

Climate Resilient City Construction from Vulnerable Perspectives

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Abstract-Climate change has triggered a series of natural disasters. It is necessary to construct climate resilient city for sustainable development. It is necessary and useful to improve city resilient ability for dealing with climate change from vulnerable perspective. According to local climate change and natural disaster characteristics, the proposals about planning climate resilient city and constructing disaster prevention and mitigation system are put forward.

Keywords-Climate Change; City Vulnerability; Climate Resilient City; Disaster Prevention and Mitigation System

The reports of the Seventeenth Communist Party of China Representative's Meeting determinates vital missions from perspectives of climate change and disaster prevention, such as enhancing ability to reply climate change, making contribution to protect global weather, reinforcing disaster prevention and mitigation. One key challenge faces the world is climate change. Climate change involves multiply aspects, such as natural resources, ecological environment, economic society, internal affairs and diplomacy, and national security. In order to improve the ability to cope with climate change comprehensively, it must update the standard about climate, economy and environmental protection. At the same time, through constructing disaster prevention and mitigation system of the climate resilient city based on scientific development perspective, it will help to improve whole society ability of disaster prevention and mitigation.

I. THE CONNOTATION AND COMPOSITION OF CITY VULNERABILITY

A. Meaning of City Vulnerability

City vulnerability involves many aspects, including the vulnerability of ecology, environment, neighborhood, energy, security and so on (Yu Xiaohong et, 2007) ^[1]. From the perspective of ecosystem, city vulnerability can be defined as the measurement of the degree of city damage and degeneration which is caused by all kinds of external pressures and interference that includes the disturbance caused by human activities and natural pressures. The analysis of city vulnerability whether underline ecosystem ^[2] or stress natural disaster ^[3] is from the angle of city risk source. Natural disaster is the manifestation of the risk source in city vulnerability while ecological environment is the root cause. The object of study about city vulnerability is hazard-affected body, which is the degree of city vulnerability caused by human activities.

B. The Connotation of City Vulnerability

The paper is about to study city vulnerability based on the background of climate change, especially natural disaster. Climate change caused by human activities results in multiply natural disaster. And climate is one of environmental factors in city ecosystem. Based on this point, city vulnerability has three

logic relationships of three elements: (1) is related to climate change; (2) is related to the problem of ecological environment caused by climate change; (3) is related to natural disaster. By analyzing the connotation if vulnerability from the internal and external reasons, the hazard-affected body of city vulnerability mainly contains the city itself, city infrastructure, city communal facilities, city communities, resident and so on. City communities and residents that are the internal causes of city vulnerability are called city in the following sections. The differences of geographic location, geological structure, population size, basic facilities and community resident set result in different degrees of city vulnerability. The external reasons of city vulnerability mainly include city ecological environment and natural disaster (Pic.1). Because of different categories, different intensities, different danger levels of ecological environment and different natural disasters, it triggers different city vulnerabilit.

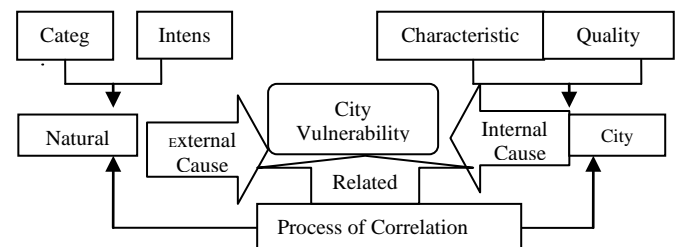


Figure 1 The External and Internal Causes of City Vulnerability

C. Composition of City Vulnerability

On the one hand, the structure of vulnerability transforms dual structure constituted by sensitiveness and responding capacity into polybasic structure that contains not only sensitiveness and responding capacity, but also exposure, adaptation capacity and so on. On the other hand, it converts sole dimensionality from the angle of natural status of internal risk or economic society status of the degree injured possibly into multidimensionality formed by nature, society, economy, environment, institution and so on. In my opinion, the structure of city vulnerability should include sensitiveness, responding capacity and resilience based on the vulnerably structure. Firstly, sensitiveness underlines nature of hazard-affected body decided by its physical property and objectively exists before the disaster happens. Secondly, responding capacity indicates the resistible capacity of socio-economic system in city during disaster generating process. Finally, resilience is measured by time, energy and efficiency that are taken to recover the status to normal after disaster occurred, which is a kind of recovery capability of socioeconomic system put particular stress on disaster occurred.

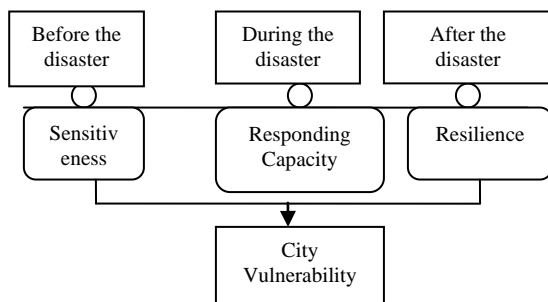


Fig. 2 The Structure of City Vulnerability

II. CITY VULNERABILITY DUE TO CLIMATE CHANGE

A. Define Climate Change

Climate is one type of average or statistic status about meteorological element and weather phenomenon for a long time. In general, we use a certain period mean and deviation value as the symbol for climate. As long as one of climate mean and deviation value shows statistical significant change, it means climate change. To be specific, the fluctuation of mean indicates climate change on average status. And deviation value increased manifests that climate status instability increases and climate unusual tends obviously. Climate change not only contains the fluctuation of mean, but also covers the rate of variability change. From the perspective of Intergovernmental Panel on Climate Change, climate change means any change of climate along with time, nevertheless change triggering factor is natural variability or human activities. On the first item of The United Nations Framework Convention on Climate Change, it defines climate change as “during a considerable period of observation, beyond natural climate change, human activities alter the composition of global atmosphere by direct or indirect way that result in climate change.” UNFCCC separate “climate change” in the aspect of changing the composition of global atmosphere which is related to human activities from “climate rate of variability” attributed to natural cause. Climate Change mainly manifests in three aspects: (1) global warming; (2) acid deposition; (3) ozone depletion. The paper uses the definition of climate change by UNFCCC which place extra emphasis on climate change caused by human activities without regard to climate rate of variability attributed by natural cause.

B. Impact of Climate Change on City

According to prediction result of IPCC's third assessment report, the global average temperature probably will rise to $1.4^{\circ}\text{C} - 5.8^{\circ}\text{C}$ at the end of this century. Although the range of warming in the future is up to detail life mode and production measures taken by human, the general variation tendency of global climate is still in the direction of becoming warm. It brings about serious impact upon the global ecosystem and every country economic social sustainable development. Climate change is not only an imperative issue about ecology and environmental protection, energy and water resources management, food security and human health, and human social sustainable development, but also a tremendous challenge which is faced by survival and development of human society. The main representation of climate change caused by human activities is artificial warm. The impacts of temperature rise are reflected in three aspects: (1) crops seed in the high latitudes of Northern Hemisphere in early spring and bushfire and insect pest put the impact on forest; (2) the death

rate in Europe related to heat wave, such as some regional transmitting media of infectious disease, pollen allergy in high latitudes of Northern Hemisphere and so on; (3) hunt and travel on the ice in the arctic regions and exercise in low elevation of high mountain region. Meanwhile, climate variation has put some impact on city as well as its system, for example living environment in mountain is faced the anabatic flood risk of glacier and lake. In addition, the rise of sea level and development of human make a large amount of regional coast to suffer much damage^[4].

C. Natural Disaster Caused by Climate Change

Meteorological disasters account for a higher proportion of natural disaster in China. The extreme meteorological phenomena are related to climate change, especially in highly relevant to climate warming. On the one hand, there is a mount of population, natural environment deterioration, high sensitiveness of natural system and human society on climate change and easily suffered by natural disasters in China. On the other hand, there are relative behindhand economic growth, low technological level, imperfect base infrastructure and lacking of effective means about resource management. Therefore, the capacity to deal with natural disaster of natural system and human society during the disaster generating process is low relatively in our country and it results in the lower capacity of post-disaster reconstruction. The natural disaster easily suffered in our country include: (1) flood disaster. According to the general headquarters of national flood control and drought relief, it reveals that direct economic loss of the whole year adds up to 711 billion Yuan and the flood disaster happens in varying degrees in almost twenty-nine Provinces on the deadline of August 24, 2009^[5]; (2) rainstorm and mudslide. The event that mudslide triggered by downpour happened in Danqu of Gansu province on August 7, 2011 makes people shock by the sight. In addition, owing to heavy rain day after day, the torrential disasters of mountain flood and mudslide occurred in many places of Sichuan province on August 12, 2011 and the direct economic loss adds up to 11.6 billion Yuan^[6]; (3) sea level rise. Our country is one of the most serious regions affected by it around the world. The average rising rate of whole sea level is 2.5 millimeters every year in China. During the years between 2004 and 2006, the whole sea level is higher than the average year, for example the whole sea level in 2006 compared with the average year exceeds 71 millimeters. Compared with the year of 2003, the whole sea level in our country trends rising during the year between 2004 and 2006 and the variation tendency of sea level on every sea area is consistent with the whole sea area^[7]. The rising sea level not only brings grave loss about land resources in coastal area, but also affects major engineering's facilities of coastal areas and coastal city development seriously. Those natural disasters and the others caused by else climate change are all the external cause of city vulnerability. They increase the intensity of city vulnerability.

III. VULNERABILITY OF CLIMATE RESILIENT CITY : TAKE NINGBO FOR EXAMPLE

A. Tendency and Characteristics of Climate Change in Ningbo

1) The Tendency of Climate Change in Ningbo

Since the beginning of 2010, numerous disasters have taken place in many places. For example, every country in Europe

encountered snowstorm and severe winter that could be seldom seen in fifty years; America suffered rare ice storm weather; Australia got stuck in more severe status; the northern part of our country suffered the most serious drought in fifty years. As one part of the global village, Ningbo also has met infrequent hail weather in the corresponding period. According to the fourth assessment report (2007) of IPCC, the main feature of global climate change has converted into becoming warm in the recent 100 years, for example global surface temperature of annual mean rises up about 0.74°C from 1906 to 2005. And fifty years on, the tendency of becoming warm is more obvious, even rising 0.13°C every year. Based on statistical data, as well as global climate, climate change in Ningbo is also obvious, especially the years between 1980 and 2005 rise in temperature presents 0.74°C every ten years that obviously goes beyond the range of global mean. Although there has been not fundamental change about the tendency of annual precipitation in Ningbo, the rainy days present the decreasing tendency, especially number of days sprinkling. While number of days above moderate rain present increasing tendency, namely, the rate of strong rain occurred in Ningbo increases. At the same time, the annual mean wind speed and windy weather above eight in Ningbo presents decreasing tendency, but number of typhoons that affect Ningbo present increasing trend slowly. Besides, foggy weather decrease, cloudy weather increase and snowy days decrease obviously in Ningbo^[8].

2) The Feature of Climate Change in Ningbo:

Take the year of 2010 as an example. The whole average temperature between January and June in 2010 is 13.7°C that is 0.6°C taller than the corresponding period. Besides, the whole average precipitation is 912.4 millimeter that overtops 26.4%. In the first half of the year, the climate change in Ningbo has the following characteristics: (1) windy and rainy weather appears frequently. It has five time of long windy and rainy process. There are January 31 to February 11 (eleven rainy days), February 25 to March 9 (twelve rainy days), March 30 to April 15 (sixteen rainy days), May 13 to May 23 (nine rainy days) and June 14 to July 1 (sixteen rainy days); (2) infrequent cold wave weather. It took place in January and February this year in Ningbo that is infrequent in recent years. During the process of cold wave in January 20 to 22, the range of temperature reduction reached 10.7°C in 24 hours and 14.7°C in 48 hours. The lowest air temperature was 2.1°C . Besides the other happened in February 9 to 11 that made the range of temperature reduction reached 13°C in 48 hours and the lowest air temperature is 1°C ; (3) floating dust weather affects air quality. Owing to the influence of sand storm weather in the North, Ningbo had appeared the most serious floating dust weather in March 21 since April 2, 2007. It resulted in high air pollution index about five hundred and serious polluted air quality^[9].

B. Analyze Nature Disaster and Features Caused by Climate Change in Ningbo

1) Nature Disaster in Ningbo

It is triggered mainly due to some severe weather, for instance flood, waterlog, seawater invasion and landslide. Typhoon always happens in the month between July and September and the average frequency is 2.8 every year. The strong typhoon (rainfall at least reaches 200 millimeter) occurs every few years and it bring serious damage to Ningbo. Since the year of 1953, there were four strong typhoons that have

took place in Ningbo. Followed by them, subsequent rainstorm brought huge damage to Ningbo. For example, No. 5612 typhoon brought huge damage to Xiangshan Country and Number 9711 one caused capital loss over 45 billion Yuan. The frequency of occurred rainstorm is within twice to three every year and it happens in the rainy season from June to the early July and typhoon period from August to September concentrated, especially, the frequency in September is higher. From the angle of space distribution, there are more rainstorms in Ninghai country than the others. As we all know, rainstorm usually causes flood disaster, such as the flood disaster caused by it in July 30, 1988 made more than one hundred people died. In addition, drought usually happens in the month from August to September. And after rainy days, especially in Ninghai country, some mountainous areas like Xiangshan country encounter once every 2-3 years, while the others meet once every 4-5 years.

2) The Frequency and Strength Analysis of Climate Change

According to the tendency and feature of climate change in Ningbo, I am going to analyze city vulnerability caused by climate change and its subsequent natural disaster for Ningbo. The paper uses frequency and severity of change as the symbol of climate change and its subsequent natural disaster. Based on the above analysis, the following conclusions can be drawn in Ningbo. Firstly, the frequency and severity of occurred typhoon are less. Secondly, the frequency and severity of hot wave and rainstorm are higher. Thirdly, although the frequency of drought is higher, the severity is lower. Finally, the frequency of snowstorm and flood is less, but the severity is higher.

C. Construct Climate Resilient City :Take Ningbo for Example

1) Aggregate Analysis for City Vulnerability in Ningbo.

Ningbo is located in the southern tip in Yangtze River delta of the middle coastline of the Eastern in Chinese mainland and owns long coastline and lots of islands. It has nature disaster in the past, such as typhoon, secondary disaster caused by it, flood, waterlog, landslide, and seawater invasion. According to the latest research of OECD (Organization for Economic Co-operation and Development), Ningbo is not only one of former twenty cities that exist high-risk and high-vulnerability dealing with climate change^[10], but also one of three high-danger cities around the world from the perspective of predicted exposed population and property. The city that owns adaptation capacity should understand the disaster it is facing, control the development of disaster and adapt to the influence caused by climate change by taking disaster risk management and subsequent activities. Ningbo aims at reducing vulnerability between city dealing with current nature disaster and predicted impact of climate change so as to improve the capacity to adapt to climate change.

2) Construct climate resilient city for Ningbo

a) Plan to Construct Climate Resilient City

The project of constructing Ningbo climate resilient city is aimed at forming the capacity to reduce the existing natural disasters and climate change anticipated influence and working out local action plan so as to take action in the future and merge investigative achievement into the process of

existing planning, such as the twelfth five-year plan. In the frame of climate resilient city, climate change and disaster risk management are advised to put into the main subject of city planning management. In consideration of the explicit evidence about climate change and the influence on the most impoverished community, the issue of climate change is brought into the high priority matter in development plan. From the relation among climate change, disaster risk and poverty, the attention on defensiveness about society, economy and environment should be emphasized, especially some cities that own high degree intensive property and population. Meanwhile, city administrators need to master special and partial strategy that can help them distinguish, reduce, manage and deal with risk by planning. In a word, the purpose of positive planning is to reduce its vulnerability and control potential impact about climate change and natural disaster obviously.

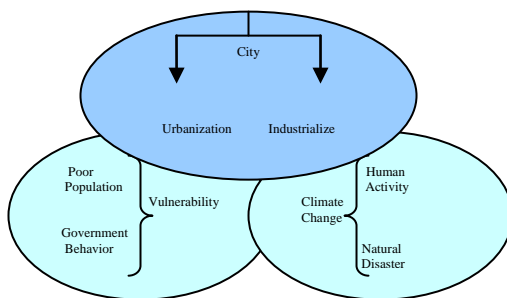


Fig. 3 Vulnerability, Climate Change and City

b) Build Disaster Prevention and Mitigation System

The government of Ningbo pays great attention to develop disaster prevention and mitigation. In order to resist natural disasters, The government of Ningbo had invested a great deal of financial and material resources in building high standard seawall, preventing flood, governing small watershed comprehensively and constructing city disaster emergency system over the past few years. By many years endeavor, almost all seawalls built has reached the standards that flood only happen once in 50 years. With the rapid development of economy, new enterprises, the scale of migrating and city size are increasing continuously, at same time, an increasing number of new disasters and secondary disasters happen frequently. For instance, the flood took place in 2007 caused that a portion of city traffic was palsied. Because existing disaster prevention and mitigation system cannot meet requirements, one of the current imperative and urgent tasks is to research how to build disaster prevention and mitigation system to promote the capacity of city sustainable development in the broader region.

IV. PATH OF BUILDING DISASTER PREVENTION AND MITIGATION SYSTEM AND CLIMATE RESILIENT CITY

A. Proposals of Building Disaster Prevention and Mitigation System

1) Enhance the ability to adapt climate change and natural disasters. In order to form national, multilayer and structured weather monitoring and forecasting network and achieve the analysis of early warning and risk about disastrous climate events, short-term and refined climate forecast about extreme climate change, grave climate phenomenon and serious impact

should be enhanced, at the same time, the accuracy rate and timeliness of grave meteorological disaster forecast also should be strengthened.

2) Strengthen the ability to adapt climate change and natural disasters. It can conduct from the following aspects. Firstly, the different levels of natural disaster emergency dispose and response systems and the graded response and local management of vertical organizational command system should be established. Secondly, the information sharing, farm-out and collaborative linkage system about horizontal departments should be set up. Finally, we should build the disaster emergency response system that government, enterprise and the common people all can take measures.

3) Accelerate the recovery capability after climate change and natural disaster happen. Government should play an important role in post-disaster reconstruction. In order to complete the job of post-disaster reconstruction recovery effectively, the government can start in the side of organization leadership, safeguard measures, implementable responsibilities and policy measures. At the same time, to make sure the job of post-disaster reconstruction carried forward, government should not only strengthen the management of capital and materials, but also deal with the relation between post-disaster reconstruction and daily work in the round.

B. Path of Building Climate Resilient City

1) From the angles of human economy and social activities, make sure that not only the characteristics of climate and the tendency of climate change about global, nationwide and region, especially extreme climate phenomenon, but also the correlations between human economic society and climate change are clearing to achieve the aim at mitigating the impact about climate change. Consequently, it is vital to establish special planning about climate change and give full play to the critical effect of planning so as to coordinate all departments to take action about climate change. Based on the planning, it also need state to reinforce legislation on climate change in order to achieve the kind of climate that is beneficial to human sustainable development through normalizing social economic activities by laws.

2) Give full play to the dominating effect of science and technology. In order to enhance the predictability of climate change and reinforce the valid and scientific response to climate change, the best way is by means of science and technology. Through studying climate change from the regular pattern, tendency and influence by it, it can be helpful to mitigate the negatives effects for human economic society caused by climate change.

3) Enhance the disaster prevention and mitigation ability for climate resilient city. The ability to answer climate change and defense extreme climate disaster is one important aspect to reflect the standard of constructing harmonious society and the comprehensive national power of the state in the next 20 years. Therefore, it is urgent to bring the response of climate change and disaster prevention and mitigation within national security system. It is also essential to mobilize societal forces to strengthen the ability of disaster prevention and mitigation and extreme climate disaster defense so as to reduce the risk of climate change and improve the capacity in the field of agricultural production, water resource safeguard, public health and so on to adapt to climate change.

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