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Research on how Urban Planning and Design can Help Vulnerable Communities Adapt to the Negative Consequences of Climate Change—A Case Study of Shanghai, China

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Abstract: *This paper investigates the public perception of two salient climate impacts, extreme heat, and heavy precipitation, in Shanghai, and urban planning and design strategies to enhance vulnerable communities' climate resilience. This paper employs mixed methods, including literature review, and survey-based analysis to examine the perceptions and preferences of citizens to the vulnerability of extreme weather events. The results show that the majority of respondents in this paper's sample perceived extreme heat as more vulnerable than heavy precipitation, revealing that more imminent action should be taken to deal with extreme heat through sustainable urban design. The water, environment, and public facilities management industry reveal the highest perception of extreme heat vulnerability with similar reasons for their disturbed planning. The three top urban design actions to deal with heavy precipitation that can be taken from a public perspective are enhancing effective management of the urban drainage network, improving drainage systems in older neighborhoods, and improving the design of permeable structures. The three top urban design actions from a public stance to address extreme heat are increasing urban green space, promoting green buildings, and strengthening the control of greenhouse gas emissions. Overall, this paper provides empirical evidence on public perceptions of severe weather and preferences for climate-resilient urban infrastructure in Shanghai as a climate adaptation strategy. The paper additionally advocates different stakeholders including government, citizens, and urban designers to collaborate to mitigate the negative influence of extreme weather.*

Keywords: *Shanghai; climate change; urban design; vulnerable communities*

1. Introduction

Extreme weather events in Shanghai and their consequences: China has faced an unprecedented 71-day heat wave in 2022, including Shanghai, a highly developed metropolitan city in China.[1] Shanghai has faced the influence of extreme weather events in higher tendency, with more skyscrapers and commercial land constructed. Compared to rural regions in China, Shanghai offers an ideal context to investigate climate-resilient urban design, considering its characteristics of industrialized and being impacted. The risks of extreme weather faced in Shanghai have progressively risen in recent years, especially after the lockdown during the pandemic. In Shanghai, the high temperature stimulated a heatwave red alert and governments have taken measures including artificial rainfall to alleviate the somatosensory temperature.[2] In the same year, there was an excessive electricity demand but there was a deficit in supply, which led to a nationwide electrical crisis. Many local governments have instituted a policy of power rationing, which restricts the supply of electricity to enterprises, to protect people's electricity consumption. Under power rationing, Shanghai also switched off the decorative lights on recreational buildings.[1] Some productions in secondary sector industries experienced economic loss. According to a report from CNN, Shanghai, China, has reached the highest May temperature of 36.1 degrees Celsius in 2023 over 100 years.[3]

Thus, in recent years extreme weather events hugely affected the living standards of households in a region, especially those who are vulnerable. Vulnerable communities, according to the IPCC, are those who are vulnerable to climate change and are marginalized on the social, economic, cultural, political, or institutional levels. In this paper, it will be more detailly defined as Shanghai citizens who are at age greater than 60 or smaller than 25, who are students or work as freelance, and who spend more than 10 hours outdoors on average in a day.

ISSN 2616-5872 Vol.5, Issue 10: 63-71, DOI: 10.25236/AJEE.2023.051009

2. Research questions

In this paper, potential climate adaptation solutions will be investigated based on urban planning and design to enhance vulnerable communities' climate resilience, which is the ability to adapt to extreme weather, one of the negative consequences of climate change. This study is focused on both the phenomenon and the corresponding solution, raising relative sub-research questions.

The first sub-question aims to investigate the effects of extreme weather events in Shanghai on vulnerable communities, mainly from socioeconomic and environmental aspects.

The second sub-question is how can Shanghai's urban infrastructure be improved to enhance resilience to heatwaves and flooding.

3. Methodology

3.1 Qualitative Analysis

This paper employers a literature review. By analyzing literature reviews from various sources, including government official reports, and academic journals, it can provide an overview of the current situation of Shanghai's urban designs and conduct a proposed urban planning system that can have potential environmental and social benefits on climate adaptation.

3.2 Quantitative Analysis

For investigating the perception of the vulnerability rate of extreme weather, favorable practices are introduced and considered from quantitative analysis. First-hand data collection via survey is chosen for the quantitative research method as it can offer numerical values in percentage for consistent and parallel comparison. The data can be more directly and straightforwardly expressed and revealed as part of the results.

The survey consists of 19 questions and was distributed through an online survey platform. The questions designed can be divided into different aims, perceiving respondents' images to identify vulnerable communities and acknowledging the extent of public perception of current extreme weather circumstances and climate resilient cities.

4. Literature Review

4.1 Impacts of extreme weather events

4.1.1 Environmental Impacts of Extreme Weathers and Schemes

Extreme weathers such as heat and rainfall have significant environmental and socioeconomic effects on a wide range of stakeholders.

4.1.2 Environmental impacts: heat, flooding, biodiversity loss

Extreme heat waves can intensify the urban heat island effect. Shanghai, as a metropolitan area, is highly urbanized in almost all districts. Skyscrapers and buildings are condensed in the major areas of the city. Urbanized areas known as heat islands have greater temperatures than nearby rural areas. On the other hand, extreme precipitation gave rise to severe urban flooding. China has prioritized building a "sponge city" as a countermeasure.[4] With designs inspired by nature, the objective is to enable cities to soak up and absorb excess water. As the two events involve the weakening of natural environments in an urban area and the destruction of habitats, living things that survive in those habitats are likely to migrate elsewhere, where they can live under a more secure ecosystem with adaptable climates, abundant food sources, water, and accessible shelter;

4.1.3 Socioeconomic impacts

Firstly, extreme weather causes harm to human health, especially to vulnerable communities. There may also be loss of tangible assets from the social perspective if the circumstance is severe. In addition, the negative influence of extreme weather further slows the efficiency rate of production not only because of the health concerns of employees but also the environmental influence on capital. Thus, it leads to lower economic output and further decreases the capability of consumption. Living standards will be

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affected and the vicious spiral may incite an unstable society in the end.

4.2 Current Climate Adaptation Strategies in Shanghai

Building a national space for climate change adaptation has been explicitly suggested in China's National Climate Change Adaptation Strategy 2035.[5] Numerous domains, including infrastructure, ecosystems, and other relevant material, are still in the early stages of investigation in the research and preparation of urban climate adaptation planning. These fields are strongly tied to national space planning. Based on this, it is suggested to create a strategic framework for Shanghai's climate adaptive designs based on the fundamental analysis of identifying key climate risks, climate factors, and planning elements. Furthermore, it pointed out to concentrate on key climate risk coping strategies and multi-level spatial planning implementation paths.

5. Survey-based quantitative analysis

5.1 Summary statistics of respondents

5.1.1 Current residence

As this paper primarily discusses the public perception of climate impact and implications for urban design in Shanghai, the respondents should adequately represent the population. By reassuring the region distribution of respondents by their IP, we find out that 93.3% of the sampling region is based in Shanghai, which is consistent with the expectation of the restriction of the questionnaire, the sample is an adequate representation of Shanghai residents.

To reassure the major types of extreme weather experienced by Shanghai citizens, a question on which types of extreme weather citizens experienced in the past is asked. From the result of survey, we can get that 68.2% of Shanghai respondents experienced high temperatures and 61.8% of Shanghai respondents experienced heavy rainfall. Thus, these two types of extreme weather events are relatively more felt by Shanghai citizens, which corresponds to our assumption beforehand.

Respondents are then analyzed from geographic and demographic aspects.

5.1.2 Gender and age distribution

Respondents' gender and age distribution according to our research. Genders are relatively equally separated but with females approximately 15% more than males. There are Approximately 60% of responses answered by female respondents. Thus, gender bias should be considered. Their perceptual answers in other designed questions may lead to a deviation in perceptions if both genders are 50% considered. As females show a greater awareness of extreme weather events due to their relatively higher vulnerability, conclusions made in the following may show a slightly upward bias. If the presupposition is reasonable, then the whole population in Shanghai may perceive a lower level of urgency of extreme weather events. As for age, respondents from 18 years old to 60 years old account for a large proportion, with the range of 26 to 40 years old as the modal group.

5.1.3 Geographical distribution

All districts are listed out for respondents to choose which district they usually live, including their work and residence. Overall, responses reveal an equal distribution but two districts are home to more respondents. After comparable analysis, the results show that 19.39% of respondents reside or work in Xuhui district, which is the center of Shanghai, considered an urban area. While 19.7% of respondents spend time in Qingpu district, which is considered the suburban area in Shanghai.

5.1.4 Occupational distribution

Different industries are provided for respondents to choose from, the design of the question intends to see respondents' occupations as different jobs are affected by extreme weather events to different extents. For example, freelancers are more likely to be restricted by the impacts of extreme heat or rainfall. From the data, students and freelance workers have the highest percentage, in total account for 17%.

5.1.5 Outdoor Spending Hours

The percentage of respondents and the number of hours spent outdoors are inversely proportional. 35.15% of respondents, which is the highest percentile, spend 0-2 hours on average a day; 6.97% of respondents, which is the lowest percentile, spend more than 10 hours. Thus, the percentage of

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respondents decreases as the number of hours spent outdoors increases.

As outdoor workers or people spending long hours outdoor belong to vulnerable groups, respondents who chose more than 10 hours will be focused because they have higher accessibility to extreme weather. Heat waves may have more significant impact on these groups.

5.1.6 Awareness of climate issues

The majority of the respondents have a lack of education on extreme weather adaptation. According to data, 67.0% of respondents never received respective training of exercise and 20.9% of respondents are uncertain whether they have received certain training on coping with extreme weather. Only 12.1% of respondents have been trained to properly adapt to extreme weather, which is a relatively small proportion.

5.2 Key findings

5.2.1 Quantitative impact on socioeconomic impacts

Cross-tabulation analyses are conducted to obtain key findings from questionnaire data.

Working class is considered separately to find out the socioeconomic impacts of extreme weather in numerical form. The survey asks working-class respondents to rate the extent of income level affected by extreme weather from 0 to 10. The mean value of all working-class respondents is 3.44, indicating that their income levels have not been hugely affected by extreme weather.

Different questions are asked based on all respondents. The questions are more inclined to their physical impacts. In the data set, the mean value of the extent of impacts by heavy rainfalls with range 0 to 10 is 3.74 and the mean value of the extent of impacts by high temperature with range 0 to 10 is 5.46. 5 of 330 respondents rated on the scale “9-10” on impacts by heavy rainfalls while 67 of all respondents rated on the scale “9-10” on which by high temperatures. As a result, Shanghai citizens are more affected by high temperatures considering their own experiences. The difference may be attributed to the high temperature in Shanghai in 2022. Citizens are more mentally affected by the heat wave than by heavy rainfall.

5.2.2 Analysis on Respondent’s Perceptions

To further investigate the willingness of Shanghai citizens to climate resilient buildings, respondents’ perceptions on the improvement of urban design have been discussed.

Investigation report revealed their perceptions of the drainage system and heat adaptive system respectively. For drainage system, a greater proportion (49.1%) of respondents is uncertain about the improvement. In the case of the heat adaptive system in Shanghai, more than half (56.7%) of respondents consider it should be improved. Overall, compared to drainage system in Shanghai, more proportion of citizens consider the heat system should be improved, and the results also have a positive correlation to the extent of their perceived climate impacts of extreme heat waves. Because they are more affected by extreme heat, citizens are more willing to see improvements in heat adaptive systems.

Respondents acknowledged the importance of building a climate resilient city, with a rate of 8.36 out of 10, expressing their great willingness to improve urban planning and design as a climate adaptation measure.

5.3 Analysis by Groups

The following includes data analysis of the self-reported, perceived degree of influence of the two types of extreme weather and their impact on income level from four perspectives, namely, gender, age, industry, and socioeconomic status. Respondents are asked to rate their subjective perceptions on a scale from 0 to 10. The following analysis is built on the average perception score, approximated to 2 decimal points.

5.3.1 Perception by Gender

In the perception of the vulnerability of heavy precipitation, compared to male respondents of 3.58, female respondents perceive a higher rate of the vulnerability of heavy precipitation, on a scale of 3.87, 8% higher than males' perception of which. However, in the perception of the vulnerability of extreme heat, both genders show a similar perception of vulnerability rate of 5.45 in the sample of 330 respondents.

ISSN 2616-5872 Vol.5, Issue 10: 63-71, DOI: 10.25236/AJEE.2023.051009

While in the perception of the impact of extreme heat on income level, males report that they have experienced a high impact on their incomes due to extreme weather compared to females. This difference may be because more males occupied as manual workers such as wholesalers and retailers than females.

In conclusion, females could be considered as vulnerable communities, but the model shown above reveals only subtle differences between the perception of them to the vulnerability of extreme weather.

5.3.2 Perception by sector

The second aspect is categorized by industries according to survey. In the perception of the vulnerability of heavy precipitation, the mining industry shows the highest vulnerability, with a rate of 4.75. This may be due to the slow-down of production due to precipitation. As safety issues are involved in operations, mines cannot be excavated under excessive rain. Mines may become flooded by heavy rain, their access roads become unusable, and operations may be suspended for days.[6] Healthcare and social security workers show the second highest. Their efficiency may be hugely affected by heavy precipitation. The third highest is culture and entertainment workers. This may be due to their schedules having to depend on weather. Heavy rainfalls may disturb their regular work, especially to of actors who work outdoors.

Regarding the vulnerability to extreme heat, workers from water, environment, and public facilities management reveal the highest rate of 6.63. This scale indicates that they have to cope with heat waves more urgently. Their works include using hydraulic resources for flood control, irrigation, river transportation, and other purposes; monitoring and treatment of environmental air, water, noise, and waste; maintenance and management of public facilities.[6] The second highest is citizens' work for scientific research. The high vulnerability may be due to the destructivity of heat on the experimental sample. High temperature may occur as a variable that affects scientific results. The third highest is citizens in the construction and architecture industry. Extreme heat conditions may slow the construction process as constructors have to work outdoors to examine sites. High temperature hugely affects their working condition and may lead to sunstroke.

In the perception of the impact of extreme weather on income level, Shanghai citizens who work in logistics and transportation are primarily affected, with an average of 4.9. This is reasonable as heavy precipitation and extreme heat cause delays in transmitting deliveries. Thus, accomplishing package deliveries falls in the medium long term, lowering the profit that can be gained. The second highest score of 4.42 is rated by workers in mining industries. Primary industries that excavate raw materials greatly depend on weathers condition. Workers' schedules may be disturbed due to extreme weather events. In addition, the manufacturers will also be affected at a comparatively high rate, approximately 4.15, with similar reasons that their production would be shut down due to extreme weather. In total, Shanghai citizens who work in the primary and secondary sectors experience a relatively more severe impact on income level than those who work in the tertiary and quaternary sectors.

Students and the unemployed are not considered on their income level. The results of the vulnerable level of extreme weather to different industries are consistent with a business report, which further ensured the validity of the data received from the mass survey.[7]

5.3.3 Perception by socioeconomic status

The third aspect is socioeconomic status. Firstly, in the perception of the vulnerability of heavy precipitation, senior management or leader report themselves in the highest rate of 4.35. Business trip flight delays often occur due to heavy rain. Flights cannot be taken off due to the weather factor. Thus, senior management may be affected by the perspective of their business. Students are ranked the second highest, scoring 4.22, as most students may have to travel home alone during rainy days. Heavy precipitation increases the security problems involved in the distance. The third highest is entry-level and junior staff. Junior staff face a relatively more vulnerable situation too heavy precipitation than the middle class, as they tend to engage in more labor-intensive, weary work such as frequent travelling than the managers and C-suite leaders. Thus, they report a higher rate.

Secondly, regarding the vulnerability of extreme heat, entry-level workers perceive the highest at a rate of 5.645, 0.05% above that of those in flexible employment. General staff may be more tended to work outdoors for manual work, so they are exposed to higher risks under high temperatures. The unemployed respondents report a rate of 5.50, ranked the third highest.

There is a gradual increase from junior staff to middle management for influence on income level, from 3.45 to 3.76. This may be attributed to the higher income that can be received by middle management as they gain more. Thus, when their incomes have been impacted, they lose more than the

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junior cohort. Flexible employment also shows a rate of 3.40, which may be due to the instability of the class.

Overall, the above analysis makes general staff relatively more vulnerable to extreme weather.

5.3.4 Perception by age groups

Among these 330 valid responses, there are no respondents in the 81 to 100 age cohort, likely due to digital illiteracy and the inaccessibility of surveys on electronic devices for aged people. As a result, the vulnerability to extreme weather to aged people may include bias, failing to reflect the vulnerability of Shanghai citizens between the ages of 81 and 100.

Overall, children and adolescents have not shown a high vulnerability to extreme weather, which is inconsistent with the presupposition. This deviation may be because they are taken care of by their parents in Shanghai and have not experienced such extreme weather events. In addition, children of early ages, such as those under six, may not have access to this survey. Overall, the working class in middle age is mainly affected by extreme weather, in which its income level is mostly affected.

Overall, from all aspects, the average perception of extreme heat is higher than that of heavy precipitation, reaching an average of 5.46, 46.0% higher than the latter. While the average perception of heavy precipitation is only 3.74, indicating that it has not reached the median value. Thus, the public may be more affected by extreme heat in their lives and work. This higher rate may be due to the characteristics of Shanghai. Shanghai experiences rain for around one-third of the year because of its location, the Yangtze River estuary. As a result, Shanghai citizens may be less sensitive to the rise in frequency and intensity of the precipitation. However, higher temperature is relatively more easily perceived due to the amount of sweat.

6. Viable Approaches to Cope with Extreme Weathers

With both quantitative and qualitative analysis, a clear image of the current situation of citizens including vulnerable communities is revealed. This raises a step forward in taking actions. Thus, different approaches to climate resilient urban design are introduced.

The survey considered two additional questions to investigate the publics' preference of approaches to cope with heavy rainfalls and heat waves.

6.1 Heavy Rainfalls

The top three approaches preferred by Shanghai residents for coping with heavy rainfalls are listed in decreasing order. Firstly, enhancing effective management of the urban drainage network. Instead of directly reducing the flood event's frequency, it moderates consequences of urban floods and fastens the recovery. Rainwater can also be collected and reused for other purposes, being recycled. Khodashenas and Yajbakhsh have formerly mentioned the application of Mike Swmm and GIS simulation to manage the urban drainage system through a mass database.[8] Secondly, improving drainage systems in older neighborhoods. Thirdly, improving the design of permeable structures, such as permeable boulevard. Permeable structures allow rainwater to flow effectively and avoid accumulation, thereby turning the city into a "sponge" with resilience and capacity to absorb intense rainfall and prevent flooding.

6.2 Extreme Heat Waves

The top three approaches preferred by Shanghai residents for coping with high temperatures are also listed out in descending order based on respondents' perceived priority. The top strategy is increasing urban green space by cultivating more trees and creating urban lawns, followed by promoting green buildings, which had been pilot-tested in Shanghai. Green buildings are buildings with economic and social benefits based on the principle of sustainable development. The third approach is strengthening the control of greenhouse gas emissions. This represents a long-term perspective, where individuals and industries have awareness and together participate in living sustainable green lifestyle to reduce greenhouse gases.

ISSN 2616-5872 Vol.5, Issue 10: 63-71, DOI: 10.25236/AJEE.2023.051009

7. Suggestions for different stakeholders

7.1 Shanghai Citizens

For Shanghai Citizens, increasing individual awareness should be considered as top priority. Citizens first should raise their self-protection awareness to lower the negative impacts they would have exposed to. Shanghai citizens, especially those who work outdoors more than 10 hours, those who have underlying diseases, should pay more attention to surrounding threats caused by extreme weathers. For example, vulnerable communities should avoid going outdoor under heavy rainfall and strong heat wave.

To better acquire knowledge on climate change and extreme weathers, citizens should be encouraged to attend additional trainings on the scientific mechanics, causes, impact and countermeasures to climate. As from former data analysis, there are over 87.9% of respondents who are uncertain or have never received education or trainings on dealing with extreme weathers, indicating there is a lack of education on extreme weather adaptations. Participating in more training on such topics citizens to deal with potential emergencies faced under extreme weathers.

7.2 Government

From a government perspective, official trainings on current climate situation and extreme weather cases should be provided to publics without limitation. Governments can organize NGO to introduce environmental knowledges to publics via approach of street speech or online live talks, in order to spread over the mass media.

Moreover, the government can invest in more climate resilient urban design.The money government majorly invest in infrastructure can be partially transferred to other aspects. New investment appraisal cannot be evaluated with consideration of expenditure on SMART city.

In addition, policymakers can enact additional policies in favorable for building climate resilient city, including constructing more test points in different region. Beyond Shanghai, all cities throughout the globe should take response to climate adaptation.

7.3 Urban Designers

Urban Designers are recommended to apply different approaches for different situation specifically. This paper discussed from two extreme weather aspect, namely schemes for extreme precipitation and extreme heat. Urban Designers can also consider from this perspective: Planning city design in response to extreme weathers. While they are designing, they should also focus more on vulnerable communities by building shelters prepared for potential natural disaster and increasing climate adaptive capacity of residential area, to alleviate the harms if extreme weathers hit.

7.4 Collaboration among stakeholders

However, except from independent forces of different stakeholders, the collaboration among them is significant to the establishment of climate resilient city. Government should act as an intermediate between citizens and urban designers by conveying public demand and response to urban designers. Government can provide official environmental courses, allowing broad dissemination of knowledge of impacts of extreme weather events. Due to the increasing awareness on adapting to extreme weathers, citizens and urban designers will be more willing to dedicate to construct a climate-resilient city. To view from a long-term perspective, government should initiate a comprehensive strategy plan that take different stakeholders' interests into account. Overall, different stakeholders have to work together to implement these actions.

8. Evaluation & Conclusion

This paper focuses on urban design aiding Shanghai's vulnerable communities to adapt to extreme weather events, in which extreme rainfalls and heat are discussed explicitly as they are experienced mainly by Shanghai residents, according to the survey. The paper considers the interests of different stakeholders and classes of society and intends to find equilibrium among stakeholders. All independent parties should be equally appraised to satisfy them and form a sustainable society.

ISSN 2616-5872 Vol.5, Issue 10: 63-71, DOI: 10.25236/AJEE.2023.051009

Overall, Shanghai residents in this paper's sample perceived extreme heat as more vulnerable than heavy precipitation, revealing that more imminent action should be taken to deal with extreme heat through sustainable urban design.

For quantitative analysis, there are 330 responses in total. Through simple and group analysis, it can tell perceptions of the vulnerability of extreme weather from different perspectives. Firstly, from the gender aspect, the perception of vulnerability to heavy precipitation is higher for females than males, while the perception of vulnerability to extreme heat is similar. This result partly strengthens that females can be considered in vulnerable communities when facing climate change, but it depends on the type of extreme weather events. Secondly, responses are analyzed from the industry sector aspect. The mining industry reports the highest perception of vulnerability to heavy rainfall due to postponed schedules. The water, environment, and public facilities management industry reveal the highest perception of extreme heat vulnerability with similar reasons for their disturbed planning. It is also logical that the logistics and transportation industry is impacted mainly by extreme weather on income as their efficiency gradually falls with the increase in the intensity of extreme weather. Longer transportation is required for each package. Thirdly, analysis from socioeconomic status aspects shows a different view. Surprisingly, heavy rainfall will also affect senior management. Thus, vulnerable communities cannot only consider citizens with low-income levels but should view differently on different occasions. Fourthly, analysis through age groups indicates that the working class is mainly affected by extreme weather on incomes and reports a high perception rate of vulnerability to extreme weather.

This research also investigated climate adaptation strategies in urban design, providing a considerable scope of future green buildings for urban designers. From both survey results and qualitative analysis from the literature review, this paper analyzed three top urban design actions that can be taken from a public perspective. The top three strategies to deal with heavy rainfall are enhancing effective management of the urban drainage network, improving drainage systems in older neighborhoods, and improving the design of permeable structures. While the top three strategies to deal with extreme heat are increasing urban green space, promoting green buildings, and strengthening the control of greenhouse gas emissions. From a comparative study, strategies to deal with extreme heat are relatively more significant, which should be considered priorly. Overall, urban designers and government can consider these public demands for public building designs.

However, the limitation of the paper should also be pointed out: there is a restriction on Shanghai respondents. First, some vulnerable communities, the elderly and the young, cannot answer the online questionnaire as they do not have access to digital media. Thus, responses from those vulnerable communities have yet to be considered in this paper, which should be better designed to include all target respondents. The lack of these two age groups increases bias in their perceptions of the vulnerability to extreme weather. Furthermore, female respondents are 15% more than male respondents, which may cause gender bias. Females respond relatively more sensitively to the heavy rainfalls in their surroundings. In addition, not only Shanghai citizens experienced the environmental and socioeconomic impacts of extreme weather, but other urban and suburban cities also faced similar circumstances. Simply collecting Shanghai data may not fully reveal the issue throughout the country.

For a future investigation, different cities such as Beijing can also be considered as a case to fill out some gaps and round out the results. Thus, a further step can be worked out to compare and contrast the communities' perceptions in different geographical areas. To studies in Beijing, climate change increases the occurrence of haze, which reduces the visibility in lives.[9] Haze significantly affects Beijing citizens' life quality. How urban designs help to mitigate and adapt to smog events in Beijing can be investigated through research in Beijing locales. Researchers can also apply questionnaires to collect Beijing citizens' perceptions of the vulnerability of smog.

Overall, the paper provides empirical evidence on public perceptions of extreme weather and preferences for climate-resilient urban infrastructure in Shanghai as a climate adaptation strategy. It reviews this strategy's positive and negative impact and provides suggestions to various parties. In the short term, the government should immediately increase citizens' and urban designers' awareness of climate-resilient cities. They can provide online courses for citizens to notice green buildings while offering subsidies for green building enactment. In the long term, as citizens of the world, all countries should collaborate to combine strategies under climate change adaptation and mitigation concepts. The future planning of city design should include consideration of Goal 11 of Sustainable Development Goals (SDGs) by creating inclusive, secure, resilient, and sustainable cities and human settlements, which are the common goal for critical stakeholders across the globe.[10]

ISSN 2616-5872 Vol.5, Issue 10: 63-71, DOI: 10.25236/AJEE.2023.051009

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