9th International Conference on Science and Technology for Sustainability, Sept.14 - 16, Kyoto , Japan

Water Resource Vulnerability & Adaptation Management to Climate Change & Human Activity in North China

XIA Jun

President of IWRA

Directors & Leading Professor

Key Lab. of Water Cycle & Related Land Surface Processes,

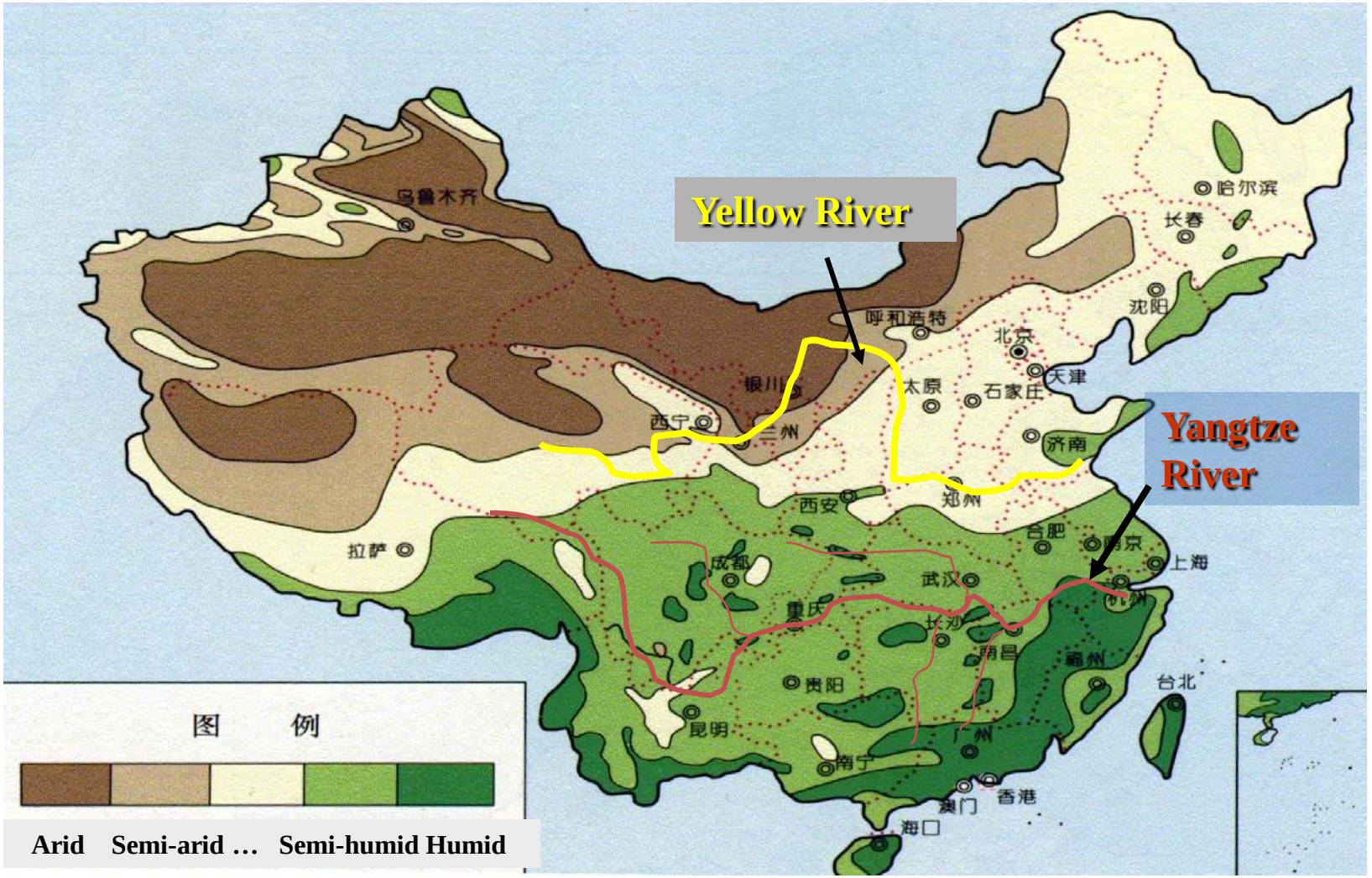
Center for Water Resources Research,

Chinese Academy of Science (CAS)

Outline

- ***Emergency water issues in China***
- ***Screening climate change impact***
- ***Research on vulnerability & adaptation***

1. China is such a country with a variety of climate & much stress from its *population & economic development*

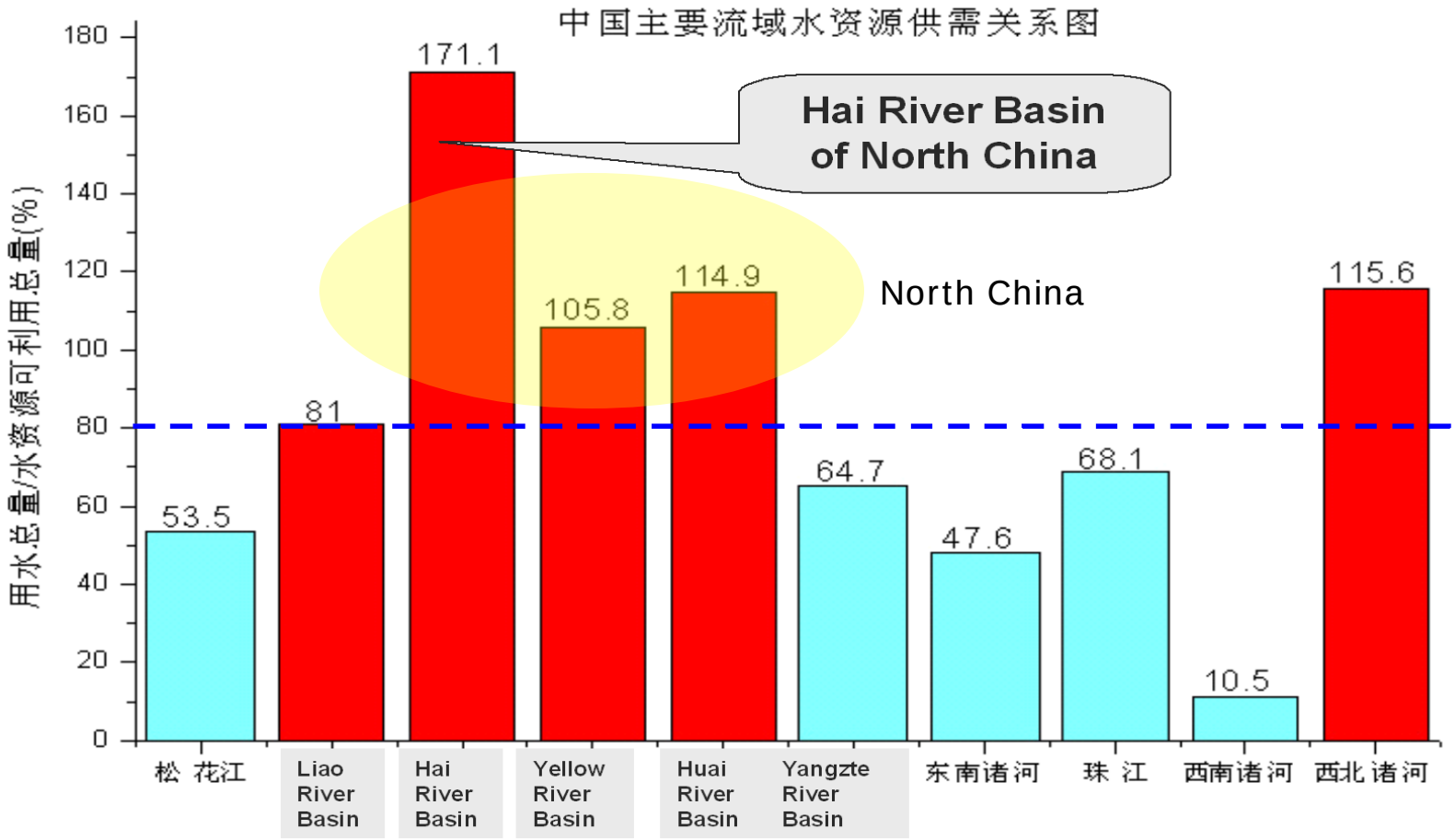


Water problem

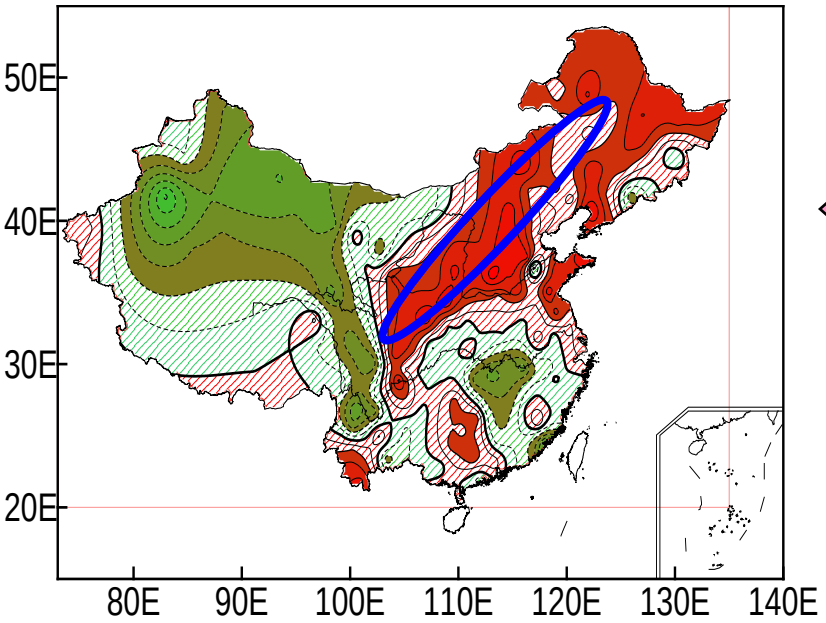
is well known in the world

Water scarcity in China

Total water use / usable water resources in China

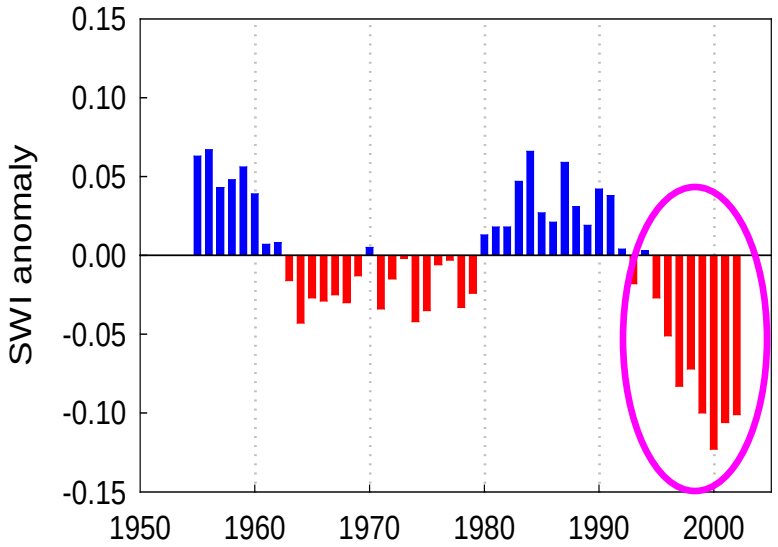


The Trend of Extreme Drought Frequency in China from 1951 to 2006



The red diagonal area is the increasing trend of extreme drought, the green diagonal area means a decreasing trend of extreme drought. (Left Figure)

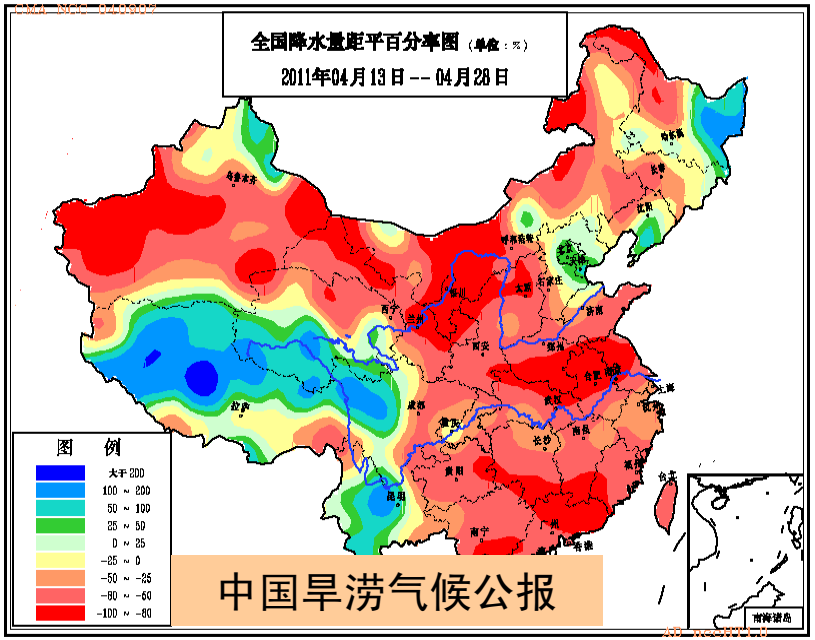
Trend of surface Wet index Variation in Northeast China (Right Figure)



An increasing trend is detected in northeast China.

Ma Zhuguo, 2006

2011's Extremely Droughts during spring in southern China, late flood dizaster



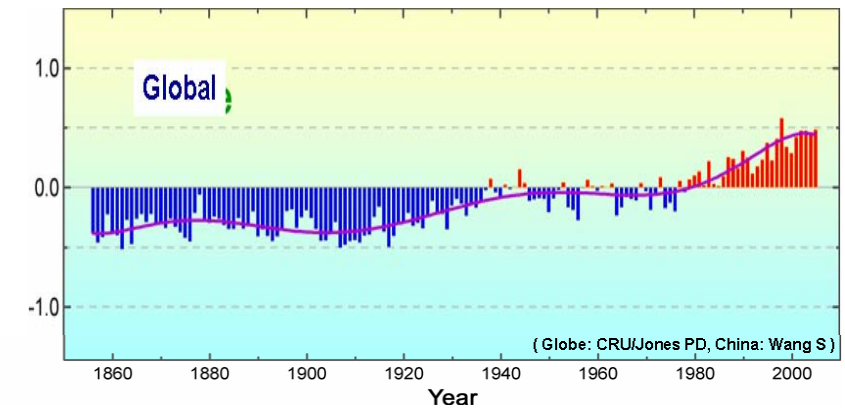
Precipitation change on April in China

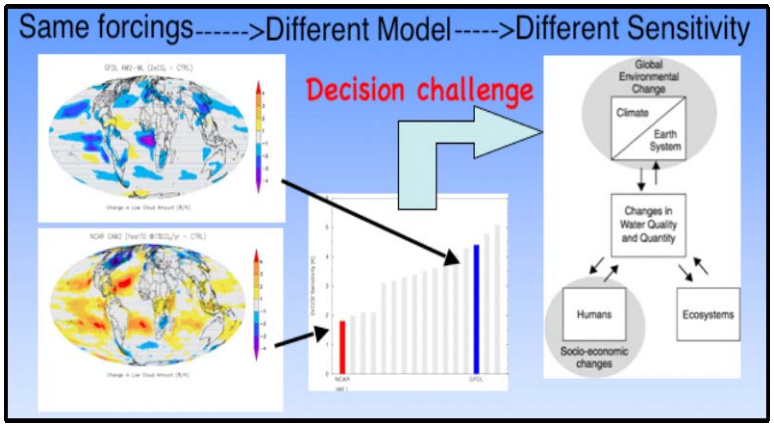
Only for *flood disaster* until July, directly economic loss reaches ***43.2 Billion RMB***,

Impacted ***27 provinces*** and regions and ***36.7 Million population***, ***239 victim ...***

There are multiple impact & challenges

(1).Climate change impact





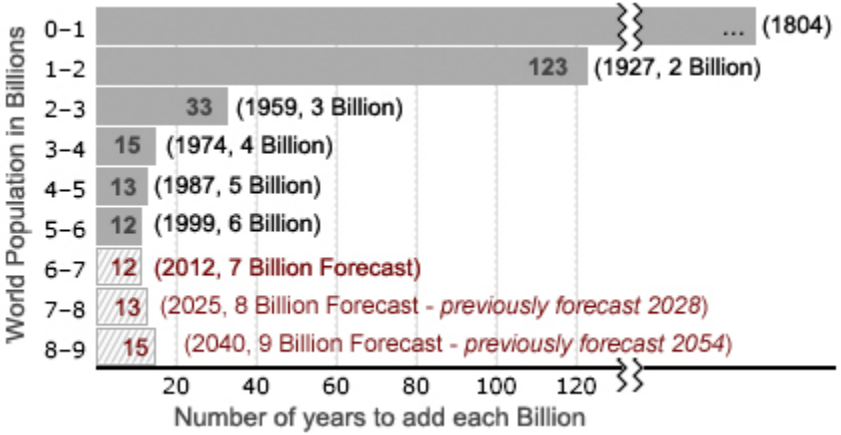
It is quite possible to

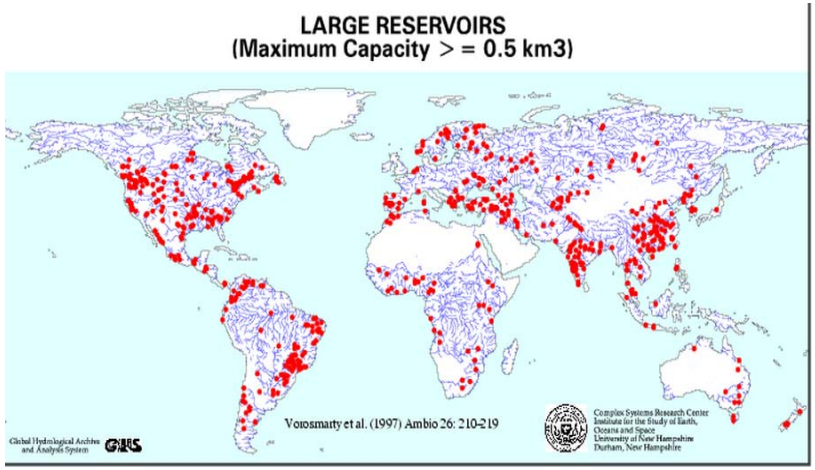
- **change water's time-space distribution**
- **increase risks on floods & droughts in water stress regions**

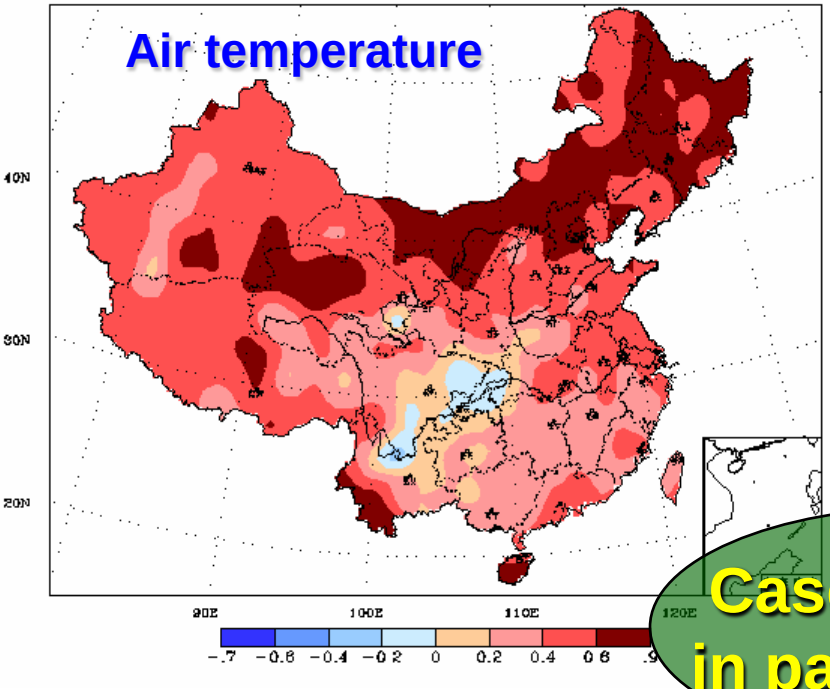
IPCC AR4 (2009)

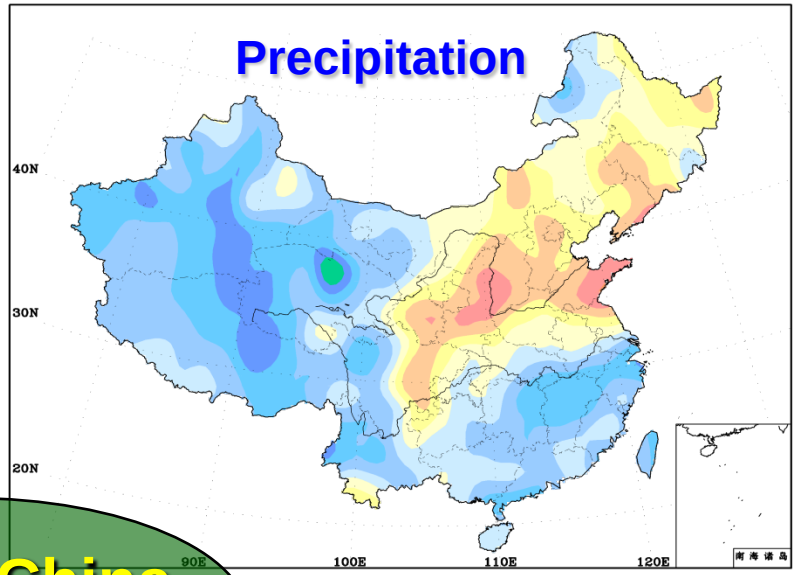
(2). Human activities impact

- **Remarkable LUCC due to rapidly urbanization, agricultural & energy developments**
- Impacts of Large Scale Land Use Patterns and Demographic Changes

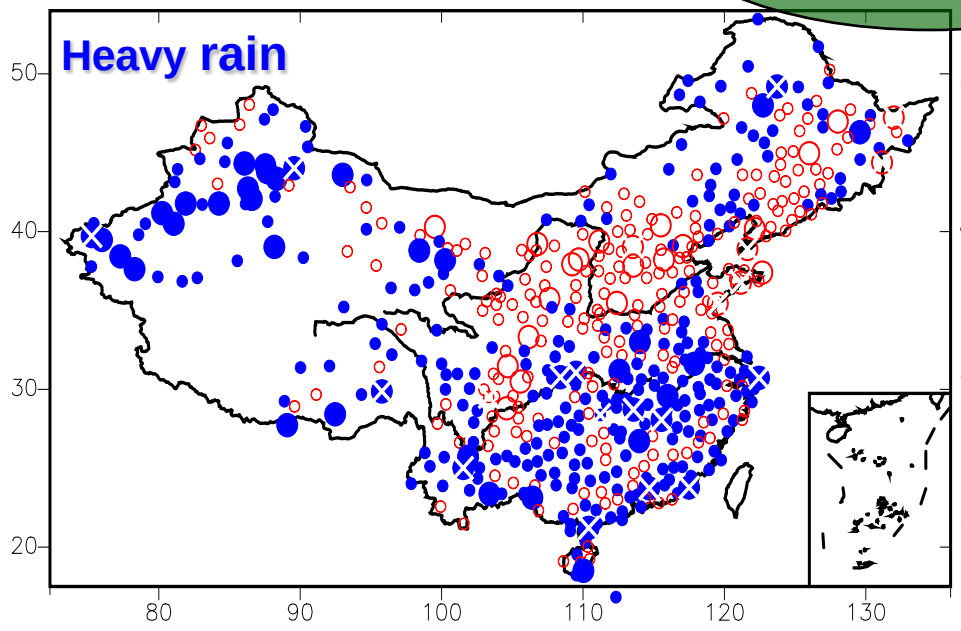


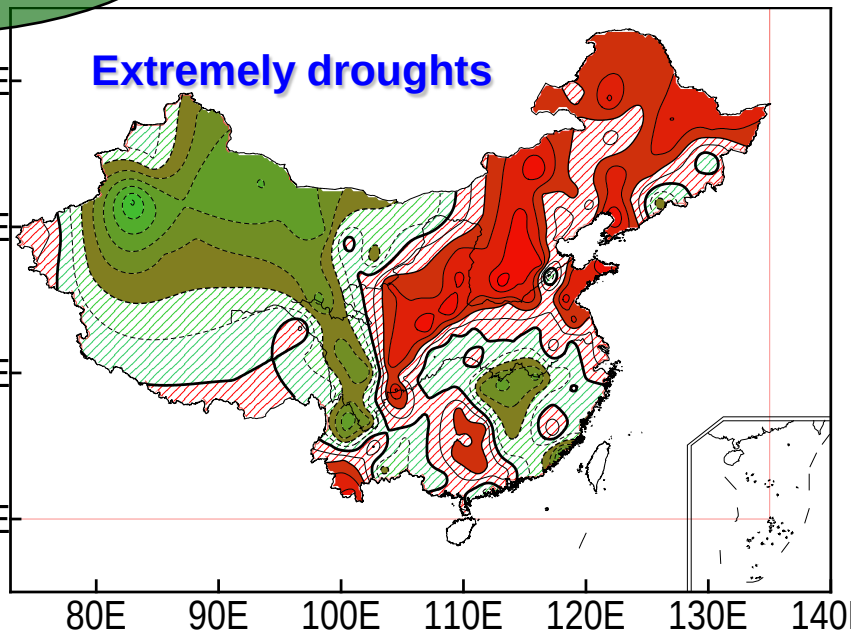






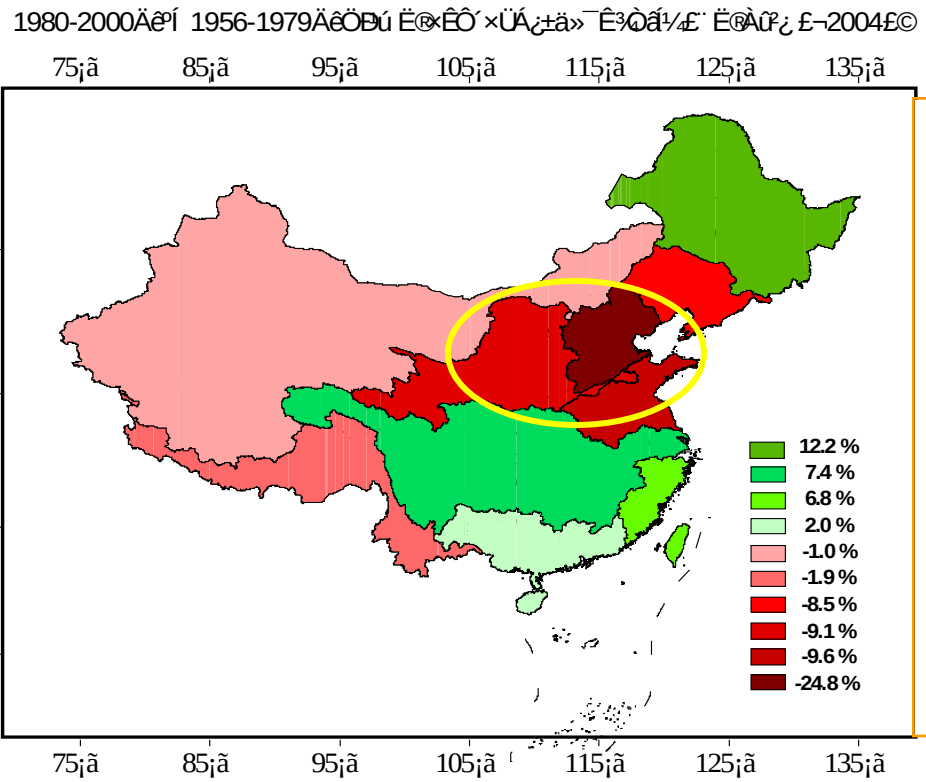
Case of China in past 50 years

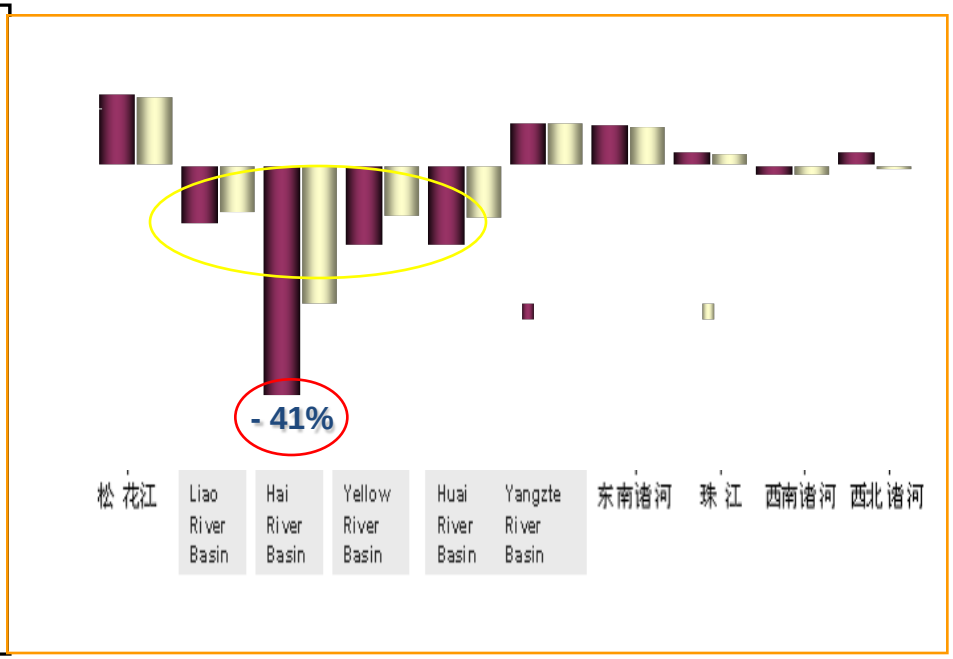




Ren Guoyu2006

Runoff change by two period comparison (1980-2000 with 1956-1979) in China

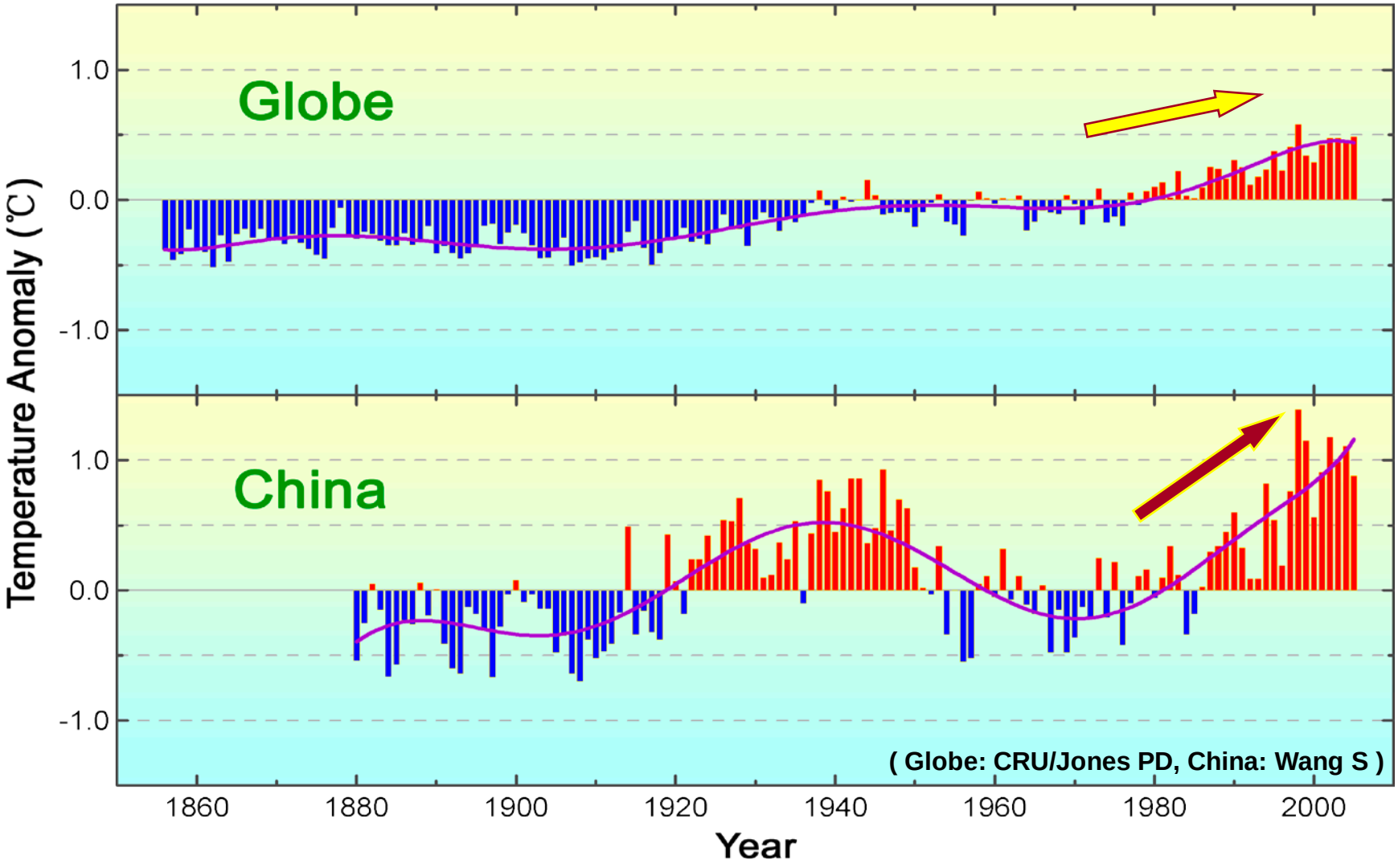




中国水资源总量变化（1980-2000年与1956-1979年的比较，水利部 2004）

中国地表水资源量变化（1980-2000年与1956-1979年的比较，水利部 2004）

There are still arguments on climate natural variation and due to global warming



Questions *related impact of climate change & LUCC to water sector*

- *How to screening climate changes impact to water sector? How to quantify water resource vulnerability related to impact of climate change and Human activity ?*

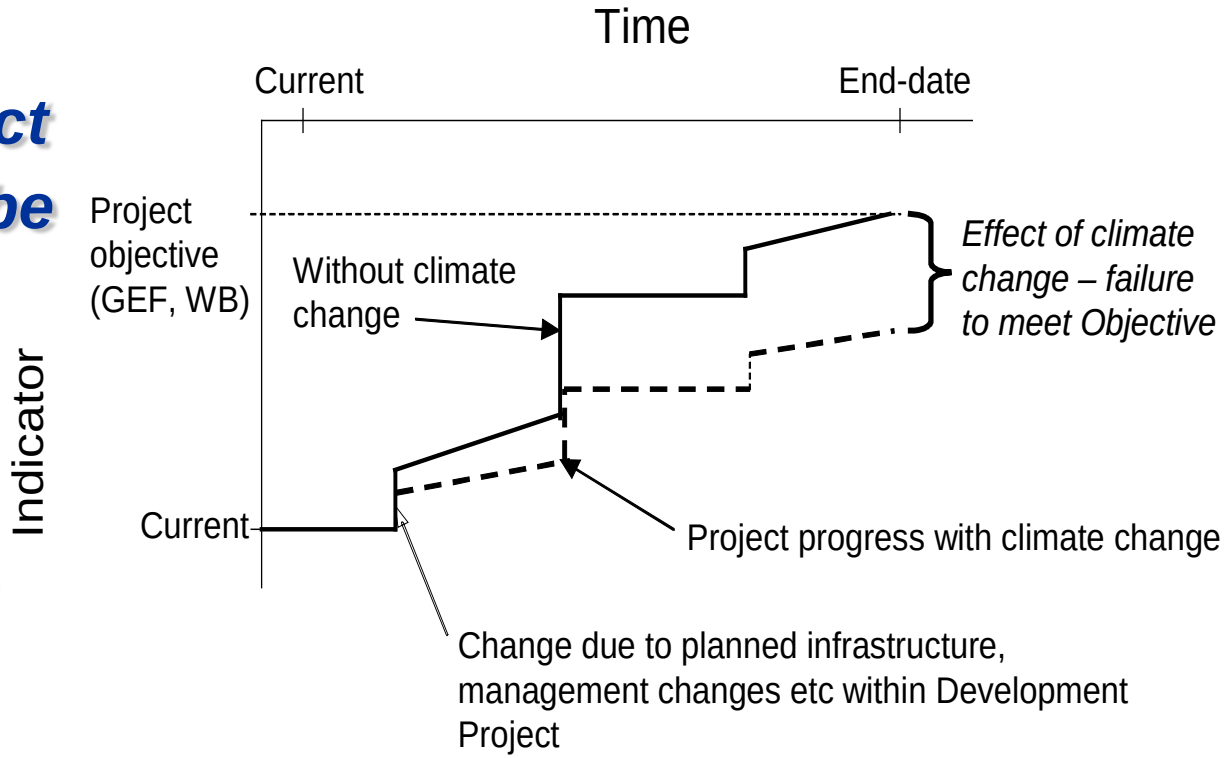
- *How to take adaptation & wisely manage water to changing environment on existing water projects and new water programme & water policy in China?*

Screening climate change impact & water vulnerability

What is climate screening?

- ***It is a process to assess how project objectives might be affected by future climate-related impacts, and***

- ***identify options to manage impacts and exploit opportunities.***



Such jobs are processed by cooperation between China & UK ,2008 & CAS & MOST since 2009.

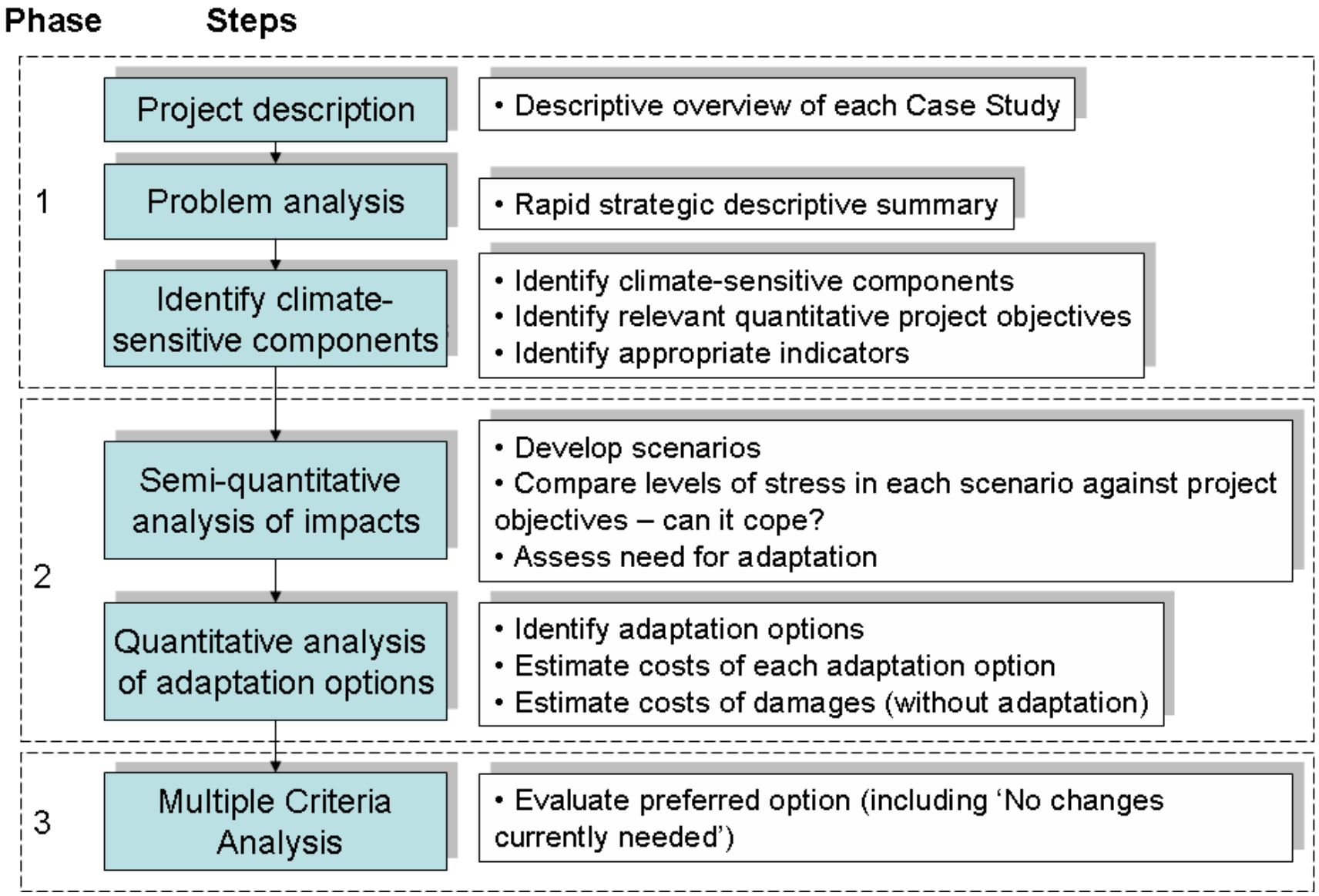
A Screening Process for Climate Impacts

- ***Key questions for the process***
  - *What is impact of climate change on the project?*
  - *Options for how to manage the impacts?*
  - *Whether to manage the impacts?*

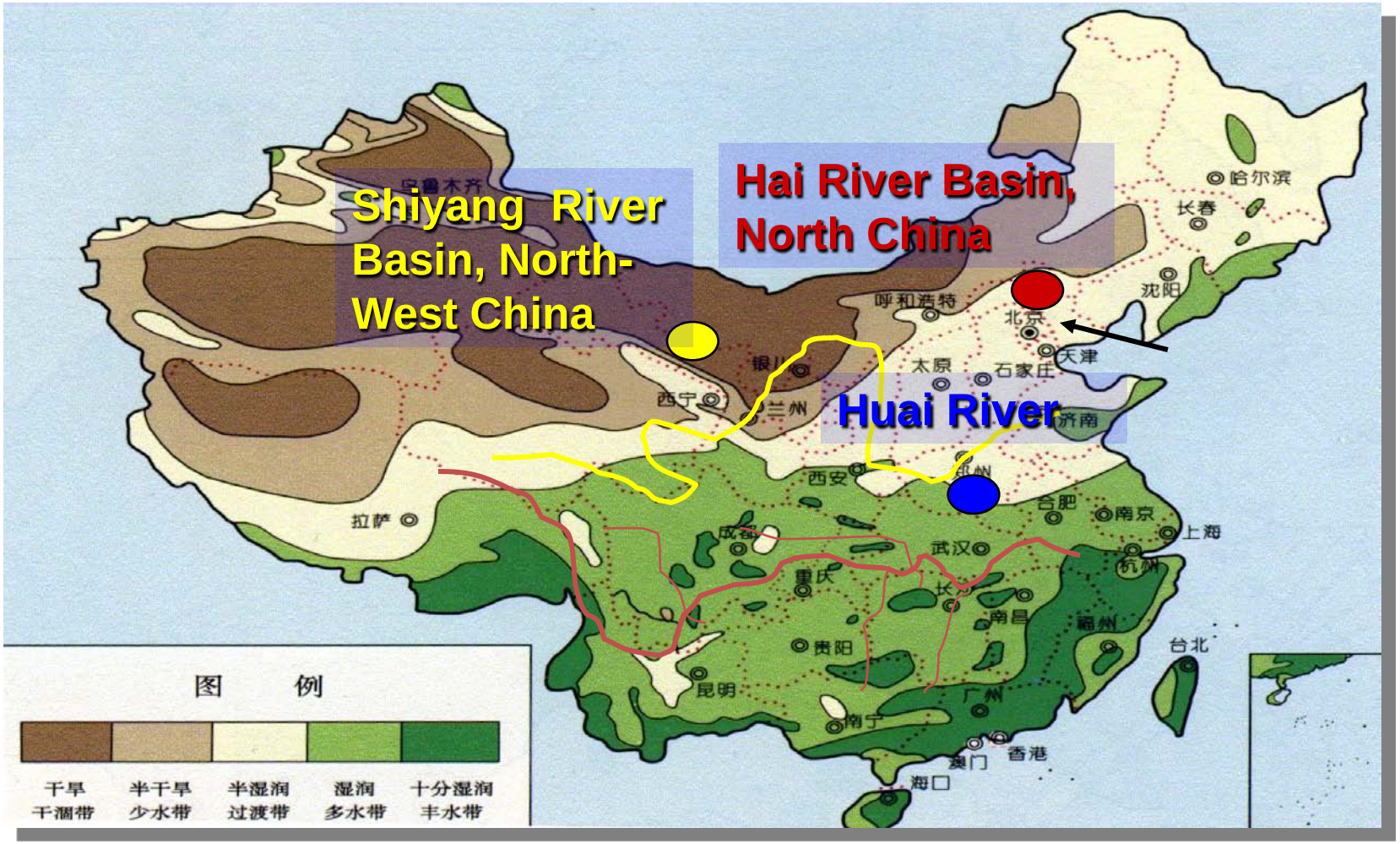
- ***Economic analysis compares costs & benefits of options***

- ***Decision on options for managing impacts is aided by a multi criteria analysis***
  - *Recognises factors other than economic cost are important in decision making*

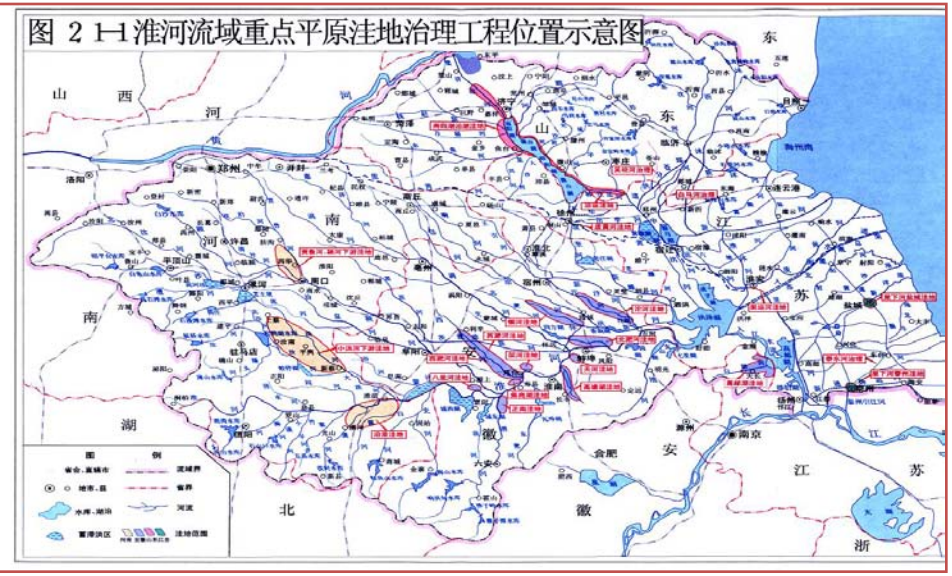
Framework of screening climate change impact



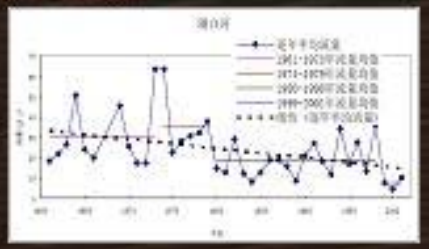
Four case studies in were selected in China for screening climate change impact to water sector



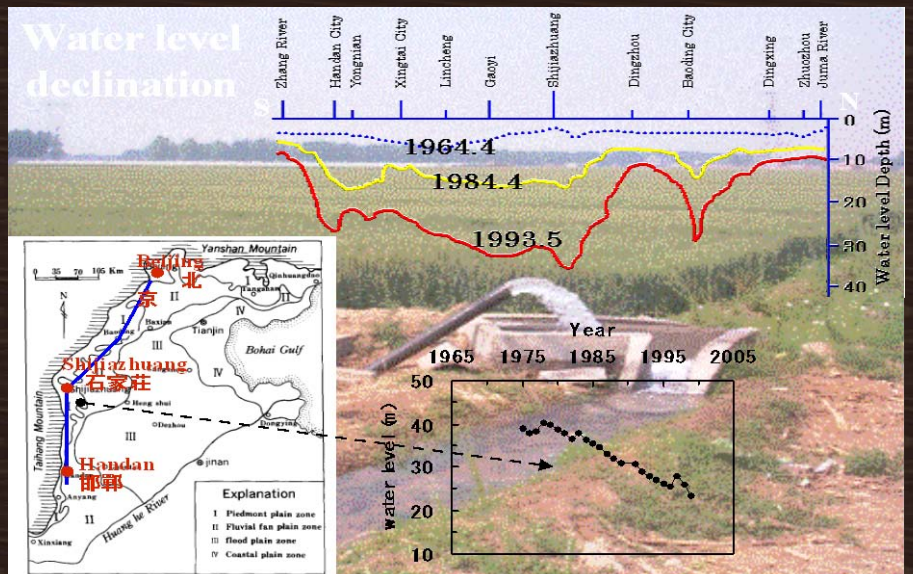
Floods in Huai River Basin



Urban Water Supply of Miyun Reservoir

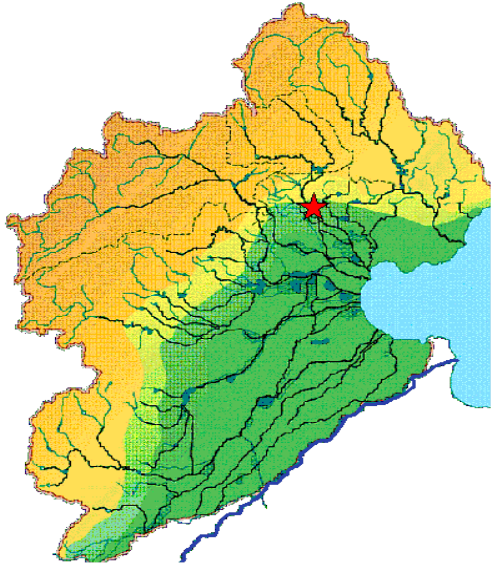


Water use in agriculture and ground water change in North China.



Integrated Water Management for Shiyang River Basin in West China

The Case in Hai River Basin



Basin area: 320,000 km^2

Center for policy, culture & economic in North China

Indexes	Beginning of 1950s		Present
Population	55 Million	→	126 Million
Urbanization	16%	→	30%
GDP	30 Billion	→	100 Billion
Water resources per capita	750m^3	→	276 m^3

Drying-up of Rivers

40% of the total rivers was changed to be seasonal rivers

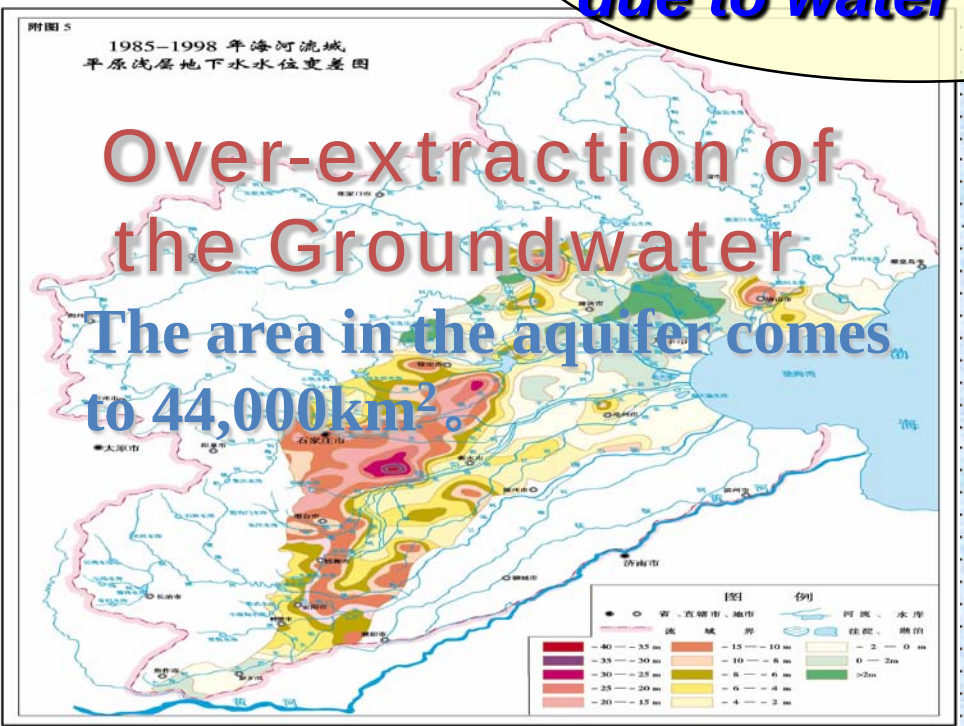
Wetland degradation

the rate reaches 90%

Eco-environment degradation in Hai River due to water shortage

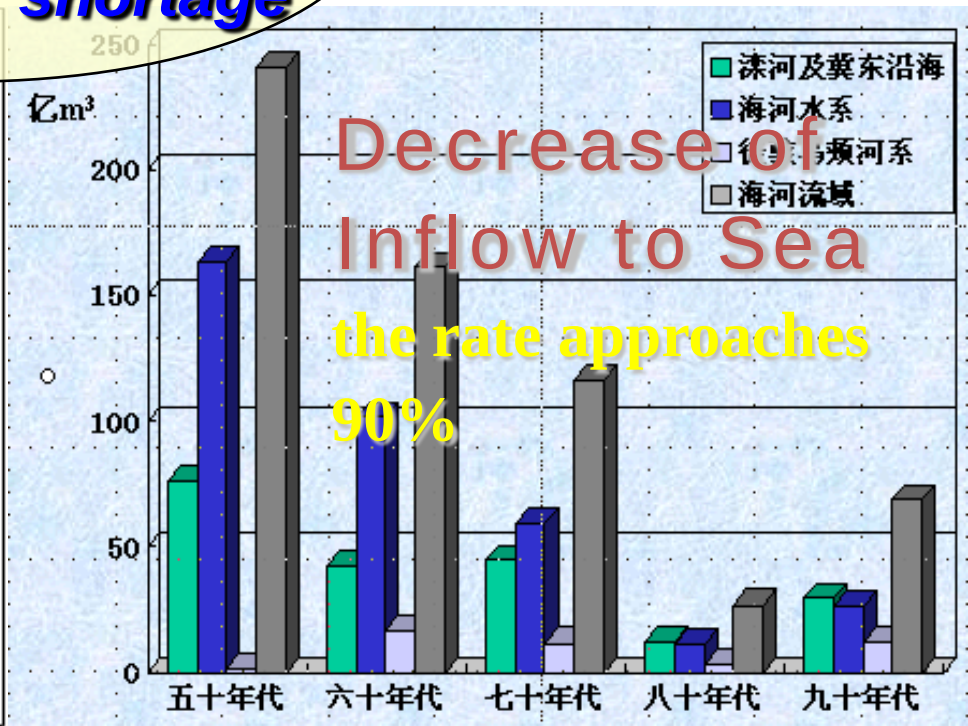
Over-extraction of the Groundwater

The area in the aquifer comes to 44,000km^2。



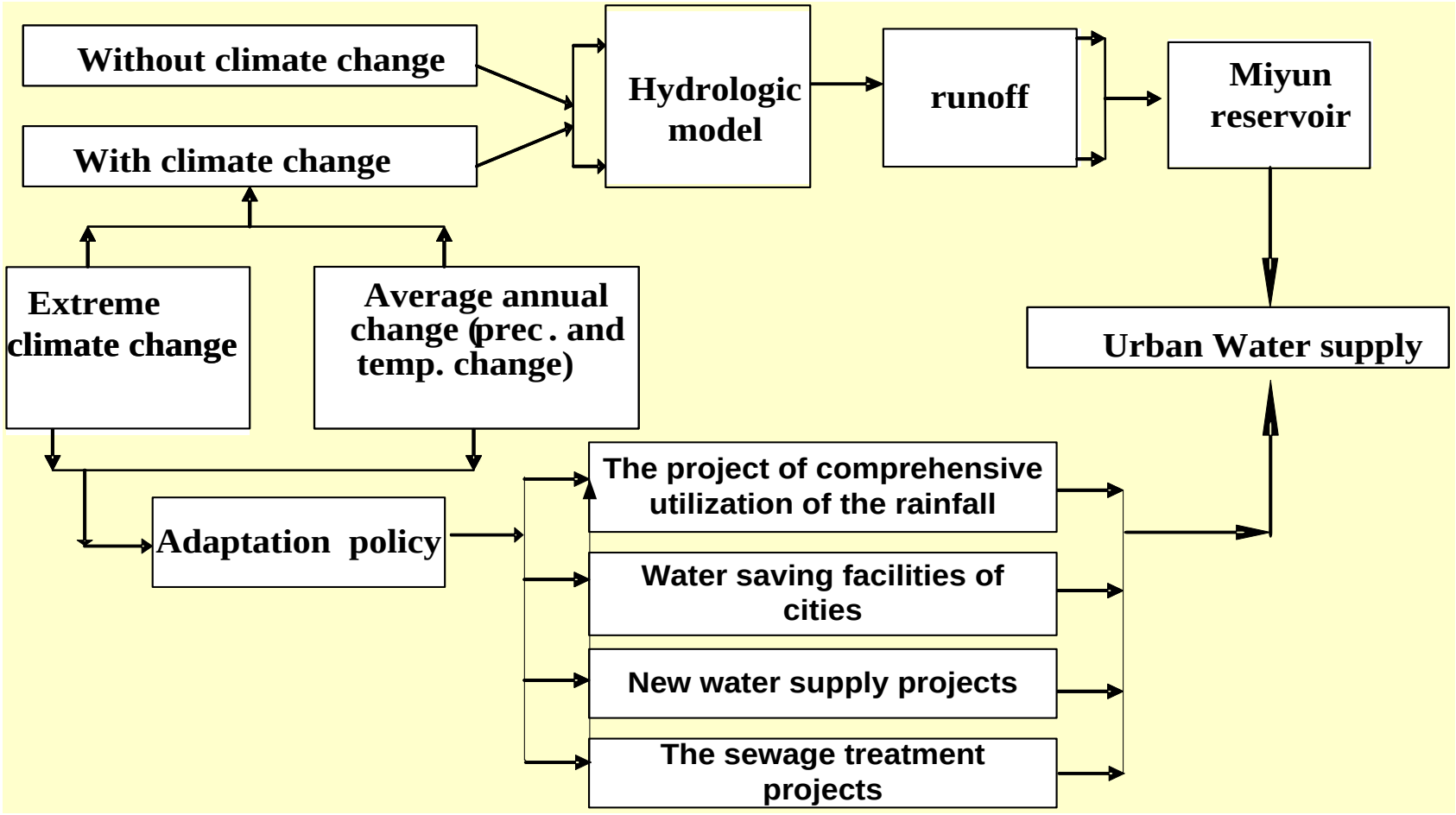
Decrease of Inflow to Sea

the rate approaches 90%



Semi quantitative and quantitative analysis

applied to Case study in Miyun Reservoir Basin, Beijing Capital



Index System

- Index System 指标体系
  - 1. Climate change
    - 1) rainfall variation
    - 2) air temperature variation
    - 3) humidity variation
    - 4) climate extreme event
    - 5) ……
  - 2. Hydrology change
    - 1) runoff
    - 2) evaporation
    - 3) soil moisture
    - 4) underground water
    - 5) extreme hydrologic events
    - 6) ……
  - 3. Influence of the reservoirs
    - 1) reservoirs inflow
    - 2) reservoirs operation
    - 3) the effective capacity of reservoirs
    - 4) ……

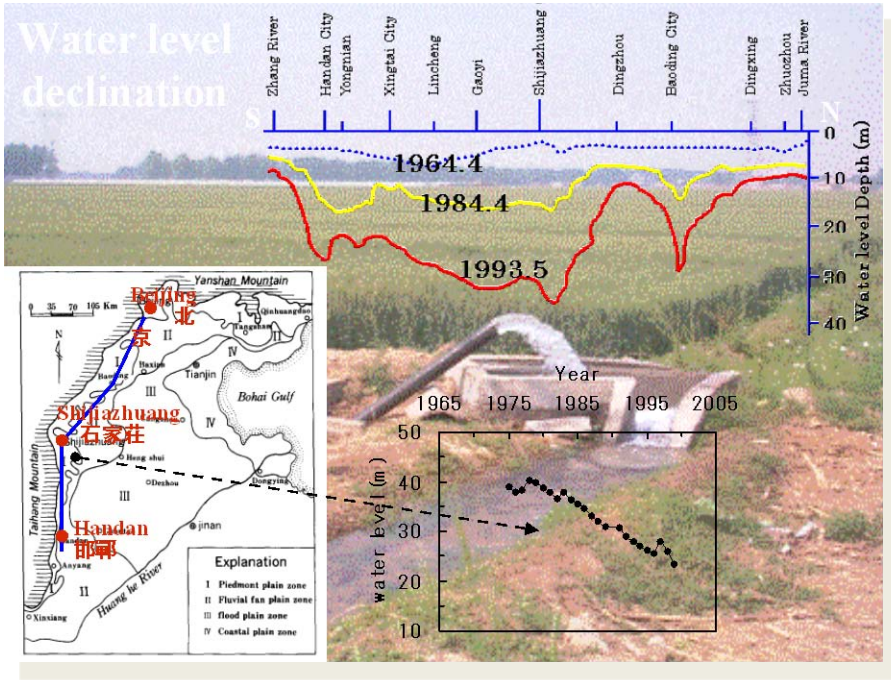
- ***Climate change***
- ***Hydrological change***
- ***Influence of reservoir operation***

- ***Urban water demand***
- ***Urban water supply***
- ***Economic analysis***
- ***Adaptaions***

- Index System 指标体系
  - 4. Effect of urban water supply
    - 1) water-supply guaranteed rate
    - 2) water volume can be transferred to other locations
    - 3) annual water supple amount
    - 4) ……
  - 5. Effect on economy
    - 1) water-transferring cost
    - 2) water-saving cost
    - 3) ……

Vision I : Human activity is a major reason of water stress, such as over exploitation to limited water resource.

- ***Water use in agricultural irrigation is almost 70% of total water use amount.***
- ***Over use of ground water is also one of major causes to reduce ground water resource.***

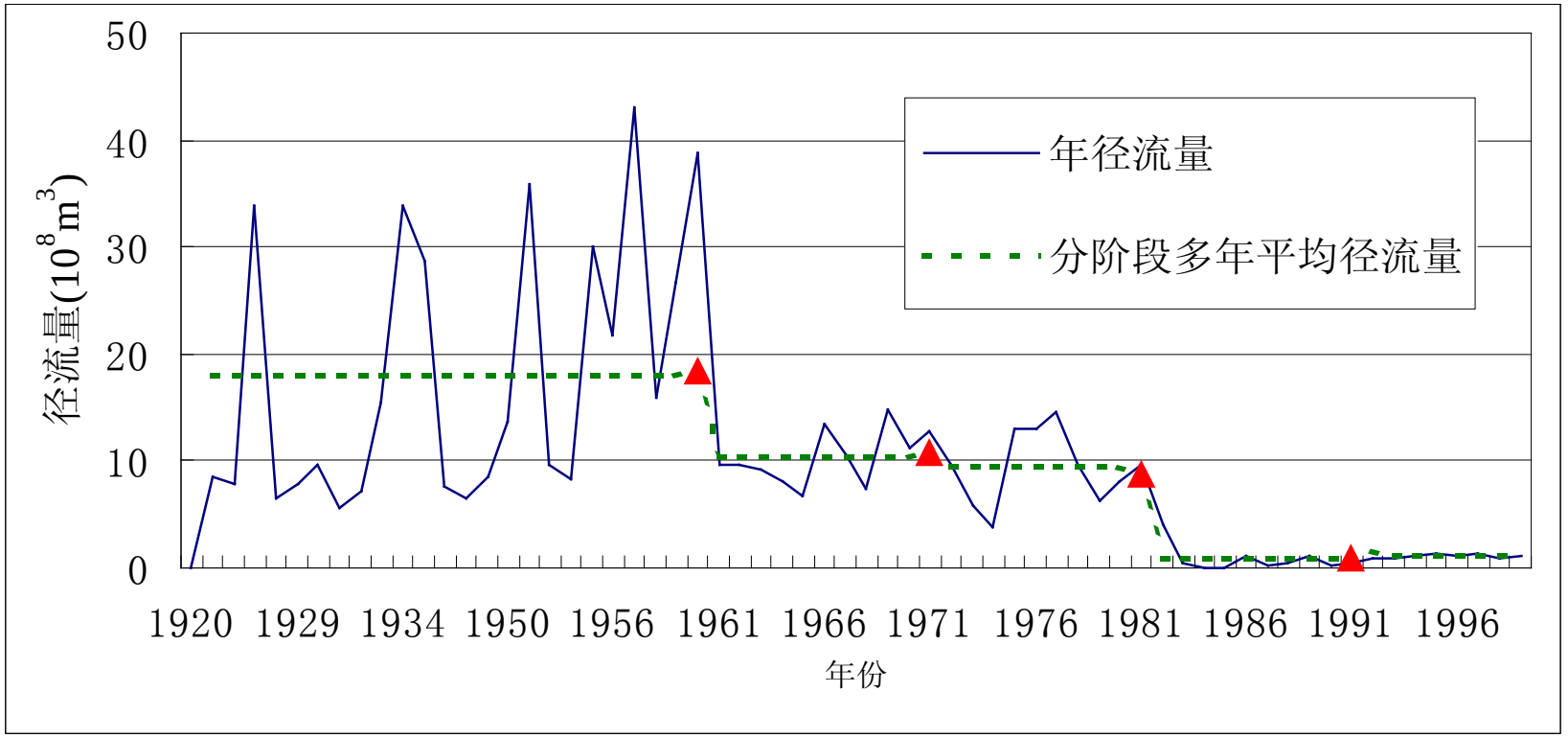


Urban development & over use of ground water

- **Big depth of ground water concerted in urban area due to continue water using behavior in the cities**

Building water projects, such as reservoirs, water conservation projects, is also reason to result in flow decease / drying up in middle & downstream of river system.

An example of annually runoff decline in the Chaobai River observed at a downstream station, Beijing

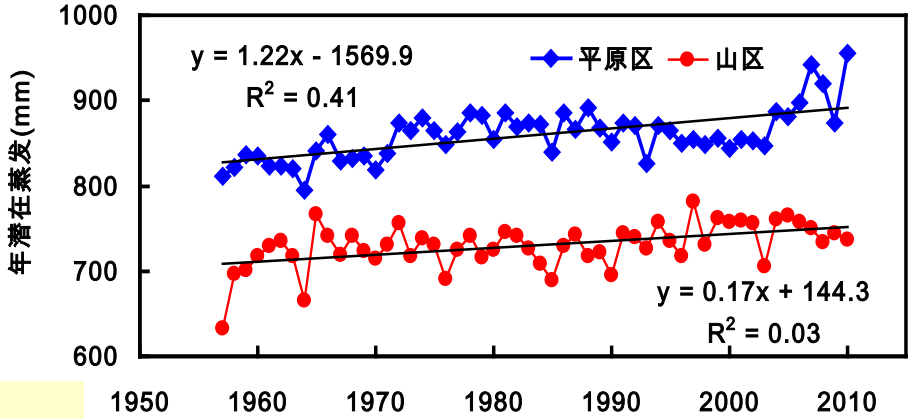


潮白河径流演化的阶段性

Fig.2 Five Periods of Annual Runoff in Chaobaihe River

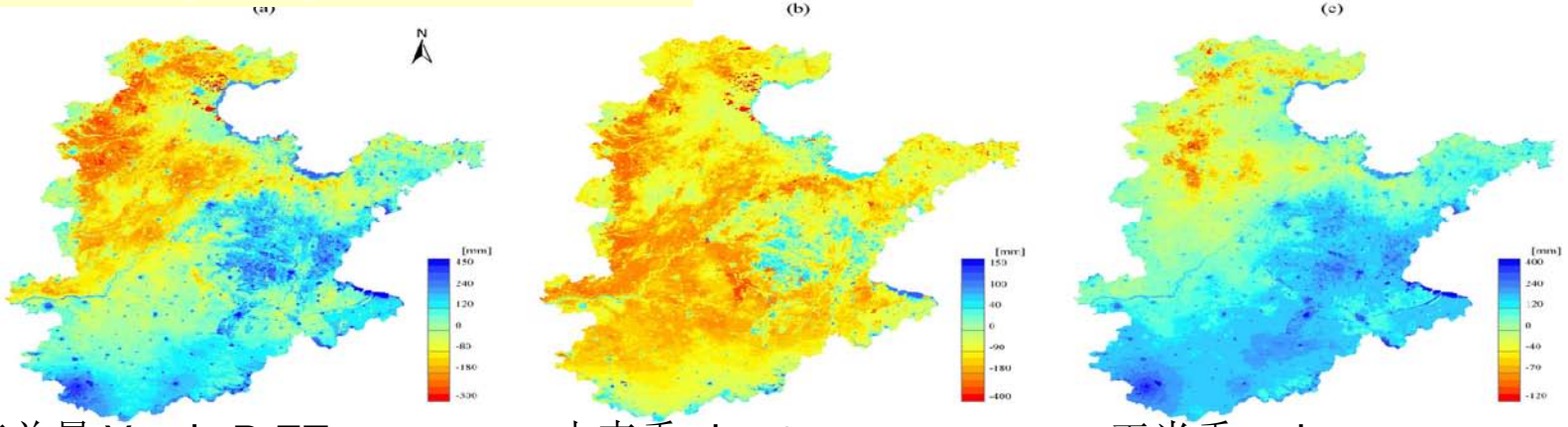
Vision II: Climate change has still an impact to regional hydrological process

1. Air Temperature increase result in ET change



华北ET_P变化趋势

2. The analysis of profit and loss, P-ET, in agriculture shows crop water shortage in recently 10 years：

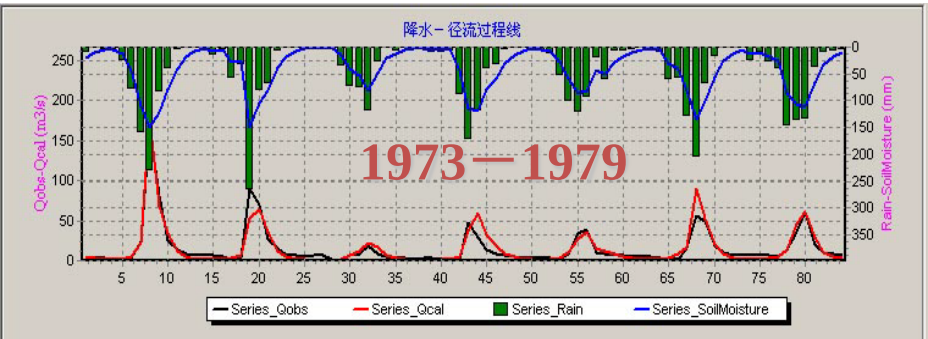


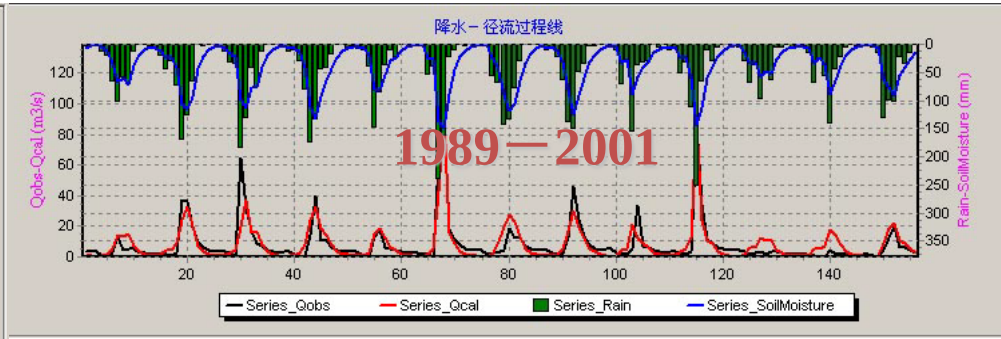
年总量 Yearly P-ET　　小麦季wheat　　玉米季maize

Case study on Climate change contribution in Chao Bai River, Hai River Basin

Comparison of runoff change in 1970s with 1990s

			Climate change	Human activity		
		DataC70 ParaC70	DataC90 ParaC70	DataC70 ParaC90	DataC90 ParaC90	变化/余额
Yearly precipitation (mm)		526.27	→	→	521.74	-0.86%
Yearly runoff (mm)	实测	79.57			52.81	-33.63%
	模拟	79.51	72.88	60.02	52.81	
Modeling change mm)			-6.63	-19.49	-26.70	-0.58
Contribution (%) (贡献率%)			-24.82	-73.01	-100	-2.17
影响			Runoff decline	Runoff decline		





Recently, MOST- China, supported a National Basic Research Project (973) on Climate Change Impact to Water Cycle & Water Security in China, *2010-2014, lead by J.Xia*


Research Area: 8 Major river basins that cover 95% population in China
Songhua River
东
Hai River
部
Huai River
季
Yellow River
风
Yangtze River
区
Zhu River
项目研究区：与季风区联系的流域系统
图 例
1 黑龙江流域
2 辽河流域
3 滦河流域
4 海河流域
5 黄河流域
6 淮河流域
7 长江流域
8 东南沿海诸河流域
9 珠江流域
10 沅江-红河流域
11 澜沧江-湄公河流域
12 怒江-萨尔温江流域
13 伊洛瓦底江流域
14 恒河流域
15 内流区
其他流域
主要流域界
内外流区域界
1：25000000

MAJOR RESERACH

- **Detection & Attribution** of non-stationary hydrological processes for past 50-100 years
- Reduced **uncertainty of future different climate-hydrological scenarios** (GCMS) & downscaling

- **Coupling Land hydrological process models with Regional climate models**

- Impact of climate change on **Drought & water security related to food security & eco-system** in North China
- Impact of climate change on **floods control security** related to South China (Huai River/Zhu River etc,.)

- **Water resources vulnerability & adaptation management**

Research shown

1. ***Climate change impact*** ***is a big issue to water sustainable use in China due to*** *existing or planning water projects and programming do not fully consider potential impact on climate change* ***, particular on possibility of increasing extremely events (floods & droughts) .***

It is possible to increase probability of the most disbennifit for both low water in N & S for the WDPSN could be 2.6-8.2%

2. *Basic research* & *adaptive management* should be *emphasized* due to much water stress & uncertainty related to climate change:

- *How to change in the past ?*
- *How to change in the future, particular to coming 20-50 years ?*
- *What's the mechanism for such changes ?*
- *How to adapt climate change & wisely manage water ?*

3. Water vulnerability & improving Water Governance to changing environment will be priority issues for adaptive management.

Water Resource Vulnerability

- It could be linkaged with water stress indicator (resilience) , C(t) & sensibility, S.

- New study:

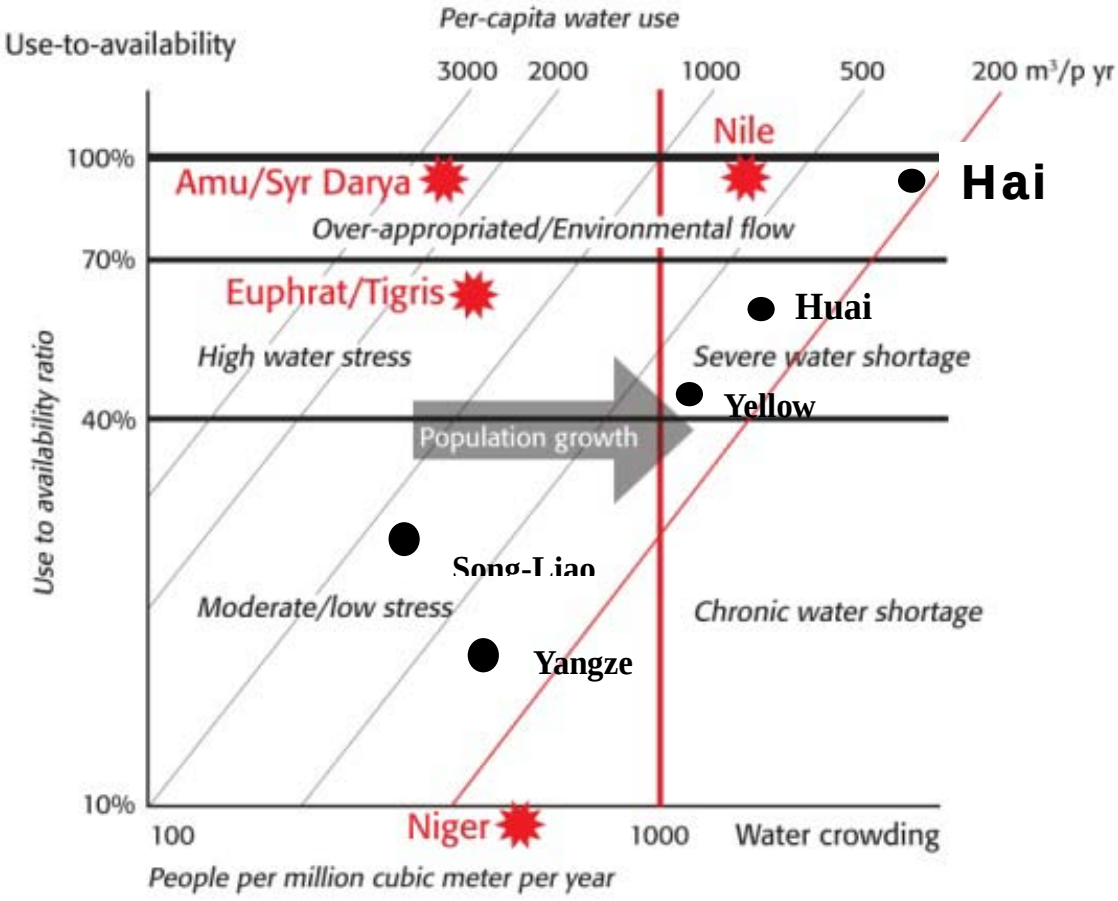
$$V(t) = \frac{S}{C(t)}$$

$$C(t) = f_1(r) \cdot f_2(1/(\frac{P}{Q} \cdot \frac{W_D}{P}))$$

r – Use to availability ratio (%)
P/Q - water crowding (p / Million m^3/ yr)
W_D/P - per capita water use (m^3/p yr)

Malin Falkenmark & *Molden (2008)* developed these indicators to show demand-driven water stress and population-driven water shortage.

Late, *Malin Falkenmark & Jun Xia* developed case study in China to address Water Security in watershort basins (2010)



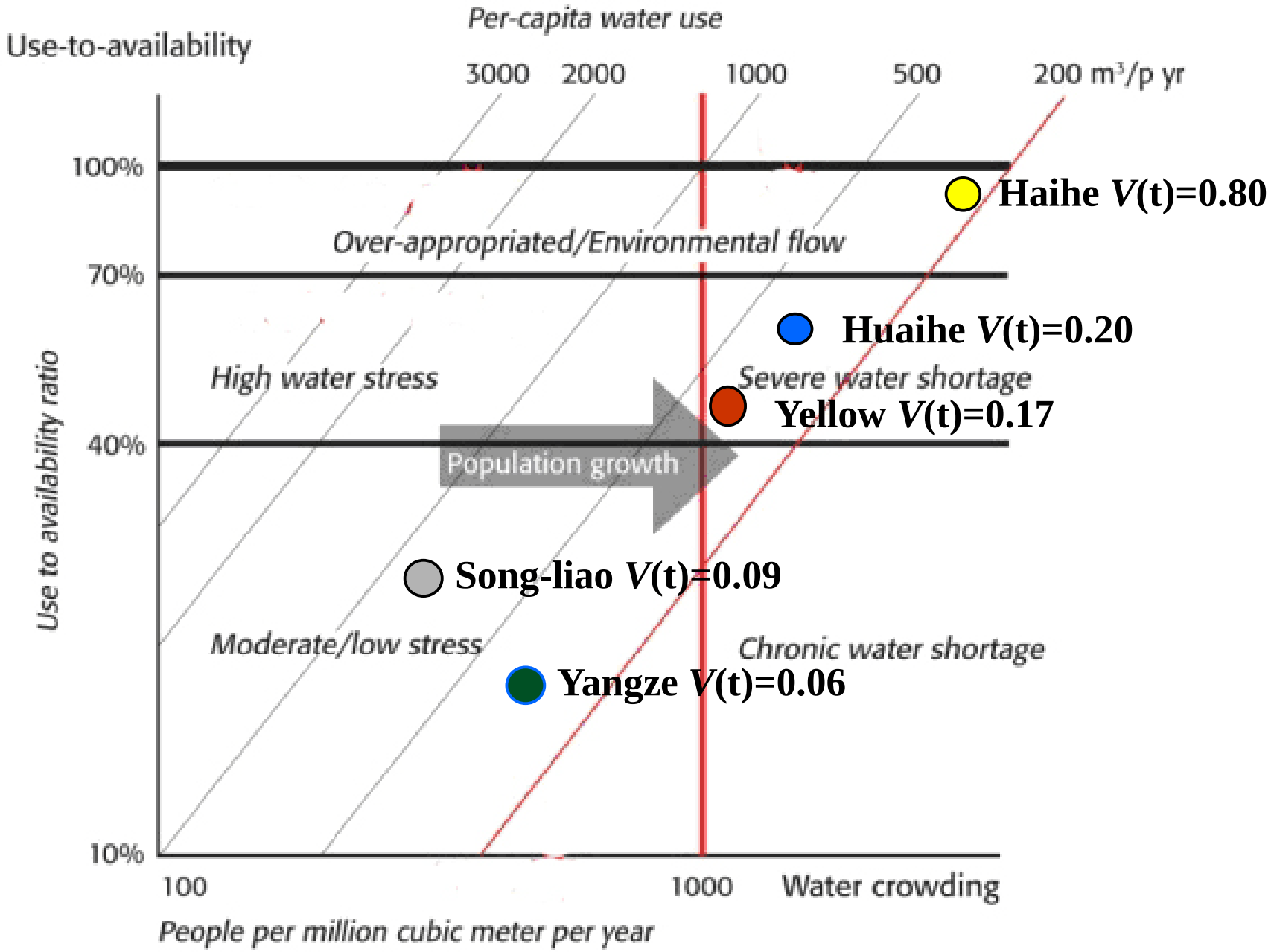
New study on quantifying **Water Resource Vulnerability**

$$C(t) = C\{r \cdot \frac{Q}{W_D}\} = \exp_1(-r \cdot k)\exp(-\frac{P}{Q} \cdot \frac{W_D}{P})$$

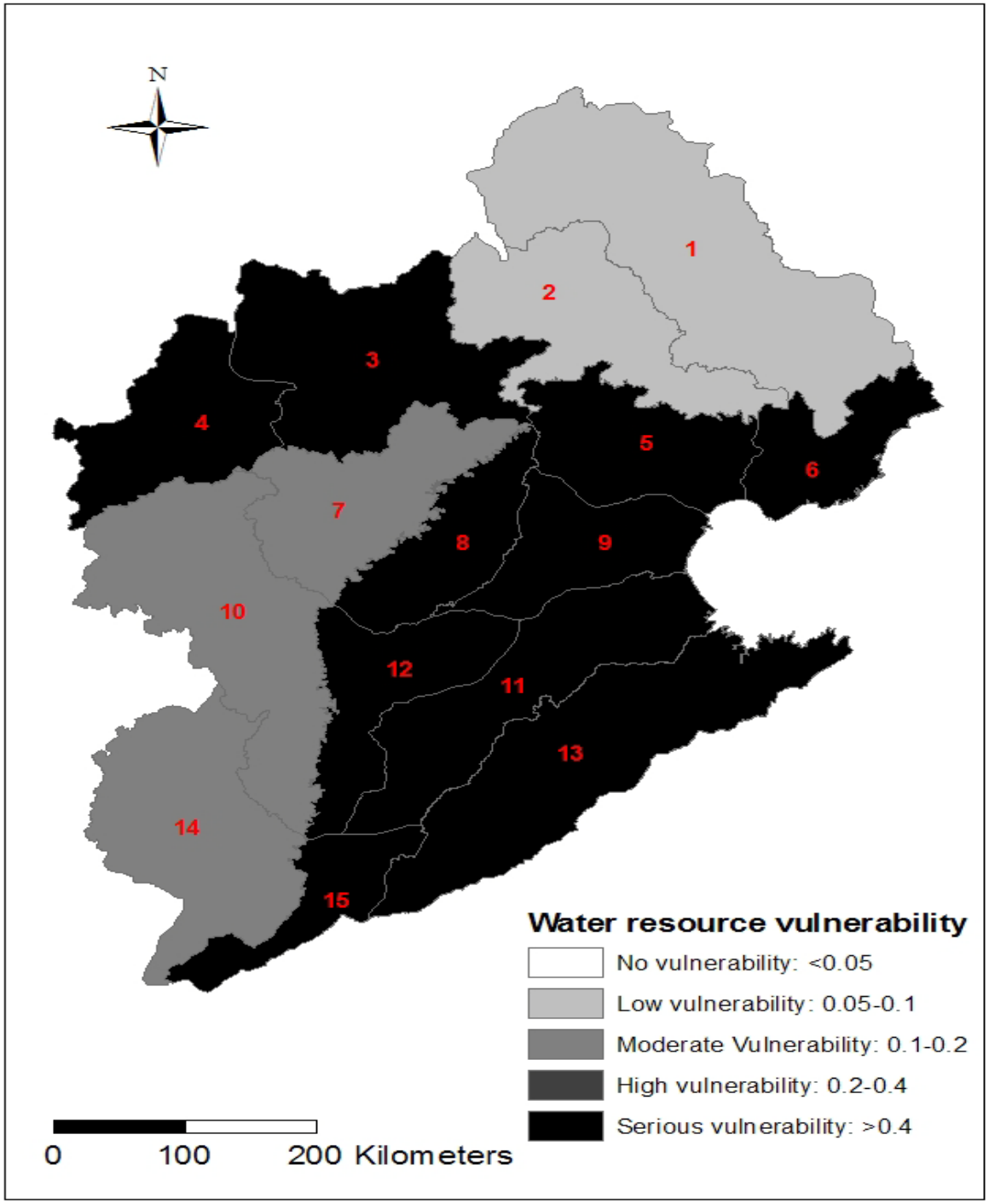
r – Use to availability ratio (%)
P/Q - water crowding (p / Million m3/ yr)
W_D/P - per capita water use (m3/p yr)

Categories of water resource vulnerability

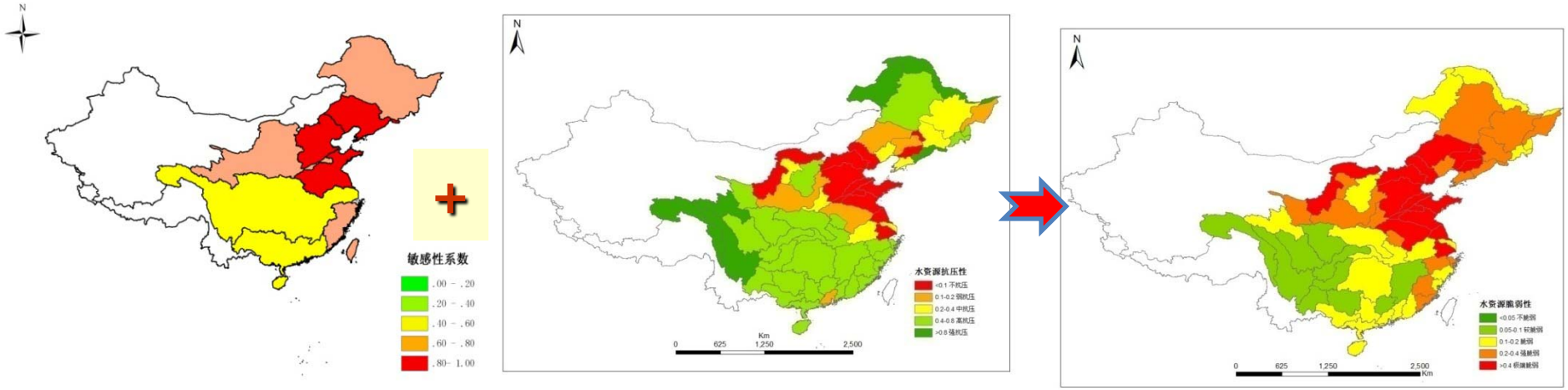
no vulnerability	low vulnerability	moderate vulnerability	high vulnerability	Serious vulnerability
<0.05	0.05-0.1	0.1-0.2	0.2-0.4	>0.4


Use-to-availability
Per-capita water use
3000
2000
1000
500
200 m³/p yr
100%
70%
40%
10%
Over-appropriated/Environmental flow
High water stress
Severe water shortage
Population growth
Moderate/low stress
Chronic water shortage
Use to availability ratio
Haihe V(t)=0.80
Huaihe V(t)=0.20
Yellow V(t)=0.17
Song-liao V(t)=0.09
Yangze V(t)=0.06
100
1000
Water crowding
People per million cubic meter per year

Water Resource Vulnerability in Hai River



New Study on mapping vulnerability

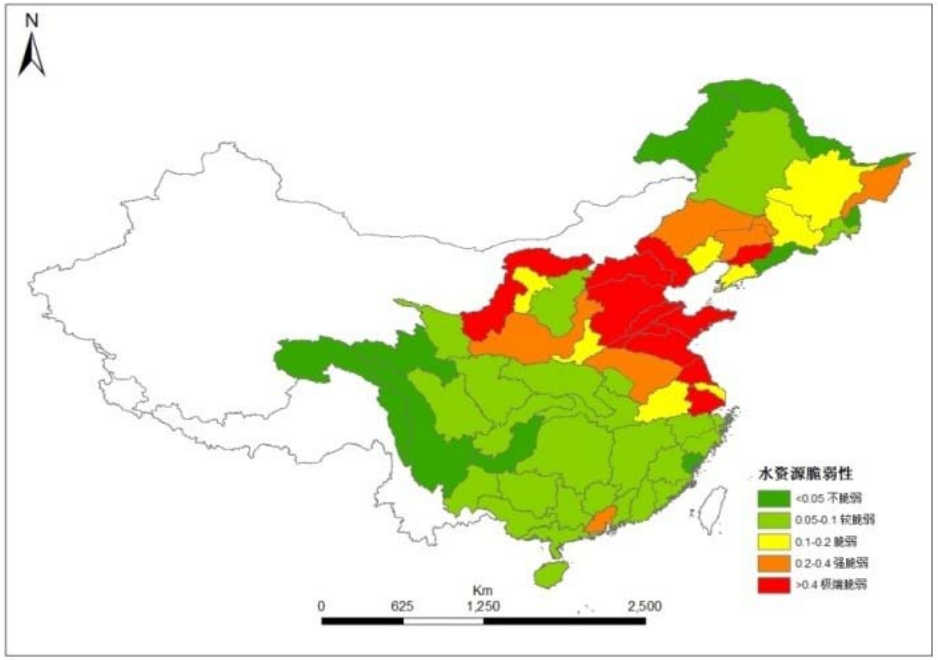


Sensibility S

water stress(resilience) C

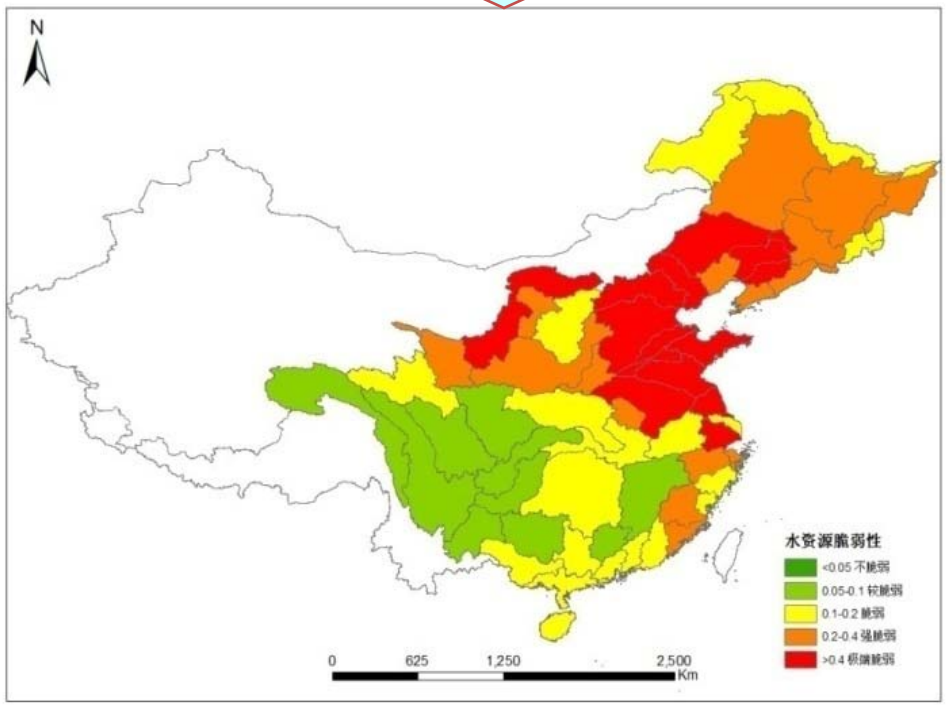
Integrated Vulnerability S/C

2000年代表年（1980-2000年序列）



Vulnerability S/C

Vulnerability 1/C without S



Water Resource Vulnerability to climate change in Hai River

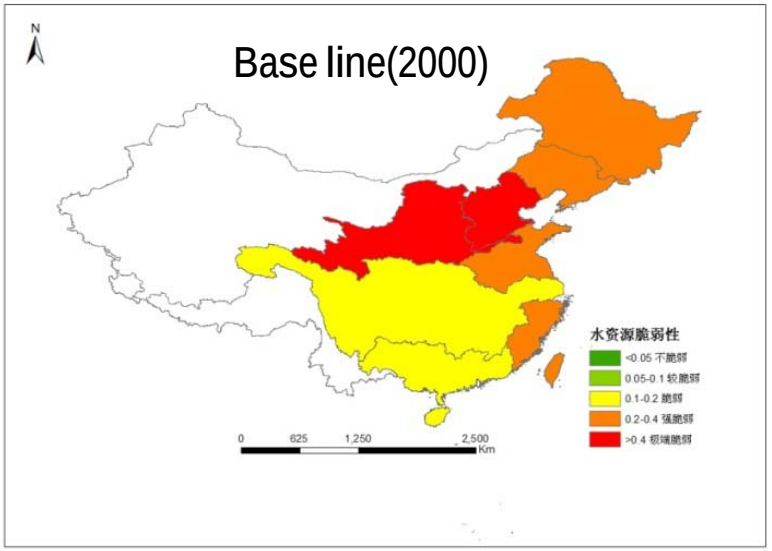
scenarios	△P/Q (人/10^6 m^3/y)	△W_D/P （m^3/p y）	△r (%)	△V(t)
Sc1	-337	0	-8.5	-0.18
Sc2	869	10	26	0.85
Sc3	452	10	15	0.57

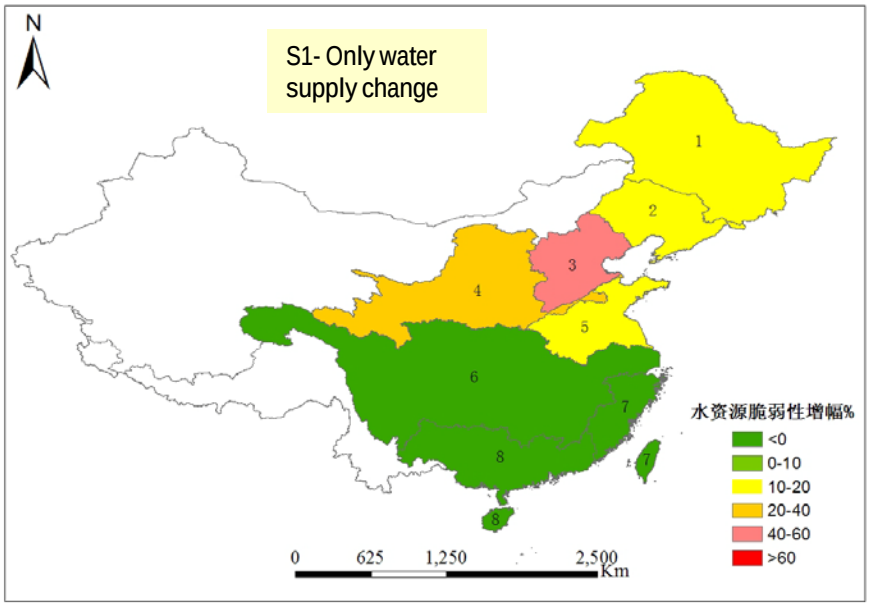
Sc1 – only available water resources change to global warming

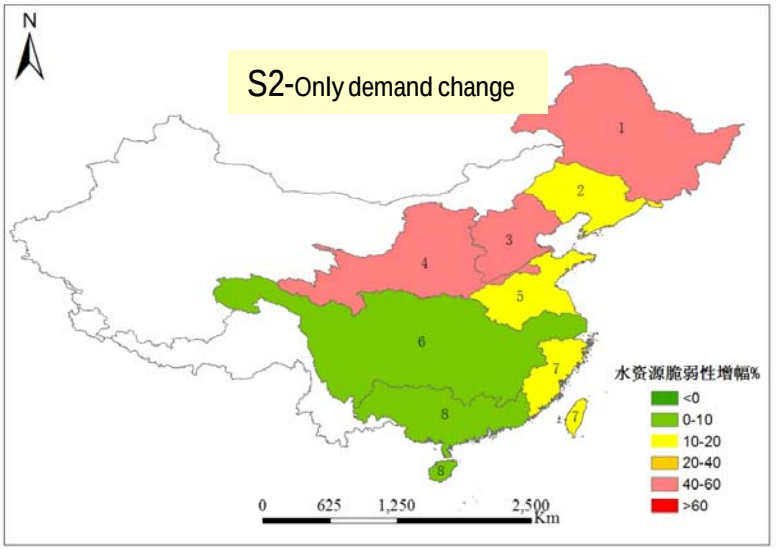
Sc2 – only water demand change

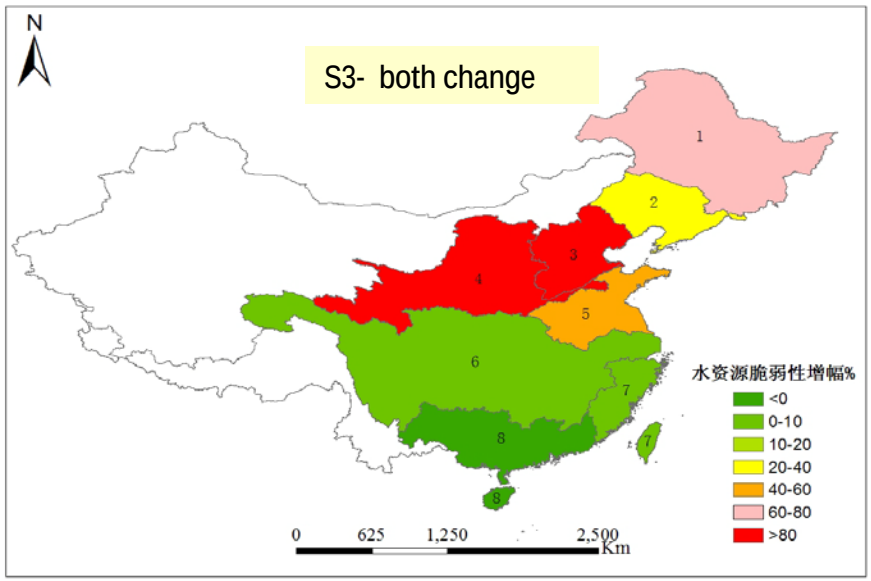
Sc3 – considering both change

Vulnerability change ΔV(t) to different scenarios



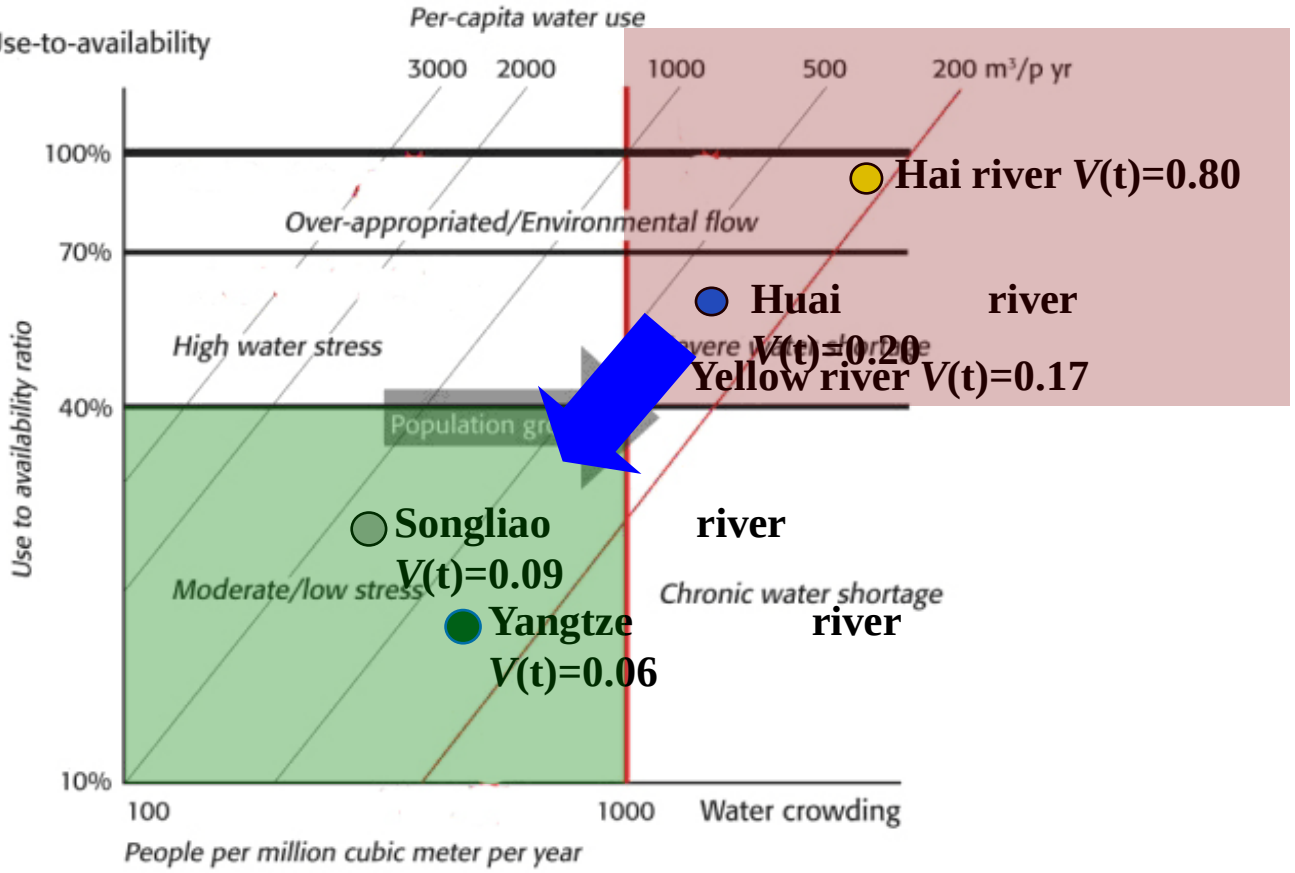






Adaption to climate change and both human activities：

Shifting from higher vulnerable into blue by adaptive management, particular good water governance, i.e. changing the rate of water developing & using water crowding & per capita water use etc.

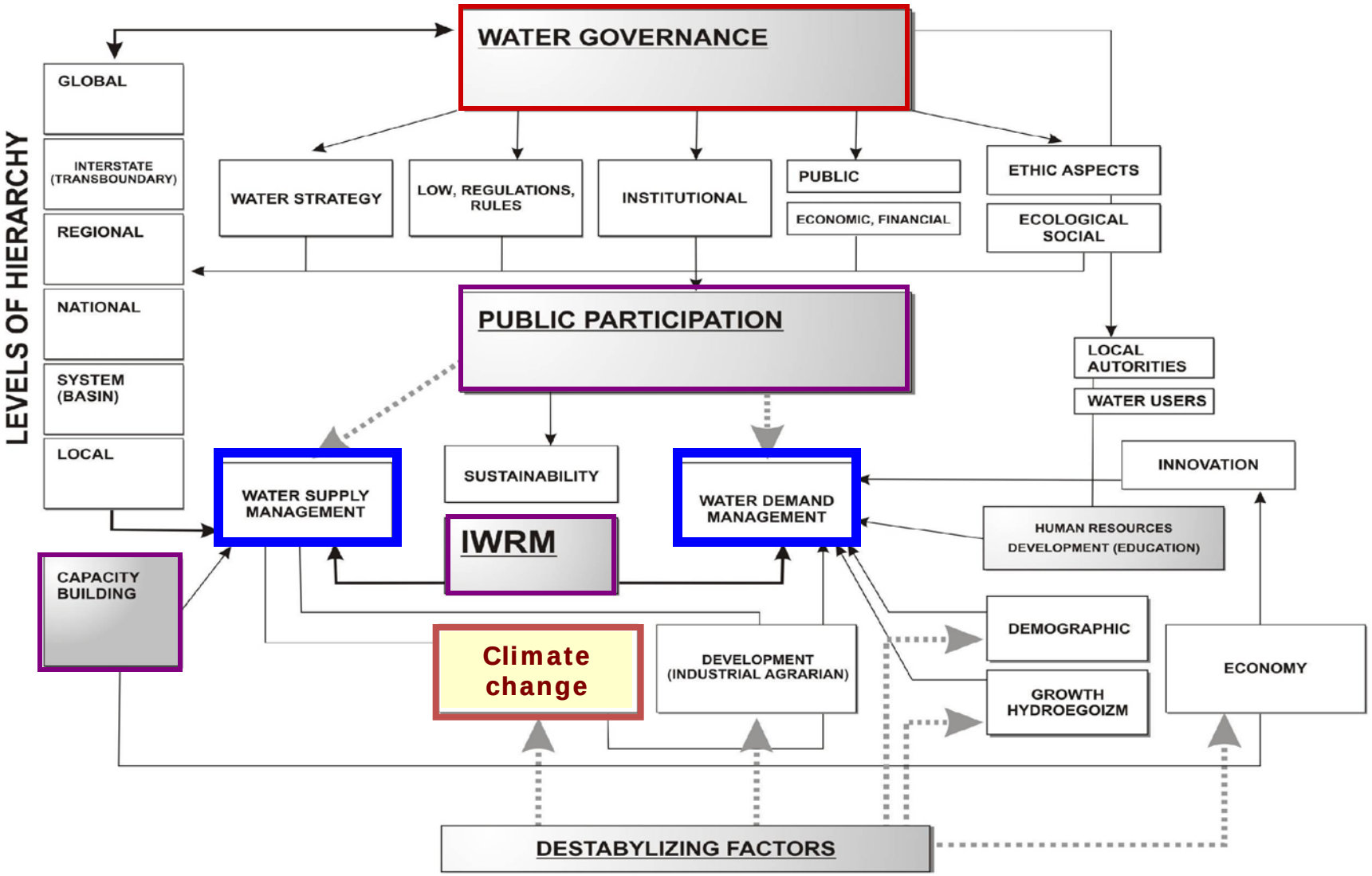


Good Water Governance

is the process in which government and society get organized to use water resources sustainably to meet needs within a legal and ethical framework in accordance to the water availability at any given time with equity and dignity.

(Kick-Off Meeting of the 6th WWF in Marseilles, June 2-5,2010)

Framework of Water Governance with Climate change and adaptation (IWRA, 2010)

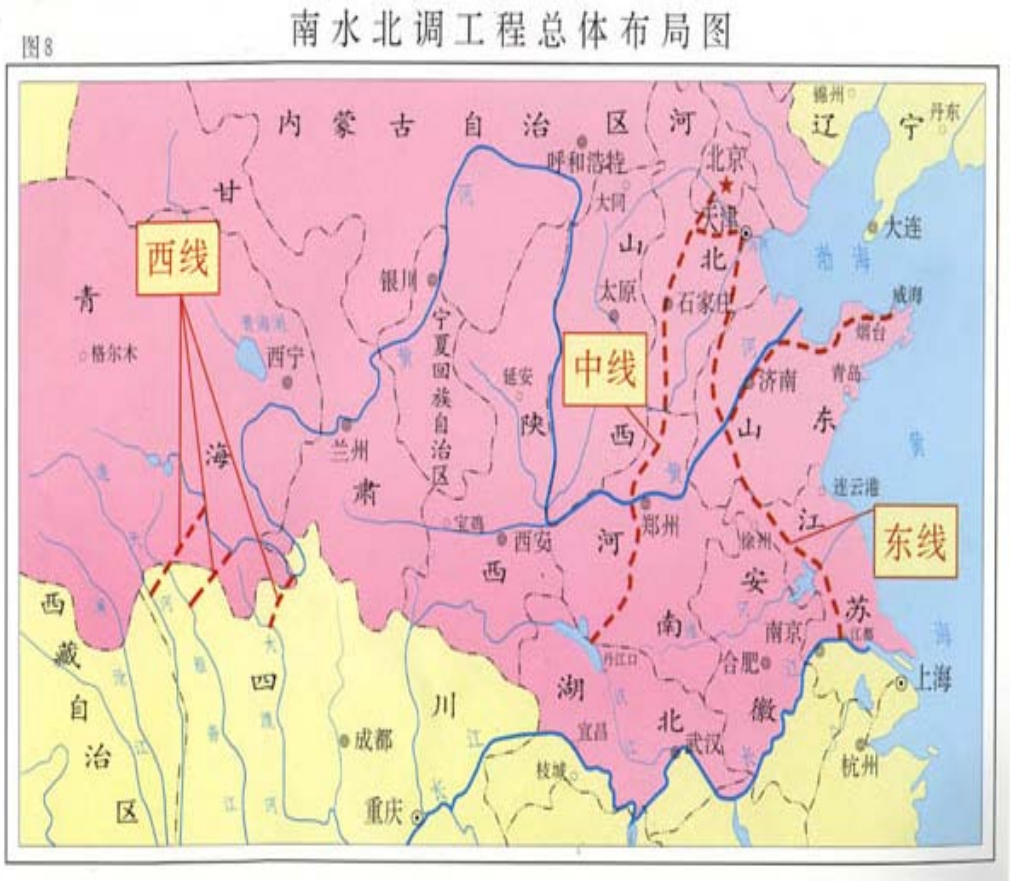


Adapted policies

- *Water saving policy*

- *Managing water wisely*

-*Infrastructure Building*: *South-to-North Water Diversion Project etc.*



Goal: **Enhancing ability to adapt climate change**

Conclusions

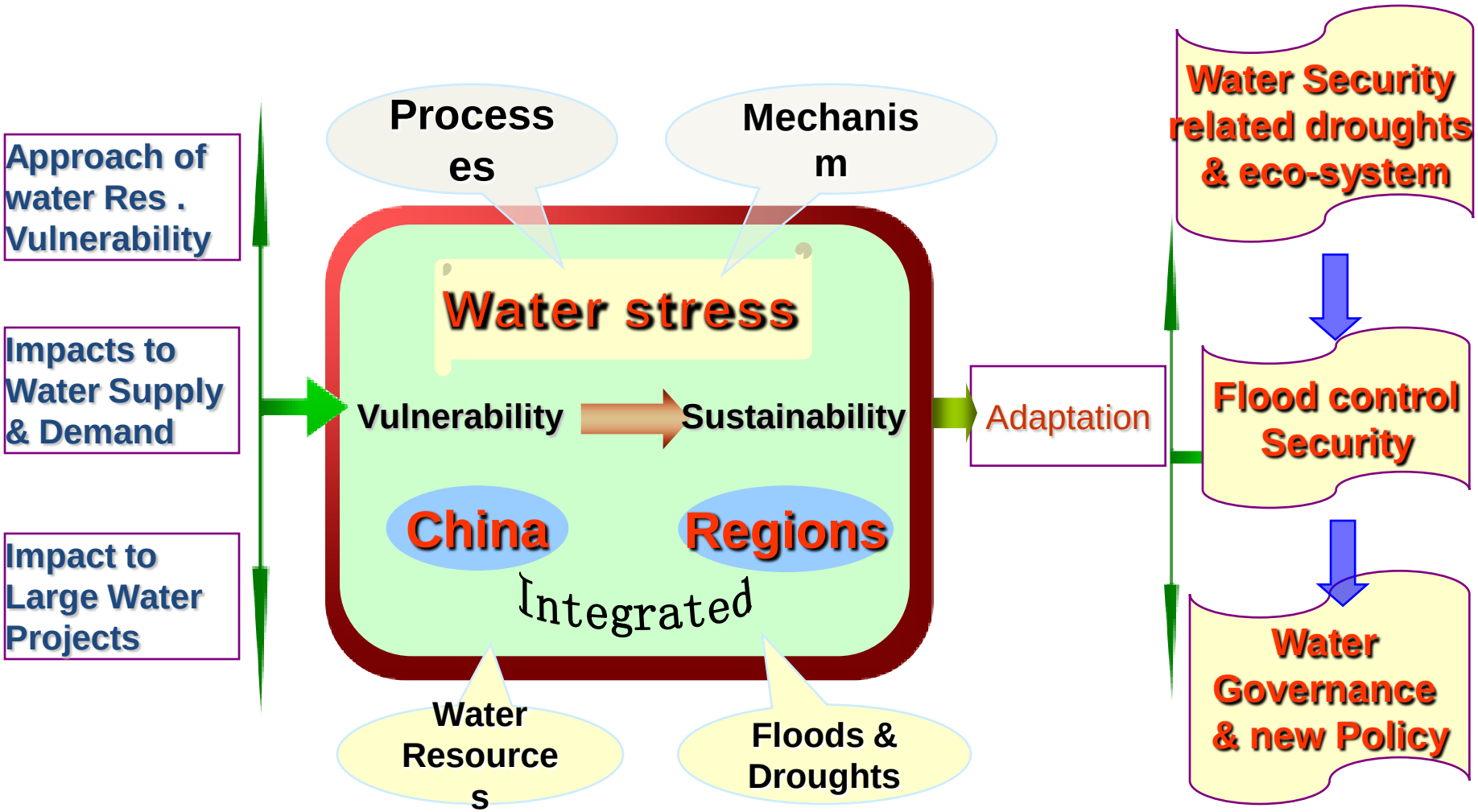
- Climate change and human activity are two big issue to water sustainable use. Science & technology will play a key role on understanding & reduce risk

  - Water policy, in China will had to shift from ***Water Quantity Management*** → ***Water Quality Management***

    Water Supply Management → ***Water Demand Management***

  - Improving Water Governance will be a priority on climate change adaptation.

Framework of Adaptation Managment to Water Sector in China



MWR in China is processing a strategies of water management based on three red lines control

- ***The red line I*** : water resources development controlled by ***Total Water Resources Quantity.***
- ***The red line II :*** water use efficiency improved by ***Water Demand Management.***
- ***The red line III:*** water resources protection by ***Water Quality Management*** (control of waster water etc.).

Adaptive management will face to new opportunity & challenges on implementing these strategies

XIVth IWRA World Water Congress

DATE: September 25-29, 2011 - VENUE: Porto de Galinhas / Recife, PE, Brazil

IWRA
International Water Resources Association

SECRETARIA DE RECURSOS HÍDRICOS E ENERGÉTICOS
Energy and Water Resources Secretariat – State of Pernambuco

International Association for Water Law

Federal University of Pernambuco

VERSeau Développement

APRH
Portuguese Water Resources Association

THE UNIVERSITY OF ARIZONA.
The University of Arizona

IDRC CRDI
International Development Research Centre

ABRH
Brazilian Water Resources Association

WELCOME MESSAGE

The XIV World Water Congress continues a tradition of meetings designed specifically for water resources professionals - practitioners, researchers, decision-

1) adaptive water management
2) water resources and global change
3) governance and water law
4) knowledge systems.

Plenary sessions and keynote speakers will set the broader context to frame individual, more detailed sessions.

We look forward to your participation and encourage you to continue checking the Congress website for updates over the coming months leading up to the Congress.

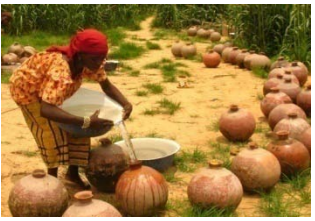
Prof. Jun Xia
President, IWRA

Prof. Christopher Scott
Chair, ISC

Dr. José Almir Cirilo
Executive Secretary, SRHE

TOWARDS WORLD WATER SOLUTIONS

WWC 49th BoG – SAN FRANCISCO, CA 14 OCTOBER 2010



6th World Water Forum

March 2012, Marseille

DRAFT THEMATIC FRAMEWORK

World Water Council

CREATING A BLUE MOVEMENT !

3 strategic directions

12 key priorities for water action:

Ensure everyone's well- being

- Guarantee access to water services for all and the Right to Water
- Guarantee access to integrated sanitation services for all
- Contribute to improved hygiene and health through water
- Protect populations and economies from risks
- Contribute to cooperation and peace

Contribute to economic development

- Balance multiple uses
- Ensure food security
- Harmonize energy and water
- Protect and value ecosystem services and green growth

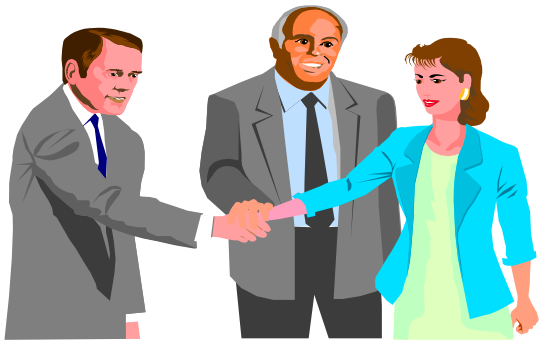
Keep the planet blue

- Improve the quality of water resources and ecosystems
- Adjust pressures and footprints of human activities on water
- Respond to climate and global changes in an urbanizing world

Conditions for success

- Good governance
- Finance water for all
- Enabling environment

International cooperation are welcome !



Thank you !

Prof. Xia Jun,
E-mail: xiaj@igsnrr.ac.cn