


## 中国、黄河流域の環境変化に関わる水資源の脆弱性

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- ・黄河は大河であり、一連の環境生態問題を内包している。中国では、環境と生態を一緒にして「環境生態 eco-environment」とし、マクロ的に人類の生存環境としている。
- ・黄河の源流域は、主要な水源地であるが、水量減少、湖と河川の流れの中断、草原の退化、沙漠化、氷河の縮小と後退、土壌侵食などの問題が起きている。
- ・中流部においては、土壌侵食と水不足、森林の伐採、沙漠化、水源の汚染、暴雨による洪水の5つの問題が深刻化している。
- ・黄河の断流は、1972年から始まって20世紀末ころは、5年に4回は断流が起きた。さらに土砂の堆積問題、天井川の問題があり、洪水による堤防の破堤の危険が増大している。また水の汚染や山東省黄河口の生態均衡の問題も出ている。
- ・下流部では、気候変化と人間活動の両方の影響で、明らかに河川流量が減少している。
- ・水資源の脆弱性は、気候と人間活動という2つの要因に由来するが、さらに水需要と水供給のミスマッチによって複雑化している。すなわち水不足と不合理な水資源の使い方が、いとも簡単に水資源の脆弱性を引き起こしている。
- ・水利用効率の異常な低さ、経済と社会の過熱、過度な経済成長などが水資源の脆弱性と関係している。良好な水利施設のある地域では水利用の規制が行われていない。
- ・黄河の年平均流量は毎秒1800m<sup>3</sup>くらいだが、そこに建設されている水利施設の引水能力は毎秒6000m<sup>3</sup>にも達し、そのほとんどが下流部に集中している。
- ・気候変化と人間活動による水資源の脆弱性は、生態環境に影響を及ぼしているが、そのフィードバックメカニズムはとても複雑で、黄河流域の生態環境は退化を続けている。
- ・対策としては、戦略的には、自然と人間の協調、とくに人口、経済、社会、水資源、生態環境を相互に関連づけて考える必要がある。
- ・また循環経済学と循環社会学の新しい概念を用いて、recycling ecologyを提示する必要がある。
- ・最後に、水とエネルギー、水と土砂、水と塩、需要と供給という4つの均衡を考慮するように、次の7つの施策を提案する。①資源水、生態水、環境水、災害水を総合的に管理する。②水収支の原則を考慮しつつ水資源の利用可能性を評価する。③ Recycling water, Reusing water, Resorcefulization, Recharging groundwater, Reallocating water resources の、5つのRを提起する。④水需要を規制する。⑤国家政策として節水を推進し、水価格の調整も行う。⑥農村貧困地域の水不足問題の解決に向けた取り組みを強化する。⑦長江から黄河への南水北調の実施。



## Water Resources Vulnerability Regarding Environmental Change in the Yellow River Basin, China


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## 1. Brief Introduction / Eco-environmental Issues

Brief introduction of the YRB



The Location Of YRB

### 1.1. Basic Characteristics of Yellow River Basin (YRB)

*Length: 5,464 km*  
*Drainage area: 742,443 km<sup>2</sup>; Basin Area*  
*800,000 km<sup>2</sup>; Farm land 12.6 million ha.*  
*Population: 107 million; Urban population*  
*making up about 24 %.*  
*Water Resources: 71.9 billion m<sup>3</sup> including*  
*groundwater of 13.9 billion m<sup>3</sup> / a.*  
*Hyper-concentrated sediment load: 1.6*  
*billion tones / a.*

### 1.2. Problems of Eco-environment in the YRB

### 2.1.1. Problems in upstream headwaters

**Major problems:**

- Shrinking of lakes at headwaters
- Drying up main channels
- Degradation of grass lands
- Desertification
- Glaciers recession



**SOIL EROSION AREA**  
**754 km<sup>2</sup>**  
After Wang Qinghai



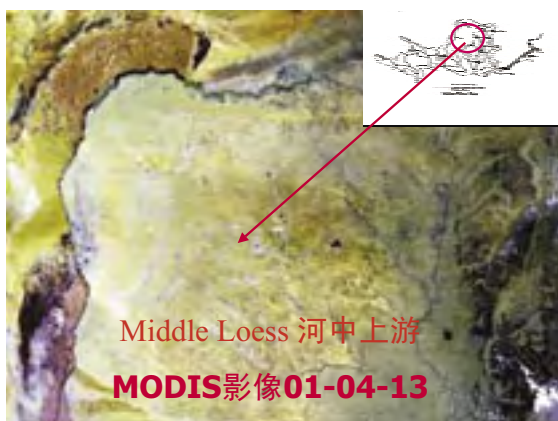
**Desertification**  
**in Headwater Area**



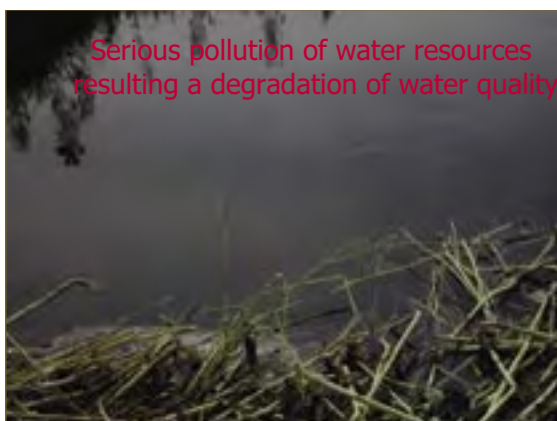
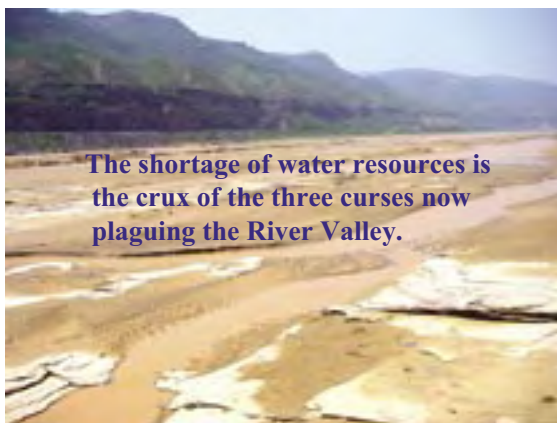
**1.2.2. Problems in middle Loess**

Major problems:

- Soil erosion and water deficit
- Deforestation
- Desertification
- Water pollution
- Storm-water flooding



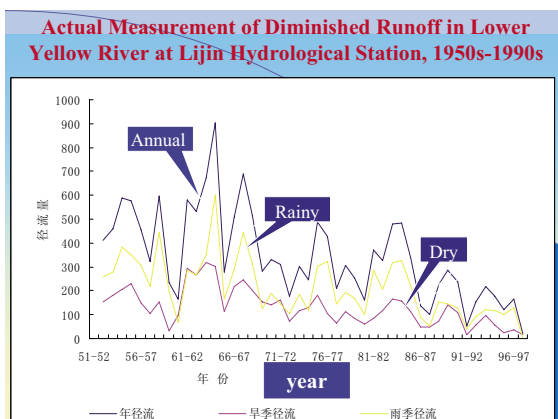
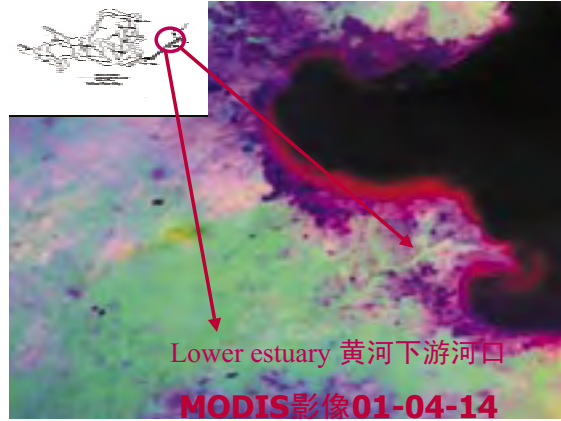




### 1.2.3. Problems in lower reaches

Major problems:

- **Drying up of main courses**
- **Sedimentation**
- **Suspending of river channel**
- **Flooding threat as dike breaching**
- **Water pollution**
- **Wetland ecology of Delta / Estuary**



### Water Scarcity under an abuses can easily increase vulnerability:

#### ESPECIALLY UNDER FOLLOWING:

- Climatologic background (aridity > 1 in YRB)
- Water pollution (> grade III)
- Lower water use efficiency (water wasting)
- Very higher growth rate of socio-economy
- Lack of adequate water projects and water management

### Water scarcity under an abuses may resulted in vulnerability:

#### Eco-environment degradation

- Eco-environment is independent on water;
- Water withdrawal, land cover & land use are main driving force for water cycle;
- Climate Change & human activities would be superposed factors for both water & the eco-environment;
- The feedbacks between them are highly complex;
- Eco-environment degradation in the Yellow River basin mainly resulted from abuse / over-use & pollution

#### Abuse & over-use

Withdrawing capacity > Discharge

Annual Flow:

黄河年平均流量 = 1840 cms

Withdrawal Capacity:

流域总引水能力 = 6000 cms

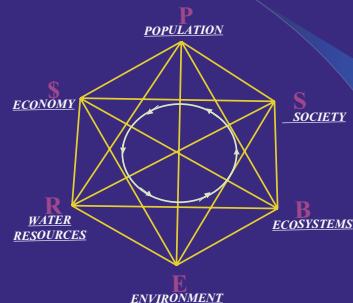
下游总引水能力 = 4000 cms

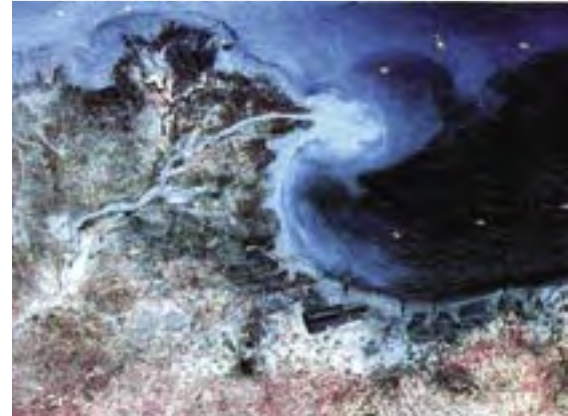
下游占流域总引水能力的67%

## 3. Discussions: Some Strategy Concerns and Countermeasures

### 3.1. Some Strategy Concerns

#### 3.1.1. A HUMAN-WATER HARMONY “SIX” CLOSELY RELATED COMPLEX: ( Human and Nature Harmony )



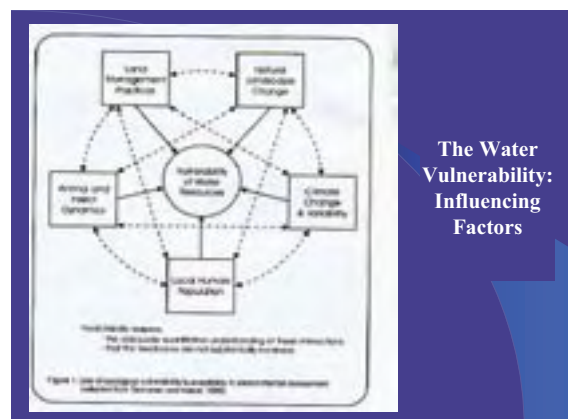


## 2. Vulnerability of Water Resources and Analysis

### Vulnerability of Water Resources

- Vulnerability of water resources system is due to unevenly temporal and spatial distributions of water resources mismatching of water supply and water demand. The annual and seasonal variance of water resources is a key issue of the system vulnerability.

- The vulnerability of the water resources system may be resulted mainly from climate change and the human activities.
  - ❑ Human activities have changed the process of water cycle and its feedbacks would increase the vulnerability.
  - ❑ Climatic change, especially the changes of the swing of precipitation and the frequency of the extreme evidence have a great impact on water resources system and
  - ❑ Many others ( pls see figure below)

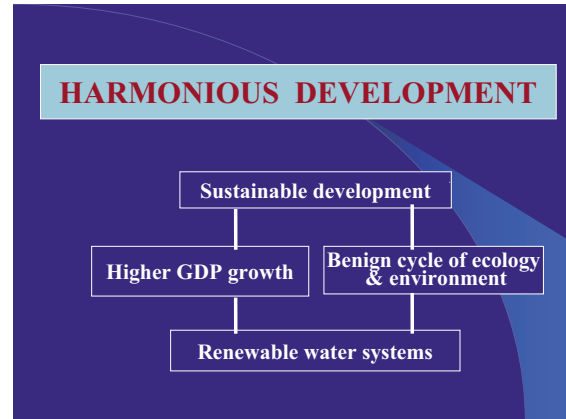




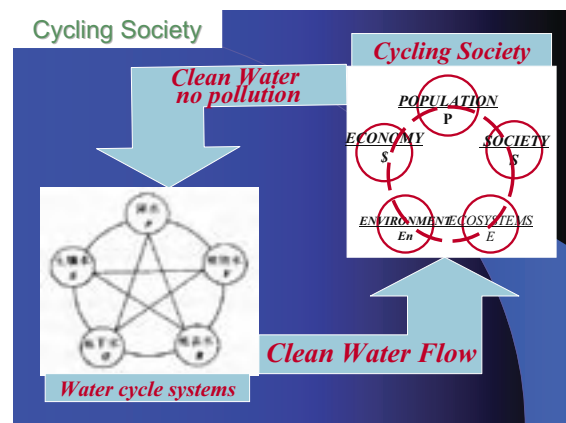
**A DEDUCTIVE MATRIX:  
30 子系统相互演绎矩阵**

	P	\$	S	R	B	E
人口	P	P/\$	P/S	P/R	P/B	P/E
经济	\$	1	\$/S	\$/R	\$/B	\$/E
社会	S	S/P	1	S/R	S/B	S/E
水源	R	R/P	R/\$	1	R/B	R/E
生态	B	B/P	B/\$	B/S	1	B/E
环境	E	E/P	E/\$	E/S	E/R	1

More coupling subsystems can be taken for study



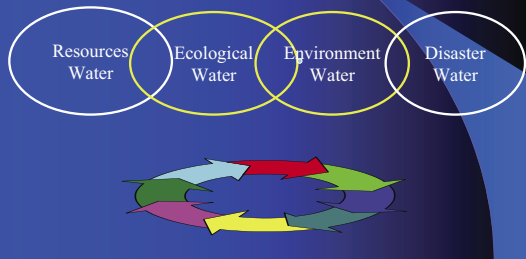
### 3.1.2. Cycling Economy & Cycling Society 循环经济与循环社会



- ### 3.1.3. : Eco-environmental Flows Need For Keeping “Four Balances”
- The balance of ecosystem is a hard base for sustainable development as water is one of the most key factors for the eco-environment and the socio-economy at basin and regional levels.
  - The “Four Balance” must be concerned:
    - water-energy balance
    - water-sediment balance
    - water-salt balance
    - water balance and demand-supply balance

## 3.2. Some Countermeasures

### 3.2.1. Integrated & unified management for “4 waters” regulating & sharing system:



### 3.2.2. Assessment of the Renewable Capacity of Water Resources

- Assessment of water resources should be on the basis of water interactions (air-surface-soil-aquifer interacted system)/transforming mechanism.
- Water quantity and quality should be assessed by water balance law. Precipitation is the origin of all kinds of water resources.

### 3.2.3. Five “R” -- Recycling Water, Reuse, Resourcefulness, Recharge & Reallocation

Five “R” are:

- Recycling water from all sectors against pollution
- Reusing water against water wasting
- Resourcefulness, incl. marginal waters
- Recharging groundwater against overdraft
- Reallocation water resources areally

### 3.2.4. Controlling Water Demand :

- Increase water use efficiency (WUE)
- Take water demand of ecosystem and environment into account
- Realize water demand to reach a “zero growth” by enhancing water-saving

### 3.2.5. Water-saving seen as the National Policy

- Integration of water-saving measures
- High tech for water-saving with training
- Helpful to pollution protection  
“Killing two birds with one stone” in terms of reducing both water demand and wasted water discharge.
- Water pricing regulation

### Price elasticity of water resources in China and Yellow River Basin:

about	-0.3 to -0.6
in industrial sector	-0.45 to -1.37
in agricultural sector	-0.37 to -1.50
(in Yellow river Basin	-0.25)

To increase 10 % of water fee would reduce 2.5% of water demand in Yellow river Basin .

3.2.6. To develop rainwater catchment:  
“strong water” and “weak water”

strong means stream flow rate in m / s  
weak means rainfall rate in mm / min

$$\text{strong} / \text{weak} = (\text{m} / \text{mm}) / (\text{min} / \text{s}) = 60000.$$

-- For rural areas where is distant from water courses, so-called micro-hydro-projects in the Yellow River basin.

3.2.7. Proved South to North Water transfers

