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RESEARCH REPORT OF URBAN FLOOD RISK MANAGEMENT CAPACITY



THIS REPORT SUPPORT BY UNDP PROJECT 00083985 EMERGENCY MANAGEMENT AND COORDINATION SUPPORT IN CHINA
THIS REPORT IS A COLLABORATION BETWEEN NATIONAL DISASTER REDUCTION CENTER OF CHINA AND UNDP CHINA

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Foreword

The Research Report on Urban Flood Risk Management Capability was completed with the massive support of the United Nations Development Program (UNDP) in China and the National Disaster Reduction Center of China (NDRCC) affiliated to the Ministry of Civil Affairs. It is also the crystallization of joint efforts of all participating members. In recent years, the risk of urban flood disaster in China has become increasingly prominent, posing threats to not only the people's lives and property safety, but also the sustainable economic and social development. Against this backdrop, UNDP has established *China Disaster Management and Coordination Support Project* and commissioned the NDRCC to carry out *the Research on Risk Management Capability of the Urban Flood Disaster*. Based on field investigation, this Report analyzes the current situation, problems and deficiencies of urban flood disaster management in Wuhan and Ganzhou and puts forward some suggestions to strengthen the risk management of the urban flood disaster.

The Report is divided into four chapters. The first chapter is the overview of flood disasters of China in 2016. The second and third chapters introduce the characteristics of flood disasters in Wuhan and Ganzhou by combining the city profiles and historical data of floods. Then, the characteristics, current situation and deficiencies of flood risk management are summarized from aspects of flood prevention and drainage project construction, capacity building for disaster preparedness as well as the monitoring and warning system construction. The fourth chapter offers policy suggestions to strengthen the risk management ability of the urban flood disaster.

The preparation for the Report started in January 2017 and the relevant research ensued. Throughout the project, we have been supported by UNDP China and NDRCC of the Ministry of Civil Affairs. In order to fully understand, analyze and summarize the risk management ability

of flood disaster in Wuhan City of Hubei Province and Ganzhou City of Jiangxi Province, a field research was made by Sanny Ramos Jegillos, Rajan Gengaie, Lu Aifeng, Zhang Baojun, Li Yi and Zheng Xiao during March 21-24. Our gratitude goes to the Department of Civil Affairs of Hubei Province, Department of Civil Affairs of Jiangxi Province, Jiangxi Provincial Disaster Reduction and Preparedness Center, Wuhan Civil Affairs Bureau, Ganzhou Civil Affairs Bureau and so on. They have provided massive support during our research.

The first draft of the Report was completed in May 2017. We want to sincerely thank Yang Siqun, Sanny Ramos Jegillos, Rajan Gengaie, Lu Aifeng for their valuable advice on the revision and refinement of the Report. Our special thanks go to Zhang Sujuan, Yu Mengfang and Fang Qian from UNDP China for their important advice after reviewing the Report. Finally, we would also like to take this opportunity to thank all those who have provided direct and indirect assistance to the accomplishment of the Report.

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On-site work in Wuhan



1	2	1. Meeting with relevant municipal departments such as departments of civil affairs, meteorology, water, urban construction in Wuhan
3	4	2. Inspecting the comprehensive treatment project of Wuqing Dam (section of the Qingshan Mountain) beach area
5	6	3. Inspecting sponge community redevelopment project in Xin'ao Community for sponge city construction
		4. Inspecting sponge community redevelopment project in 2 nd Gangtie Middle School for sponge city construction
		5. Inspecting the pipeline project at 2 nd drainage pump station (Jiangnan Pump Station)
		6. Reviewing records about Wuhan's highest water level in history at Hankou, juncture of Hanjiang and Yangtze River

On-site work in Ganzhou



1	2	1. Meeting with relevant municipal departments such as departments of civil affairs, meteorology, water, urban construction in Ganzhou
3	4	2. Photo at the Ganzhou Flood Control and Drought Relief Headquarter 3&4. Inspecting the drainage system in Fushougou, an old town in Ganzhou
5	6	5. Inspecting the flood prevention valve at Yongjin Gate in Ganzhou 6. Convening group seminar for discussion of the report outline

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Charter 1 :

2016 Overview of Floods in China

Multiple medium-and-large-sized Chinese cities have suffered from severe urban floods frequently. More than 200 urban floods have been troubling Chinese cities to different extents each year since 2000¹. According to incomplete statistics from journalists of China Economic Weekly, among 30 pilot cities of “sponge city” programs across China, 19 of them, such as Wuhan, Nanning, and Fuzhou, suffered from urban floods in 2016².

In 2016, the flood season arrived 16 days earlier than normal years and 45 days earlier than 2015 – the earliest in seven years. Witnessing 46 regional rainstorms, 2016 has the fourth most rainstorms since 1961; with three quarters of counties in China attacked by rainstorms, 2016 has the most days with rainstorms since 1961. Precipitation in plum rain season in the middle and lower reaches of Yangtze River is 70% more than in plum rain seasons of normal years. Yangtze River basin was hit by the severest floods since 1998, and Taihu Lake was hit by severe basin-wide flood. The widest and strongest basin-wide rainstorm since 1996 occurred in Haihe River basin, resulting in the severest floods in records in some rivers. Floods in 473 rivers across China were above warning stage, 118 were above safety level, and 51 had the highest water levels in records. As a result of intense rainfalls, near 100 cities in 26 provinces (autonomous regions and municipalities) suffered from urban floods. The heaviest rainfalls occurred in June 30 - July 4 in the South and July 18 - 21 in the North. Cities in both South and North such as Wuhan, Nanjing, Hefei, Xinxiang, Anyang, Shijiazhuang, Handan, Taiyuan were hit by severe urban floods, with serious damage dealt to life and property safety and economic and social development in disaster area. According to statistics, across China, 99.549 million

¹ “China has more than 200 urban flood every year, which is a reflection of city expansion problem” , http://news.xinhuanet.com/politics/2016-08/04/c_129203176.htm.

² “19 of 30 sponge pilot cities had waterlogging, why not see results?” , http://news.xinhuanet.com/city/2016-09/06/c_129270980.htm.

people were afflicted by floods and geological disasters, 968 died from disasters, 6.042 million relocated, and 2.845 million were in need for emergent life relief; 8.531 million hectares of crops were affected, with 1.2973 million hectares resulting in crop failure. 441 thousands houses were destroyed, another 2.155 million damaged to different extents. The total direct economic loss was 313.44 billion RMB. In overview, the situation of floods and geological disasters is obviously more severe than that in the 12th “five-year plan”, with the highest number of people being relocated emergently and direct economic losses. Hebei, Hubei, Anhui and Jiangxi were the most damaged³.

³ “Ministry of Civil Affairs issued the basic information of natural disasters in 2016” , <http://www.mca.gov.cn/article/zwgk/mzyw/201701/20170100002965.shtml>.

Charter 2 :

Urban Flood Risk Management Capacity of Wuhan

2.1 City Overview

Wuhan, located in the central part of China, is a megalopolis in the middle reaches of Yangtze River as well as the capital city of Hubei Province. It covers a total area of 8494 square kilometers and enjoys extensive river and lake systems that construct the special natural environment of Wuhan. Wuhan is the renowned “river city” in China. China’s largest river of the Yangtze River and its largest branch of Han River merges in the city and forms the spectacular scenes of the tripartite existence of Wuchang, Hankou and Hanyang. Wuhan is also referred to as “the city of one hundred lakes”, holding the size of Donghu Lake, the largest inner-city lake all across China, as well as many other lakes. Water area of the city accounts for one fourth of the total. The city of Wuhan has the sub-tropical continental monsoon climate with abundant rainfall concentrated during May to October, accounting for 73.6% of the year total. For June to August, rainfall accounts for 40% of the year total. Its multi-year average annual precipitation is 1280.9mm (average for 107 years), and highest average annual precipitation, 2105.3mm (in 1889). As for Wuhan’s GDP in 2016, it reaches 1191.261 billion RMB, 7.8% up than the previous year. And the total social fixed asset investment amounts to 709.317 billion, 2.6% down than the previous year. By the end of 2016, its permanent residents totaled 10.7662 million, with an increase of 158,500 people. Among them, 8,588,200 are urban dwellers, contributing to an urbanization ratio of 79.77%⁴.

⁴ “Statistical Bulletin of National Economic and Social Development of Wuhan in 2016” , <http://www.whjt.gov.cn/details.aspx?id=3439>.

2.2 Flood Impact on City

Flood Characteristics

Geographically, the mainstream of the Yangtze River is affected by the flood discharge from Sichuan Basin, the Dongting Lake system, the Qingjiang River and Hanjiang River as well as the backwater effect of the Poyang Lake system, hence the following characteristics of the flood during the high-water season⁵.

Long flood season

The Yangtze River and its tributaries are mainly supplied by precipitation. The time and area of the flood occurrence corresponds with the occurrence of rainstorm. Usually, the middle to lower reaches of the river experience floods earlier than the upper reaches, and the Southern part earlier than the Northern. For Sichuan Basin, Dongting Lake and Poyang Lake system, floods usually take place during May to August, while for Hanjiang, from July to October. Therefore, the flood season for Wuhan extends about six months in total.

Abundant discharge

Based on the observed data, the multi-year annual discharge of the Yangtze River in Wuhan is 712.223 billion cubic meters. The smallest annual runoff is 567 billion cubic meters (in 1972), and the largest, 1013 billion cubic meters (in 1954), the peak flow discharge is 76100 cubic meters per second. Flood discharge that passes 60000 cubic meters per second reaches 16 times per year.

High water were more frequent occurrence (before establishment of the Three Gorges)

From 1865 to 2013, water level in Wuhan has 20 times surpassed 27.00m, while only 8 times during the 100 years from 1865 to 1965, which means a frequency of about once every 13 years on average. Ever since establishment of the New China, there occurred 13 such cases, driving up the frequency to once every five years on average. Among them, 12 took place before the Three Gorges Project (9 times between 1980 to 2003), and only once after establishment of the Reservoir. Altogether, there were 14 times that the river exceeded the

⁵ “Emergency Plan for Flood Control in Wuhan City (Revised)” , <http://www.whwater.gov.cn/water/u/cms/www/201511/02103003w6n7.doc>.

warning water level.

Flood Type and Influencing Factors

Composition of the flood

The Yangtze River is categorized as the storm flood river where the gush flood can either be at whole basin or at local areas. For the section of Yangtze River in Wuhan, there are four factors affecting the flood: First, flood from the upper reaches of the Yangtze River (above Yichang); Second, flood around the Dongting Lake basin; third, flood from the numerous tributaries along the Yangtze River within Hubei province; fourth, backwater of the flood around the Poyang Lake basin⁶.

Contributing factors

- Affected by the plum rain and other changing climate trends, over the recent 20 years, the Yangtze River basin has shown more consecutive rainy years with higher volumes of rainfall in general.
- Sedimentation and reclamation along rivers and lakes lead to the drop of their regulating capabilities. The area of those Yangtze River-connected lakes from Yichang to Hukou has already shrunk from the 13450 square kilometers at the early years since establishment of the New China to the current 6600 square kilometers. Among them, the area of Dongting Lake diminished from 4350 square kilometers to 2625 square kilometers while its volume dropped down to 16.7 billion cubic meters from the former 29.3. The combined discharge of the tributaries of Dongting Lake is decreasing, with shrinking capabilities to regulate and reduce the flood peak. In 1950s, the average was 13246m³/s; in the 70s, 10182m³/s; in the 80s, only 5660m³/s.
- The increasing draining capabilities of the river ease pressure of waterlogging to a certain extent, however, it also adds to burden of the flood discharge into the Yangtze River. For example, there are already 75 drainage pump stations along the river in Hubei Province. Its designed discharge volume is 5200m³/s, and the volume discharged directly into Yangtze River on the upper reaches of Wuhan is 2900m³/s; for Dongting Lake area, large-scale drainage pump stations in existence count as 19, designed discharge volume, 700m³/s. According to calculation, every increase of 10000 m³/s of discharge in Wuhan will cause 1-1.3m up in water level. Therefore, when there comes a great flood, proper control should be imposed upon relevant drainage pump stations to ensure safety of the dam at the expense of the regional

⁶ “Emergency Plan for Flood Control in Wuhan City (Revised)” , <http://www.whwater.gov.cn/water/u/cms/www/201511/02103003w6n7.doc>.

area.

- After the Three Gorges project gets completed, sedimentation in the middle and lower reaches of the river changed, so will the storage and detention relationship of tributaries, the regulation relationship of the rivers and lakes, as well as the relationship of the middle and lower reaches of the Yangtze River. All these hydrological changes contribute to the complexity of flood prevention.

Flood Losses

In 2016, the Yangtze River witnessed the biggest flood ever since 1998. From June to July, Wuhan was affected by serious waterlogging. According to statistics, the 2016 flood affected 1.06 million people in Wuhan; 15 died from the disaster and 263,000 people were urgently relocated; with a direct economic loss of 5.3 billion Yuan.

In the plum rain season from June 19 to July 20, 2016, the precipitation in main stream of the middle and lower reaches of Yangtze River basin was 1 time higher than the average of 30 a. The persistent and intense rain during this season caused the regional floods in middle and lower reaches of Yangtze River basin in July. The main climatic factors that contributed to the intense rainfalls in this region are strong El Nino events, strong and wide subtropical ridge, 500 hPa of meridional circulation in mid-&-high altitudes, and low polar vortex index, etc.

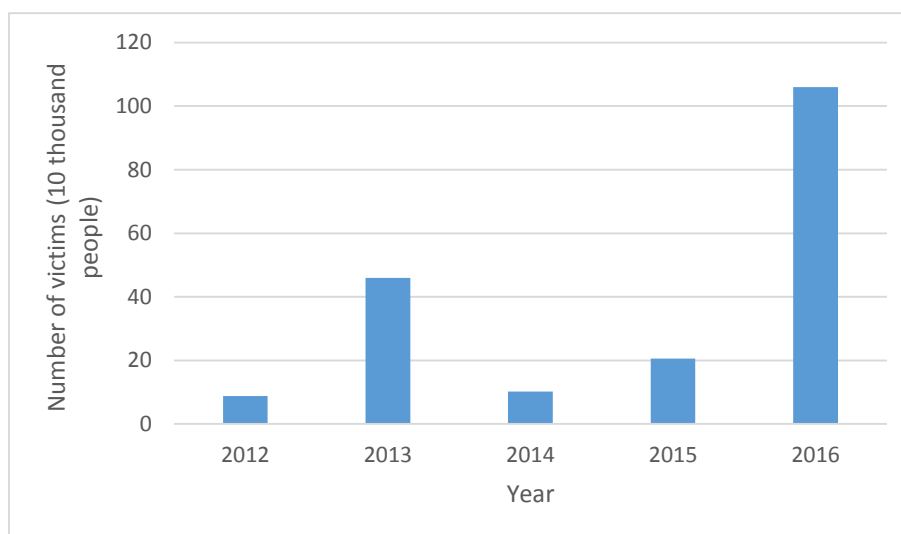


Figure 1 Number of flood victims in Wuhan, 2012-2016

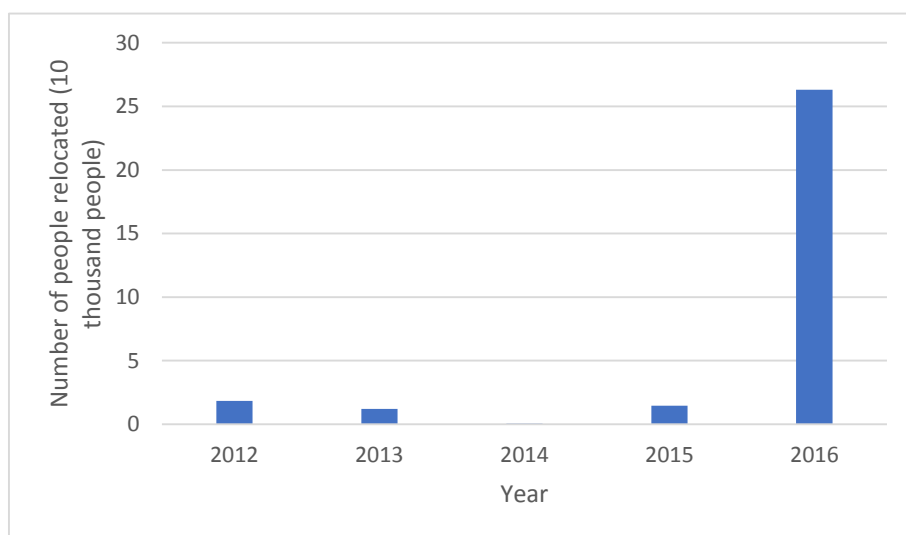


Figure 2 Number of people relocated during floods in Wuhan, 2012-2016

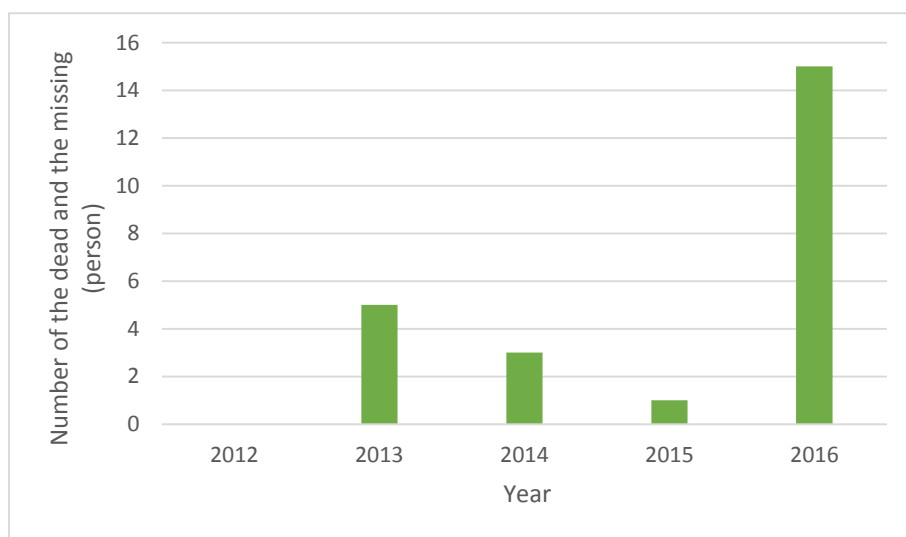


Figure 3 Number of death during floods in Wuhan, 2012-2016

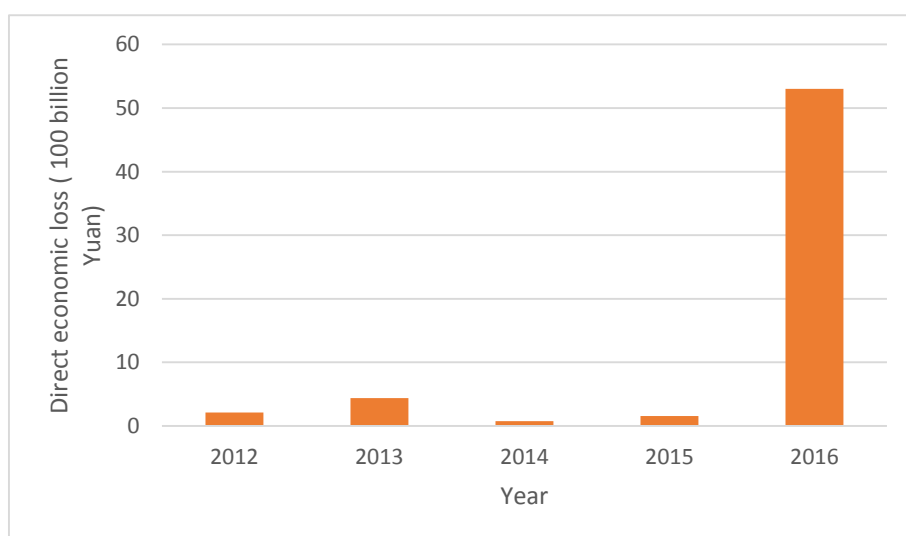


Figure 4 Amount of direct economic loss during floods in Wuhan, 2012-2016

Typical Flood Cases

1998 Flood

1998 witnessed a second mega-flood that affecting the whole area since 1954. In that case, the water level was very high, the discharge tremendous, the intensity formidable, the flood peaks densely coming, the situation, more than risky, the time span, long-lasting, almost all at a level that is unprecedented in history. The total flood season lasted 93 days, with 8 flood peaks, reaching the highest flood level of 29.43m in Wuhan (21:00, August 19th), the historical second in Wuhan record. 1.777 million people became victims of the disaster and 9990 houses fell to the ground; 166,000 got trapped in the flood and direct economic loss, 4.126 billion Yuan.

2010 Flood

Afflicted by intense rainfalls in July 2010, the main stream and multiple tributaries of Hanjiang River were hit by unprecedentedly severe floods. After handling two rounds of large flood inflow, Danjiangkou Reservoir increased its flood discharge. As a result, the highest water level monitored by Xingou Station of Hanjiang River at 19:00, July 28 was 30.25 meters, 2.75 meters above the warning stage and the second highest since record statistics in 1933. For 35 days the water level monitored by Xingou Station was above “protection-needed level” (which means the flood water is above river beach), and 20 days were above warning stage. 16 breaches were found in dykes of Yangtze and Hanjiang Rivers and reservoirs in Wuhan city. 509 thousands people were affected, 8,449 rooms of 3,179 households were destroyed, 23 thousands people were relocated emergently. The direct economic losses stood at 2.28 billion RMB, in which 1.259 million mu of crops and 144.8 thousands mu of fishery farms were hit, with a direct economic losses of 1.296 billion RMB to agricultural industry. Water conservation facilities were severely damaged, and the losses brought to roads were 106 million RMB.

2011 Flood

From September 6 to 19, 2011, three intense rainfalls occurred in the upper reaches of Hanjiang River, with the highest inflow volume into Danjiangkou Reservoir being 27,000 m³/s. The highest outflow volume from the reservoir was 13,200 m³/s on September 15. An autumn flood once in 20 years hit Hanjiang River. Due to flood discharge of Danjiangkou Reservoir, all hydrometric stations in lower reaches monitored surging water levels. The water level monitored by Xingou Station of Hanjiang River at 14:00, September 21 was 28.04 meters, 0.54 meters higher than warning stage. At same time, since Three Gorges Dam in Yangtze River was in storage period and hence water level in Yangtze River was low, the highest drop of

Hanjiang in Wuahn section was 8.83 meters, resulting the highest flow velocity in records: 6.36 m/s. Banks of Wuhan section of Hanjiang River were severely scoured, with the deepest scouring depth in some sections being above 10 meters. Banks in Dongcaiyuan and Qinnan of Hanyang District collapsed and banks of Chailinwan was damaged to different extents. To relieve the flood control pressure in lower reaches of Hanjiang River, flood was directed into Dujiatai flood diversion and storage area from 12:30, September 21, 2011. By September 23, 200 million cubes of water was diverted.

Water-logging in July, 1998

Wuhan experienced frequent rainfalls in 1998. The total precipitation and its intensity were rarely seen in a century. From 4 o'clock on the morning of July 21st to 8 o'clock on the morning of July 25th, the greatest hourly rainfall reached 102.0mm (from 06:27 to 07:27 on the morning of July 21st), and the greatest rainfall within 24 hours, 493mm, a record high since data 118 years before. The 54 pump stations in the city were all functioning at full load under extremely high water level and above peak conditions. The lengthy operation time also was never seen in history. This mega-rainstorm caused about 46 km² of waterlogging in the downtown. In the new development area, 1.11665 million mu of farmland were affected, with 520,500 mu in total disaster and 455,400 mu in total crop failure which led to a serious cutback in harvest of oil, cotton and grains by 957 million jin.

Water-logging in July, 2004

From 8:00 p.m. July 18th to 11:00 a.m. on the 19th, precipitation in 15 hours reached 160mm, the maximum hourly rainfall, 40mm. There were 68 places that got water-logged in the downtown.

Water-logging in June, 2011

On June 18th, 2011, rainstorm swept across Wuhan. The maximum rainfall within 24 hours reached 200.5mm, a record high in 13 years for daily rainfall, which caused water-logging of different severity in 88 sections in the downtown.

Water-logging in July, 2013

From July 5th to 7th, Wuhan witnessed torrential rainfall, giving a maximum precipitation of 321mm, and causing 22 main roads and 75 communities in the city in water-logging.

Water-logging in June, 2016

From June 30th to July 2nd, Wuhan experienced torrential rainstorm and had an accumulated rainfall of 322mm, with serious waterlogging in the city.

2.3 Flood Control Structural Measures and Standards

Flood control system in Wuhan consist of dykes, flood diversion and storage areas, reservoirs, waterlogging discharge system, flood discharge system, and mountain torrents prevention system.

Floodwall

The total floodwall in Wuhan extends 807.755 km and protects 13 administrative zones, Wuhan Eco Tech Development Zone, Wuhan Donghu Eco-tourism Scenic Area, Wuhan Donghu New Tech Development Zone as well as Wuhan Chemical Industrial Zone. Altogether there are 17 flood prevention circles and zones. Categorized by water systems: floodwall of the Yangtze River, 307.716 km, Hanjiang River, 112.13 km; others, 387.909 km. Along the Wuhan floodwall, there are 264 water gates, 164 drainage outlets, 181 valves (ditch tunnels excluded) and 194 pump stations.

In flood season of 1998, 2,215 flood dangers were found across the city of Wuhan. After the flood, floodwall was enhanced and reinforced on a large scale, and flood prevention capability was enhanced. In flood season of 1999, 114 flood dangers were found in Wuhan. The amount of flood dangers was obviously reduced and the level of danger was largely reduced. In flood season of 2002, hydrometric station at Wuhan Customs monitored a water level of 27.76 meters, and basically no flood dangers appeared.

Though Three Gorges Dam played a huge role in Wuhan's flood prevention, the water volume from Yangtze River and tributaries in the basin is still large, and the flood inflow volume is still way higher than the discharging capability in middle and lower reaches of Yangtze River. The gap between flood inflow volume and the discharging capability still exists. Though dyke has been reinforced, weaknesses and potential risks in some areas still persist. Since rivers have undergone changes, old risks have not been completely terminated, and new risks will emerge, especially in dykes that are built on soft and sand banks, bank collapses and piping effects are

prone to happen. Due to sand deposition and artificial reclamation, storage and discharging capabilities of rivers and lakes are reduced, resulting in poor discharging channels and increasingly sharp storage and discharging problems. Inhabitants along river banks usually build their own dykes, which damages discharging capability. This means for the same level of flood, the water level will be elevated, putting more pressure to flood control. Constraint by economic condition, safety monitoring and rescue equipment and technical skills required for dykes in middle and lower reaches of Yangtze River have not been equipped universally. Dyke inspection still relies on blanket inspection by manpower, and rescue machines are still insufficient. Therefore every time before a flood season, flood prevention burdens on huge amount of manpower and material.

Flood Storage Area

Around Wuhan, there are six flood storage areas, namely, Zaojiatai, Wuhu lake, Zhangdu lake, Baitan lake, Xiliang Lake, Dongxi Lake. They together cover 2956 km² (2186.6 km² of which situates within Wuhan) of land and has an effective volume of 12.21 billion cubic meters, responsible for storing 6.8 billion cubic meters of water when flood strikes. Among them, Wuhu lake, Zhangdu and Dongxi lake all lie fully within the border of Wuhan. Zaojiatai and Xiliang lake, partly within; Baitan lake, in the lower-reach Huanggang of Wuhan.

The dykes around flood diversion and storage areas in Wuhan are thin, flood discharging equipment is outdated, and discharging capability is insufficient. Construction of safety zone is lagged behind, flood prevention facility is backward, and development of related supporting facility lags behind. Management is also relatively weak. In addition, due to fast economic development within flood diversion areas, the difficulty of flood diverging has increased. Once flood is diverted into this areas, economic losses will be huge.

Reservoir

So far, there are 283 reservoirs in the city, 3 really large-scale ones: Xiajiasi Reservoir, Meidian Reservoir, Daoguanhe Reservoir; 6 middle-sized: Yuanjisi Reservoir, Kuangshan Reservoir, Bashan Reservoir, Sangujing Reservoir, Shaotan Reservoir; and 263 small ones. The whole city has an area of 881.26 km² for taking rainfall with a total volume of 0.00 billion cubic meters.

Among the 283 reservoirs in Wuhan, 138 are with risks. By 2014, 97 have been reinforced and risks of them have been eliminated, and the remaining ones are in the process of reinforcement.

But new risks and dangers emerged in other reservoirs. Therefore emergent plans should be developed and rescue material be prepared according to rainfalls and water level.

Rainwater Drainage System for Urban Area

The Wuhan downtown area has, Huangxiao River, Changqing, Hankou, etc, altogether 22 drainage systems for the urban area (5 in Hankou district, 8 in Hanyang, 9 in Wuchang), covering an area of 1374.46 km², 438.7 km² of which lies in the downtown. Also, there are 37 drainage pump stations, now at a discharging rate of 736.92m³/s, and planned at a rate of 1316.84m³/s. The storm sewers and combined sewers extended a total length of 6037.5km, with the major drainage pipe, Xianghanmingqu extending 2596.1km and community pipes, 3441.4km.

In the New Urban area, there are 20 major flood discharge systems: Zhangdu Lake, Wuhu Lake, Chaipo Lake, Yanjia Lake, Beihu Lake, Tangxun Lake, Haikou, Jinshuihe Lake, Liangzi Lake, Dongxi Lake, Dongjia Lake, Houhu Lake, Shizai Lake, Panlong Lake, Caidiandong Lake, Xihu Lake, Dajunshan, Chuanjiangchi, Lanni Lake, Zhushan Lake, etc. Among them, four water systems of Caidiandong Lake, Beihu Lake, Tangxun Lake and Dongxi Lake have some overlapping roles with the downtown drainage systems.

At the same time, problems exist in flood drainage and discharge in center areas of Wuhan. First, the discharging standards are low. The existing discharging piping network in Wuhan was design based on $p=1$ (rainstorm recurrence interval). In some old districts, the piping network was based on the assumption of $p=0.33-0.5$. Wuhan's discharging system is only able to handle rainfalls with daily precipitation of 100 mm, or hourly precipitation of 34.5 mm. This standard is below national standard that such system should be able to handle heavy rainfall once in 50 years. Second, the discharging facility construction is lagged behind. The pumping drainage capability of pumping stations is 959 m³/s. If this design standard and planning capacity are not improved largely, the capacity is only half of the planned demand. The gap of main piping network in Wuhan is above 400 km. Third, the input into facility maintenance is insufficient. The amount of drainage and discharge facilities is huge, but aging problem is severe. 50% of pipes with middle-&-small-sized bores are beyond designed durable years. Due to constraint of small maintenance budget and outdated maintenance practices, pressure of daily maintenance and dredging needs of middle-&-small-sized pipes are enormous. Fourth, emergent joint efforts are to be enhanced. Since rainwater drainage and sewage go through the same pipes, lakes'

function of flood storage and water quality protection are in conflict. And for some lakes, the functions of fishing, flood adjustment and landscape cannot coexist, resulting in underused flood storage capacity of lakes.



Figure 5 Pump station for Wuhan Port, Phase II and the matching pipeline project



Figure 6 The pipeline project

Urban Waterlogging Control Standards

The main city area of Wuhan sets the flood prevention standard to that resists 50 years of rainstorm; in important areas, 100 years of rainstorm. In the new urban area, standards vary for the drainage systems. Some are to discharge water from the once-in-10 to 20-year-rainstorm in three days; some, in three to five days; for areas growing vegetables, in one day. All the middle-sized and large-scale reservoirs are designed to resist rainstorm that occurs once in 50 years or even beyond⁷.

⁷ “Emergency Plan for Flood Control in Wuhan City (Revised)”, <http://www.whwater.gov.cn/water/u/cms/www/201511/02103003w6n7.doc>.

2.4 Capacity Building for Flood Preparedness

Emergency Planning System

In order to effectively prevent and deal with disasters like flood, waterlogging, and mountain torrents, guarantee that risk relief work is carried out in an orderly way and cut back casualties and damages to the maximum extent so as to ensure safe, stable and sustainable urban economic and social development, Flood Control and Drought Relief Headquarter in Wuhan compiled the *Flood Control Emergency Plan of Wuhan City* in 2009 and revised it in 2016. Main improvements in 2016 revision include: related laws and regulations, rules, planning and emergent plans that are newly developed are added to the compiling basis; related fundamental data are 2013 data; 2010 Yangtze River and Hanjiang River flood and 2011 Hanjiang River flood are added in flood analysis section; data are updated in flood prevention and drainage system; standards of flood prevention of middle and small sized rivers, and urban flood prevention and treatment standards in center districts and newly developed areas are clarified; warning levels of both flood and urban waterlogging are categorized, emergent response and countermeasures are put forward according to different warning stages. According to The Plan, the Wuhan Municipal government sets up the municipal flood control and drought relief headquarter and the offices accordingly. The secretary of the municipal party committee serves as the commissar; the mayor, the commander; deputy mayor in charge of flood issues, standing deputy commander; heads of certain departments and organizations, deputy commanders. In this way, Wuhan Municipal Flood Control and Drought Relief Headquarter is in charge of all the flood prevention and flood relief work in the city. The HQ office in charge of the daily work.

In order to establish and improve the emergency relief system and the operation mechanism concerning sudden major natural disasters, regulate emergency relief actions in accordance with the law and improve the emergency relief capabilities so as to implement emergency relief in a quick, proper, orderly and efficient way, with maximum prevention of people's life and fortune losses, and maintain stability in the disaster-stricken areas, Wuhan has issued the *Natural Disaster Relief Emergency Plan of Wuhan City*. According to The Plan, when major natural disasters occur, Wuhan Municipal Disaster Reduction Committee will change into the Wuhan Natural Disaster Relief headquarter and act as the organizing and leading role to study and make principles and policies for disaster relief. In Wuhan Natural Disaster Relief Headquarter, there is an office in charge of the daily disaster relief work. The HQ office is

located in the Municipal Bureau of Civil Affairs, with bureau director also serving the office director; deputy bureau director as the deputy office director; headquarter member offices sending out liaison officers to participate in the office work.

In the meanwhile, the counties (districts) of Wuhan have respectively compiled flood prevention emergency plans and natural disaster relief emergency plans. Villages (townships) and communities (villages) have also compiled disaster emergency plans which have established a relatively comprehensive emergency response system.

Capacity Building of Community DRR

Community, as the place of living, has a fundamental and critical role in risk management of natural disasters, and has an important function of emergent response and disaster prevention and alleviation. In communities, which is an important primary social organization, both population and property are in high clusters, and hence communities carry the function of offer material support for people's living. In communities, people's activities are frequent. The risk of disasters of all types is high, and the damage and social influence of such disasters are profound. Disaster prevention and alleviation in communities are key content of harmonious co-existence between human beings and their living environment, and also are the indispensable topic of life safety and property safety protection.

The construction of a holistic disaster alleviation demonstrative community will win initiative in the fight against disaster and rescue works, and hence will effectively reduce the losses arising from disasters. We should enhance disaster prevention and alleviation efforts, build a cooperation relation among all players in communities, such as inhabitants, enterprises, non-government organizations, and local governments, and equip them with necessary abilities of "self-rescue" and "mutual aid". Once disaster happens, local community residents can win valuable time before rescuers' arrival by self-rescue and mutual aid at first time and on site. This period of time is essentially important for protection of life and property.

Wuhan has 1288 communities, 73 of which have created national comprehensive disaster relief models. In Hubei Province, there are 96 provincial level model communities for comprehensive disaster reduction; and 542 municipal level ones in Wuhan. Across the city, there are 3683 disaster information staff and all of them are trained as professionals.



Figure 7 Emergency Drill in Model Community of Comprehensive Disaster Relief

Waterlogging Risk Map of Urban Area

Wuhan has set up a waterlogging risk warning mechanism, compiled the waterlogging risk map of urban areas and the distribution of major waterlogging areas of the urban areas. With severity of the rainstorm categorized into four levels: once a year, once every five years, once every ten years and once every twenty years, as well as model demonstration and analysis, the major waterlogging spots of different levels are marked in the waterlogging risk map.

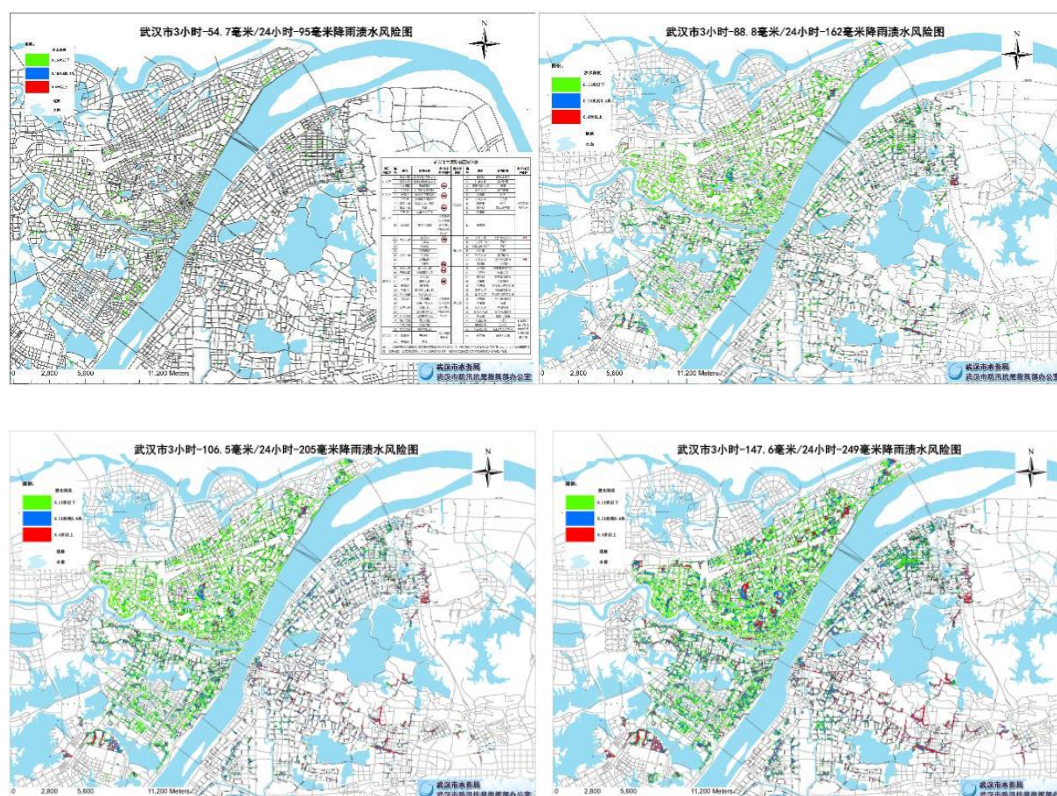


Figure 8 Waterlogging risk map of urban areas, Wuhan

Disaster Relief Supplies

The building of a disaster relief material storage system is the key content of disaster emergent aid, critical link in the building of disaster emergent response system, and an important measure to practice people-oriented concept in disaster relief and disaster alleviation. The effects of relief material storage have direct impact on the quality and efficiency of disaster relief and disaster alleviation, and also on the guarantee of basic living of residents in disaster areas and the social stability of disaster areas.

Wuhan strives to build a Disaster Relief Supplies Station System featuring “1+7+6+64”, namely, one major supply station in Wuhan appointed by the central government to play the leading role, seven provincial level regions serving as the pillar, seventy municipal and county level supply stations for emergency use, and multiple village and township level stations functioning as complementary measures to effectively improve disaster relief capacity.



Figure 9 Central Level Disaster Relief Supplies Station in Wuhan

Shelters

Emergency shelter, a safety shelter for residents in modern metropolis in event of fire disaster, explosion, flood, earthquake, epidemics and other major emergent public events, is a relocation measure in response to emergent public accident. There are four main categories of shelters in Wuhan for disaster relief: Emergency Shelters, Permanent Shelters, Centralized Permanent

Shelters and Shelters Reserved for Disaster Relief⁸.

Emergency Shelters

Temporary shelters close by disaster stricken areas used for no more than three days before people are sent to permanent shelters, which mostly refers to open space in small parks or squares within cities.

Permanent Shelters

With accommodation and supporting facilities used for permanent protection and centralized relief measures for no more than 100 days, which are usually located in parks, squares, sports venues and disaster relief stations of large size and capacity. Regional and above level Emergency Commanding Office, Medical Care Center, Disaster Relief Supplies Storage Center etc. can be established in some medium and large scale permanent shelters.

Centralized Permanent Shelters

Large-scale permanent shelters with comprehensive functions that can accommodate disaster relief commands, supplies storage, medical relief, and emergency housing for no more than 100 days. They usually enjoy convenient transportation to facilitate the transfer of injured people and material supplies with large open space and safe evacuation passages to surrounding shelters. Emergency management zone, emergency supplies storage zone, medical zone, professional disaster relief troop zone are usually set up. Centralized Permanent Shelters can usually integrate the presentation, drilling, education and training functions of disaster relief.

Shelters Reserved for Disaster Relief

Refers to land reserved for large-scale evacuation action in safe regions. With water and electricity supply, this category of shelters serves as temporary transferring zone prior to long-distance evacuation of personnel and storing disaster relief supplies imported from outside should an extremely rare disaster strikes a city, which can also function as centralized relief stations during the post-disaster relief period for a prolong period of time. There's a very slight chance that this land would be utilized but is usually reserved within the boundary of land for non-construction purposed in order to provide for disaster relief or accommodation in case of emergency after simple treatment of the land.

⁸ “Comprehensive Disaster Prevention and Evacuation Planning of Wuhan Metropolitan Development Area” , <http://www.wpdi.cn/nry.aspx?pageid=14&menuid=16>。

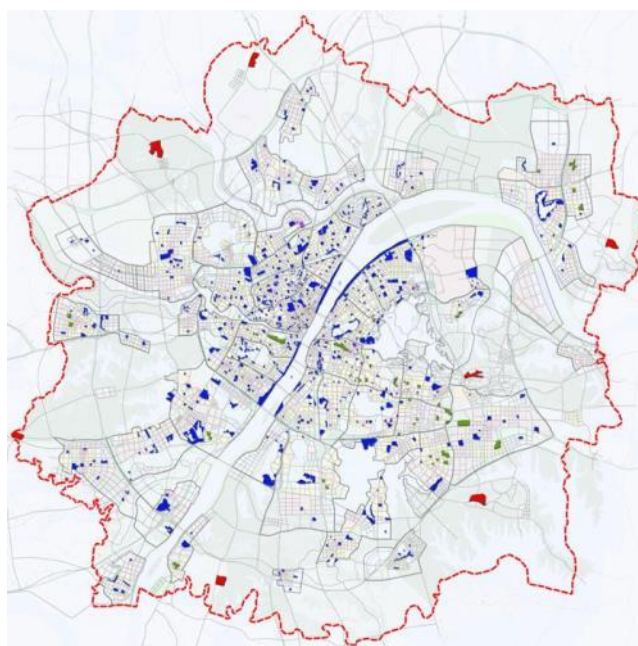


Figure 10 Master Plan of Comprehensive Emergency Shelters

There are altogether 404 emergency shelters in Wuhan with an accommodation capacity of 2 million people, 300 of which can be used for emergency transfer and accommodation of people in flood stricken areas with a capacity of 300,000 people.

2.5 Early Warning System

Early Warning System for meteorological disasters is constantly improving with 5 national level ground observation stations, 118 regional automatic ones, 5 vertical atmospheric moisture detection stations and 14 lightning GPS monitoring stations in Wuhan. The new generation weather radar system can predict rainstorm 24 hours; a polar stationary meteorological satellite receiving system and the national standard ionosphere (spatial weather) monitor station are set up. A 3D monitoring system, featuring ground, air and spatial meteorological monitoring capacity, is established to play a key role in the prediction, early-warning and early prediction system of disasters. After years of development, Wuhan Meteorological Bureau has developed a precise meteorological forecast system and made full use of APP, grid meteorological service system, television and other information carriers to release grid weather forecasts and warnings so as to provide more refined urban meteorological forecast and early warning service.

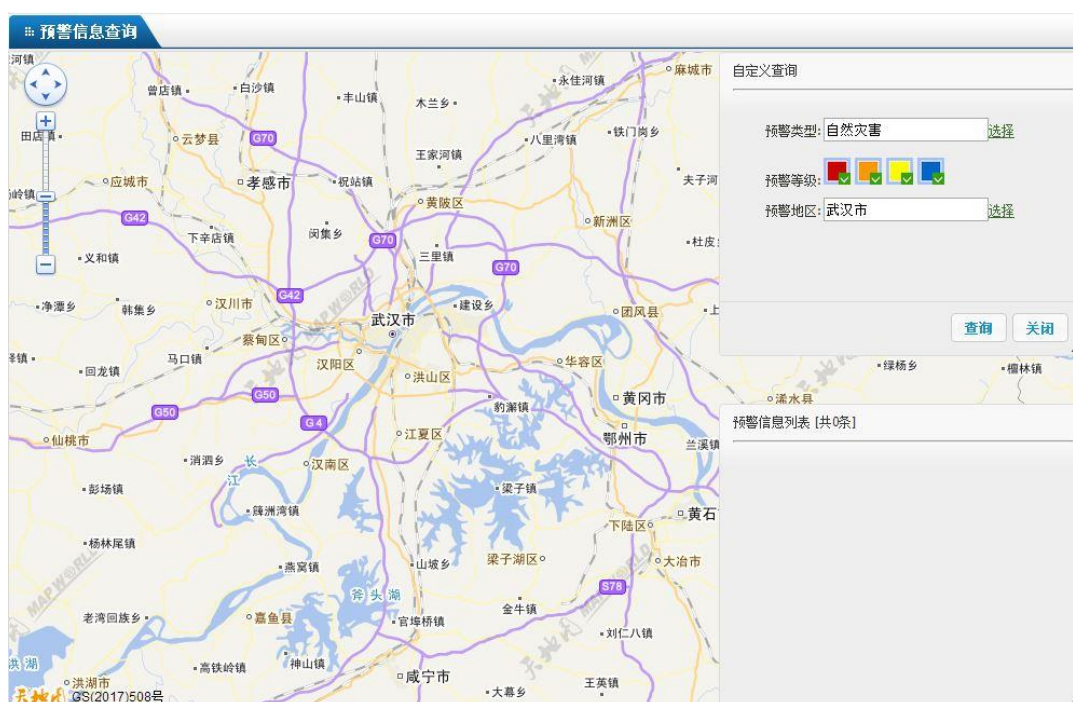


Figure 13 Release natural disasters alert messages in Wuhan through national emergency real-time warning platform

2.6 Sponge City Building

Plan of Sponge City

Wuhan, as one of the first batch of pilot "sponge cities", released "Sponge City Master Planning and Guidelines of Wuhan (Trial)" in 2015, issued "Wuhan Sponge City Pilot Implementation Plan" in 2016⁹, and compiled "Specialized Plan of Sponge City in Wuhan"¹⁰ with the goal to strengthen the planning and management of urban planning and construction. Measures such as "infiltration, stagnation, storage, purification, utilization and discharge" are taken to give full play to the role of ecosystem of architecture, road, green plot, water system etc. in the absorption, infiltration and slow release of rainwater so as to effectively control rainwater runoff, achieve natural accumulation, infiltration and purification of water system. Gradually, small rain can seep through the ground and heavy rain will not cause flood, lessening water pollution and heat island effect. Meanwhile, through pilot sponge city building in certain region, we can accumulate experience and explore new model to lay the foundation for citywide promotion of

⁹ "Notice of the General Office of the Wuhan Municipal People's Government on Issuing the Implementation Plan of the Pilot Project of Sponge City Construction in Wuhan", http://www.wuhan.gov.cn/hbgovinfo_47/szfggxxml/gzghjh/gzjh/201604/t20160420_72432.html.

¹⁰ "Specialized Plan of Sponge City in Wuhan (2016-2030)" (draft), <http://www.wpl.gov.cn/pc-114-100667.html>.

such practices. The goal is that, 20% and 80% of the completion zones of Wuhan city should achieve the sponge city requirements by 2020 and 2030 respectively.



Figure 14 Measures to build "Sponge City"

The principle for building sponge city in Wuhan is “planning as the guide, ecology as the priority, safety comes first, adapting to local environment, and taking an overall approach”. The goal is that the realization of rainwater runoff volume control shall reach 80% in the new area and 70% in old area. Goals for flood control is that, waterlogging prevention standards to achieve a capacity to resist 20 years of storm by the end of 2017 and 50 years of storm in the long run. River flood control standard shall amount to resist more than 100 years of storm rain. The overall objective is that small rain shall be able to seep through the ground and heavy rain shall not cause flood, therefore lessening water pollution and heat island effect.

In survey we found that, in respect of urban waterlogging treatment in demo program of sponge city construction, in areas and on roads after renovation, rainwater rapidly infiltrates the ground and leaves no trace of rainstorm thanks to permeable material, and concave greenbelt and water storage module. But in old areas where no renovation was performed, risk of waterlogging still exists. The construction of sponge city faces the following difficulties¹¹:

Great difficulty for renovation in existing communities. The construction of sponge city aims to renovate existed communities, especially areas suffering from frequent waterlogging. But renovation in existed communities will confront various difficulties. For example, new concave greenbelt means fewer parking space; roof plantation will face problems of dismantling of illegal buildings. And therefore the difficulty to realize the planning targets is extremely high.

Construction standards are not clarified. For sponge projects, some focuses on water storage, some on waterlogging drainage and discharge, and some on water pollution. Without practical construction standards, the construction of sponge city may follow a zigzag course, or even end up with exactly opposite effects.

Government's supporting facilities are not matching up. The construction of sponge city requires coordination of authorities of planning, city construction, water affairs, and landscape. Especially for the construction in newly-developed areas, pre-planning and systemic construction are required even for cities and areas that are not in pilot programs.

Pilot Projects

Qingshan Demonstration Area of Wuhan Sponge City Program covers an area of 23 km²

¹¹ “Nearly half of 30 sponge pilot cities had waterlogging” sponge “effect geometry?” , <http://house.people.com.cn/GB/n1/2016/0727/c164220-28587296.html>.

(Qingshan Area: 15.6km²; Yangchun Lake Area of Hongshan District: 15.6km²). Projects in the demonstration area include five major categories, namely infrastructure in community, municipal roads, parks and green land, pipes, urban waterways, whose master plan is featured by “one center, two belts and four districts”, namely one Yangchun Lake sub-center, eco-demonstration belt along two rivers and river-side prevention belt, shanty-town renovation demo zone, red mansion demo zone, Hongwei Road demo zone and Nanganqu Eco-demo zone.



Figure 15 Renovation Community of Qingshan Demonstration Zone of Wuhan “Sponge City” program

Charter 3 :

Urban Flood Risk Management Capacity of Ganzhou

3.1 City Overview

Located in the upper reaches of Ganjiang River in south Jiangxi Province, Ganzhou city is frequented by rainstorm and floods. With a total area of 39379.64 km², the city accounts for 23.6% of the province's total and is the largest administrative region of the province and is embraced by mountains on all sides. Duanxian Basin spans across the city with mountains and hills all over, covering 80.98% of the total area. Located in southern border of tropical belt, Ganzhou city enjoys tropical seasonal climate featuring rampant seasonal wind in winter and summer and concentrated precipitation in spring and summer with clear division of seasons, lukewarm temperature, abundant heat and rainfall, and continuous hills, with the formation of intensive streams and crisscross rivers. The land is in the shape of a basin with the south in a higher altitude than the north and waterways flowing from all directions to the center, Zhanggong District. In 2016, GDP of Ganzhou district reached 219.434 billion yuan, an increase of 9.5%. Fixed asset investment reached 220.551 billion yuan, up by 16.6% compared with last year. By the end of 2016, the total registered population reached 9.7078 million, 101,500 more than last year. Urbanization rate of permanent residents stood at 47.1%. The completed area of the city center covers 158 km² with a total population of 1.6 million¹².

¹² “Statistical Bulletin of National Economic and Social Development of Ganzhou in 2016” , <http://www.gztj.gov.cn/article.html?id=13507>.

3.2 Flood Impact on City

Flood Characteristics

Ganzhou city center is located in the "3-rivers, 6-banks" zone of the confluence of Zhang and Gong River with Wan'an reservoir 90 km away in the lower reaches. Due to heavy rainfall and floods from Zhang and Gong river, Ganzhou is frequented by floods, surface and subsurface waterlogging. Flood season generally occurs from March to September, among which March to April are rainy seasons, May to June more rainstorm featuring wide range, long duration and high-intensity; July to September are typhoon seasons which rains heavily but shorter and narrower in range. According to the statistics of urban hydrological stations, the average annual rainfall is 1406mm (the city's average being 1583mm), the maximum rainfall of 69.5mm (the city's maximum being 121mm), the maximum 24h rainfall of 145mm (the city's largest is 528mm).

Flood season and rainstorm season go hand in hand which can be categorized into spring, summer and autumn flood season, with the summer flood being the most serious one. According to an investigation conducted in 1915, when a flood most serious in more than a hundred years took place in Ganjiang, the flood was mainly caused by upstream water, and waterlogging mainly happened due to river water intrusion, and surface waterlogging mainly resultant from short duration of heavy rain. Although floods often told hold of the city center and triggered warnings to the river level, major damages to the city were rarely seen.



Figure 16 Juncture of the Zhangjiang and Gongjiang Rivers

Flood Losses

Ganzhou witnessed a slighter damage caused by flood in 2016 with 569,000 being affected, causing 11 deaths and 47,000 being evacuated. Total direct losses reached 1 billion yuan, of which only 27,000 people suffering in the main city areas (Zhanggong District and Nankang District) and over 800 people for emergency relocation and direct losses of over 54 million yuan.

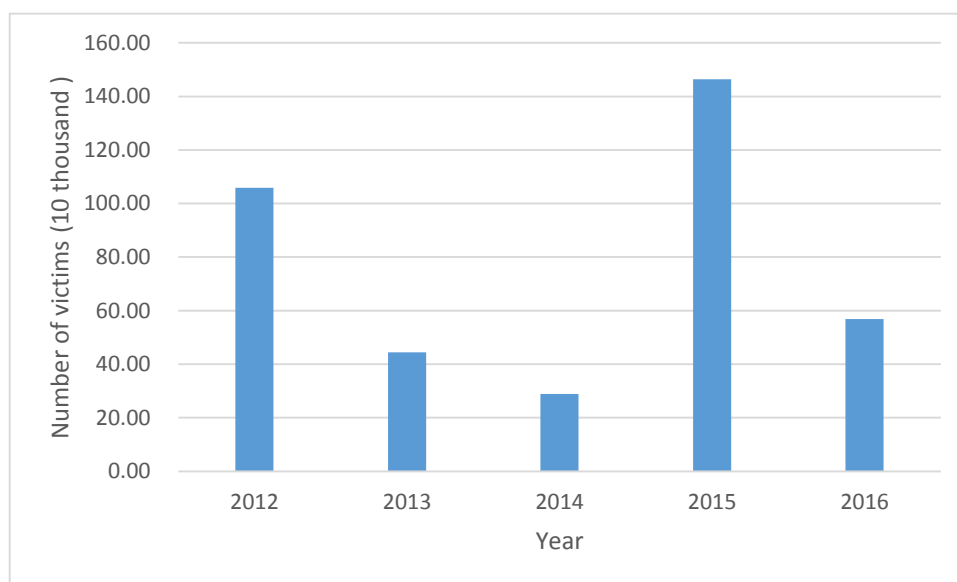


Figure 17 Population of Victims from flood in Ganzhou, 2012-2016

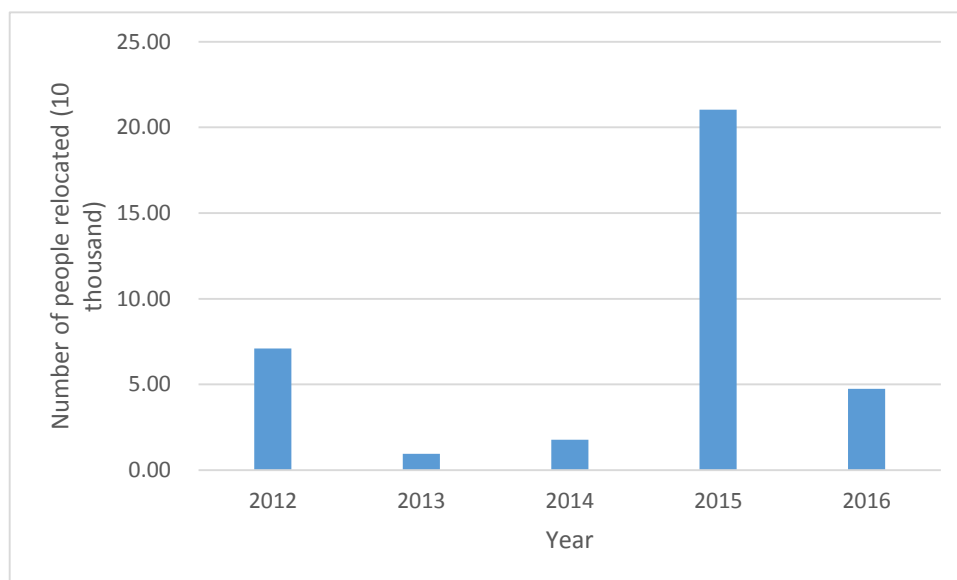


Figure 18 Number of people relocated due to flood in Ganzhou, 2012-2016

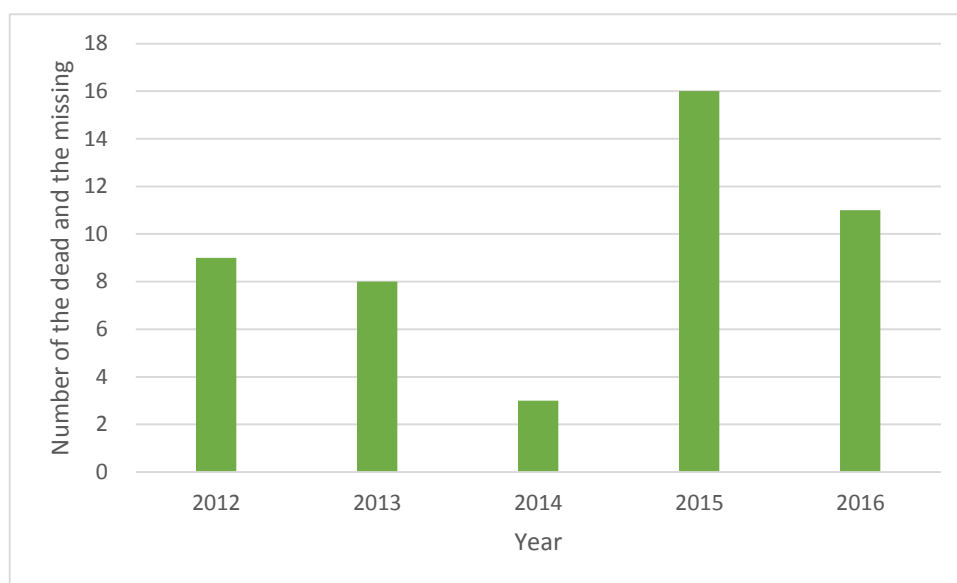


Figure 19 Number of the dead and the missing due to flood in Ganzhou, 2012-2016

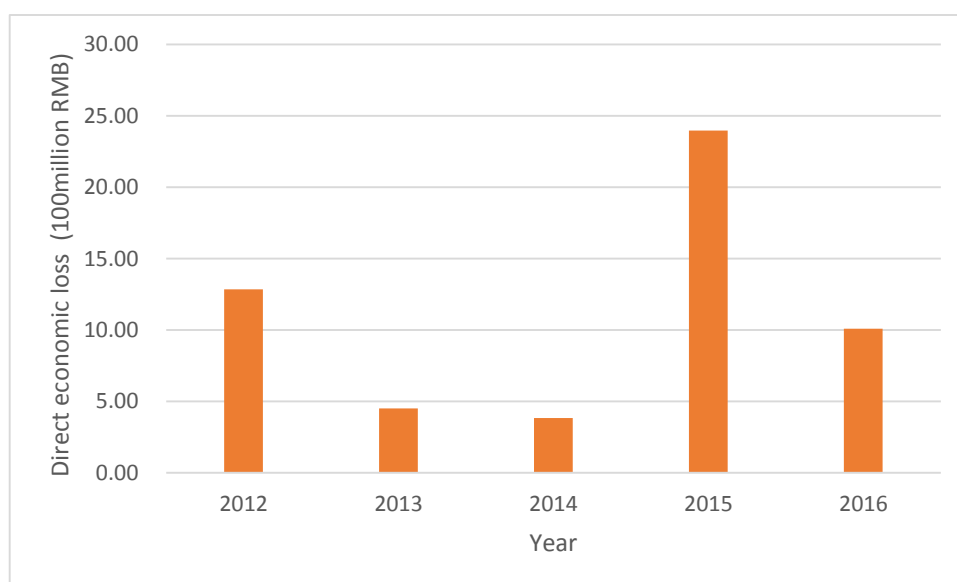


Figure 20 Direct Economic loss due to flood in Ganzhou, 2012-2016

Typical Flood Cases

According to the statistical analysis of Gongshui Ganzhou and Zhangshui Dam Hydrological Station, 42 years out of 66 years from 1950-2006 in Ganzhou hydrological station saw a maximum water level beyond the warning level and 18 years being 2 meters higher than the alarm water level, 5 years beyond the warning level; in Zhangshui dam hydrological station, out of 63 years from 1953 to 2016, 20 years saw a water level being 2 meters beyond the alarm level, 8 years being 3 meters beyond the alarm level. And nine major floods occurred in 1961, 1962, 1964, 1968, 1992, 1994, 1995, 1998 and 2002 caused grave damages and economic

losses to Ganzhou city.

Autumn flood in 2002 saw an above-warning water level for three days, flooding Guijiaowei and Erkang Temple of Ganzhou city and causing waterlogging to Orange Garden of Yangmeidu and the upper side of Yingjiao as well as severe floods to six towns, 14 villages and partial farmlands along the two banks of the rivers. 1046 houses were collapsed with 1312 being destroyed and 246,000 mu of land being flooded, causing an economic loss of 130 million yuan.

3.3 Flood Control Structural Measures and Standards

Floodwall



Figure 21 Floodwall and floodgate in Gan River

Meeting the requirements of urban planning and construction, floodwalls in Ganzhou are built along the rivers. Some are connected to roads, some connected with walls and some with parks. The coastline is 48.12 km long with the main flood control shoreline being 41.57km. Five dams are planned to resist against 50 years of storm rain with 4 drainage channels and 5 traffic gates. The flood prevention dams built already measures 23.54 km long with 4 dams capable of resisting 50 years of storm rain and one dam resisting 20 year storm rain. Upon completion, the flood control standards in Ganzhou city center will increase from 5 years to 50 years.

Rainwater Drainage System for Urban Area

Apart from the drainage piping system—Fushou Pipe, built in Song Dynasty in 3.2km²-old-town of Ganzhou, the rest of the 130 km² area in city center relies on constantly newly built projects for drainage. There are already nine drainage pump stations built out of the 23 planned stations with total piping distance reaching 1401.75 km by 2015 in city center (Nankang region included). Upon completion, the flood control standard of city center can reach 20 years. However, the built drainage pumps are narrow in size and adopt the standard of one-year repetition of rainstorm and the number of drainage pump station is also quite limited, causing huge pressure on drainage during floods and great potential risks to waterlog.

On June 21st, 2010, precipitation reached nearly 100mm in certain regions of Ganzhou city while there is no obvious waterlog in city center, not even a car being flooded. This is all largely thanks to the urban drainage system represented by Fushou Pipe built in Song Dynasty and still playing an important role. The 12.6 km-long Fushou pipe still functions as a discharger of wastewater for nearly 100,000 residents in old town. Some experts remark that, given the current population in water-collection areas and wastewater disposal capacity, the system can accommodate even three to four times more than the current rate without waterlogging. “Our ancestors are indeed quite remarkable in their great foresights and vision.”¹³

Urban Waterlogging Control Standards

The current rainfall pipes adopt one-year rainstorm recurring period while the future urban waterlogging control standards shall be effective to resist 20 years of storm.

¹³ “Jiangxi Ganzhou had flood but not waterlogging, the Song Dynasty urban drainage system is still working”, <http://news.163.com/10/0714/05/6BHG044G00014AEE.html>.

3.4 Capacity Building for Flood Preparedness

Emergency Planning System

In order to prevent and deal with flood and drought disasters and bring them into control, *Contingency Plan for Flood and Drought Control of Ganzhou City* was compiled in 2003 to ensure effective and efficient flood and drought control work and minimize casualties and economic losses to ensure a comprehensive, coordinated and sustainable economic and social development. The plan was later revised in 2011, 2014 and 2016 respectively. According to the plan, a Commanding Office was set up under the Ganzhou Government to ensure the implementation of disaster relief plans, execute disaster relief orders from higher authorities and implement approved contingency plans for flood prevention, flood control and floodwater dispatch, conduct examination and clear obstacles before flood occurs as well as urging relevant departments to deal with flood issues in waterways on time, organize and establish metrological and water level warning system to issue real-time information citywide and announce the start or end of emergency flood control period. The authority should also be responsible for disaster prevention and relief fundraising, as well as managing and dispatching the funds and materials, inspect and urge relevant project construction and restoration of flood-stricken areas.

Natural Disaster Relief Emergency Plan of Ganzhou City was compiled in order to establish and improve the disaster relief system and working mechanism in all levels of the government, regulate relief measures, and strengthen capacity building so as to realize prompt, efficient and orderly execution and minimize casualties and property losses, as well as safeguarding social security in disaster-stricken areas. According to the Plan, as the coordination office for natural disaster relief and aid, the Disaster Relief Committee of Ganzhou city is responsible for organizing and guiding relevant relief measures and launching campaigns to cope with super serious and serious natural disasters.

Meanwhile, all prefectures and regions of the city have also worked out emergency plan for flood control and drought relief and natural disaster relief contingency plan; so do the villages and townships and communities. Hence a relatively comprehensive emergency plan system is in place.

Capacity Building of Community DRR

There are altogether 1308 urban communities in the city, 49 of which have become national-level disaster relief demonstration communities, 91 are provincial-level model communities, 586 of which have compiled disaster risk map in their communities. The city boasts a total of 4215 information officers for disasters, including 332 specially trained disaster information staff. The number of disaster relief volunteers also reaches nearly one thousand.

Disaster Relief Supplies

One prefecture-level disaster relief supplies station has been established which can provide basic relief supplies to 10,000 people. Nineteen county-level disaster relief supplies stations have been built which can provide basic relief supplies to 50,000 people. At the community (township) level, there are fifty-two stations which can support 50,000 people.

Shelters

There are altogether 90 emergency shelters (emergency and disaster refuge sites) in the city with a maximum capacity of 910,000 people. There are 81 emergency shelters (emergency and disaster refuge sites) for flood disaster relocation which can accommodate a maximum of 820,000 people.

3.5 Early Warning System

By launching the automatic meteorological observation station and fine weather forecast of big cities, a well-developed meteorological disaster monitoring and forecast warning system has been so far established in Ganzhou city. The early warning information will be published on several platforms and via various modern communication means including the National Emergency Information Release Platform, 12121 Audio Processing System, TV, radio, internet, Weibo, Wechat, electronic display and text message and etc.

全省江河水位概述

4月12日各江河重点站警戒水位以下，其中离水位最近的是干都县 峡山

操作提示：
鼠标移至水位站点或水位数据时，系统自动显示该站水位、警戒水位、流量、水势等信息。

图例：
○ 重点江河水位站
● 警戒水位站
■ 水位
■ 流量

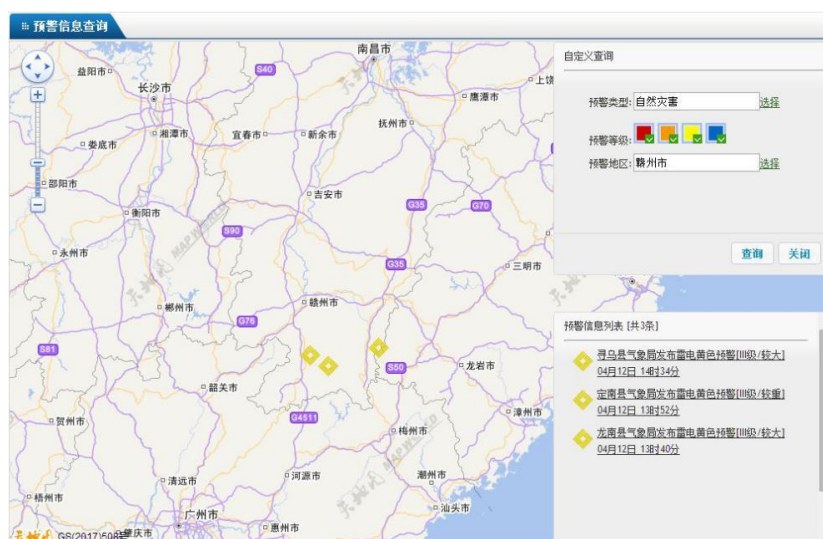
图例：
○ 河流
○ 湖泊

图例：
○ 重点江河水位站
● 警戒水位站
■ 水位
■ 流量

图例：
○ 河流
○ 湖泊

(b) Real-time flood information on April 12th, 2017

Information Website



33

3.6 Fushougou Underground Drainage System

Sewer is a testimony of the “conscience” of city planning. In recent years, many Chinese cities have suffered from water-logging. Thanks to its ancient sewage system Fushougou, Ganzhou city—the ancient city first built in the Song Dynasty, the city has never experienced any waterlogging, which makes it outstand from other cities¹⁴. Fushougou—the underground hydraulic engineering project—was built in Ganzhou city of Jiangxi Province during the Northern Song period. Liu Yi—a hydraulic expert—who served as the Director of Mater Resources Ministry at that time—was in charge of this project. Fushougou is an ancient city sewage system that is rarely found all over the world in terms of its well-developed and fine design. Based on streets layout and topographic features of Ganzhou city, Liu Yi designed 2 main drainage channel systems to realize drainage in separate divisions. The layout of two channels is like the words “Fu” (福, means happiness) and “Shou” (寿, means longevity) of Chinese seal characters, therefore the project name of “Fushougou”. After 900 years, Fushougou is still serving as the major sewage channel of Ganzhou people.

Chinese Premier Li Keqiang visited Fushougou on Aug 22nd, 2016 and commented that “China has experience in building urban underground drainage system and existing ancient projects. Fushougou enjoys a long history and has been benefiting people. It’s a project in the interests of people as well as a conscience project. Yangtze River has experienced the largest flood since 1998 and many cities are mired in water-logging. The major cause that our underground drainage system is far from satisfactory. Therefore, we must promote the construction of underground drainage system, especially water supply and drainage system, which will provide a secure and comfortable living environment for people but also show our conscience in city development.”

Currently the Fushougou Protection and Inheritance project has been approved. Investigation and protection and maintenance activities will be carried out for the existing 12.6km-long Fushougou in Zhanggong old city area. Besides, an 8,000-square-meter Fushougou museum will be constructed. The overall project investment is as high as 98 million RMB.

¹⁴ “Tomorrow, what kind of city do we live - focus on sponge city construction” , http://www.gov.cn/xinwen/2015-10/17/content_2948523.htm.



Figure 25 Premier Li Keqiang's visit to Fushougou on Aug 22nd, 2016¹⁵



Figure 26 Fushougou Internal Structure and Manhole

In reference to the working principle of Fushougou that connects ponds for water regulation and storage and drainage, a central park has been built in the new city area of Ganzhou. The central park is a theme park with multiple functions of leisure, landscape, ecology, wetland, flood storage and drainage. The park covers an area of 1,002 mu in which 626 mu are lakes, 323 mu are rivers and 53 mu are diversion channels and consists of a central lake area and waterfront green belts. The park is lively with the central lake district that has the best landscapes, full of local cultural elements and natural landscapes and characterized in leisure activities with various themes and features. The total investment is about 130 million RMB¹⁶.

¹⁵ “Li Keqiang 's Inspection Photos on August 22 in Jiangxi Ganzhou” , http://www.gov.cn/xinwen/2016-08/23/content_5101420.htm.

¹⁶ “Ganzhou Central Park” , [https://baike.baidu.com/item/中央公园/6208614?fr=aladdin#reference-\[1\]-7396975-wrap](https://baike.baidu.com/item/中央公园/6208614?fr=aladdin#reference-[1]-7396975-wrap).



Figure 27 Central Eco Park in Ganzhou New City Area

Charter 4 :

Policy Suggestions in Increasing Urban Flood DRR capacity

Strengthen and Optimize the Urban Drainage System

The lack of drainage and storage capacity in cities is the main reason for urban waterlogging. According to the revised China National Standard of Outdoor Drainage Design Code in 2014, the urban rainwater pipes should be able to resist floods of various return periods: 1 to 3 years for non-central parts of the city, 3 to 5 years for the center of the megacity. The standard requires a decentralized source of waterlogging drainage system with a standard of 2 to 5 years. According to the standard, the city waterlogging control and prevention should resist floods with various return periods: 20 to 30 years for small and medium-sized cities, 30 to 50 years for large cities and 50 to 100 years for megacities.

According to the ground water design standards, the design must meet two requirements concurrently. First, the ground floor of residential, industrial or commercial buildings cannot be flooded. Second, the water depth of a lane on the road cannot exceed 15 cm and the continuous water accumulation time on the road cannot exceed 2 hours. This standard requires that in terms of the residential and commercial buildings and roads, the excess runoff that cannot be drained by conventional rainwater pipes must be drained by constructing infiltration, storage, pumping and other facilities to meet the protection requirements.

Before the revised Outdoor Drainage Design Code was introduced in 2014, most China's urban drainage systems adopted the Soviet model. As the Soviet Union had less rainfall, it had a

lower standard for drainage pipelines: most of the design standards for urban rainwater pipes are 1/3 to 3 years, and there was no clear standard for urban waterlogging prevention. As for the developed countries and regions, the standard for urban drainage network is higher. The American drainage standard is 2 to 15 years for residential areas and it is generally 10 years. The commercial and high value areas are 10-100 years, compared with the 30 years in the UK. Therefore, China's actual urban rainwater drainage design standards are generally lower than the newly revised standards and international standards. And because of the expansion of the city area, the drainage area of original pipes has increased, thus lowering the actual standards they achieve. At the same time, pipe network aging is also one of the reasons for urban waterlogging. Some pipe networks in Wuhan were even constructed in the Qing Dynasty with seriously degraded drainage capacity.

Wuhan city has a water surface ratio of 25%, the highest in China. Excluding Yangtze River and Han River, its lakes contribute to a water surface ratio of 11%. The lakes in Wuhan city have great flood water storage potentials by lowering the water level before heavy rainfalls and storing water during the rainfall. So Wuhan government is suggested to conduct more researches to study the role of lakes in addressing city waterlogging. Also the government is suggested to follow the idea of safety first and eco and coordinated development and to analyze and build a mechanism to address waterlogging with lakes. Besides, measures should be taken to improve artificial pumping and drainage capacities, build a better network between lakes and rivers for connection and dredging, improve the quality of water entering lakes via rain and sewage diversion, mitigate waterlogging with the idea of spongy city. Therefore, Wuhan city is expected to release more potential in waterlogging prevention and treatment.

The Fushougou underground drainage system in Ganzhou city is precious treasure left by the great hydraulic expert Liu Yi. Even after 900 years, it remains a main sewage channel for Ganzhou people. However, urban development has caused some damages to the system and its supporting lakes and ponds are being exploited in city development. So Fushougou is facing serious challenges in terms of its flood control and drainage functions. In light of such situation, Ganzhou city is suggested to take enhanced efforts to repair, protect and leverage Fushougou. Also, successful practices and experience should be summarized and spongy city development ideas should be considered to make the city stronger in preventing flood disaster risks. By doing so, a Ganzhou city will have stronger flood control and drainage capacities, a better eco environment and more resilience against city disasters.

Understanding and Analyzing Potential Disaster Risk Due to Flood in the Context of Urbanization

Despite decades of flooding, developing countries in Asia-Pacific including China where rapid urbanization is happening, the characterization of hazards, vulnerability, exposure, capacity and impact to urban areas are not well understood. This results in inadequate anticipation of the potential impact of a flood risk in urban environments. As observed in the 2016 flood, reporting of damages and losses were more focused in agriculture, i.e. crop losses, number of collapsed houses and associated household level assets, typically applicable to rural areas. There was limited information about effects to urban services like drinking water supplies and/or contamination of sources, spread of pollutions, number of days when schools were closed, small, micro enterprises, impact on private and public assets, cultural heritage, areas of tourism, damage and disruption of electrical power supply and other critical infrastructure.

The lack of understanding about urban risk can contribute to inadequate and/or uneven level of preparedness, mitigation and prevention particularly in areas where this severe flooding had no precedence and/or population may lack the necessary social cohesion and coping mechanism to protect themselves and their assets. This can also result in untimely delivery of emergency services, poor selection of beneficiaries, and under estimation of recovery and reconstruction needs.

For China, improvements on flood risk assessment in urban areas particularly in big cities like Wuhan are recommended. This should not only focus on characterization of hazards such as precipitation and area of water catchment. It must include assessment of storage capacities- through natural ecosystem like lakes, rivers and wetlands but also manmade reservoirs, drainage, flood flows and redistribution in streets during peak storms and flooding. To illustrate the importance of these information- plans and decisions for safe evacuation of population and measures to protect assets are dependent on information about flow velocity, water depth and fluctuations of both. Additionally, as this applies to Wuhan and other cities where the sponge city is applied- hazard assessment should also consider the role of surface porosity i.e. sponge bricks and green spaces, park lands in absorbing and diverting excess water.

Urban risk assessment in China also needs improvement in research and understanding of the

typology of elements exposed to flood. As earlier mentioned, urban environments constitute different types of exposure compared to rural environment. The most important difference is the concentration of population and infrastructure in a relatively smaller place and thus risks are amplified and damages can be catastrophic. In the cities visited, there is also a high concentration of enterprises and diverse sets of economic assets, ranging from small to big industrial and heavy industries. Wuhan is also the location for many historical and heritage sites. These elements and the economic, political and social systems can be impacted individually and collectively thereby contributing to damages, losses, disruption of economic activities, foregone income and reducing quality of peoples' well-being.

It is also important to improve understanding of the dynamics of urban risks and that changes can happen rapidly in population density, increase in infrastructure and housing. In the 2016 event, it is also important to understand the temporal aspect of the flood and the extreme rainfall that occurred is seen to be strongly connected to El Niño seasonal variability. The deluge therefore should not be unexpected. Heavy rain often affects China after an [strong El Niño year](#). Indeed, after a strong El Niño in 1998, similar floods struck the Yangtze River Basin, causing \$44 billion in damage and 3,656 deaths. [Multiple studies](#) also suggest that [global warming](#) is likely increasing the intensity of the monsoon in Asia. Given this, it is recommended that capacity for early warning and early action be improved using seasonal climate models, long term forecasts (10 day) and short term and real time forecasting and dissemination. Integrated solutions incorporating climate change adaptation and disaster risk reduction is increasingly relevant in this case.

Understanding and Analyzing Realized Risk Based on Actual Impact of Flood: Reporting of Damages and Needs Assessment

The Ministry of Civil Affairs manages a technologically advanced information management system. The system collects data real time and provides urgent information for emergency response particularly if it involves support from the central government. The information system combine multiple sources- including reports from local authorities, remote sensing and satellite imagery.

When a flood occurred, the risk is realized and become actual damages and losses. The

financial consequences of 2016 flood can be much larger than previously anticipated. This happens when an extreme weather event resulted to anomalous impact exceeding historical and statistical trends. It is noteworthy that despite of this severity, deaths due to flood are decreasing in China. However, though statistical data is not analyzed, damages to public and private assets and economic losses are increasing.

It is observed that information on details for assessment of damages and needs are not comprehensive and is not comparable to international best practices. To add on observations elaborated in previous section, economic losses due to flood is not limited to Wuhan City and flood effects have macro economic impact as it has substantial contribution to nation's GDP among other cities affected by the 2016 floods. It is also the source of important products and services and the disruption in production and delivery of these may have also impacted other areas that were not directly hit by the floods.

It is recommended that improvements and changes be undertaken in collecting and analyzing data related to damages and needs. It is recommended that China uses the recommendations to apply minimum reporting based on terminologies agreed under the Sendai Framework for Disaster Risk Reduction. This document http://www.preventionweb.net/files/50683_oiewg_reportenglish.pdf, provides an explanation and guidance to how the following can be collected, reported and analyzed:

- Deaths and missing persons;
- Affected population- injured or ill; people with damaged and destroyed dwellings; people whose livelihoods were disrupted or destroyed
- Direct economic losses- agricultural loss; damaged or destroyed productive assets; economic loss in the housing sector; economic loss from damaged or destroyed critical infrastructure; economic loss to cultural heritage damaged or destroyed
- Critical Infrastructure – damaged or destroyed health facilities; educational facilities; disruptions to basic services; disruptions to educational services, health and other services (such as water)

When this is standardized, it is recommended that this information is stored in national disaster damage and loss databases so that trend analysis can be undertaken. The database should have capacities for disaggregation at the sub national level, sectoral concerns, and sex and age disaggregation. This can provide information for better planning and decision making.

UNDP has supported 16 countries in the Asia Pacific region and this methodology can be adopted in China.

Furthermore, floods in urban areas have long term economic consequences and lingering effects to peoples' well-being. Assets destroyed must be reconstructed and needs of people particularly the poor should be responded to not only in the immediate aftermath but also in the long term so that they are not vulnerable to future disasters or impact of flooding. It is recommended that China improves its damage and needs assessment for recovery and reconstruction and use the universally agreed methodology. This is referred to as Post Disaster Needs Assessment (PDNA) developed by UNDP, World Bank and the European Union. This PDNA tool <http://www.mx.undp.org/content/undp/en/home/librarypage/climate-and-disaster-resilience-/post-disaster-needs-assessment.html> provides a standardized and comprehensive assessment methodology in the post disaster period. It is multi-sectoral, addressing recovery needs related to infrastructure, shelter, livelihoods, and social and community services in a balanced and comprehensive manner and represents a harmonized and coordinated approach, providing for an objective, comprehensive and government-led assessment of the post disaster damages, losses and recovery needs, and paving the way for a consolidated recovery framework. The overarching purpose of this guide is to provide technical support to practitioners as they plan for and implement the needs assessment and design the recovery framework. It is hoped that the guide will allow for a consistent and coherent approach to the post-disaster assessment, provide an objective and comprehensive estimate of recovery needs, while facilitating quick decision-making and action.

Increase and Improve Stakeholders' Responsibilities in Preparedness, in Reducing Damages and Losses, in Emergency Response and Recovery

Especially in an urban setting, there is a variety of stakeholders who are both exposed to flood risk and have accountability to manage and reduce damages and losses. It means that the responsibility is not only by the government but also the private sector and the communities themselves. In large event such as this, the involvement of central government is also

imperative and mutual aid support from other cities and provinces can also add to capacities for responding and recovering from disasters. This whole of society approach is favorable based on other countries' experiences. Organizations working in siloes are ineffective and prone to duplication and overlaps. There is an existing system that promotes coordination at the city level. However, there is a continuous challenge in its complexity and require improvement of coordination, information sharing and capacities of city level authorities to improve the multi sectoral response. It is recommended that a standard operating procedure, especially for large catastrophic events be developed and organizations are provided with capacity and skills to implement these. To enhance effectiveness, joint and multi sectoral training is recommended that will allow development of familiarity and operational relationship among planners and responders.

Multi sectoral efforts for reducing flood risk should be continued and to be further enhanced. The mission is impressed with the commitment and active engagement not only by the Civil Affairs authorities but also the organizations involved in urban planning, water management and meteorological agencies. These organizations can also provide timely analysis and information for improving emergency relief services including in identifying where flood can be worse and pre-positioning of these interventions.

The community based disaster risk management approach in model villages are reported to be working very well and this ought to continue and be expanded in villages affected by the 2016 flood. It is important that this is integrated into structural and other non structural measures. Since those who died in the flood seem to have not responded to warning or were late in evacuating, efforts to increase awareness on what to do when warning is received must be undertaken. The message on "self-help" need to continue to be emphasized.

The private sector should be encouraged to undertake appropriate measures to protect their assets, implement business continuity plan and acquire insurance coverage. A study (Aon Benfield) states that insurance penetration is significantly low and therefore recovery of damages assets and income will be challenging. With changes in severity of disasters and increasing private sector owned enterprises, the enforcement of building codes is an imperative. They have to be aware that investment in disaster risk reduction is not a cost but rather very crucial for business continuity and enhances viability.

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