DOI: 10.54254/2754-1169/123/2024MUR0116

Urban Planning Strategies for Coastal Cities in China in Response to Climate Change

Qile Yi[1,a,*]

[1]*Architecture, Planning & Landscape, Newcastle University, Newcastle, UK,*
a. yiqile@ldy.edu.rs
**corresponding author*

Abstract: Global climate change has increasingly posed a serious threat to coastal cities, rendering them particularly vulnerable to the adverse effects of rising sea levels, more frequent and intense extreme weather events, and the shifting patterns of climate. Traditional urban planning methods, which had been the cornerstone of city development, were found to be inadequate in addressing these escalating challenges. The previous studies often failed to account for the critical importance of integrating climate factors into the planning process, leading to vulnerabilities in urban infrastructure and design. This study meticulously examined the limitations of these conventional urban planning approaches and explored the potential for adapting urban planning strategies in China's coastal cities to better respond to the looming threat of climate change. By conducting a thorough analysis of the impacts of high temperatures, floods, and other climate-related events, the study proposed a comprehensive series of response measures tailored to the specific conditions of the time. These measures included the integration of green policies into urban planning to enhance environmental sustainability, the strategic selection of building materials aimed at mitigating urban heat, and the enhancement of water resource management systems to alleviate the urban heat island effect. Moreover, the study closely investigated existing climate response measures through detailed case studies in Xiamen and Dalian, two prominent coastal cities in China. The primary objective was to significantly enhance the resilience of these cities, effectively reduce the risks associated with climate change, and promote a path towards sustainable development. Ultimately, the goal was to create more livable, safer, and sustainable urban environments that would be better equipped to face the challenges posed by an unpredictable climate future.

Keywords: Climate change, Coastal cities, Urban planning, Sustainable development, China.

1. Introduction

In recent years, the global climate has undergone significant changes. Record-breaking high temperatures, frequent floods, storms, and rising sea levels, have underscored the undeniable impact of climate change. Due to their special geographical location, coastal cities are climate particularly vulnerable to climate change. The sustainable development of China's coastal cities is increasingly threatened by climate change. Traditional urban planning, which guides urban development, had shown limitations in addressing this global issue. Therefore, traditional urban planning methods need to evolve to effectively respond to climate change [1].

DOI: 10.54254/2754-1169/123/2024MUR0116

Traditional urban planning methods often neglected climate change factors. Existing cities are unable to predict and respond to future challenges brought by climate change. Additionally, these methods had the disadvantages of a single spatial layout, lack of diversity and flexibility. At the same time, aging infrastructure also weakens the ability of cities to cope with extreme weather events and rising sea levels [2-3]. These limitations made it difficult for traditional urban planning to cope with the impacts of climate warming, such as the intensification of urban heat island effects, water shortages, damaged infrastructure, and ecosystem degradation [4].

In a study by Zhang et al., the impact of post-earthquake tsunamis on integrated harbor cities was analyzed. It was found that the accessibility of tsunami shelters is a key factor in measuring the city's response to climate change. The study therefore proposes strategies to enhance urban disaster risk resilience based on the impact of tsunamis [5]. In Yang and Chen's study, the potential flooding impacts due to sea level rise were modeled using Macau as an example. The results showed that sea level rise will significantly shorten the return period of flooding events. This implies that coastal cities were not prepared for climate change and were not currently developing appropriate engineering responses. Laina and Iglesias assessed the potential climate change hazards for 10 European cities through a variety of precise indicators. The study helped to prioritize interventions in these cities [6].

This study aimed to explore the progress of coastal urban planning in China in response to climate change by critically analyzing traditional methods and examining the challenges faced by current coastal urban planning. Case studies [7-8] from Xiamen, Shanghai, and Dalian are used to summarize potential planning methods and propose measures to enhance urban resilience and sustainability.

2. Traditional Urban Planning and Coastal Urban Planning in Response to Climate Change

2.1. Analysis of the Characteristics, Advantages, and Disadvantages of Traditional Urban Planning

Traditional urban planning was born with the Industrial Revolution and aimed at industrialization and modernization. Traditional urban planning has played a key role in developing and expanding cities in history. First of all, traditional urban planning takes economic growth as its core and effectively promotes cities' economic development and prosperity by building infrastructure and developing industries. This design concept based on functional zoning, such as separating industrial, commercial, and residential areas, helps to improve the operating efficiency of cities, reduce interference between different functions, and thus promote the rational use of urban space. Secondly, traditional urban planning also focuses on the beautification and image enhancement of cities. Building public spaces such as parks, green spaces, and squares, improves the urban environment, enhances the cultural atmosphere of the city, and improves the quality of life of residents. For example, the famous Chicago urban planning and the transformation of Paris both reflected the powerful role of traditional urban planning in optimizing urban space. In addition, these two plans and transformations had enhanced the attractiveness of cities, and many individuals from surrounding rural areas poured into cities. These labor forces not only fit the development of the Industrial Revolution but also injected momentum into the economic development of cities. Finally, traditional urban planning had accumulated rich experience in the long-term development process and formed a mature theoretical system and methodology, which provided valuable reference and reference for subsequent urban planning [9].

However, as cities develop, this method had also demonstrated many limitations, especially in responding to climate change. Traditional urban planning lacked consideration of climate change, especially the lack of assessment and prediction of flood disasters given rise to sea level rise and

DOI: 10.54254/2754-1169/123/2024MUR0116

storm surges, as well as urban high temperatures led to extreme weather events, making it difficult for urban planning and construction to adapt to the challenges brought about by future climate change.

2.2. Coastal Urban Planning to Address Climate Change

In the future, China's coastal cities will be more widely affected by climate change. At present, the impacts of climate change mainly include urban water logging giving rise to high temperatures and floods. Urban high temperatures lead to the combination of high-temperature heat waves and urban heat island effects are global weather disasters; extreme rainstorms and floods caused by climate change can easily lead to urban waterlogging, which has a profound impact on urban planning. Urban planning must consider the impact of these factors to ensure the sustainability of cities and the safety of residents [10].

China, as a country with a long coastline, was significantly affected by climate change. Unfortunately, few countries or cities had developed measures to address the challenges of coastal climate change. Existing measures also focus only on a certain type of disaster, such as tsunamis or floods. There was an inadequate assessment of the full range of hazards that may be caused by climate change. Extreme weather and disasters in recent years have reminded coastal cities of the urban problems caused by climate change [11-12]. Therefore, from now on, it is necessary to take measures to address the climate change challenges faced by coastal cities. The government plays an important role in China's urban planning. Therefore, it is necessary to strengthen the detection and early warning of climate change impacts in urban planning.

3. Case Studies in Coastal City Planning to Cope with Climate Change

3.1. Planning for Flood Disaster Response on Islands: The Case of Xiamen

Xiamen is located on the southeast coast of China and is a typical island city. In recent years, with the intensification of global climate change, Xiamen has faced climate risks such as rising sea levels and frequent storm surges. To effectively respond to these challenges, Xiamen implemented a mangrove ecological disaster reduction plan in the Xiatanwei area to improve the city's ability to resist climate change by protecting and restoring the mangrove ecosystem [13].

In this Xiatanwei’s plan, to protect and restore the area of mangroves, artificial planting, and natural restoration have been adopted. In addition, the structure of the mangrove ecosystem was optimized through scientific planning and reasonable layout. This measure improved its ecological service functions such as tide and wave prevention, embankment reinforcement, and bank protection. At the same time, the monitoring and evaluation of the mangrove ecosystem were strengthened to timely discover and solve ecological problems. To enhance the risk of disaster prevention, the plan combines the characteristics of the mangrove ecosystem and formulates targeted disaster risk prevention measures. Flood control embankments, tide gates, and other engineering facilities were set up around the mangrove reserve to improve the city's ability to resist natural disasters such as storm surges [14] .

3.2. Coastal City Planning: The Cases of Shanghai and Dalian

As China's most prosperous coastal city, Shanghai is particularly affected by climate change. In terms of coping with high temperatures, Lujiazui Greenland Center is Shanghai's core CBD. The ultra-high-density office buildings not only consume a lot of resources and energy but also generate a lot of carbon dioxide emissions. The heat island effect in this area was more obvious than in other areas of Shanghai, especially in the context of global warming. To cope with the challenges brought by climate change, Shanghai Lujiazui Greenland Center had adopted a variety of energy-saving technologies and green design methods, such as solar power generation systems, ground-source heat pump systems, and rainwater collection and utilization systems. These measures had effectively reduced the impact on the environment and improved the climate adaptability of the building. In addition, to cope with the flood threat posed by the Huangpu River to Lujiazui, Lujiazui Greenland Center introduced the concept of sunken green space design and rainwater garden design. On the one hand, it reduced the pressure on the drainage system in the area, and on the other hand, it improved the area's flood resistance, which has a significant effect in dealing with several short-term extreme rainstorms. To cope with more extreme flood disasters, Shanghai's urban management department has improved the flood control capacity of the embankment in the Lujiazui area.

Dalian, Liaoning Province, is a typical coastal city. To cope with the impact of climate change, Dalian had set an urban development goal by 2035 or even beyond, namely, to build a coastal city with high climate resilience. To cope with the combined impact of extremely high-temperature climate and urban heat island effect, Dalian had implemented a park city strategy. By connecting green spaces of different sizes such as national forest parks, citizen parks, and pocket parks, Dalian's local climate had been effectively improved, alleviating the adverse effects of urban high temperatures on the health of citizens.

In terms of reducing the city's vulnerability to flood disasters, Dalian's key planning areas included improving meteorological monitoring and early warning capabilities and building a disaster prevention and mitigation system.

(1) Dalian plans to add and upgrade multiple automatic weather observation stations in the next few years to ensure the accuracy and real-time nature of weather data. Early warning of extreme weather is an important prerequisite for effective prevention. Dalian has successfully avoided many urban risks that led to extreme weather through a complete meteorological monitoring network and early warning system.

(2) To cope with possible tsunamis and floods in the Bohai Sea, Dalian City has taken measures to strengthen the construction of coastal protection projects such as flood control dams and seawalls and has formulated emergency plans for various extreme weather events to ensure rapid response when disasters occur.

4. Possible Measures for Urban Planning to Cope with Climate Change

At present, the main climate change threats facing China's coastal cities include extreme heat and urban waterlogging, so urban planning to cope with climate change needs to be given priority consideration. Coping with climate change is not only a beneficial exploration for the future transformation and development of cities but also a major step forward in the health and well-being of all mankind.

4.1. Measures to Deal with Extreme High Temperatures in Cities

To cope with the impact of high-temperature weather on urban planning, urban planning can take measures in terms of urban design, green space, and water resource management.

Increase green space and urban greening. Adding parks and green spaces to urban planning can provide more shade and cooling effects for residents. Parks and green spaces can not only provide leisure and entertainment space but also reduce the temperature of the surrounding environment through the transpiration of plants. Promoting roof gardens and green roofs can reduce the surface temperature of buildings and reduce the urban heat island effect. Green roofs can absorb part of the solar radiation, reducing heat absorption and heat accumulation inside the building.

Choose reasonable building materials. Coastal urban planning can cope with urban heat through urban design and the selection of building materials. Use permeable paving and low-reflectivity

DOI: 10.54254/2754-1169/123/2024MUR0116

materials in urban planning to reduce surface temperature and improve the urban thermal environment. Permeable paving can increase surface water evaporation and reduce surface temperature. Low-reflectivity materials can reduce the reflection of solar radiation and reduce surface temperature. Use insulation materials and reflective building materials in building design to reduce heat absorption and heat accumulation inside buildings. Insulation materials can reduce heat transfer, and reflective materials can reduce the reflection of solar radiation and reduce surface temperature.

Strengthen water resources management to mitigate the heat island effect. Urban planning can address urban heat through water resource management and urban planning. For example, a rainwater collection and reuse system can be established to increase urban water resources and reduce the urban heat island effect. Rainwater collection and reuse systems can be used to irrigate green spaces, wash roads, and cool the interior of buildings. Open waters and wetlands can be retained in urban planning to provide evaporative cooling effects and reduce urban temperatures. Open waters and wetlands can increase urban water evaporation and reduce urban temperatures.

4.2. Measures to Deal with Flood Disasters

Construct an urban flood control and drainage engineering system. The urban drainage and flood control engineering system includes the management and restoration of river and lake systems and ecological spaces, the protection of urban mountains, the restoration of rivers, lakes, wetlands, etc., and the preservation of natural rainwater and flood channels and flood storage spaces. At the same time, it is also necessary to implement the construction and renovation of pipelines and pumping stations, increase the construction of drainage pipelines, gradually eliminate the blank areas of pipelines, renovate the rainwater and sewage pipelines that are prone to waterlogging and mixed and misconnected, and repair damaged and dysfunctional drainage and flood control facilities.

Distinguish the difference between flood control and flood control. Although urban waterlogging and floods are both disasters caused by precipitation, their causes, impact ranges and control measures are different. Urban waterlogging mainly gives rise to the accumulation of surface runoff generated by local heavy rainfall or long-duration rainfall in certain low-lying areas, while floods usually lead to heavy rainfall or long-duration rainfall in the basin, especially in the upper reaches, which leads to large flow or high-water levels in rivers or lakes. Therefore, comprehensive consideration of flood control measures is required to control urban waterlogging.

Develop a planning strategy that is tailored to local conditions. Urban waterlogging control should follow the principle of " one city, one policy" and scientifically determine the control strategy and construction tasks based on factors such as natural geographical conditions, hydrological and meteorological characteristics, and urban scale. For example, old urban areas should be renovated and renovated to restore the natural ecosystem, while new urban areas need to be planned from a high starting point and have drainage and waterlogging control facilities built to high standards.

5. Conclusion

At present, traditional urban planning mainly faces problems such as neglecting climate change factors, single spatial layout, and aging infrastructure. This paper discussed possible strategies for cities to cope with climate change through island planning and coastal city planning cases to address climate change issues such as extremely high temperatures and urban waterlogging. To cope with extremely high-temperature weather in cities, it was recommended to increase green space and urban greening, such as parks, green spaces, roof gardens, etc. And reasonably select building materials, such as permeable pavement, low reflectivity materials, and thermal insulation materials. To cope with flood problems such as urban waterlogging, it was recommended to establish an urban drainage and flood control engineering system, such as repairing river and lake water systems and building drainage networks. In the planning stage, it was recommended to formulate scientific planning and strategies adapted to local conditions, such as the " one city, one policy" principle. The method of this study focused on qualitative research. It is hoped that future research can explore urban data and quantitative research to achieve a balance between climate change and urban planning and promote sustainable urban development. In order to improve the adaptability of cities to climate change as soon as possible, the combination of green buildings and resilient urban design may be a potential research direction in future research. Although a lot of theoretical research has been completed in the field of resilient cities, there are few successful cases of fully implementing these concepts in actual planning strategies. When coastal cities make strategic plans, it is necessary to combine long-term planning with short-term action plans to make resilient urban designs that adapt to climate change. Therefore, it may be necessary to formulate special urban planning to deal with climate change.

References

[1] Maganioti, A.E., Chrissanthi, H.D., Charalabos, P.C., Andreas, R.D., George, P.N. and Christos, C.N. (2010) Cointegration of Event-Related Potential (ERP) Signals in Experiments with Different Electromagnetic Field (EMF) Conditions. Health, 2, 400-406.

[2] Hayashi, K., Tanaka, T., and Inachi, S. (2012). A study on the summer outdoor temperature distribution in coastal low-rise and high-density urban areas. Journal of the City Planning Institute of Japan, 47(3), 925–930.

[3] Ihara, H., Nakai, N., Numata, M., and Sakamura, K. (2021). A study on the making of flood risk reduction measures of cities damaged by floods. Journal of the City Planning Institute of Japan, 56(3), 960–967.

[4] Lourenço Neves, J. (2024). Urban planning for flood resilience under technical and financial constraints: The role of planners and competence development in building a flood-resilient city in Matola, Mozambique. City and Environment Interactions, 22, 100147.

[5] Yang, J. and Zheng, B. (2020) 'Spatial Structure Planning and Optimization Strategy of Sponge City in Coastal Area', Journal of Coastal Research, 103(1), 561-567.

[6] Mukheibir, P., and Ziervogel, G. (2017) Municipal Adaptation Planning (MAP): A city-based framework for climate change adaptation. Green CITYnomics: The Urban War against Climate Change, 58(9), 72–88.

[7] Vicuña, M., León, J., and Guzmán, S. (2022). Urban form planning and tsunami risk vulnerability: Analysis of 12 Chilean coastal cities. Environment and Planning B: Urban Analytics and City Science, 49(7), 1967–1979.

[8] Nakano, T., and Kiuchi, N. (2020). Applicability and issues of the flood inundation risk area for urban planning regarding flood risks. Journal of the City Planning Institute of Japan, 55(3), 888–895.

[9] Murakami, A., and Hoyano, A. (2008). Study on the urban heat island phenomenon in a small city using the surface temperature of the Homestead Woodland. Journal of the City Planning Institute of Japan, 43.3(0), 691–696.

[10] LeGates, R. T. (2022). Climate change and energy planning. City and Regional Planning, 395–420.

[11] Kim, K. G. (2017) 'Methods and techniques for climate resilient and low-carbon smart city planning', Low-Carbon Smart Cities, 5, 177–213.

[12] Yang, J. and Chen, M. (2022) 'Potential impacts of flood risk with rising sea level in Macau: Dynamic simulation from historical typhoon mangkhut (2018)', Ocean Engineering, 246, p. 110605.

[13] Zhang, W., Wu, J. and Yun, Y. (2019) 'Strategies for increasing tsunami shelter accessibility to enhance hazard risk adaptive capacity in coastal port cities: A study of Nagoya City, Japan', Natural Hazards and Earth System Sciences, 19(4), pp. 927–940.

[14] Laino, E. and Iglesias, G. (2024) 'Multi-hazard assessment of climate-related hazards for European coastal cities', Journal of Environmental Management, 357, p. 120787.