

# Research on the Causes and Prevention Measures of Urban Waterlogging

Xiaoxian Lu<sup>1</sup>, Xiaoqing Gao<sup>2\*</sup>

<sup>1</sup> Duihekou Reservoir Management Center of Deqing County, Huzhou 313200, China;

<sup>2</sup> School of Hydrology and Water Resources, Hohai University, Nanjing 210003, China

\* Corresponding author e-mail: 107988173@qq.com

**Abstract.** Flood disaster is one of the major natural disasters in China, due to the influence of monsoon climate, seasonal distribution of precipitation and unbalanced spatial distribution, urban flood disasters in China are prone to occur frequently, endangering the safety of life and property of urban residents, and also affecting the safe operation and sustainable development of cities. Therefore, the prevention and control of urban waterlogging is not only a major livelihood project, but also a major development project. In view of the repeated failures of urban waterlogging prevention and control in China, this paper analyzes the causes of urban waterlogging from four aspects: climate change, urban expansion, drainage system, and emergency rescue, analyzes the mechanism of urban waterlogging from the perspective of disaster system theory, and finally summarizes the coping strategies of urban waterlogging based on four aspects: stormwater management, institutional mechanism, engineering construction, and emergency management, in order to provide reference and reference for urban waterlogging control.

**Keywords:** urban waterlogging, causes of waterlogging, waterlogging mechanism, hazard analysis, coping strategies.

## 1. Introduction

At present, China is in the stage of rapid urbanization, but urban waterlogging disasters occur frequently, causing serious economic losses and casualties, which has become a common concern of all sectors of society. Under the combined effect of human activities and natural environment anomalies, the risk and damage rate of urban waterlogging in China continue to rise. According to the Ministry of Housing and Urban-Rural Development, from 2008 to 2010, 62% of cities of our country experienced waterlogging, 137 cities experienced waterlogging disasters for multiple times, and 57 cities had a maximum water accumulation time of more than 12 hours. According to the “China Flood and Drought Disaster Bulletin” issued by the Ministry of Water Resources, from 2008 to 2018, the average number of people who died from floods was about 760 per year, causing direct economic losses of 211.95 billion yuan [1]. Urban waterlogging has become a focus of attention at the national strategic level. Therefore, this paper reviews and summarizes the causes, mechanisms, and coping strategies of urban waterlogging in China, in order to provide a reference for the study of waterlogging disasters and urban disaster prevention and mitigation [2-3].

## 2. Analysis of the causes of urban waterlogging

### 2.1 Impacts of climate change

First, climate change has led to more frequent and intense extreme rainfall events. Increased rainfall intensity can exceed the capacity of urban drainage systems, preventing water from draining out quickly, leading to waterlogging. Second, climate change is leading to an exacerbation of the urban heat island effect, in which cities are hotter than surrounding farmland and suburbs. This leads to the formation of an atmospheric stability layer, making it easier for rainfall to concentrate within the city, increasing the risk of waterlogging. Thirdly, the frequency and intensity of urban rainstorms, the increase of impervious area caused by rapid urbanization construction, and the frequent occurrence of extreme weather are important reasons for the formation of urban

waterlogging, and due to the comprehensive effects of urban population density, heat exhaust from factories and vehicles, and the release of residents' domestic energy, heavy rainfall often occurs in cities, which in turn causes waterlogging. In addition, climate change is causing global sea levels to rise, which is a huge threat to low-lying cities. Rising sea levels will lead to higher river levels and more tidal impacts, increasing the risk of urban waterlogging [4].

## 2.2 Effects of Urban Expansion

First, urban expansion usually requires a lot of land development and construction, which causes large areas of land to be covered with hard materials such as cement and asphalt, reducing the natural permeability of the surface. Rainwater cannot quickly seep into the soil, but flows into the drainage system, increasing the load on the urban drainage system, which is easy to cause water accumulation and waterlogging.

Second, urban expansion often requires the filling of natural water bodies such as lakes, rivers, and wetlands, which reduces the city's natural water storage and buffering capacity. Natural water bodies can absorb and store large amounts of rainwater and release it during the rainfall, reducing the city's flood risk. When these natural water bodies are destroyed or disappear, the risk of urban waterlogging increases. Thirdly, urban expansion often requires large-scale land formation and filling works, which alter the original topography and topography. Changes in topography can lead to blockages in water flows, alter water paths and velocities, and increase the risk of urban waterlogging.

## 2.3 Effects of the Drainage System

First, the pipes, sewers, and rivers in the drainage system may be clogged or damaged, preventing the flow of water from flowing smoothly. This can lead to rainwater accumulating on roads and low-lying areas, increasing the risk of urban waterlogging. Second, the capacity of the drainage system may not be able to meet the needs of heavy rainfall. If the drainage system is not designed to handle large amounts of rainwater, then in the event of heavy rain or sustained rainfall, the flow of water may exceed the carrying capacity of the drainage system, leading to urban waterlogging. Thirdly, there may be problems in the construction of the drainage system, such as the unreasonable layout of the pipes, the improper selection of the location of the drainage outlets, etc. These problems can cause water to not flow efficiently to the outfall, increasing the risk of urban waterlogging. Finally, the drainage system needs regular maintenance and cleaning to ensure that it is functioning properly. If not maintained in time, debris and sediment in the drainage system can clog pipes, affecting the flow of water and increasing the risk of urban waterlogging.

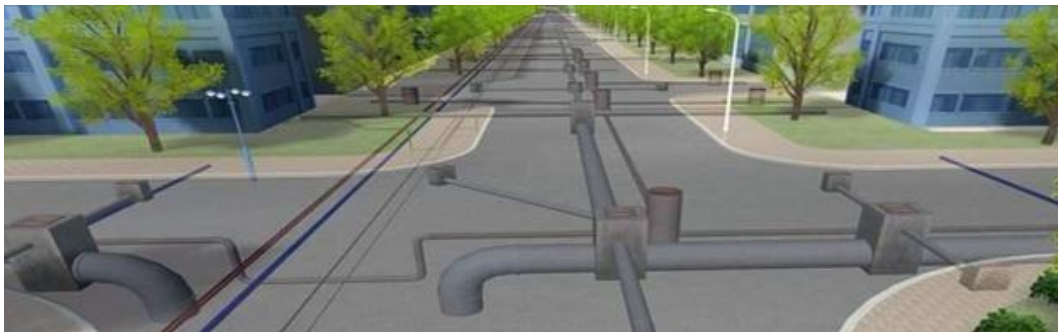


Fig.1 Schematic diagram of urban drainage pipeline system

## 2.4 The impact of emergency rescue

First, if emergency rescue management is inadequate, the relevant departments may not be able to obtain information on waterlogging incidents in time and take swift action. This will lead to delays in rescue operations, making the problem of waterlogging even worse. Second, the lack of emergency rescue management may lead to a lack of effective coordination and cooperation among

relevant departments. In the event of waterlogging, the coordinated action of multiple departments is required to effectively carry out rescue and rescue work. If there is no effective communication and cooperation mechanism between the various departments, it will lead to chaos and inefficiency of rescue operations.

Thirdly, waterlogging events usually require professional knowledge and technical support to effectively carry out rescue and drainage work. If the emergency rescue management is insufficient, the relevant departments lack the necessary professional knowledge and technical means to deal with the complex waterlogging situation, resulting in poor rescue work. In addition, in the event of waterlogging, the human, material and financial resources required for rescue and rescue are very valuable. Inadequate emergency management can lead to an uneven distribution of resources, and some areas or communities may not receive timely assistance, exacerbating the impact of waterlogging. Finally, emergency management should include waterlogging prevention and mitigation. If this is not done sufficiently, the problem of urban waterlogging will become more frequent and severe. Disaster prevention and mitigation efforts include improving urban drainage systems, strengthening urban planning and construction, and raising residents' awareness of disaster prevention [5].

### **3. Formation Mechanism of Urban Waterlogging**

Urban waterlogging disasters are the result of the interaction between disaster-bearing bodies, disaster-producing environments, and disaster-causing factors [6-7]. First of all, in terms of disaster-bearing bodies: the biggest feature of disaster-bearing bodies is vulnerability, which causes damage to the disaster-bearing environment due to the influence of human activities, and then stimulates the increase of the intensity of disaster-causing factors. Secondly, in terms of disaster-bearing environment: the most important feature of disaster-pregnant environment is exposure and sensitivity, which can easily be affected by human activities and natural factors, so as to increase the intensity of disaster-causing factors and reverse stimulate the disaster-bearing body to improve its ability to defend against disasters. Finally, in terms of disaster factors: climate change has led to an increase in heavy rainfall and extreme weather events, and the intensity and duration of precipitation are high, which destroys the safety of the disaster-bearing environment and disaster-bearing bodies, and increases the risk of urban waterlogging. Therefore, to understand the causes of urban waterlogging, it is necessary to study them from multiple perspectives, find out their internal laws, and formulate flood prevention strategies.

## **4. Hazard Analysis of Urban Waterlogging**

### **4.1 Economic and Safety Hazards**

Waterlogging can lead to damage to the foundation of the house, loss of property ingress, traffic paralysis affecting the logistics industry, and losses caused by the shutdown of construction sites. Waterlogging will bring greater drainage pressure to the city in a short period of time, affect the flood flow of the downstream city, and bring drainage pressure to the downstream city. Waterlogging will seriously affect the road drainage system, paralyze traffic, cause inconvenience to citizens, and even threaten life safety.



Fig.2 A real scene of city waterlogging

#### **4.2 Sanitation and environmental hazards**

Waterlogging may cause overflow pollution from the confluence system, and soaking garbage for a long time will produce foul odors, which will have a serious impact on the surrounding water bodies; Long-term flooding conditions will have a serious impact on the growth of animals and plants, and damage the surrounding ecological environment. After waterlogging, a large amount of garbage and waste is washed into the water, and the rapid increase of bio-source pollution and industrial waste that cannot be treated in time may cause serious chemical pollution.

#### **4.3 Other hazards**

The city is in a system with an extremely fragile ecological environment, and the occurrence of urban waterlogging is not conducive to the sustainable development of the city.

### **5. Strategies for coping with urban waterlogging**

#### **5.1 Coping strategies based on stormwater management**

First, build rainwater harvesting systems, including rainwater collection ponds, rain gardens, etc., and direct rainwater to these systems for storage and utilization. The collected rainwater can be used for plant watering, public toilet flushing, road washing, etc., reducing the burden on the city's drainage system. Second, increase the coverage of urban green spaces, including parks, flower beds, grasslands, etc., which can absorb rainwater, reduce runoff, improve soil permeability, and reduce the risk of urban waterlogging. Thirdly, the construction of flood storage facilities, such as flood storage ponds and flood storage lakes, is used to temporarily store large amounts of rainwater, slow down the flow of rainwater into the urban drainage system, and reduce the risk of waterlogging.

#### **5.2 Institutional Mechanism-based Coping Strategies**

First, improve the urban planning and construction management system to ensure that the urban infrastructure construction meets the requirements of flood control and drainage. Strengthen flood prevention considerations in urban planning, rationally plan drainage systems and green space coverage, and ensure urban drainage capacity and soil infiltration capacity. Second, clarify the responsibilities of governments at all levels and relevant departments in the prevention and control of urban waterlogging, and establish and improve coordination mechanisms and work processes. Strengthen cross-departmental and cross-industry cooperation and coordination to form a joint force to deal with urban waterlogging. Thirdly, formulate and improve the relevant laws, regulations and technical standards for the prevention and control of urban waterlogging, and clarify the rights and responsibilities of all parties and the standard requirements. Strengthen the research and development and popularization of urban waterlogging prevention and control technology, and improve the scientific and effective prevention and control of urban waterlogging.

### 5.3 Coping strategies based on engineering construction

First, ensure that the design and layout of the urban drainage system are reasonable. This includes the construction of stormwater pipes, rainwater harvesting facilities and reservoirs. These facilities can collect and store rainwater, reduce runoff, and reduce the load on the drainage system. Secondly, ensure the smooth and stable operation of the drainage network. Regularly inspect and clean drains to prevent water accumulation and blockages. At the same time, the expansion and renovation of the pipe network should be carried out in a timely manner to improve the drainage capacity. Thirdly, in road construction, appropriate slopes and drainage facilities are adopted to ensure that the road can be drained quickly. For example, set up stormwater outlets, rainwater collection ditches, and stormwater runoff ponds. Finally, in the design and construction of the building, consider the setting of the drainage system. This includes the installation of stormwater pipes, rainwater harvesting facilities and waterproofing measures to ensure that rainwater can be quickly removed from the surrounding buildings.

### 5.4 Countermeasures based on emergency management

First, establish an urban waterlogging monitoring system, including rainfall monitoring, water level monitoring, pumping station operation monitoring, etc. Modern technologies, such as remote sensing and satellite imagery, are used to monitor rain and water conditions in real time and warn of waterlogging risks in a timely manner. Second, establish a sound emergency plan for urban waterlogging, and clarify the division of responsibilities and emergency measures. Strengthen the construction and training of emergency rescue teams and improve emergency response capabilities. In the event of waterlogging, the emergency plan should be activated in a timely manner, and the evacuation, rescue and rescue work of personnel should be organized. Thirdly, after the waterlogging event is over, assess the damage in a timely manner and develop a recovery plan. Strengthen public awareness and education to improve residents' awareness of self-protection and coping ability [8].

## 6. Conclusions and Suggestions

This paper summarizes the causes, mechanisms and coping strategies of waterlogging: (1) Urban waterlogging is the result of a combination of multiple factors [9], including the aging and insufficiency of drainage systems, and the lack of timely emergency warning. The impact of climate change on urban waterlogging is becoming increasingly prominent, and the frequency and intensity of heavy rainfall are increasing, which puts forward higher requirements for urban drainage systems. (2) Urban expansion affects the natural water cycle of the city, changes the disaster-bearing body, disaster-causing factors and disaster-pregnant environment, and increases the risk of waterlogging. (3) In dealing with waterlogging, the concept of flood control in China has changed, focusing on the combination of engineering and non-engineering measures, but it still faces challenges in the specific implementation of system, regulations and technology. In short, urban waterlogging control is a systematic project, which requires the cooperation of the government, experts, and the public. We must always adhere to the people-centered, adhere to the harmonious coexistence of man and nature, regard the city as an organic life, and take the governance of urban waterlogging as an important task to ensure the safe development of the city.

## References

- [1] Ren Jianchao, Xie Yongbo, Liu Hui, etc. Research on urban waterlogging prevention and control strategy under the background of sponge city[J]. Water Resources Planning and Design, 2020(11):35-38+105.
- [2] Zhao Chaohui, Wan Jinhong, Zhang Yunxia, etc. Review of the Characteristics, Causes and Governance of Urban Flood in China[J]. Journal of Catastrophology, 2023,38(01),220-228.

- [3] Fu Le, Zhang Shiyuan. Design Essentials and Case Analysis of Urban Waterlogging Control System[J]. Science Technology and Industry, 2022,22(01),236-240.
- [4] Lu Yongqing, Yan Yan, Ding Ding, etc. Trends of extreme precipitation in China and their influence on urban drainage pressure[J]. Acta Ecologica Sinica: 2018,38(05),1661-1667.
- [5] Zhou Hong, Liu Jun, Gao Cheng, etc. Analysis of Current Situation and Problems of Urban Waterlogging Control in China[J]. Journal of Catastrophology, 2018,33(03),147-151.
- [6] Du Zhiqiang Gu Jieye. A Domain Ontology Construction Method of Disaster Chain-Case Study of Rainstorm Flood Disaster Chain[J]. Journal of Spatio-temporal Information, 2016,23(04),7-13.
- [7] Lu Wengang. Problems and Suggestions on Guangzhou Urban Flood Disaster Management[J]. Chinese Public Administration, 2014,(01),106-108.
- [8] Peng Dongzhi. Analysis of urban residents' ability to respond to regional major accidents [J]. Statistics & Decision, 2004,(11),47-48+3.
- [9] Pu Xiaofen. Discussion on the causes of urban waterlogging in China and the ways of landscape mitigation[J]. Science and Technology Innovation Herald, 2016,13(2):72-73.