

**Water systems approach applied to  
characterizing hydrological response in a  
changing environment**

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# Outline



**01 Water Security Issue in YR**

**02 Urban Water System Approach**

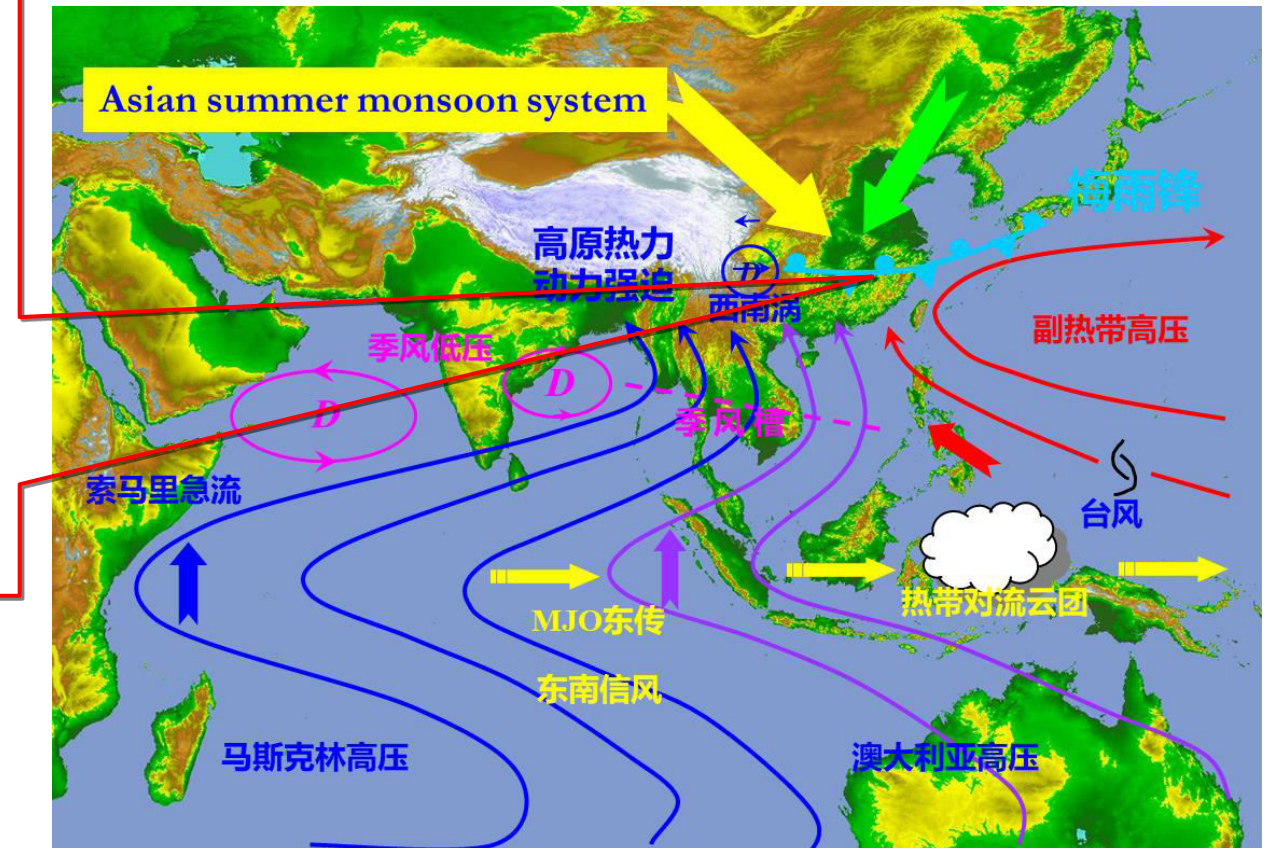
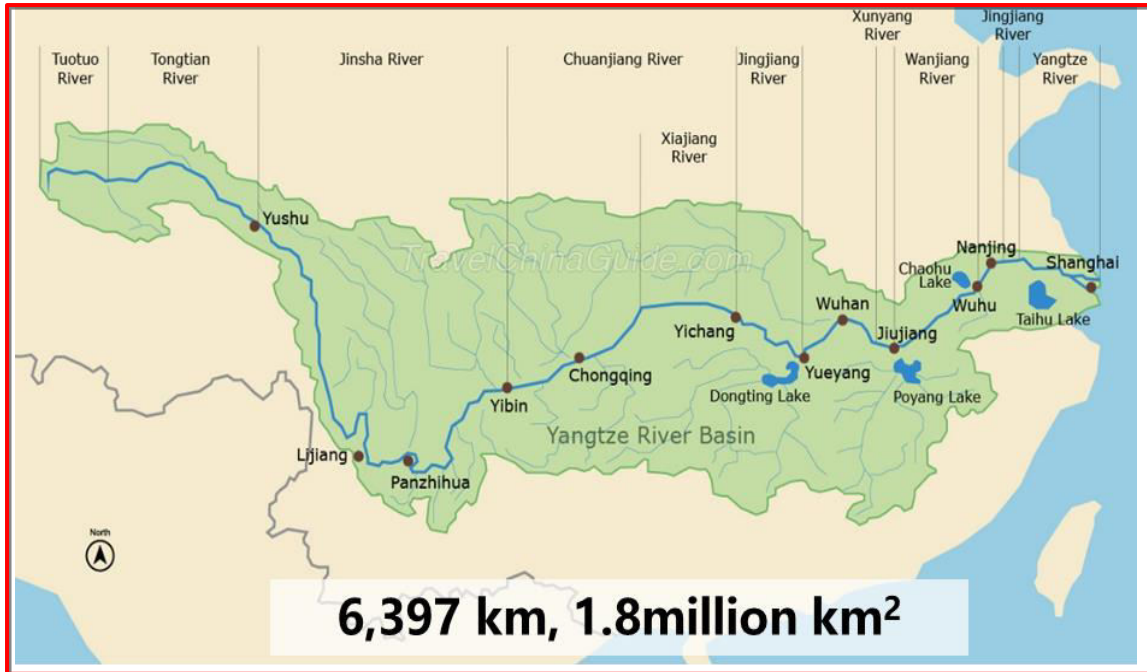
**03 Conclusion Remark**

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# 1. Water Security Issue



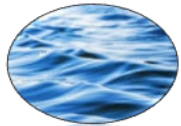
**Yangtze River (YR) is the largest river in China and the 3rd largest river in the world, located East Monsoon Area in Asia region**



# 1. Water Security Issue



**Yangtze River Economic Belt** with megacities, such as **Chongqing, Chendu** (upstream), **Wuhan** (middle stream) and **Nanjing, Shanghai** (downstream), plays a key role on socio-economic development in the China



**33% Freshwater** in China



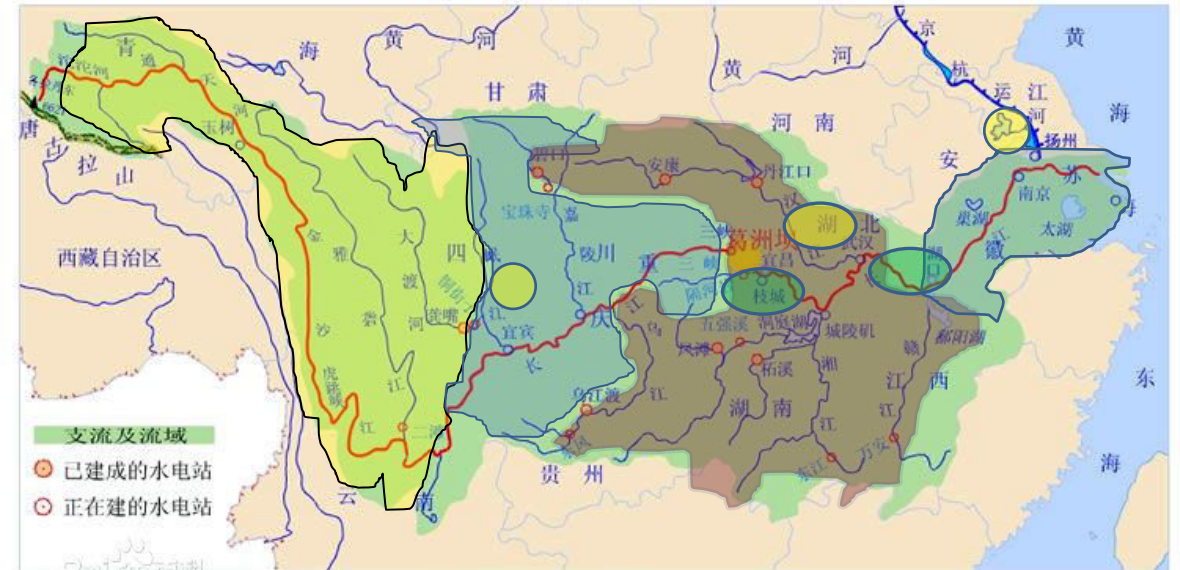
**33% Food product** in China



**40% Population** in China



**40% GDP** in China



长江流域水系图



Chongqing



Chendu



Wuhan



Shanghai

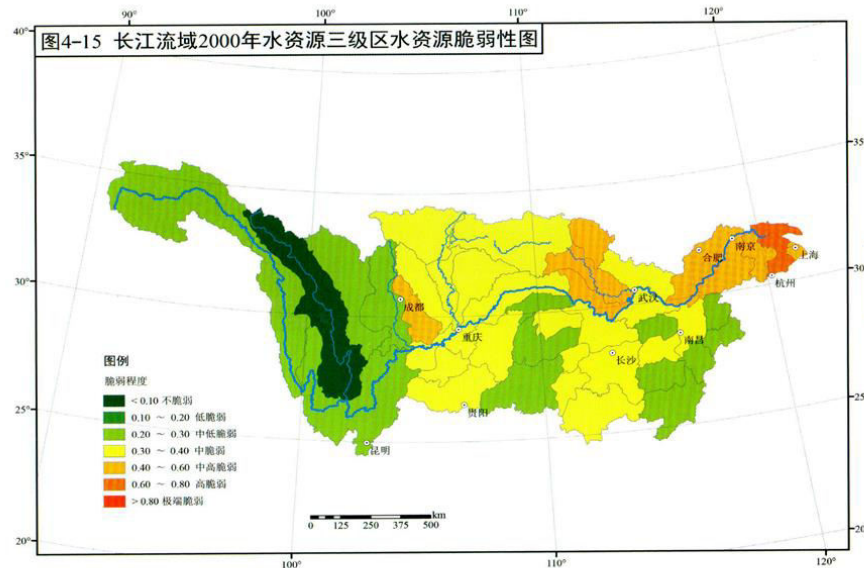
# 1. Water Security Issue



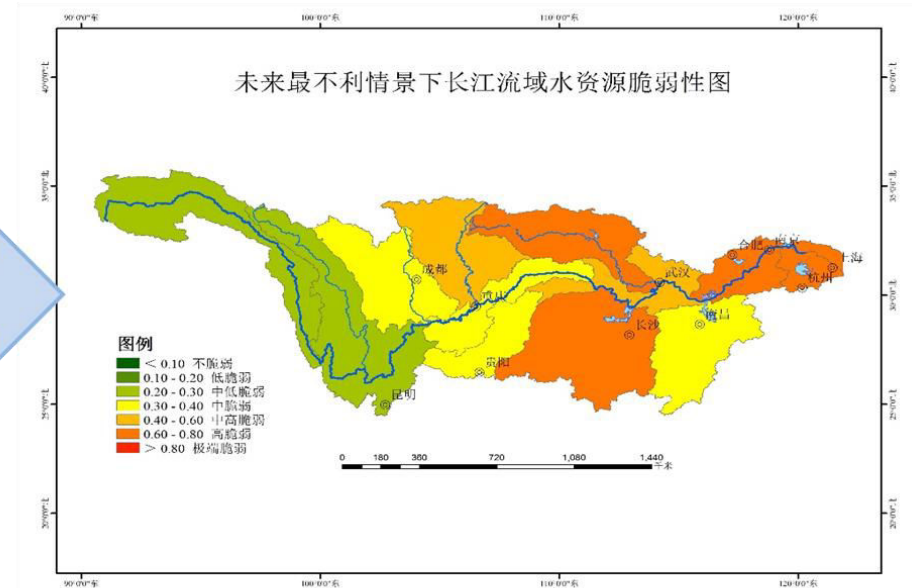
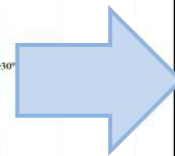
However, major challenges to megacities of YR from two aspects

## 1) Climate Change Impact

It is shown that *climate Change will increase the vulnerability of water resources in Yangtze River* (Xia et al., 2014)



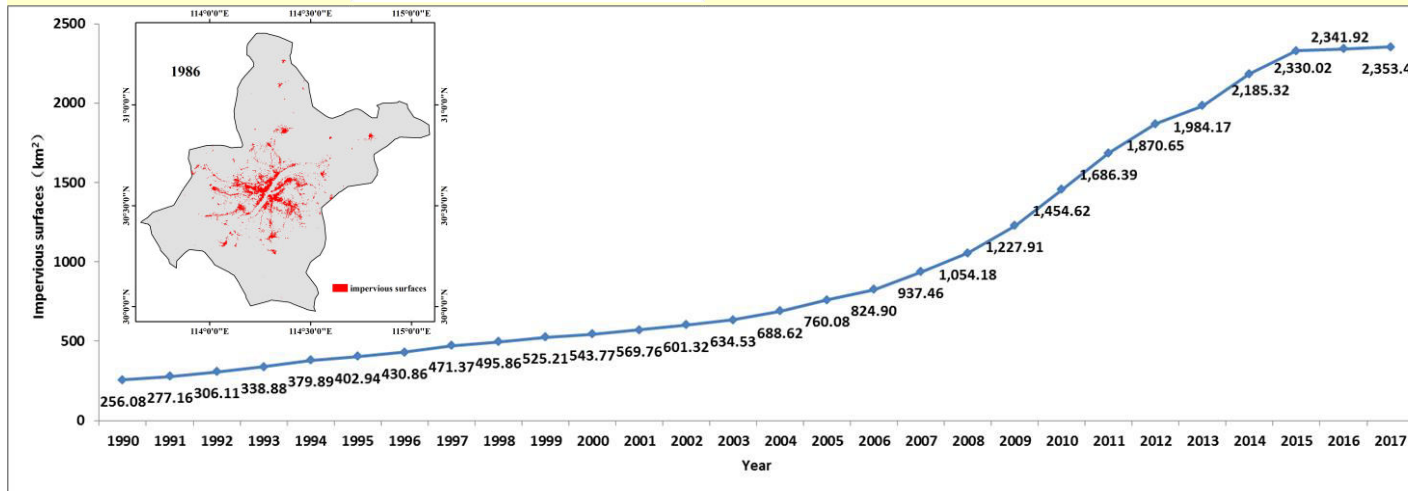
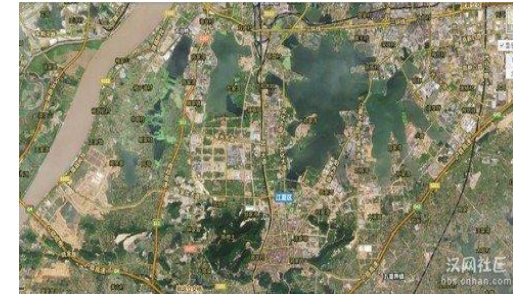
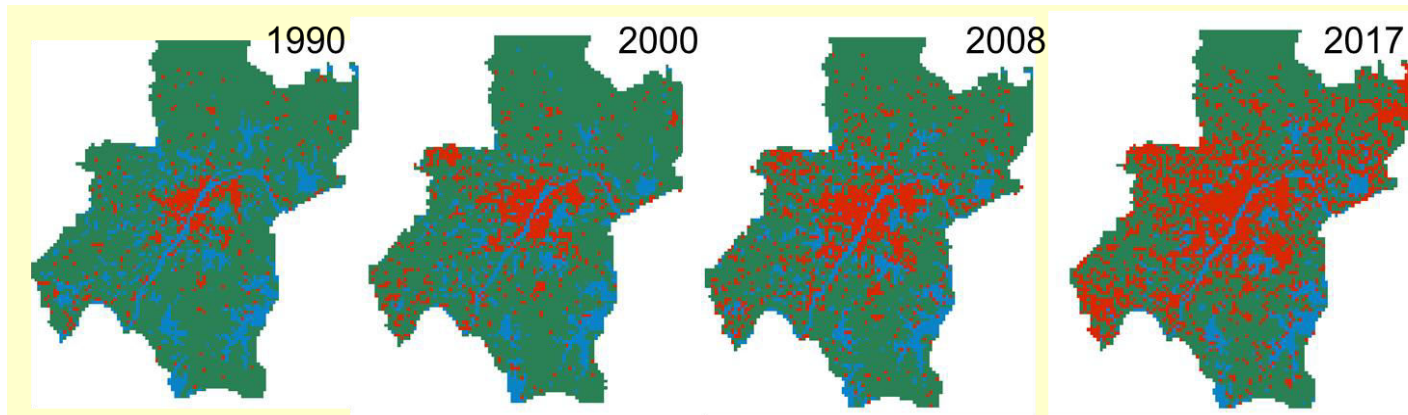
Current status of water resources vulnerability (2000)



Water resources vulnerability due to future climate change (2030)

(Xia et al., 2014)

## 2) Remarkable Land Use & Cover Change(LUCC) due to rapidly social-economic development



Change of the impervious area in Wuhan City, China (Shao Z F., 2017)

# 1. Water Security Issue



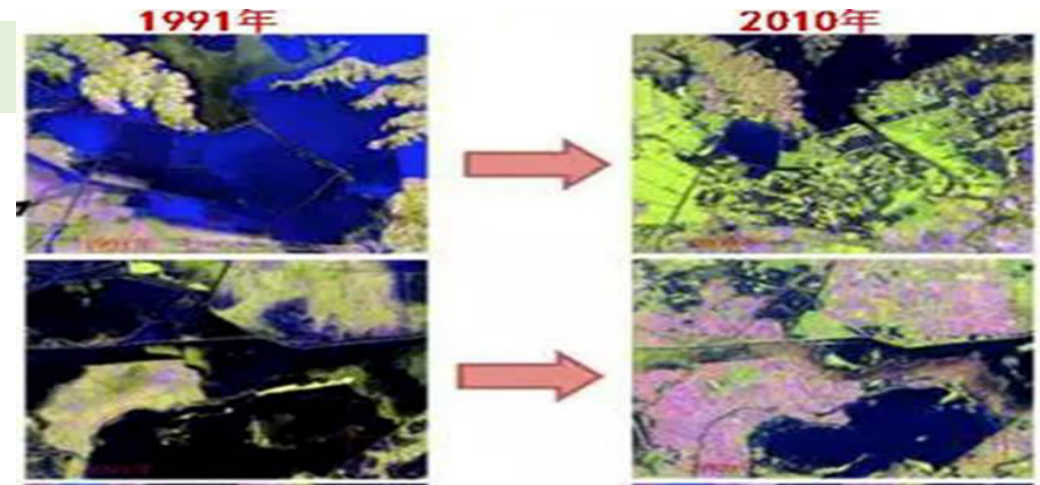
This is one of major reasons resulting in

◆ **Waterlogging** problem in the megacities, such as



◆ **Ecosystem degradation**

Lake shrinking and eutrophication etc.



# 1. Water Security Issue



## Water Security in megacities

has become a most important issue for the sustainable Yangtze





# Outline



**01 Water Security Issue**

**02 Urban Water System Approach**

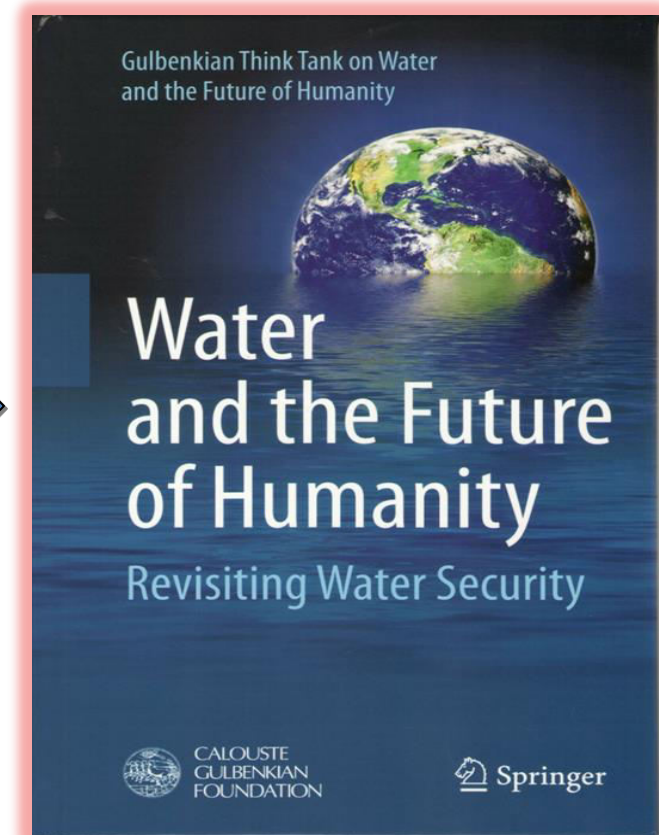
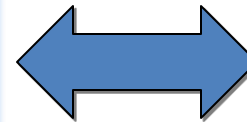
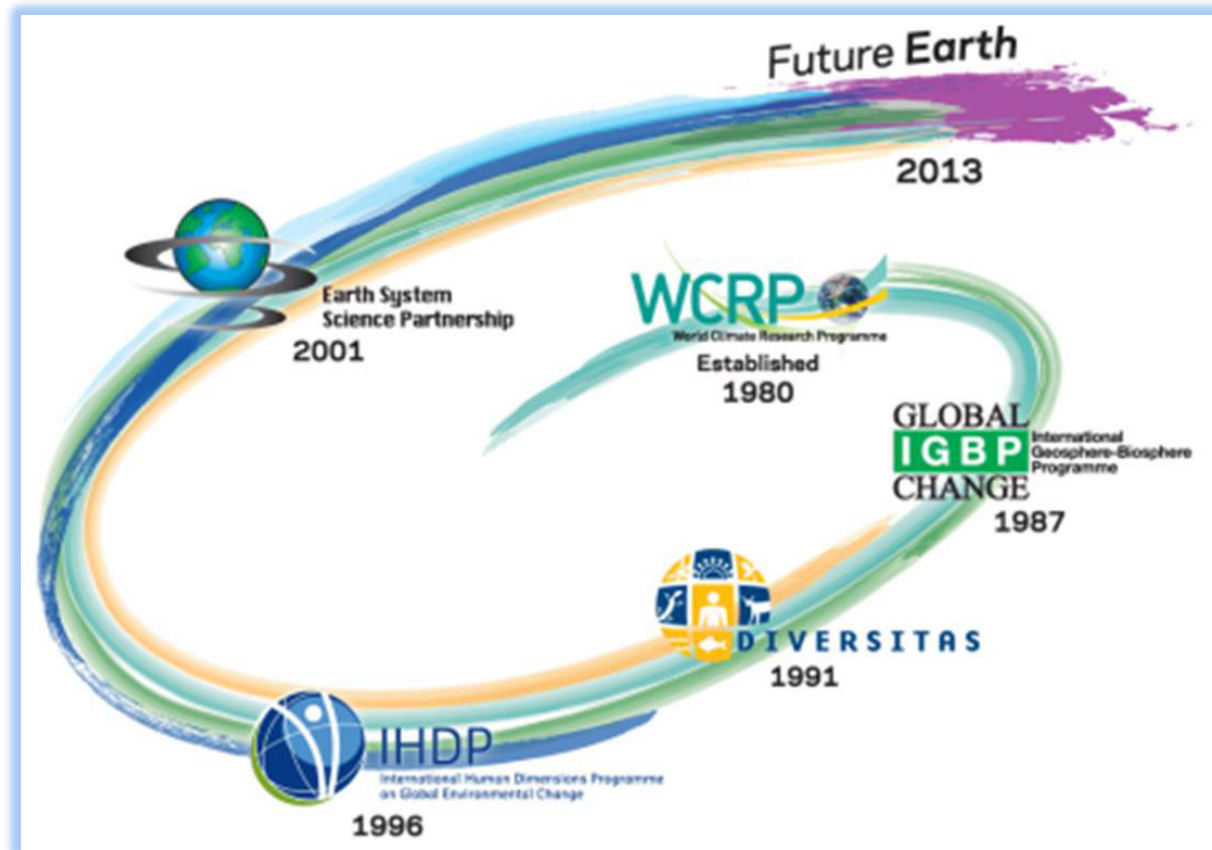
**03 Conclusion Remark**

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## 2. Urban Water System Approach

### Earth system sciences

Large river basin is the important part of the earth system, and water plays a key role for the future of humanity



## 2. Urban Water System Approach

The methodology of **River/Urban Simulator** applied to **wisely managing water**, has become a very important issue for SDGs

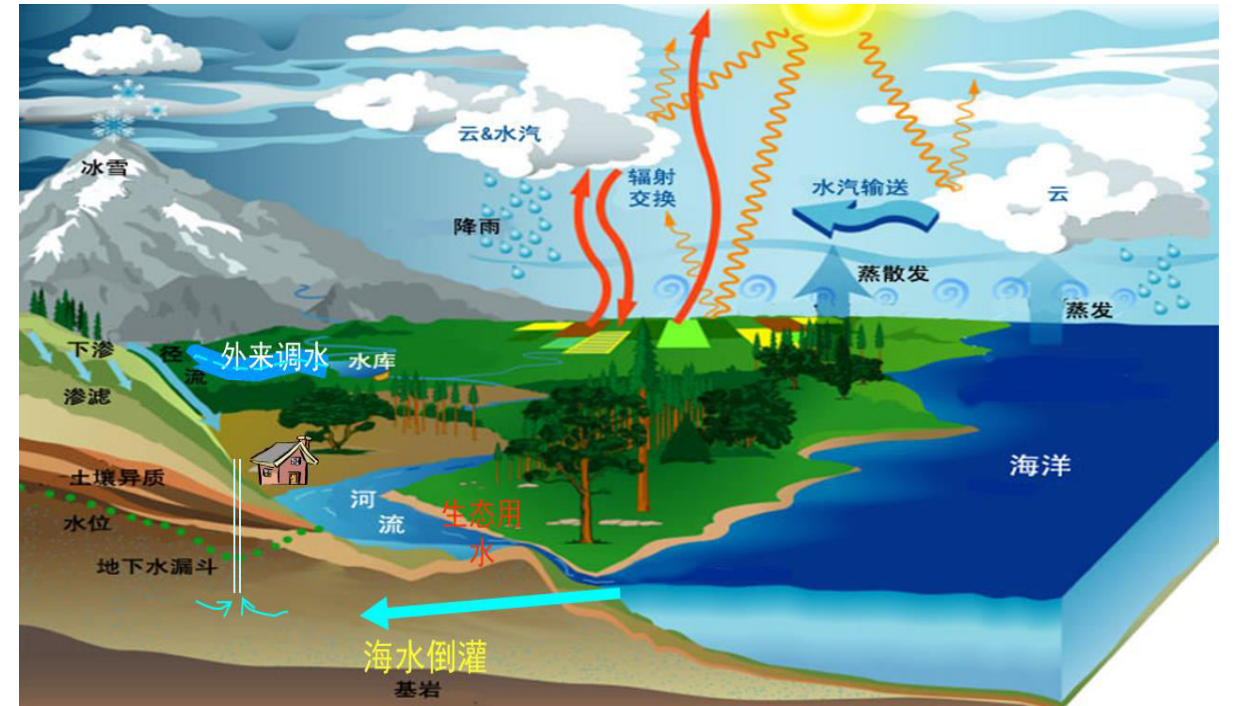
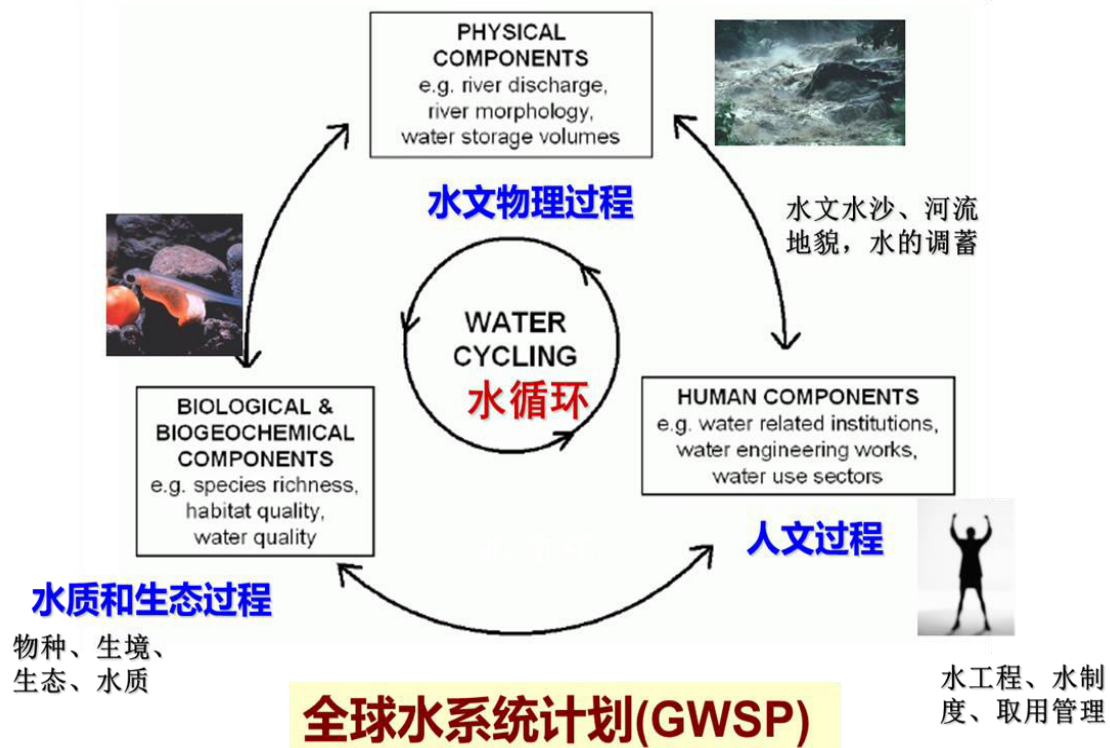


Global Water Systems Project  
Open Science Conference

7-9 OCTOBER 2003



Initiative of Catchment System(ICS)

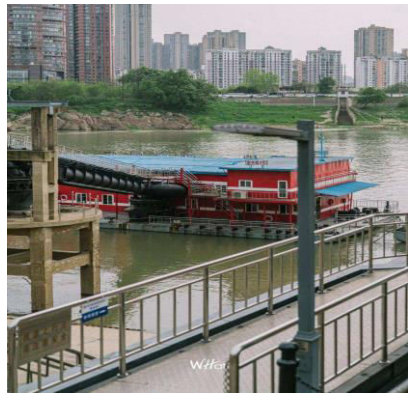


## 2. Urban Water System Approach



# Key points for urban water system

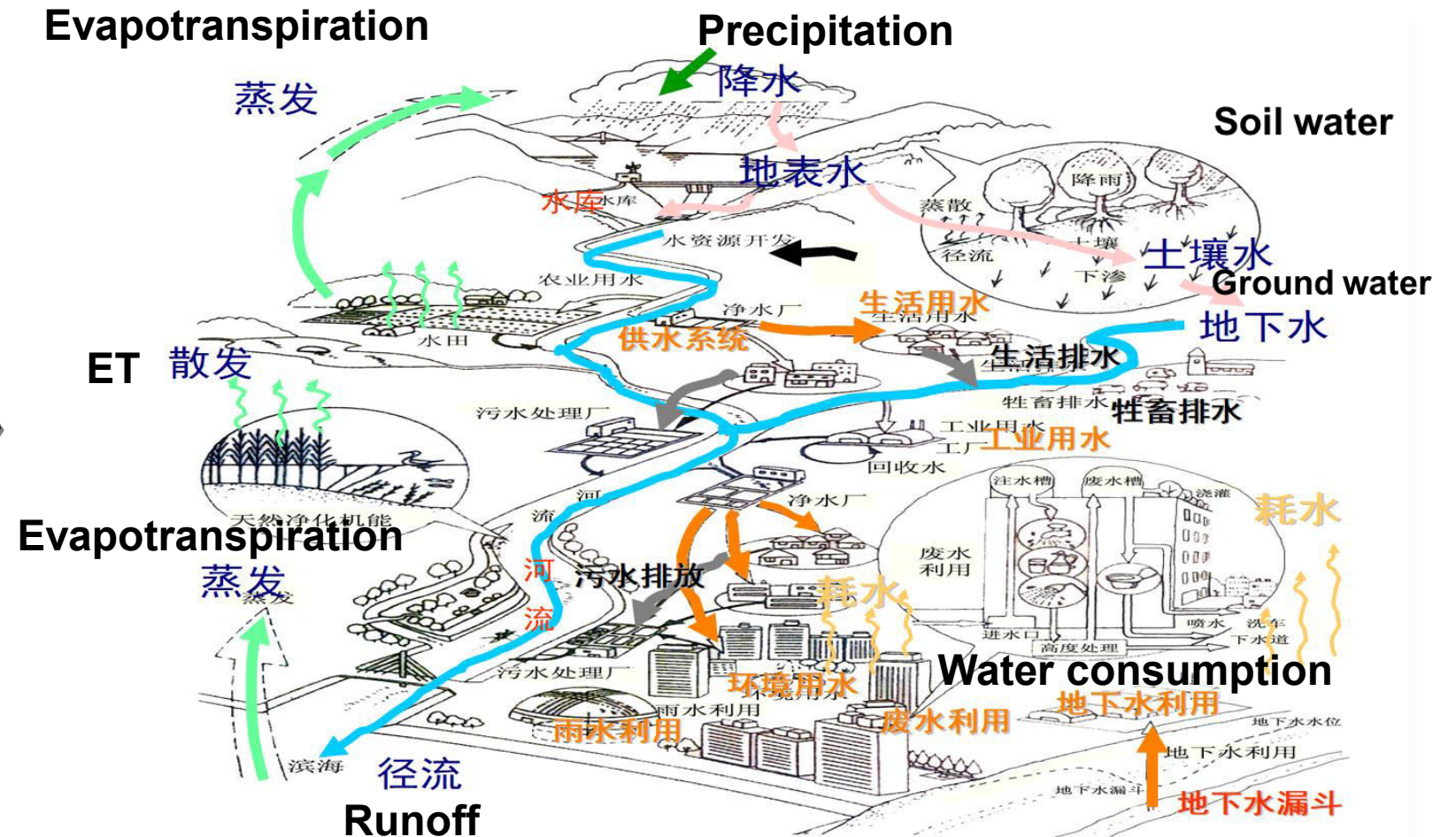
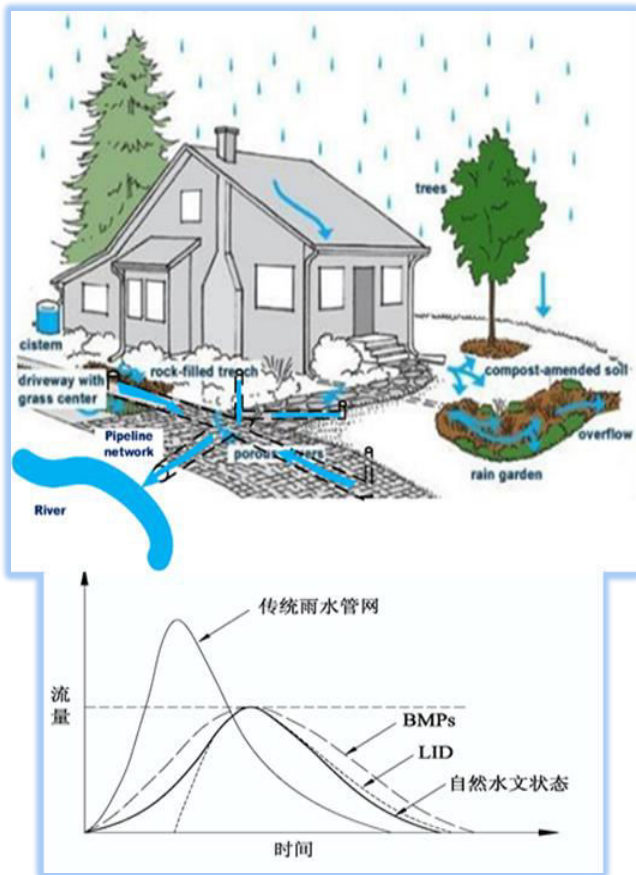
Traditional urban water system is only focus on **water supply** and **sewage treatment plant**



## 2. Urban Water System Approach



**Challenge:** How to improve our understanding to Sponge City Construction from **real system**, particular **multiple scale interaction**?



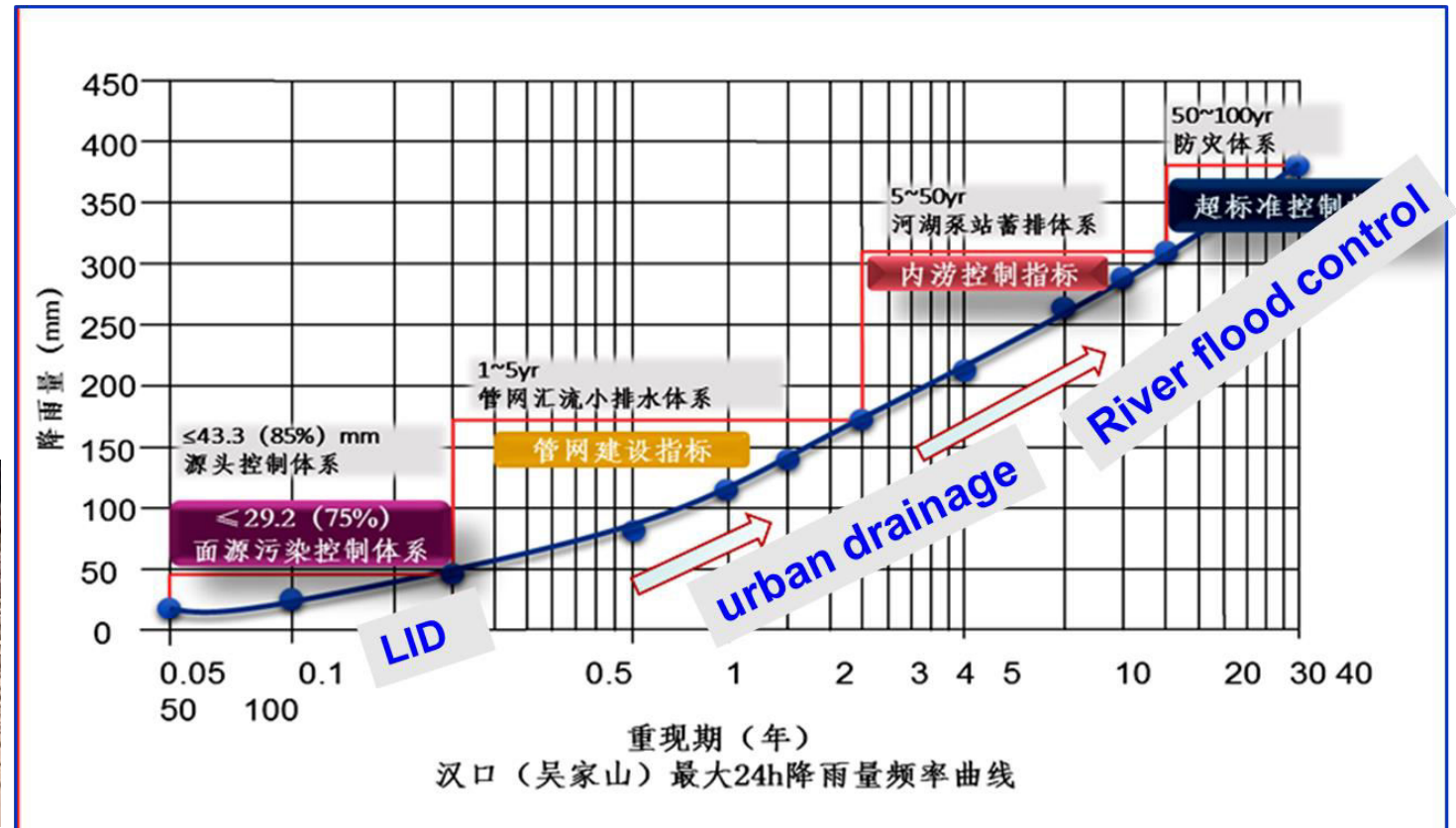
## 2. Urban Water System Approach



The 2016's case of Wuhan City shows that **multiple scale issue**, e.g., such as the solution of city waterlogging and green development, **should be considered and applied to Sponge City Construction**



Wuhan city linked with Yangtze River and 2016's waterlogging event

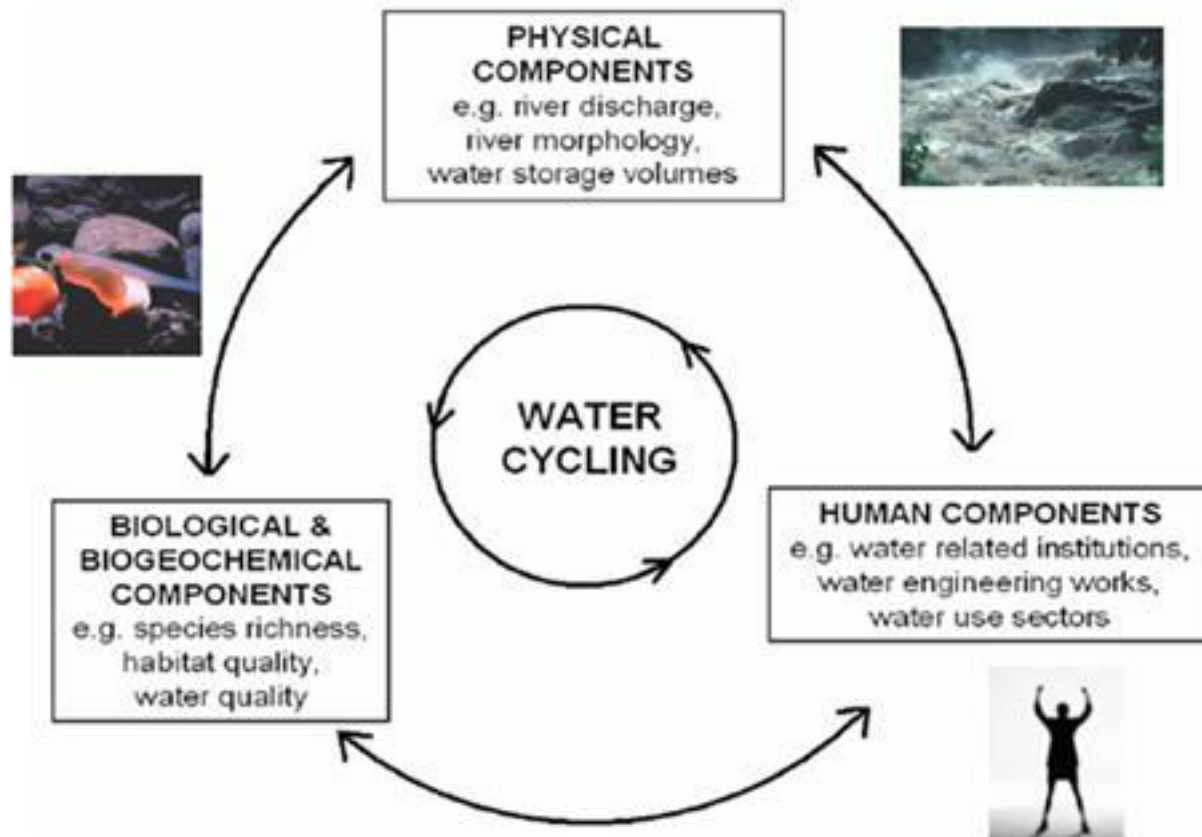


Example for Wuhan (J.Z. Wang, 2017)

## 2. Urban Water System Approach



It would be improved by developing  
**Urban Water System Methodology** (Xia et al, 2017)



Xia J. et al., *Opportunities and challenges of the Sponge City Construction related to Urban Water Issue in China*, **SCIENCE CHINA: Earth Sciences**, 2017, 60 (4) : 652-658

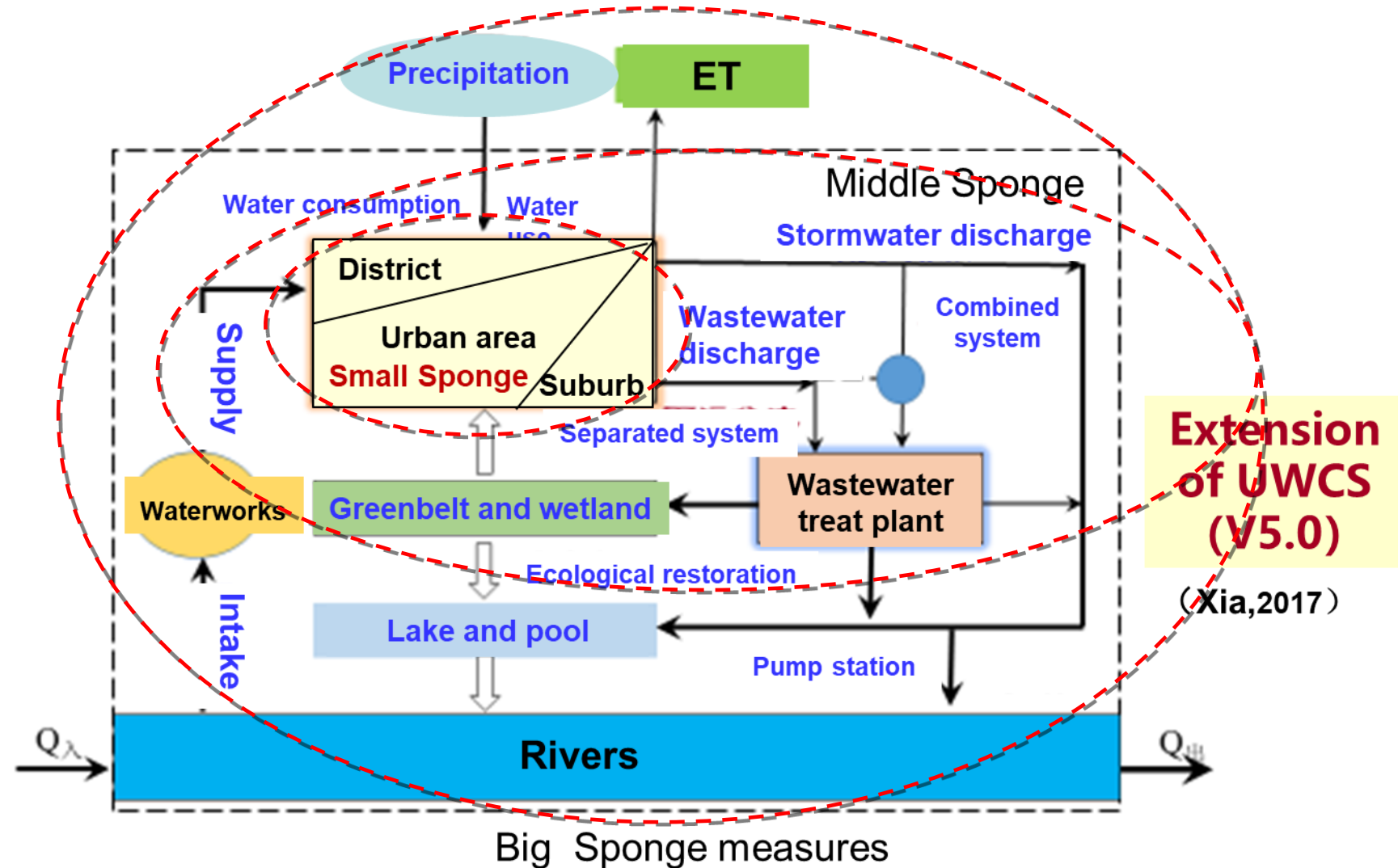


## 2. Urban Water System Approach



**Urban Water Cycling System (version 5.0)** was developed (Xia, 2017-)

Integration of **urban water system** with **river & lake and basin system**, which has the multiple functions on infiltration, retention, storage, purification, use and drainage, to **benefit the objectives of Sponge City Construction**



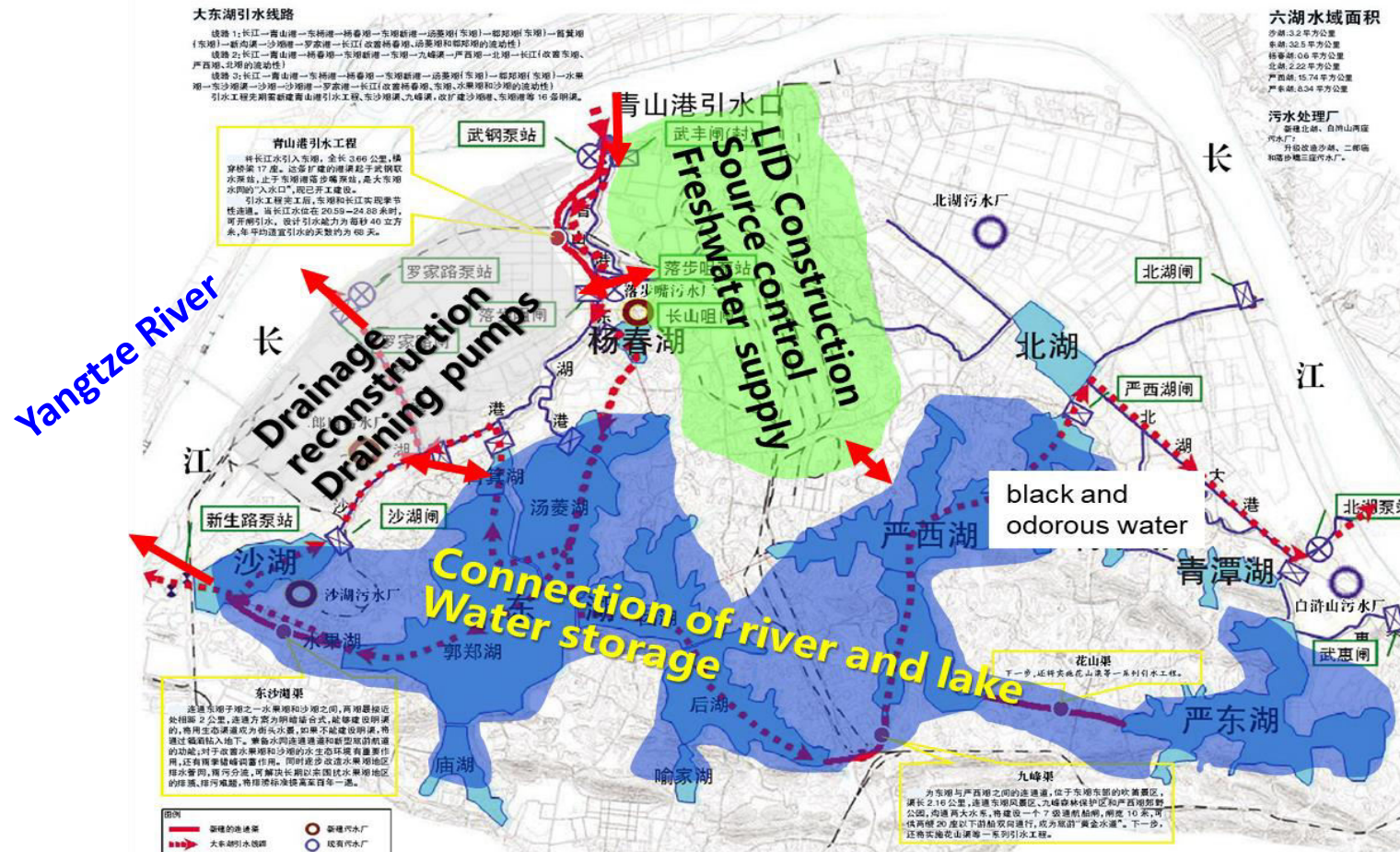


## 2. Urban Water System Approach



### Case study : Wuhan water cycle system

### Design and regulation for "LID-Drainage network-river and lake" system



- Small LID construction
- Drainage reconstruction
- Pump expansion
- Drainage channel
- NPS control
- Treatment of black and odorous water
- Wastewater treatment plant
- East Lake governance
- Flood control of Yangtze river
- Connection of six lakes

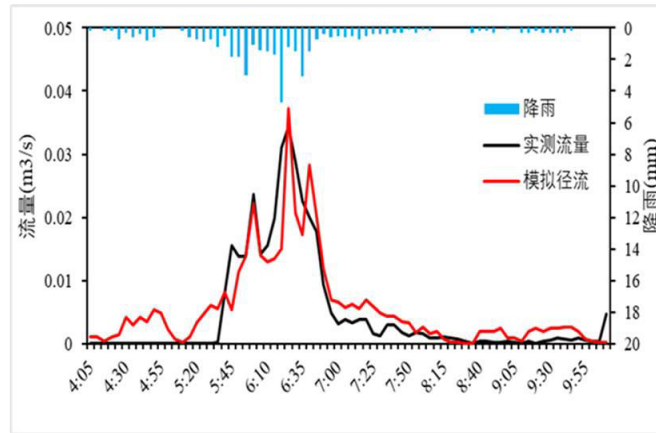
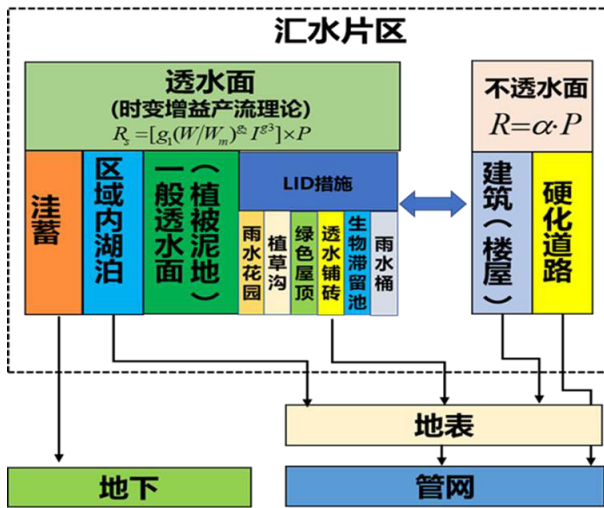
### The case of Qingshan District Wuhan City

# 2. Urban Water System Approach



## Urban hydrological modelling

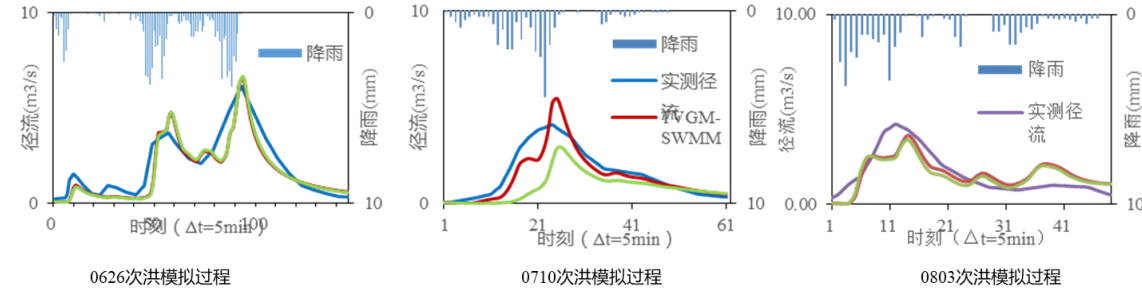
Time-Variant Gain Model applied to Urban (TVGM-Urban V1.0) was developed (Xia, 2017)



测流: 地面径流  
 TVGM-Urban 等  
 测流: 管网出口  
 SWMM/管网等效模型

TVGM-Urban Model (Xia, 2017-)

### 武汉典型小区产流计算验证



| 模型            | 次洪编号 | 相关系数          | NSE          | 水量相对误差        | 洪峰误差         |
|---------------|------|---------------|--------------|---------------|--------------|
| SWMM          | 0626 | 0.922         | 0.819        | 12.92%        | 8.02%        |
|               | 0710 | 0.636         | 0.751        | 38.37%        | 28.61%       |
|               | 0803 | 0.999         | 0.59         | 3.81%         | 6.21%        |
| TVGM_Urban    | 0626 | 0.922         | 0.819        | 13.49%        | 6.39%        |
|               | 0710 | 0.900         | 0.808        | 4.82%         | 33.52%       |
| <b>模拟效果提升</b> |      | <b>10.29%</b> | <b>4.26%</b> | <b>44.07%</b> | <b>4.93%</b> |

**综合精度提升: 15.8% > 10.0%**

TVGM-Urban Model's Verification

# 2. Urban Water System Approach



## Key Technologies for Integrated Urban Water System

Urban water cycling

Nonpoint Pollution

水量水质源头控制技术

水量水质源头控制技术

产流产污模块

Water quality monitoring & treatment

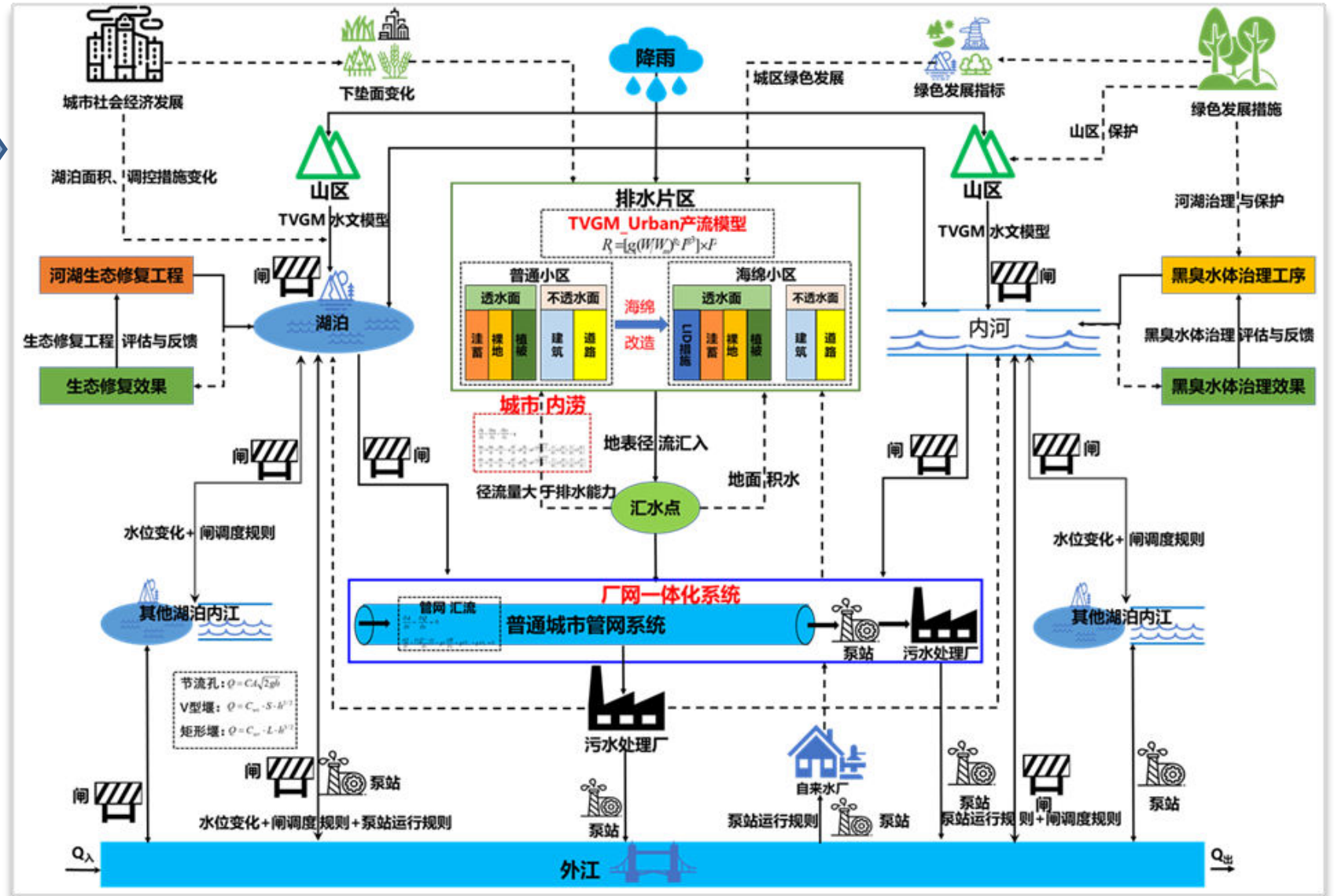
Ecological restoration of rivers and lakes

黑臭水体治理技术

河湖生态修复技术

Integrated management of urban water system

## Key Technologies



## 2. Urban Water System Approach



# Design and regulation for "LID-Drainage network-river and lake" system



雨水管网改造图

### LID subsystem:

171 small sponge measures

- Region of Jiangnan(83)
- Region of Hankou and dongxi lake(36)
- Region of Huangpi and Xinzhou(17)
- Region of Caidian(35)



### Drainage subsystem:

- Drainage network construction
- 18 pump stations
- Reformation of pipe network and channel
- Storage Space of rainstorm
- Wastewater collection and treatment

**Systematic improvement and regulation**

### River and lake subsystem:

- Connections of east lake and Yangtze River
- Eco-river network of big east lake
- Connections of six lakes in Hanyang
- Mainstream dredging in urban region
- Storage projects of 11 urban lakes



## 2. Urban Water System Approach



**Implement effect** for Wuhan city is very significant

After three years of construction, 288 projects in Demonstration Zone of Wuhan Sponge City, have been completed, covering an area of 38.5 km<sup>2</sup>, and the spongy body has initially realized the functions of “breathing” ...



青山江滩二期

桥南公园

戴家湖公园

南干渠游园

## 2. Urban Water System Approach

- **Water quality** in the demonstration zones in Wuhan has been **significant improved**
- On August 24, 2017, there was **extremely rainstorm in Wuhan with 113.5mm**. There was **no prolonged waterlogging** in the demonstration area
- On May 25, 2019, there was a heavy rain in Wuhan, and **no road was waterlogged for a long time**

青山港湿地雨、污水整治及水环境修复工程



跌水改造

水体改造

入口改造



改造前

改造后

钢城二中海绵改造工程



改造后学校环境得到极大提升

4月8日-9日, 青山累计降水147.8毫米, 钢城二中未发生积水情况

### 大暴雨未造成武汉大面积积水

金报讯 (记者戴辉 通讯员黄金波)4月8日至9日, 武汉普降暴雨, 汉口地区最大降雨量73.9毫米, 武昌地区最大降雨量140.6毫米(省委), 汉阳地区最大降雨量33.5毫米, 为大暴雨级别。本次降雨时间短强度大, 其中小时最大降雨量为70.5毫米(化工区)。

建设十一路



•青康居

•钢城49中



青山区4月(新闻报道)与8月(实景图)两场降雨积水情况

## 2. Urban Water System Approach



### 2020's Wuhan floods: "Sponge city" help to solve the waterlogging dilemma

In 2020's flood season in Wuhan, both intensity and total amount of rainfall are larger than that of 2016. However, the waterlogging problem was significantly improved in the sponge demonstration areas, when the rainstorm peaks coming

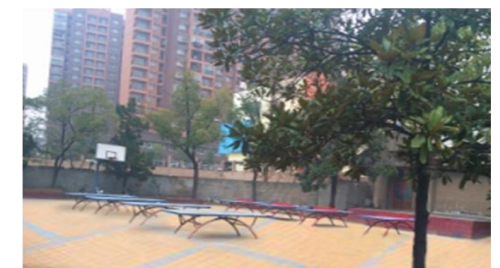


The two "sponge" demonstration areas (Qing-shan & Si-xing) benefit **500,000 residents** due to water system governance



Before the construction

Sponge and effect



No waterlogging when the rainfall is 147.58mm

# Looking for the Future of Yangtze

- ◆ **Yangtze River Protection Law**, also was passed at the 24th Standing Committee session of the 13th National People's Congress on Dec.27, 2020



- ◆ **Integrated & systematic solutions for Sustainable Yangtze including megacities green development, will be major tasks in the future**

1. Coordinating **relationships** among upper, middle & lower reach, human & nature
2. Emphasizing **carrying capacity** of water resources, environment & ecology
3. Supporting **the solutions** by integrated ways:  
headwater → lakes/reservoir → shoreline → **urban system** → delta/estuary



### 3. Conclusion Remark

- **Yangtze River** faces big challenges on its water security issue under the climate change, and also LUCC, particular on urban system due to high intensity human activities
- **Strategy on Great Protection & Green Development of Yangtze River** provide new demands & opportunities on how to wisely managing water. **Urban Water System Version 5.0** was developed and applied to *Integrated Urban Water Management (IUWM)* in adaptation to climate changing impact
- Chinese scientists through **Sponge City Construction** did some of jobs, and expect **more international cooperation with other scientists and manager** in the world on *Urban Green Development*.

**Thank you for your attention!**