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DOI
10.1007/978-3-030-89828-1_1

Publication date
2023

Document Version
Final published version

Published in
Adaptive Urban Transformation. Urban Landscape Dynamics, Regional Design and Territorial Governance in the Pearl River Delta, China

Citation (APA)
Nijhuis, S., Sun, Y., & Lange, E. (2023). Introduction: Adaptive Urban Transformation in the Pearl River Delta, China. In S. Nijhuis, Y. Sun, & E. Lange (Eds.), *Adaptive Urban Transformation. Urban Landscape Dynamics, Regional Design and Territorial Governance in the Pearl River Delta, China* (1 ed., pp. 3-19). (The Urban Book Series). Springer Nature. https://doi.org/10.1007/978-3-030-89828-1_1

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Chapter 1
Introduction: Adaptive Urban Transformation in the Pearl River Delta, China

Steffen Nijhuis, Yimin Sun, and Eckart Lange

Abstract Deltaic areas are amidst the most favourable territories around the globe. Their strategic location and superior quality of their soils are core factors supporting both human development and the rise of these regions as global economic hubs. At the same time, deltas are extremely vulnerable to multiple threats from both climate change and the rush to urbanisation. These include an increased flood risk combined with the loss of ecological and social–cultural values. To ensure a more sustainable future for urbanising deltas, spatial strategies are needed to strengthen resilience, i.e. help the systems to cope with their vulnerabilities as well as enhance their capacity to overcome natural and anthropogenic threats. In this chapter, we outline the basic concepts and backgrounds of a joint research project with academic and societal partners called adaptive urban transformation. The objective of this research is to develop and test an integrative and multiscale design and planning approach for the adaptive urban transformation of urbanising deltas, in which the Pearl River Delta serves as a case study. In this approach, landscape-based regional design plays a key role in adaptive urban transformation, as well as innovative participation and visualisation techniques. Applications in urban design, planning, and governance in the PRD are also introduced. This chapter is foundational for the rest of the research presented in the chapters in this volume.

Keywords Resilient urban planning and management · Landscape-based regional design · Adaptive urban planning · Visualisation · Stakeholder participation · Chief urban designer system · Territorial governance

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S. Nijhuis et al. (eds.), *Adaptive Urban Transformation*, The Urban Book Series,
https://doi.org/10.1007/978-3-030-89828-1_1

1.1 Introduction

Urbanising deltas are among the most promising and dynamic regions of the world.[1] As well as contributing greatly to the global economy, they are also valuable ecosystems (Meyer et al. 2016; Costanza et al. 1997). Deltas frequently accommodate large populations in particularly sensitive environments that are dominated by water systems. As a result, urbanising deltas are extremely vulnerable to multiple threats (Nicholls and Cazenave 2010; Ericson et al. 2006). Due to difficulties in steering the intensification of urban land use and economic activity within a sensitive water environment, compounded by the absence of effective governance, the outcomes of delta management are often a combination of ecosystem damage and the loss of sociocultural values. This weakens the capacity of deltas to resist natural hazards as well as the risks associated with climate change, thereby negatively impacting the environment, the local economy as well as the health and prosperity of citizens that live around these water systems (Nijhuis et al. 2017).

Urbanising deltas can be understood as a set of complex social–ecological systems and subsystems, each with their own dynamics and speed of change (Fig. 1.1). To ensure a more sustainable future, spatial strategies are needed to strengthen resilience, assist systems to cope with their vulnerabilities, and strengthen their capacity to face natural and human-made threats. These strategies have to consider the complex interrelation of systems in order to avoid damaging ripple effects, such as when urban development increases the risk of flooding. Strategies like these can highlight the potential of ecologically sensitive urban development that ensures economic and social growth, while also providing opportunities to strengthen natural systems and lower the risk of flooding (Nijhuis et al. 2017). At the same time, such spatial strategies must involve a wide range of social and economic actors, while also supporting the social, economic, and cultural conditions of local people. These strategies should be communicated in persuasive ways in order to gain wide understanding, support, and influence (Albrechts 2010; Healey 2006).

Of course, dedicated spatial strategies should not merely improve the living conditions within urban deltas but also promote adaptive measures to climate change in order to decrease the level of risk. Urban planning and management must display a certain degree of adaptive capacity in order to successfully create more resilient deltas. Strategies must also identify eco-dynamic design options that not only enable the integration of nature alongside urban development processes, but also implement adaptive design principles that ensure low flood risk. Additionally, it is necessary to integrate transformative processes in governance combining spatial planning, design, and disaster management in order to optimise land use, institutions, and mechanisms for an efficient, sustainable, and inclusive urbanisation (Nijhuis et al. 2017).

In this chapter, we outline an integrative and multiscale design and planning approach for the adaptive urban transformation of urbanising deltas, taking the Pearl River Delta (PRD) as a case study. In this approach, landscape-based regional design

[1] This chapter is based on Nijhuis et al. (2017). Parts of this chapter have been published in adapted form in Nijhuis et al. (2019, Chinese, 2020, English).

Fig. 1.1 Fast urbanisation process within the PRD leads to confrontations between incremental long-term urban developments and fast short-term developments. Typical fishing villages and new urban developments in Pazhou, Guangzhou. *Photo* Guangyuan Xie, TU Delft

plays a key role, as well as innovative participation and visualisation techniques. Applications in urban design, planning, and governance in the PRD are also introduced. This chapter is foundational for the research presented in the chapters in this volume.

1.2 Adaptive Urban Transformation

From the 2000s onwards, there have been serious attempts to develop an adaptive systems approach to the planning and designing of urbanising deltas. Examples of such attempts include the Rhine–Meuse–Scheldt (RMS) Delta in the Netherlands (Meyer et al. 2015; Rhee 2012), the Mississippi River Delta in the USA (Wagonner et al. 2014; Campanella 2010), and the Mekong Delta in Vietnam (Marchand et al. 2014; Shannon and De Meulder 2013). The research as presented here suggests a much greater potential benefit in using urban landscape dynamics in territorial governance than more traditional planning strategies (Meyer and Nijhuis 2013, 2014, 2016; Van Veelen et al. 2015) (Fig. 1.2).

The main assumption is that urban dynamics, such as processes of urban transformation, regional development, and renovation cycles of individual buildings and assets, offer significant ‘windows of opportunity’ for incorporating adaptation measures at relatively low costs. For example, when buildings are being adapted as part of the normal development cycle, there are opportunities to include flood safety

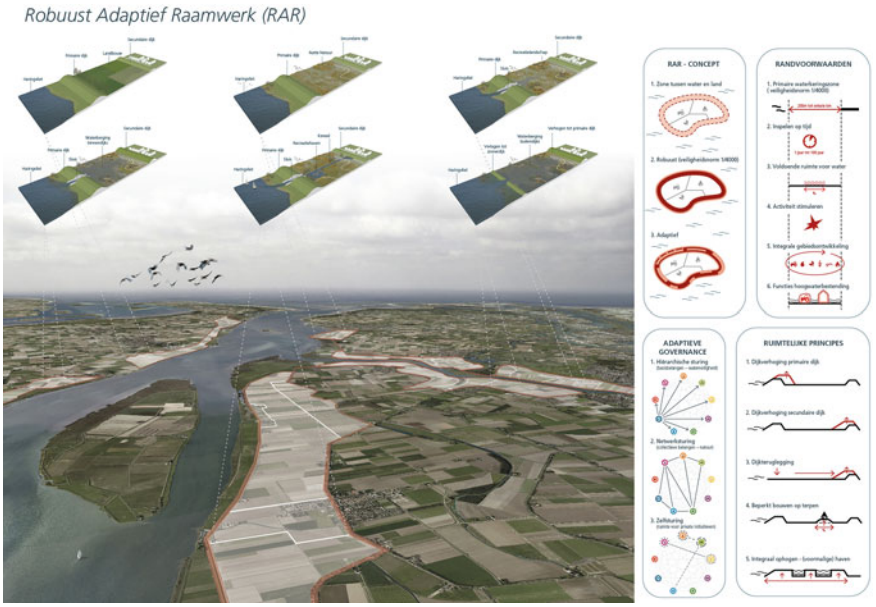

Fig. 1.2 Adaptive planning in the south-western delta of the Netherlands. Design explorations for the application of Robust Adaptive Frameworks for the Embankments of the Haringvliet. *Source* Meyer and Nijhuis (2014)

measures. When larger-scale urban transformation is underway, there is an opportunity to make fundamental adaptations to the urban structure through ecosystem design. On a regional scale, changes in port infrastructure, transformation of agricultural landscapes, or patterns of urbanisation create (or prevent) opportunities for creating adaptive capacity. The windows of opportunity in cycles of urban transformation can be used to develop a resilient socio-ecological urban system over the longer term and in a regional context. It requires an integrative approach towards planning and design of urban landscapes that can be channelled through effective territorial governance. Territorial governance can be understood as a process of spatial strategy making which integrates public policies, programmes, and projects for the development of a place/territory (Schmitt and Van Well 2015; Faludi 2012). It coordinates public and private actors that have responsibility or influence over social and ecological systems over large territories. Territorial governance is particularly concerned with integrating policy sectors such as land, water, environment, and transport so as to achieve social cohesion alongside prosperity and sustainability. Territorial governance offers potential to consider the interrelations of systems and avoid the damaging consequences of non-coordination that undermine the resilience of deltas—that is their capacity to absorb shocks while maintaining essential functions (Nijhuis et al. 2017).

At the same time, it is necessary to improve the living conditions in urban deltas and to adapt to climate change in order to decrease their risk level. Urban planning and

management for more resilient deltas necessitate adaptive capacity. That is strategies must identify eco-dynamic design options that could provide opportunities for nature alongside urban development processes and apply adaptive design principles that ensure water safety. In addition, there is also the need to make use of transformative processes in governance that combine spatial planning and disaster management by optimising land use, institutions, and mechanisms for efficient, sustainable, and inclusive urbanisation (Nijhuis et al. 2017). In policy, natural and urban dynamics must set the pace and nature of adaptation that is adaptive urban transformation (AUT).

This volume discussed joint research project with academic and societal partners that addresses AUT and, in particular, adaptive socio-ecological inclusive design strategies and principles that employ natural and urban dynamics to address increasing flood risk and loss of biodiversity in fast urbanising deltas. The research consisted of three interrelated research strands. The first strand focused on understanding dynamics of transformation and principles of adaptation, but also elaborated theoretical backgrounds and identified planning and design strategies and principles for adaptive urban development. The second research strand centred on stakeholder involvement and visualisation and provided methodical and technical input regarding state-of-the-art technology to involve stakeholders and to provide the basis for communication among experts and lay people. The third research strand concentrated on the application of AUT in urban design, planning, and governance in the Pearl River Delta. But before we elaborate on these three research strands, we briefly introduce the Pearl River Delta as a case study (Fig. 1.3).

Fig. 1.3 In the space of forty years, the delta area in the Pearl River has been transformed from a predominantly agricultural landscape into one of the world's largest metropolitan areas of water. *Photo* Guangyuan Xie, TU Delft

1.3 Pearl River Delta as a Case Study

For the past four decades, the world's fastest developing delta has been the Pearl River Delta (PRD) in the province of Guangdong in southern China. The delta area in the Pearl River has been transformed from a predominantly agricultural landscape into one of the world's largest metropolitan areas, encompassing such megacities as Guangzhou, Dongguan, Shenzhen, Zhuhai, and Hong Kong (Fig. 1.4). Residential and industrial complexes are being built at breakneck speed. Already in 2014, the PRD replaced Tokyo as the largest and most populated urbanised area on the planet (World Bank 2015). Since the 1980s, the PRD has been at the vanguard of China's groundbreaking spatial planning and socio-economic thinking (Yeh and Li 1999). At the same time, this rapid development is causing such problems as reduced biodiversity and flooding made worse by excessive rainfall and rising sea levels. There are also looming social problems because generic urbanisation alienates people from their environment, offering no space for them to have any significant interaction with nature. In other words, the PRD now faces immense challenges regarding its long-term economic development because of threats posed by climate change and environmental degradation. These challenges include issues such as the disappearance of mangroves (Zhao 2010), the loss of farmland (Hu and He 2003), air and water pollution (Li et al. 2008), water shortages (Wang et al. 2006), and a decrease in social security (Xiong 2016).

On the one hand, the region is exposed to increasing flood risks due to urbanisation in flood-prone areas as well as rising sea levels and extreme typhoons/storms in summer, placing stress on the regions infrastructural systems. On the other hand, the

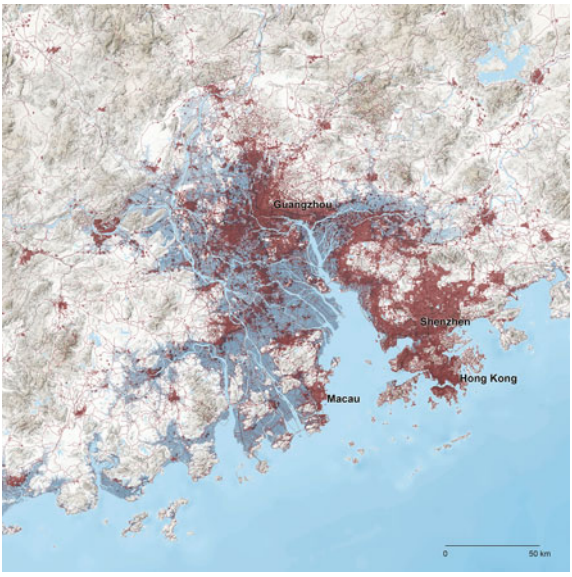

Fig. 1.4 The Pearl River Delta in the province of Guangdong in southern China is one of the most rapidly urbanising deltas in the world. More than sixty million people now live in the flood-prone lowland (+10 m zone, here indicated in dark blue), thereby increasing the flood risk. *Map* Steffen Nijhuis

deltaic ecosystem is becoming increasingly fragmented and vulnerable (Gao et al. 2012), resulting in a decline in both ecological services (Ye and Dong 2010) and environmental carrying capacity (Huang 2003). Standardisation of solutions (e.g. infrastructure, buildings) also lead to loss of spatial, cultural, and ecological diversity (Figs. 1.5 and 1.6). For instance, at the local level, large-scale interventions have replaced the historically diverse environmental and cultural heritage of the PRD with more uniform, featureless topographies (Guo and Situ 2010). While local and national authorities are showing increasing awareness of the value of more integrated planning and design approaches, these have not yet been widely introduced (Xiong and Nijhuis 2018). For example, the implementation of the so-called national Sponge City policy—a concept of integrated urban water management—has met with delays in the elaboration of both multiple and separate sectoral plans (Che 2016). In general, sectoral and disciplinary silos cause friction between the much-needed integral solutions and the demand for specialisation of knowledge and governance. To overcome these knowledge and institutional barriers, the development multi-, inter-, and transdisciplinary ways of working is a necessity (Epstein 2021). The alignment of regional ambitions and local projects is also needed to prevent fragmented solutions and spatial conflict, as well as the friction between long-term objectives and short-term needs needs to be resolved (Krznaric 2020).

In order to guide the PRD towards a more sustainable future, there is an urgent need for new ways of planning and design in the practice of its urban development. The application of the emerging concept and practice of landscape-based regional design offers a way of resolving the conflicts and threats that arise between economic development and environmental recovery, as well as reducing the negative repercussions of climate change. Landscape-based regional design is also an inter- and transdisciplinary approach that combines long-term perspectives with short-term actions and works throughout the scales. The high speed at which the PRD has developed makes it a particularly valuable case study to explore and test the potential of more adaptive integrated planning approaches, such as landscape-based regional design and the

Fig. 1.5 Mai Po Nature Reserve and the surrounding area—consisting of Gei wai, freshwater ponds, inter-tidal mudflats, mangroves, and reed beds—are recognised as a Wetland of International Importance under the prestigious Ramsar Convention. *Photo* Eckart Lange

Fig. 1.6 The region has a unique cultural history that reflects a strong connection to the landscape. *Photo* Steffen Nijhuis

chief urban designer system. In that regard, the PRD can serve as a practical learning case for other urbanising deltas across the globe.

1.4 AUT Through Landscape-Based Regional Design in the PRD (Research Strand 1)

AUT employed landscape-based regional design as an integrative and multiscale design and planning approach (Nijhuis 2022). Landscape-based regional design relates to a form of territorial governance that takes the natural and urban landscape as the basis to steer urban–rural transformative processes through a combination of sector activities towards more coordinated sustainable outcomes. In that regard, landscape-based regional design is considered an important strategy that shapes the physical form of regions using landscape as the basic condition to generate sustainable urbanised deltas (Nijhuis 2022). In AUT, we employed spatial planning and design to open up pathways to long-term sustainable urban landscape development and at the same time set conditions for short-term interventions. In that regard, regional design is an inter- and transdisciplinary effort that not only safeguards sustainable and coherent development, but also guides and shapes changes that are brought about by socio-economic and environmental processes, while establishing local identity in a region through tangible relationships (Nijhuis 2022). Regional design offers a mode for urban transformation, preservation of biodiversity, management of water resources, leisure, community building, cultural identity, and economic

development (Neumann 2000). Such a strategy needs to be persuasive and to influence the actions of others and public opinion as the final aim is to implement ideas via projects.

Therefore, landscape-based regional design also means striking a new balance in the relation between experts, citizens, governments, and other stakeholders and seeks for their active involvement. The idea is that the participation of all relevant stakeholders in strategic planning, design, and decision-making will enhance the resilience and adaptability, and the resilience and adaptive capacity of urban landscapes will be increased, not only in physical terms but certainly also in socio-economic terms (Ahern 2011). Resilience is defined as a system's ability to react to change or disruption without any alteration to the primary condition (Walker and Salt 2006). Adaptability is the degree to which certain practices, processes, or structures can be modified to suit changing social, economic, or ecological circumstances (Folke 2016). Modifications can be spontaneous or pre-planned, carried out in response to, or in anticipation of such changes (Folke 2016). This implies a shared understanding of how the landscape system works on the part of all participants. It also requires a forward-looking, proactive approach in which the interaction between all stakeholders is pivotal. Communication is a central issue, and it is crucial to develop and utilise innovative visualisation methods and tools that permit involvement of local stakeholders and decision-makers (Gill and Lange 2015; Lange and Hehl-lange 2010).

Landscape-based regional design is thus also a design process that entails four key phases: (1) diagnosis, (2) strategy making, (3) design explorations, and (4) action perspective. This process is supported by a combination of research and design, meaningful stakeholder involvement, and imagination (Nijhuis 2022) (Fig. 1.7). These phases as well as their application in de PRD are elaborated in Chap. 5 of this volume. Furthermore, more details on territorial governance can be found in Chaps. 2 and 4 of this volume, on spatial dynamics in Chaps. 3 and 11, and Chaps. 6, 7, 12, and 14 for design explorations in the PRD.

Fig. 1.7 Research through design to explore possible and desirable spatial developments for a future-proof delta. *Photo* Steffen Nijhuis

1.5 AUT Through Stakeholder Involvement and Visualisation in the PRD (Research Strand 2)

Visualisation for communication of planning and design contents is key to integration of stakeholders on multiple scales in planning and design processes. It allows to represent and communicate past, existing, and proposed natural and urban environments. Globally rather unique in this domain, in China, there are altogether over 1000 Urban Planning Exhibition Halls (UPEHs). These are large, dedicated facilities equipped with sophisticated technology and providing opportunities for the wider public to be informed about planning and design (Lu et al. 2020). Typically, in planning and design practice, and also in UPEHs, analogue and digital visualisations are used as an endpoint to communicate the results of a process, rather than as an integrated tool in planning and design. In contrast to this, we aim for visualisation and modelling to be used in a more interactive and iterative way thus offering the potential to facilitate dialogue between experts and the wider public in order to develop solutions to problems in planning and design.

The research centred on developing new techniques and approaches to better inform decision-makers and stakeholders in participatory processes on the potential of integrated adaptation measures and potential of adaptation planning. The focus was on stakeholder involvement and visualisation enabling a multiscale systemic understanding of urban landscape dynamics and transformations through ex-post evaluation of existing urban planning strategies and projects and ex-ante evaluation of scenarios of potential adaptation strategies. Visualisations as stimuli are integrated into the feedback mechanisms either through a paper-based format and/or via digital means. In this context, 3D visualisations are developed for off-site use as well as for on-site use for stakeholder involvement. The visualisation approaches build on recently developed innovations and state-of-the-art immersive visualisations, e.g. for display in a virtual reality laboratory or for devices such as the Oculus Rift as well as innovative onsite visualisations for use on mobile devices (Tomkins and Lange 2020). Mixed qualitative semi-structured interview approaches are employed as well as quantitative methods (e.g. semantic differential, contingent valuation) investigating the views of planning and design experts and lay persons as well as considering off-site (laboratory based) versus on-site (mobile devices) feedback and assessment.

As part of our research, we implemented immersive virtual reality (VR) representations using head mounted displays for testing stakeholder behaviour and perception of different scenarios for large-scale urban developments (Lu t al. 2021) (Fig. 1.8). We developed a novel augmented reality (AR) interface that allows enriching GIS maps with overlays of design alternatives while running a dynamic multi-criteria analysis (Fig. 1.9). Bridging the classic analogue–digital divide in representation, we visually enrich physical models with mobile tablet-based AR by implementing 3D model recognition and tracking with superimposed designs of blue and green infrastructure as well as providing opportunities for object occlusion allowing, for example, a virtual replacement of existing buildings with alternative designs (Fig. 1.10). Using

a mixed reality toolkit, on-site visualisation approaches permit to enrich the reality, for example with visualised procedural vegetation models.

In a broader context, we explored several research strands. This includes studying how the wider public perceives wetland parks in terms of providing a range of ecosystem services (Zhai and Lange 2021), how stakeholders as consumers can be integrated in novel agricultural production systems such as community supported agriculture and investigating how park users are provided with the opportunity to access urban green space by developing GIS-based models as well as stakeholder surveys to look into specific demands, usage patterns, and perceptions of different user groups, thereby aiming to deliver input to green infrastructure planning (Ma et al. 2022).

In Chaps. 8, 9, and 10, one can find elaborations on stakeholder participation and visualisation, as well as applications in the PRD from the social–ecological perspective in Chaps. 13, 14, and 16 in this volume.

Fig. 1.8 Immersive virtual reality (VR) representations using head mounted displays for testing stakeholder behaviour and perceptions of different planning scenarios for large-scale urban developments. *Photo* Eckart Lange

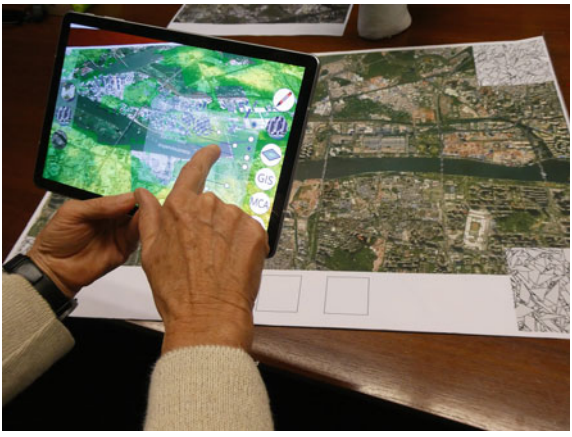

Fig. 1.9 Augmented reality (AR) interface that allows for enriching GIS maps with overlays of design alternatives while running a dynamic multi-criteria analysis. *Photo* Eckart Lange

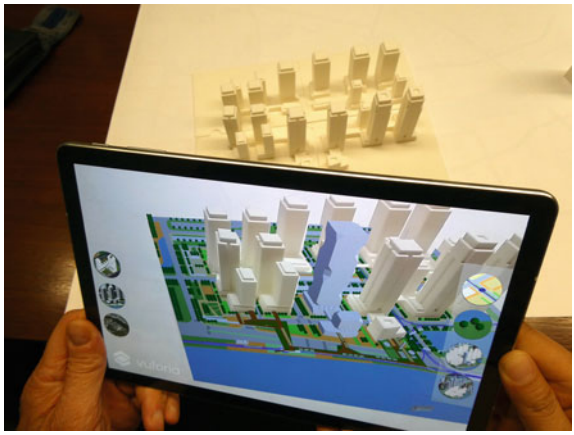

Fig. 1.10 Mobile tablet-based AR by implementing with 3D model recognition and tracking with for superimposing designs of blue and green infrastructure and virtual replacement of buildings in the physical model. *Photo* Eckart Lange

1.6 AUT Through Applications in Urban Design, Planning, and Governance in the PRD (Research Strand 3)

In order to implement AUT in urban design, planning, and territorial governance in the PRD, the planning system was evaluated for its potential to adopt integrative approaches to design, planning, and flood risk management for more sustainable and inclusive urbanisation. Through literature review and interviews with different local stakeholders, constraints in the current territorial planning and policies are identified that block integrated adaptation measures. Urban design projects and related research are trapped in the concept of single-construction engineering and lack a 'helicopter view' that relates the development to the bigger context, such as the city or the overall thinking of the city, the whole bay area. Therefore, we proposed and implemented the 'chief designer system' to transcend the professional boundaries of architecture, urban design, landscape architecture, and project development, to develop an inclusive platform for negotiation and communication, and to implement adaptive design principles in urban projects.

Urban design implementation is at the core of the chief urban designer system. It can optimise and correct the detailed control plans, explore and design adaptive urban open spaces, and establish a balance between economic development, the integration of cultural heritage, the creation of a green–blue environment (water and ecology), and lively public spaces (Fig. 1.11). On the basis of that, the urban design guidelines are therefore incorporated into the legal control, i.e. into the general contract documents of land transactions, legally secured the contractual binding of the fundamental application of the guidelines, and avoided various possible negative impacts. Thus, the urban design guidelines would become the starting point for negotiation and coordination among multiple parties, and the 'chief design team' can seek win–win results through negotiation under the premise of safeguarding public interest and environmental benefits. Because of this procedure, landscape-based regional design has a strong platform on which to implement the fundamental idea of 'proposing the best solution and challenging the limitations of urban development'.

Fig. 1.11 Lively public space with water as a play feature and for a pleasant microclimate. *Photo* Steffen Nijhuis

The chief urban designer system evolves around 'grand urban projects' (Fig. 1.12). These types of project are developed and constructed at a mesoscale (measured by kilometres) of the city and are intensively built to meet the multi-objective needs of urban development such as accelerated growth in the number of buildings and the speed of construction, as well as the limited land resources and the pressure of population density. For a long time, in the Chinese context, urban construction and architecture were based on a single block, and the basic purpose of planning management was also based on the individual plot. So, there are many bottlenecks in the engineering science and technology research on the concept of urban mesoscale. Therefore, based on our practice of grand urban projects, we break through the traditional architectural boundaries and combine the urban design concept of 'smart construction' and the chief urban designer system to realise the territorial governance and regulate the overall built environment in the PRD so as to adapt to the future flood risks and create social–ecological inclusive public spaces with identity.

In Chap. 5, two urban projects in Nansha Lingshan Island and Pazhou West District (Guangzhou) testify how the chief designer system helped to implement AUT successfully and showcase the benefits of this approach (Fig. 1.13). In Chaps. 5, 6, 7, 11, 12, and 14 in this volume, one can find more background and elaboration regarding AUT in urban design, planning, and governance.

1.7 Conclusion

Adaptive urban transformation addresses socio-ecological inclusive design strategies and principles that employ natural and urban dynamics to address increasing flood risk and loss of biodiversity in fast urbanising deltas. The PRD served as a learning case for exploring the potential of AUT through landscape-based regional design, novel forms of stakeholder involvement and visualisation, and applications in urban design, planning, and governance.

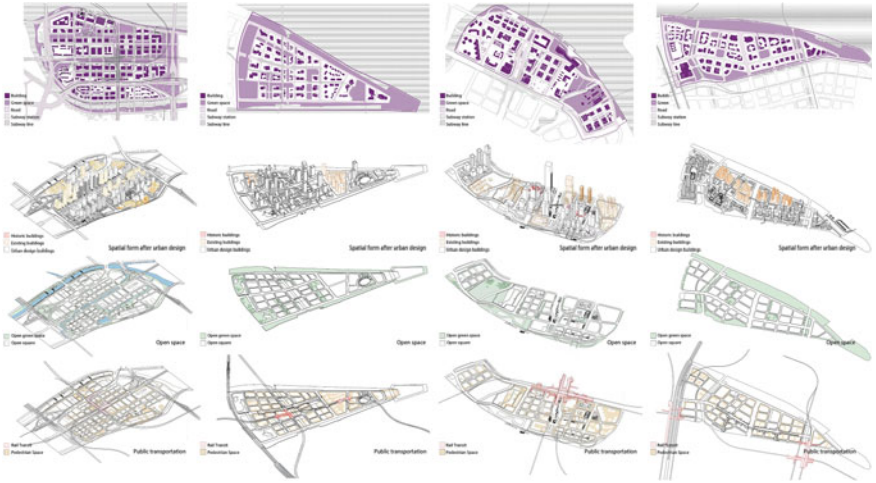

Fig. 1.12 Some urban grand projects were developed and managed by chief urban designer system in PRD, from left to right Pazhou West District, Nansha Lingshan Island, Hengli Island North District, and CBD Baietan. *Images* Yimin Sun

Fig. 1.13 Pazhou West District as a successful application of the chief urban designer system; left the situation in 2012, right the situation in 2022. *Photos* Yimin Sun

Landscape-based regional design proofed to provide a new operational power for spatial design—as an integrative, creative activity—and recognises the regional urban landscape as a significant field of inquiry that is context-driven, solution-focused, and transdisciplinary. As will be exemplified by the other chapters in this volume, this approach offered alternative ways of understanding the urban landscape, as well as provided a spatial design process that served as a vehicle for collaboration and co-creation of knowledge and ideas.

In the case of the PRD, this process facilitated mutual learning across disciplines, stakeholders, and cultures. In addition, as a spatial design approach it helped to establish relationships between ecology and cultural aspects, process and form, long-term and short-term developments, and regional strategies and local interventions. As such, landscape-based regional design turned out to be a powerful vehicle for guiding

territorial transformations in the PRD through a process of creating local identity and safeguarding regional relationships and at the same time linking ecological and social processes and urban forms. The newly developed visualisation and modelling approaches proofed to be highly effective in visualising a range of data and scenarios in interactive ways while integrating stakeholders at multiple stages and on multiple planning and design levels in the decision-making process.

In terms of applications in urban design, planning and governance in the PRD AUT turned out to be very effective, especially through the implementation of the chief urban designer system. This approach operated as coordination and communication platform for government, architects, and other stakeholders. The grand urban project at the mesoscale proved to be an effective instrument for the chief urban designer to connect the regional landscape with building blocks and individual buildings and align sustainable long-term perspectives and short-term urban projects. In this respect, AUT helped to break through individual building plot borders to establish comprehensive territorial administration and save money by coordinated and joint action.

The case of AUT in the PRD showcases that understanding and employing the relations between urban landscape dynamics, landscape-based regional design, and territorial governance help the urban landscape to cope with its vulnerabilities as well as to enhance its capacity to overcome natural and artificial threats. Next to strengthening resiliency, such an integrative and multiscale design and planning approach provides powerful means for adaptive urban transformation that leads to more sustainable futures of urban deltas in which social–ecological inclusive communities and economy thrive.

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