

Development of flood control engineering system
to rebuild harmony between man and nature
in the changing environment
变化环境下重构人与自然和谐的防洪工程体系

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Water disasters have always been the most widespread natural disasters in the world

Figure 9

Total number of people affected by disaster type (2000-2019)

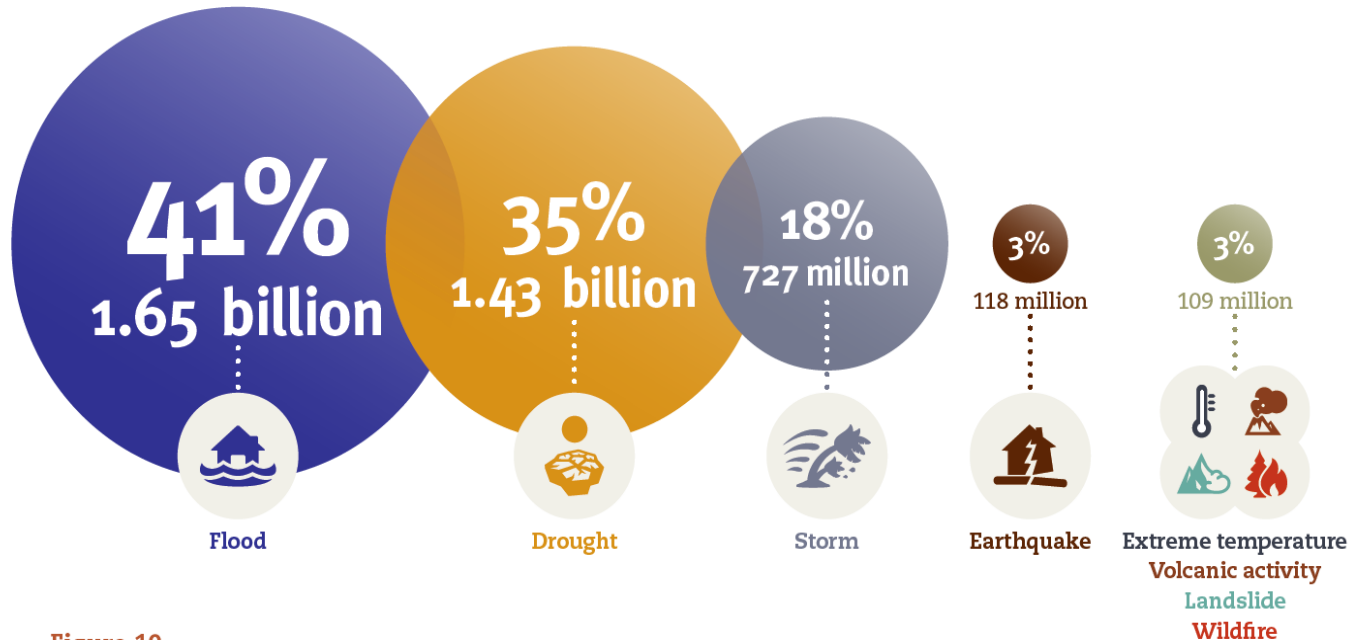


Figure 10

Source: The human cost of disasters: an overview of the last 20 years (2000-2019). UN Office for Disaster Risk Reduction, 2020

“善为国者必先除五害。水一害也，旱一害也，风雾雹霜一害也，疠（瘟疫）一害也，虫一害也，此谓五害。五害之属水为大”

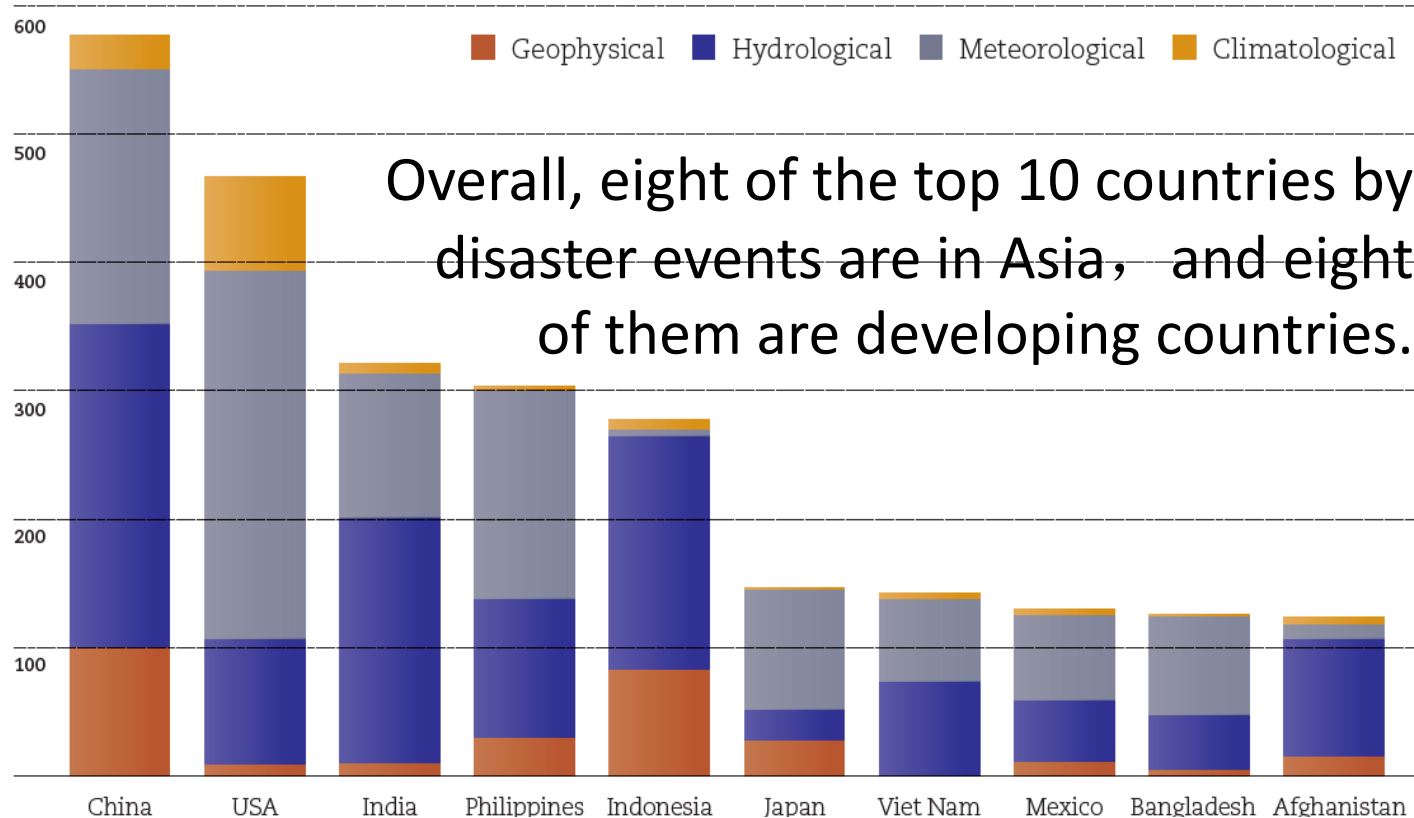
——《管子·度地篇》

A man who is adept at running a state should eliminate Five Hazards ahead. One is flood; one is drought; one is harmful weather including wind storm, fog, hail and frost; one is epidemic, and one is pest. These are called the Five Hazards. Flood is the severest one among the Five Hazards. From Guanzi (475-221 BC)

China suffered the highest number of disaster events in the world, especially affected by floods

Figure 6

Top 10 countries by occurrence of disaster sub-groups (2000-2019)



Source: The human cost of disasters: an overview of the last 20 years (2000-2019). UN Office for Disaster Risk Reduction, 2020

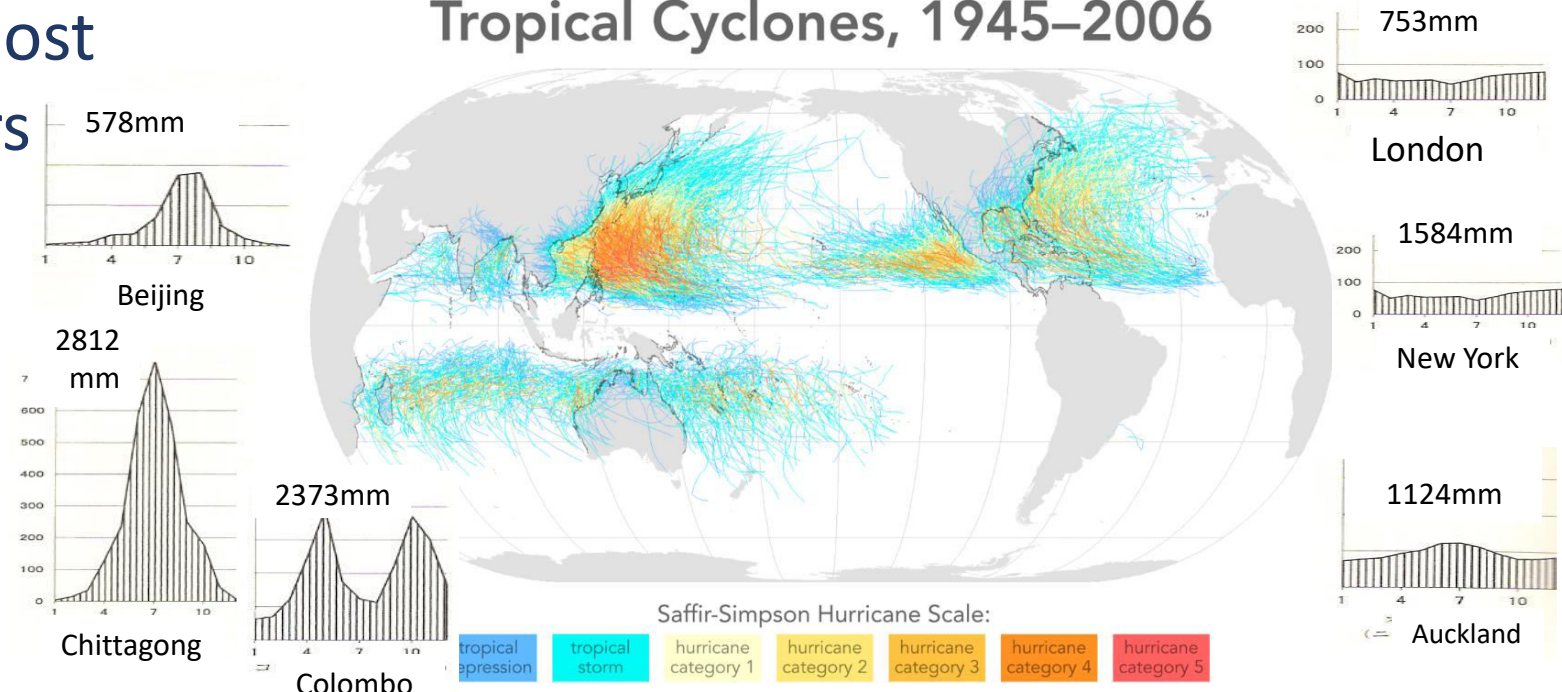
The most affected country by flooding in the past two decades was China, which experienced an average of 20 floods per year. **Flooding in China affected a total of 900 million people over the two decades, accounting for approximately 55% of people affected by flooding worldwide.** India is the 2nd most affected country by floods: it experienced an average of 17 flood events per year and had a total of approximately **345 million** people affected.

Floods have the highest impacts in Asia, as the continent experienced **41%** of all flooding events and with a total of **1.5 billion** people affected, accounted for **93%** of people affected by floods worldwide. **Many of these impacts are preventable since flooding, unlike most types of disasters, has affordable mechanisms of primary prevention, such as dams, dykes and drainage systems.**

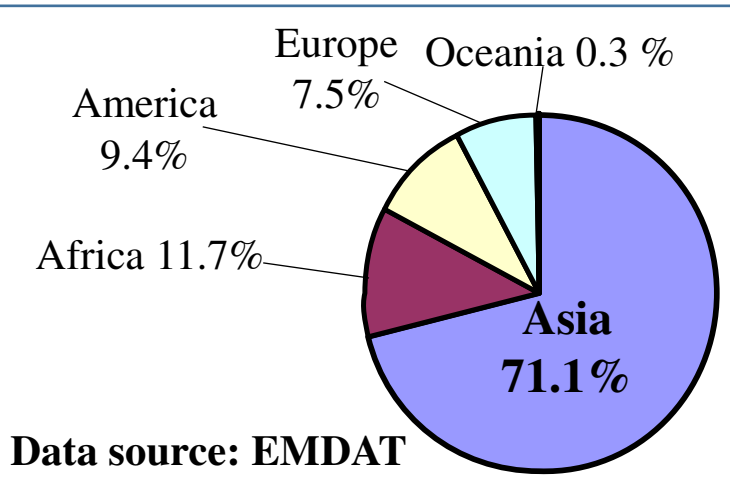
Asian countries suffered the most severe flood-related disasters



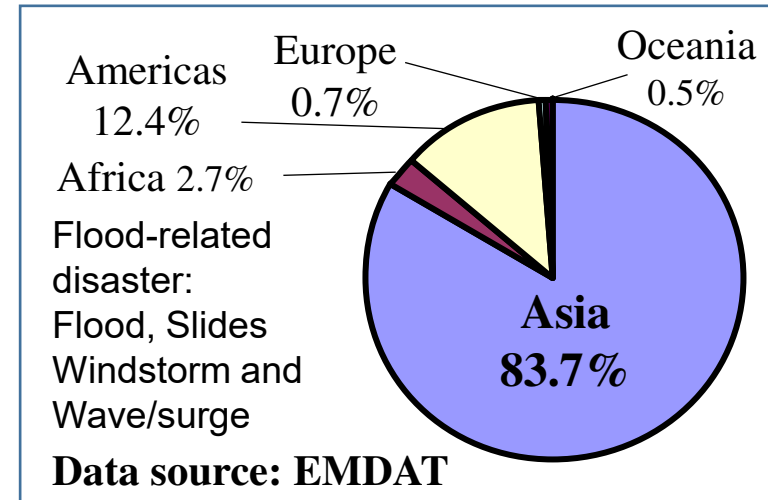
Tropical Cyclones, 1945–2006



Global Total Fatalities of Flood-related Disaster from 1986 to 2006



Global Total Fatalities of All the Natural Disaster from 1986 to 2006

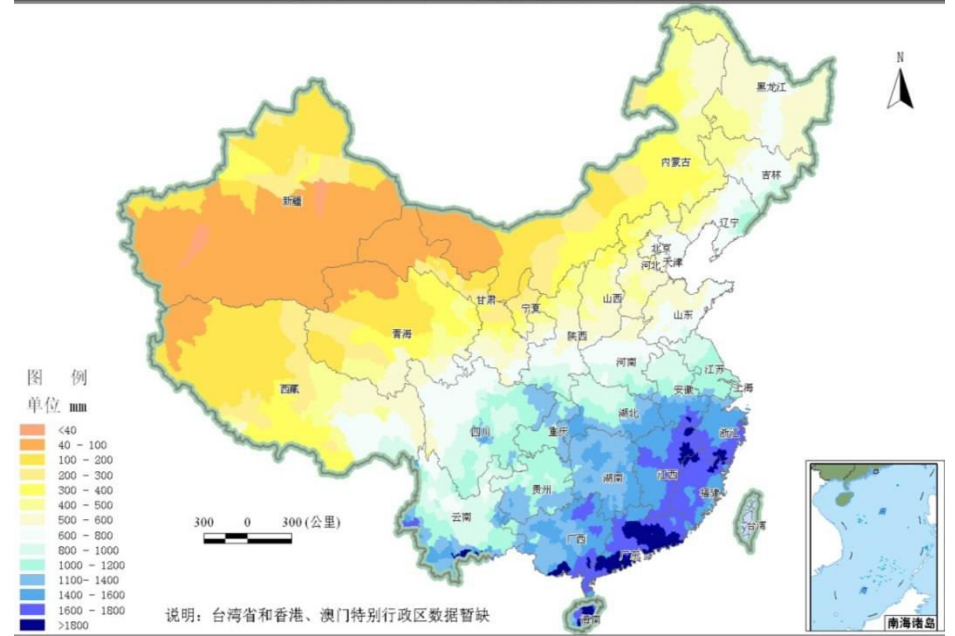


Why is the number of flood affected people so high in China?

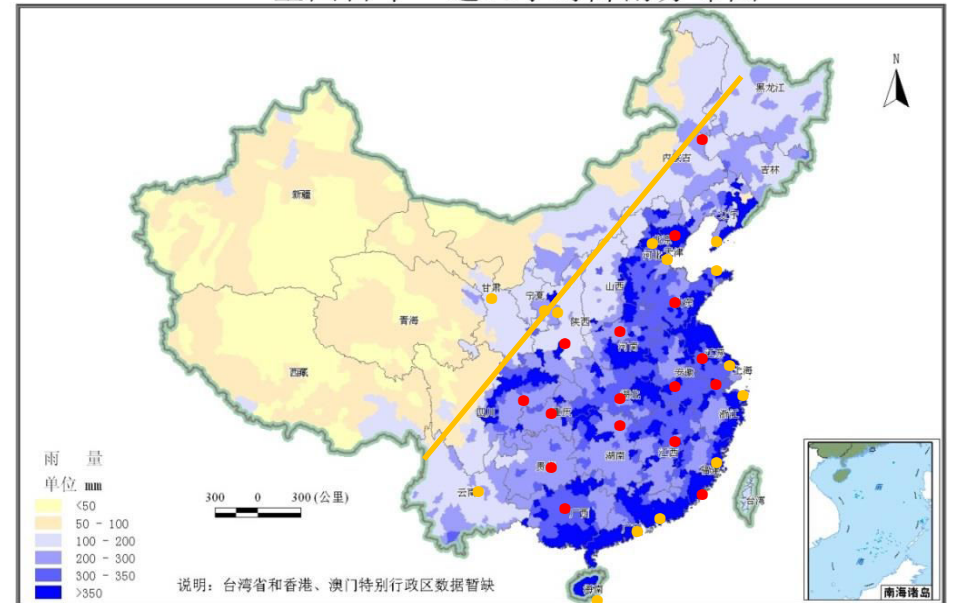
- Among the current 654 cities in mainland China, 642 of them are under threat of floods.
- Among them, there are
 - Coastal cities: 57 (8.9%)
 - Plain cities: 288 (44.8%)
 - Hilly cities: 297(46.3%)

Distribution of population and assets is highly coincident with the flood-prone areas.

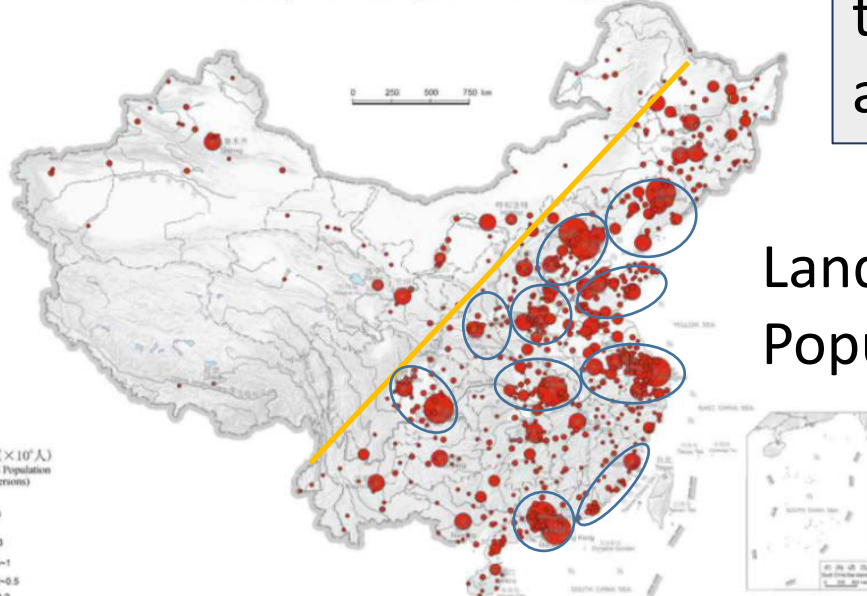
Average annual rainfall distribution map



100-year 24 hr. rainfall distribution map



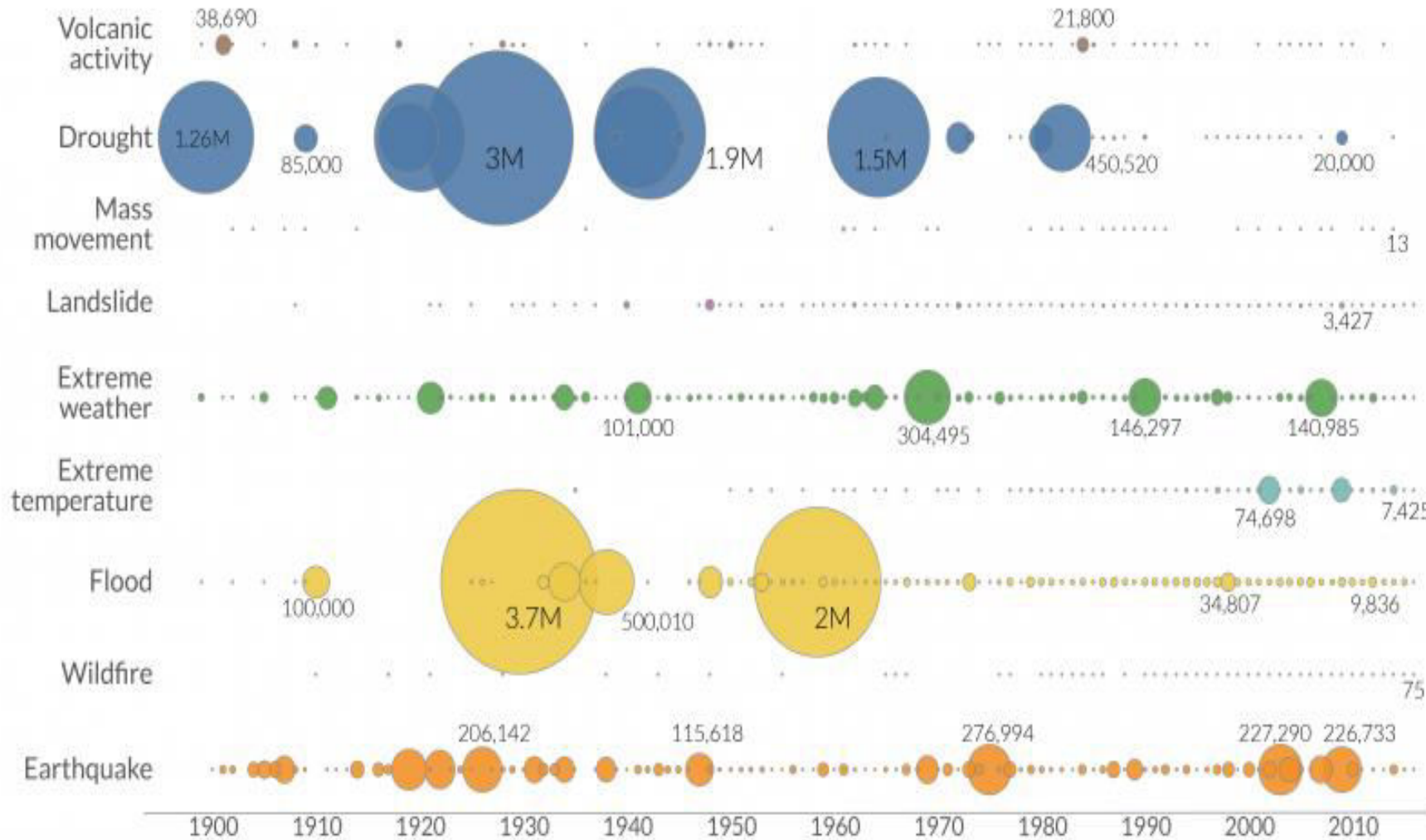
中国主要城市人口(2000年)
Urban Population of Major Cities in China (2000)



Land area: 43.8%
Population: 94.1%

Global deaths from natural disasters (1900-2016)

The size of the bubble represents the total death count per year, by type of disaster.

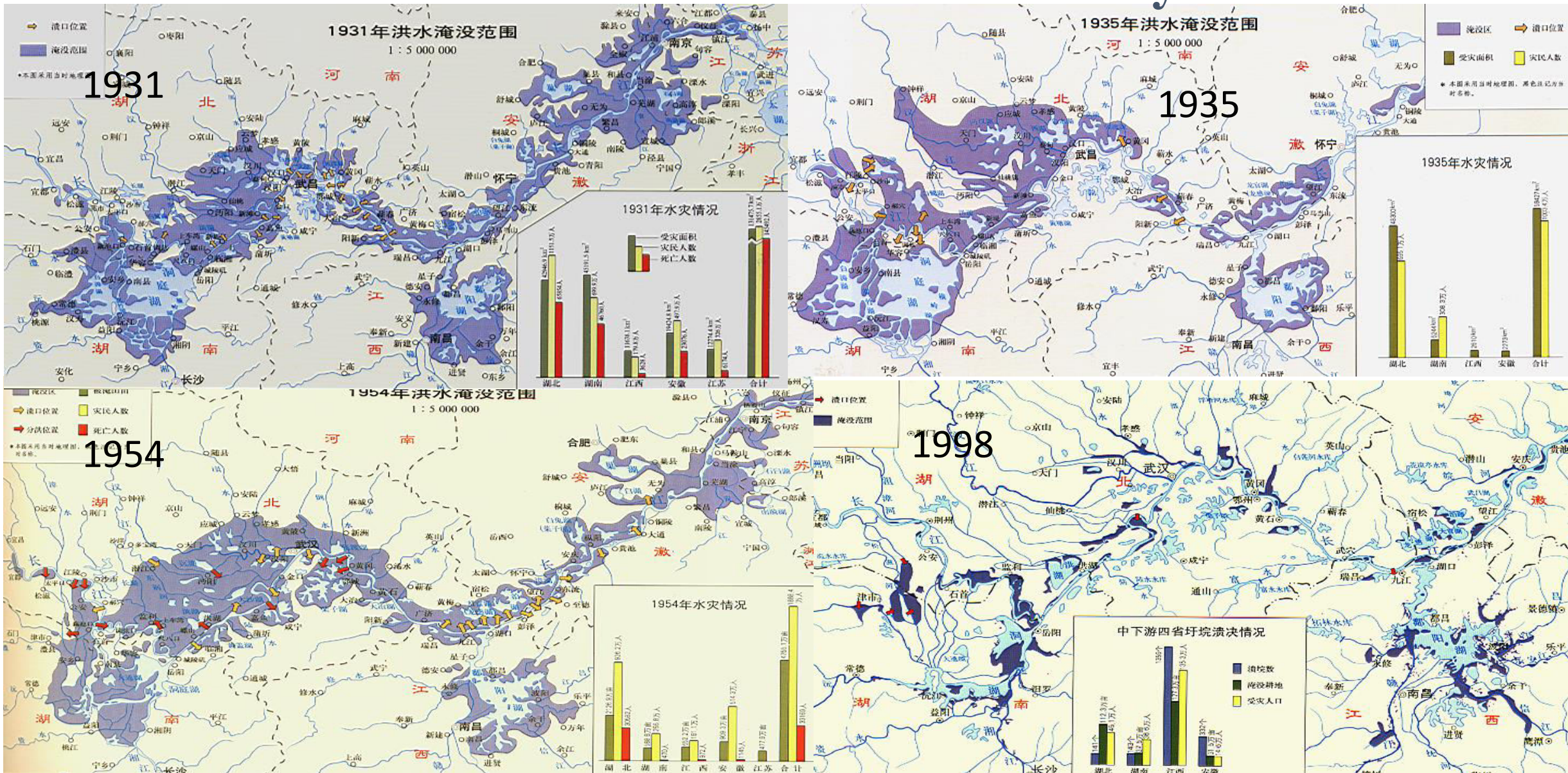


Flood and drought have certain controllability. Although the risk of natural disasters has increased due to global warming, the number of deaths from floods and droughts has fallen sharply from millions in the extreme years of the last century to tens of thousands. **It is because of the construction of the water conservancy engineering system, the improvement of forecasting and early warning and emergency response capacities, and the improvement of housing construction, food supply and medical and epidemic prevention conditions.**

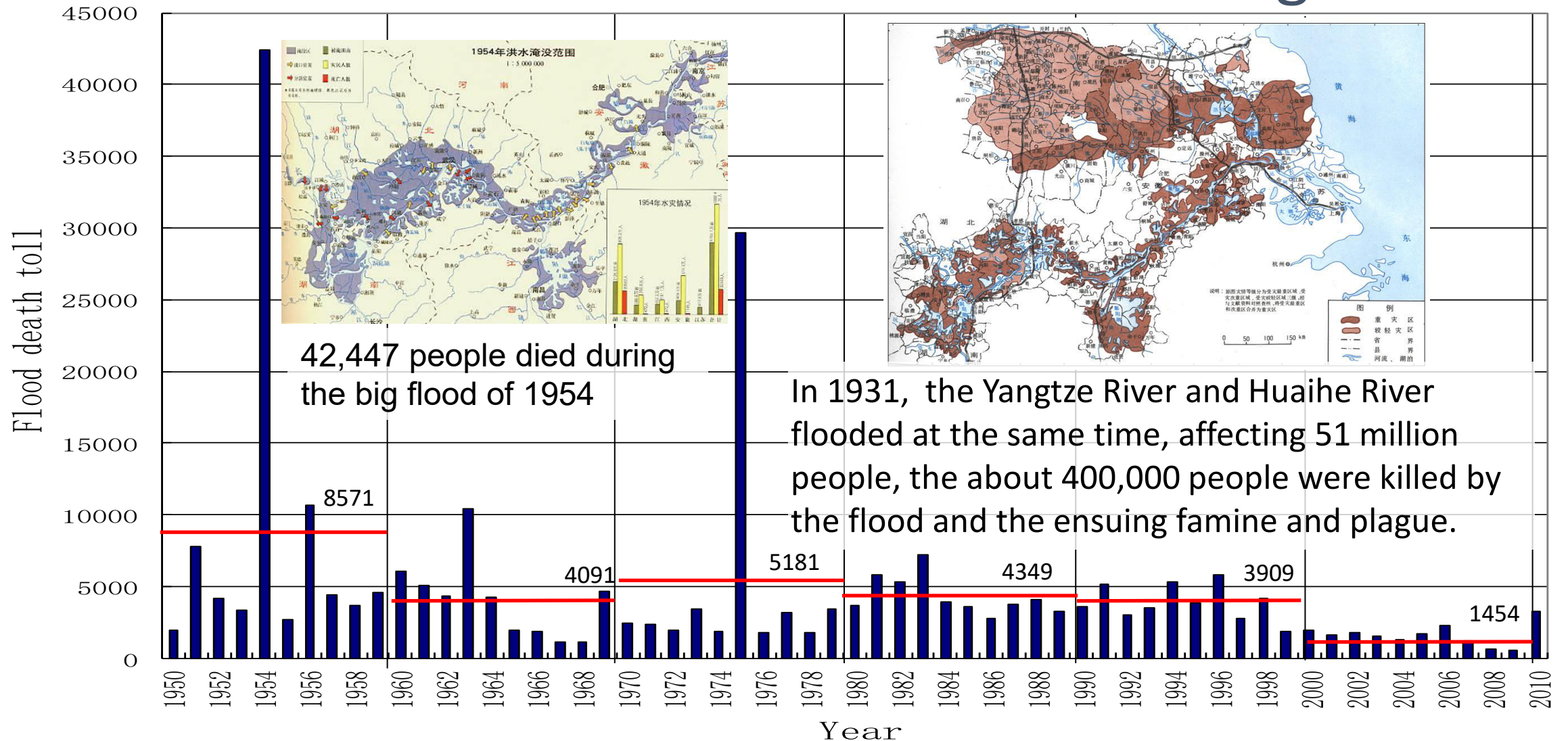
Data source: EMDAT (2017): OFDA/CRED International Disaster Database, Université catholique de Louvain - Brussels - Belgium. OurWorldInData.org - Research and data to make progress against the world's largest problems.

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The extent of flooded areas reduced obviously due to the construction of the flood control systems



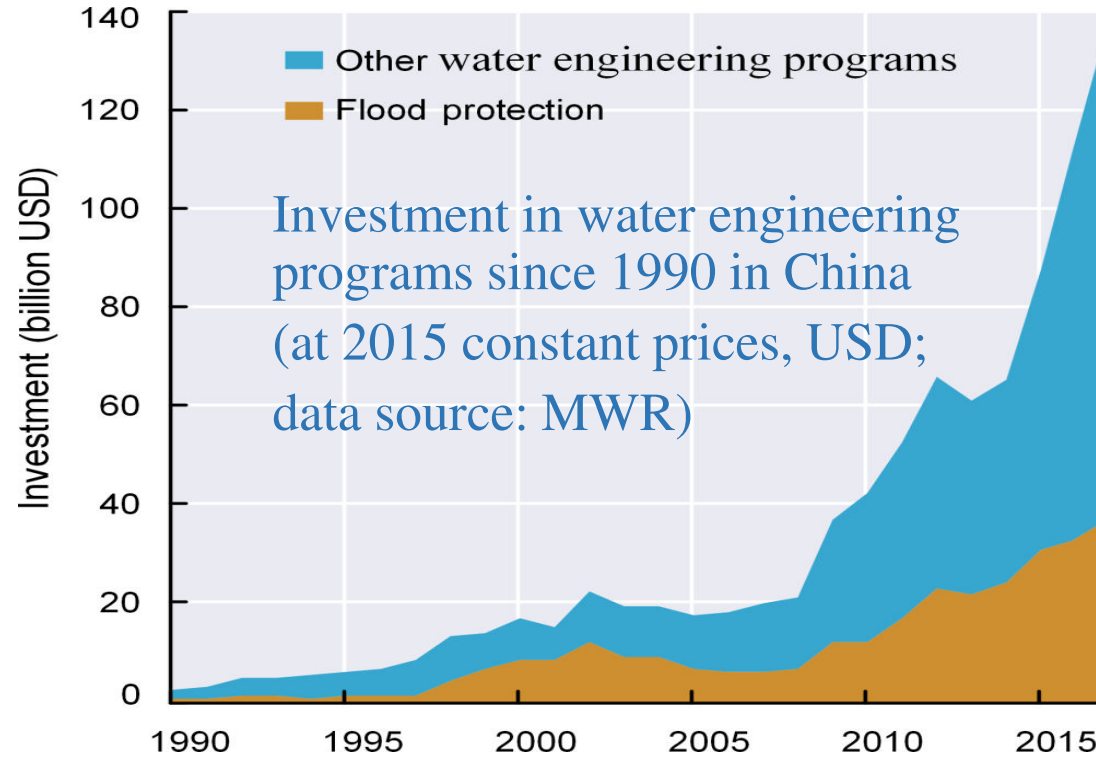
Development of flood control systems has reduced the number of deaths due to flooding



Deaths due to flooding in China (1950–2010)

Significantly improved flood control capacity since 1998

- The lengths of the river banks protected by well-maintained dikes increased from 76 532 km in 1998 to 201 124 km in 2016 and reservoir capacity increased from 493 billion to 897 billion cubic meters.



Main dikes reinforcement of the Yangtze River: 3576k



Standardization dike of Yellow River 923km (2002—2015)

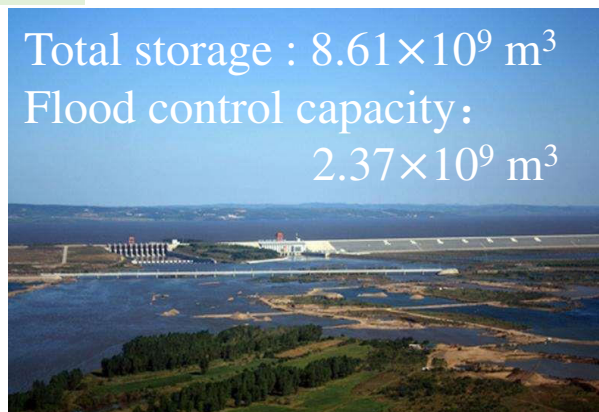


Total storage: $12.65 \times 10^9 \text{ m}^3$
Flood control capacity: $4.05 \times 10^9 \text{ m}^3$



Xiaolangdi Project (2001)

Total storage: $8.61 \times 10^9 \text{ m}^3$
Flood control capacity: $2.37 \times 10^9 \text{ m}^3$



Nierji Project (2006)

Flood control capacity: $8.56 \times 10^9 \text{ m}^3$



Linhuaigang Flood Control Project (2006)

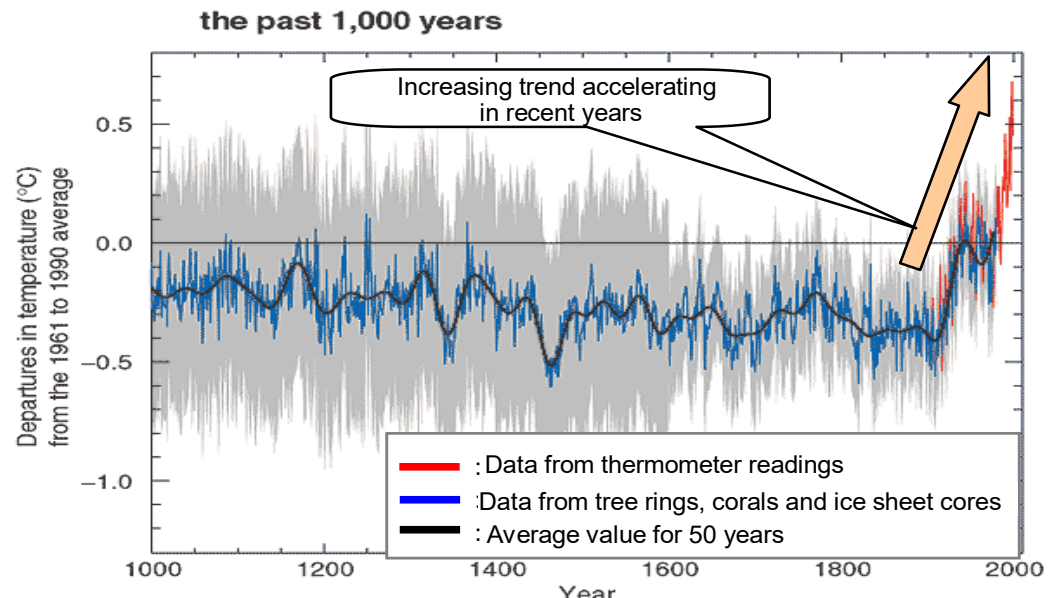
Flood control capacity: $22.15 \times 10^9 \text{ m}^3$



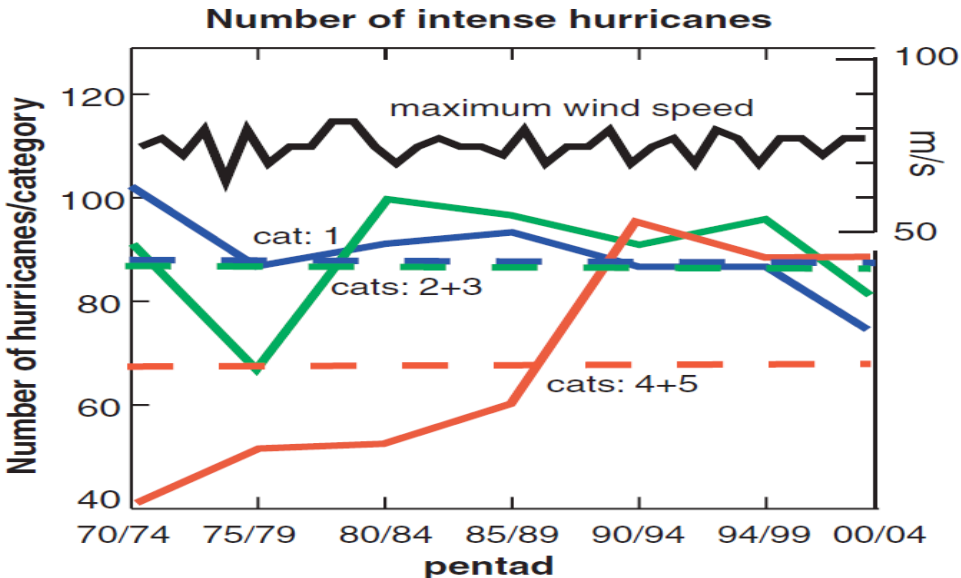
Three Gorges Project (2009)

Effects of changing environment on extreme flood events

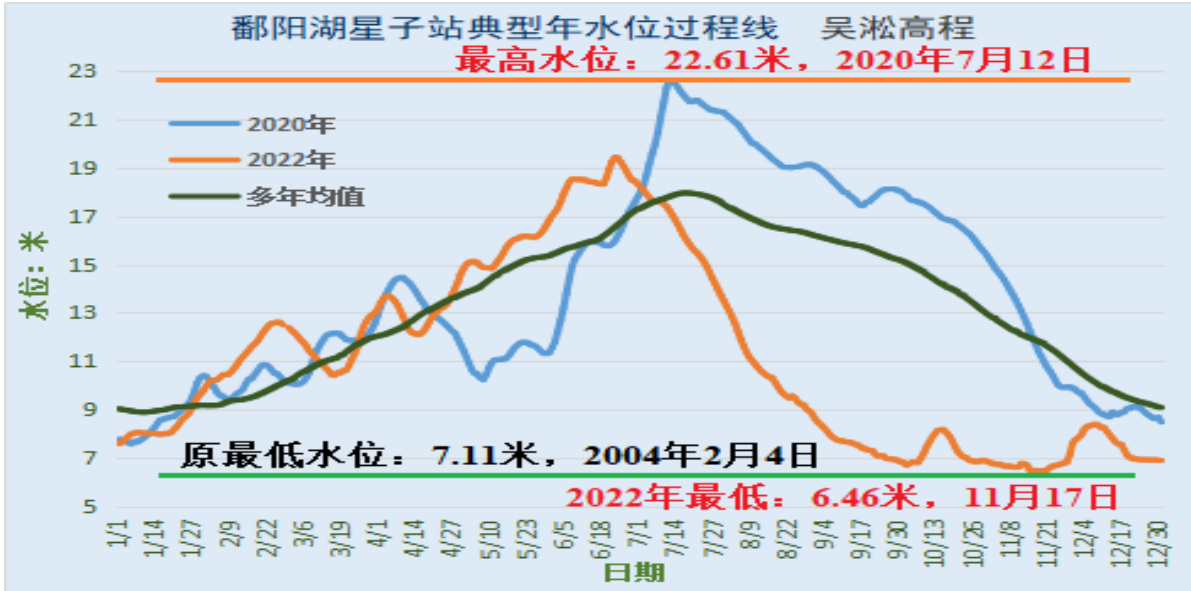
Global warming increases the probability of extreme weather events, and the established flood control system and emergency response system have to face greater pressure and challenge.



Excerpts from "Climatic Change 2001", a Report of the First Working Group in the Third Evaluation Report of the IPCC



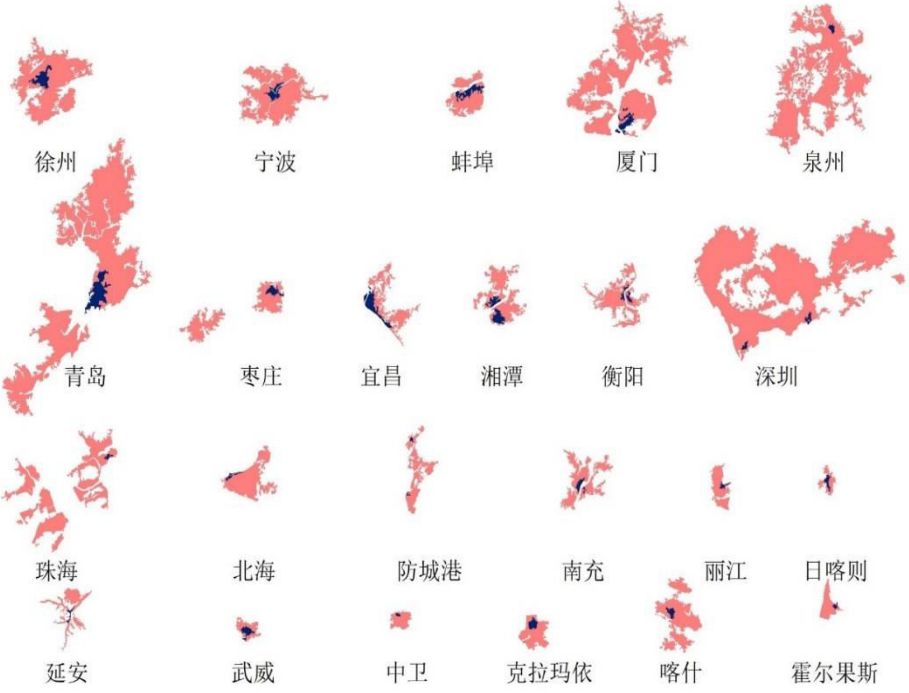
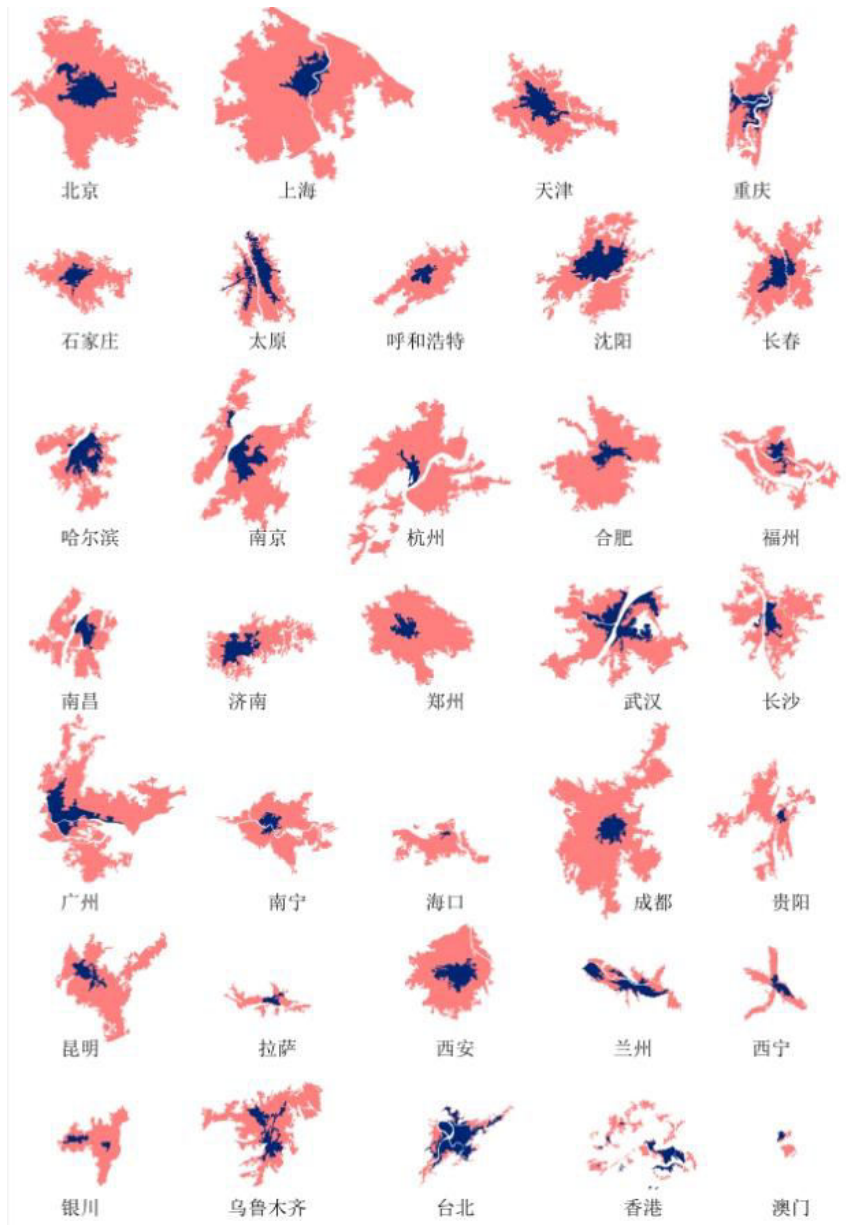
Source: Webster et al, Science 309, 2005



引自: 雷声, 石莎, 屈艳萍, 等. 2022年鄱阳湖流域特大干旱特征及未来应对启示[J]. 水利学报, 2023, 54 (3), 333-346

The bigger impact of changing environment on flood risk evolution in China comes from rapid urbanization

China's urban population increased from 450 million (36.1% in 2000) to 902 million (63.9% in 2020), increasing 27.8% in 20 years, while the built-up area has expanded from 22,439 km² to 60,300 km².

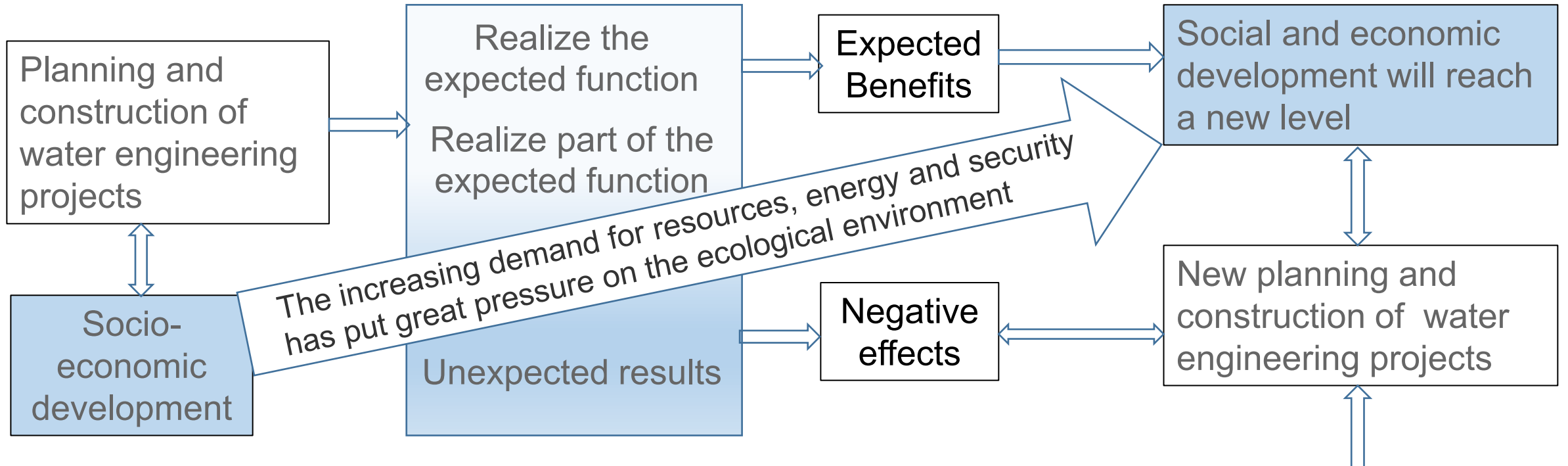


图例
 ■ 20世纪70年代建成区面积
 ■ 2020年建成区范围

Unprecedented urbanization process in China has significantly changed the natural disaster risk characteristics and has a far-reaching impact on flood control and drought relief situation.

Source: Extended remote sensing monitoring database of typical cities in China, National Remote Sensing Application Engineering Technology Research Center

Engineering means are still the basic means to reconstruct the harmony between man and water



Under the guidance of the concept of ecological civilization, aiming at the sustainable development of harmony between human and water, we should make overall planning and integrated management, follow the laws of nature and integrate the forces of man and nature, and to construct an eco-environment-friendly water engineering system by relying on the progress of technology and management.