

# Experience and enlightenment of urban waterlogging disaster prevention in foreign countries

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**Abstract:** As an important type of disaster, urban waterlogging has become a great challenge for urban governance around the world, threatening people's lives, health and safety and property safety. The United States, Britain, Japan, Singapore and other countries have accumulated rich experience in the prevention and control of urban waterlogging. Foreign countries have strengthened the prevention and control of urban waterlogging disasters mainly in terms of condensing concepts and awareness, improving laws and regulations, paying attention to planning and construction, using scientific and technological means, strengthening knowledge popularization, strengthening risk assessment and early warning, implementing project-driven and active participation of multiple subjects, and achieved certain results. It is of reference and enlightening significance. In terms of the current and future urban waterlogging prevention and control in China, we should continuously improve the concept and awareness of urban waterlogging prevention and control, scientifically and systematically plan and construct the city; comprehensively use various policies and scientific and technological effective means to improve the effectiveness of urban waterlogging prevention; pay attention to waterlogging Risk assessment and disaster early warning work to realize the advancement of waterlogging disaster governance; strengthen knowledge promotion, popularization and multi-subject participation, create a joint force in urban waterlogging prevention and governance, and promote the modernization of urban waterlogging management systems and capabilities.

**Keywords:** Urban waterlogging; Disaster prevention and control; Urban governance; Urban emergency management.

## 1. Introduction

As the global climate continues to change, natural disasters occur frequently and easily.. Coupled with the continuous acceleration of the urbanization process, municipal planning, construction, management, etc. do not match the speed of urban development, which also makes the risk of urban waterlogging continue to increase. It is generally believed that urban waterlogging has become another major "urban disease" after "traffic congestion" and "environmental pollution". It is a severe challenge that all countries in the world need to face together. At present, China's permanent urban population has exceeded 800 million, and the urbanization rate has exceeded 60.6 percent, creating a miracle of urbanization in the world. In recent years, urban waterlogging disasters occur frequently in China, causing huge casualties and property losses, disturbing the safety of people's lives and property and the high-quality sustainable development of cities, and restricting the level of urbanization and urban development (as shown in Table 1). Urban waterlogging control is not only a major livelihood project, but also a

major development project. General Secretary Xi Jinping stated that we must adhere to "the people are supreme, life is supreme" and "put the protection of the people's lives and property safety in the first place." In 2021, the central government issued "Implementation Opinions of the General Office of the State Council on Strengthening Urban Waterlogging Control" (Guobanfa [2021] No. 11) and other relevant documents, to accelerate the overall requirements of urban waterlogging control, waterlogging prevention and drainage systems, and drainage management levels, waterlogging control work, and waterlogging prevention safeguard measures have been deployed (as shown in Table 2). (as shown in table 2). In July 2021, Henan province and other places suffered continuous heavy rainfall, Zhengzhou and other cities experienced severe waterlogging, some rivers exceeded the warning level, some reservoirs broke their DAMS, and some railways were suspended and flights were cancelled, especially the flooding accident of Zhengzhou Metro Line 5, causing heavy casualties and property losses, making urban waterlogging and its related prevention and control problems become the focus of public opinion and

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academic circles. Systematic research and analysis of relevant foreign experience is of great significance to improve China's urban waterlogging disaster management system and capacity modernization.

## **2. Concept, cause and harm of urban waterlogging**

### **2.1 The concept of urban waterlogging**

Urban waterlogging and flooding are collectively referred to as "floods", both of which are important types of disasters caused by precipitation. They are both a phenomenon caused by the excessive accumulation of water in a specific area, and they are closely related to each other. It is generally believed that urban waterlogging refers to the extreme phenomenon of water accumulation in cities due to heavy precipitation or continuous precipitation exceeding the urban drainage capacity [1]. Some scholars also believe that urban waterlogging is a response to changes in the process of urban rain flood, and it is one of the water disasters that threaten urban security [2].

### **2.2 Causes of urban waterlogging**

Domestic scholars have conducted relevant researches on the causes of urban waterlogging. For instance, Che Wu [3] believed that unscientific planning, design and standard of urban drainage system were the main causes of urban waterlogging. Xie Yingxia [4] believes that the causes of urban waterlogging are related to urban planning and land use. Ye Bin et al. [5] believe that poor urban construction, management and citizens' awareness of environmental protection could easily lead to urban waterlogging. Hu Yinghui [6] out that the frequent occurrence of urban waterlogging in China is due to the mismatch between planning, construction and management and the speed of urban development, as well as the imperfect regulations and meteorological service system, which restrict the level of waterlogging prevention and control of the government and amplify the impact of disasters. Shao Rui et al. [7] believe that increased frequency of short-duration heavy rainfall in cities, insufficient municipal engineering infrastructure, and limitations of geographical factors and flood control technical factors are likely to cause insufficient drainage capacity of the urban road network, serious flood disasters, and damage to the traffic system. Problems caused the city's functions to fail to operate normally during the disasters. Zhang Jianyu et al. [8] proposed that ground hardening, unreasonable land use, and structural degradation of river network changed the underlying surface conditions such as original topography, landform, vegetation, etc., significantly reduced the capacity of urban precipitation regulation and storage, and significantly shortened the confluence time, thus leading to urban waterlogging. Zhang Dongdong et al. [9] believed that urban waterlogging is the result of both natural and social factors: natural factors mainly refer to extreme rainstorm weather brought by climate change; social factors mainly refer to the low level of engineering

construction in the process of urbanization. This leads to urban waterlogging.

This study considers that urban waterlogging disasters are the result of multiple factors: both direct and indirect causes; both subjective and objective reasons. In addition, natural factors, social factors and human factors may cause urban waterlogging. Such as global warming and ecological environmental damage caused by the extreme weather, urban terrain structure and permeability of displacement, city planning design and construction, urban management and disaster management level, infrastructure, weather service level, the complement of the mass consciousness and ability, emergency support capability of disaster prevention and mitigation are directly associated with urban waterlogging.

### **2.3 The hazards of urban waterlogging**

Urban waterlogging will cause great impact and damage to the safety of people's life and property, the order of production and life, and the ecological environment. For example, urban waterlogging can cause damage to urban buildings, plant facilities, transportation facilities, water conservancy facilities, power facilities, etc. [10], paralyze transportation and logistics, and cause great impact or loss to the normal operation of urban industries and people's social life [11], and even interrupt social and economic activities. In terms of ecological environment, once urban waterlogging occurs, drainage pipes and sewage pipes are not discharged in a timely manner, which causes pollutants and garbage to stay on the ground and pollute urban water bodies with water flow and bring pollution to surrounding water bodies [12]. The fragile urban geological conditions continue to deteriorate, which will have a serious impact on the growth of animals and plants, not only polluting the sanitation of the entire city, but even destroying the ecological environment [13]. In short, urban waterlogging is harmful to both short-term and long-term urban development, and attention needs to be paid to its prevention and control work.

## **3. Methods of urban waterlogging disaster prevention and control in foreign countries**

### **3.1 Urban waterlogging disaster prevention measures in the United States**

The United States is a country with high incidence of natural disasters, which mainly include floods, storm surges, tsunamis, earthquakes, typhoons and landslides. Waterlogging is one of the important disaster types. It has taken the following measures in urban waterlogging disaster prevention and control:

First, the United States has clarified relevant concepts, strategies and paid attention to source control. Since the 1970s, it has successively put forward the best management measures (MBPs), low impact development (LID) and green infrastructure (GI) for waterlogging disaster management, focusing on source governance. The best management measures (MBPs) have become the comprehensive measures of waterlogging disaster

management [14], which can be divided into engineering and non-engineering measures. The former emphasizes on the runoff control process as the core and prevents waterlogging with the help of engineering facilities construction. The latter focuses on improving laws and regulations and publicity and education, highlighting prevention, governance and accountability [15]. Low impact Development (LID) takes the site hydrological cycle as a whole, emphasizes the planning and design stage. Various small, scattered and practical technical measures should be used to maintain or restore the site hydrological ecological cycle before development. So as to solve the comprehensive problem of rainwater system economically and efficiently. Green Infrastructure (GI) emphasizes making full use of natural rainwater storage facilities. Such as existing urban green Spaces, parks, lakes and wetlands to reduce the rate of surface hardening and the pressure of surface runoff and urban drainage system [16].

Second, improve the urban prevention and control system to ensure scientific measures. At present, the United States has a relatively mature and perfect urban flood control system in the world, focusing on the implementation of regulatory, adaptive and emergency scientific measures [17]. Regulatory measures include mandatory engineering measures and guiding engineering measures. The former standardizes the installation and construction standards of engineering facilities through relevant laws and regulations. The latter is mainly to use smart technology and green engineering materials in urban construction to avoid or weaken the purpose of flood. The adaptive strategy attaches importance to natural ecological protection and restoration, emphasizes the harmonious coexistence of urban construction and natural environment, attaches importance to enhancing the enthusiasm of communities and people to participate in flood control affairs, and promotes their participation in community planning, public facilities allocation and the publicity and popularization of flood control and disaster relief knowledge. Emergency response strategies mainly include building advanced flood monitoring and early warning system, effective disaster relief system, perfect flood insurance system and so on. The Flood insurance plan of the United States is based on the flood risk map approved by the government and enforced by law, with detailed regulations on the insured people, responsibilities of government agencies at all levels and insurance rates.

Third, establish hydrological control indicators and improve the standard system. According to the surface runoff of each state and its impact on urban environment, ecology, water resources and water security, the United States is divided into an urban stormwater management hydrological control index system composed of six indicators, including early warning and forecast emergency hedging, seepage control, non-point source pollution control, small-magnitude flood control, extreme flood control and river erosion control [18]. The United States has established a standard system of urban stormwater management based on runoff volume control, which consists of source emission reduction volume control standard, river protection volume standard, floodplain flood and extreme flood volume standard, etc.,

and attaches importance to the optimization, connection and implementation of each standard [19]. These indexes and related standards play a key role in urban waterlogging prevention.

### **3.2 Urban waterlogging disaster prevention measures in Japan**

Japan is located at the eastern edge of the Asian Monsoon climate belt, with high annual precipitation intensity and concentrated rainfall time, and annual rainfall is twice of the global average [20]. Urban waterlogging is also an important disaster type. So Japan attaches importance to the following measures.

First, attach importance to urban spatial planning and improve the refinement of urban construction. On the one hand, pay attention to the construction of drainage system. Adhering to the concept of rainwater sharing, Japan emphasizes the use of natural ecological and artificial facilities to share different flows of rainwater, and improves micro-drainage system, small drainage system and large drainage system combined with sponge city construction. Tokyo, Japan, has built a perfect "big drainage system" - the urban underground drainage tunnel, which is located 50 meters below the ground, connecting the urban sewer and the river, realizing the rapid discharge of urban surface runoff, and greatly improving the urban drainage capacity of waterlogging. In order to solve the phenomenon of "flooded streets" during torrential rains in Tokyo, Japan has carried out the construction and reconstruction of sewers for more than 100 years since 1883. The sewer diameter varies from 25cm to 8.5m, equipped with facilities such as rainwater regulation pool, underground temple and underground rainwater trunk line in waterlogging areas 21 [21]. On the other hand, Japan attach importance to urban spatial planning. In Japan, airports, stations, docks, stadiums, parklands, parking lots, inter-building Spaces, squares, and roofs of large buildings are generally equipped with underground or rooftop rain storage facilities to ensure the mutual transformation of the conventional and emergency states of public facilities and enhance the resilience of urban waterlogging emergency response. Although the individual capacity of the above-mentioned facilities is small, "many a little make a mickle", and the total water storage in the region can reach thousands or even tens of thousands of cubic meters, which can be converted into a part of urban water emergency resources at critical moments.

Second, attach importance to the study of public behavior and strengthen the popularization and education of disaster prevention and mitigation. On the one hand, Japan attaches great importance to the study of public flood risk cognition and disaster avoidance behavior. Since the 21st century, the Japanese pay attention to the residents of the flood risk acceptable degree, disaster prevention activities to intend, escape behavior of the public, analyzing the relation between related factors, the residents' awareness of disaster prevention and evacuation behavior characteristics, etc. On the basis of the simulation model Japanese established the effective prediction, and developed and applied flood occurs

residents escape behavior simulation system. Most studies have pointed out that the degree of public participation will directly affect the magnitude of disaster loss, and will have a significant impact on the post-disaster social stability and reconstruction process [22]. On the other hand, Japan carries out comprehensive disaster prevention knowledge popularization and propaganda education. In order to ensure that people can respond to flood disasters in a timely and correct manner, Japan has carried out science popularization education from the central and local governments, schools, communities and other levels in a long-term and comprehensive way. Disaster prevention courses, drills and training have been set up to popularize disaster prevention knowledge and strengthen the awareness of prevention. Japan has designated September 1 as "National Disaster Prevention Day". To improve their ability to respond to disasters millions of people repeated disaster prevention training every year. When floods strike, Japan scrolls emergency messages through tram stations, television stations and disaster prevention apps. It is worth noting that the government has also opened multilingual channels for foreigners in Japan to ensure the accessibility and coverage of information.

Third, attach importance to relevant legislation and establish urban waterlogging disaster insurance system. On the one hand, Japan attached importance to legislation. The relevant laws and regulations of Japan make corresponding provisions for the prevention and control of urban waterlogging. For example, in order to give full play to the function of forest vegetation water storage, overall planning of disaster prevention and mitigation and environmental protection. In order to strengthen the construction standard of urban drainage and waterlogging system, Japanese laws have also made specific provisions [16-2]. On the other hand, Japan has improved the insurance system. At the beginning of 2020, the Japanese government required real estate practitioners to make clear whether houses have flood risk when trading real estate. Residents must purchase "flood compensation" insurance when buying a house. Relevant regulations make flood insurance as a quasi-public good and make it mandatory to reduce flood damage. In addition, "catastrophe insurance" is mostly led by the government. In Japan, when citizens are forced to take insurance for tsunami and flood, the government will provide backup deposit and reinsurance support [23].

Fourth, attach importance to the application of scientific and technological means and bring into full play the participation of multiple entities in the control of waterlogging disasters. On the one hand, Japan attach importance to the application of scientific and technological means. Japanese government pay attention to use modern technology to solve the problem of rain floods, Waseda university and other institutions according to the Japan meteorological agency observation and forecast data of rainfall, topography, rivers, and buildings in Tokyo, and combining with density and so on developed urban waterlogging disaster forecast system, the system can advance forecast rainstorm waterlogging area in Tokyo, the updated once every few minutes. And different colors to show the depth of water in different

areas. In Japan, modern scientific and technological means have been used to make "flood risk map of potentially disaster-affected areas" to strengthen river flood forecast in important cities [24-1]. The application of the above scientific and technological means is helpful to reduce the impact of urban rainstorm disaster. On the other hand, Japan values multi-agent participation. In order to do a good job in urban waterlogging disaster prevention, on the one hand, Japan attaches importance to strengthening the construction of fire department, flood control group, flood control affairs organization and rescue self-defense Force [24-2]. On the other hand, it establishes a multi-subject pattern with administrative subjects as the leading body and participation of news media, schools, communities, enterprises and social organizations [25].

### **3.3 Urban waterlogging disaster prevention measures in English**

Flooding is the most common and costly natural disaster in the UK, with more than 3 million homes and critical infrastructure at risk of flooding. The prevention and control measures of urban waterlogging disaster in Britain are as follows:

First, attach importance to policy planning and improve the flood insurance system. On the one hand, the UK attaches great importance to policy planning. The UK government published a National planning Policy Framework in 2012, which set out strict guidelines to protect people's lives and property from flooding and will not allow new projects to be built if local plans fail to meet the policy requirements. In 2014, the UK issued a series of supporting planning practice guidelines, including guidelines on flood risk and coastal change, to guide the land use planning of administrative regions at all levels and strengthen flood risk assessment and prevention [26]. On the other hand, the UK attaches great importance to the flood insurance system. The legal system of flood insurance in England has a long history, with special legislation as early as 1531. According to insurance regulations, flood insurance is taken as part of family property insurance [27]. In the 1950s and 1960s, Britain suffered from flood erosion many times. The government paid more attention to the importance of non-engineering measures. Such as flood insurance while strengthening engineering flood prevention.

Second, implementing flood control projects and attaching importance to the construction of drainage systems. On the one hand, Britain attaches great importance to the construction of flood control projects. As the River Thames flows through London, flooding can easily bring disaster to the area and threaten the safety of the city. In the 1940s, the government began to pay attention to the construction of flood control works in London. From 1975 to 1982, Britain built a key flood control tide gate to resist river flood, tide and storm surge and other threats to London city. And tide gate and downstream flood control can prevent the flood caused by the once-in-a-millennium high water level [28]. On the other hand, improve the urban drainage system. Sustainable sewerage systems have been built in the UK,

where rainwater is collected and stored locally or nearby to ensure reuse. New developments in the UK require the construction of soakholes, soakable walkways and roof greening to ensure that surface water is retained at its source as far as possible. The drainage system can also introduce rainwater into pools or basins, absorb rainwater in ponds or wetlands, and reduce the impact of urban rainwater disasters [29]. The British government attaches importance to scientific drainage through drainage system in construction planning to improve the situation of urban waterlogging in Britain [30-1].

Third, the UK attaches great importance to risk assessment and improves the flood disaster early warning mechanism. On the one hand, the UK attaches great importance to disaster risk assessment. Based on the basic principles of "coexistence with water and space for water supply", the British government carries out disaster assessment based on residents' life, sustainable urban development, annual flood risk and other factors, and takes flood risk assessment as a prerequisite for urban planning and construction. Infrastructure construction will be determined according to the flood risk level of buildings and their uses in British cities. Sensitive facilities such as hospitals, schools and emergency services should be kept away from floods. Insensitive facilities such as parks and landscapes can be allowed to be built in flood-prone areas [31]. On the other hand, the UK attaches great importance to disaster warning. The urban waterlogging prevention system in Britain is mainly composed of basic modules such as timely warning and scientific drainage [30-2]. British government departments at all levels have developed perfect emergency plans for waterlogging prevention and control and systematic and comprehensive early warning and forecasting mechanism. For example, when the probability of heavy rainfall in a city reaches 20 percent or more, meteorological authorities will issue warnings in advance to remind people to prepare for possible heavy rainfall. In the urban waterlogging emergency management plan, the local government will mobilize all kinds of emergency supplies in advance, and mobilize social organizations and the public to participate in emergency response and waterlogging management, so as to minimize the impact of disasters [16-3].

### **3.4 Urban waterlogging disaster prevention measures in Singapore**

Singapore is a tropical city-state with abundant rainfall, with an average annual rainfall of up to 2400mm and frequent floods. In the 1960s, heavy rain often turned the whole city into a country of waters, greatly affecting the life and travel of citizens. Nowadays, serious waterlogging rarely occurs in Singapore, which is related to effective control measures.

First, Singapore coordinated water supply and waterlogging control and implemented catchment plan. The Singapore government has formulated a unique catchment plan by coordinating water supply, waterlogging prevention and urban spatial planning. Two-thirds of the territory is divided into three types of catchment areas. One is the nature reserve, mainly located

in the central mountains, the land is mainly collected rainwater, do not do development. Second, river reservoir, mainly distributed on both sides of the river, to achieve the combination of rainwater regulation and storage. Three is torrential rain city collection system, it is using building roof rainwater harvesting, near the building and construction of special reservoirs through pipeline and reservoir is linked together, form the 17 tank, article 32 the artificial river, 8000 km channel with prudent "sponge" waterway network composed of drain, organic as a whole the water demand and waterlogging prevention [22-2]. In recent years, Singapore's focuses on the integration of urban space design and the construction of drainage and waterlogging control system using urban topography and original urban landscape planning.

Second, the UK attaches great importance to non-engineering measures to control waterlogging disasters and strengthens monitoring and early warning. In terms of non-engineering measures, Singapore has improved the urban drainage monitoring system, built a new urban waterlogging early warning system, improved the supporting laws, regulations and policy means, and formulated the strategic planning for public participation in urban waterlogging management to strengthen waterlogging disaster management and achieved good results [32-1]. Government departments pay attention to the use of early warning and forecast system and urban data center to develop urban waterlogging risk map, improve drainage standards in waterlogging prone areas, and effectively improve urban drainage capacity [32-2]. Third, the UK values public participation, multi-stakeholder participation and risk communication. By integrating resources through special plans or projects, Singapore has combined multiple action subjects in high-density built-up areas, completed island-wide water renewal with high quality, and strengthened public participation in waterlogging management [33]. The Singapore government attaches great importance to providing detailed and accurate early warning information to the public and strengthening risk communication on waterlogging disasters [32-3]. Promote public disaster prevention and mitigation education, embed public participation in urban waterlogging prevention and control measures regard as an important strategy for future urban waterlogging prevention and control in Singapore.

### **4. Experience and enlightenment of urban waterlogging control in foreign countries**

Abroad mainly from the consciousness of refining and improving conception, perfecting the relevant laws and regulations, formulate planning and construction standards, using the modern means of science and technology, popularization of disaster prevention knowledge, attaches great importance to the risk assessment, early warning, implement special projects driven and actively involved in promoting subject to strengthen urban waterlogging disasters prevention and control work, and achieved good effect. It has strong

indirect and enlightening significance. In terms of the current and future urban waterlogging prevention and control in China, efforts should be made in the following aspects.

#### **4.1 Improve the concept and awareness of urban waterlogging prevention and control, and do a good job in urban planning and construction scientifically and systematically**

First, condense and enhance ideological awareness. Western countries attach importance to the promotion of ideology and control of urban waterlogging prevention. For example, the concept of "low impact development" and "best management" in the United States emphasizes source management and comprehensive management, the concept of "refined management and natural and artificial rainwater sharing" in Japan, the concept of "Coexistence with water, water supply space" in the United Kingdom, the concept of integrated water supply and waterlogging prevention and control in Singapore all have very important reference significance. In terms of Chinese country's urban waterlogging prevention, Concept consciousness is the soul of the prevention and control work and important premise. Adhering to the "safety toughness" and "sustainable" concept in a whole city and sponge toughness of city construction. Adhering to a mixture of non engineering measures and engineering measures. Taking the city planning, construction and management work to be done as a whole, and Systematic thinking of the whole chain and watershed of flood is carried out to realize the "joint governance" of underground and overland space. Overall consideration will be given to the whole process before, during and after the disaster to promote the systematization, standardization and refinement of urban waterlogging prevention and control.

Second, we will systematically implement urban planning and development. In the planning and construction of urban construction, western countries take urban waterlogging disaster prevention and control as an indispensable reference factor to do waterlogging prevention and control work well in advance. For example, in the urban planning stage, the United States attaches importance to the urban rainwater circulation and storage, so achieve a harmonious coexistence between urban construction and natural environment. Japan attaches great importance to urban spatial planning and drainage system construction, as well as the transformation of conventional emergency response of public facilities. The UK has issued a planning policy framework in urban planning, and substandard projects will not be built, and urban flood control projects will be built. Singapore integrated water supply, flood prevention and spatial planning, and built a developed "sponge body" waterway network. In terms of urban waterlogging control need to draw lessons from the experience of western countries, owing to the different city in the urban planning, adjust measures to local conditions, the urban construction, urban management and the natural environment. As a whole, with a scientific, long-term planning and

operational planning guide to guide the urban construction, to effectively prevent the happening of the urban waterlogging disasters and reduce accident loss.

#### **4.2 Comprehensive application of various policies and scientific and technological effective means to improve the modernization level of urban waterlogging prevention and control**

One is to pay attention to comprehensive transport policies and regulations. In urban waterlogging prevention and control, western countries not only invest in the construction of hardware facilities but also pay more attention to the constraint function of software such as policy regulation and regulations, which provides an effective starting point for prevention and control work. For example, the Federal government and local governments in the United States have implemented comprehensive, regulatory, adaptive and stressful scientific measures in their policies and regulations to highlight prevention, governance and accountability through sound regulations. In the legislation of Japan, the relevant provisions or clauses of urban waterlogging prevention are highlighted, and a perfect urban waterlogging insurance system is established. The United Kingdom has promulgated a policy framework at the central level, based on which it has established strict planning, construction and governance guidelines, as well as a complete legal system of flood insurance. Singapore sees better regulation and policy as an important part of its "non-engineering" approach. For the prevention and control of urban waterlogging in China, the improvement of policies and regulations is not only a solution but also a way to solve the root causes. We should not only pay attention to the improvement and formulation of relevant policies and regulations, but also pay attention to the implementation and implementation of policies and regulations to provide a starting point for the prevention and control of urban waterlogging disaster.

Second, attach importance to the use of modern scientific and technological means. In order to improve the prevention and control efficiency western countries attach importance to the application of modern scientific and technological means in the prevention and control of urban waterlogging disaster. For example, the United States comprehensively uses scientific and technological means to maintain and assist the urban hydrological ecological cycle, and adopts smart technologies and new materials in urban construction to achieve the goal of economic, green and efficient urban waterlogging prevention and control. Japan uses a variety of available data to build models and develop specialized systems to prevent and control urban flooding hazards and impacts. The United Kingdom and Singapore use modern scientific and technological means as part of their non-engineering construction to improve the effectiveness of urban waterlogging control. In terms of China's urban waterlogging control, should be the problem oriented, and effective use of spatial information, modern communications, the Internet of things, artificial intelligence technology, big data, etc, to play as a whole

resources technology, analyze data, sharing information, synergy management and scientific decision of "combination", to improve the level of intelligent control and precision.

#### **4.3 Attach importance to waterlogging risk assessment and disaster early warning, and realize the advance of waterlogging disaster management**

One is to attach importance to the risk assessment of waterlogging. In western countries, the risk assessment of waterlogging disaster is regarded as an important basic work of urban waterlogging disaster management. For example, the United States, Japan and Singapore all regard disaster risk assessment as a basic part of urban disaster prevention and control. On the basis of risk assessment, they have formulated urban flood "risk map", and improved and formulated corresponding insurance system on this basis. In Japan, housing flood risk assessment information is taken as an important transaction basis in real estate sale, purchase and rental. In Britain, flood risk assessment is a prerequisite for urban construction, and risk assessment data are used in the construction of general and sensitive urban facilities. For urban waterlogging prevention and control in China, urban waterlogging risk assessment should be promoted as an important basic work to strengthen the construction of drainage and waterlogging prevention system and the management of waterlogging disaster. Through risk assessment, the probability, distribution, formation, evolution, influence and intensity of waterlogging disasters are described scientifically, and the risk map of urban waterlogging is drawn on the basis of the assessment, providing scientific basis for risk assessment, risk insurance, disaster warning, disaster management and emergency rescue.

Second, we attach importance to disaster warning. Western countries attach importance to disaster risk warning. For example, the United States established urban hydrological control indicators to provide the basis for early warning, and to build advanced flood early warning system as an important part of stress strategy. In Japan, a sensitive and efficient early warning system has been developed based on factors such as different urban topography, rivers and building density to enhance flood forecasting. In the UK, departments from the central government to local governments have set up a systematic and comprehensive early warning and forecasting mechanism to prepare for the arrival of floods, including personnel and materials. The Public Services Authority of Singapore is specially responsible for the construction of the urban waterlogging early warning system, making full use of the early warning system to effectively improve the drainage and prevention capacity of the city. In terms of urban waterlogging disaster prevention in China, on the basis of the overall emergency on-duty, rain water level monitoring, data acquisition, analysis and information sharing, timely grasp the dynamic and prepare for disasters in city early warning, early warning and across to the early warning work to make sure the important information release and safety relief work ahead of time.

#### **4.4 Strengthen knowledge publicity, popularization, and multi-subject participation to build joint force for urban waterlogging prevention and management**

First, strengthen the publicity and popularization of knowledge. Western countries attach importance to the publicity and popularization of knowledge of disaster prevention and reduction. For example, the United States and The United Kingdom regard the popularization of urban waterlogging and flood control and disaster relief knowledge as an important part of adaptive strategies and non-engineering measures, and do a good job in the popularization of relevant knowledge for community residents. On the basis of strengthening the public's understanding of urban water supply risk and research on disaster avoidance behavior, Japan carried out popular science education from various levels and attached importance to relevant training and drills to improve residents' ability of emergency response. Singapore has embedded the popularization of emergency and disaster prevention knowledge of waterlogging disaster into urban waterlogging prevention and control measures as an important strategy to promote. In terms of urban waterlogging prevention and control in China, the popularization of related disaster knowledge is the basic work. In combination with the overall disaster situation in China and the characteristics of flood disasters in different cities, on the basis of developing the characteristics of public risk awareness and disaster avoidance behavior, all sectors of society should pay high attention to disaster prevention and mitigation. We will build a three-dimensional knowledge dissemination pattern and long-term mechanism for family education, school education and social education by coordinating the government, enterprises and social forces. We should enhance the public's awareness of disaster prevention and reduction, popularize the knowledge of disaster prevention and reduction as well as the skills of avoiding risks and saving ourselves from disasters, improve the comprehensive capacity for disaster reduction at all levels to minimize the losses caused by natural disasters build a line of defense for the people .

Second, we need to promote multi-stakeholder participation. Western countries attach importance to promoting the participation of multiple subjects in urban waterlogging prevention and control, creating a pattern of "public assistance" by the government, "joint assistance" by multiple subjects and "self-help" by residents. For example, in the adaptive strategy implemented by the United States, the participation of communities and residents in planning and construction, public facilities configuration and flood control is an important part. On the basis of strengthening multi-stakeholder participation, Japan not only attaches great importance to the participation of forces such as fire control, flood control and self-defense Force rescue, but also attaches great importance to the diversified participation of media, schools, communities, enterprises and social organizations. In the urban waterlogging plan of Britain, it is clear that social organizations and ordinary people should be mobilized to participate in the emergency response and related governance work of waterlogging.

Singapore is driven by special projects to embed multi-agent participation in urban waterlogging prevention and control, and promote multi-agent participation in knowledge popularization, prediction and early warning, risk communication and other aspects. As far as China is concerned, urban waterlogging management is a systematic and three-dimensional project involving multiple subjects, which also needs multiple co-governance and holistic response. At present and in the future, urban waterlogging management needs to mobilize the enthusiasm, enthusiasm and effectiveness of participation of multiple subjects, build a government-led pattern with participation of multiple forces, and truly achieve the participation, responsibility and responsibility of everyone. At the same time, the government-led, mobilize the public participation and integrity is the biggest characteristic of our country and institutional advantages. This is not only the realize the modernization of the urban waterlogging control system and the ability to give it a strong mass base and more effective force, but also improve the urban waterlogging disaster governance efficiency of the most key link. We will promote urban waterlogging control to a new level.

**Table 1** Typical urban waterlogging accidents and losses of China in recent years

time	incident	primary cause	losses
2007.7.18	Torrential rain in Jinan	Excessive rainfall in a short period of time and inadequate drainage system in the city.	More than 30 people died, more than 170 people were injured, about 330,000 people were affected by the disaster, about 1,800 houses collapsed, about 800 damaged vehicles, about 14,000 square meters of urban roads damaged, more than 500 sets of manhole covers lost, more than 20 lines of power outage, more than 140 enterprises flooded, the city's direct economic loss of about 1.32 billion yuan

2012.7.21	Heavy rainstorm in Beijing	The cold air moving southward from the north meets strongly with the strong warm and wet air from the southwest over north China, resulting in heavy rainfall	79 people died, 163 immovable cultural relics were damaged to varying degrees, and the economic losses totaled about 11.64 billion yuan
2015.5.19	Torrential rain in Guangdong	Prolonged heavy rainfall	A total of 687,400 people were affected by the disaster, including 2 people who died and 44,400 people who were evacuated
2016.7.6	Wuhan flood disaster	Continuous heavy rainfall caused pipe gushing in yong 'an section of Yangtze River dyke	757,000 people in 12 districts of the city were affected, a total of 167,897 people were relocated, 5,848 houses of 2,357 households collapsed, and the direct economic loss was 2.265 billion yuan. Fourteen people died and one is missing
2017.5.7	Severe rainstorm in Guangzhou	The spatial and temporal distribution of heavy precipitation is highly concentrated, the duration of heavy precipitation is long, and the accumulated rainfall is large	172 houses collapsed and 6,925 people were evacuated
2018.7.16	heavy rain in Beijing	Widespread heavy rainfall, resulting in urban flooding	As of July 18, 2018, the heavy rain caused a total of 35 road



			collapses in the city
2019.4.11	Heavy rain in shenzhen	Severe convective weather, such as hail, wind, thunderstorms and heavy rainfall, caused by the intersection of warm and cold air currents	As of 1 o'clock pm on 13 April 2019, there were 11 deaths
2020.8.11	Heavy rain in Sichuan	Torrential rains and floods caused the embankment of laojiang Dam in Angu Town, High-tech Zone of Leshan city to collapse more than 400 meters against the water	Wutong bridge Guanying town tao river dike collapsed 120 meters against the water, many areas in the central city area serious waterlogging, fengzhou Island in downtown district 1020 people trapped
2021.7.20	Zhengzhou metro Line 5 water accident	A train of Zhengzhou Metro Line 5 was forced to stop in the area between Shakou Road station and Tangsi Station after water burst out of the retaining wall of the entrance line and entered the main line	Twelve passengers died after rescue efforts

**Table 2** Documents and governance Requirements of urban Waterlogging Disaster Prevention and Control issued by The State Council

Time	document name	document name
2013.4	Circular of The General Office of the State Council concerning the construction of Urban drainage and Waterlogging Prevention Facilities	Carefully check hidden danger points, take temporary emergency measures, effectively solve the problem of serious water logging; To compile and complete

		construction plans for urban drainage and waterlogging prevention facilities; In about 10 years, a relatively perfect urban drainage and waterlogging control engineering system will be built
2013.9	Opinions of The State Council on strengthening urban infrastructure Construction	The local people's governments at or above the county level shall, on the basis of the local rainfall law and the risk of rainstorm waterlogging and in combination with meteorological and hydrological data, establish a geographic information system for drainage facilities, strengthen the management of rainwater discharge and raise the level of urban waterlogging prevention and control.
2014.06	Guiding opinions of The General Office of the State Council on strengthening the Administration of Urban Underground Pipeline Construction	Water supply and drainage networks with more than 50 years of service life, outdated materials and serious leakage should be reformed to eliminate potential safety hazards. By the end of 2015, the urban underground pipeline survey will be completed, the comprehensive management information system will be established, and

		the comprehensive planning of underground pipeline will be completed
2015.06	Circular of China Meteorological Administration of the General Office of the Ministry of Housing and Urban-Rural Development on Strengthening information Sharing and Warning Information Release of Urban Waterlogging	To further strengthen urban waterlogging risk warning and information release, it is necessary to strengthen urban waterlogging information sharing, establish urban waterlogging risk warning joint consultation system and establish urban waterlogging risk warning information joint release system
2015.10	Guiding opinions of The General Office of the State Council on promoting sponge City Construction	The construction of sponge cities is emphasized, and measures such as "infiltration, stagnation, storage, purification, use and drainage" will be taken to minimize the impact of urban development and construction on the ecological environment, and 70% of the rainfall will be absorbed and utilized locally
2016.11	Circular of The State Council on printing and distributing the 13th Five-Year Plan for Ecological and Environmental Protection	We will accelerate the improvement of the urban sewage treatment system, comprehensively strengthen urban sewage treatment and the construction of supporting sewage networks, and upgrade the networks for diverting rainwater and sewage, cleaning and mixed-flow sewage

2017.01	Circular of The State Council on printing and distributing the Outline of national Land Planning (2016-2030)	We should speed up the construction of water conservancy infrastructure, strengthen the construction of emergency and standby water sources in major cities, and steadily promote the development of sponge cities
2019.03	Circular of the General Office of the Ministry of Housing and Urban-Rural Development on Urban Drainage and Waterlogging Prevention in 2019	We will strictly carry out urban drainage and waterlogging prevention responsibilities, make solid progress in urban drainage and waterlogging prevention and strengthening weak spots, and comprehensively carry out pre-flood inspections
2020.03	Circular of the General Office of the Ministry of Housing and Urban-Rural Development on The Work of Urban Drainage and Flood Prevention in 2020	Strict implementation of work responsibilities; Strengthen the investigation and rectification of potential safety hazards; Strengthen the protection of operators; Improve and implement emergency plan; To speed up the rectification work of highly vulnerable areas; Do a good job in the flood season on duty and information reporting; Strengthen publicity and guidance
2021.04	Implementation opinions of The General Office of the State Council on strengthening the control of Urban waterlogging	Accelerate the overall requirements of urban waterlogging control, waterlogging drainage system, drainage management

		level, waterlogging control work and waterlogging safeguard measures
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## Submission declaration

This work has not been published previously and it is not under consideration for publication elsewhere. Its publication is approved by all authors and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.

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