https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

Brief communication: **Comprehensive Resilience to Typhoon Disasters: An Urban Assessment of 27 Cities in Seven Major River Basin, China**

Zezhao Liu[1,2] Jiahui Yang[1] and Cong Wu[1]

[1]Department of Politics & Government, Jiangsu Normal University, Xuzhou, 221110,China

[2]School of Government, Nanjing University, Nanjing, 210023, China

Correspondence to: Zezhao Liu (zzliu@jsnu.edu.cn)

Abstract. The urban resilience based on typhoon disasters are often not assessed. In this communication, we reflect on this issue by analyzing 27 cities around seven major river basin in mainland China. In specific, we build a comprehensive indicator-based model, and adopted the entropy-weighting TOPSIS method. Results show that the *Hai River Basin* and the provincial capitals had a higher resilience to typhoon than others, while cities of the *Pearl River Basin* are weaker. In some regions with weaker economy, however, the resilience was relatively higher partly attributing to infrastructure, water conservation projects, and level of information disclosure. The analysis is helpful for agencies and professionals to enhance urban capability of resilience, and provides a realistic reference in response to typhoon threats.

1. Introduction

Typhoons are among the most damaging natural hazards around the globe.According to the report of U.N Office for Disaster Risk Reduction (UNDRR), natural hazard by disasters exceed $3000 billion economic loss and 4.5 billion death or injured worldwide between 1998 and 2020. Of the recorded disasters, typhoon is one of the frequent hazards, which caused widespread damage in particularly those coastal areas and become a growing threat as global climate change evolves (Pauline, et al., 2020; Zhang, et al., 2020). China has long suffered from frequent floods and rainstorm caused by typhoon, resulting in significant losses and casualties (China's MEM, 2019). Accordingly, since the 2010s, the China central administration has been committing to promote a series of actions of disaster reduction to enhance resilience. The strategy of resilience has also been written into China's long-term 14th Five-year Development Plan and the *2035 Vision Goal Outline*. By the statement of UNDRR, the core annotation of "resilience" is taken as a capacity test in a pressure environment to achieve quick recovery from disasters and enhance strategies of risk mitigation through overall adaptive measures (UNDRR, 2018). For many decades, the disaster resilience in fighting against typhoon received heated discussions in related domains, such as geographic science, geology, and physics. Meanwhile, how to measure disaster resilience in a specific societal scenarios has obtained more attention both at home and abroad (Peng, 2023), with emerging indicators for assessment (Yang, 2022; Sawaid, 2020) as well as analysis by multidisciplinary methods and multi-criteria techniques（Huang and Ling, 2018; Bao, et al., 2019; Ping, et al. 2021）.

Although researchers have been studying resilience related to the influence of typhoon-induced disasters on specific dimensions or regions (Siebeneck et al., 2015; Moghadas, 2019), systematic mapping of large river basin areas or habitats potentially exposed to typhoon is relatively limited, particularly in China with complex geographical conditions. There remain gaps in reflecting the typhoon heterogeneity in terms of demographics, lifeline, and critical infrastructure. This could also be attributed to the fact that the magnitude of typhoon resilience of regions and potential for cascade effects are difficult to qualitatively and quantitatively estimate.

This brief communication aims at bringing up the subject of urban resilience on the societal system by highlighting the impacts reported after several typhoon disasters upon China river basins since the 2010s. Specifically, we take both natural and social dimensions into account and construct a comprehensive indicator-based frame, covering the economic, social, environmental and administrative aspects. By applying the entropy weighted TOPSIS method, we measured the urban resilience of 27 key cities in the seven major river basins in China (the Songhua River, the Liaohe River, the Haihe River, the Yellow River, the Yangtze River, the Pearl River, and the Nandu River), considering the heterogeneity of typhoon-prone regions and the accessibility of data. A greater consciousness on the relevance of the resilience topics is essential to foster additional investigation and attention in other spacial geographical contexts.

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

2. Assessing indicators and method

2.1 Indicators

The World Meteorological Organization (WMO) considers a typhoon a tropical cyclone with central sustained winds of force rating 12 to 13. According to China's Climate Bulletin, China incurred 345.45 billion yuan of direct economic losses from various types of disasters in 2023, of which typhoons caused a total of 47.49 billion yuan. In 2022, China's National Disaster Reduction Commission (NDRC) issued the Plan for Comprehensive Disaster Prevention and Mitigation, which stated that it will strengthen all-phrase control, and establish a comprehensive risk-based database on natural hazards including typhoon. By the report from the State Flood Control and Drought Relief Headquarters, there are seven major river basins in China's coastal regions that more affected by typhoon including the *Yangtze, Yellow, Pearl, Hai, Huai, Liao*, and *Songhua Rivers*, and these river basins cover 27 large and medium-sized key cities threatened by typhoon annually. Compared to inland cities, cities within the river basin are at a higher immediate risk of being struck by typhoon disaster, imposing stronger demand for resilience enhancement.

After searching literature both in China and abroad, departmental policies, and disaster-based studies, we identified 19 indicators for resilience assessment on typhoon basis, which are abstracted into four dimensions(see Table1). In specific, *the economic dimension* herein measures the overall economic capacity in a city, which encompasses the financial capacity, individual economic support capacity, and health care capacity. Usually struck by a typhoon disaster, urban response and post-disaster reconstruction is closely related to its economic support from the local government and status of individuals.The investment in water conservation and disaster reduction was more stressed for fiscal inputs. *The social dimension* describes the demographic and medical level in the city region. The demographic aspect contains two correlated indicators. Densely populated areas are vulnerable to typhoon disasters due to its production activities, while on the contrary, urban areas with lower population density are generally less victimized. Consequently, the population density usually serves as a negative correlation relative to urban resilience for typhoons. The number of hospital and health center beds per 1,000 people is a vital indicator that can reflect medical level in a city to typhoon risks. *The environmental dimension* includes the natural and man-made condition, in which the former includes precipitation positively linked with typhoon, and the latter incorporates human modification of the natural environment coupled with urban construction, such as the area sown by crops, the green space coverage rate in built-up areas, the quality rating of water conservancy projects, and the storage level of reservoirs. *The administrative dimension* herein is to measure the response capacity to typhoon, containing the level of urban lifeline project construction, the performance of disaster prevention construction, the development level of water management team construction, and the level of water sector information service.

Table 1. Indicators of urban resilience for typhoon disaster

Dimension	Factor	Indicator	Direction
Economic	Economic development level	Per capita GDP (yuan)	Positive
	financial support capability	Per capita fiscal expenditure (yuan)	Positive
	Personal financial support capability	Per capita disposable income of residents (yuan)	Positive
	Medical security support capability	Proportion of healthcare fiscal expenditure (%)	Positive
Social	Demographic factors	Density of population (person/sq.km)	Negative
		The proportion of urban permanent population aged 65 and above, and 14 and below to the total urban permanent population (%)	Negative
	Medical and health conditions	Number of beds in hospitals and health centers per thousand people (unit)	Positive
Environmental	Climate conditions	Annual precipitation (mm)	Negative
		Annual average temperature (°C)	Negative
		Annual surface runoff (100 million cu.m)	Positive
	Land factors	Crop sowing area (thousand hectares)	Positive
		Density of green space in built-up areas (%)	Positive
	Water project	Quality evaluation level of water conservancy engineering	Positive

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

	construction level	(level)	
	Lifeline engineering construction level	Density of drainage pipelines (km/sq.km)	Positive
		Per capita area of paved roads (sq.m)	Positive
Managerial	Disaster prevention construction effectiveness	The number of national comprehensive disaster reduction demonstration communities(unit)	Positive
	Construction of water affair management team	The number of water resources and environmental management professionals per ten thousand population (unit)	Positive
	Service level of water information disclosure	Total number of online information published by water conservancy bureau (pcs)	Positive

2.2 Method

Concerning the analytical dimensions of resilience proposed by Bruneau (2003) and the DROP model proposed by Cutter (2014), we delineated urban resilience to typhoon disaster into four dimensions as stipulated in the section above. This categorization approach intuitively mirrored the economic and social dynamics within urban settings and bore significant relevance to the managing typhoon disaster.

Meanwhile, the TOPSIS method was in specific introduced herein, which is a sorting algorithm tool to approximates optimal solution. This method exhibits flexibility in accommodating various data distribution states and sample sizes, boasting an uncomplicated calculation process and a broad applicability range (Pishyar et al., 2016; Hajek, et al., 2019; Zhang et al., 2021). We briefly instruct the operational steps in this study as follows:

First, the indicator weights based on the entropy weight method were used to measure the standardized judgment matrix:

$$v_{ij} = \omega_j x_{ij}^{'} \tag{1}$$

Second, the positive ideal solution v_j^+ and the negative ideal solution v_j^- for each selected indicator are handled based on the following matrix:

$$v_j^+ = max\{v_{1j}, v_{2j}, \cdots, v_{mj}\}, v_j^- = min\{v_{1j}, v_{2j}, \cdots, v_{mj}\} \tag{2}$$

Third, by the routine procedures we calculate the Euclidean distances S_i^+ and S_i^- between each selected indicator, as well as the positive-negative ideal solutions by the following Eq. (3):

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}, S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \tag{3}$$

Fourth, on this basis we further calculate the proximity of each sample city to the ideal solution, which herein is denoted as C_i representing the resilience index.:

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{4}$$

where and a larger C_i indicates better assessment results of the object.

2.3 Data collection

The data were obtained from the statistical yearbooks published by the selected sample city governments, China's population census, the water resources bulletins, the annual city reports posted on the website of meteorological department, press releases, and urban archive documents. By strictly selection and considering the data access, a sample of total 27 cities in China's seven major river basins was identified for this research. Although typhoon is categorized in magnitudes, such as tropical depression, tropical storm, severe typhoon and super typhoon, across the 27 sampled cities, there were no data for each category of typhoon after careful investigation. For this reason, we failed to classify the typhoon into subcategories by the magnitude. Apart from this, after process of standardizing for the data, the weights of assessment indicators were obtained by the Entropy-TOPSIS method, as here is omitted due to editor layout limits.

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

3. Results and discussion

3.1 Spatial variation in urban resilience

Figure.1 shows the urban resilience level imposed by typhoons, and the sample cities within the seven river basin could be categorized into four levels. The higher the index was, the weaker for the urban resilience to external shocks of typhoons, which could also possibly lead to greater risks of derivative damages. In specific, cities at *Level 1* to *Level 3* are Shanghai (average 0.5907), Yantai (average 0.4087), Haikou and Beijing, respectively. Cities at Level 4 with a composite rating from 0.2 to 0.3, include Xuzhou, Zhanjiang, Tianjin, Shenyang, Guangzhou, Harbin, Taizhou, Changchun, Hangzhou, Changsha, and Bengbu. Level 5, rating from 0.1 to 0.2, include Nanjing, Wuhan, Jinan, Fuzhou, Zhengzhou, Wenzhou, Yulin, Wuhu, Hefei, Nanning, and Dandong. Level 6 is labeled to Kaifeng with a composite score of less than 0.1.

Generally, typhoons are affected by the geographical and meterological factors. Therefore, it needs to examine differences in similar settings. Thus, we classified the 27 key cities into seven regions by river basins where they are geographically located, and further calculated resilience scores at each assessment dimension .

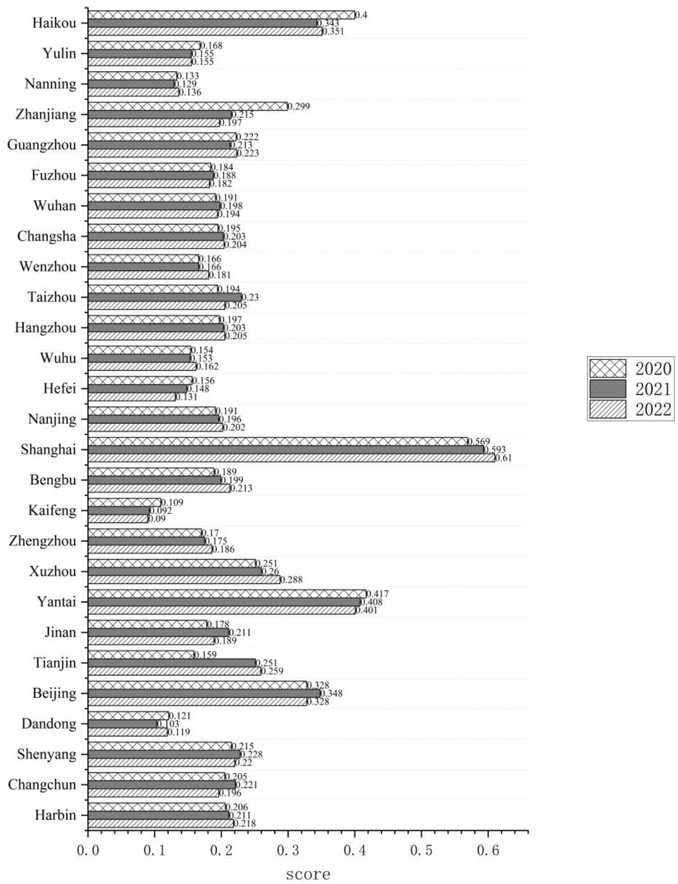

Figure 1. Comprehensive assessment value of urban resilience of 27 selected cities in China.

Notes: The score denotes the urban resilience rating in a specific year. These scores are between 0 and 1. The higher the score is, the stronger resilient the city is to typhoon disaster.

3.2. Inter-watershed comparison

The watershed scores were the arithmetic means of the assessment values in all typhoon-affected cities (Table 2). Specifically, urban resilience in the Haihe River Basin scores the highest value, as it encompasses the China's capital Beijing and the Metropolitan city of Tianjin. The Beijing-Tianjin region holds the advantages both in the

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

infrastructures and economic strength as well as a large number of high-level professional staffs in the fields of public health care, water conservancy, and a abundance of financial support from the central administration, which laid a solid foundation to enhancing the capacity of typhoon reduction. The resilience score of cities in the Nandu River Basin is the lowest by calculation. The reasons for this result can be summarized in multiple aspects. First, compared to others, the city of Haikou has a relatively weaker industrial level due to its more remote geographical distance from China's major industrial bases or the economic delta, yielding a lower economic value of per capital GDP on average. Secondly, Haikou occupied a relatively high population density, which underscores the potential for risk exposure to typhoon disasters. Thirdly, the frequent cross-provincial outflow of population from Hainan to developed Guangdong province caused the loss of technical expertise, which was one of the obstacles for disaster reduction.

Table 2 Dimensional ratings of 27 main typhoon-affected cities with respect to watersheds in China

City	Score	Economic	Social	Environmental	Managerial
Songhua River Basin					
Harbin	0.3336	0.2717	0.5143	0.3860	0.1623
Changchun	0.3446	0.3053	0.4390	0.2090	0.4250
Basin Score	0.3391				
Liaohe River Basin					
Shenyang	0.4030	0.3343	0.8303	0.1733	0.2740
Dandong	0.3202	0.1753	0.8210	0.1990	0.0853
Basin Score	0.3616				
Haihe River Basin					
Beijing	0.4755	0.7313	0.3923	0.2057	0.5727
Tianjin	0.4384	0.4303	0.3133	0.6220	0.3880
Basin Score	0.4570				
Yellow River -Huaihe River Basin					
Jinan	0.3876	0.4730	0.5973	0.1643	0.3157
Yantai	0.3676	0.4140	0.5057	0.1710	0.3797
Zhengzhou	0.3185	0.3183	0.4357	0.1673	0.3527
Xuzhou	0.3192	0.3060	0.4237	0.0740	0.4730
Kaifeng	0.2157	0.2697	0.2677	0.0817	0.2437
Bengbu	0.3105	0.3160	0.4110	0.1613	0.3537
Basin Score	0.3198				
Yangtze River Basin					
Shanghai	0.4462	0.7417	0.5230	0.1610	0.3590
Nanjing	0.3657	0.6253	0.4247	0.1713	0.2413
Hefei	0.3263	0.4003	0.4460	0.1867	0.2720
Wuhu	0.3482	0.4260	0.3933	0.1607	0.4127
Hangzhou	0.4164	0.5863	0.2303	0.4047	0.4443
Taizhou	0.2734	0.3953	0.3273	0.1810	0.1900
Wenzhou	0.2940	0.4590	0.1977	0.2043	0.3150
Changsha	0.3353	0.3780	0.4153	0.1233	0.4247
Wuhan	0.3798	0.5423	0.3383	0.1690	0.4697
Fuzhou	0.3313	0.4880	0.2860	0.1893	0.3620
Basin Score	0.3517				
Zhujiang River Basin					
Guangzhou	0.2970	0.5763	0.1643	0.1667	0.2807
Zhanjiang	0.2428	0.3147	0.1743	0.1753	0.3067
Nanning	0.1877	0.2343	0.2473	0.1167	0.1523
Yulin	0.1970	0.2027	0.1863	0.0820	0.3170
Basin Score	0.2311				
Nandu River Basin					
Haikou	0.2821	0.2917	0.3707	0.0310	0.4350
Basin Score	0.2821				

Comparatively, the resilience scores to typhoon in northeast region (Songhua & Liao River Basin) was slightly stronger than southeast region (Pearl River Basin). Although southeast coaster region possesses advantages in economic strength and growth in comparison with the northeast, the former displayed a relatively lower proportion of investment in the field of reservoir construction, as constituted one of the principal indicators on

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

the economic dimension in our study.（assessment weight >10%). By governmental statistics, the water storage capacity of large and medium-sized reservoirs in the Northeast region of *Songhua* and *Liao* River Basins is significantly higher than that of other basins.Overall, the Pearl River Basin has a tropical and subtropical climate with an average annual temperature exceeding 22°C and precipitation exceeding 1,500 mm (Sheng, 2015), making them highly vulnerable to typhoons. Besides, as for the social dimension, the river basin of southeast with higher population density actually necessitated medical and rescue capacities in typhoon disaster, while the northeast basin is insufficient in the water facilities. For the environmental dimension, compared to the southeastern coastal regions with annual higher precipitation, the cities in northeast exhibited a lower risk of typhoons. Moreover, the calculated resilience vulue of the Yellow-Huai River Basin and Yangtze River Basin (including major cities in China's coaster provinces), is stronger than that of the Northeast. Both basins perform better in terms of social and administrative dimension, which can be attributed to the influx of R&D investment and government capacity (Ju, 2020). The Yellow-Huai River Basin is located in the eastern regions of China, with suitable temperatures and a high level of urbanization, which attracts a large inflow of talents and creates a better pool of specialized human resources in the fields of water conservancy and environment protection.

3.3. Intra-watershed comparison

China's administrative system endows a superior status either in economic and political aspects for provincial capitals, and these cities exhibit higher levels of urban resilience than other prefecture-level cities. Likewise these cities include Harbin, Nanjing, and Guangzhou, all of which have higher resilience scores than other types of cities in the province. Namely, we demonstrates that provincial capital cities are more resilient compared to the prefecture-level cities in confronting typhoon disasters. However, there are exceptions in some watersheds. For instance, Jinan, the capital city of Shandong Province, is slightly lower in resilience score than Yantai, a common prefecture-level city in Jiaodong Peninsula, which can be attributed to the following factors. On one side, Yantai was a city distinguished by economic prosperity thanks to industries and infrastructures. For economic strength and geographical location, Yantai administration puts emphasis on investments in typhoon-induced disaster prevention, with three to four times annual expenditures than that of Jinan, the capital city of Shandong Province. Secondly, Yantai was relatively low in the population density compared with Jinan, which was advantageous for the city when calculating per capital indicators.

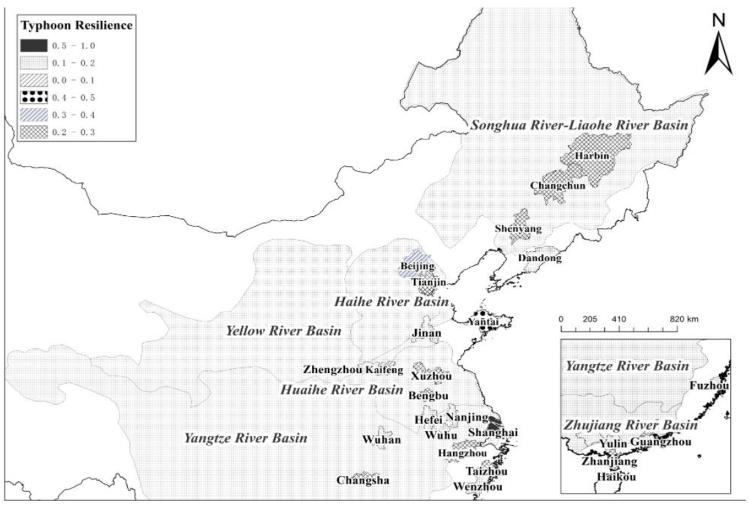

Figure 2. Resilience rating of 27 typhoon-affected cities in respect to watersheds.

In the *Songhua* and *Liao* River Basin, cities perform poorly in economic and administrative dimensions but relatively better in social and environmental dimensions. Compared to Shenyang, the capital of Liaoning Province, Dandong has a weaker heavy industry base and a long coastline in Northeast China, but hold an advantage in terms of water conservancy conditions in geographical location. In the Songhua River basin, Harbin ranks 10th out of 27 cities in terms of typhoon resilience level, while Changchun ranks 12th. This difference may be closely related to the high population density in Changchun, and weaker reservoir storage capacity compared

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

to capital city of Harbin. For the whole northeast region in China, Harbin City has the largest reservoir capacity (12,966 million cubic meters). Reservoirs play an important role in dissipating heavy precipitation caused by typhoon in a short period of time and staggering the peaks. Besides, the Haihe River Basin presents the difference in typhoon resilience between Beijing and other municipalities. In terms of typhoon resilience scores for 2020-2022, Tianjin (0.2230) is significantly lower than Beijing (0.3347). specifically, Beijing performs well in the economic, social and administrative dimensions, with its water resources sector ranking first in terms of information disclosure and disaster response.

In the Yellow-Huai River Basin, the observed city with the highest level of resilience is Jinan, which may be closely related to its administrative location as the capital city of Shandong province and the command center of the Liberation Army in China's Northern Theater of Operations. By the calculation result, Jinan scores high on the social and administrative dimensions. Besides, Jinan has an advantage of personnel in typhoon disaster rescues, including 27 water and environmental practitioners per 10,000 population in 2022, far more than any other city in the basin. By comparison, as a provincial capital city in Henan province, Zhengzhou scored lower on the social and administrative dimensions. The scale of inter-provincial population outflow in Henan Province is among the highest in China, resulting in a lower level of technical level expertise for disaster reduction, which is one of the barriers to enhancing resilience to typhoon disasters.

In the developed economic regions of Yangtze River Basin, Hangzhou City has the highest level of overall resilience, mainly due to its high ranking in reservoir capacity and environmental management practitioners. The leading development position in the Yangtze River Delta region gives the cities of Shanghai, Hangzhou, and Nanjing a very high economic advantage, attracting high-level talents from all over the country to work and settle, and provide abundant talents including disaster reduction of water conservancy and emergency aids. Among the Yangtze River Basin, Taizhou City has the lowest level of resilience, which may be related to the city's low reservoir capacity and lack of facilities to mitigate heavy rainfall caused by typhoons.

Cities in the Pearl River Basin are categorized into two levels, with two cities (Guangzhou, ZhanJiang) in Guangdong Province rating the fourth status and one city (Nanjing) in Guangxi Province rating the fifth position. The Pearl River Basin has abundant rainfall and is a typical rainy river with big river runoff, accounting for about 13% of the national runoff. The Xijiang and Beijiang rivers meet and have traditionally been the main source of typhoon-induced flooding in the delta. Nanning and Yulin, although less pressurized in terms of population density and large reservoirs of capacity, the level of water conservancy construction and disaster mitigation demonstration communities is low, which leads to a weaker ability to confront typhoons. From an economic perspective, the city of Nanning and Yulin was relatively laggard than that of other provincial capital cities, particularly in terms of financial support. In terms of the environmental dimension, the capital city of Nanning in Guangxi province encountered a highly frequent typhoon landfall, but the limited volume of local reservoirs made it difficult to handle the erupt typhoon-induced rainfalls.

3.4. Temporal evolution of urban resilience to typhoon

By calculation, the metropolis of Shanghai ranked first in the comprehensive rating for confronting typhoon, and the resilience score has been increasing every year (see Figure 1). Haikou, a city also with a high resilience score, ranked steadily and possessed relatively high performance in social dimension. The decline of the overall score in 2022 is related to the decrease in the number of disaster reduction model communities. The growth in the density of drainage network in the built-up area of Haikou City demonstrates the government's determination to improve the city's drainage capacity and to improve the mechanism for preventing typhoon disasters beforehand. Besides, Xuzhou City, as the top-ranked city among the three tiers and a prefecture-level city in Jiangsu Province, exceeds many provincial capitals in resilience scores, and its composite scores show an increasing tendency annually. The spread of drainage network around the city and lifeline project enhanced its performance of resilience to typhoon. Tianjin, the city with top overall score for resilience, improved its ranking from No. 22 in 2020 to No. 6 in 2022, with an average overall score of 0.2230, and the number of public information published online by the Water Resources Bureau reflects the increased level of information capacity of typhoon disasters.

4. Conclusion

The brief communication reports an assessment framework for urban resilience to typhoon disaster and applies in 27 cities in China's seven river basins based on watersheds during 2020–2022. Indicators with the economic, social, environmental, and administrative dimensions were selected using the Entropy –TOPSIS method. The resilience score to typhoons in these watersheds apparently differs and ranked as follows: *the Haihe*

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

River Basin, the Liao River Basin, the Yangtze River Basin, the Songhua River Basin, the Yellow-Huai River Basin, the Nandu River Basin and the Zhujiang River Basin. We thus conclude in the following aspects:

(1) Level of economic power is not synchronized with resilience to typhoons. Overall, despite the economic advantages in southeast, its resilience score is lower than that of the northeast. As some research indicate, government expenditure and economic capacity in disaster reduction is positively correlated with the economic losses when cities face typhoon disasters (Cutter, 2016; Hechanova, et al., 2018; Guo, 2020). Some cities with a higher percentage of financial expenditure on typhoon and healthcare demonstrated a stronger capacity for medical rescue and minimized casualties.

(2) In the environmental dimension, climatic condition, land resource, and the level of infrastructure are important factors in affecting city's resilience capability to typhoon disaster. We found that some coaster cities with higher precipitation annually scored high mainly thanks to to its urban infrastructure and large-scale facilities of water conservation, such as large and medium-sized reservoirs, hydropower station, waterway and harbor projects,. A typical city case was the Fuzhou in the coaster Fujian province. Although it received more annual precipitation due to its location of subtropical monsoon, the reservoirs with large capacity and infrastructure reduced risks of flood damages caused by typhoon.

(3) The administrative dimension with respect to resilience herein refers to the capacity of water conservancy for local administration that better respond before, during, and after a city encounters typhoon. In this study, the status of disaster reduction pilot communities was an important assessment indicator. With the help of community construction, cities can strengthen the capacity of response on the grassroots level through effective learning, and improve early warning measures for typhoon-induced disaster reduction. Besides, the government ought to enhance the level of information disclosure of typhoon in the frontline water sector, for instance, strengthening the information warning by adequate channels, such as government websites, weather forecasts, and social platform.

To sum up, although we tried to make resilience assessment in a comprehensive dimensions to typhoons based on complexity of China's geographical river basin context, there are still more gaps awaiting filled. More cities of different types and the factor of heterogeneity are supposed to be added with a dynamic perspective. Also, we could conduct future's research aiming at conceptualizing cascading impacts. of typhoon disaster to further explore resilience assessment.

Data availability

The data set is available on request.

Author contribution

Liu: conceptualization, analysis, writing – original draft, and funding acquisition.

Yang: data curation, writing – original draft, **Wu**: visualization, writing – review, and editing

Declaration of competing interest

The authors declare that neither of the authors has any competing interests.

Financial support. This research was funded by National Social Science Fund of China (23BZZ049) and the Scientific & Technology Supporting Program for Sustainability (Soft Science) funded by Xuzhou administration （23KC101）

References

Chen, L. Xu, D. Zhao, T. et al.: A new model for describing the urban resilience considering adaptability, resistance and recovery, *Safety Science.* 128. https://doi.org/10.1016/j.ssci.2020.104756, 2020.

Cutter. A.: A multi-criteria decision making method for urban flood resilience evaluation with hybrid uncertainties. *Int J Disast Risk Re.* 36. 101140. https://doi.org/10.1016/j.ijdrr.2019.101140, 2019.

Cutter, Susan L.: The landscape of disaster resilience indicators in the USA.*Natural Hazards* 80.2:741-758. https://doi.org/10.1007/s11069-015-1993-2, 2016.

Hajek, P. , and Froelich, W.: Integrating TOPSIS with interval-valued intuitionistic fuzzy cognitive maps for effective group decision making. *Information Sciences*, 485. https://doi.org/10.1016/j.ins.2019.02.035, 2019.

https://doi.org/10.5194/egusphere-2024-2343
Preprint. Discussion started: 8 October 2024

Hechanova Maria Regina, et al.: Evaluation of a resilience intervention for Filipino displaced survivors of Super Typhoon Haiyan.*Disaster Prevention and Management* 27.3:346-359. https://doi.org/10.1108/dpm-01-2018-0001, 2018.

Huang, W. and Ling, M.: System resilience assessment method of urban lifeline system for GIS. Computers Environment & Urban Systems, 71(9), 67-80. https://doi.org/10.1016/j.compenvurbsys.2018.04.003, 2018.

LIu Z, and Huang J.: Factors Contributing to Social Risk Management in China: Evaluation in the Context of SSRA Initiative, *Chinese Public Administration Review* 8(2): 120-139. https://doi.org/10.22140/cpar.v8i2.158, 2017.

Moghadas M, Asadzadeh, A. Vafeidis, A. et al.: A multi-criteria approach for assessing urban flood resilience in Tehran, Iran. *International Journal of Disaster Risk Science.* 35,101069. https://doi.org/10.1016/j.ij01069, 2019.

Pauline Eadie,Maria E,and May Tan-Mullins. : Livelihood and vulnerability in the wake of Typhoon Yolanda: lessons of community and resilience. *Natural Hazards* 103,1:1-20. https://doi.org/10.1007/s11069-020-03984-z, 2020.

Peng Y., Zheng R, Yuan T. et al.: Evaluating perception of community resilience to typhoon disasters in China based on grey relational TOPSIS model. *International Journal of Disaster Risk Reduction*, 84, 1. https://doi.org/10.1016/j.ijdrr.2022.103468, 2023.

Ping J, Zhou, J., Huang K., et al.: Modeling the typhoon disturbance effect on ecosystem carbon storage dynamics in a subtropical forest of China's coastal region. *Ecological Modelling*, 455. https://doi.org/10.1016/j.ecolmodel.2021.109636, 2021.

Pishyar, S. , Khosravi, H. , Tavili, A. , et al.: Ranking effective desertification indices using TOPSIS and analytic hierarchy process. *Environmental Hazards,* 15(8). https://doi.org/10.1007/s11069-012-0139-z, 2016.

Sawaid Abbas.: Impact assessment of a super-typhoon on Hong Kong's secondary vegetation and recommendations for restoration of resilience in the forest succession.*Agricultural and Forest Meteorology* 280:107784. https://doi.org/10.1016/j.agrformet.2019.107784, 2020.

Sefa Mızrak Handan Çam. : Determining the factors affecting the disaster resilience of countries by eographical weighted regression. *Int J Disast Risk Re.* 15. https://doi.org/10.1016/j.ijdrr.2022.103311, 2020.

Sheng, C. , Wei-Biao, L. I. , Yao-Dong, D. U. , et al.: Urbanization effect on precipitation over the Pearl River Delta based on CMORPH data. *Progress in Climate Change*, 6(1): 7. https://doi.org/10.1016/j.accre.2015.08.002, 2015.

Siebeneck, C.L. Arlikatti, S. SAndrew.: A.Using provincial baseline indicators to model geographic variations of disaster resilience in Thailand. *Natural Hazards* 79(2) :955–975. https://doi.org/10.1007/s11069-015-1886-4, 2015.

Tang, X. , Shu, Y. , Liu, W. et al.: An optimized weighted Naieve Bayes method for flood risk assessment. *Risk analysis*(12), 41. https://doi.org/10.1111/risa.13743, 2021.

Tengjiao Guo,and Guosheng Li.: Study on methods to identify the impact factors of economic losses due to typhoon storm surge based on confirmatory factor analysis. *Natural Hazards,*100,2:515-534. https://doi.org/10.1007/s11069-019-03823-w, 2020.

The State Flood Control and Drought Relief Headquarters, Ministry of Water Resources of the People's Republic of China. *China Flood and Drought Disaster Bulletin in 2018*, SinoMaps Press, Beijing, China, 2019. https://www.gov.cn/xinwen/2019-01/10/content_5355888.htm (last access: 10, January 2024). 2024.

UNISDR. Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction., *Int J Disast Risk Re.* https://doi.org/10.18356/bd3a73ea-en, 2015.

Yang Rui,and Li Yang.: Resilience assessment and improvement for electric power transmission systems against typhoon disasters: A data-model hybrid driven approach. *Energy Reports* 8, 10923-10936. https://doi.org/10.1016/j.egyr.2022.08.226, 2022.

Yvonne Su,and Loïc Le Dé.: Whose views matter in post-disaster recovery? A case study of "build back better" in Tacloban City after Typhoon Haiyan. *International Journal of Disaster Risk Reduction*, 51:101786. https://doi.org/10.1016/j.ijdrr.2020.101786, 2020.

Zhang, H. , Yang, J. , Li, L. , Shen, D. , & Dong, S.：Measuring the resilience to floods: a comparative analysis of key flood control cities in China. *International Journal of Disaster Risk Reduction*, 59(4), 102248. https://doi.org/10.1016/j.ijdrr.2021.102248，2021.