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# Eco-environment Oriented Water Resources Management in China

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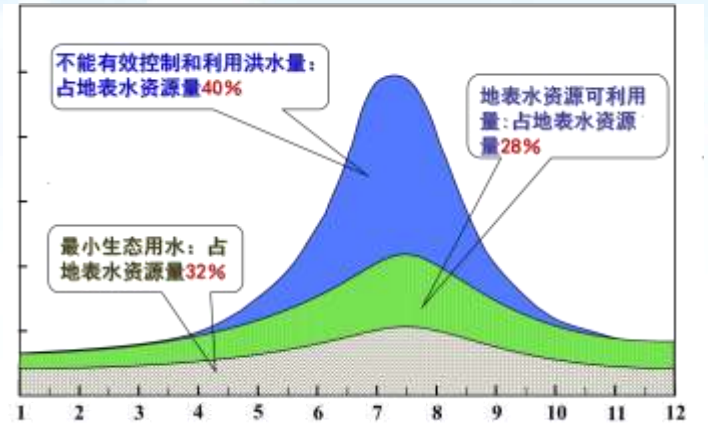
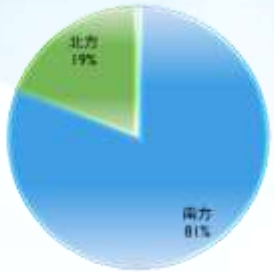
# Outline

# Introduction

# ◆Uneven spatial-temporal distributions of water resources in China

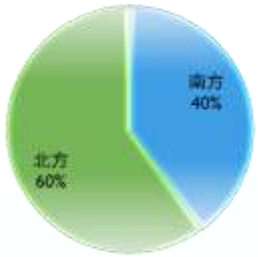



Averaged monthly river flow




Water resources

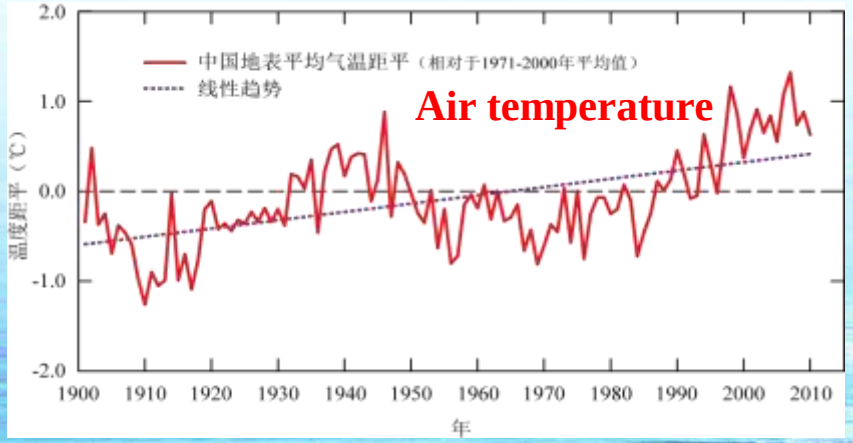

Land area

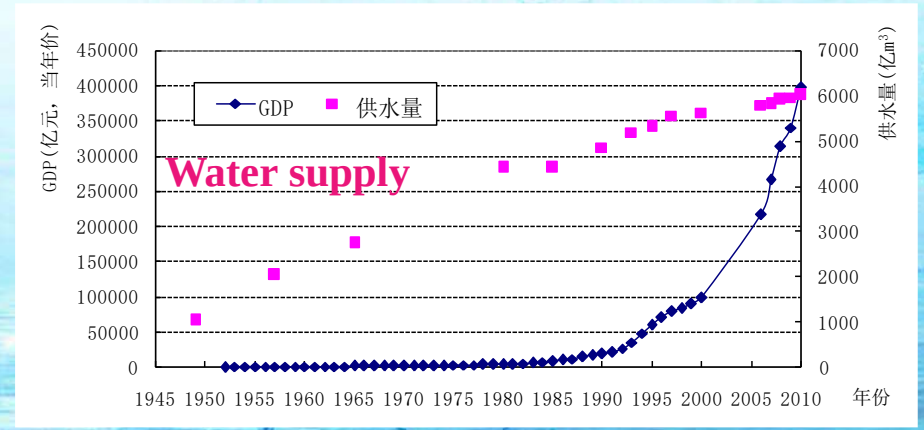



Population


GDP

# ◆Impacts of climate change and human activities

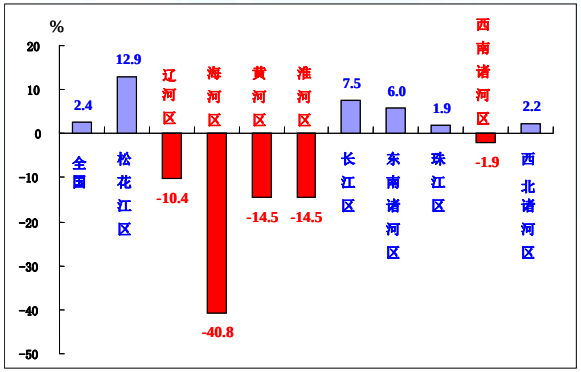


# Main water issues

## Focus: conflicts of socio-economic water use and eco-environmental water use

**Water resources attenuation**




**Water shortage**

**Ecology degeneration**

**Water pollution**

**River Dried up**

**Flood and drought**

# Change of Development Mode in China

**Innovation-driven development & green and low-carbon development mode ---**

**'5 in 1' integrated development strategy:**

- ***Ecological civilization construction* was put forward in the report of 18th CPC Congress on 8 November 2012**

  **Main aims: to optimize national space development layout, comprehensively promote resources saving, and enhance protection of ecological system and environment and constitutional arrangement**

- ***Hydro-ecological civilization construction, Ministry of Water Resources, 2013***


# Typical pilot cities for hydro-ecological civilization construction

1 Jinan city：Spring City

2 Suzhou city：Developed Stream-net Area

3 Longnan city：Undeveloped area, life-improving

4 Haibei city：Key ecological function zone

5 Taian city：Hill-city-river-lake-farm-culture integrated

6 Chengde city：Ecological protection

7 Tieling city：North-east China

8 Lianyungang city：Water pollution treatment

1 济南市：开创全国水生态文明建设工作

2 苏州市：经济发达富水地区建设典范

3 陇南市：以改善民生提升水安全保障为核心

4 海北州：国家重要生态功能区建设试点

5 泰安市：山-城-河-湖-田-文一体化建设示范

6 承德市：构筑生态防线，提升文明水平

7 铁岭市：建设水生态文明，促进区域经济发展

8 连云港市：水污染治理为核心水生态文明建设

# Eco-environment oriented water resources management


- **Strict Management of Water Resources System (2011/2012, CC-CPC/the State Council)**
  - ➢ **Three Red Lines:**
    1) Total amount of water use
    2) Water use efficiency
    3) Constrained pollutant into water function zones


- **Action Plan for Prevention and Treatment of Water Pollution (2 April 2015, the State Council)**
  - ➢ **Reduce pollutants**
  - ➢ **Improve the quality of drinking water**
  - ➢ **Promote water saving**
  - ➢ **Guarantee ecological flow of rivers**
- **Sponge city/basin construction program**
  - ➢ **Give space to nature system**
  - ➢ **Reduce disturbance on natural water cycle by human activities**
  - ➢ **Systematic layout of infrastructures**
  - ➢ **Integrate modern technology development**

# Eco-environmental Flow & Regulation

# Framework and concepts

**Eco-environmental flow assessment**

- Satisfying both requirements of eco-system and environment
- Holistic method: hydrology+hydraulic+stakeholders

**Ecological regulation**

- Water demand management
- Joint operation of reservoirs
- Hierarchical water use

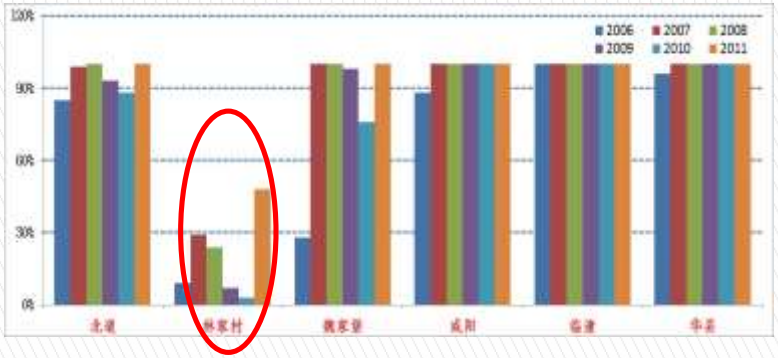
**Ecological compensation**

- Transfer payment between protector and beneficiary
- Local and central government compensation

# Case study of the Weihe River

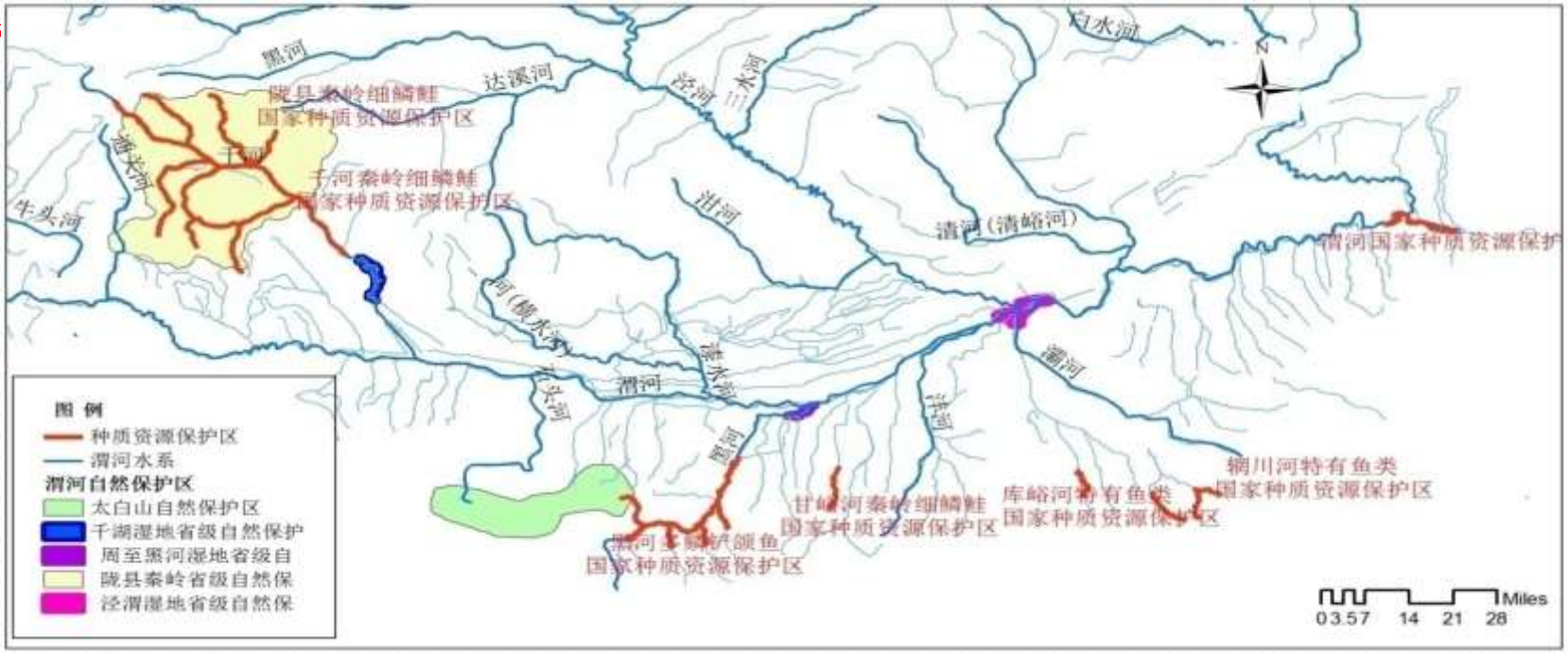
- The Weihe river is the biggest tributary of the Yellow River, the cradle of Chinese Civilization. The basin area is about 134800 $km^2$, total population is 34 million in 2009, GDP is 620 billion RMB Yuan, annual average water resources is 11 billion $m^3$, and annual water use is 6 billion $m^3$. Its annual water resources per capita is only 300 $m^3$, a typical water-stressed region.
- Water use for the hydro-ecological system has been greatly reduced by water resources decrease and socio-economic water consumption increase.


- **Linjiacun section**



# Targets for eco-environmental restoration

- **Ecosystem: Fish, benthic flora and fauna, wetland plants and birds;**
- **Water environment: water function zones with water quality targets ;**
-

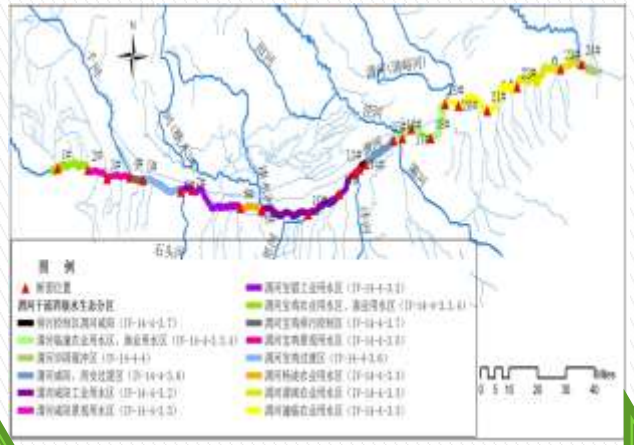



Fish germ-plasm, wetland, natural resources protection areas

# Eco-environmental flow assessment

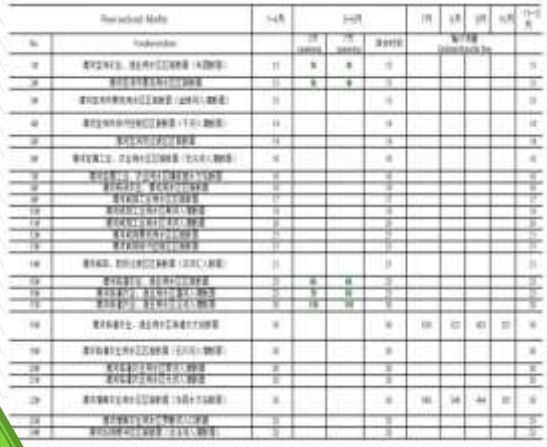
## Hydro-ecological zoning


Fish zoning



24 river sections of Weihe mainstream

## Integrated assessment



Weihe Mainstream

| 一级功能区名称 | 二级功能区名称 | 起始断面 | 终止断面 | 长度(km) | 水质目标 |
|---|---|---|---|---|---|
| 甘陕缓冲区 | | 木碾 | 顾家河 | 8.3 | III |
| | 宝鸡农业用水区 | 顾家河 | 林家村 | 43.9 | III |
| | 宝鸡市景观区 | 林家村 | 卧龙寺 | 20 | IV |
| | 宝鸡市排污控制区 | 卧龙寺 | 虢镇 | 12 | IV |
| | 宝鸡市过渡区 | 虢镇 | 蔡家坡 | 22 | III |
| | 宝眉工业、农业用水区 | 蔡家坡 | 汤峪入渭口处 | 44 | IV |
| 宝鸡——渭南开发利用区 | 杨凌农业、景观用水区 | 汤峪入渭口 | 漆水河入口 | 16 | |
| | 咸阳工业用水区 | 漆水河入口 | 咸阳公路桥 | 63 | IV |
| | 咸阳市景观用水区 | 咸阳公路桥 | 咸阳铁路桥 | 3.8 | IV |
| | 咸阳排污控制区 | 咸阳铁路桥 | 沣河入口 | 5.4 | IV |
| | 咸阳西安过渡区 | 沣河入口 | 210 国道桥 | 19 | IV |
| | 临潼农业用水区 | 210 国道桥 | 零河入口 | 56.4 | IV |
| | 渭南农业用水区 | 零河入口 | 王家城子 | 96.8 | IV |
| 华阳缓冲区 | | 王家城子 | 入黄口 | 29.7 | IV |

Water function zoning


30 key sections of 18 tributaries

Weihe River tributaries

# Eco-environmental flow at 5 key sections

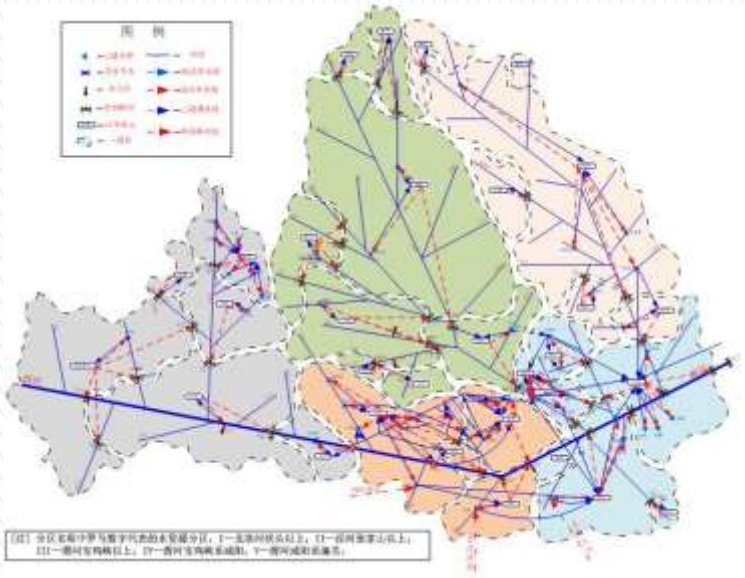
| Section No. | Name | Base flow ($m^3/s$) | Low flow ($m^3/s$) | Minimal ($m^3/s$) | Suitable ($m^3/s$) |
|---|---|---|---|---|---|
| 2# | Linjiacun | 7.8 | 8.6 | 5.4 | 12.8 |
| 7# | Weijiapu | 7.2 | 11.6 | 8.4 | 23.5 |
| 12# | Xianyang | 6.2 | 15.1 | 10.0 | 31.7 |
| 18# | Lintong | 6.5 | 20.1 | 12.0 | 34.3 |
| 22# | Huaxian | 6.5 | 12 | 12.0 | 34.1 |

# Ecological regulation and compensation

- **Ecological regulation**

  - **Nodes: 94 reservoirs and cross-section, 3 inter-basin diversion project**

  - **Lines: 185 water supply canals, 13 diversion canals, 94 natural water ways, 103 discharge waterways**



- **Ecological compensation**

  - **Stop water diversion for power generation by Baojixia water control project in dry season (upsteam of Linjiacun section) to ensure 8.6~20 $m^3/s$ eco-environmental flow**

  - **Compensation from Shaanxi Province government**

# Case study of the Songhua River

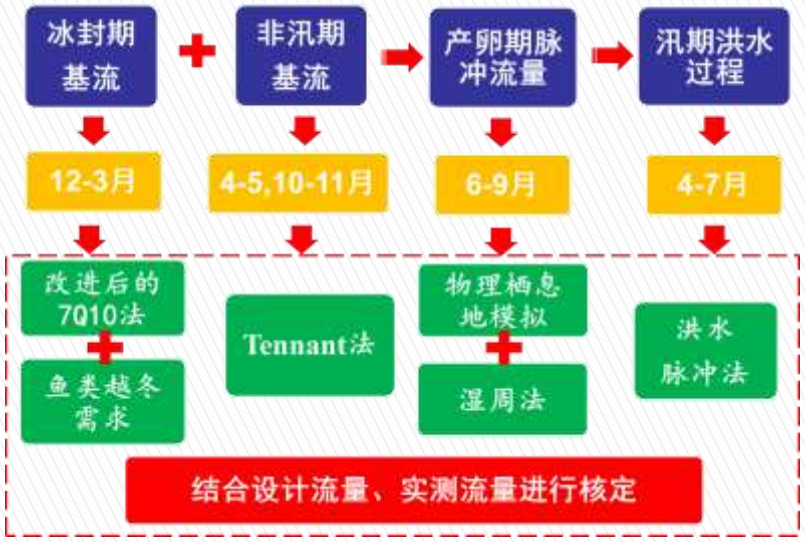
- The Songhua River basin area is about 560000 km$^2$, with three main rivers of Neng River, Second Songhua River and Songhua River stem.
- Icebound season from December to March
- 150 reservoirs (big and middle scale), 20 irrigation districts
- 19 fish germ-plasm protection area, 95 species of fish
- Important wetlands of Zhalong, Momoge, Xianghai
- Important lakes of Chagan Lake and Jiingpo Lake
- Conflict of water use during irrigation period and fish spawning season, especially for May

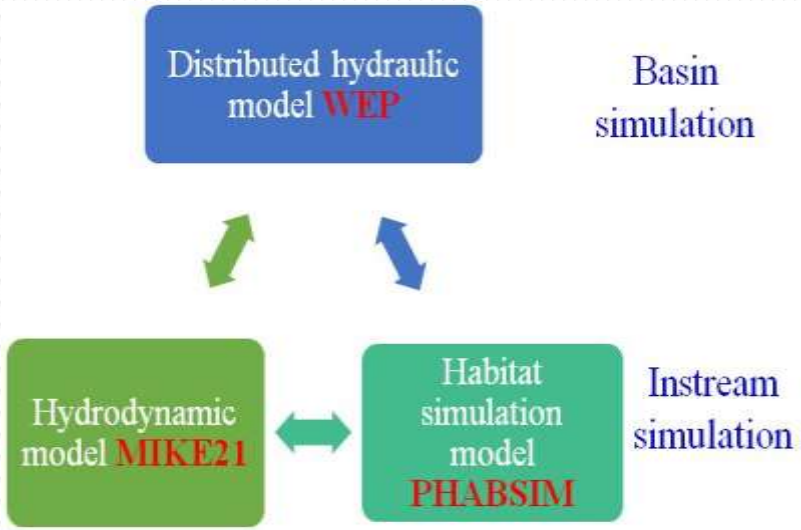
The Songhua River basin

Ussuri Pseudobagrus

Amur grayling

# Eco-environmental flow




**Icebound season base flow**

| 编号 | 河段 | 冰封期生态基流结果 | 对应水文站点 | 确定依据 |
|---|---|---|---|---|
| 1 | 嫩江嫩江县段 | 0.26 | 石灰窑 | 最枯连续7天 |
| 2 | 甘河 | 3.33 | 柳家屯 | 近10年冰封期75% |
| 3 | 嫩江尼尔基段 | 42.5 | 尼尔基（坝下） | 水资源保护规划 |
| 4 | 讷谟尔河 | 0 | 德都 | 连底冻 |
| 5 | 诺敏河 | 2.55 | 小二沟 | 近10年冰封期75% |
| 6 | 嫩江齐齐哈尔段 | 56 | 富拉尔基 | 设计流量 |
| 7 | 阿伦河 | 0.14 | 那吉 | 最枯连续7天 |
| 8 | 音河 | 0 | 音河水库（坝下） | 连底冻 |
| 9 | 雅鲁河 | 2.05 | 碾子山 | 近10年冰封期75% |
| 10 | 绰尔河 | 0.84 | 两家子 | 最枯连续7天 |

**Dry season base flow**

| 编号 | 河段 | 冰封期生态基流结果 | 对应水文站点 | 确定依据 |
|---|---|---|---|---|
| 1 | 嫩江嫩江县段 | 9.51 | 石灰窑 | 多年平均径流10% |
| 2 | 甘河 | 11.27 | 柳家屯 | 多年平均径流10% |
| 3 | 嫩江尼尔基段 | 42.5 | 尼尔基（坝下） | 水资源保护规划 |
| 4 | 讷谟尔河 | 3.5 | 德都 | 多年平均径流10% |
| 5 | 诺敏河 | 18.63 | 小二沟 | 水资源保护规划 |
| 6 | 嫩江齐齐哈尔段 | 58 | 富拉尔基 | 多年平均径流10% |
| 7 | 阿伦河 | 1.91 | 那吉 | 多年平均径流10% |
| 8 | 音河 | 0.39 | 音河水库（坝下） | 多年平均径流10% |
| 9 | 雅鲁河 | 7.67 | 碾子山 | 水资源保护规划 |
| 10 | 绰尔河 | 8.40 | 两家子 | 设计流量 |
| 11 | 乌裕尔河 | 2.23 | 依安大桥 | 多年平均径流10% |

**Flood pulse in fish spawning period**

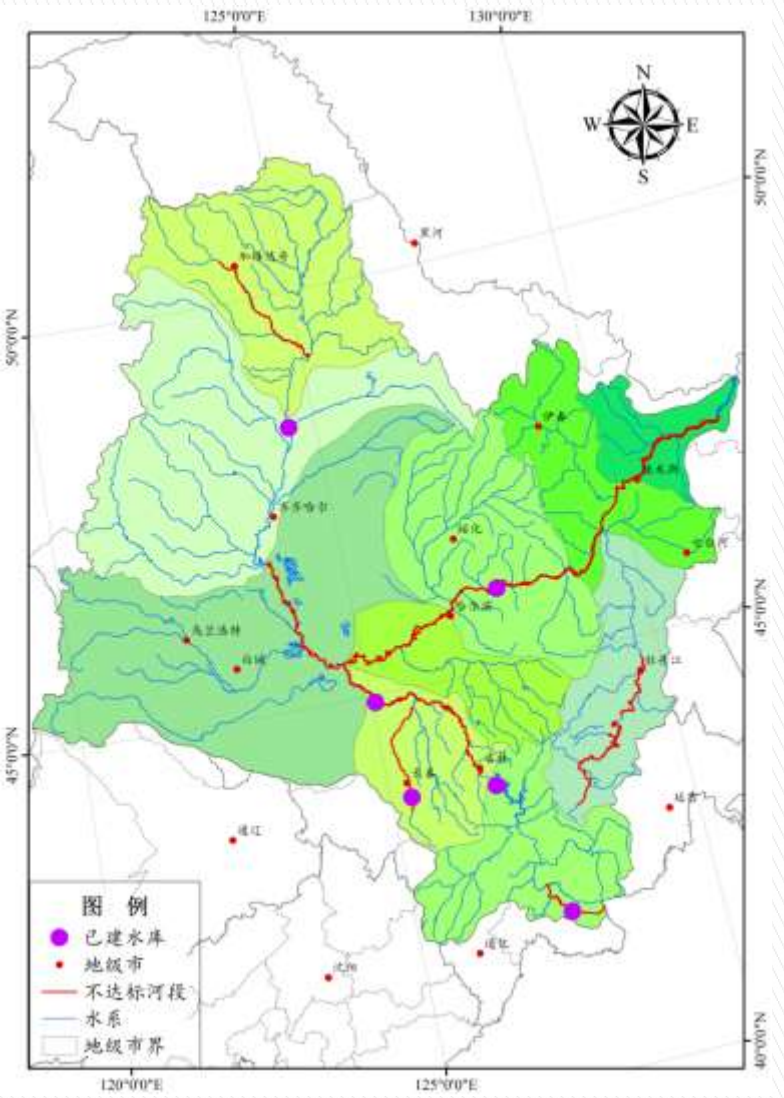
| 河段 | 对应水文站 | 4月 | | 5月 | | 6~7月 | |
|---|---|---|---|---|---|---|---|
| | | 最小值 | 适宜值 | 最小值 | 适宜值 | 最小值 | 适宜值 |
| 二松 | 扶余 | 314 | 550 | 251 | 550 | 612 | 680 |
| 嫩江 | 大赉 | 246 | 450 | 385 | 450 | 483 | 500 |
| 松干 | 哈尔滨 | 534 | 950 | 750 | 950 | 1045 | 1070 |
| 甘河 | 柳家屯 | 56 | 65 | 52 | 65 | 59 | 65 |
| 洮儿河 | 洮南 | 6.00 | 12 | 6.11 | 12 | 11.42 | 12 |
| 三统河 | 样子哨 | 12.61 | 17 | 6.44 | 17 | 4.34 | 17 |
| 蓮河 | 东丰 | 0.70 | 3 | 0.44 | 3 | 0.36 | 3.5 |
| 头道江 | 漫江 | 17.8 | 22 | 17.8 | 22 | 33.2 | 22 |
| 沐石河 | 浮家桥 | 0.63 | 0.8 | 0.41 | 0.8 | 0.49 | 0.8 |
| 呼兰河 | 兰西 | 66.83 | 83 | 51.53 | 83 | 69.84 | 83 |
| 牡丹江上游 | 大山咀子 | 101 | 72 | 72 | 72 | 104 | 72 |
| 海浪河 | 长汀子 | 46.82 | 19 | 5.64 | 19 | 16.24 | 19 |
| 梧桐河 | 宝泉岭 | 23.11 | 12 | 9.75 | 12 | 12.48 | 15 |
| 珠尔多河 | 鹤穆 | 12.68 | 18 | 2.20 | 18 | 10.44 | 18 |
| 饮马河 | 德惠 | 4.39 | 5.5 | 3.58 | 5.5 | 5.80 | 7.9 |

**Flood in wet season**

| 河段 | 大洪水 | 小洪水 | 河段 | 大洪水 | 小洪水 |
|---|---|---|---|---|---|
| 洮儿河白城 | 1016 | 215 | 甘河鄂伦春 | 1910 | 870 |
| 霍林河白城市 | 281 | 67 | 霍林河 | 195 | 29 |
| 霍林河前郭县 | 305 | 106 | 嫩江黑吉缓冲区 | 8130 | 4616 |
| 嫩江泰来县 | 7481 | 4583 | 头道松花江抚松县 | 468 | 198 |
| 一统河 | 615 | 157 | 第二松花江松原市 | 6983 | 2913 |
| 三统河 | 549 | 164 | 松花江黑吉缓冲区 | 12215 | 7534 |
| 蓮河 | 109 | 20 | 松花江哈尔滨市 | 13018 | 7962 |
| 伊通河长春市 | 393 | 81 | 松花江杰兰县 | 12874 | 8519 |
| 饮马河长春 | 501 | 172 | 牡丹江 | 1477 | 686 |
| 盐路河 | 222 | 67 | 海浪河 | 566 | 206 |
| 雾开河 | 58 | 17 | 松花江佳木斯市 | 16837 | 10279 |
| 沐石河 | 70 | 11 | 珠尔多河 | 259 | 98 |
| 呼兰河 | 2661 | 1118 | 卧都河 | 79 | 44 |
| 梧桐河 | 463 | 218 | 小石河 | 68 | 27 |

# Guarantee rate and Ecological regulation

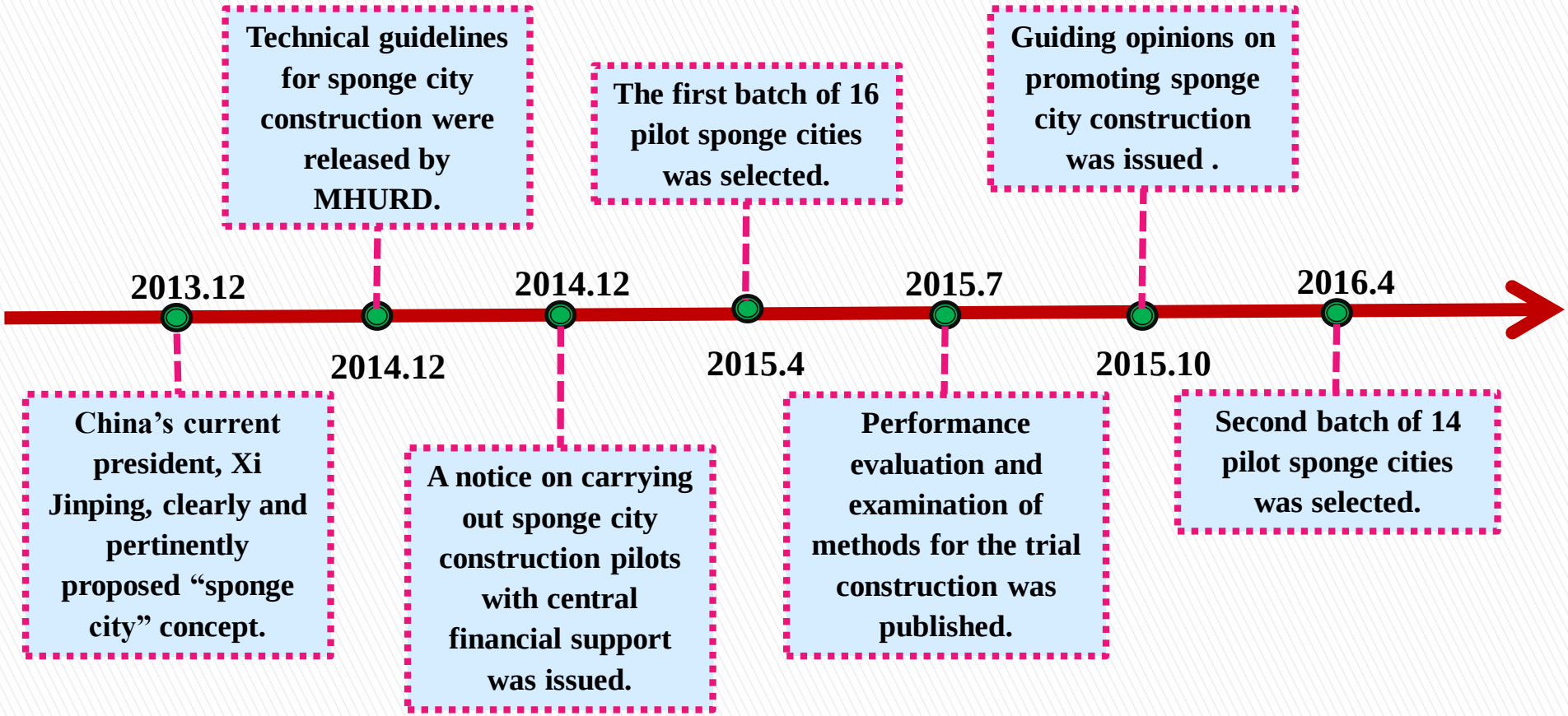
- Guarantee rate
  - Icebound season base flow, 81%
  - Dry season base flow, 81%
  - Flood pulse in April, May and June, 58%、69%、77%
  - Flood in wet season, 10%~90%
- Countermeasures
  - Ecological operation of upstream hydraulic facilities (dams and weirs)
  - Reduce off-stream water intake



# Ecological Sponge City/Basin

# Sponge city background

**"Sponge city" concept is devoted to find ecologically suitable alternatives to transform urban infrastructures into green infrastructures so these could capture, control and reuse rainwater in a useful, ecologically sound way.**



# Main guidelines

- **It emphasizes a top priority in environmental protection in urban planning and construction.**
- **Remediation of contaminated waters and other damaged natural ecological systems.**
- **Low Impact Development (LID).**
- **Control and utilization of urban rainwater runoff.**

Rainwater infiltration

Rainwater stagnation

Rainwater storage

Rainwater purification

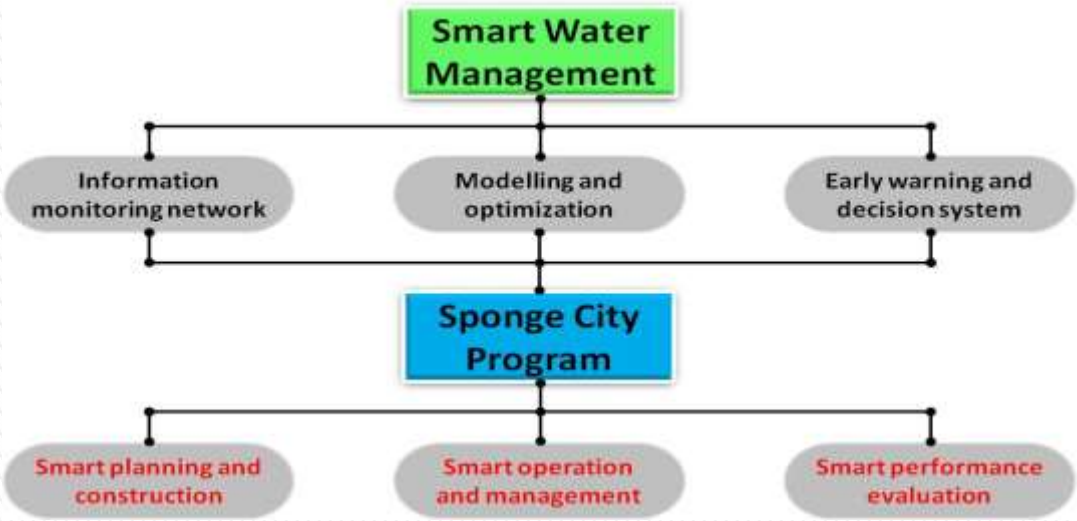
Rainwater utilization

Rainwater discharge

# Sponge city program

Program Construction → Program Management → Program Evaluation

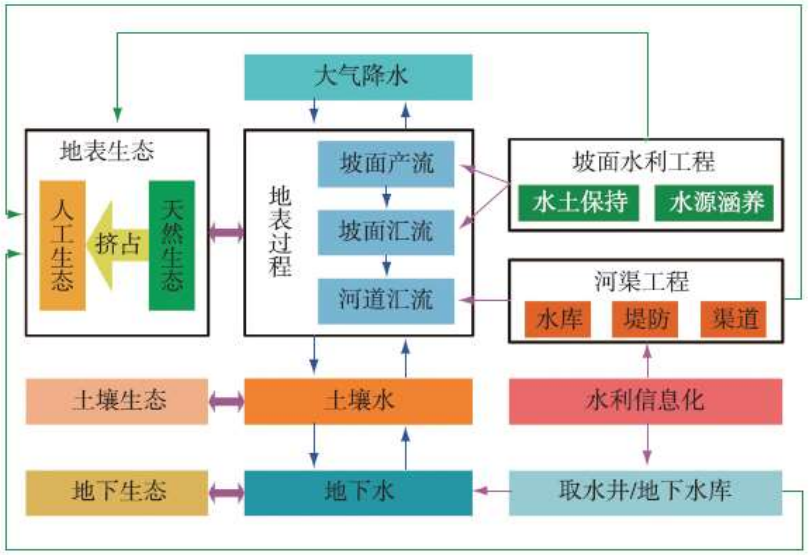
- Construction scale and overall layout of Sponge Infrastructures.
- Integrated operation and protection of Sponge Infrastructures.
- Appropriate evaluation indexes and methods.




**SWM in Sponge City Program**

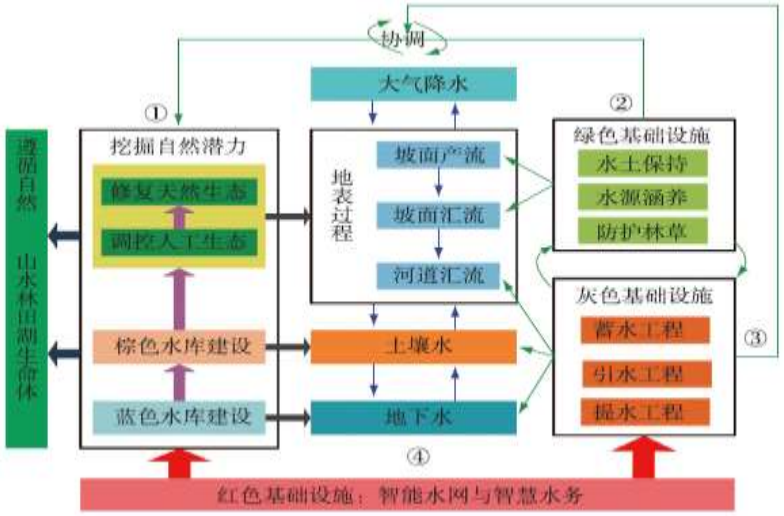
# Ecological Sponge basin

- **Water management problems**
  - ➢ **Basin regulative capability not fully developed**
  - ➢ **Focus on end treatment**
  - ➢ **Lack of overall planning on water cycle processes**




**Traditional water management**

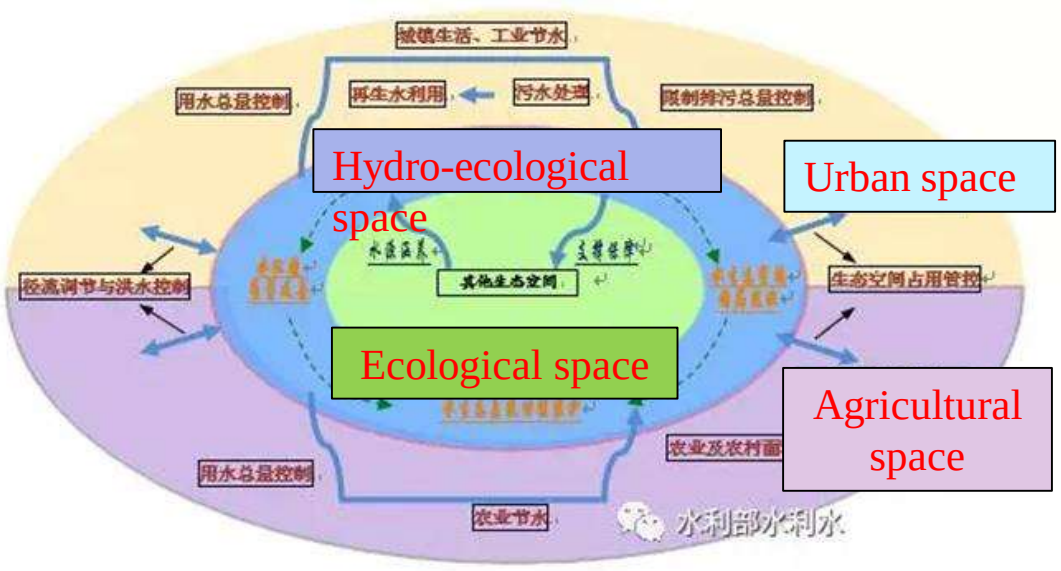
- **Sponge basin system**
  - ➢ **Gray infrastructure (reservoir, dike, tunnel, pump station, well)**
  - ➢ **Green infrastructure (forest, grassland, wetland)**
  - ➢ **Brown reservoir (Soil water)**
  - ➢ **Blue reservoir (Acquifer )**
  - ➢ **Red infrastructure (Smart water network)**

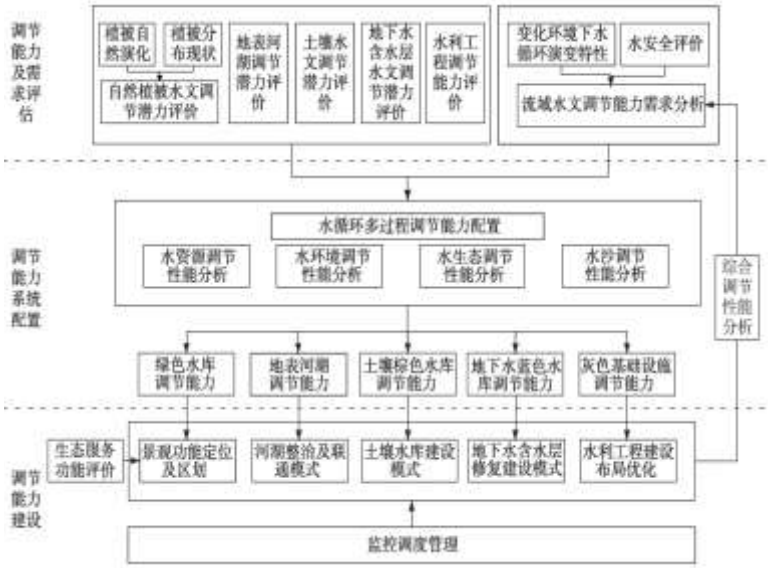



**Ecological Sponge basin framework**

# Ecological Sponge basin

- **Hydro-ecological space**
  - ➢ **Setup ecological red line to expand hydro-ecological space**
  - ➢ **Optimize regional layout based on water resources carrying capacity**
  - ➢ **Retain a portion of area for water and riparian zone in urban planning**



# Summary

- **The eco-environment oriented water resources management is desired to solve water issues in China.**
- **The study and practice of eco-environmental flow assessment, ecological regulation and compensation have made notable progress in China.**
- **The constructions of sponge city/basin are new attempts to reduce human's impacts on water cycle and enhance green development capability.**


Thank You !