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Climate Change and Adaptive Water Management:

Challenges for a Changing World

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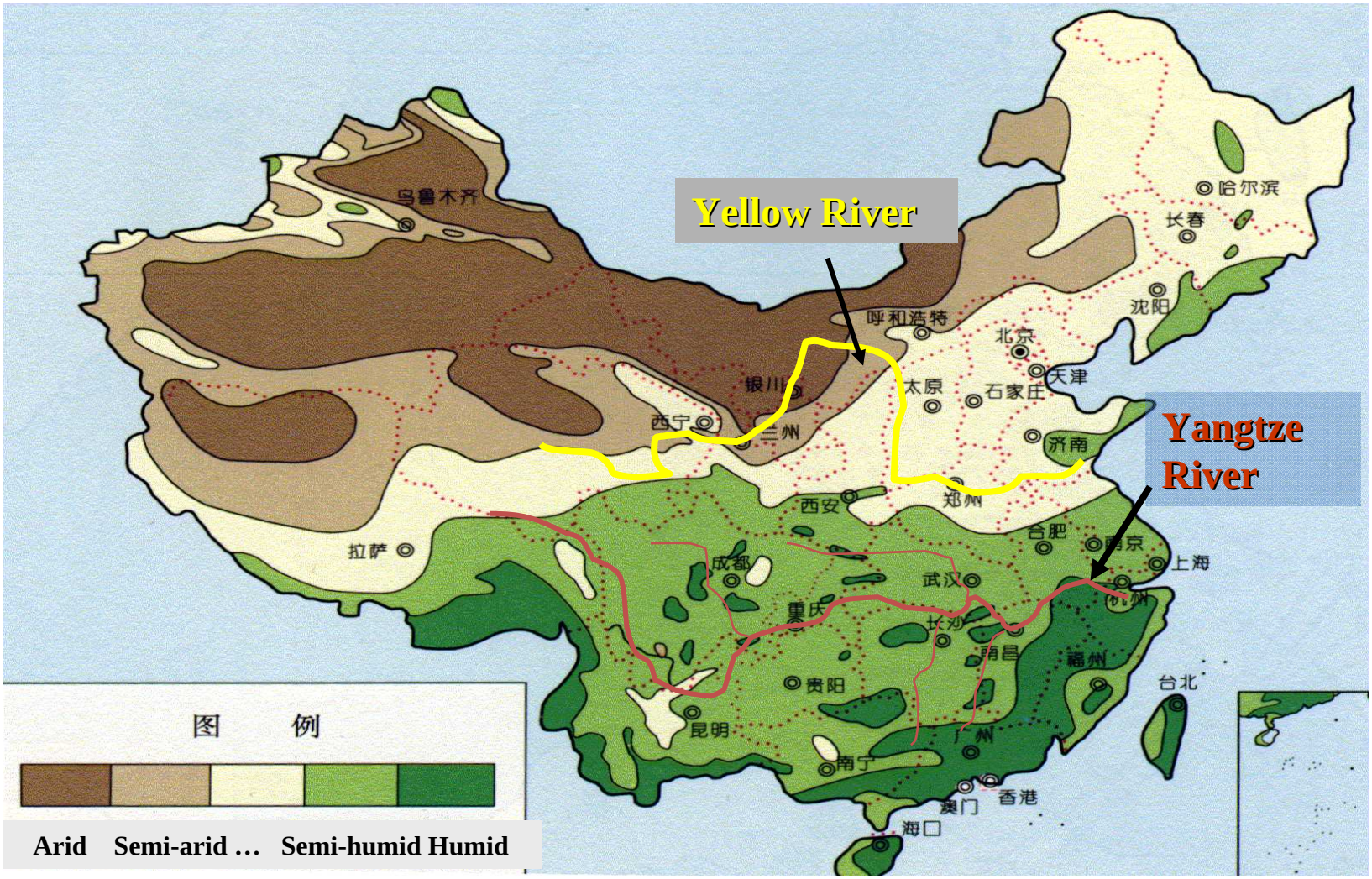
Outline

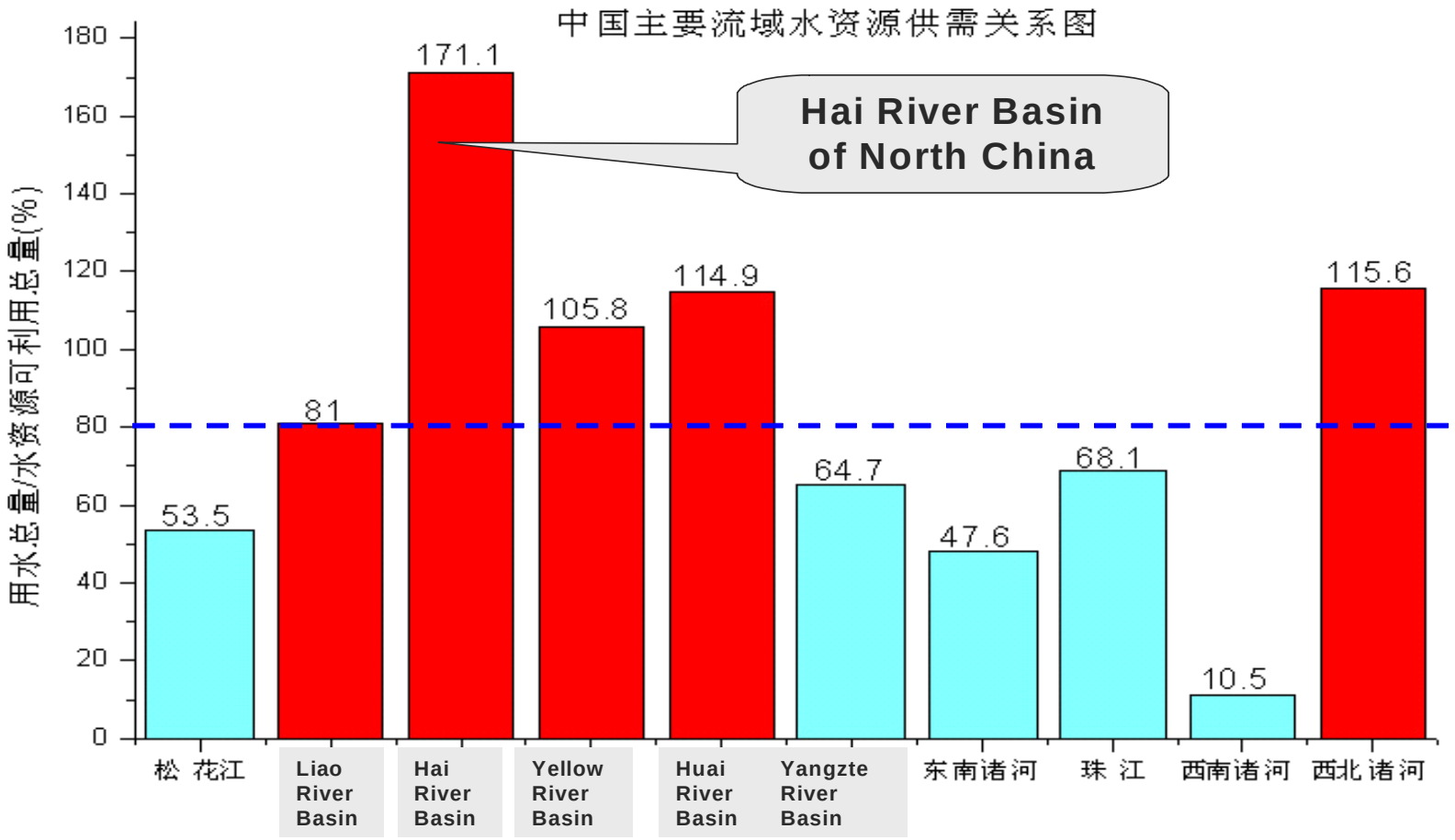
- ***Emergency water issues in China***
- ***Research project on climate change***
- ***Vulnerability & adaptation***

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



Water scarcity in China

Total water use / usable water resources in China



Along with social & economic growth and impact of environment change,

usable water is also declining

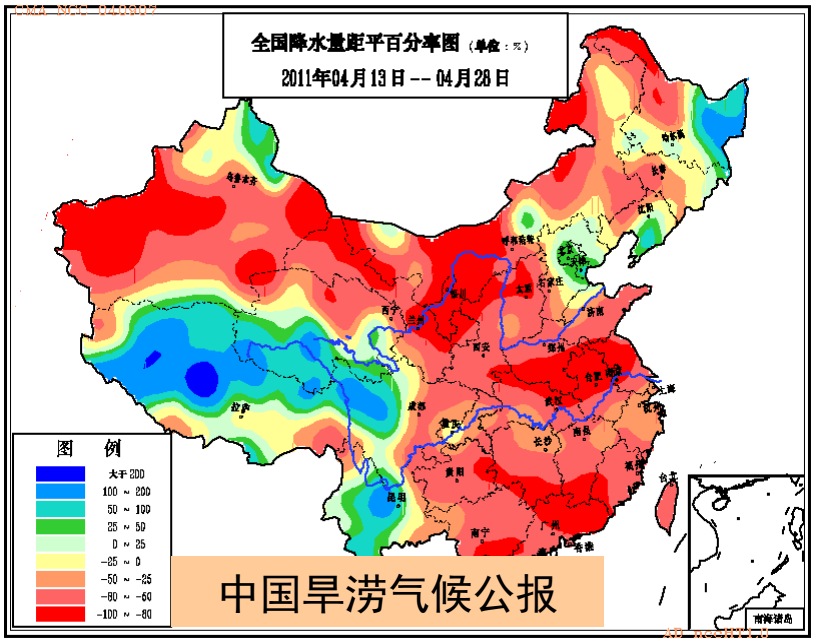
Water vaulnability is increasing

Year	Population (Billion)	Total Actual Water Use (Billion M^3)	Useable Water Res. per capita in North (M^3/p)	Useable Water Res. per capita (M^3/p)
2000	1.3	563.2	359	628
2030	1.6 ⇧	710.1 ⇧	292 ⇩	508 ⇩

Water problem

becomes as a key issue
for China Sustainable Development

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 …***

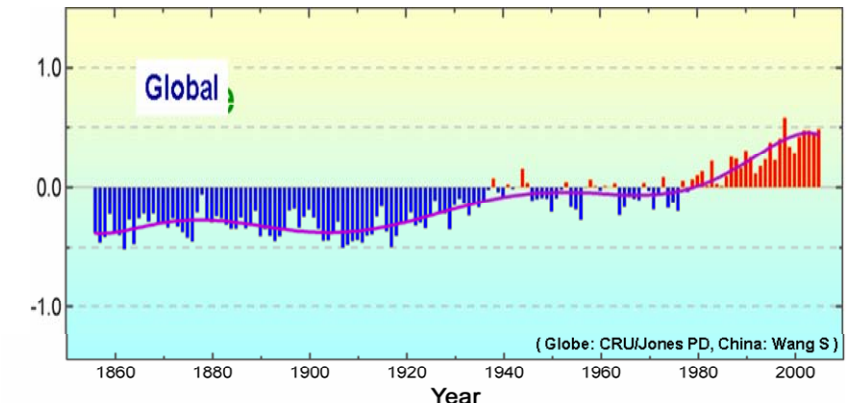
2012's May- June Floods in South China & Drought in North China

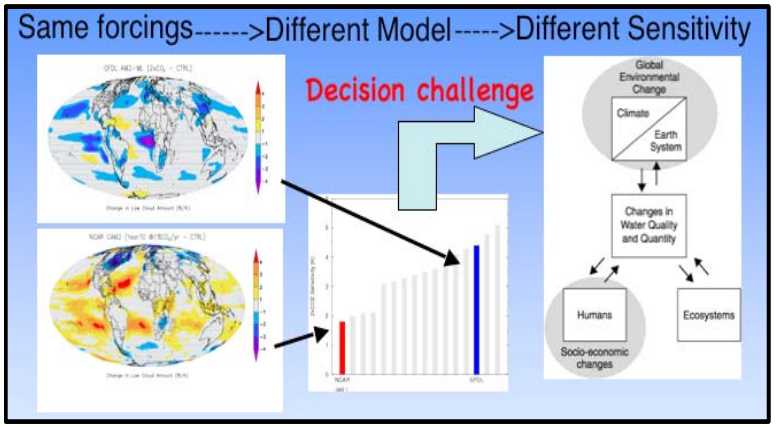
Just in Guanxi, the heavy rainfall resulted in 21 million peoples to suffer *flood disaster!*

Same in Yellow R Huai R & Hai R, the extremely draught resulted in 67 million *affected farm!*

There are multiple impact & challenges

(1).Climate change impact





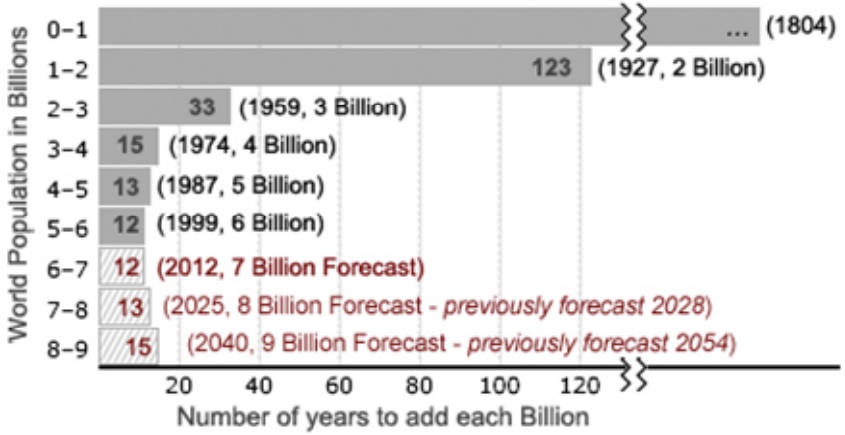
It is quite possible to

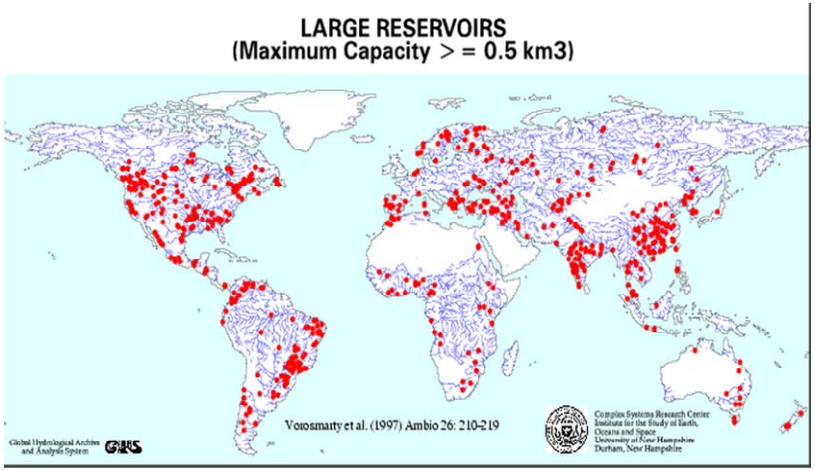
- **change water's time-space distribution**
- **increase risks on floods & droughts in water stress regions**

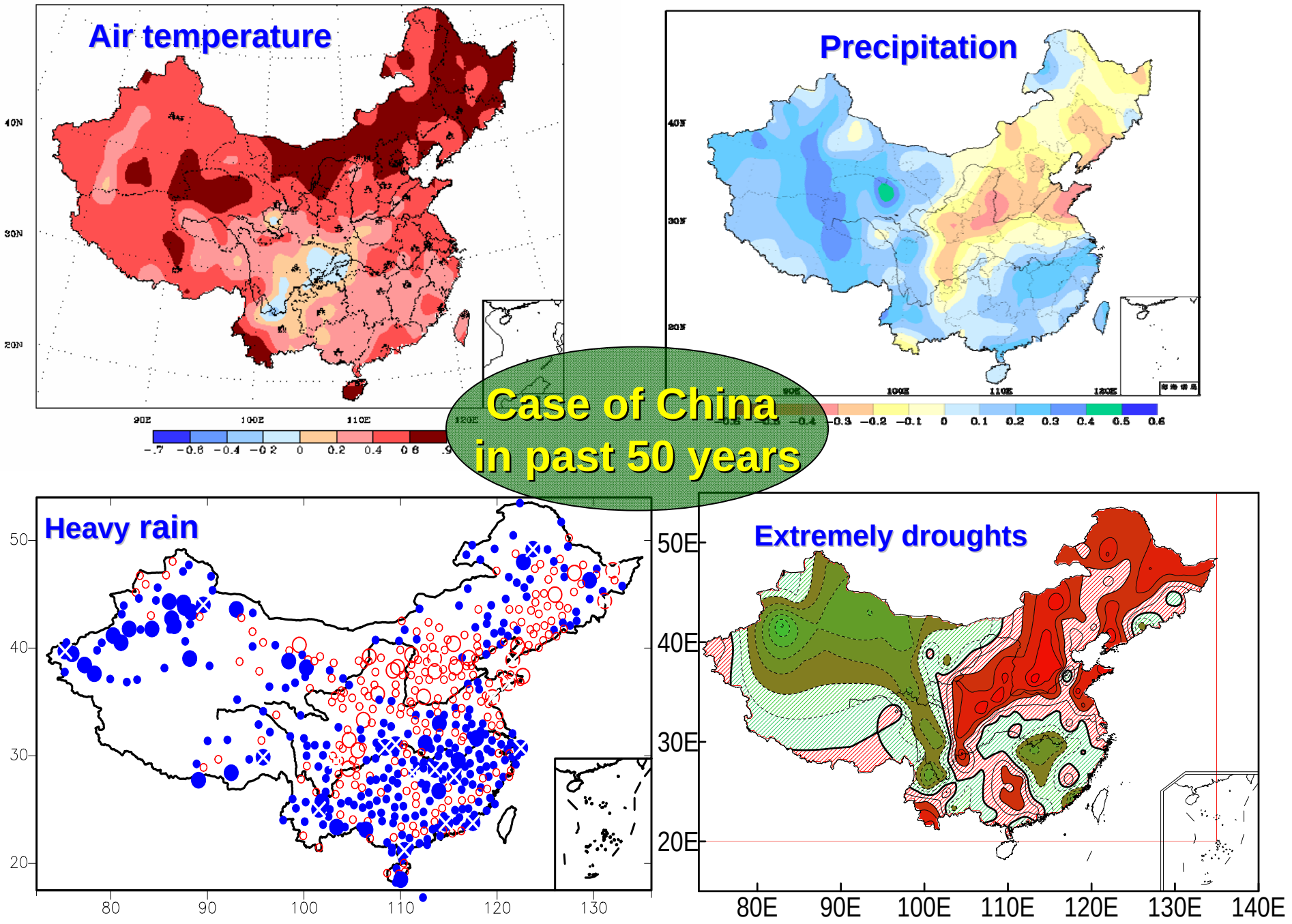
IPCC AR4 (2009)

(2). Human activities impact

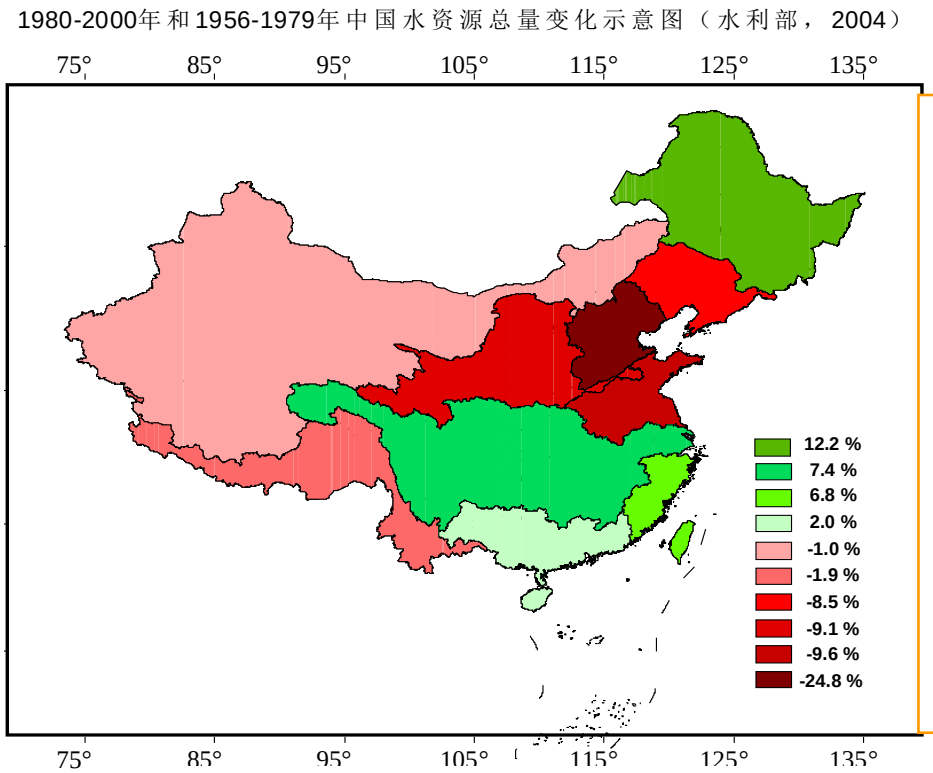
- **Remarkable LUCC due to rapidly urbanization, agricultural & energy developments**
- Impacts of Large Scale Land Use Patterns and Demographic Changes



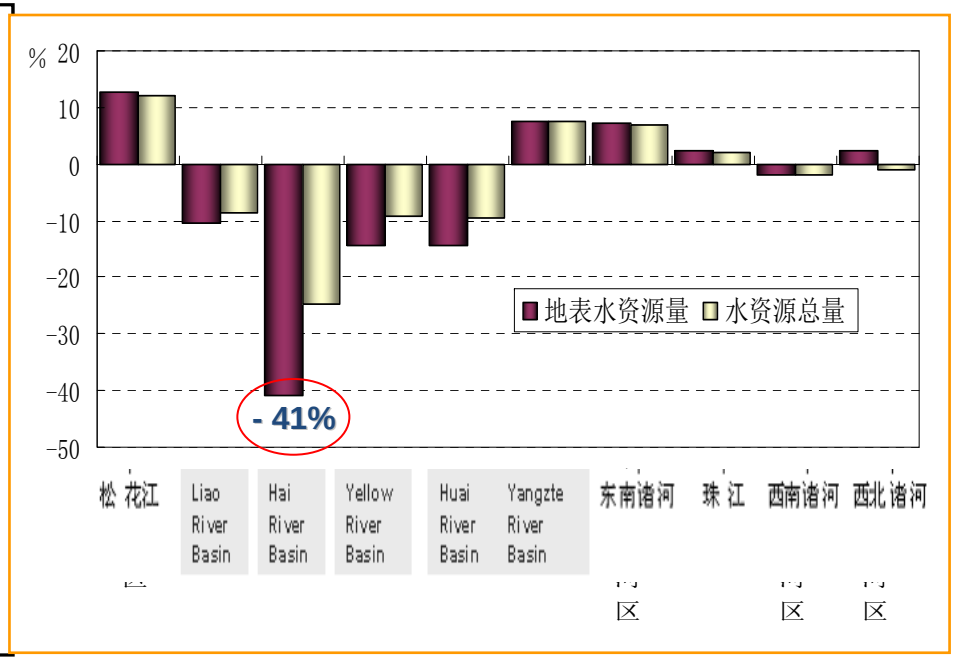



Air temperature
Precipitation
Case of China
in past 50 years
Heavy rain
Extremely droughts
40N
30N
20N
90E
100E
110E
120E
-.7 -0.6 -0.4 -0.2 0 0.2 0.4 0.6
-0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6
50
40
30
20
80
90
100
110
120
130
50E
40E
30E
20E
80E
90E
100E
110E
120E
130E
140E

Available water resources change between 1980-2000 and 1956-1979 in China

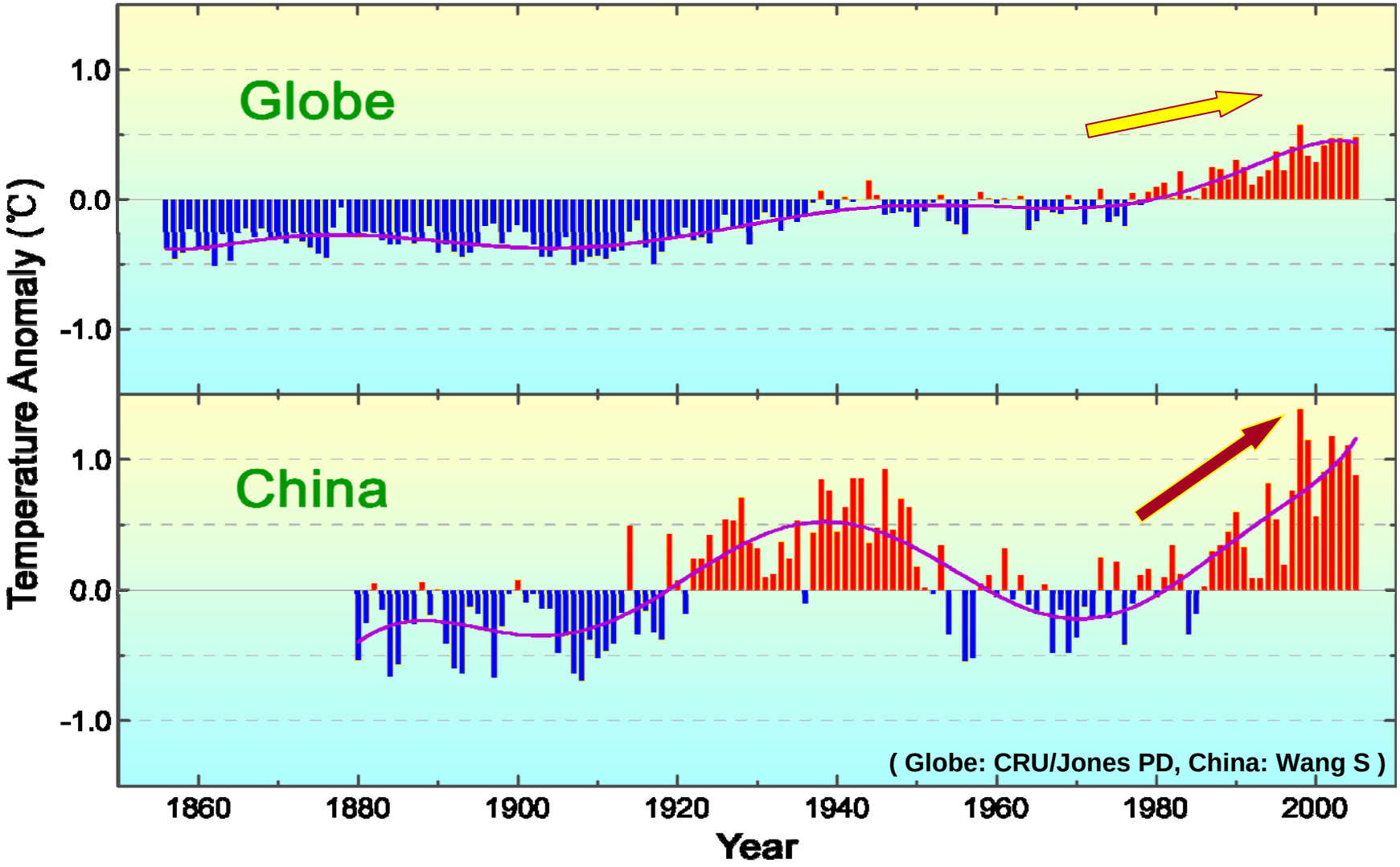


Total water resources change between 1980-2000 and1956-1979， MWR, China(2004)



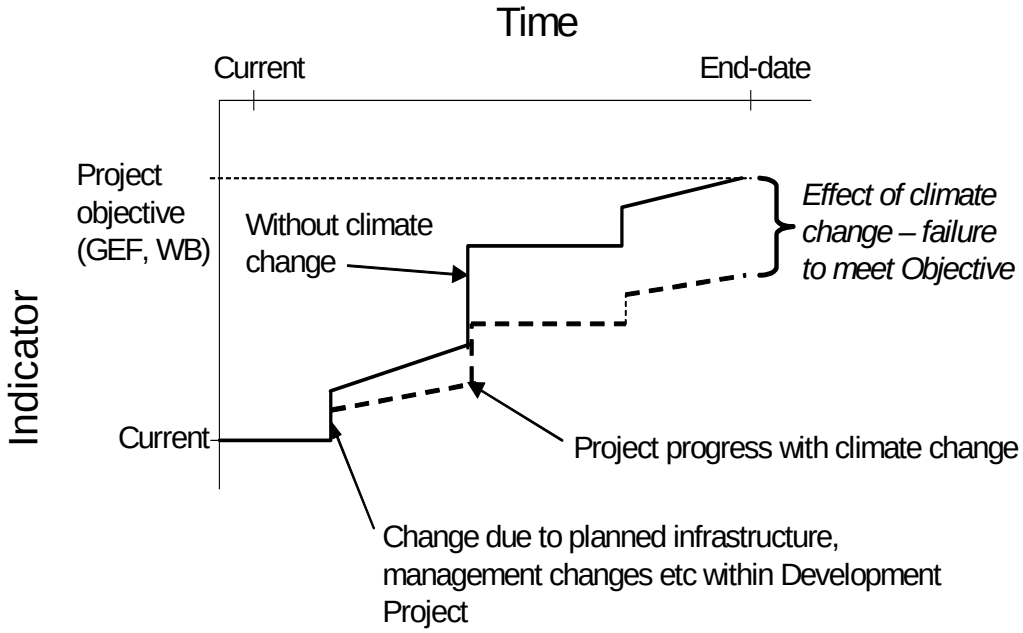
Total surface water resources change between 1980-2000 and1956-1979， MWR, China(2004)

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



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

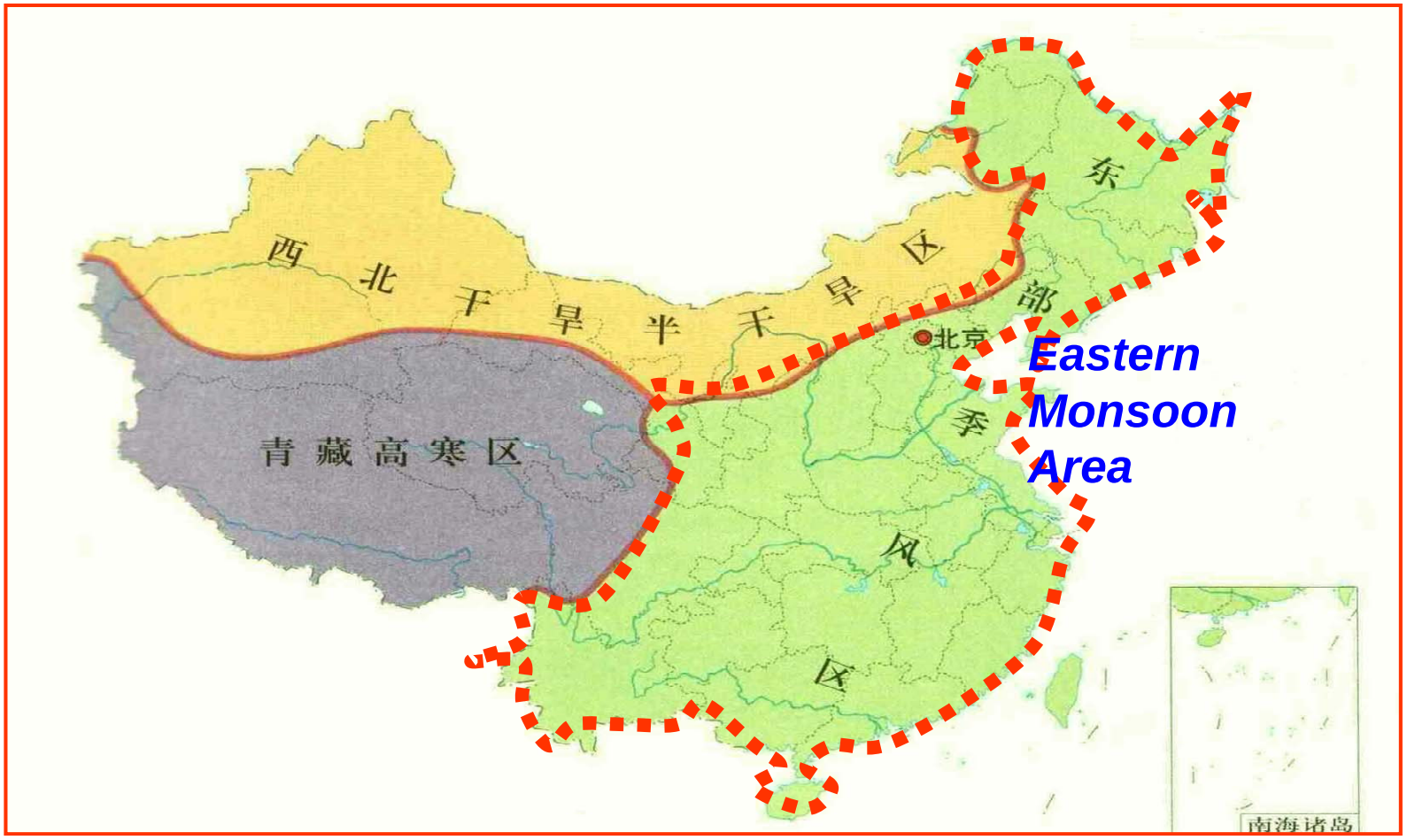
- ***How to detect & understand climate changes impact to water sector? and How to quantify water resource vulnerability related to impact of climate change and Human activity ?***



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

A National Basic Research Project (973) on Climate Change & Water

Since 2010, Ministry of Sciences & Technology (MOST), China, fund a National Basic Research Project (973) on Climate Change Impact to Water Cycle & Water Security in China, with 33 Million CNY, *2010-2014, lead by Jun XIA*

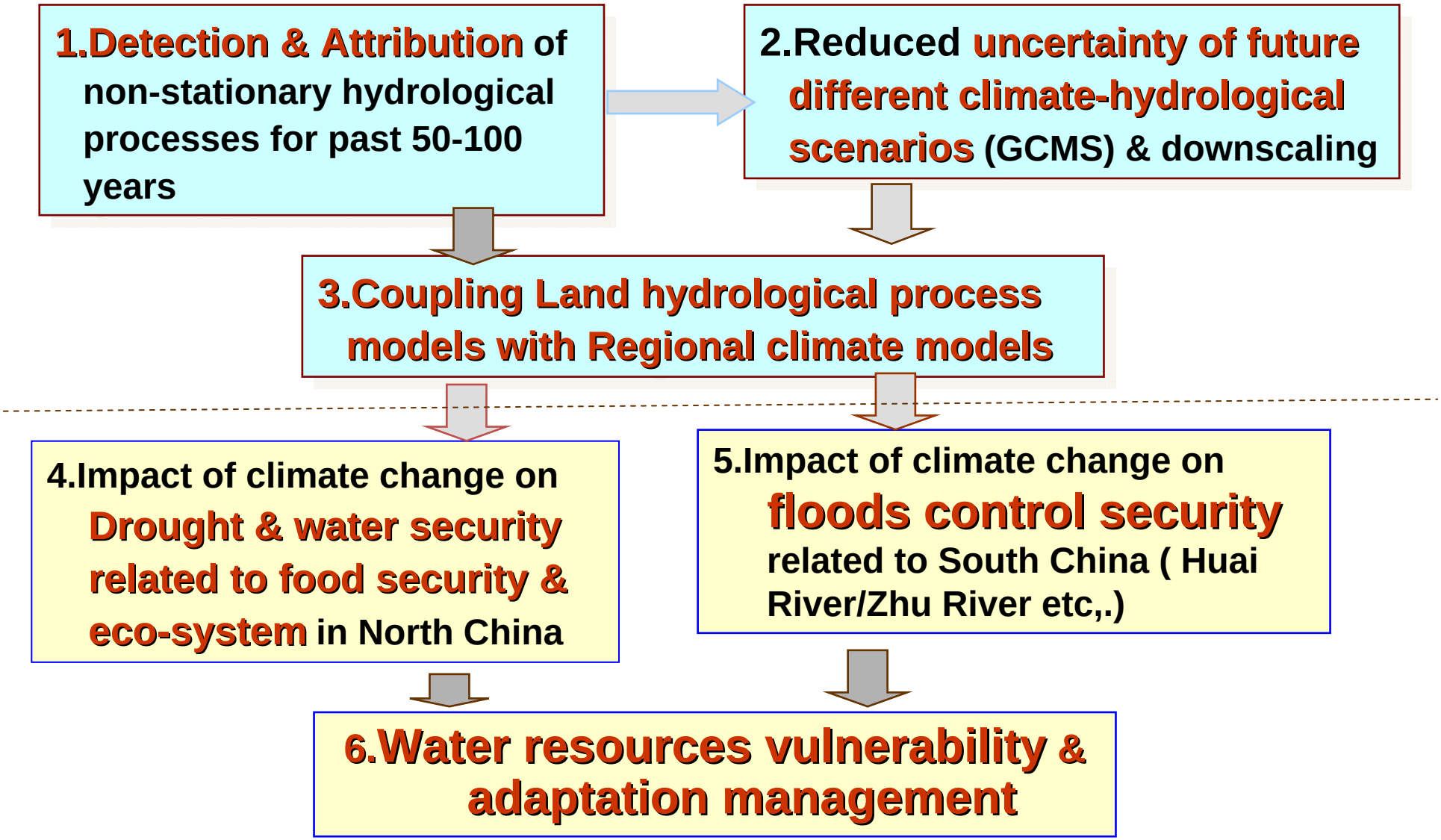


Research Team for the Project

- **Chinese Academy of Sciences (CAS)**
  - *Institute of Geographic Sciences and Natural Resources Research (CAS/IGSNRR)*
  - *Institute of Atmospheric Physics (CAS/IAP)*
  - *Center for Agricultural Resources Research (CAS/CARR)*
- **Chinese Meteorological Administration (CMA)**
  - *National Climate Centre (CMA/NCC)*
- **Ministry of Water Resources (MWR)**
  - *Bureau of Hydrology*
  - *Water Resources and Hydropower Planning & Design Institute (WRHPDI)*
- **Ministry of Education**
  - *Beijing Normal University – College of Global Change and Earth System Science (BNU-GCESS)*
  - *Wuhan University-State Key Lab. of Water Res. & Hydropower Eng. Science (WU-SKLWRHES)*


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 RESEARCH THEMES



Targets: Besides **whole 8 big river basins** including **water transfer project from south to north**, **two major areas** related ***drought & food security*** in **North China & North-East China**, and ***extremely flooding events*** in **South China** (Huai River & Zhu River) are focused in the project

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:

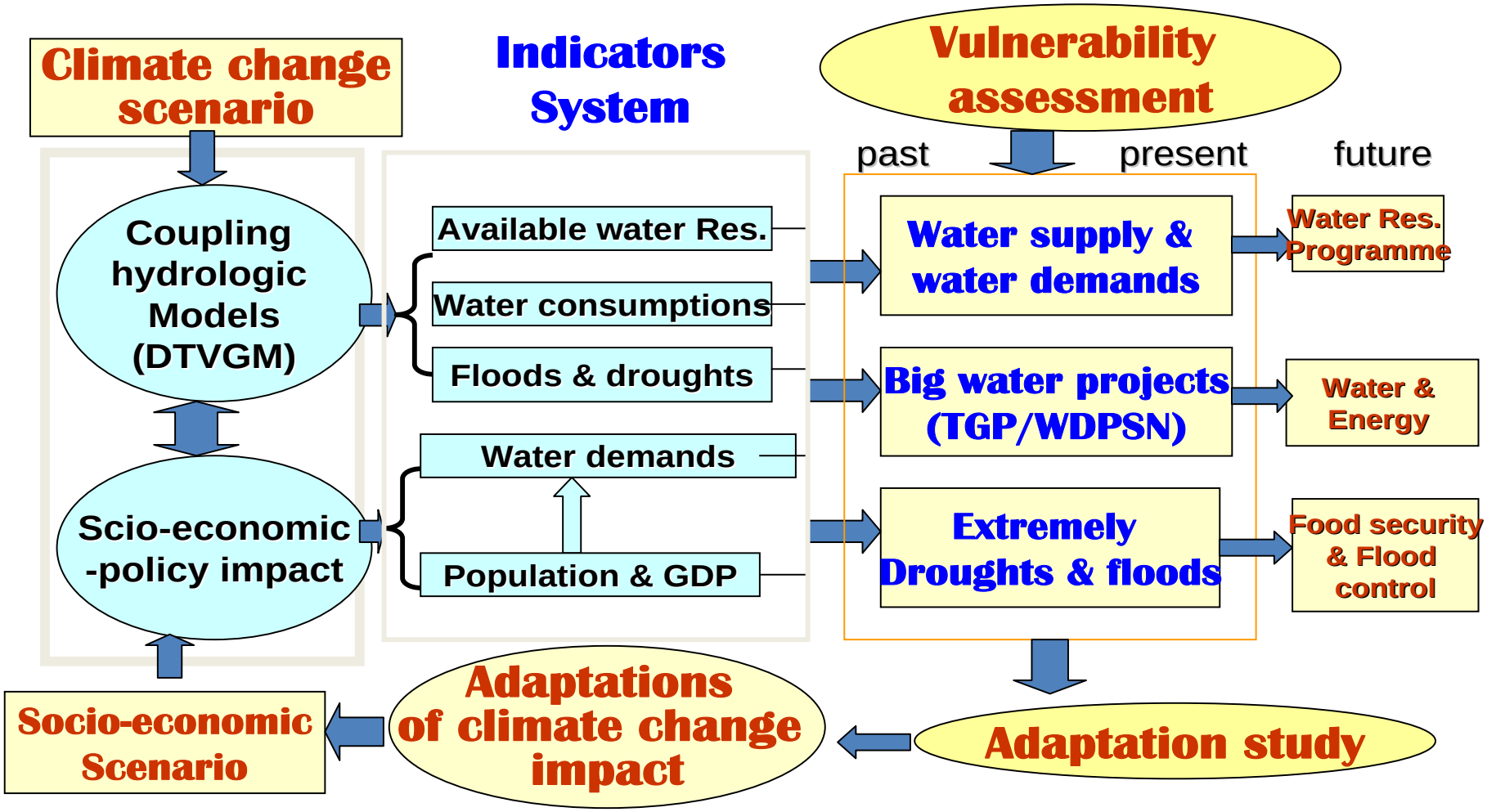
- *How to change in the past ?*
- *How to change in the future, particular to coming 20-50 years ?*
- *What's the mechanism for such changes ?*
- *How to adapt climate change & wisely manage water ?*

3. Vulnerability & Adaptation will be priority issues for adaptive water management.

Framework of Vulnerability & Adaptation

Interaction system with 2 kind of scenarios and

Adaptation is the function of Vulnerability



Water Resource Vulnerability

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

- New study:

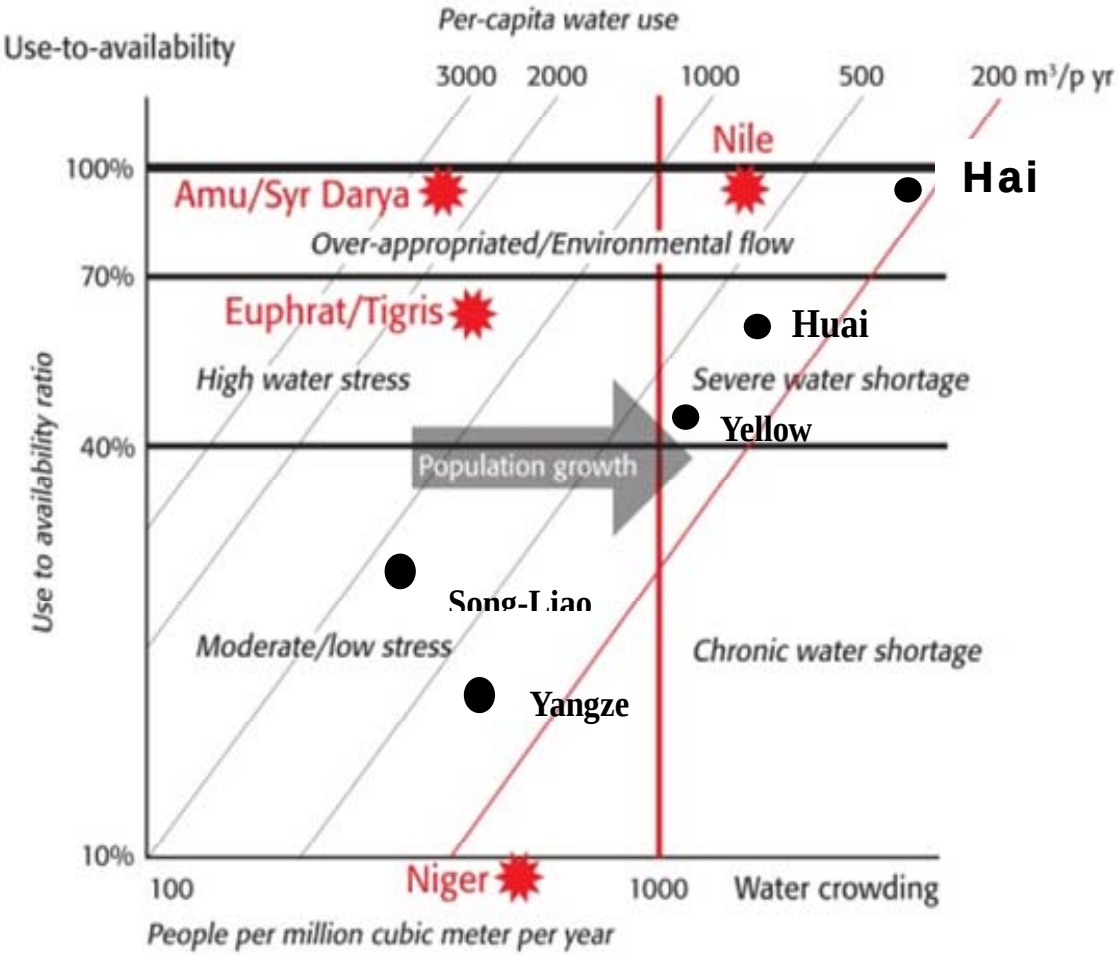
$$V(t) = \frac{S}{C(t)}$$

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

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)



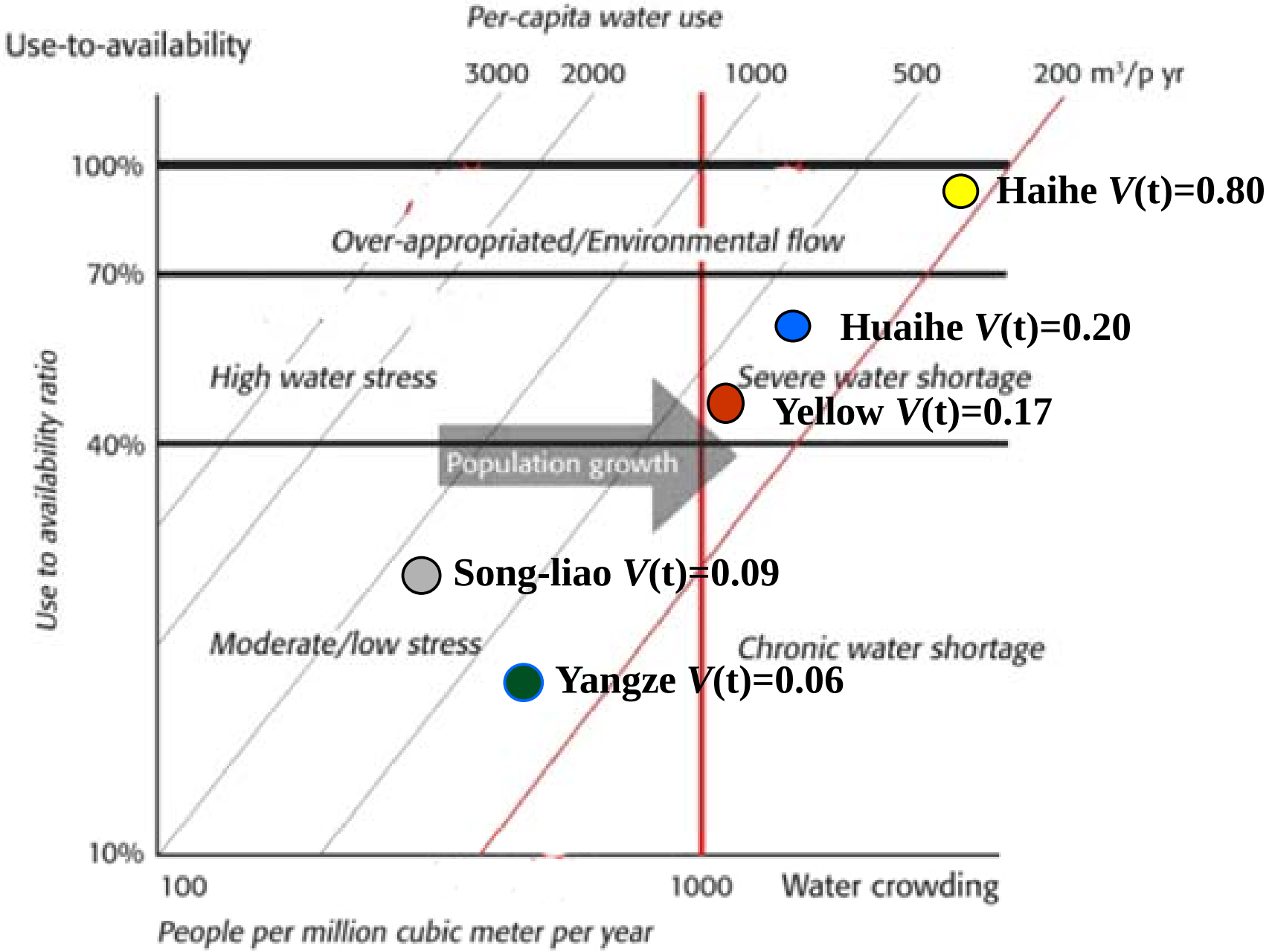
New study on quantifying
Water Resource Vulnerability

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

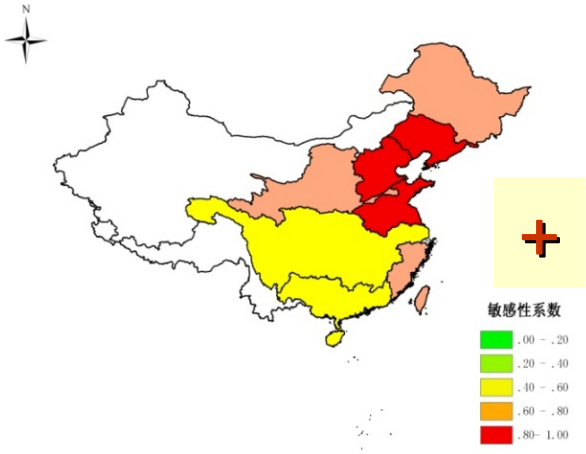
r – Use to availability ratio (%)
P/Q - water crowding (p / Million m3/ yr)
W_D/P - per capita water use (m3/p yr)

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
100
1000
Water crowding
People per million cubic meter per year
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

New Study



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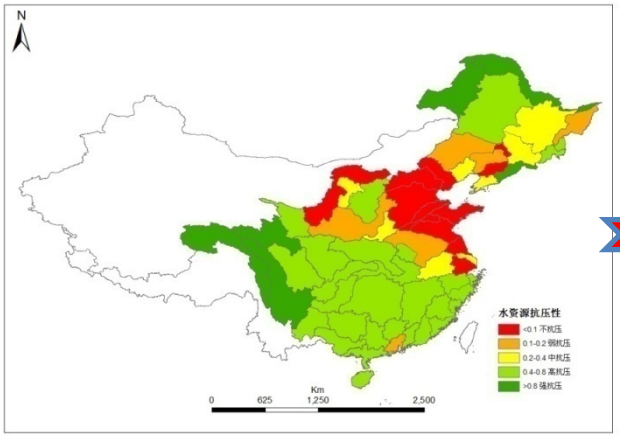
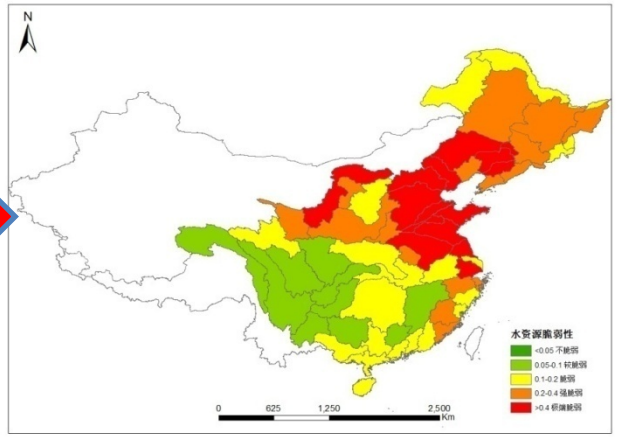




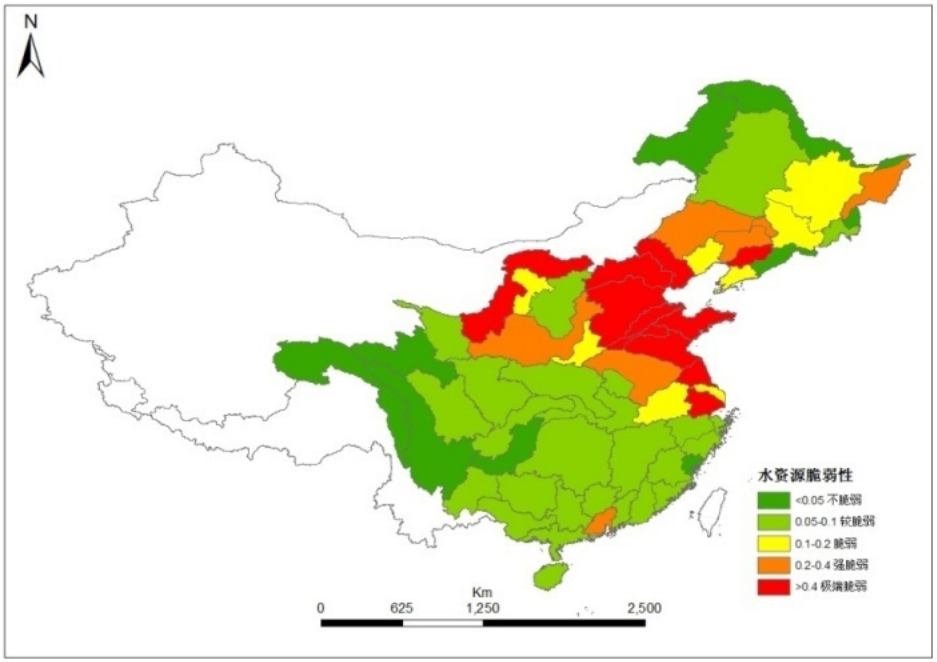
Sensibility S

water stress(resilience) C

Integrated Vulnerability S/C

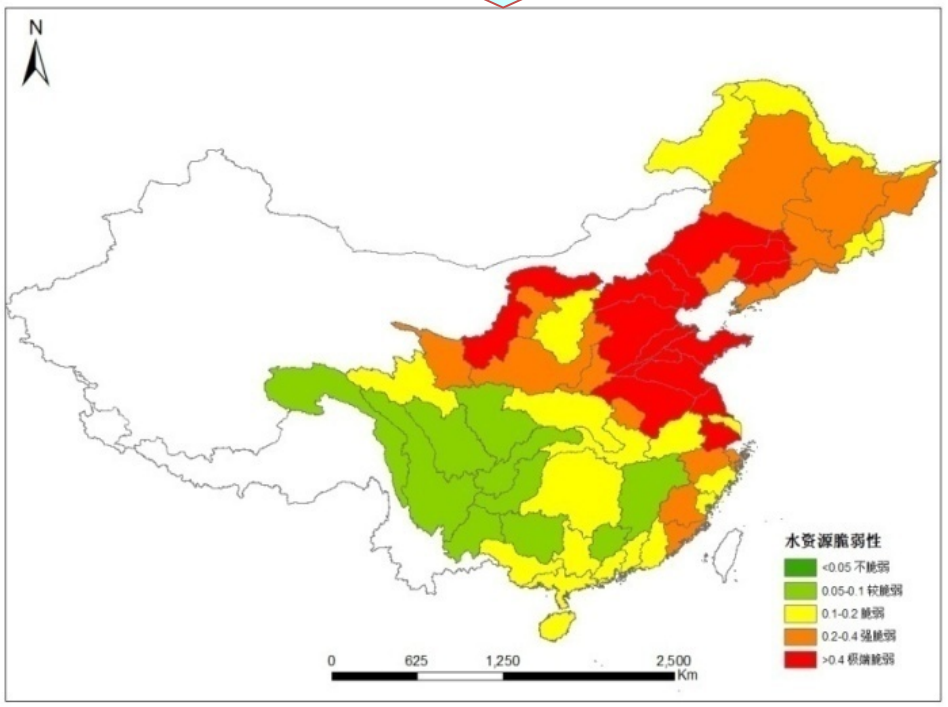
Baseline year: 2000

Data series: 1970-2010

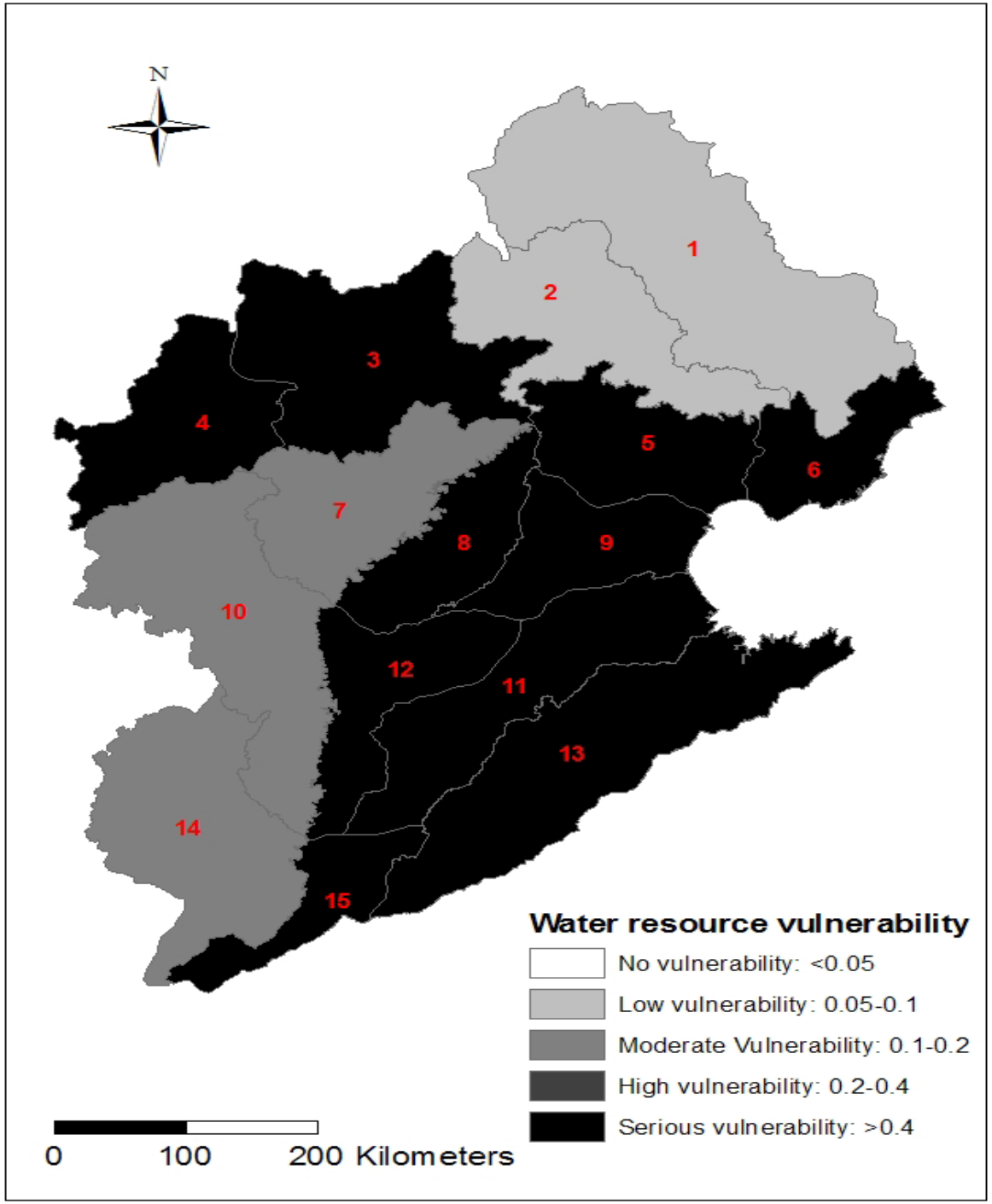


Vulnerability
S/C

Vulnerability
1/C without S



Water Resource Vulnerability in Hai River



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

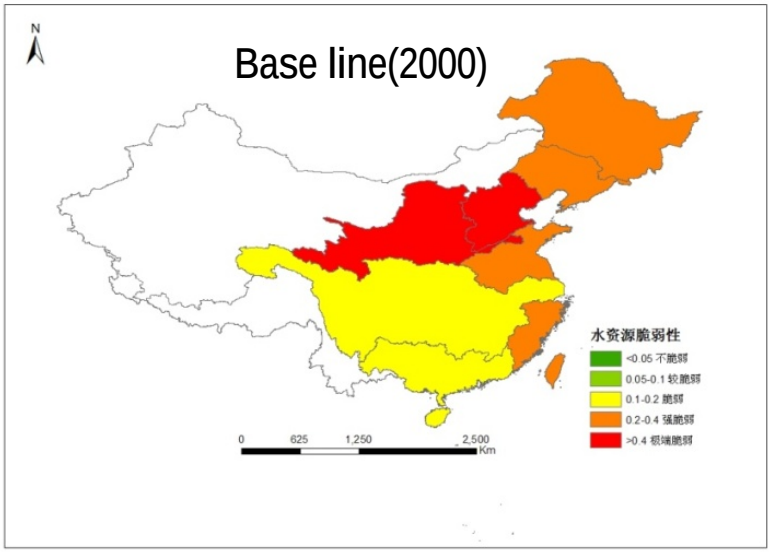
Sc1 – only available water resources change to global warming

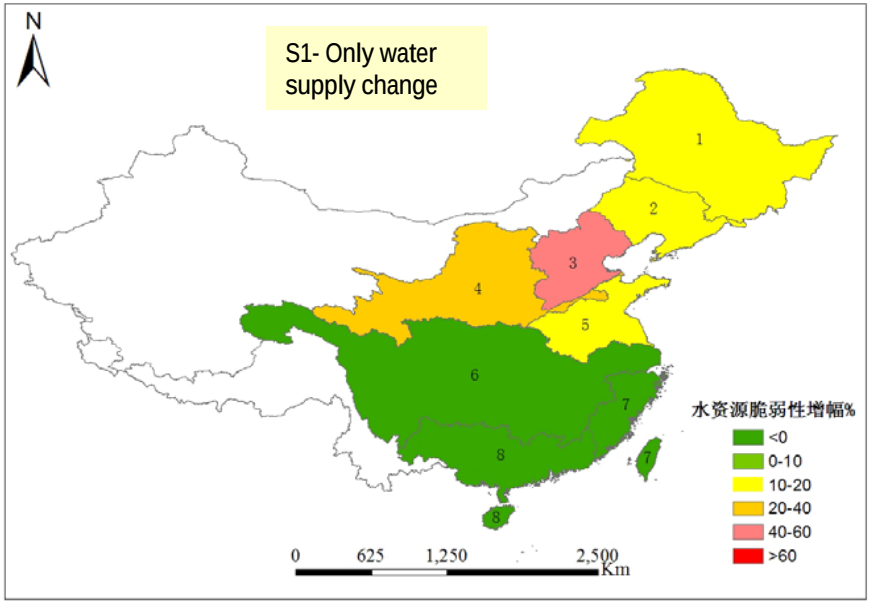
Sc2 – only water demand change

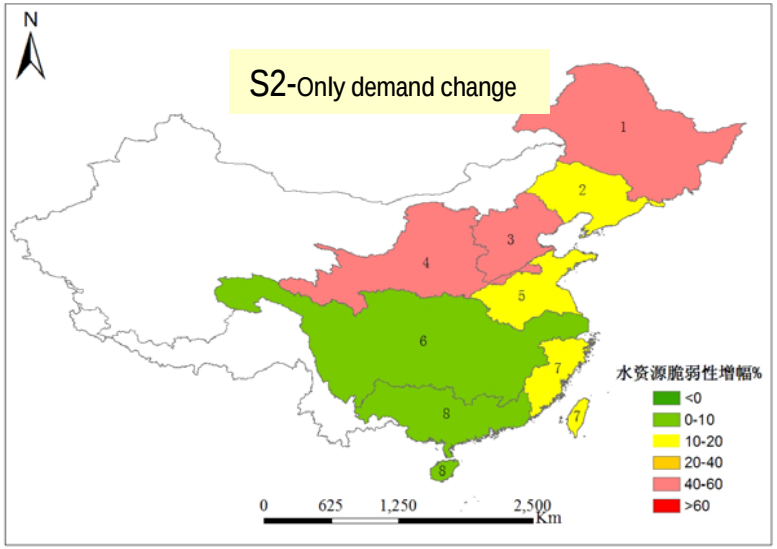
Sc3 – considering both change

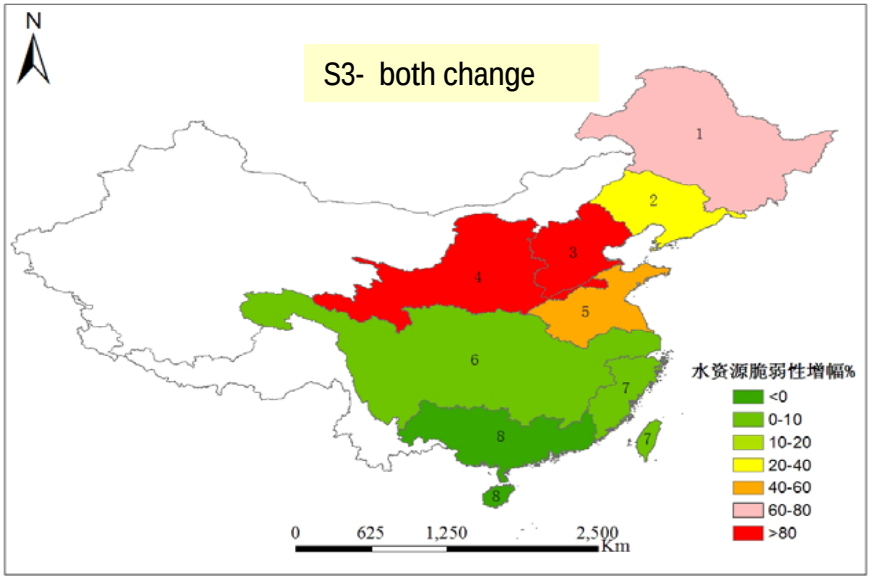
xiajun5

Vulnerability change △V(t) to different scenarios





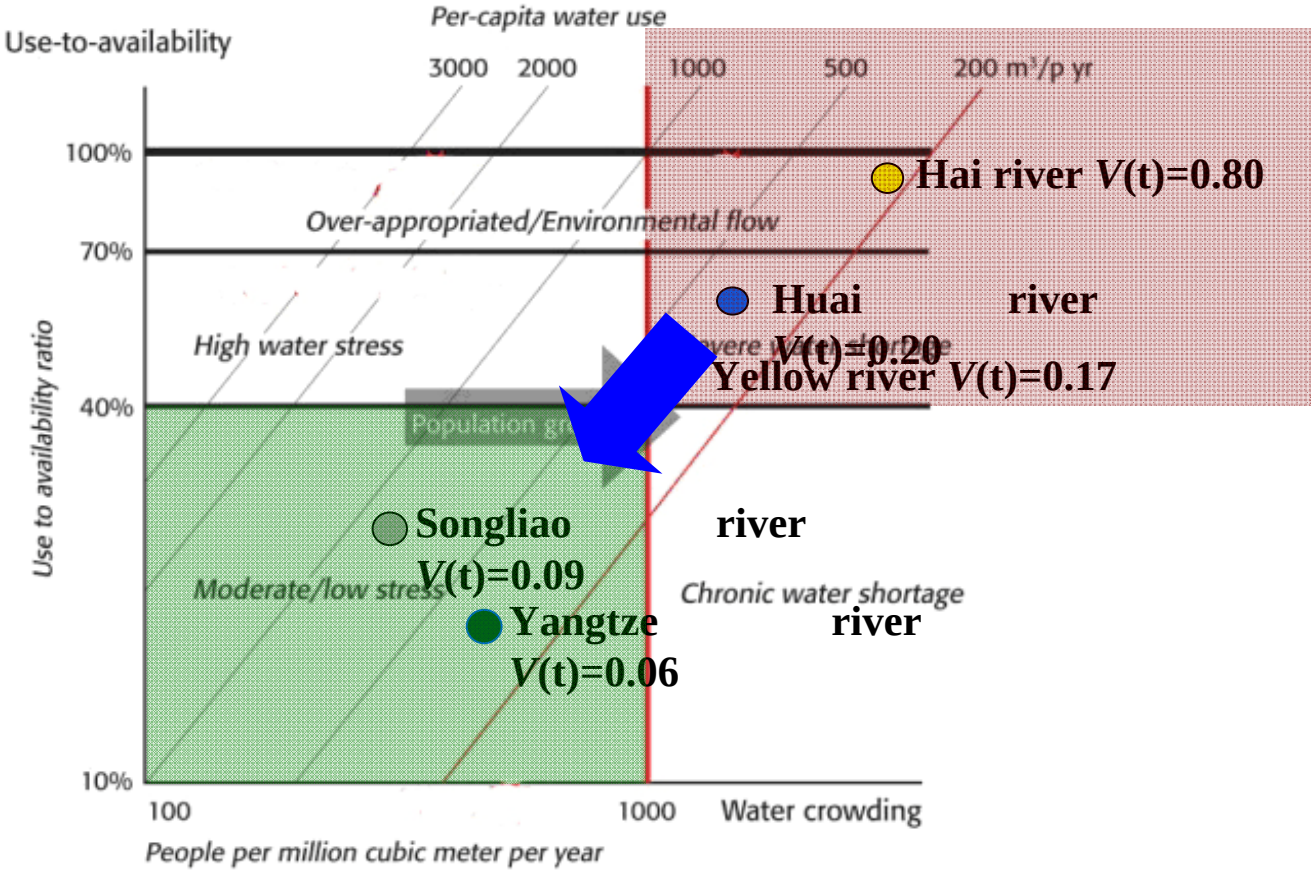




xiajun5 夏军，2011/4/10

Adaption to climate change and both human activities：

Identify key control variable, and shift V from red zone into blue one by adaptive management, i.e., changing the rate of water developing & using water crowding & per capita water use etc.



Adapted policies

- *Water saving policy*
- *Managing water wisely*
- *Infrastructure Building*: *South-to-North Water Diversion Project etc.*
- *Good water governance*

Goal: **Enhancing abilities & ways to adapt climate change**

Conclusions

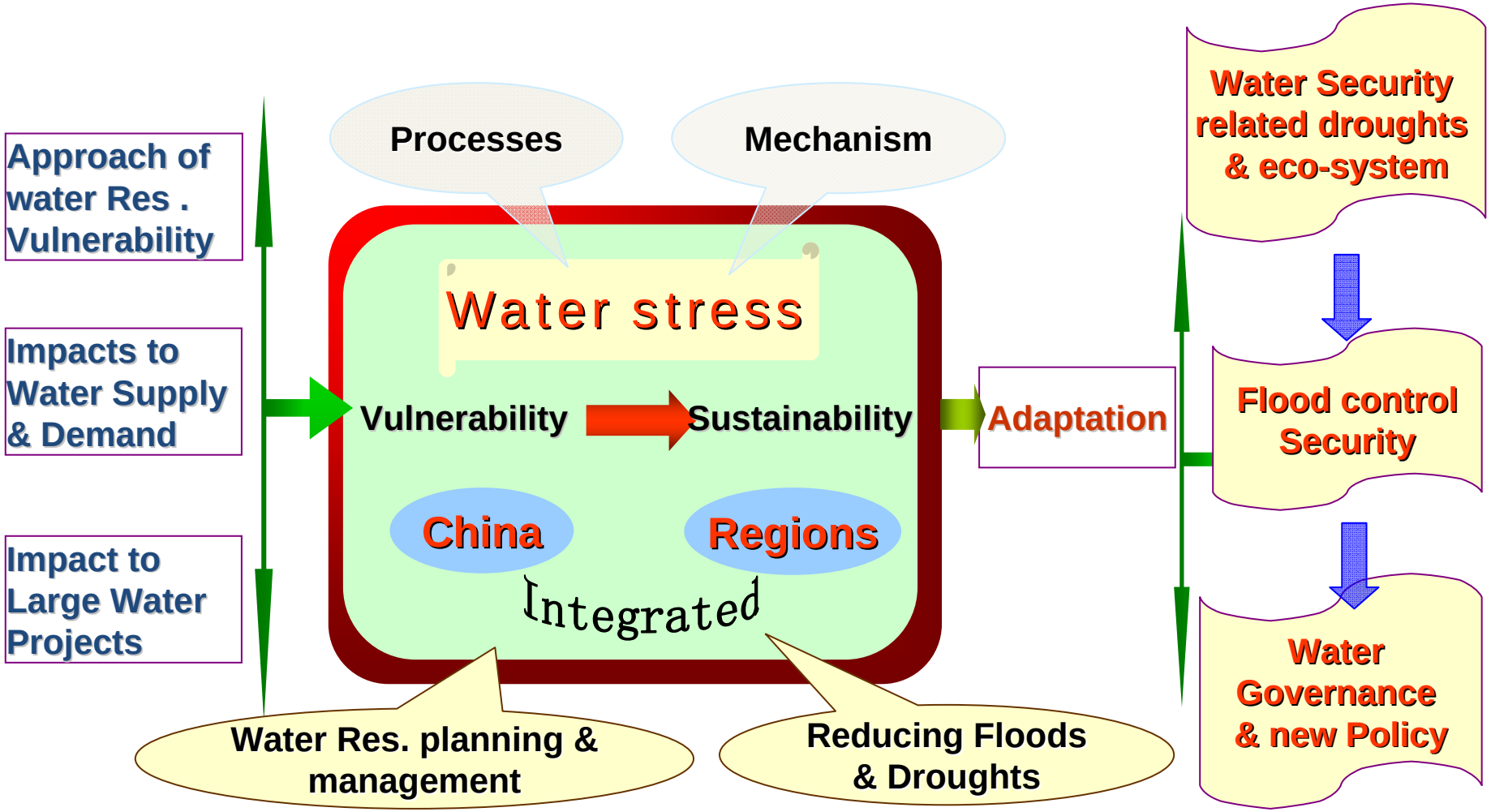
- Climate change and human activity are two big issue to water sustainable use. Science & technology will play a key role on understanding & reduce risk

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

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

  - Adaptive Water Management will be a priority issue in China.

Framework of Adaptation Management to Water Sector in China



MWR in China is processing a new water strategy based on three red lines control

- *The red line I* : ***Control of total water use***
  by *Total Water Resources Allocation.*
- *The red line II* ***: Control of lower water use efficiency***
  by *Water Demand Management.*
- *The red line III*: ***Control of total waste water load***
  by *Water Quality Management.*

Adaptive water management will face to new opportunity & challenges on global and regional.

XIVth IWRA World Water Congress,
Adaptive Water Management:
Looking to the Future


Prof. Jun Xia
President, IWRA


Prof. Christopher Scott
Chair, ISC


Dr. José Almir Cirilo
Executive Secretary, SRHE

Four major themes

- ***Adaptive water management***
- ***Water resources and global change***
- ***Governance and water law***
- ***Knowledge systems***

Those have good linkages with ***Tasks of Global Water Strategy*** (WWC/ IAP/IAC water programme & others)

XIVth World Water Congress
25-29 Sept., 2011, Recife, Brazil

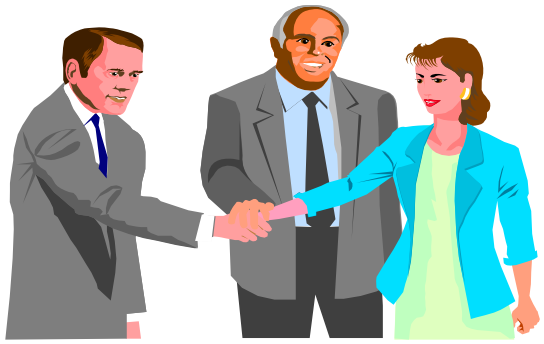
IAP /IAC Water Programme

InterAcademy Council

Science & Technology for Sustainable Water

IAC Water Study

International cooperation are welcome !



Thank you !

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