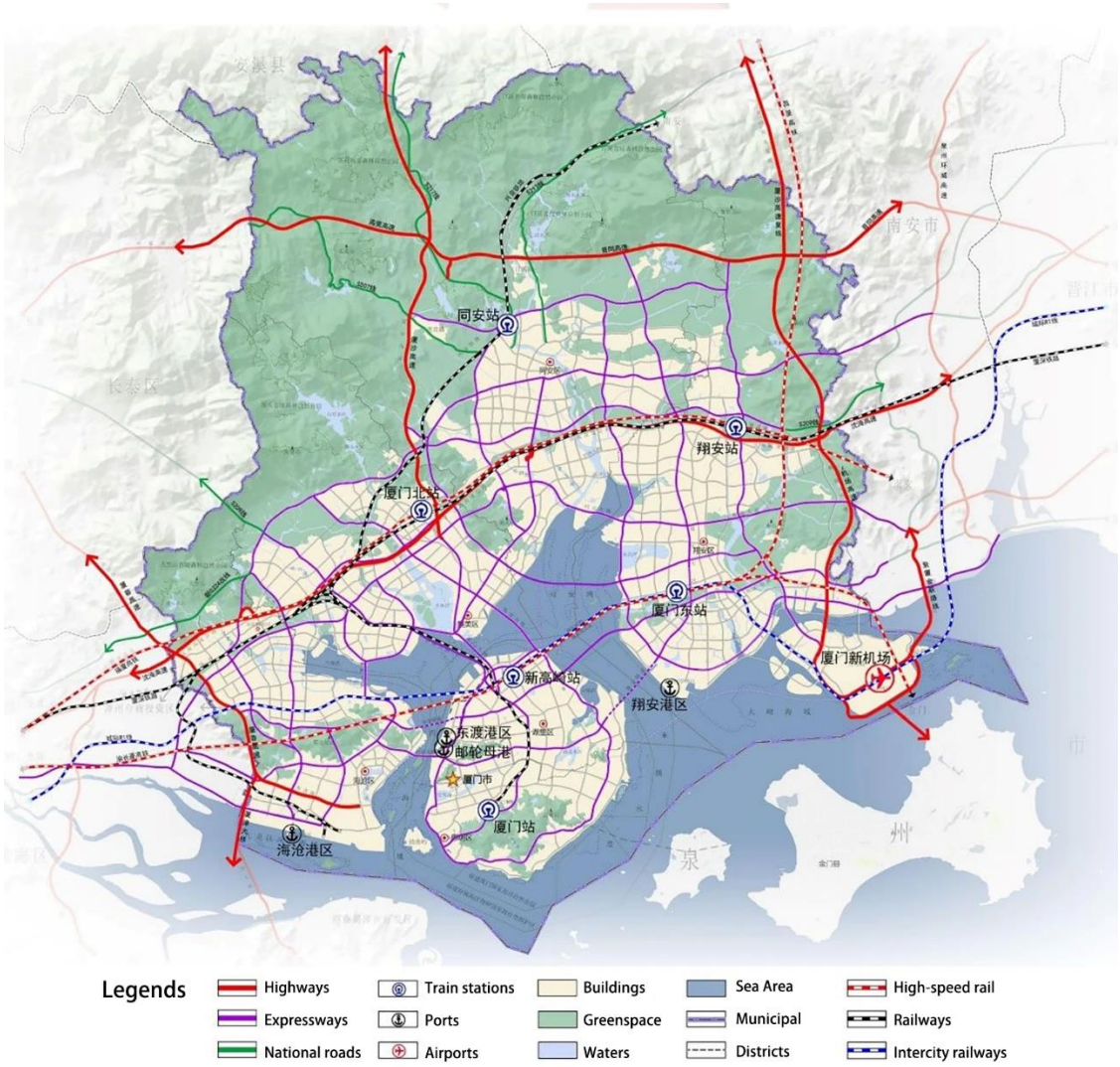


Fig.19. Xiamen Comprehensive Transportation Plan (Basic Source from: http://zygh.xm.gov.cn/)

In terms of transportation, the Xiamen Comprehensive Transportation System Plan, the Urban Rail Transit Line Network Plan, the Port Master Plan and the Xiamen Regional Railway Hub Plan have been prepared. The formation of a low-carbon urban spatial structure requires the support of a green transportation system. Xiamen City has adopted "public transport + slow walking" as its green transport development strategy, insisting on giving priority to public transport, actively building green islands and slow walking systems, and developing diversified transport modes such as water transport, tourism transport and new energy vehicles.

The study of urban spatial structure mainly focuses on the Xiamen island region, with the Xiamen island as the central system. As a typical bay city, the urban ecosystem has a rich and well-developed water system both inside and outside the city, with the development of the city, the increase in population density human activities, spatial resource urgency has led to a gradual decline in land use diversity in Xiamen. The increased disturbance of the ecosystem by human activities has intensified the fragmentation of the natural landscape of Xiamen, which is a distinct coastal water landscape pattern. The traditional spatial structure of the city is becoming increasingly vulnerable, and the combination of economic growth-focused urban development and a multitude of uncertain urban climate issues is increasing the vulnerability of the city. Optimizing the climate resilience of the city and the spatial optimization of a complex combination of spatial climate adaptations according to different regions is essential for the coastal city of Xiamen to cope with climate change from the community level, to the district level and then to the city level, forming a resilient and balanced network structure. The highest priority is given to those with the greatest impact, such as natural spaces in rivers and waters, to disaster prevention and refuge spaces, to green spaces and to living spaces for residents.

4.3 Xiamen City Planning Policy Analysis

Resilience city strategy, ecological planning and water environment strategy in Xiamen Cities should identify and analyze the key factors and consequences affected by disasters based on the built environment of disaster-bearing bodies such as spaces, buildings, and infrastructure, and predict and evaluate the gap between the current disaster-bearing bodies and the expected disaster-resistance goals. Formulate scientific, reasonable and feasible disaster response plans.

Taking the urban medical system's response to earthquake disasters as an

example, when a general hospital exists as an emergency rescue organization for post-earthquake disaster relief, its expected disaster resistance goal is not only to ensure the safety of the hospital building structure after the earthquake disaster, but also to hope that the hospital It can keep the function uninterrupted in the event of a disaster. At this time, only rigid measures (such as improving the seismic fortification capability) cannot meet its expected disaster prevention goals, and resilient measures (such as adopting a self-recovery structural system, configuring emergency power supply, emergency water supply facilities, etc.). However, if it only exists as a normal medical facility in the city, it only needs to meet the goals required by the regulations and take rigid measures.

What kind of response to disaster-bearing bodies is related to people's acceptable level of disaster risk. When the acceptable risk level is high, the first line of defense against disasters can often be constructed by relying on rigid measures. When the acceptable risk level is reduced, continuing to adopt rigid measures will soon reach a marginal effect, even if the "robustness" of the disaster-bearing body is further improved, it will not be effective for disaster risk reduction. effect is not obvious. At this time, adopting elastic or resilient countermeasures to build multiple lines of defense against disasters can often achieve twice the result with half the effort.

The planning and management of various industries in Xiamen has provided good support for the construction of a resilient city. In terms of industrial layout, the city's industrial spatial layout plan and Xiamen City Industrial Layout Plan have been compiled. The industrial layout plan follows the principle of intensive and efficient use of land, focusing on the direction of industrial development, spatial scale and layout, and land use control methods to promote the high-end, intelligent and green development of Xiamen's manufacturing industry.

In terms of transportation, the Xiamen Comprehensive Transportation System Plan, the Urban Rail Transit Line Network Plan, the Port Master Plan and the Xiamen Regional Railway Hub Plan have been prepared. The formation of a low-carbon urban spatial structure requires the support of a green transportation system. Xiamen City has adopted "public transport + slow walking" as its green transport development strategy, insisting on giving priority to public transport, actively building green islands and slow walking systems, and developing diversified transport modes such as water transport, tourism transport and new energy vehicles.

In terms of urban support, Xiamen has prepared underground space planning, comprehensive pipeline corridor planning, gas special planning, electricity special planning and environmental sanitation special planning. The city's energy structure has been continuously optimised, and urban waste recycling and resourcefulness have been strengthened.

The planning and management of various industries in Xiamen provides good support for the construction of a low-carbon city. In terms of industrial layout, the city's industrial spatial layout plan and Xiamen City Industrial Layout Plan have been prepared. Among them, the industrial layout planning follows the principle of intensive and efficient use of land, focusing on the direction of industrial development, spatial scale and layout, land control methods, etc., to promote the development of high-end, intelligent and green manufacturing in Xiamen.

In order to implement low-carbon city construction, the Xiamen Municipal Government issued a pilot implementation plan for a low-carbon city in Xiamen in 2012, and formulated the "Xiamen 13th Five-Year Plan" for controlling greenhouse gas emissions. The relevant program set the target of reducing carbon emission intensity, and made arrangements mainly in promoting low-carbon industrial development, creating low-carbon energy,

developing low-carbon transportation, developing green buildings, strengthening waste resource utilization, increasing carbon sinks in ecosystems, improving market mechanisms, strengthening basic capacity support and strengthening safeguard measures. The annual work plan and task division of low-carbon city construction designated by Xiamen City are implemented quarterly by department for the tasks proposed in the relevant documents and plans, and at the same time, one provincial-level and six municipal-level cities are selected. At the same time, one provincial-level and six municipal-level low-carbon communities were selected for pilot construction.

Xiamen's water environment landscape is characterised by a distinctive water resource volume of 1.234 billion m³ on average over many years, with a per capita water resource volume of 331 m³, which is only 10.9% of that of Fujian Province, China, and a high dependence on water transfers from abroad. According to the referable 2015 Xiamen Environmental Quality Report, Xiamen has a low environmental carrying capacity in terms of water ecology, insufficient ecological water consumption in the main watershed water bodies, poor self-purification capacity of water ecology such as receiving pollution from anthropogenic interference from residents' activities, and a lack of biodiversity. It is also geographically vulnerable to typhoons and extremely intense rainfall, which puts enormous pressure on the internal drainage system of the city.

As a result, Xiamen is also the most active region in sponge city construction and is the only coastal city in China's first batch of sponge city pilot projects, which reinforces the special characteristics of the city and the need to study its urban resilience.

Xiamen City prepared the Xiamen Water Conservation Plan (2005-2020) in 2006, and in recent years has completed the Xiamen City Water Resources

Strategic Plan (2015-2030), the Xiamen City Water Security Near-Term Action Plan (2015-2020), the Xiamen City Water Conservation Society Construction "13th Five-Year Plan The "Xiamen City Water Resources Strategic Plan (2015-2030)", "Xiamen City Recent Action Plan for Water Resources Security (2015-2020)" and "Xiamen City Reclaimed Water Development and Utilization Plan", which put forward the general ideas, overall objectives and general layout of Xiamen's water-saving city construction according to the characteristics of local industries and water resources, and provided a guide for the city's water-saving work.

The current sponge city pilot project in Xiamen focuses on urban waterlogging, rainwater resource utilisation, black odour of water bodies and other issues, making full use of the advantages of the city's obvious landscape features and good natural endowment, actively exploring sponge construction models for southern mountain water flow, cities around national parks and southeastern coastal cities, forming a sponge city construction experience that is suitable for southern regional characteristics and can be replicated and promoted.

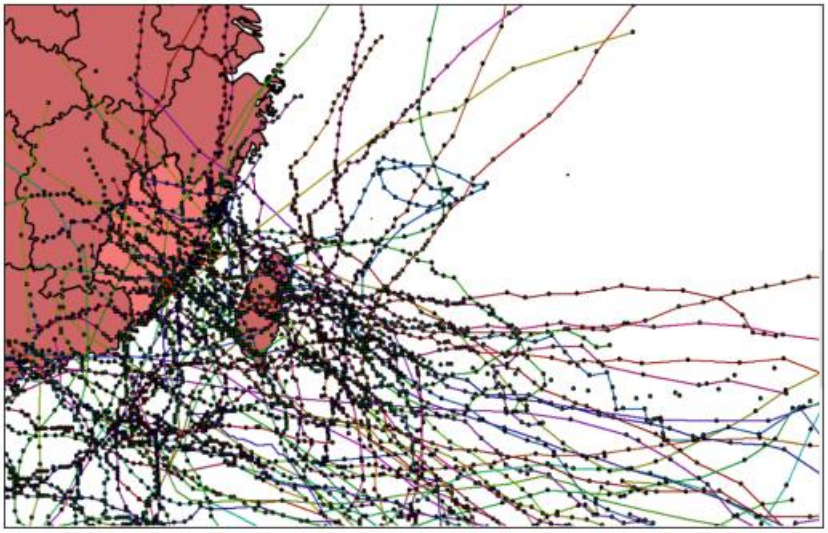
4.4 Climate change hazard risk characteristics of Xiamen and the eastern coast of China

Disaster exposure and vulnerability in China's coastal cities are similar overall compared to other cities in general, with the differences being mainly in coastal environmental factors, focusing mainly on urban disaster-causing factors. Due to their special geographical location, China's eastern coastal cities are subject to more frequent and multiple types of climatic

hazards. The eastern coast of China is located northwest of the Northwest Pacific storm, the largest tropical storm basin in the world, making the eastern coastal region frequently exposed to both marine and land-based natural geo-climatic hazards. Frequent typhoons, extreme rainfall due to storm surges, tropical cyclones and extreme climatic hazards such as red tides.

This is coupled with the disturbance of the land and surrounding marine ecology caused by the expansion of reclamation in the context of Xiamen's rapid urbanization and economic growth and the urgency of land resources. The original special geographical location has led to a chain reaction of interaction of various disaster-causing factors increasing the vulnerability of the area and, together with the perceived disaster-causing factors, the increase in the number of disasters brought about by reclamation projects. As a result, cities are forced to provide greater resilience and recovery in the face of extreme and unpredictable natural hazards. The scenarios of resilience also tend to be more explosive, high frequency and continuous high loss scenarios.

Types of climate risk and disaster vulnerability in Xiamen,China	
Extreme rainstorms and flooding	There are two main types of flooding in Xiamen: non-typhoon extreme rainstorms and rainstorms accompanied by typhoons. Flooding occurs in Xiamen from 15 April to 31 October each year, with the months concentrated in the summer months of July, August and September. Due to the low-lying topography of Xiamen Island and the coastal areas, extreme precipitation events can cause tidal toppling, making drainage more difficult and local flooding in the city severe. In 2016, Typhoon 14 "Moranti" landed in Xiamen during the astronomical high tide, which triggered heavy rainfall

	and storm surges at the same time, leading to severe secondary disasters within the city.
Typhoon	Xiamen's special geographical location and climatic conditions place the area in and around Xiamen in an area frequently affected by tropical cyclones. Typhoons in Xiamen are seasonal, frequent and characterised by high rainfall intensity, long duration and a wide area of influence. They also continuously cause secondary hazards such as storm surges and floods, and their timing coincides with the period of abundant rainfall in Xiamen, again concentrated in July, August and September. Extreme rainfall caused by typhoons can lead to secondary hazards such as inundation, flash floods, landslides and mudslides to varying degrees. According to the Xiamen Water Resources Journal for the past 60 years.  Fig.20 Typhoon tracks affecting Xiamen from 1996 to 2016.(sources form: Xiamen Natural Resources and Planning Bureau) According to 60 years of statistics, a major typhoon disaster occurs in Xiamen every 1.6 years on average, causing serious property damage.
Earthquake	Xiamen is located in the middle of the coastal fault seismic zone and is in an earthquake prone area. Historically, Xiamen has suffered few local records of earthquake disasters, but the earth's crustal movement is evident and the tremors are strong.

In addition to the three main climatic hazards in Xiamen mentioned above, other meteorological hazards within Xiamen, such as tsunamis, coastal erosion, and regional high temperatures in densely populated areas of Xiamen proper, high temperature heat waves occur more frequently and occasionally strong level heat waves occur.

4.5 Resilience measures practice and resilience evaluation

It is agreed that urban resilience is characterized by a co-evolution, self-adaptiveness, and learning capacity; the question on how to operationalize the concept into urban planning procedures remains unsolved to the lack of empirical knowledge of how to measure the degree of resilience in a specific context. [70]Resilient evaluation is a breakthrough for the instrumentalization and grounding of resilience theory. At present, scholars from various disciplines around the world have conducted rich theoretical studies on the concept and characteristics of resilient cities, and although different perspectives from engineering, sociology, ecology and other fields have explored them, the corresponding evaluation system of resilient cities still lacks a systematic and operable collation, and a unified and recognized evaluation system has not yet been formed. Resilient evaluation system. A perfect resilient city evaluation system not only helps to enrich the research

[70] Proag, V . Assessing and Measuring Resilience. Procedia Econ. Financ. 2014, 18, 222–229. [CrossRef]

Quinlan, A.E.; Berbés-Blázquez, M.; Haider, L.J.; Peterson, G.D. Measuring and assessing resilience: Broadening understanding through multiple disciplinary perspectives. J. Appl. Ecol. 2016, 53, 677–687. [CrossRef]

of resilient city theory, but also can truly reflect the construction practice of resilient cities and guide cities to improve strategies and policies based on the evaluation, which has both theoretical and practical significance. Although the theoretical debate on resilience is deeply investigated, several methodological challenges remain mainly related to the concept's practical sphere. As a matter of fact, resilience is commonly criticised for being too ambiguous and empty meaning. At the same time, turning resilience into practice is not easy to do.[71]

The same scholarship is explored in the study by Grazia Brunetta and Ombretta Caldarice, professors at the Politecnico di Torino, in the paragraph "Future Directions: Overcoming Gaps of Spatial Resilience In the paragraph "Future Directions: Overcoming Gaps of Spatial Resilience" three future directions are mentioned, concerning gaps in the theory and practice of resilience, including structural gaps, technological gaps and policy gaps. Amongst the technical gaps in particular, the difficulty of assessing resilience in practice is mentioned in detail, the main problem being that existing methods of assessing and measuring resilience are constrained by the complex definition of spatial resilience. This problem is also found in China's traditional integrated disaster prevention and mitigation plans, such as the plans for urban flooding and the newly introduced pilot projects, which are separate from other plans, and this means that there is a lack of systematic response to complex unpredictable multi-dimensional areas of disaster cities. In the summary of the professors' research on the current state of spatial resiliencemeasurement, the following general problems with current measurement and resilience assessment are revealed：“These studies predominately (i) measure resilience as a city's performance, i.e.,

[71] Grazia Brunetta,Alessandra Faggian,Ombretta Caldarice. Bridging the Gap: The Measure of Urban Resilience. *Sustainability* 2021, 13(3), 1113.

urban

system's reaction to urban challenges, instead of as a city's competence; (ii) use indicator not resilience-oriented but existing indicators used for developing an urban resilience assessment tool; and (iii) pay no attention on the interaction between different urban system components, although they use indicators that cover multiple dimensions of urban resilience. "[72]

One of the better known international measurement frameworks is developed by Arup with support from the Rockefeller Foundation, based on extensive research in cities: "The City Resilience Framework". [73] In this report it's says: "Every city is unique. The way resilience manifests itself plays out differently in different places."

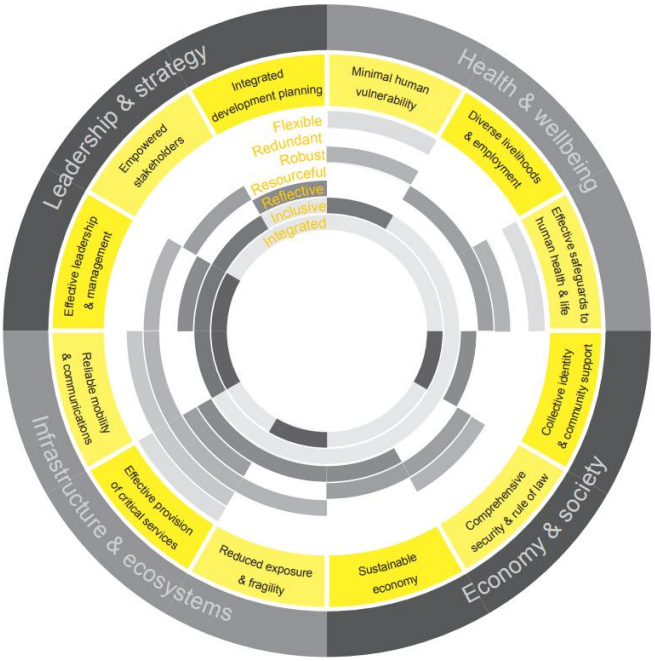


Fig21 . The 12 goals fall into four categories. City Resilience Framework.. The Rockefeller Foundation | Arup

The 12 goals fall into four categories: the health and wellbeing of individuals (people); urban systems and services (place); economy and society (organization); and,

[72] Brunetta, G.; Caldarice, O. Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. In Sustainable Cities and Communities. Encyclopedia of the UN Sustainable Development Goals; Leal Filho, W., Azul, A., Brandli, L.,Özuyar, P ., Wall., T., Eds.; Springer: Cham, Switzerland, 2020; pp. 1–12.

[73] https://www.rockefellerfoundation.org/report/city-resilience-framework-2/

finally, leadership and strategy (knowledge). For each, it is possible to envisage a best case which represents a resilient city, and a worst case which equates to breakdown or collapse.[74]

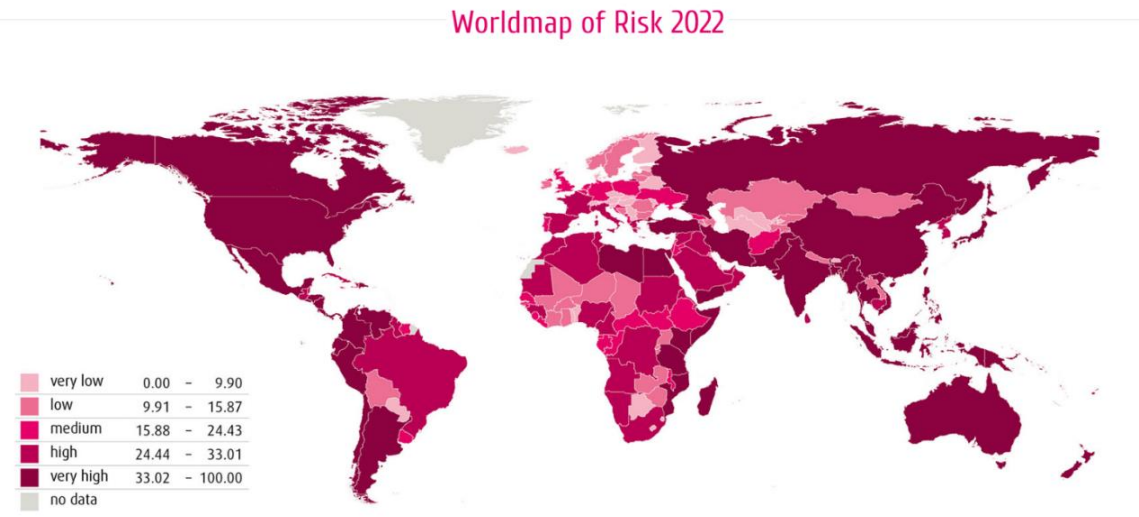
The assessment of urban resilience includes both qualitative and quantitative assessments: qualitative assessments use questionnaires and interviews to conduct qualitative analysis and explore the elements that make up urban resilience. The quantitative assessment consists of a quantitative statistical analysis and validation of the factors influencing resilience, as well as a numerical measure of the level of resilience.

One of the operational ways to measure the adaptive capacity of cities to climate change is to use indicators for assessment. One of the example is the *World Risk Index (WRI)* that is an approach to assess global exposure, vulnerability and risk patterns based on national scale resolution data[75]. The concept of the WorldRiskIndex focuses on the understanding of risk which is defined as the interaction of physical hazards and the vulnerability of exposed elements. The exposure to natural hazards was assessed by using five indicators that describe the expsoure of people towards earthquakes, cyclones, floods, droughts, and sea level rise. Whereas vulnerability consists of susceptibility, coping capacity and adaptive capacity was calculated on the basis of 23 indicators which comprise social, economic and environmental conditions of a society. The method and the results of the WorldRiskIndex were validated by using statistical analysis such as reliability, sensitivity and uncertainty analysis. The results of the

[74] City Resilience Framework. April 2014 (Updated December 2015). The Rockefeller Foundation | Arup. https://www.rockefellerfoundation.org/wp-content/uploads/City-Resilience-Framework-2015.pdf

[75] Mingshun Zhang ,Yaguang Yang,Huanhuan Li ,Meine Pieter van Dijk. Measuring Urban Resilience to Climate Change in Three Chinese Cities. *Sustainability* 2020, 12(22), 9735.

WorldRiskIndex were mapped and classified by means of a GIS system to



show different patterns of exposure, vulnerability and risk on global scale.[76]

Fig22. Worldmap of risk 2022. Sources from: https://weltrisikobericht.de/weltrisikobericht-2022-e/

Worldmap of Risk 2022, "Regarding the intercontinental distribution of risks, the Americas have the highest median, ahead of Asia, Africa, Oceania, and Europe." (source: https://weltrisikobericht.de/weltrisikobericht-2022-e/)

The WorldRiskIndex is a model that aims to raise awareness about the relevance of social capacities in disaster preparedness among the public and decision-makers in all sectors of society, The aim is to create an understanding that the emergence and progression of disasters are highly dependent on the social conditions of the people, regions, and countries affected, to accompany the shift from reactive to proactive action.[77]

According to the 2022 risk report, China is also among the ten countries with the highest risk values, mainly due to multiple exposures and high-

[76] Welle Tand Birkmann, J. The World Risk Index—An approach to assess risk and vulnerability on a global scale. J. Extrem. Events 2015, 2, 34. [CrossRef]

[77] WorldRiskReport 2022,

intensity complex effects, but very high exposure levels in the report do not imply very high risks, which can be reduced through vulnerability reduction and thus disaster risk; very low vulnerability in some countries also contributes to risk reduction. Report on Asia. Asia ranks second in the global comparison. With a median of 5.93 for 47 countries, Asia is well above the global risk median. Regarding the individual components of the model, Asia is also in second place and above the global medians in each case, except for adaptive capacities.[78]

Classification	WorldRiskIndex	Exposure	Vulnerability	Susceptibility	Lack of Coping Capacities	Lack of Adaptive Capacities
very low	0.00 – 1.84	0.00 – 0.17	0.00 – 9.90	0.00 – 7.17	0.00 – 3.47	0.00 – 25.28
low	1.85 – 3.20	0.18 – 0.56	9.91 – 15.87	7.18 – 11.85	3.48 – 10.01	25.29 – 37.47
medium	3.21 – 5.87	0.57 – 1.76	15.88 – 24.43	11.86 – 19.31	10.02 – 12.64	37.48 – 48.04
high	5.88 – 12.88	1.77 – 7.78	24.44 – 33.01	19.32 – 34.16	12.65 – 39.05	48.05 – 59.00
very high	12.89 – 100.00	7.79 – 100.00	33.02 – 100.00	34.17 – 100.00	39.06 – 100.00	59.01 – 100.00

As of this year, the WorldRiskIndex and its elements will use fixed thresholds for the classification of countries to enable medium- and long-term trends analyses. These threshold values for the WorldRiskIndex and each dimension were calculated as the median of the quintiles from the results of the last 20 years.

Rank	Country	WorldRiskIndex	Exposure	Vulnerability	Susceptibility	Lack of Coping Capacities	Lack of Adaptive Capacities
1.	Philippines	46.82	39.99	54.81	51.35	57.81	55.48
2.	India	42.31	35.99	49.75	39.50	55.38	56.29
3.	Indonesia	41.46	39.89	43.10	33.48	50.67	47.19
4.	Colombia	38.37	31.54	46.69	47.84	48.23	44.11
5.	Mexico	37.55	50.08	28.16	37.26	12.09	49.55
6.	Myanmar	35.49	22.43	56.14	53.39	58.85	56.30
7.	Mozambique	34.37	18.10	65.28	64.57	64.54	66.76
8.	China	28.70	64.59	12.75	15.78	12.11	10.84
9.	Bangladesh	27.90	16.57	46.97	36.81	59.18	47.58
10.	Pakistan	26.75	13.11	54.58	41.42	60.96	64.41
11.	Russian Federation	26.54	28.35	24.85	11.22	39.19	34.91
12.	Viet Nam	25.85	26.73	25.00	26.54	12.98	45.38
13.	Peru	25.41	16.65	38.79	26.38	48.09	46.00
14.	Somalia	25.07	8.55	73.49	65.01	79.09	77.20
15.	Yemen	24.26	9.12	64.52	60.66	68.05	65.06
16.	Papua New Guinea	24.10	18.84	30.82	30.86	14.12	67.21
17.	Madagascar	23.48	18.38	29.99	25.36	15.49	68.69
18.	United States of America	22.73	39.59	13.05	11.60	6.15	31.16
19.	Bolivarian Republic of Venezuela	22.45	19.52	25.82	22.87	12.30	61.16
20.	Ecuador	22.42	14.57	34.51	20.20	46.01	44.21
21.	Nicaragua	22.35	18.71	26.71	28.28	14.02	48.06

Fig23. Worldmap of risk 2022. Sources from: https://weltrisikobericht.de/weltrisikobericht-2022-e/

In the 2021 WorldRiskIndex Overview, China ranks 8th in the risk index, with only two indices in the "Vulnerability" and "Lack of Adaptive Capacities" categories. China is ranked 8th in the WorldRiskIndex Overview for 2021,

[78] WorldRiskReport 2022,

with only two indices in "Vulnerability" and "Lack of Adaptive Capacities" in the lower registration categories, especially in "Exposure" where the risk registration is very high.

Through the expansion and updating of the worldriskindex, and especially the gradual transition to digital, the indicator has added new technologies and more available data to increase the accuracy of risk prediction and guidance for crisis prevention and management. The future development is also increasingly oriented towards long-term disaster risk analysis and disaster management. as its structure and processes have been consistently designed to integrate new aspects and data quickly.[79] This can reduce the uncertainty caused by the complexity of modern cities with their large and complex complex systems, the variability of different regions in the same country, complex strategies and decisions of organizers.

The data is mainly obtained from the websites of various government agencies: Xiamen Natural Resources and Planning Bureau, Xiamen Municipal People's Government Website, the 《Xiamen Special Economic Zone Yearbook》, 《Comprehensive climate change risk regionalization of China》, 《Code of Practice for the Design of Disaster Preparedness and Shelter》 (GB51143-2015), etc. Data is collected on various urban disasters in Xiamen's history and China National Meteorological Science Data Centre, Xiamen National Weather Station, 《Xiamen City Climate Annual Report》, 《Xiamen Meteorological Hazard Risk Zones》including earthquakes, typhoons, floods, fires, etc. The data is also available on economic and social development.

Chinese approaches to urban resilience assessment are generally based on

[79] WorldRiskReport 2022,

the selection of representative factors, riskiness of the causative factor, exposure of the hazard-bearing body, response capacity of the hazard-bearing body and recovery capacity of the hazard-bearing body. Resilience models and indicator systems are constructed. The assessment factors include climate hazard impact data analysis; engineering infrastructure (human defence facilities, fire fighting facilities, emergency shelters, road density, etc.); economic and demographic aspects including economic density, population density, population structure, GDP per capita, etc.; urban community support facilities (hospital distribution, social security, land type); natural ecological aspects including terrain data analysis, water system, green space distribution, road density, etc.etc. The indicators are assigned weights, and the classified disaster information is imported into ArcGIS to establish the assessment and analysis maps respectively, and finally form a comprehensive disaster risk assessment zone map of the research object.

Some studies have also used resilience measures based on the BRIC model to construct disaster resilience evaluation models in the context of the study population. the BRIC resilience assessment indicator system covers social resilience (population education level, health service capacity); economic resilience (employment rate, business, gender income gap); environmental resilience (natural disaster buffer, water use, land use); organizational resilience; infrastructure resilience (evacuation (evacuation sites, evacuation routes and accessibility); and community resilience (civic organisation, disaster response, population mobility, etc.). The model is practical and its resilience evaluation results can better The model is practical and its resilience evaluation results are a good reflection of a region's ability to cope with and recover from disasters.

4.6 Urban disaster prevention strategies and resilience evaluation in Xiamen

China's urban disaster risk assessment is mostly focused on the macro level of the city, while risk assessment and urban resilience evaluation are a mutual feedback test process. Data on process rainfall and historical disaster conditions are from the Xiamen Climate Bulletin (2005-2016), and typhoon tracks are from the Fujian Provincial Water Resources Information Network's Flood Dissemination System.

The most significant flood risks in Xiamen were selected to analyse the flooding problems in the city and the standards of the current flood control and drainage facilities. The risk assessment method is based on the selection of flood analysis factors, the risk of disaster-causing factors, the sensitivity of the disaster-preventing environment, the vulnerability of disaster-bearing subjects and the flood prevention and control capacity.

The risk assessment method is based on a comprehensive assessment of the risk of heavy rainfall and flooding in Xiamen from four perspectives: the risk of disaster-causing factors, the sensitivity of the disaster-prone environment, the vulnerability of disaster-bearing bodies, and the flood prevention and control capacity.

The 19 typhoons with complete rainfall data affecting Xiamen since 2005 were counted, and the rainfall amounts at 23 stations were normalised to obtain a hazard distribution map for each region, and Xiamen was divided into five risk zones according to the magnitude of the hazard-causing factors.

Vulnerability of the hazard-bearing body is mainly considered in terms of building quality, population density and GDP per land.. There are six

administrative districts in Xiamen, and the population, GDP and area of each district were obtained from the Xiamen Special Economic Zone Statistical Yearbook 2016.

The environmental sensitivity of the pregnant environment mainly considers the influence of topographic factors, and two factors, slope and elevation, were selected.

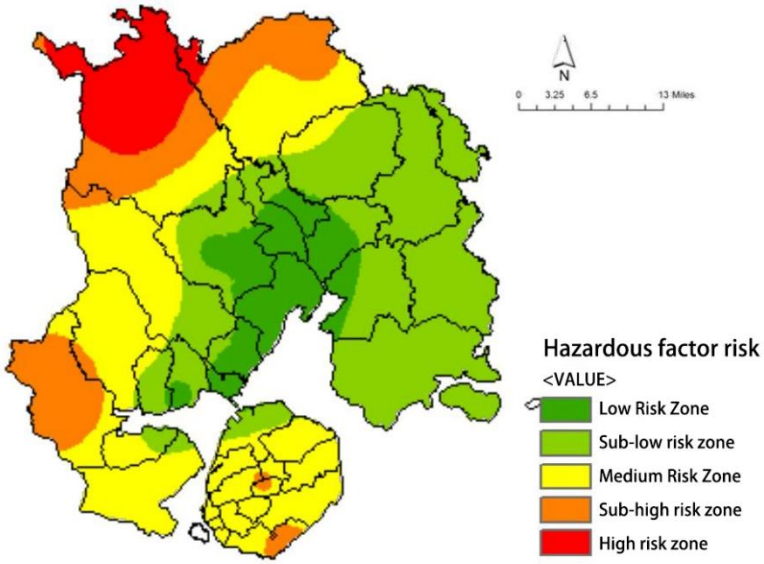


Fig24. Hazard distribution of disaster-causing factors by region in Xiamen. Modified by the author，Data Sources from: Thematic Study on Xiamen City Master Plan (2017-2035)

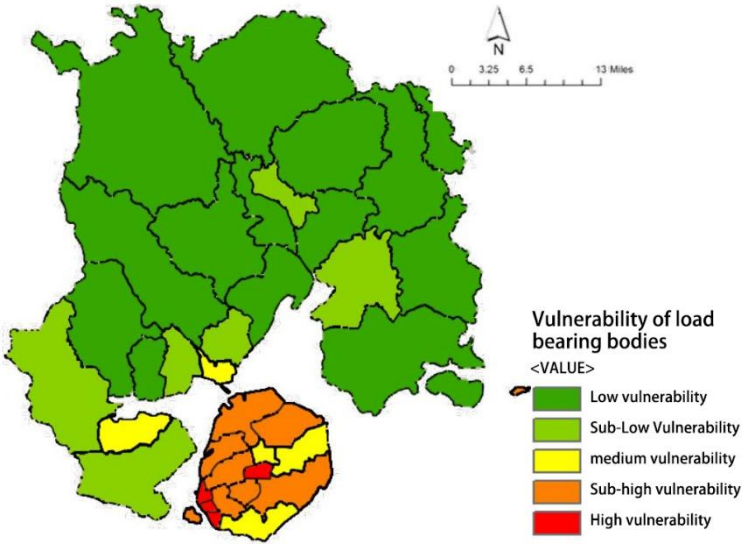


Fig25. Vulnerability of load bearing bodies by region in Xiamen. Modified by the author，Data Sources from: Thematic Study on Xiamen City Master Plan (2017-2035)

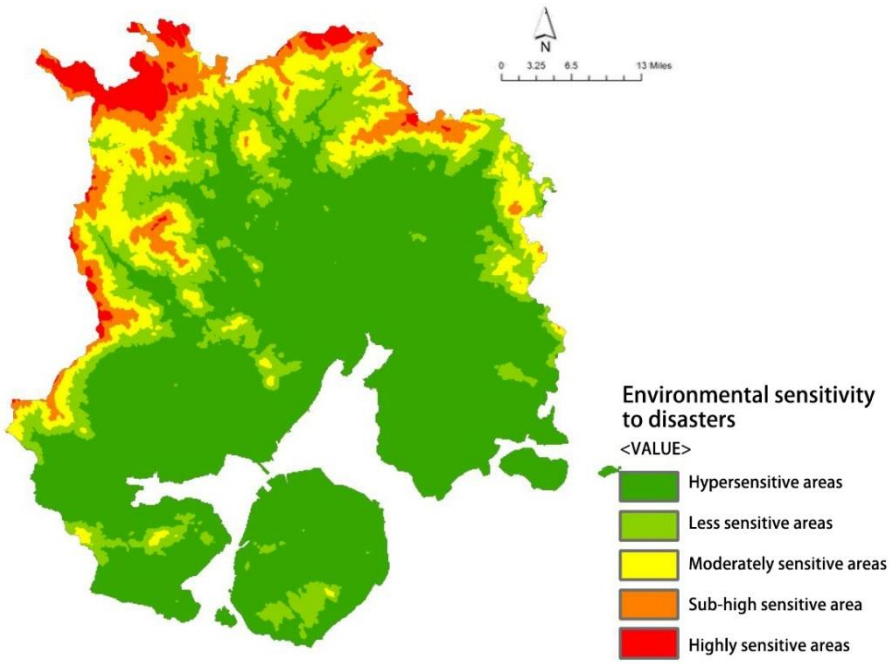


Fig26. Environmental sensitivity to disaster by region in Xiamen. Modified by the author，Data Sources from: Thematic Study on Xiamen City Master Plan (2017-2035)

Disaster prevention and mitigation capacity Engineering and non-engineering measures to cope with the damage caused by typhoon hazards. Based on Xiamen Road Based on the road distribution map of Xiamen and the data from the Xiamen Special Economic Zone Statistical Yearbook 2016, including local financial expenditure, fixed asset investment and hospital The assessment of the disaster prevention and mitigation capacity of Xiamen was carried out based on the road distribution map and the Xiamen Special Economic Zone Statistical Yearbook 2016, including local financial expenditure, fixed asset investment and hospital beds.

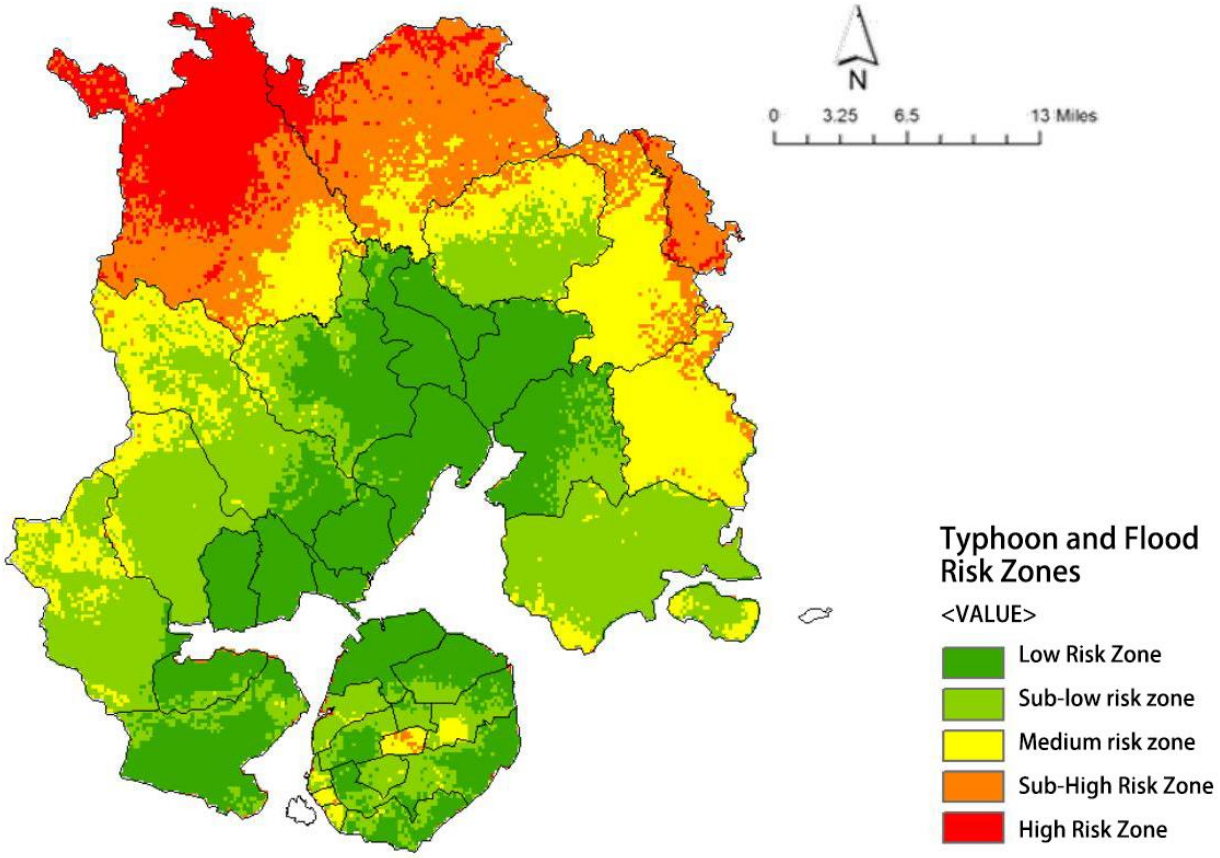


Fig27. Comprehensive risk distribution map of typhoon and flooding in Xiamen. Modified by the author, Data Sources from: Thematic Study on Xiamen City Master Plan (2017-2035)

The high and secondary risk areas are the northern low and medium hilly areas. These areas have weak disaster prevention and mitigation capabilities, high disaster risk, low building quality, high environmental sensitivity and, on balance, the highest disaster risk. The medium risk area is the central low hills and terraces. These areas have a high risk of disaster, a high vulnerability of the carrier, and a weak disaster prevention and mitigation capacity, but they have a low environmental sensitivity and a medium risk value.

Most of Xiamen Island and Haicang District belong to the second lowest risk zone, with relatively good infrastructure and strong disaster prevention and

mitigation capabilities, as well as good quality construction and the lowest vulnerability. Most of Xiang'an and Jimei districts have the lowest typhoon risk and are the least risky due to low hazard-causing hazards and high disaster prevention and mitigation capacity.

The distribution of the river network in the city was considered. The land use type also affects the natural regulating capacity of the area and the runoff of rainwater on the surface depending on the land type. The topographic and geomorphological analysis considers the higher topography in the northern part of Xiamen City, which slopes from north-west to south-east within the city limits.

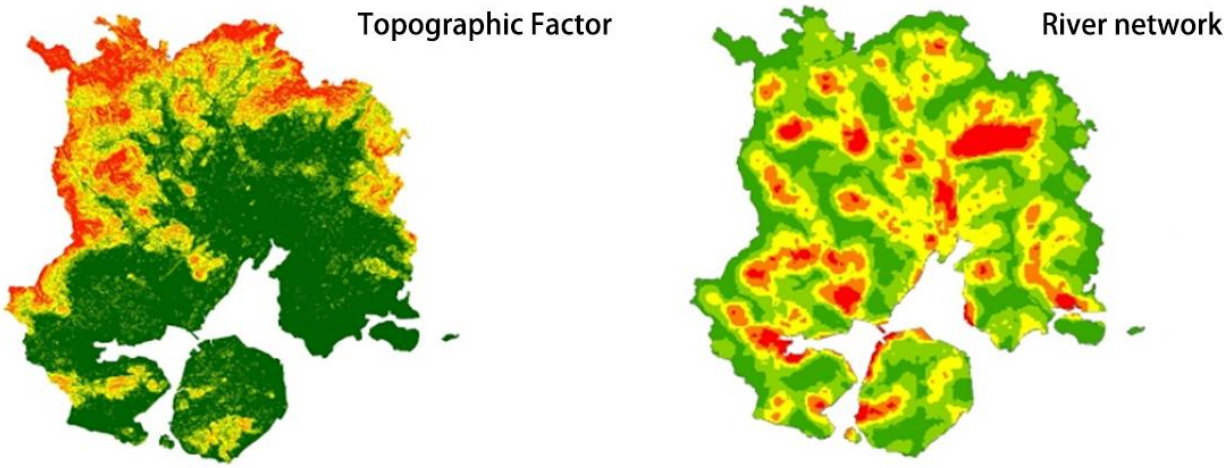


Fig28. topography and river network analysis in Xiamen. Sources from: Thematic Study on Xiamen City Master Plan (2017-2035)

The flood prevention and drainage capacity of Xiamen is analysed in terms of the city's disaster prevention and mitigation infrastructure, taking into account factors such as infrastructure construction, urbanisation level, development intensity, road network density and other construction indicators, and an overall analysis of Xiamen's disaster prevention and

mitigation capacity. The analysis shows that the flood prevention and drainage capacity of Xiamen is significantly higher than that of other administrative districts within the city.

The risk of flooding among the administrative districts of Xiamen is greatly affected by typhoons, and the planning standard of the drainage network is generally low, especially in the old urban areas, where the drainage capacity is seriously inadequate and water accumulates significantly in low-lying areas of the terrain. Responses to uncertain extreme rainfall still need to be improved. The intervention of sponge city projects, black smelly water treatment, pipe network traceability and drainage, rain and sewage diversion transformation, floodplain construction, demolition of illegal roads, tree planting and landscape construction, old neighbourhood transformation and pocket parks can effectively assist cities in coping with extreme climate disasters.

The risk of flooding among the administrative districts of Xiamen is greatly affected by typhoons, and the planning standard of the drainage network is generally low, especially in the old urban areas, where the drainage capacity is seriously inadequate and water accumulates significantly in low-lying areas of the terrain. Responses to uncertain extreme rainfall still need to be improved. The intervention of sponge city projects, black smelly water treatment, pipe network tracing and drainage, rain and sewage diversion transformation, floodplain construction, demolition of illegal roads, tree planting and landscape construction, old district renovation and pocket parks can effectively assist cities in coping with extreme climate disasters. According to the documents of the Ministry of Housing and Urban-Rural Development of China, the main objectives revolve around water ecology, water environment, water security and water resources, combined with landscape requirements to provide additional green belts around the water

system, ensuring the implementation of the control of the blue and green lines in the area, leaving enough space and outlets for water. At the same time, in accordance with the maximum, maintain the original drainage slope for the planning of the road vertical elevation, in order not to change the direction of drainage as far as possible, smooth the road elevation, reduce the road low points, so that urban rivers, lakes and wetlands and other ecological space to be protected and restored.

From traditional "end-of-pipe" treatment to "source reduction, process control and system treatment", from engineering measures to ecological measures and engineering measures, we have built a "micro, small and large "A three-tier drainage system has been built, forming a healthy water ecological cycle facility system.

Through the construction of the "micro, small and large" three-tier drainage system, the daily drainage capacity reaches 583,000 cubic metres, which can effectively withstand heavy rainfall (553,000 cubic metres of water catchment) in a 50-year event in the area.[80]

Micro-drainage system: strict sponge index control is applied to buildings and plots, urban roads, parks and green areas and other sites in the construction area, with a total annual runoff control rate of up to 78% (corresponding to a design rainfall of 35mm), which can control 58,000 cubic metres of water.

Small drainage system: The rainwater pipe network in the area is designed according to the standard of 1 in 3 years. Planning of future and near-term road plans, taking into account existing waterways, storage space and the current flood risk, to ensure adequate pathways for stormwater to enter the storage water bodies.

Large drainage system: In conjunction with land planning, additional

[80] Exploring a new model for building a sponge city.(2022) www.mohurd.gov.cn.

areas for water storage, green space and water storage space.

Analysis of the current situation of urban disaster prevention in Xiamen

At present, Xiamen has only one central shelter in the Convention and Exhibition Centre. The remaining districts are all less than 20km^2 in size and can only meet the needs of short- and medium-term shelters and emergency shelters. The remaining districts are all less than 20km^2 in size and can only meet the demand for short- and medium-term shelters and disaster prevention and emergency shelters. At present, Siming District, Huli District and Haicang District have more than 1m^2 of effective shelter area per person. The effective evacuation area per capita in Siming District, Huli District and Haicang District is more than 1m^2/person, while in Jimei District and Xiangan District it is less than 1m^2/person, so the effective evacuation area per capita is low and only meets the demand for temporary evacuation. The effective evacuation area per capita is low and can only meet the temporary evacuation needs. From a comprehensive perspective, the city's evacuation sites are inadequate in terms of service capacity.

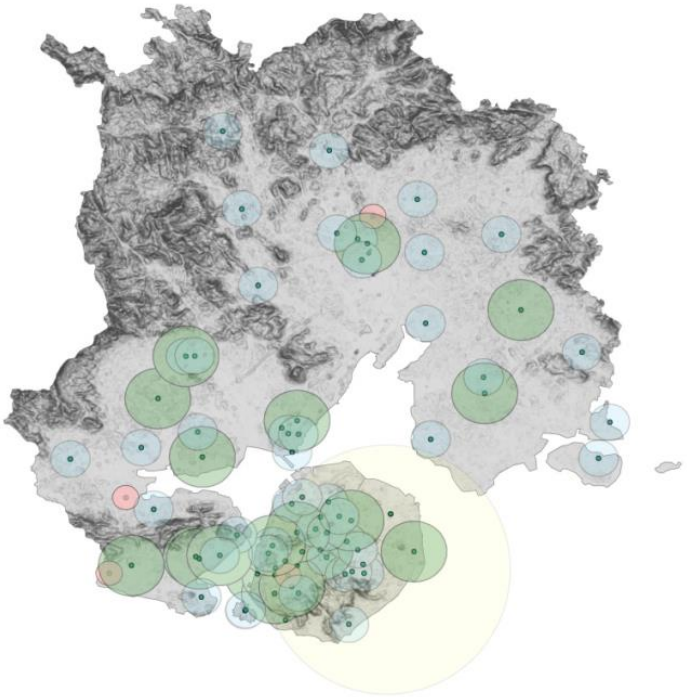


Fig29. Scope of services of refuge places at all levels in Xiamen. There are 82 emergency

shelters in Xiamen, including schools, squares, parks, gymnasiums, airports, etc. Sources from: Thematic Study on Xiamen City Master Plan (2017-2035)

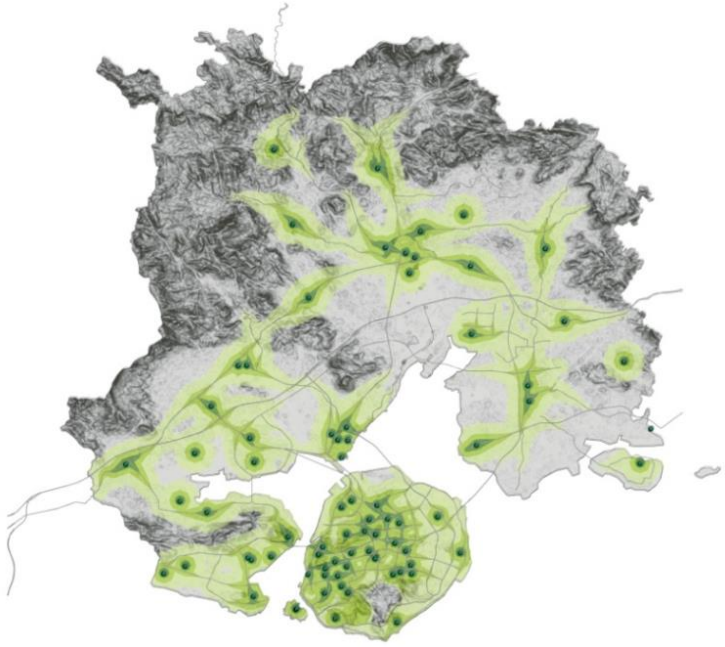


Fig30. Current status of accessibility of shelters in Xiamen. The layout of evacuation sites in Huli and Siming districts on Xiamen Island is basically The rest of the districts are less accessible.
Sources from：Xiamen Urban Master Plan (2017-2035) - Thematic Study Comprehensive Disaster Prevention System for Xiamen City Study on the Implementation Path of Resilient City Construction.

The number of shelters should be increased and the type of disaster risk should be taken into account in the selection and construction of shelters, and the safety of the shelters themselves should be taken into account in the selection of sites. As the current total number of places of refuge in Xiamen is clearly inadequate, new places of refuge should be sited in a way that avoids high-risk areas such as those likely to suffer from flooding. At the same time, the existing places of refuge can be maintained and improved in a targeted manner to reduce the risk of disasters.

4.7 Obstacles and problems of resilience in Xiamen

China's national strategy explicitly aims to strengthen the observation of the impact of global warming on vulnerable areas and to enhance the capacity of urban and rural construction, agricultural production and infrastructure to adapt to climate change. Economic development and technological advances have also provided favourable conditions for enhanced adaptation efforts. All these factors will be important contributors to China's efforts to improve its understanding of climate adaptation and enrich its means of adaptation. On the other hand, however, the current focus on climate adaptation is relatively weak and fragmented compared to climate mitigation, and China's enhanced climate adaptation efforts face a number of challenges. the analysis and assessment of climate change impacts and risks is still inadequate, and there is a lack of universal tools. Climate adaptation involves many areas, with multiple sectors and disciplines intersecting, making coordination difficult, and the governance system for climate change adaptation needs to be further improved. In addition, it is difficult to assess the profitability of adaptation projects and measures, as they are relatively public goods, and market incentives and instruments are limited. Finally, theories, technologies, knowledge, experience and awareness in the field of climate adaptation are still relatively weak, and there is a need to further strengthen concepts and consensus.

At the same time, Resilience planning requires coordination and collaboration among multiple government agencies, departments, and stakeholders. In China, the existing institutional setup may pose challenges

in terms of inter-agency coordination, information sharing, and decision-making processes. Overcoming institutional silos and fostering integrated approaches to resilience planning can be a significant challenge.

At present in China, although various government documents and news reports repeatedly emphasise the need to improve urban resilience applying the concept of resilience, in the actual implementation of construction, the traditional integrated disaster prevention research is still the main line, with most research emphasising a particular aspect or type of disaster in disaster prevention and mitigation, while the concept of resilience in cities emphasises holistic integration. Although Xiamen has been one of the first cities in China to put in place a large number of policies on the concept of 'resilience', it is not well suited to the particular urban development conditions and contexts of different regions, based on the general technical specifications for construction. Focusing on individual cities while ignoring internal regional differences is a weakness that makes it difficult to accurately identify urban resilience.

There is a general lack of uniformity in the framework and criteria for assessing resilient cities in China, and the relationship between indicators of urban resilience and the goals to be achieved is blurred. There is an urgent need for China's new integrated disaster prevention planning to be integrated with the concept of resilience. Existing urban disaster preparedness plans, sponge cities and low carbon city projects are not closely linked. There is a lack of regular resilient city building.

Finally，Xiamen still lacks meaningful community engagement. Engaging diverse stakeholders, including local communities, NGOs, and grassroots organizations, is vital to understanding local needs, enhancing social resilience, and ensuring that resilience strategies address the specific challenges faced by different communities. However, community

engagement processes can be complex and time-consuming, requiring effective communication, trust-building, and inclusive decision-making mechanisms.

Long-Term Planning and Policy Integration: Resilience planning requires a long-term perspective and the integration of adaptation considerations into various policy domains. Aligning resilience objectives with existing urban planning, land use, and development policies can be challenging. Integrating resilience principles into policy frameworks and ensuring cross-sectoral coordination is essential for effective implementation.

4.8 Towards Resilience: Optimization Measures to Enhance Xiamen's Urban Resilience

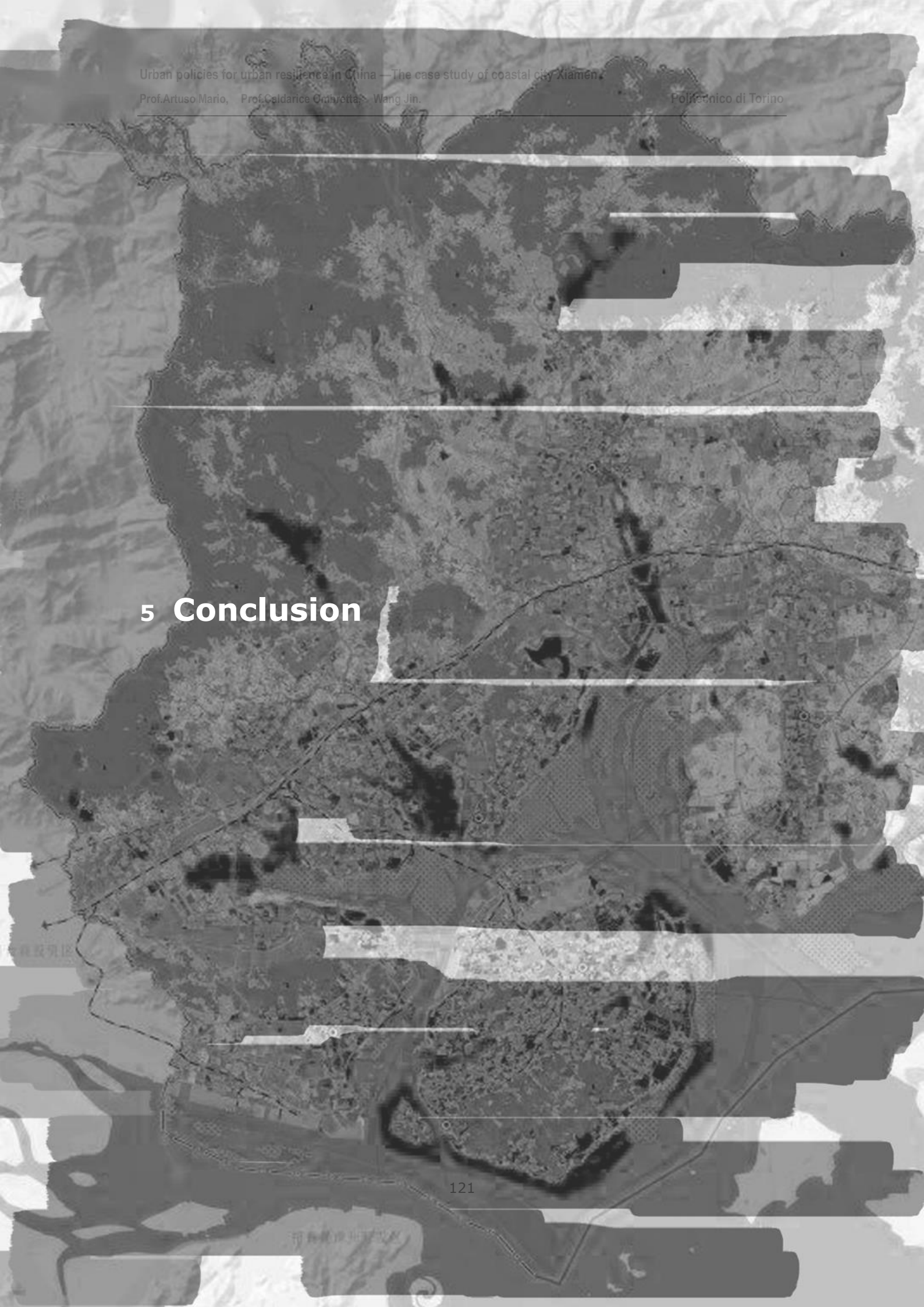
Based on the current development of Xiamen,China, there are several optimization measures and strategies that can be considered for future resilience policies:

Reduce the differences in resilience between administrative districts in Xiamen, where different resilience shortcomings currently occur in each part of the city, constraining the overall resilience of the Xiamen region. Respect and attention should be paid to regional economic levels and infrastructure development levels, making the capacity for disaster response and rapid recovery functions balanced between districts. The difference in economic levels and resilience development between the island of Xiamen and the rest of the island is significant, and policy and funding investment in other administrative regions can be appropriately increased.

Strengthening organisational resilience in Xiamen. The main emphasis is on

government management, social security in the community in building resilience. In government administration, management agencies are scattered and departments lack a unified mechanism and standardised guidance for resilience building. It is recommended that an integrated management platform be established to make information and data intelligent and facilitate linkage and collaboration between departments. Encourage the construction of public spaces with diverse forms and complex functions, while also providing a variety of options for places of refuge.

Emphasising the importance of people's participation and increasing community resilience Although Xiamen has become the first of its kind among Chinese cities in resilient city building, there is still much room for provision, and one of the things that should not be overlooked is the power of resident participation. The construction of safety facilities is the material basis of community disaster prevention construction, with particular emphasis on the renovation and renewal of housing in older communities that gather large numbers of people. Community safety facilities mainly include buildings, lifeline systems and post-disaster relief facilities, etc. The construction and safeguarding measures of safety facilities should be planned rationally. Residents' awareness and coping skills should be actively developed, and their suggestions should be practically incorporated into the construction of specific projects. Focusing on community resilience will be an effective breakthrough point for enhancing urban resilience in Xiamen in the future



5 Conclusion

Conclusion

According to the feedback study on Xiamen's urban space and urban resilience policy development, implementation policy implementation, in the process of urban resilience system construction, each administrative district in Xiamen city has a resilience shortcomings that restrict the effectiveness of the overall urban resilience, the current standardized scientific and index-based resilience assessment system fails to incorporate the assessment of planning implementation, combined with the comprehensive disaster prevention and mitigation system, in space and policy system on the macro policy to the micro implementation of the role, improve the area infrastructure construction and resource environment optimization, pay attention to the community perspective of the work of participation.

Consider long-term adaptive capacity, a high level of prediction and response coordination, and the ability to proactively restore the spatial environment and social structure to its operational capacity through its own resilience. China's sense of community is relatively weak, and residents' sense of belonging and relational networks are weak. However, as a basic unit of resilient cities and disaster prevention and mitigation, community space is an indispensable basic cellular component of the urban resilience ecology. The practice and application of sponge cities in actual communities is therefore also emphasised.

The existing single-hazard independent management model has fragmented management bodies, cross-cutting affairs between departments but lacking unified guidance, and unclear authority and responsibility in complex situations; the emergency relief command in times of disaster is a temporary body and requires a permanent body for specialised management. Therefore, an authoritative body should be set up

to co-ordinate the overall situation and establish an integrated management platform. This will facilitate inter-departmental coordination and joint response to disasters. Secondly, the evaluation of the implementation of comprehensive urban disaster prevention plans should improve the system of evaluation indicators, pay more attention to pre-disaster prevention, promote disaster prevention publicity and disaster awareness, improve the ability to disseminate information and emergency response in a timely manner after a disaster, and include the level of governmental disaster management and social security systems in the initial assessment of the organisation. Finally, integrate multi-channel funds for disaster prevention and mitigation, actively attract social capital and capital market investment, and make full use of innovative investment and financing models and diversified investment and financing channels to provide diversified economic support for disaster prevention and mitigation work.

Building a resilient governance system that combines regularity and emergency response to enhance the robustness and reflexivity of the urban governance system. By integrating urban resilience into all aspects of urban governance, such as planning and rehearsal, risk monitoring and early warning, emergency response, post-disaster recovery and reconstruction, we can on the one hand reduce the disturbance of uncertain risks to normal governance activities in all areas of the city and enhance the robustness of the urban governance system; on the other hand, we can form a closed loop of governance, so that we can draw lessons from disasters and crises through organisational learning, thereby promoting the continuous improvement of the urban governance system. This will enable us to draw lessons from disasters and crises through organisational learning, thereby promoting the continuous improvement of the urban governance system.
Explore the formation of localized experience in building resilient cities and

continuously improve the institutionalisation of resilient city building in China. Resilient city construction is not a competitive tournament among different cities, but a governance practice with distinctive problem-oriented characteristics. In the future, in the face of highly uncertain compound disaster risk impacts, the construction of resilient cities in China needs to focus on improving the institutionalisation of resilient city construction while adhering to the premise of problem-orientation, and gradually institutionalise and systematise the experience of resilient city construction in various places through the formulation and introduction of industry norms, departmental regulations and local laws and regulations. In particular, for China's megacities and mega-cities, it is necessary to actively explore the localised and institutionalised experience of resilient city construction, to continuously promote the modernisation of the governance system and governance capacity of megacities, and to continuously meet and adapt to the uncertainty of future risks with the resilience of the existing institutional system of cities. The resilience of the existing institutional system of the city to meet and adapt to the uncertainty of future risks.

6 Annexes: Interview with Prof. Nicola Tollin(SDU).

Professor Nicola Tollin – University of Southern Denmark
April, 21st, 2023

First group of questions: "The concept of resilience and cities ":

A1. The first question concerns the concept of *resilience* in general and its application to cities. In particular, on the basis of your experiences, what *transformations* are necessary in the *decision-making processe*s as well as in the *processes of formation of urban planning policies and tools*.
What are the "pillars" that make up an effective resilience policy? And Which role does it attribute to the different levels of territorial governance for improving resilient policies?

PROF.TOLLIN: So regarding what to define our resilience before understanding what is fundamental to domestic policies, is this specific understanding that the use for other(all the) resilience.
most of the United Nation processes in the policy, use resilience in a rather than limited manner.
They refer to resilience as synonym of climate adaptation, or a synonym of disaster risk reduction, which is a rather limited type of understanding of it.

And the definition that tried to use is that resilience shall respond to urban challenges and urbanism challenges and among this challenge is the most urgent and it's the one of climate change.
Urban resilience Is shall not only be intended as substitute of climate adaptation was at about the level but shall consider both causes and effects of climate change as an entry point, but not limiting the concept to climate.

This is also to stress another important factor, which is the fact that I'm a resilience in practice. And in policy, is having three different types of Geneses.

one that's coming from climate science studies and the second one that is coming from not studies but policies. The second one that is coming out from disaster risk reduction type of policies.

And the third one that broadly considering it humanitarian development work.

For that reason, that's a fundamental premises to or regarding the effectiveness of the policy.

Because it's again, a broader type of understanding, the effectiveness of the policy is the main pillar, it's about integration. the integration is having three fundamental aspects.

The first one, it's the cross-sector reality.

Meaning that so far and also for understandable reason, intervention in the urban space, are mostly sectarian or specific story issues that can be regarding transport could be looked at in wastewater etc.

Or to consider for example, a very specific type of risk or assets. Versus heatwave some.

Resilience policies tend to be translated into planning, require to have a cross sectorial title of approach.

This is, particularly in order to avoid replication of Walker rebound effects for considering the fact that we are acting in terms of urgency, in terms of very high stake that we're taking, in terms of very high level of uncertainty, and in terms of very limited financial and human resources.

We don't have resources and time available in order to work for one side into transport and other ways to look only at floods, Without considering droughts, we seek to make some examples.

The other level of integration that is needed the one more specifically regarding policies in terms of multilevel governance.
and this is a subcomponent that one from one side, related about vertical integration, meaning the level of collaboration between the national level and sub national levels
particularly, of trying to understand which way in national policies can be achieved through the operationalization of local level, and in which way local plans and actions actually aligned with national policies and then and this is also related to a location of resources.

The other subcomponent of the multi level governance it's the horizontal component and this horizontal integration that happens at the different levels mentioned is collaboration among different types of ministries and national level of different types of department on local level. the third component, as I say, my premises is the one not too limited the scope is to disaster risk reduction in humanitarian work or to climate change.
That level also integrated perspective on all that. if you are intervening in particular developing contexts, only in trying to reduce the impact of a specific risk without taking into account that the priority in specific local context is actually survival because the province, most of the populations living below extreme poverty rate, then it's difficult to try to respond to that.
Finally, the last pillar is the that instrument in order to reach this level in the three-folder level of integration is the participation.
And then we have other components that again, instrumental that its capacity building in general, it's finance.
And it's that technology, that's following it more or less socially taxonomy defined by human nation under the Paris Agreement, etc.

A2. In relation to the study published by you in article: 《Building Resilient Cities: Climate Change and Health Interlinkages in the Planning of Public Spaces》2022
In your opinion, does the outcome of the experiences of the study in Copenhagen - in terms of decision-making processes and specific data to support the design phase – can be shared or replicated in other geographical areas?

PROF.TOLLIN: The couple of levels of consideration this matter,
First of all, the analytical part of that specific article trying to look at the interlinkages as any type of scientific level, it's replicable, because the methodology should be always clearly described transparent and that should give you a possibility to be replicated just to test, the conclusion but also for further development of the world. So on that level, yes, it's replicable. As a matter of fact, I don't know if you had the possibility to look at it. But that work also was instrumental in order to develop that project in collaboration. With CDP and the World Health Organization, to which we've been developing profile, herbal profiles for six cities, looking at health and climate interlinkages.

Then another factor for replicability. It's very much and that's limiting the applicability.
That's related to the specific context.

When I speak about the specific context, I'm speaking about a number of different variable, the most obvious one is the physical one, physical and which we can put also question regarding specific climatic methodological conditions etc.

But most importantly, we have a legislative and normative frame. And we have also social, cultural one.

Meanings on that and this define also specificity of the case in Copenhagen. I will point out specifically to the social cultural work because eventually is the one that it's a little bit more oversighted.

Sorry, not really taking property into account or like to cite the metaphase method.

Meaning that in Copenhagen, the relation with public open spaces, and the use of means of mobility that are not based on a motorized vehicle is much broader and open with respect many the context, not only global level that's evident but also within same Europe. meaning it's more much more natural, culturally for citizens in Copenhagen, to use, for example, bike as a means of transport or working instead to use cars or motorized transport.

This is something that has been also supported by policy, policy decision. And these reflect also on the way in which citizens are understanding and living public spaces, particularly green public spaces.

To give you a couple of practical examples. within the project to construct the new Metro underground stations.

It was mandated for the project implementation that we're consideration regarding public spaces that were consideration regarding climate change adaptation. That we're going beyond the simple provisional of the station for the port.

And it's again, it's an example of a cross sectoral integration as we are speaking about before.

So they're out of the case of Copenhagen. We can then summarize that these interlinkages shall be based on a clearer understanding in terms of planning of the about the inclusion of else considering it.

So we need more that information that we need clear policy and planning guidelines. And then we also need some level of capacity building both among the professionals and the policymakers.

A3. For what it concerns *climate change*? How does policies and planning tools must be adapted - especially on an urban scale - to implement a resilience process in detail?

PROF.TOLLIN:
It's a basic radical change. Well, resilience is a radical change in terms of planning. Process instruments.
This is due to the fact that with urban resilience particularly with reference to its climate change component we are facing a high level of uncertainty.
And also, in the latest definitions, at least in the latest scientific developments, the concept is clear that urban resilience requires a dynamic approach. Urban resilience is defined as an evolutionary process.

So, the uncertainty and the dynamic characteristic that are mandated in order to manage the urban resilience transition to require a change in planning. planning can still nowadays it's often intended in a more than view of it. 19 Century based type of approach where you're planning something on the base or challenges that refer are fixed, in the pre preparation of the plan then you are implementing some works that often are resulting in some physical structure, infrastructure to be built, the work is done and is finished. in reality and nobody through all the implementation phase that can be extremely long is ever reviewing what were the promises of that.

when we are and that it's creating some monsters. Give you an example for this, please take my statement regarding this example as illustrative and not take it as granted and just making general reference, I'm not going to be very precise.

Venice, you know Venice, and it's problem of floods. That are further accentuated by sea level rise due to climate change.
The solution that the government agree upon over 20 years ago
almost 30 years ago, to also to realize some movable diet closing completely the……lagoon
The issue was that actually the scenarios that were prepared in order to take a decision and then implemented projects were done 30 years ago. the entire project and entire Walk was basically developed. considering scenarios that have never been fully updated or that were not using through mentally in order to review and eventually upscale or eventually manage.

The project implementation better.
So we are constantly and rapidly developing more knowledge regarding both climate change impact and possible solutions.
Working what is not working. been able to build up a system of planning more is a process, a dynamic process that can constantly be retrofitted by base new knowledge.
Then thing up with things that are going to be at best useless.
of course, having the even more negative effect and positive ones.
in terms of resilience also, as we are speaking about wicked problems, problems that are very matching to tween and difficult to understand.

The planet doesn't have the possibility to be wrong and to invest resources in sensing that it's just not completely almost resolving the problem. It's

creating, it's enhancing the negative impact of the phenomenon that you're trying to respond to.

A4. You have carried out many studies in different geographical contexts: what elements do you think are common to all contexts when it comes to resilience?

PROF.TOLLIN:
As I said before, I arranged to actually already respond to that before but, just taking time of another example.

Working from Europa, we implicitly think that cities are responsible for the planning process here locally.
Local authorities are responsible for local planning and cities. That's not the case in in all countries.
Many countries around the world the responsibility for urban planning and reciting within the national government.
Already that paragraph graphical but it's just a different in context that already that a single one issue changed completely the way in which planning understood. what was said before regarding social cultural background, and those difficult one.

A5. I understand that the *National Adaptation Plans* (NAP) referred to in the publication you made with Professor Caldarice are a very important element.
China is updating its *National Climate Change Plan*. A number of thematic projects have also been carried out, such as the *Sponge City Pilot Project*,

Eco-City and Low Carbon City construction

Taking up the final sentence of your publication

"…(i)…. In a nutshell, to make the NAP's urban content review a functional tool for national and local governments to implement climate actions, the methodology should be replicated across all countries that submitted NAPs up to the present. Reviewing the urban content would help Un Habitat define a stronger focus on implementing climate action within new guidelines that strengthen the urban content in NAPs. Secondly, it will allow nations to understand their policies' limitations or strengths while also comp …(i)…"

Today what priority advice - in terms of guidelines - could be suggested for a NAP updating process?[81]

PROF.TOLLIN:

So we've been carrying out the preliminary review of the urban content of labs but was more internal exercises was published data. we've been carrying out an extensive review of the urban content on nationally determined contribution.

So for your knowledge under the Paris Agreement, the main policy that all countries are mandated to submit regularly is national determined contribution and this is having elements of mitigation adaptation, and then also include consideration of institutional capacity technology and finance.

Then we have two other documents.

type of documents one is national reputation plans, that in this case, referring to non-annex one countries, meaning countries, developing and transition countries. And then we have also that's more focusing on

[81] Pizzorni, M., Caldarice, O., & Tollin, N. (2021). A methodological framework to assess the urban content in climate change policies. Valori e Valutazioni, 27(29), 123-132. https://doi.org/10.48264/VVSIEV-20212909

adaptation as we say, and then we have long term, low emission strategies that brief LT legs that are having a predominant focus but not exclusive on the issue.

So just to clarify what is the architecture the Paris Agreement for you. So, I cannot speak specifically about the NAPS because it shall be based on an appropriate type of study that we are planning and partially already undertaking for publication but I can refer to the official component of the measurement contribution allowances, for example the content that will be published. So that report states very clearly that there is a major gap for example, in between the determination of climate hazards. So, again, for to give the climate risk. It's composed by climate hazards, that phenomena, specific meteorological phenomena, the frequency the magnitude, etc. multiplied the exposure are multiplied by the vulnerability. divided by the action to reduce disaster risk.

So that's the out is normally understood. Now, the fact that we found that in the NDCs with urban content the urban climate action, so we're listed at different level, but these were not paid by a recognition within this policy document about the actual climate risk, and by a proper understanding of climate hazards.

So The policy define some possible actions. But these actions were not supported by information on the actual assets and the protection.

This was one of our fun things. so already to have a good baseline. It's an important factor particularly if we're considering that without that baseline, it's very difficult to monitor and evaluate the effectiveness of actions in time and to assess the future impact and the Evergreen back to the fact that planning for resilience shall be considered a process that continuously get integrated with new knowledge.

B. Second group of questions: "The Chinese experience" :

B1. The second specific question concerns your opinion on the Chinese *Sponge cities programme*. If you were to deepen a study on this experience from a point of view of "supporting the resilience of cities", what could be the main questions you should be interest about? .

B2. The Chinese government's policy of investing in "sponge cities", such as the empirical case of Wuhan where it is intervening with precise urban planning choices such as[82]:

Integrating the sponge programs into urban plans; *Zoning*;

Safeguard measures;

In accordance with your experience, which further main topics could be identified and involved in policies to enhance resilience towards flood risks? In particular, do you agree with the conclusions reached by a Chinese study on the subject summarized below?

" *….urging local governments to adopt sponge city regulations and permits to alleviate water quality and urban pluvial flooding issues, fully measuring and accounting for economic and environmental benefits, embracing regional flexibility and results-oriented approaches, and focusing on a wider range of funding resources to finance the sponge city program. Coordination among other government agencies is critical, and this is true at all level of governments. Only through greater coordination, education, and broader funding could the sponge city program be advanced meaningfully and sustainably. ….*" [83]

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[82] "Using Nature to Reshape Cities and Live with Water: An Overview of the Chinese Sponge City Programme and Its Implementation in Wuhan" *IUCN European Regional Office.* https://growgreenproject.eu/wp-content/uploads/2021/01/Sponge-City-Programme-in-Wuhan-China.pdf

[83] Hui Li, Liuqian Ding, Minglei Ren, ORCID,Changzhi Li, Hong Wang. Sponge City Construction in China: A Survey of the Challenges and Opportunities. *Water* 2017, 9(9), 594. https://www.mdpi.com/2073-4441/9/9/594

PROF.TOLLIN：

Up to a certain point, so that I notice it，

So what I appreciate about it, it's, first of all, sponge city it's a specific use in Chinese context and it was also a way to brand a specific approach. in Australia we have the same concept that is referred to water sensitive cities. And we can find some similar variation but we're speaking more or less about the same.

So when we're speaking about sponge cities, in this case, as you know, we are referring to the specific national policies for the implementation of this concept. Water, I for my limited knowledge on the matter. I find it interesting that it's try to be quite integrated approach. Some possible limitations related to the water will define the smartness. Of the smartness of the solution. Because you'll know the concept of smart cities so that I always found that concept rather limited or more used, let's say for marketing purposes, of a city, actual some factual things because often it's a resolving itself. In saying that anything getting including information technology is fine. All the rest is done. But that's finding intellectually quite limited.

So I'm not saying that sponge city is the same, but there is a strong Information Technologies factor. That it's important but shall not be exclusive versus all particular versus social cultural words. The importance of it particularly within the very diverse context, within China itself. It shall give also space to a better context aware applications. Some provinces more than others, having within this sponge city, not only problem of flooding and cloudburst but there is one problem in terms of droughts.

If I'm not mistaken, that will be more provinces that in central China, that I believe that will be done with it.

Just to simplify that ,So we need to understand that the issue, if we're looking just at the issue of flooding. It's for actually the flooding is the harzard, we are having a very limited understanding of the issue. without a systemic approach and systemic understanding of the issues, thereby sectorial one, we fail to understand that in the moment in which we are the level so high, such a high level of urbanization and there is from one side the need to build entire new cities at once, at a pace that has almost no precedence in human history.

We need to consider that as part of the problem. trying just to fix the problem of flooding as an hazard. Looking at technological solution. we are missing we are going to know to reduce only partially the impact so that without taking into account the real in the tween then we get closer so it will be challenge itself. this is ultimately this is going in the right direction, but there is different not only different way to improve it, but also to rethink it and the more systemic.

That was referred to smart cities because as to reward with my previous line of salt. The solution cannot be only technological. It's not about runoff through phases. that's not only about that.

What do you think about the current independence of different special plans and master plans in China, and about promoting the integration of multiple plans?

PROF.TOLLIN: Yes. There may be for to sectorial approaches. And this is the training the case and the way which was pressing it already within multi level governance. In China, you have a very complex system of sovereign national governments. So the integration between those is fundamental. And these also counting that I'm not sure about it, but there might be a water authorities urban level for each one of the city. The other thority, for

example, that is looking at specific mobility infrastructures. So without taking this also into account in the picture we have risk to create more problems than the one that we're trying to solve.

B3. In your experience, what are the most virtuous examples of urban resilience projects carried out, if possible, in relation to the consequences of climate change on urban water systems?

PROF.TOLLIN: On that, there is one important, it’s not a specific project, but it’s a approach to more integrated planning. So you can basically pick up, The example among the resilience city network.
so you can pick up some of the cities there. And you can look, Paris, Barcelona doing a lot. We have a lot or in Mexico City. more than in Milano. There are many examples. The important thing is that this network , for example, the city that are members of it, are opening a position for urban resilience officer, that depends directly under the mayor, so it doesn't work on specific apartment.

okay, thanks a lot professor, Here are all the questions I have prepared for your interview today.
you are very welcome!

7 References

Alessandro Bonifazi ,Carlo Rega. The Rise of Resilience in Spatial Planning: A Journey through Disciplinary Boundaries and Contested Practices. *Sustainability 2020, 12(18), 7277.*

Adger W N. Social and Ecological Resilience: Are They Related? [J]. *Progress in Human Geography, 2000, 24(3): 347-364.*

Ayyoob Sharifi and Yoshiki Yamagata(2018) Resilient Urban Form: A Conceptual Framework. *Resilience-Oriented Urban Planning pp 167–179*

Barnett J. Adapting to Climate Change in Pacific Island Countries: the Problem of Uncertainty[J]. *World Development, 2001, 29(6): 977-993.*

BOYD E, OSBAHR H, ERICKSEN P J, et al.Resilience and ' Climatizing' Development:Examples and Policy Implications[J]. *Development,2008,51(3):390-396.*

Carl Folke, Resilience: The emergence of a perspective for social–ecological systems analyses. Global environmental change. *Global Environmental Change Volume 16, Issue 3, August 2006, Pages 253-267*

Chao Qingduan. "Increasing climate risks, increasing urgency for adaptation action". *National Climate Centre*.2022

COTE M, NIGHTINGALE A J. Resilience thinking meets social theory: situating social change in socio-ecological systems (ses)research[J]. *Progress in human geography, 2012,36:475-489.*

Clout H. Lawrence J. Vale, Thomas J. Campanella, eds. The Resilient City: How Modern Cities Recover from Disaster[J]. *Journal of Historical Geography, 2007, 33(2): 458-459.*

Carpenter S, Walker B, Anderies J M, et al. From Metaphor to Measurement: Resilience of What to What? [J]. *Ecosystems, 2001, 4(8): 765-781.*

Donghyun Kim, Up Lim. Urban Resilience in Climate Change Adaptation: A Conceptual Framework. *Sustainability 2016, 8(4), 405.*

Feng Kong, Yifei Wang. Better understanding of climate catastrophe insurance in China: issues and opportunities, international insights, and directions for development. *Natural Hazards volume 114, pages2969–2990 (2022)*

Grazia Brunetta,Alessandra Faggian,Ombretta Caldarice. Bridging the Gap: The Measure of Urban Resilience. *Sustainability* 2021, 13(3), 1113.

Grazia Brunetta and Ombretta Caldarice. (2020). Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. Encyclopedia of the UN Sustainable Development Goals. *Sustainable Cities and Communities pp 628–640.*

Hans Dieter Hellige. Matthias RuthStefan G Reisemann (2018) The metaphorical processes in the history of the resilience notion and the rise of the ecosystem resilience theory. The resilience concept: From its historical roots to theoretical framework for critical infrastructure design. *Handbook on Resilience of Socio-Technical Systems, chapter 3, pages 30-51*

Holling CS. Resilience and Stability of Ecological Systems[M]. *Annual Review of Ecology and Systematics, 1973, 4(4): 1-23.*

Holling C S. Engineering Resilience Versus Ecological Resilience[J]. *Engineering Within Ecological Constraints, 1996: 31-44.*

HABRAKEN N J. The Uses of Levels[J]. *Open House International,2002,27(2):9-20*

HE Lei； XIE Zi'ang.Towards Resilience: Review and Prospects of Urban Integrated Disaster Prevention Planning. *National Key Research and Development Program "Cross-Scale Cross-Scale Linkages and Multi-System Synergy Mechanisms" (Project No: 2020YFB2103901-2) TU984. 2096-3025（2021）03-0043-12*

Hui Li, Liuqian Ding, Minglei Ren, ORCID,Changzhi Li, Hong Wang. Sponge City Construction in China: A Survey of the Challenges and Opportunities. *Water* 2017, 9(9), 594.

Zhou Quan, Hong Liangping. Research of "3A" Method in Urban Planning Responding to Climate Change, *Huazhong University of Science and Technology, Wuhan 430074, P. R. China, January 2013.*

JABAREEN Y. Planning the resilient city: concepts and strategies for coping with climate change and environmental risk[J]. *Cities,2013,31:220-229*

Judy Bush, Andreanne Doyon (2019),《Cities》Building urban resilience with nature-based solutions: How can urban planning contribute? , Volume 95.

Klein R J T, Nicholls R J, Thomalla F. Resilience to Natural Hazards: How Useful is This Concept?[J]. *Global Environmental Change Part B: Environmental Hazards, 2003, 5(1): 35-45.*

KECK M, SAKDAPOLRAK P. What is social resilience? Lessons learned and ways forward[J]. *Erdkunde, 2013,67:5-19.*

Li Tongyue, New Progress in Study on Resilient Cities. *TU984, 1673-9493（2017）05-0015-11.*

LI Kexin, LI Chaosu.(2021) Exploring the Linkages of Urban Form and Climate Resilience from a Multidimensional Perspective. *URP:Urban and Rural Planning 2021/3. TU984*

LEICHENKO R. Climate change and urban resilience[J]. *Current Opinion in Environmental Sustainability Volume 3, Issue 3, May 2011, Pages*

164-168

Lianjijian, Xukui.(2014), Investigation on joint characteristics of rainstorm and tide and staged control of flooding risk in a coastal city. *Tianjin University*

Maru Y T. Resilient Regions: Clarity of Concepts and Challenges to Systemic Measurement[R]. *CSIRO Sustainable Ecosystems, 2010.*

Mingshun Zhang ,Yaguang Yang,Huanhuan Li ,Meine Pieter van Dijk. Measuring Urban Resilience to Climate Change in Three Chinese Cities. *Sustainability* 2020, 12(22), 9735.

Paulo Jorge Gomes，Ribeiro，Luís António，Pena Jardim Gonçalves（2019）Urban resilience: A conceptual framework. *Sustainable Cities and Society. Volume 50, October 2019, 101625*

Pickett S T A, Cadenasso M L, Grove J M. Resilient Cities: Meaning,Models, and Metaphor for Integrating the Ecological, Socio-economic, and Planning Realms[J]. *Landscape and Urban Planning, 2004, 69(4): 369-384.*

PELLING M. The Vulnerability of Cities: Natural Disasters and Social Resilience[M]. *Earthscan, (2005) The Vulnerability of Cities: Natural Disasters and Social Resilience, Environmental Sciences, 2:4, 463-464*

Pizzorni, M., Caldarice, O., & Tollin, N. (2021). A methodological framework to assess the urban content in climate change policies. *Valori e Valutazioni, 27(29), 123-132. https://doi.org/10.48264/VVSIEV-20212909*

Sara Meerow, Joshua P. Newell, Melissa Stults. Defining urban resilience: A review. *Landscape and Urban Planning, Volume 147, March 2016, Pages 38-49.*

Sara Meerow, Pani pajouhesh&Thaddeus R. Miller. (2019) Social equity in urban resilience planning. *Local Environment, 24:9, 793-808*

SILVA M C, HORTA I M, LEAL V, et al. A Spatially-explicit Methodological Framework Based on Neural Networks to Assess the Effect of Urban form on energy demand. ***Applied Energy*** *Volume 202, 15 September 2017, Pages 386-398*

Thomalla F, Downing T, Spanger-Siegfried E, et al. Reducing Hazard Vulnerability: Towards a Common Approach Between Disaster Risk Reduction and Climate Adaptation[J]. *Disasters, 2006, 30(1): 39-48*

United Nations. "Transforming Our World: The 2030 Agenda for Sustainable Development", *adopted by the United Nations General Assembly in Resolution 70/1 on September 25, 2015 [R]*

Walker B, Holling C S, Carpenter S R, et al. Resilience, Adaptability, and Transformability in Social-ecological Systems[J]. *Ecology and Society, 2004,9(2): 5.*

Wildavsky A B. Searching for safety[M]. *Transaction Publishers, 1988.*

Zhen kaixiong, Yun yingxia (2018) Research on Adaptation Model of Coastal City Spatial Structure in Response to Climate Change 一 A Case of Xiamen City. *Tianjin university.*

ZUMELZU A, BARRIENTOS-TRINANES M. Analysis of the Effects of Urban Form on Neighborhood Vitality: Five Cases in Valdivia, Southern Chile[J]. *Journal of Housing and the Built Environment,2019*

曹康，章怡（2020）空间战略规划与中国规划制度——制度变迁与关键节点. «*UPI: Urban Planning International*» *2020/4.138*

陈鸿，戴慎志．城市综合防灾规划编制体系与管理体制的新探索 [J]. *现代城市研究 , 2013, 28(7): 116-120*

蔡云楠，温钊鹏，雷明洋．高密度城市绿色开敞空间的建设误区和优化策略 [J]. *中国园林，2016(12)：76-80*

吕悦风，项铭涛，王梦婧，吴次芳 （2021）从安全防灾到韧性建设—国土空间治理背景下韧性规划的探索与展. *自然资源学报(Journal of Natural Resources.) 2021.36(9):2281-2293*

刘春成(2017). *城市隐秩序： 复杂适应系统理论的城市应用 [M].* **北京：社会科学文献出版社 , 2017**

赫磊 ，戴慎志 ，宋彦 ．城市综合防灾规划编制与评估的美国经验及对我国的启示 [J]. *城市规划学刊, 2011(5): 87-94*

邵亦文，徐江.（2015） 城市韧性： 基于国际文献综述的概念解析 [J]. *国际城市规划 , 2015,30(2): 48-54*

唐诺亚（2018）厦门城市灾害风险与韧性评估及提升策略研究. *共享与品质——2018 中国城市规划年会论文集(01 城市安全与防灾规划)*

王思斌 . 社会韧性与经济韧性的关系及建构 [J]. *探索与争鸣 ,2016(3):4-8,2*

朱正威 (2021) 海绵城市的实践探索与韧性治理. *http://www.rmlt.com.cn/2021/1129/633070.shtml*.

赵方杜 , 石阳阳 . 社会韧性与风险治理 [J]. *华东理工大学学报 (社会科学版),2018,33(2):17-24.*

C2ES:Center for Climate and Energy Solutions.
https://www.c2es.org/content/climate-resilience-overview/.

China National development and reform Commission.
https://www.ndrc.gov.cn/fggz/dqjj/qt/202207/t20220701_1329875_ext.html

United nations climate change(UNFCCC): https://unfccc.int/?gclid=Cj0KCQjwy9-kBhCHARIsAHpBjHi72fY4YkG9pfk5F0kZCv2MZbyzeyIj2ljl2aAGbl4S-QHIeSkh_PwaAsEpEALw_wcB

The Rockefeller Foundation; ARUP. City Resilience Framework. 2015. Available online: https://www.rockefellerfoundation.org/wp-content/uploads/City-Resilience-Framework-2015.pdf

Central People's Government of the PRC.(2022). “National Adaptation Strategy 2035 issued”. https://www.gov.cn/xinwen/2022-06/14/content_5695549.htm

Central People's Government of the People's Republic of China.
http://www.gov.cn/zhengce/2022-07/22/content_5702141.htm.

Institute of Engineering Mechanics, China Earthquake Administration.
https://www.iem.ac.cn.

Development talk: http://cn.chinagate.cn/news/node_7230454.htm.

Xiamen Municipal People's Government. http://www.xm.gov.cn

Ministry of Housing and Urban-Rural Development of the People's Republic of China.
https://www.mohurd.gov.cn

National Climate Change Adaptation Strategy 2035.
https://www.gov.cn/zhengce/zhengceku/202206/14/5695555/files/9ce4e0a942ff4000a8a68b84b2fd791b.pdf

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