Flood and Drought Management in China

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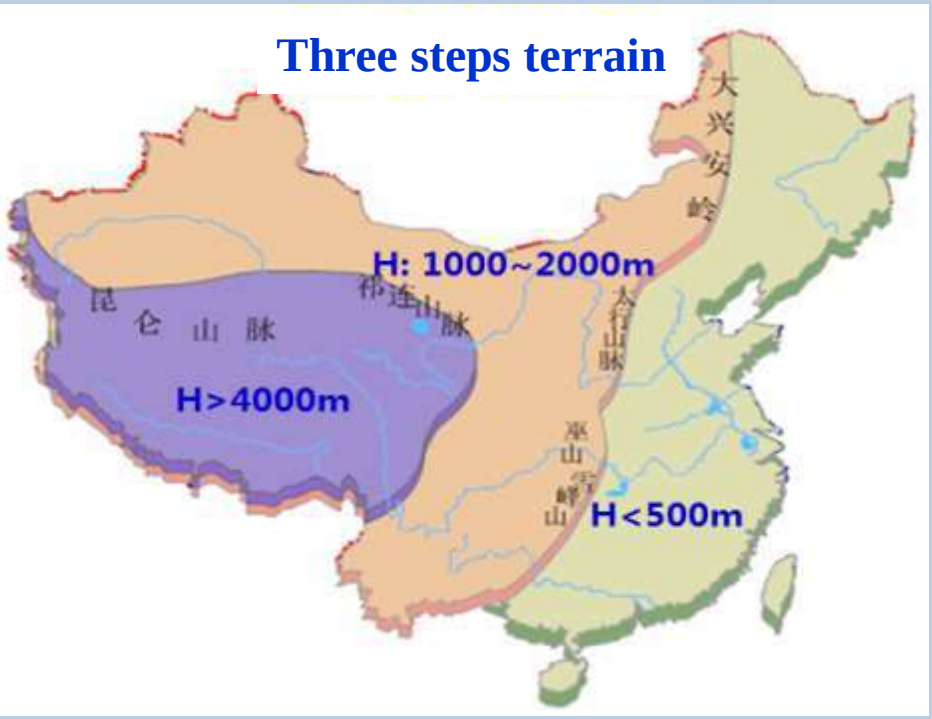
Outline

1. Overview of Flood and Drought Disaster Situation
2. Introduction to Construction of Structural Disaster Mitigation Engineering
3. Introduction to Construction of Non-structural Disaster Mitigation Engineering
4. Flood Achievements in Flood Control, Drought Relief and Disaster Reduction
5. Future challenges and countermeasures

1 Overview

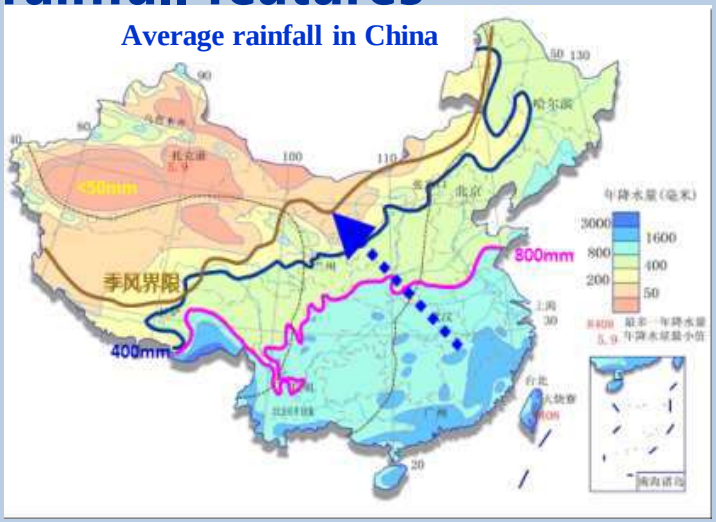
1.1 Physical geography and rainfall features



- China lies in the Eurasian continent, facing the Pacific on the east and the Indian Ocean on the west. China is located in East Asian monsoon region.
- China's terrain descends in three steps from west to east, which will influence and control water vapor when it enters into the continent.

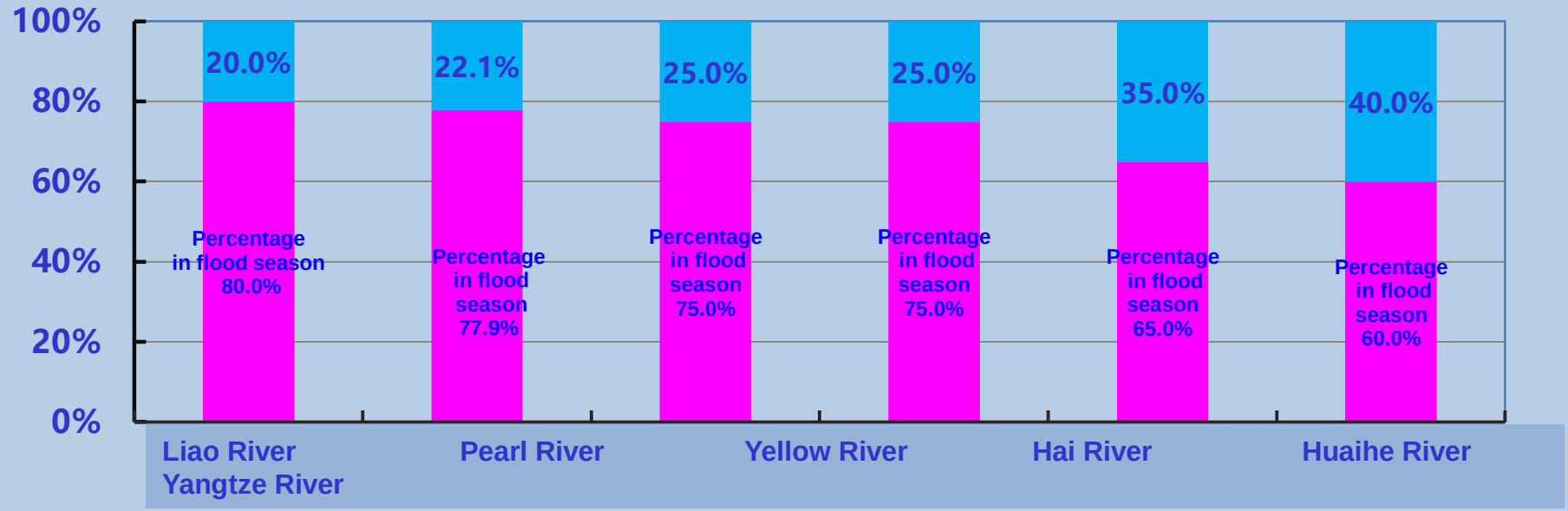
1 Overview

1.1 Physical geography and rainfall features



Influenced and controlled by sea-land circulation, monsoon, tropical cyclone and three steps terrain, precipitation in China is characterized by uneven spatial and temporal distribution. The precipitation decreases from the southeast to the northwest. 60%~over 80% rainfalls occur in the flood season from May to September. It is very difficult to use water resources. Maximum storm in eastern areas in different periods reaches the world record. China is one of the countries that are seriously affected by drought and flood disasters in the world.

Precipitation rates of main rivers in flood season



1 Overview

1.2 Numerous river system, 1.8 km continental coastline and serious flood mitigation task

>10,000km^2/ 228 rivers/overall length: 132,500km

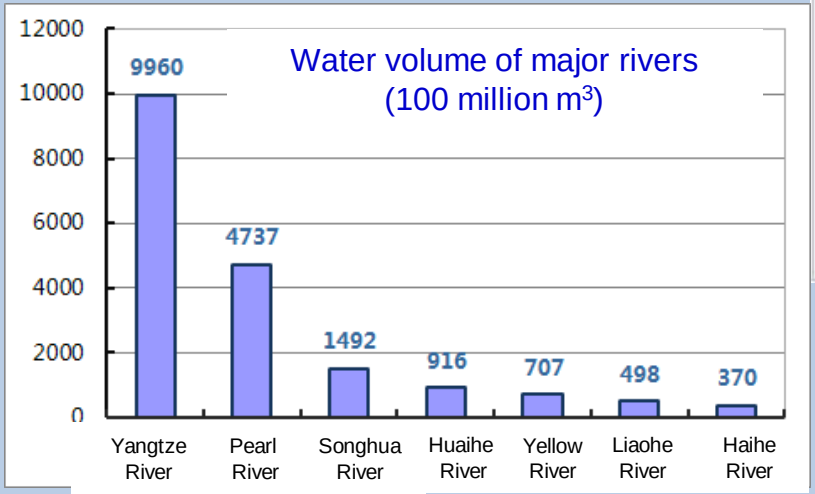
>1,000km^2/ 2,221 rivers/overall length: 386,500km

>100km^2/22,909 rivers/overall length: 1,114,600km

>50km^2 /45,203 rivers/overall length: 1,508,500km

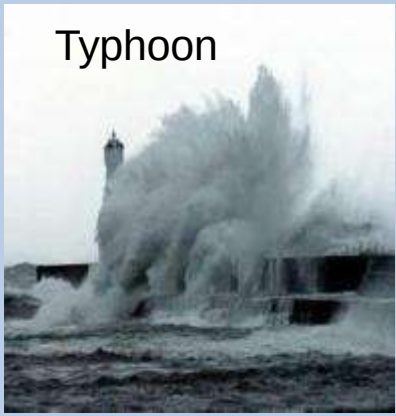
Seven major rivers:

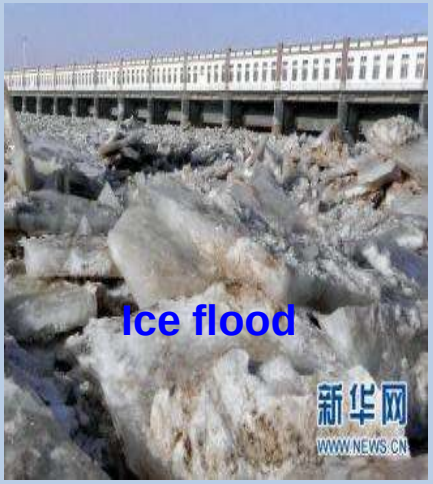
Yangtze River, Yellow River, Pearl River, Huai River, Hai River, Songhua River, Liao River



1 Overview

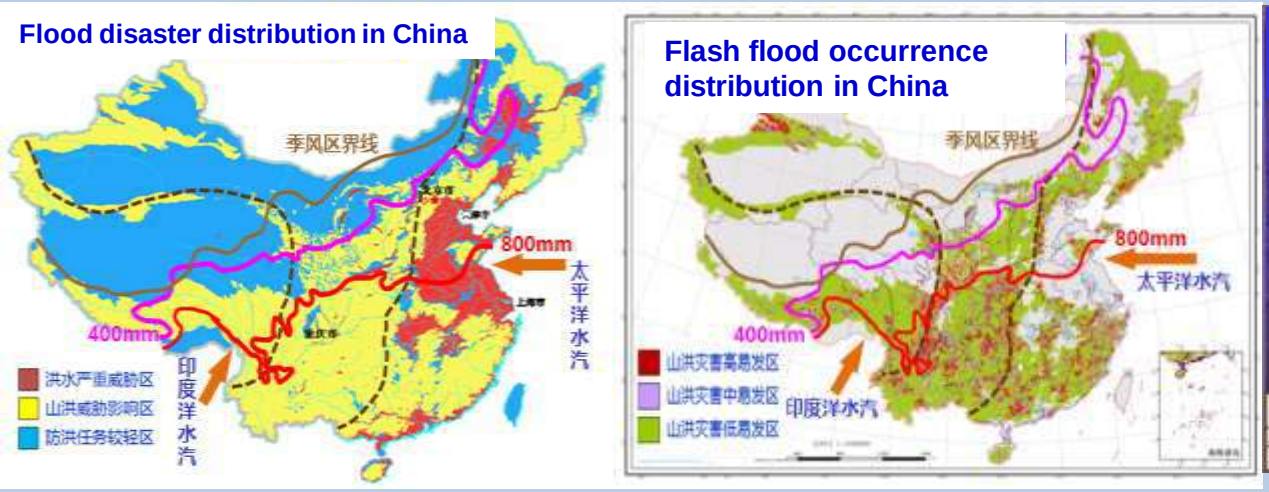
1.3 Flood and drought disaster characteristics --- various disaster types

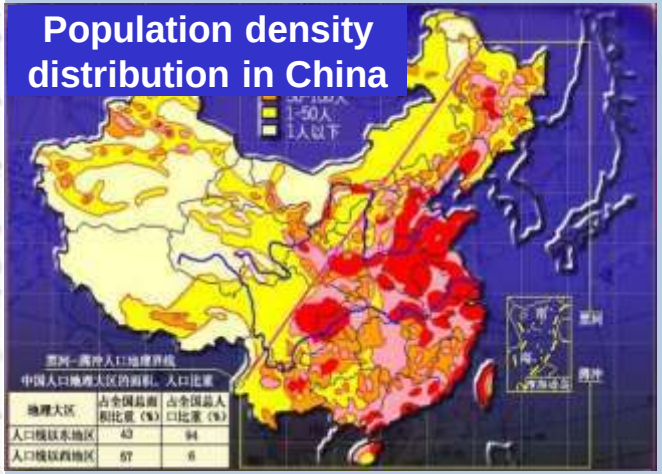




1 Overview

1.3 Flood and drought disaster characteristics --- extensive influence



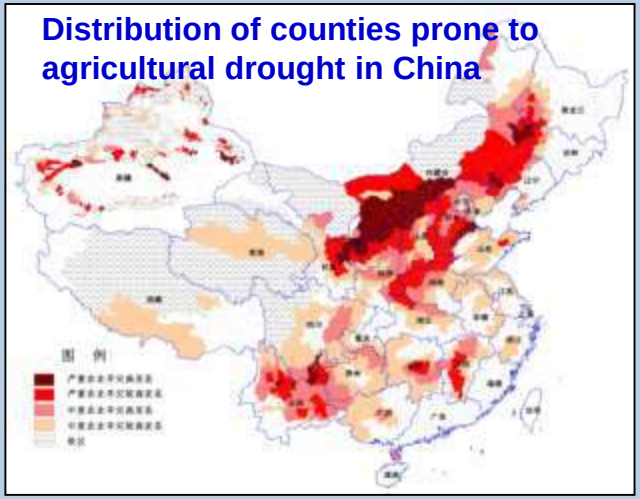


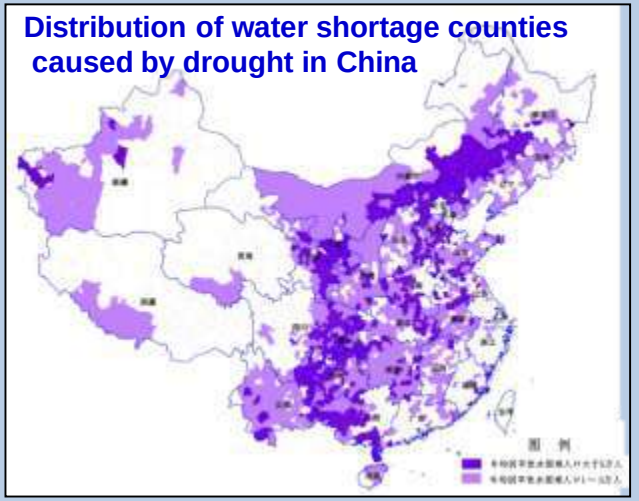
The middle and lower reaches of seven major rivers and coastal plains are flood-prone areas, which covers 8% of total country's area with the area of 800,000km^2. 1/2 national population, 1/3 farmland and 3/4 GDP are concentrated here.

The protection area of flash flood is 4,600,000 km^2, nearly half of national territory, with 2058 counties (72% of whole counties), ½ country's area, 1/3 farmland and 560 million population (40% of national population).

1 Overview

1.3 Flood and drought disaster characteristics --- extensive influence





Among 2,863 counties in China, 2,025 drought stricken counties (accounting for 71% of total number of counties), including 584 seriously drought-stricken counties, 1,400 counties with drinking water shortage caused by drought and 1,608 agricultural drought counties.

1 Overview

1.3 Flood and drought disaster characteristics --- high occurrence frequency

Number of severe floods and droughts since 1949: over 60 times, more than once a year

Inundated Wuhan in 1954

Drought stricken Liaoning in 2009

1 Overview

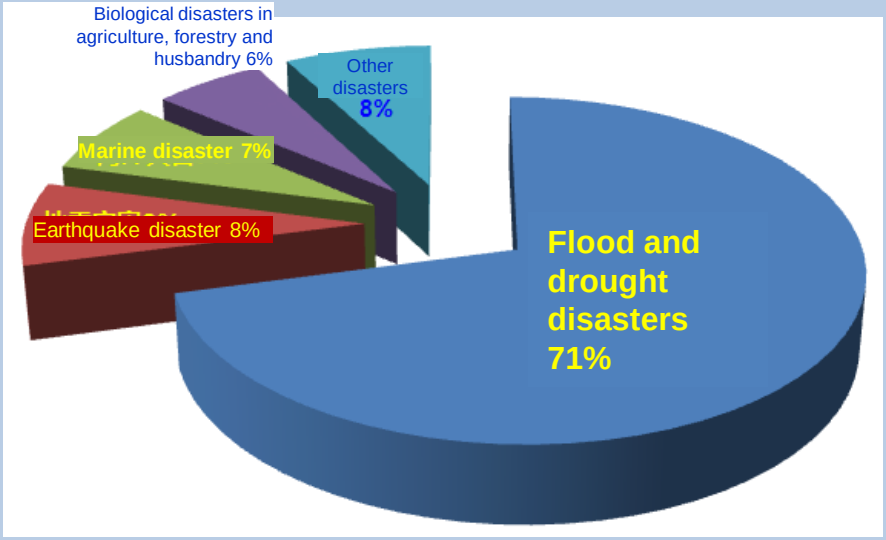
1.3 Flood and drought disaster characteristics --- severe disaster losses

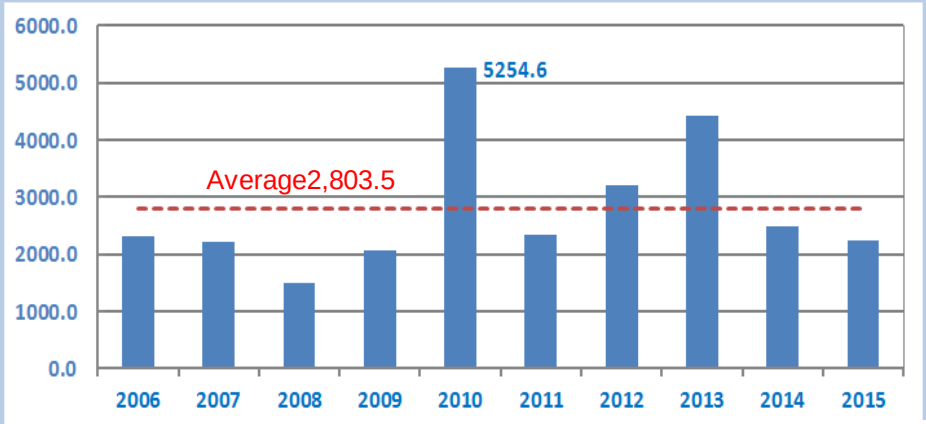
1950 ~ 2015:

Flood disaster: more than 280,000 deaths and 4266 annual average deaths; 9.72 million hectares affected annually; 122 million houses collapsed and annual average 1.848 million houses collapsed.

Drought disaster: 20.82 million hectares affected annually; 16.26 billion kilograms of annual average grain loss.

From 2006 to 2015, the annual direct economic losses caused by flood and drought reach RMB280.35 billion, accounting for 71% of direct economic losses caused by natural disasters





Annual direct economic losses caused by flood and drought (unit: RMB 100 million)

2 Introduction to Construction of Structural Disaster Mitigation Engineering

Because of the special natural geographical and climatic conditions, China must be a country seriously affected by flood and drought. Moderate standard system is the basis and fundamental guarantee for flood control, Drought Relief and disaster reduction, which haven been proved by the history of national development.

- **Dike: 414,000km in length, including 275,000km dikes at level-5 and above**


Jingjiang dike of Yangtze river


Dike of Yellow river


Dike of Songhua river


Dike of Shanghai

2 Introduction to Construction of Structural Disaster Mitigation Engineering

➢ Reservoirs:

Total number of reservoirs : 98,000

Large-sized reservoirs: 756

Total storage capacity: $9,323 \times 10^8 m^3$

Medium-sized reservoirs: 3,938

Three Gorge Reservoir on Yangtze River

Xiaolangdi reservoir on Yellow River

Introduction to Construction of Structural Disaster Mitigation Engineering

➢ Key flood detention areas:

Total key flood detention areas: 98

Total area of flood detention areas : 3,3700km^2

Storage capacity of flood detention areas : 1074×10^{8}m^3

Jingjiang flood detention basin

Dongping Lake flood detention basin

➢ Sluices

Total sluices: 97,000

Large-sized sluices: 860

Medium-sized sluices: 6,332

Sanshenggong sluice on Yellow river

Bengbu sluice on Huai river

➢ Irrigation areas

Total number of irrigation districts: over 2,000,000

Number of Irrigation districts with area more than 30,0000 mu: 456

Irrigation area: 280,000,000 mu

Irrigation area of Ganfu plain in Jiangxi

Canal of Jiamakou irrigation area in Shanxi

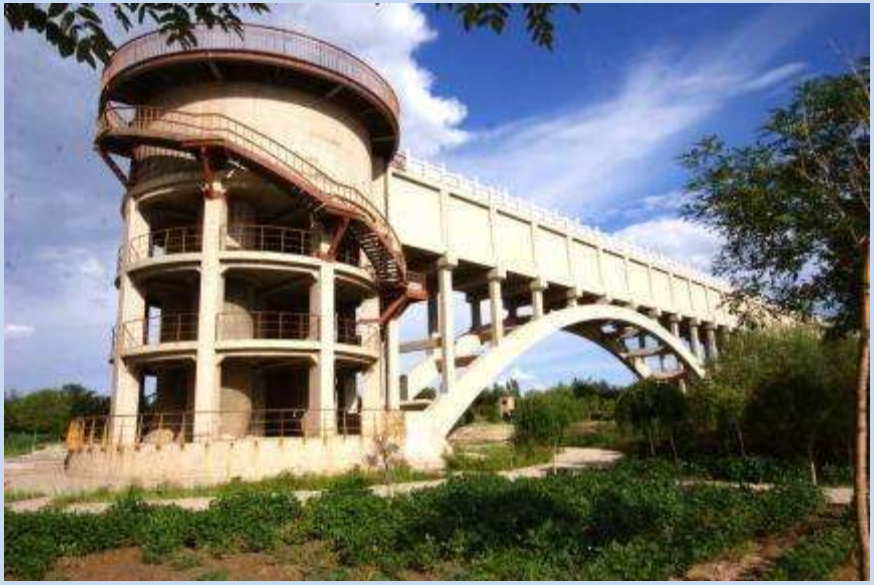
Introduction to Construction of Structural Disaster Mitigation Engineering

➢ Water supply projects

Number of rural water supply projects: 58,870,000

Benefitted population: 812 million

Water pumping station



Water supply project

2 Introduction to Construction of Structural Disaster Mitigation Engineering

➢ Large water diversion projects

Both east Route and middle route of the South to North Water Transfer Project have been put into use, with 3000km main lines and designed amount of diversion water of 18.27 billion m^3 per year. They effectively alleviate the water shortage in the north and serious ecological deterioration situation in Baiyangdian.

Baiyangdian before water diversion

Baiyangdian after water diversion

Transferring water from the Yellow river to Tianjin through Hebei province

2 Introduction to Construction of Structural Disaster Mitigation Engineering

The construction of engineering system provides fundamental guarantee and plays an important role in flood control and drought relief.

- **Large rivers' capacity to withstand flood： Main reaches of large rivers have the ability to withstand the biggest floods since 1949**
- **Middle and small rivers' capacity to withstand flood：They can withstand common flood**

Dike of Yellow river's mainstream

Medium/small rivers harness project in Jiangxi

2 Introduction to Construction of Structural Disaster Mitigation Engineering

- **Urban flood control capacity: Generally constructed to control the flood occurred once every 50-200 years**
- **Key sea embankments: Generally constructed to control the flood occurred once every 50-100 years**

Dike of Wuhan city

Sea embankment in Zhejiang province

2 Introduction to Construction of Structural Disaster Mitigation Engineering

- People's domestic water use both in cities or rural areas can be guaranteed when severe droughts occur.
- Water use for agriculture, industry and ecology can mostly be guaranteed when medium droughts occur.

Domestic water use

Sprinkle irrigation

3 Introduction to Construction of Non-structural Disaster Mitigation Engineering

Non-structural system is an indispensable part and important guarantee for flood control, drought relief and disaster reduction. Non-structural system has and will play an increasingly important role in flood control, drought relief and disaster reduction. Non-structural system has great potential.

➢ Legislation system

Regulation system of flood control and Drought Relief has been established. A series of laws or regulations have been enacted and implemented, including Water Law, Flood Control Law, Flood Prevention Regulation, Drought Relief Regulation etc.

3 Introduction to Construction of Non-structural Disaster Mitigation Engineering

➢ Technical standard system

More than 30 standards closely related to flood control, Drought Relief and disaster reduction, involving in prevention and control, planning, design, forecasting, division, prediction scheme, disaster evaluation etc.

1	Standard for flood control	GB50201-2014
2	Code for formulation of flood control planning	SL669-2014
3	Standard for waterlogging control	SL723-2016
4	Standard for hydrological information and hydrological forecasting	GB/T22482-2008
5	Regulation for calculating design flood of water resources and hydropower projects	SL44-2006
6	Safety rules of lifting appliances for water resources and electric power construction	SL428-2008
7	Guidelines for formulation of reservoir regulation rules	SL706-2015
8	Design specification of reservoir	GB/T50587-2010
9	Compilation guide of flood control operation plan	SL596-2012
10	Regulation for simulation of dam-break flow	SL164-2010
11	Guidelines for emergency preparedness plan of reservoir dam safety management	SL/Z720-2015
12	Design Specification for Flood Detention Retarding Basin	GB50773-2012
13	Guidelines for flood storage and detention area preplan	SL488-2010
14	Guidelines for assessment of flood control risk	SL602-2013
15	Compilation guidelines for flood impact assessment report	SL520-2014
16	Flood disaster assessment	SL579-2012
17	Flood Risk Mapping Guidelines	SL483-2010
18	Technique guideline for emergency disposal of landslide lake	SL451-2009
19	Standard for classification of risk grade of landslide lake	SL450-2009
20	Guideline on the Compilation of Emergency Preparedness Plan for the Prevention of Flash Flood Disaster	SL666-2014
21	Guidelines on the design of monitoring and warning systems for flash flood disaster prevention	SL675-2014

➢ Technical standard system

22	Guideline of emergency preparedness plan for typhoon prevention	SL611-2012
23	Standard of classification for drought severity	GB/T32135-2015
24	Standard of classification for drought disaster	SL663-2014
25	Compilation guidelines for drought response plan	SL590-2013
26	Classification for drought information	SL546-2013
27	Code for design of levee project	GB50286-2013
28	Guidelines for levee safety evaluation	SL/Z679-2015
29	Code for design of sea dike project	GB/T51015-2014
30	Specification of exploration for dike hidden trouble	SL436-2008
31	Design standard of flood control project in city	GB/T50805-2012
32	Code for design of river regulation	GB50707-2011
33	Code of practice for compilation of river sand-mining planning	SL423-2008

There are 140 technical standards related to hydrological and hydraulic information, playing an important role in the construction of flood control engineering and non-engineering measures in a scientific and standardized manner.

3 Introduction to Construction of Non-structural Disaster Mitigation Engineering

➢ Administrative structure

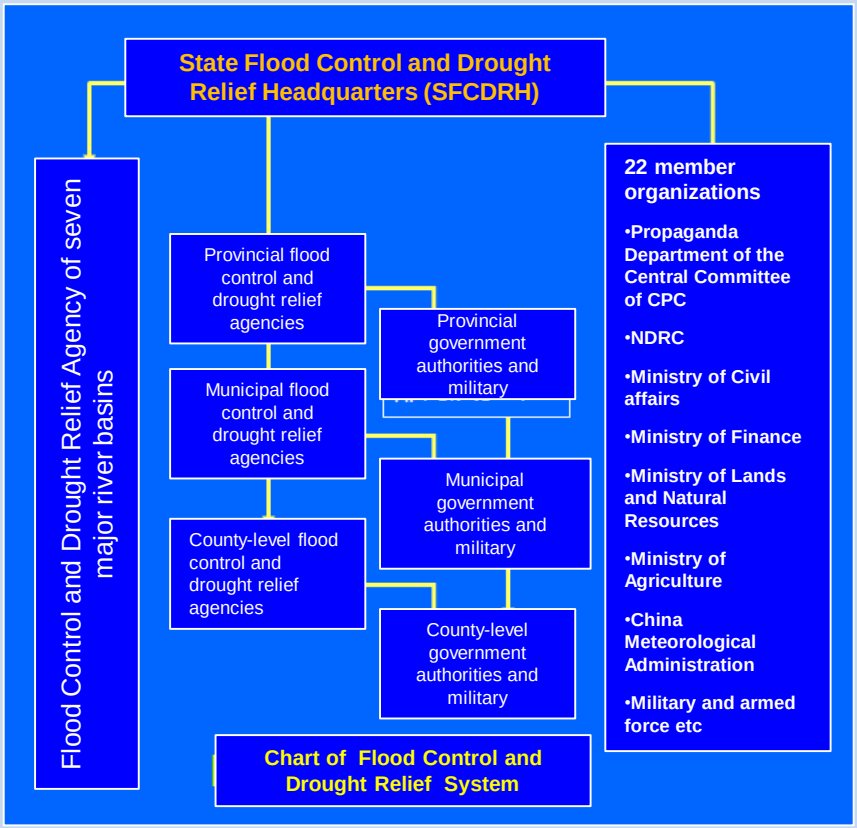
Organization and command system at three levels of national, basin and local

· unified command

· interdepartmental communication

· identified responsibility

· cooperation between army and civilian



3 Introduction to Construction of Non-structural Disaster Mitigation Engineering

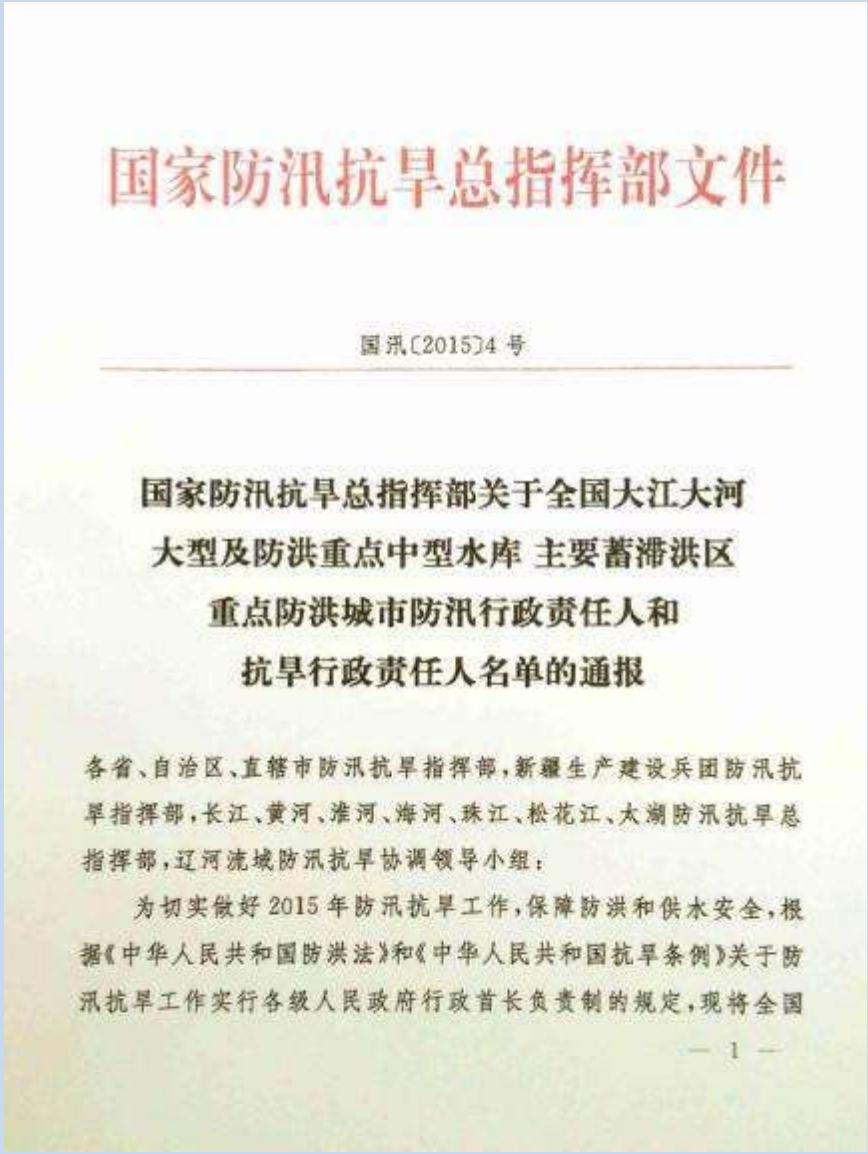
➢ Responsibility system

The chief administrative officials of people's governments at all levels shall assume overall responsibility for the work of flood control and drought management.

Make public announcement about chief officials, strengthen responsibility oversight and accountability.

- Flood control and Drought Relief responsibility system
  - Chief administrative official responsibility system
  - Responsibility system at all levels
  - Responsibility system department
  - Responsibility system on post
  - Responsibility system in technical term

Flood control and Drought Relief responsibility system



国家防汛抗旱总指挥部文件

国汛〔2015〕4号

国家防汛抗旱总指挥部关于全国大江大河
大型及防洪重点中型水库 主要蓄滞洪区
重点防洪城市防汛行政责任人和
抗旱行政责任人名单的通报

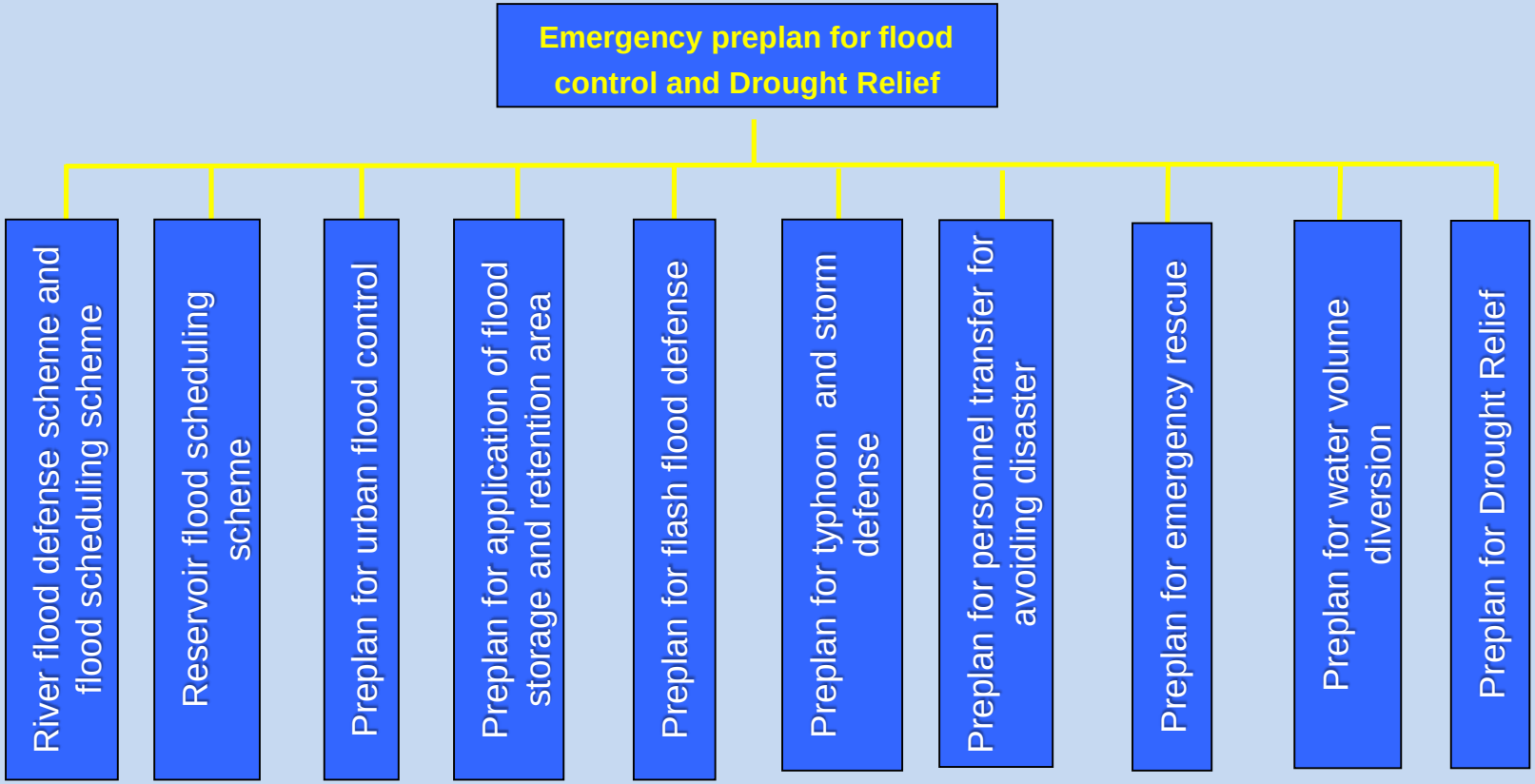
各省、自治区、直辖市防汛抗旱指挥部，新疆生产建设兵团防汛抗旱指挥部，长江、黄河、淮河、海河、珠江、松花江、太湖防汛抗旱总指挥部，辽河流域防汛抗旱协调领导小组：

为切实做好2015年防汛抗旱工作，保障防洪和供水安全，根据《中华人民共和国防洪法》和《中华人民共和国抗旱条例》关于防汛抗旱工作实行各级人民政府行政首长负责制的规定，现将全国

— 1 —

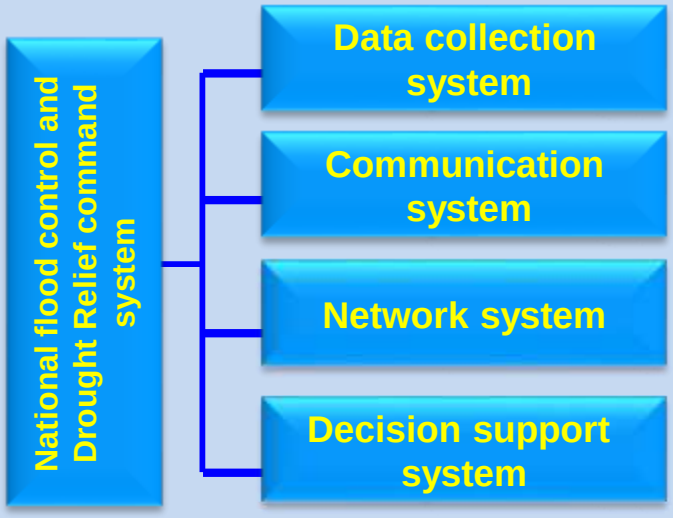
➢ Preplan system

Kinds of prepared plans have been formulated both at national and local level.

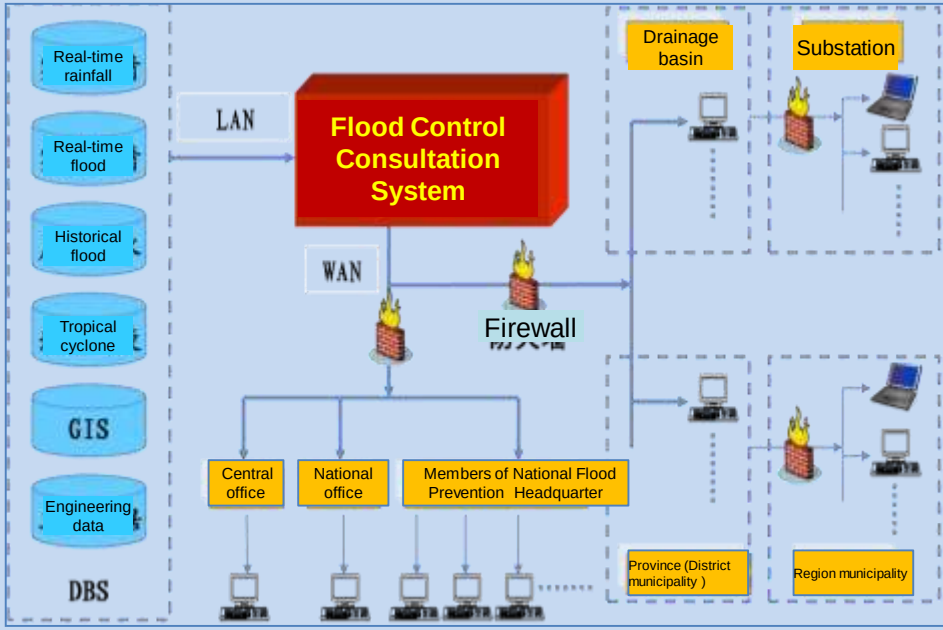


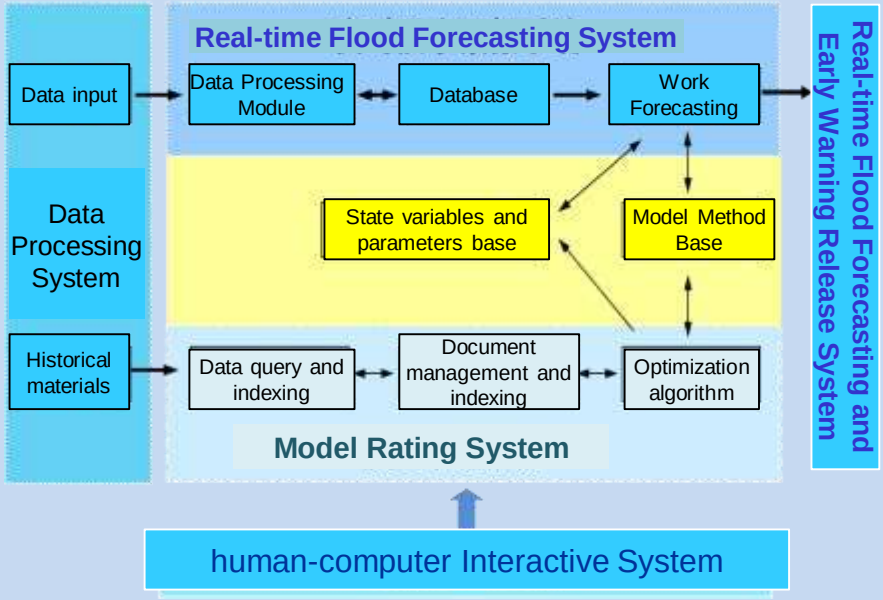
3 Introduction to Construction of Non-structural Disaster Mitigation Engineering

- **National flood control and Drought Relief command system**



Forecasting and early warning
Project scheduling
Consultation and decision





➢ Guarantee system

Various disaster rescue teams by combining people with professionals or military: more than 10 million of people

PLA, army police force and professional rescue teams: over 300,000 people

Reserved materials for flood control and drought relief: over 11 billion Yuan

P.L.A.'s emergency flood rescue force

Flood rescue rehearsal

Reserved materials for flood control

3 Introduction to Construction of Non-structural Disaster Mitigation Engineering

➢ Emergency management

Keep watch

Consultation

Emergency response

Emergency transfer

Emergency rescue

Post-disaster recover

4 Flood Achievements in Flood Control, Drought Relief and Disaster Reduction

Flood control benefits

Since 1950s:

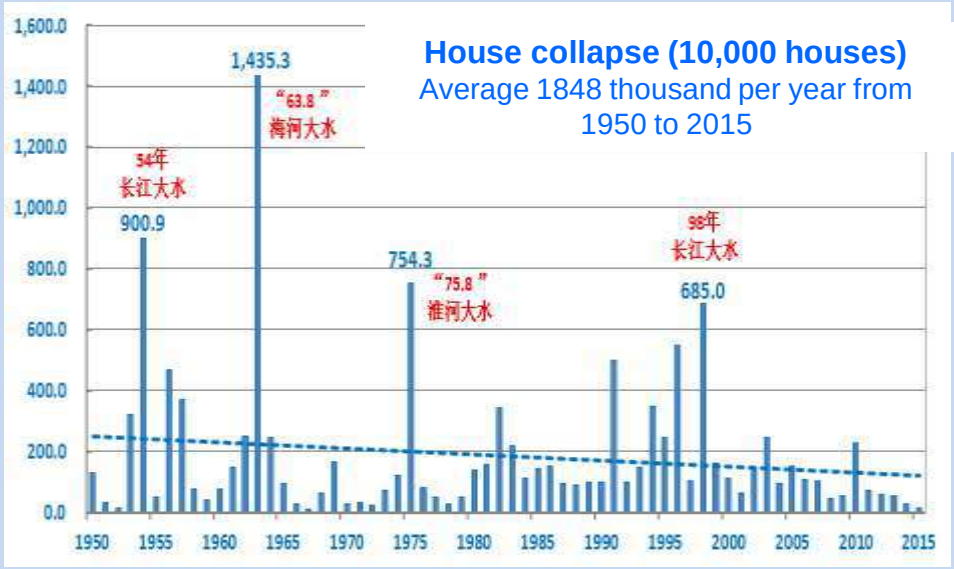
Flood mitigation benefit: RMB4600 billion;

Reduced farmland inundation: 0.18 billion hector;

Reduced grain losses: 0.76 billion tons;

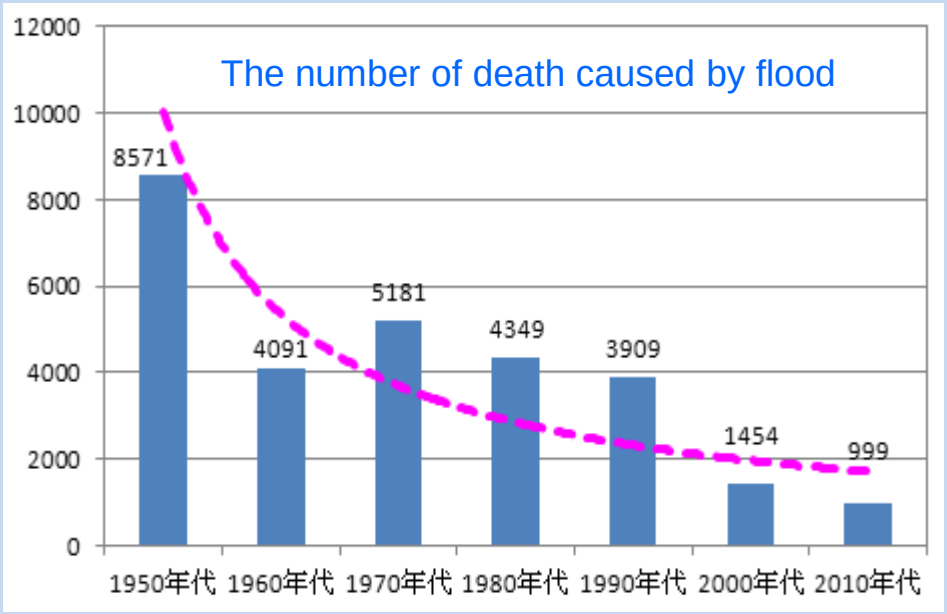
Greatly reduced property collapse;

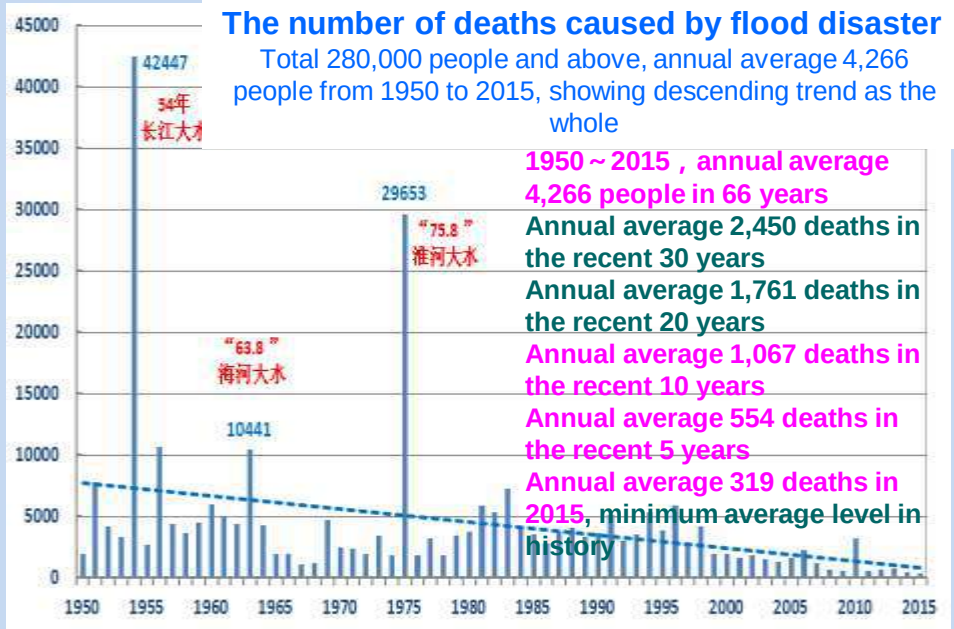
Significantly reduced fatality.



House collapse (10,000 houses)

Average 1848 thousand per year from 1950 to 2015





The number of deaths caused by flood disaster

Total 280,000 people and above, annual average 4,266 people from 1950 to 2015, showing descending trend as the whole

1950～2015，annual average 4,266 people in 66 years

Annual average 2,450 deaths in the recent 30 years

Annual average 1,761 deaths in the recent 20 years

Annual average 1,067 deaths in the recent 10 years

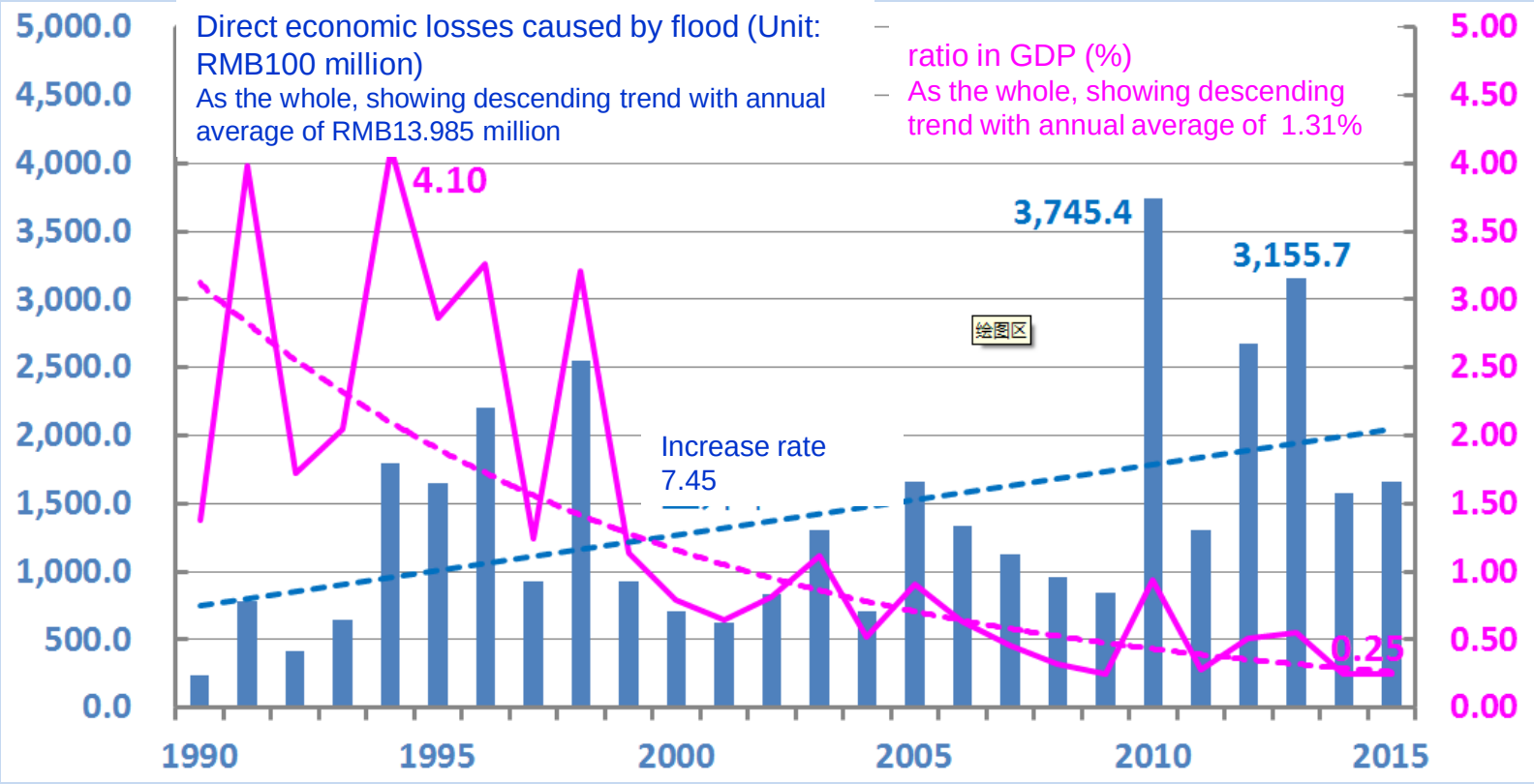
Annual average 554 deaths in the recent 5 years

Annual average 319 deaths in 2015, minimum average level in history

Flood control benefits

1990-2015:

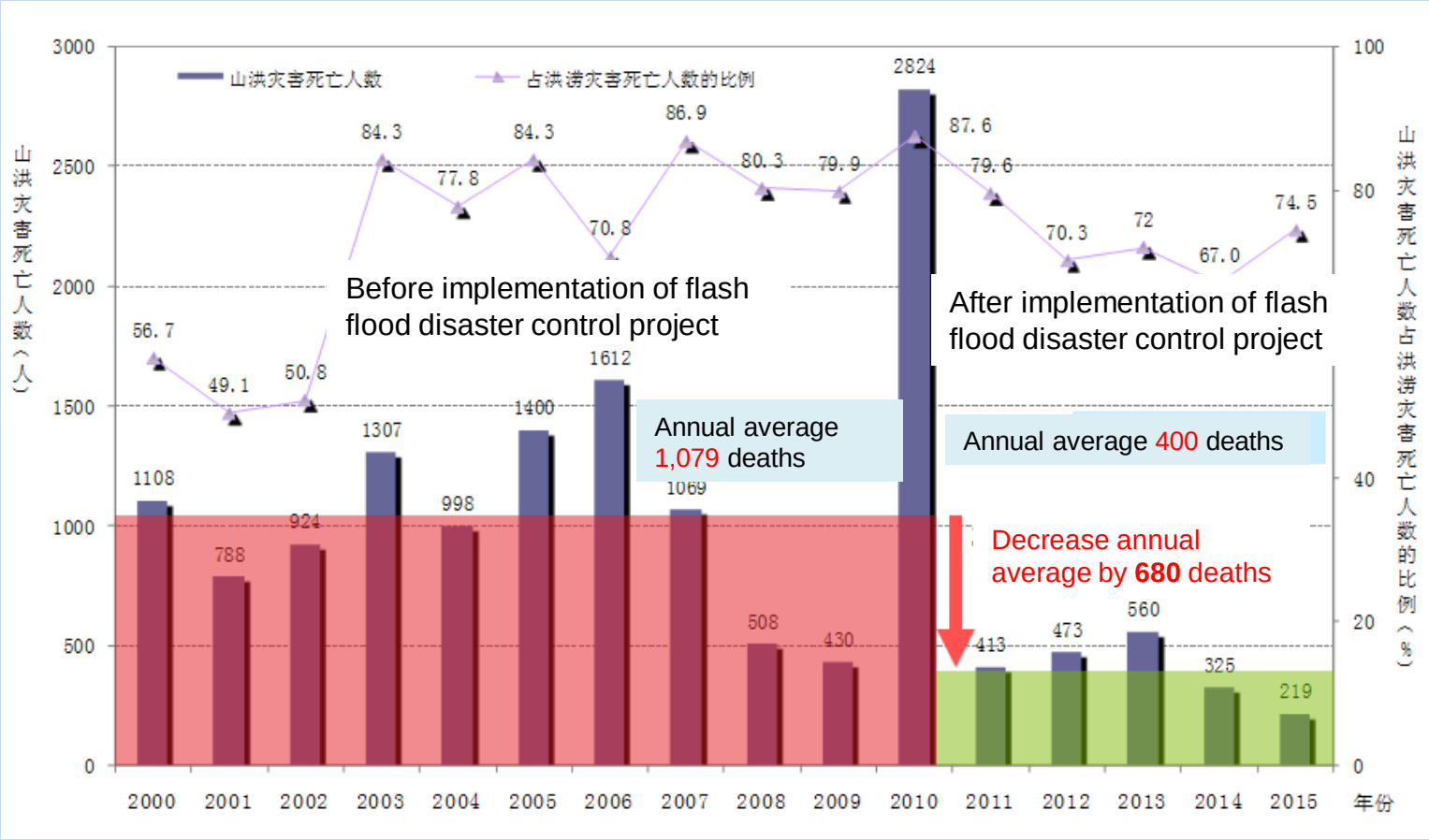
Direct economic loss increased linearly by 7.4%, nearly half of GDP increase;
The ratio decreased gradually: from 0.91% 20 years ago to 0.25% at present.



4 Flood Achievements in Flood Control, Drought Relief and Disaster Reduction

Flood control benefits

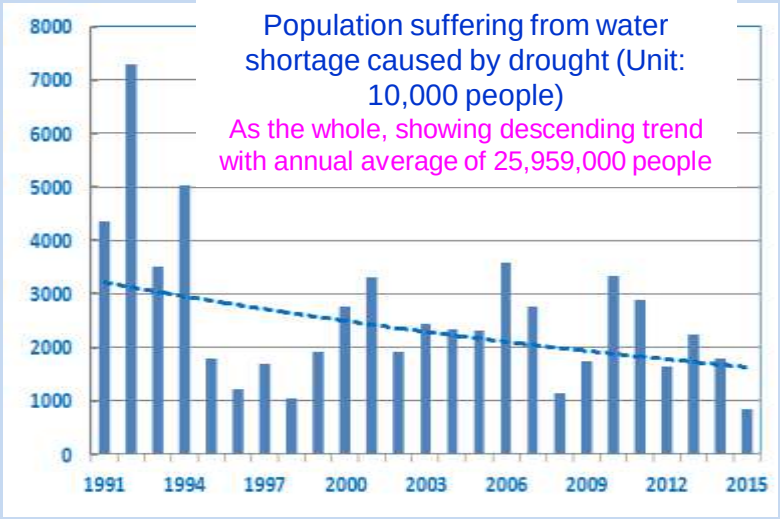
Since 2010, based on the construction of flash flood prevention projects, population fatality induced by flash flood was greatly reduced by 680 deaths in average.

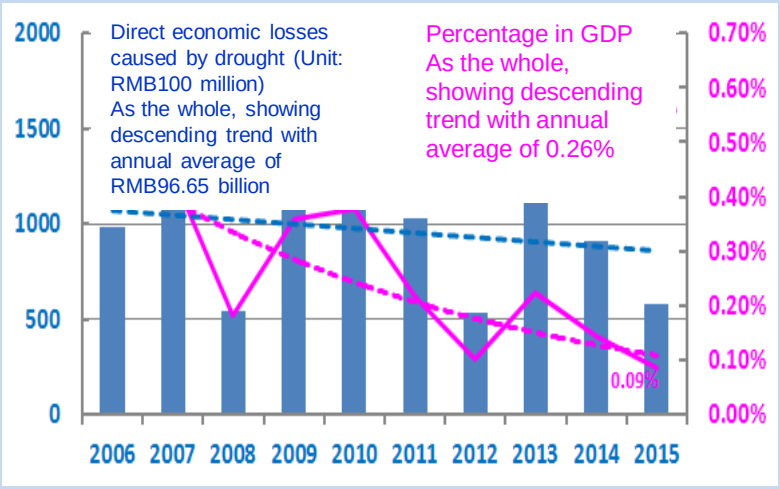


4 Flood Achievements in Flood Control, Drought Relief and Disaster Reduction

Drought Relief benefits

The drinking problem of 231.9 million population annually was solved, reducing irrigation areas of 0.43 billion mu and grain losses of 39.02 million tons. The population suffered from drinking shortage and direct economic loss due to drought were reduced step by step.

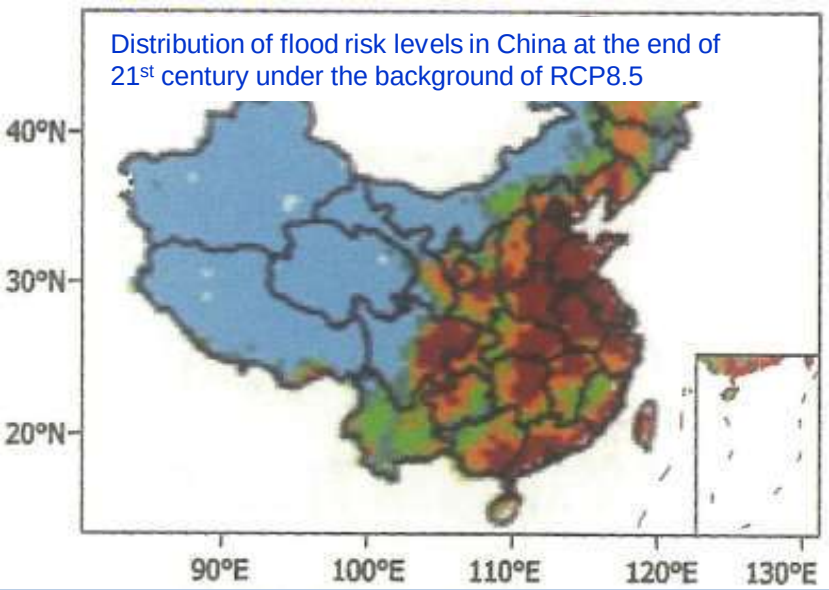


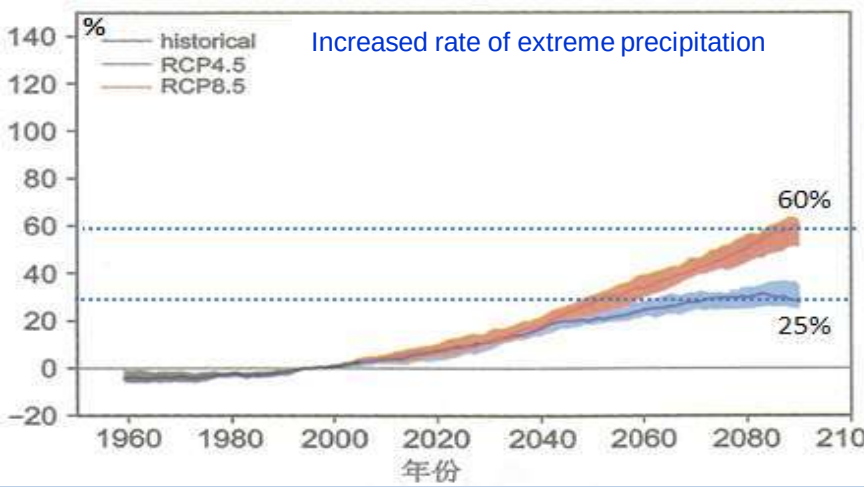


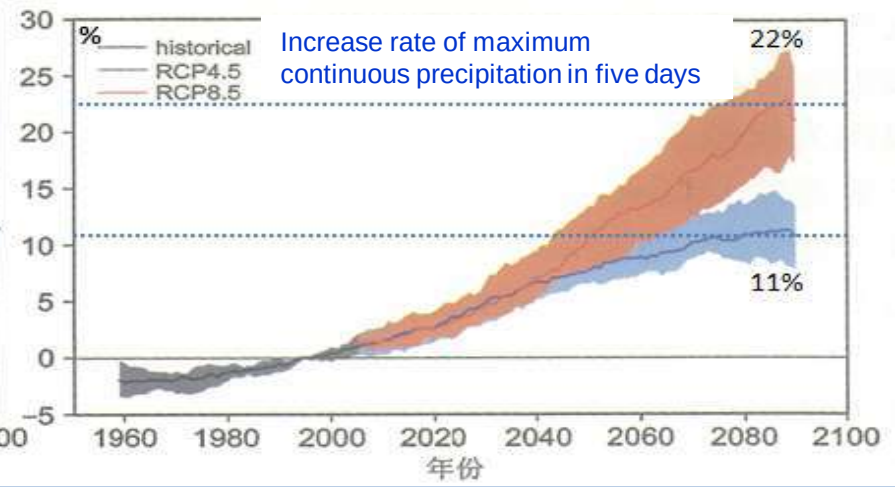
5 Future challenges and countermeasures

➢ Climate change will increase extreme precipitation and flood risks

Compared with 1986-2005, under Scenario RCP 4.5, extreme precipitation, 5-day maximum precipitation will increase by 25% and 11%, storm frequency will increase by 58%, and flood and drought risk will also increase largely. High risk areas include middle east, southeast coastal areas, northeast capital cities and parts in Shaanxi and Shanxi provinces.







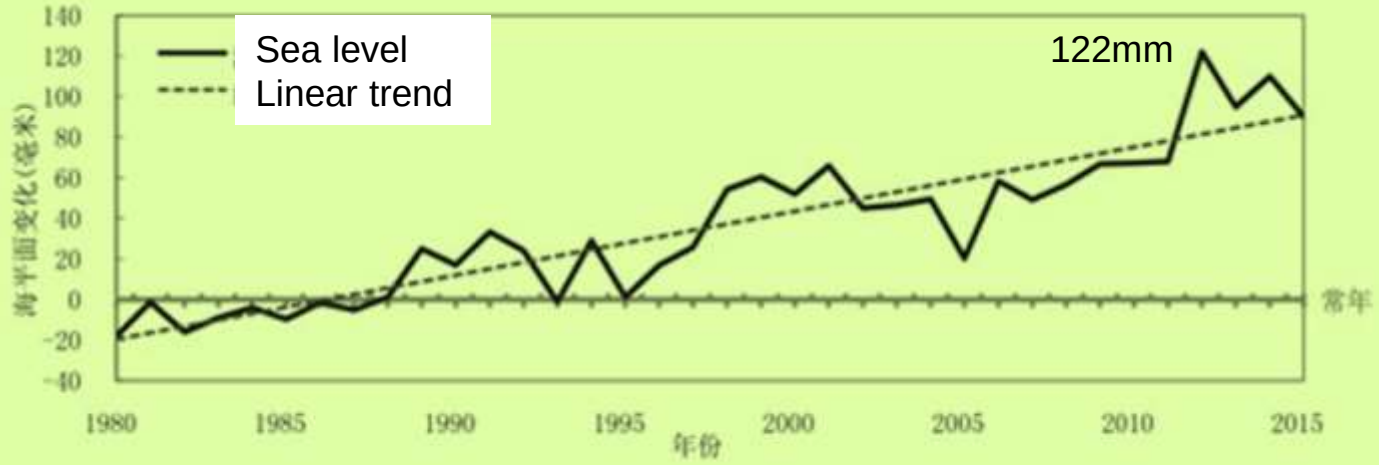
5 Future challenges and countermeasures

➢ Rising of sea level will increase flood risks in coastal areas

From 1980 to 2005, the increasing rate of sea level is 3.0 mm/a, higher than global average, and continue to increase in the future.

Flood drainage difficulties in coastal cities will increase, making flood control capacity of present works lower, typhoon and tidal disaster losses larger, and flood risks greater.

Name	2015	Future 30 years
Bohai Sea	94mm	+65 ~ 155mm
Huanghai Sea	91mm	+75 ~ 165mm
East China Sea	96mm	+70 ~ 160mm
South China Sea	82mm	+75 ~ 165mm

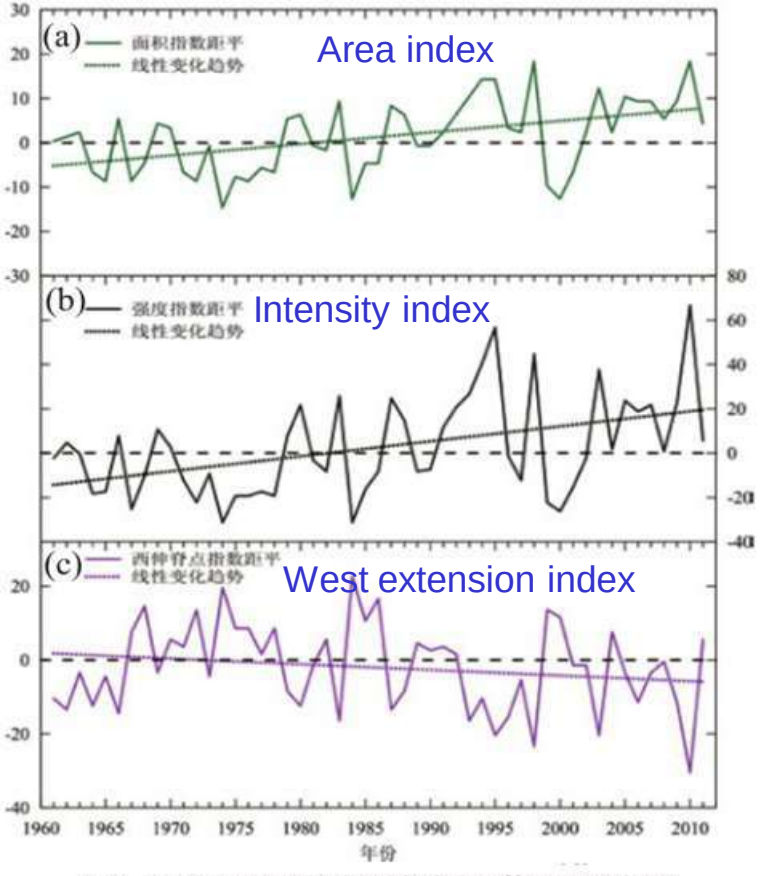


1980~2015 Changes in sea level in coastal areas in China

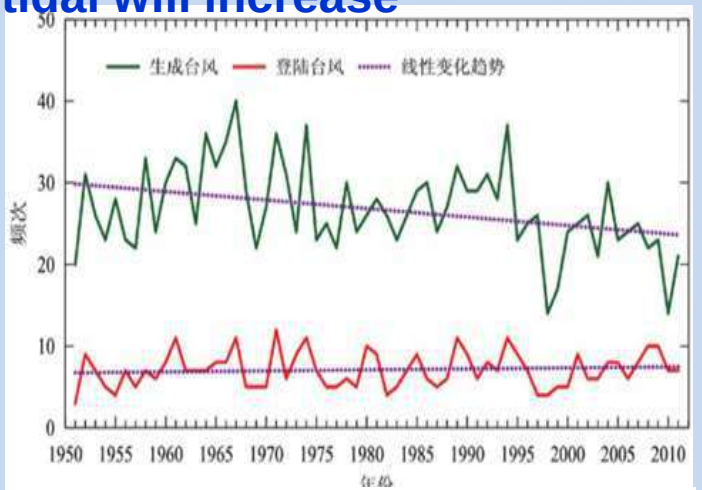
5 Future challenges and countermeasures

Extreme disaster risks of typhoon, storm and tidal will increase

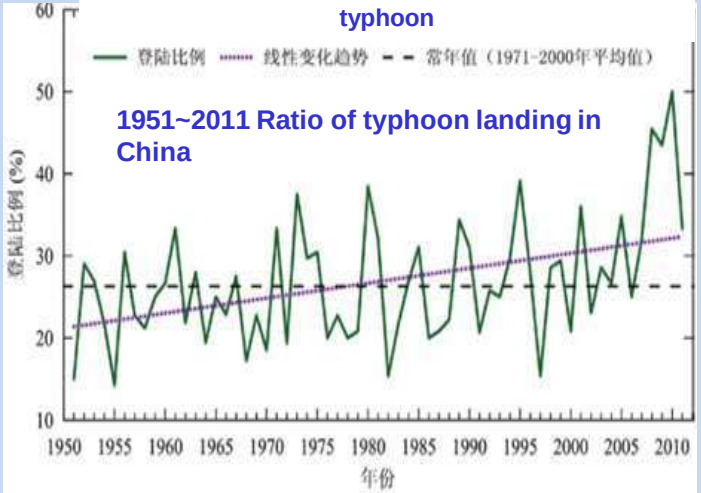
- **Future: Frequency of typhoon will decrease, while landing ratio and intensity will increase, as well as typhoon, storm and tidal intensity and extreme flood disaster risks.**



1961~2011 Changes in West Pacific subtropical high-pressure characteristics variation



1951~2011 Frequency of generation and landing of Northwest Pacific and South China Sea typhoon

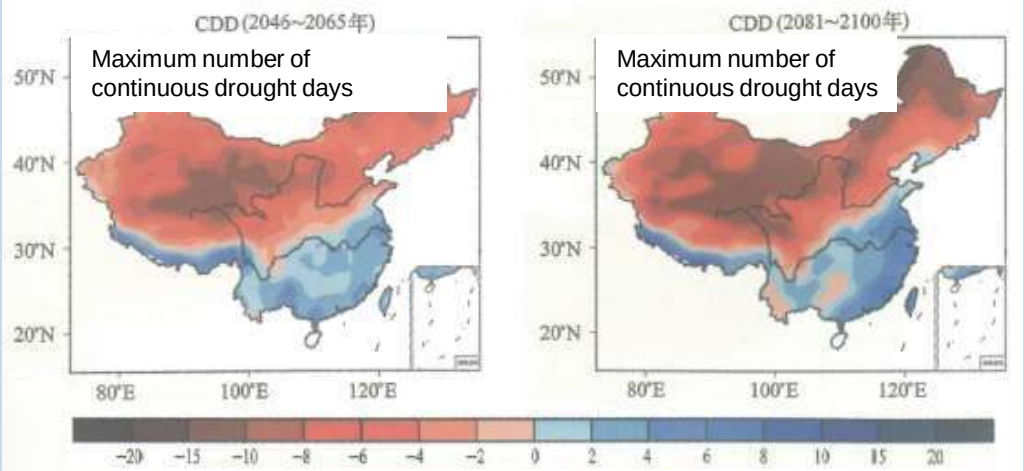


1951~2011 Ratio of typhoon landing in China

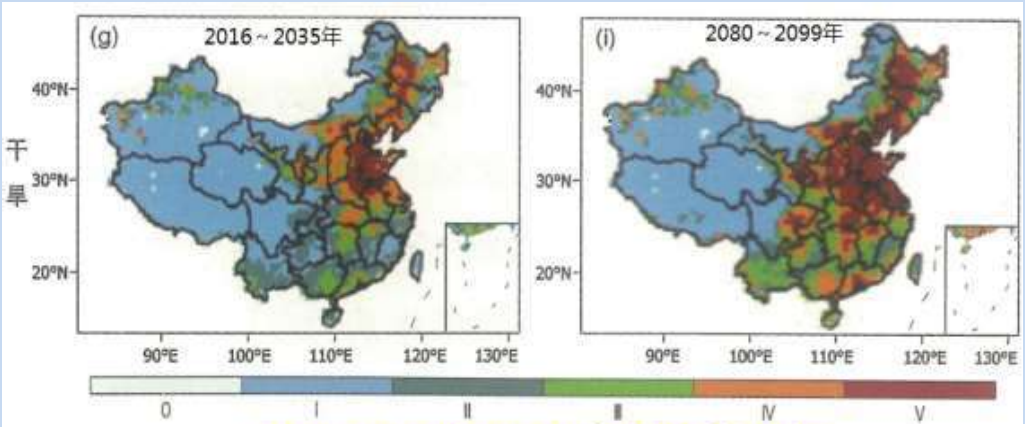
5 Future challenges and countermeasures

➢ Climate change in future will increase the range of high risk to drought

The annual precipitation in China will keep increasing in the future of the 21st century. The average growth rate at the end of the century will be 2%~5%, where the average growth rate of the northern area will be 5%~15%. Drought will be mitigated to a certain degree and the drought frequency will decrease in the overall. However, the frequency of high temperature and extreme drought events will increase. The north China, east China, central of northeast and southwest will be exposed to high risk to drought. In the late of 21st century, the range of high drought risk will increase significantly.



Changes in China's maximum number of continuous drought days under the background of RCP4.5 compared with 1985~2005

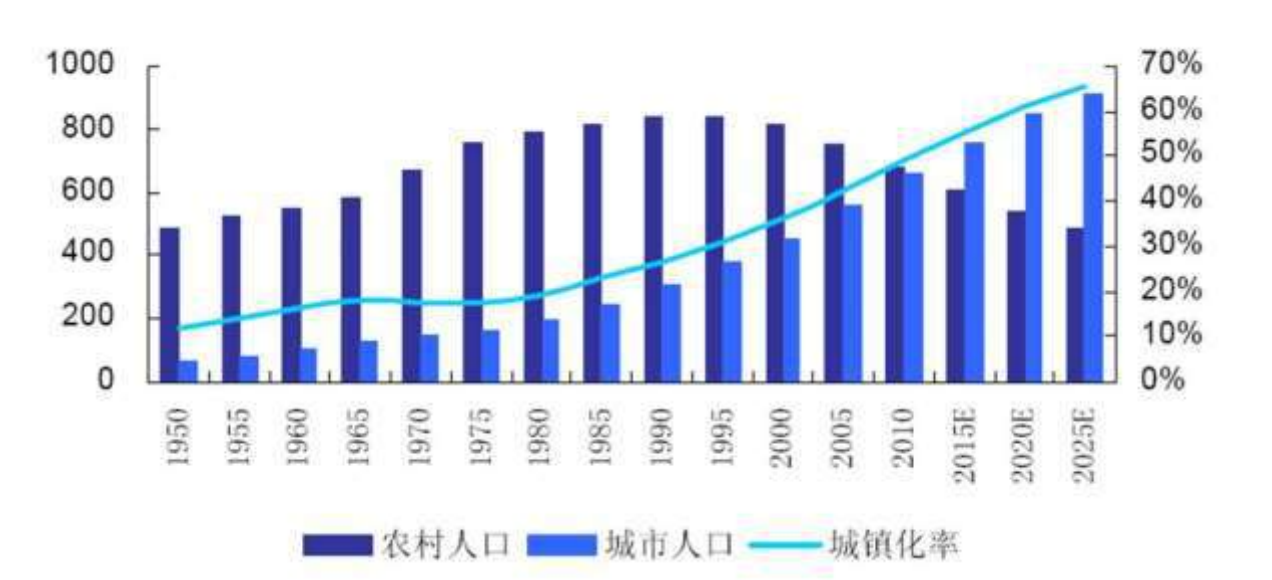


Distribution of drought disaster risk levels in China under the background of RCP4.5 in the future

5 Future challenges and countermeasures

➢ Economic and social development set higher requirements for flood control and drought relief

Urbanization, rapid development of coastal regions, poverty elimination in mountainous areas, construction of ecological civilization and beautiful China and realization of human-oriented concept and well-off society have set higher requirements for flood control and drought relief. The tasks in flood control and drought relief will be still heavy in future.



Rural population Urban population Urbanization rate

5 Future challenges and countermeasures

Climate change promotes extreme development of precipitation and increases frequency, intensity and scope of extreme precipitation. Coupled with rising sea level, impact caused by urbanization and repaid economic and social development, the risk of flood and drought disasters increases. The main problems are:

- Not all rivers reach the planned standard for flood control. There is large uncertainty for superstandard floods.
- Medium and small rivers and flash flood disasters are serious and have become a weak point in flood control.
- Urban flood disasters are highlighted and have big impact.
- Coastal storm surge defense with low standard.
- Dikes and reservoirs have many potential safety hazards.
- The contradiction between flood control and flood resource utilization is highlighted.
- The capacity for dealing with severe drought incidents still needs to be improved.
- Non-structural measures are still lacked and risk management needs to be improved.

5 Future challenges and countermeasures

Countermeasures:

In addition to taking emission reduction measure and reducing man-made temperature rise, follow "No Regrets" principle, continue to construct and improve appropriate standards and coordinated structural and non-structural engineering systems, implement and enhance the integrated management on flood and drought risks.

- **Structural engineering measures**

✓ Considering the impact caused by climate change, study and review the changes in design conditions and standards, make adjustment and standard construction, achieve the defense standards that are planned and matched with the level of economic and social development

✓ Strengthen the construction of weak links in engineering

Strengthen the construction of non-qualified large river projects, urban flood control projects, medium and small river governance projects, sea embankment projects, rivers and lakes connection projects, basin control projects, drought relief infrastructure and emergency water supply projects. Meanwhile, improve the operation and maintenance of the projects that have been constructed, make sure the safety and function standards are not lowered.

5 Future challenges and countermeasures

Countermeasures:

➢ Non-structural engineering measures

- **Improve policy and regulation system, create innovation in institutional mechanisms for flood management**

Including four levels: laws, administrative regulations, work rules and technical standards

Based on the needs in new situation, timely review and improve unreasonable issues and construct the much-needed projects, such as:

Establish flood risk notification system: Finish flood risk mapping and release it to the public, enhance social awareness to risks, promote social management and involvement in flood control, drought relief and disaster reduction;

Strengthen flood impact evaluation and land use management, regulate human activities and reduce man-made disasters;

Establish flood insurance system and effectively share and avoid risks etc.

- **Continue to strengthen and constantly improve the construction of national flood control and drought relief command system**

Strengthen the capacity building in monitoring forecasting and early warning, improve timeliness and accuracy of rainfall and drought forecasting and early warning as well as engineering system scheduling, improve the capacity and level of emergency decision-making and command.

5 Future challenges and countermeasures

Countermeasures:

- **Non-structural engineering measures**
- **Improve various emergency preplans**

Strengthen training, improve operability and practice effectiveness, reduce the losses caused by disasters, reduce the risk of heavy impact on economic and social development caused by extreme disasters.

- **Strengthen scientific and technological support**

Enhance the interaction of human activities and evolution of natural system, and the study of impact on flood and drought disasters caused by climate change;

Strengthen the study on the theories, strategies and application technologies about flood and drought disaster risk management, and improve the scientific and technological levels in the sectors of planning, construction, operation, management and evaluation;

Focus on integrated multi-disciplinary study and improve international communication and cooperation etc.

5 Future challenges and countermeasures

Key research directions

- **Monitoring, forecasting, early warning, adjustment and control of flood disasters in river basins**
  - Key technologies and instrumentation used in monitoring storms and floods
  - Technologies supporting river flood forecasting and integrated optimization of scheduling decisions
  - Desktop deduction system used for superstandard flood disasters occurring in large rivers
  - Forecasting methods and key technologies used for accurate monitoring of local heavy rainfall in mountainous regions
  - Simulation technique for law of runoff yield in small watersheds
  - Flash flood dynamics forecasting and early warning technology
  - Flood vulnerability assessment and monitoring technology
  - Integrated management on flood disaster risks in watersheds
- **Monitoring, forecasting, early warning and integrated response to urban flood disasters**
  - Urban rainwater flood characteristics and flood simulation technology
  - Technology supporting urban flood monitoring, early warning and decision
  - Integrated planning technology for rainwater flood management and construction of "Sponge City"
  - Study on integrated management on urban flood disaster risks

5 Future challenges and countermeasures

Key research directions

- **Monitoring, forecasting, early warning and risk management on drought disasters**
  - Key technologies for monitoring and forecasting of drought disaster
  - Key technologies for assessment, adjustment and control of agricultural drought risk dynamics
  - Key technologies for early warning of hydrological drought in rivers, lakes and reservoirs
  - Key technologies for emergency water diversion for ecological drought
  - Integrated management on drought disaster risk
- **Technologies and equipment used for flood control, emergency rescue and drought relief**
  - Technologies and equipment used for hidden hazard detection and safety assessment
  - Technologies and equipment used for dike emergency rescue
  - Technologies and equipment used for barrier dam emergency rescue
  - Key technologies and equipment used for ice flood emergency rescue
  - Key technologies and equipment used for emergency drought relief


Thank you!
Looking forward to discussion and exchange!