与中国黄河流域环境变化相关的水资源脆弱性

刘 昌 明

- 黄河是大河，包含着一系列的环境生态问题。在中国，环境和生态一起被称为“环境生态 eco-enviroment”，指宏观上的人类的生存环境。
- 黄河的源流地区是主要的水源地。但是，出现了水量减少、湖河断流、草原退化、沙漠化、冰河缩小及后退、土壤侵蚀等问题。
- 中游地区的土壤侵蚀及水不足、森林采伐、沙漠化、水源污染、暴雨带来的洪水五个问题日益严重。
- 1972年开始到20世纪末，黄河每五年发生四次断流。并且存在土石堆积、河床升高等问题，因洪水而起的堤防破裂的危险性也在增大。此外，还存在着水污染、山东省黄河口的生态平衡问题。
- 下游地区，由于气候变化和人类活动两方面的影响，河川流量明显减少。
- 水资源的脆弱性源于气候和人类活动两个方面，并且由于水的需求和供给之间的不平衡，问题变得更加复杂。即，由于水资源不足和水资源利用方法的不合理，水资源的脆弱性问题很轻易的就发生了。
- 异常低的水资源利用效率、经济和社会的过热及过度发展关系着水资源的脆弱性。在有良好水利设施的地方没有对水资源利用的限制。
- 黄河年均流量约每秒1800m^3，但是黄河流域水利设施的引水能力每秒达6000m^3，其中大部分集中在下游。
- 气候变化和人类活动引起的水资源的脆弱性对生态环境也造成了影响。其反馈机制非常复杂，黄河流域的生态环境退化在持续。
- 作为对策，战略上我们应该思考自然和人的和谐，特别是有必要将人口、经济、社会、水资源、生态环境相互联系起来。
- 并且，循环经济学和循环社会学有必要运用新的概念，提示 recycling ecology。
- 最后，为了思考水和能源、水和土砂、水和盐、供给和需求 4 个平衡，提出以下 7 点措施。①综合管理资源水、生态水、环境水、灾害水；②考虑水收支原则的同时，评价水资源的利用可能性；③提出 5 个 R：Recycling water, Reusing water, Resorcefulization, Recharging groundwater, Reallocating water resources；④限制水需求；⑤作为国家政策来推进节水，调整水价；⑥加快解决农村贫困地区的水资源不足问题的步伐；⑦实施从长江到黄河的南水北调。

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

Changming LIU,
College of Environmental Sciences, Beijing Normal University; Beijing 100875, China;
Institute of Geographical Science and Natural Resource Research, The Chinese Academy of Sciences, Beijing 100101, China; E-mail: cmliu@cmliu.org

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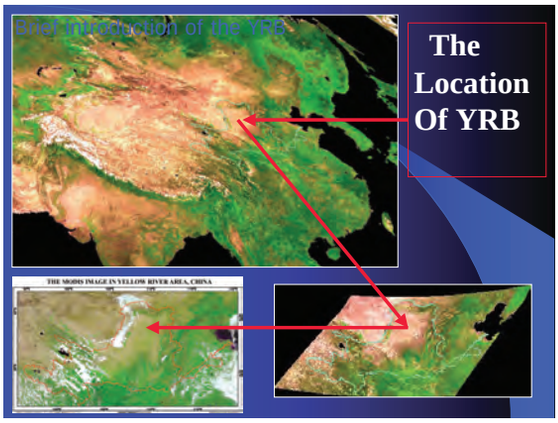
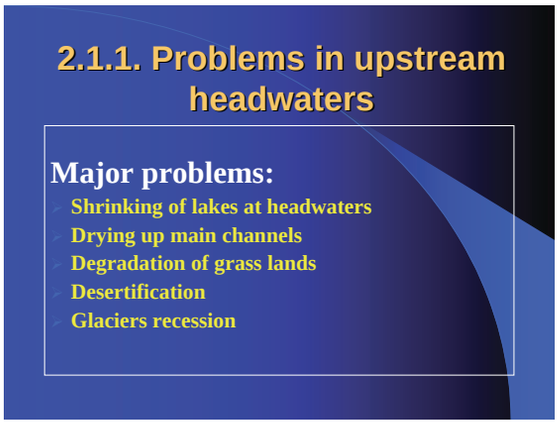
1. Brief Introduction / Eco-environmental Issues

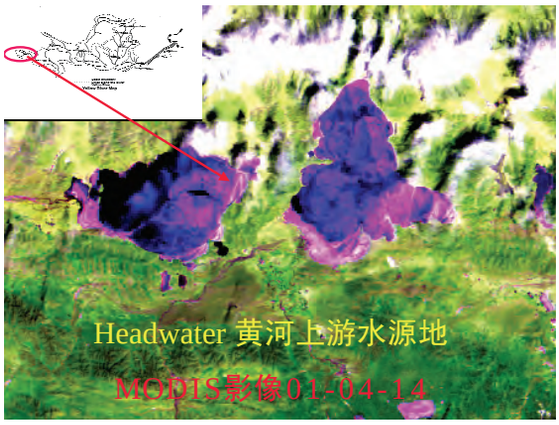


1.1.Basic Characteristics of Yellow River Basin (YRB)

Length: 5,464 km
Drainage area: 742,443 km²; Basin Area 800,000 km²; Farm land 12.6 million ha.
Population: 107 million; Urban population making up about 24 %.
Water Resources: 71.9 billion m³ including groundwater of 13.9 billion m³ / 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


Headwater 黄河上游水源地
MODIS影像01-04-14

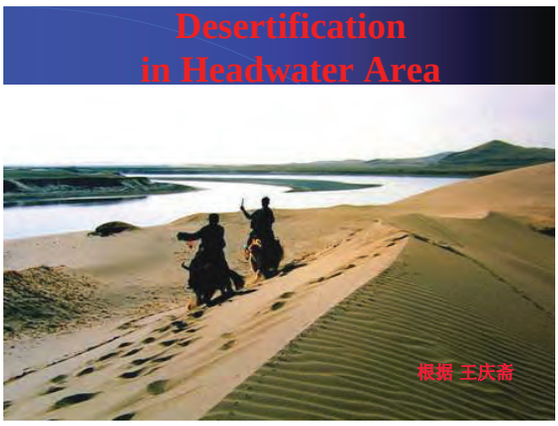

LAKE SHRINKING AT HEADWATERS
根据 王庆斋
2002 9 22
After Wang Qingzhai

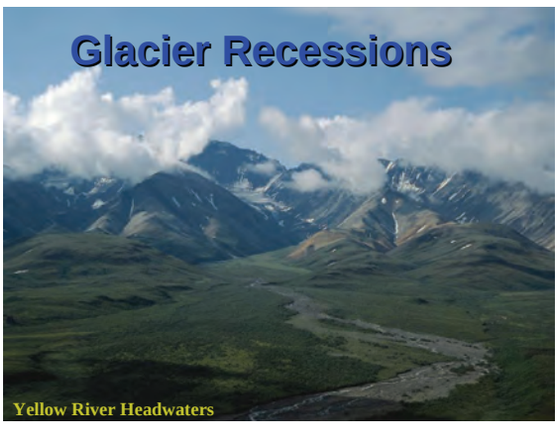

Overgrazing
根据 王庆斋

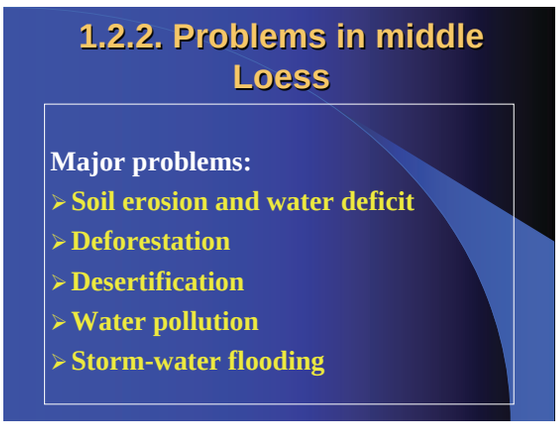

Pasture degrading and losing biodiversity
根据 王庆斋

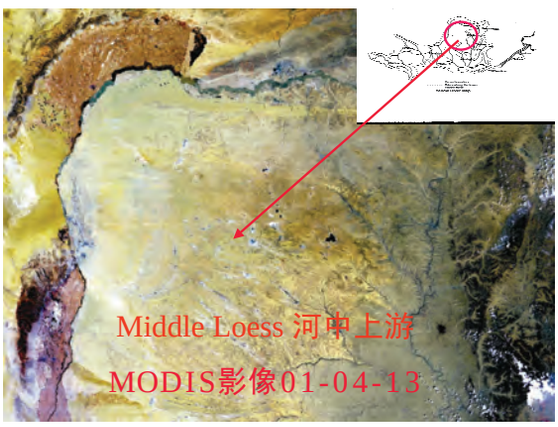

Pasture degradating And habitants removing
After Wang Qingzhai
根据 王庆斋
Mouse disaster


SOIL EROSION AREA
754 km²
After Wang Qingzhai
根据 王庆斋


Desertification
in Headwater Area
根据 王庆斋


Glacier Recessions
Yellow River Headwaters

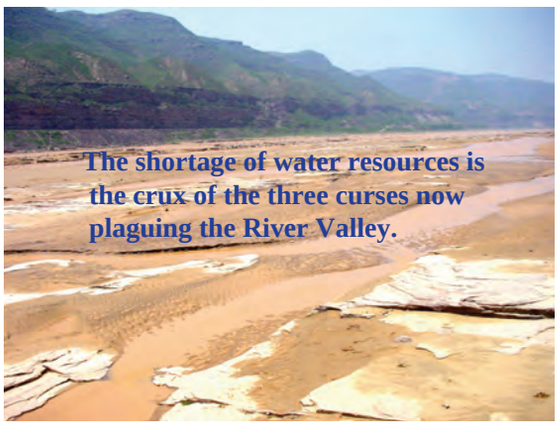

1.2.2. Problems in middle Loess
Major problems:
➢ Soil erosion and water deficit
➢ Deforestation
➢ Desertification
➢ Water pollution
➢ Storm-water flooding


Middle Loess 河中上游
MODIS影像01-04-13


Landscape: Soil Erosion


Deforestation in Middle Reaches


Desertification in the mid-reaches
The areas of desertification have mainly happened in following localities
(1) Degraded grassland; (2) Sandy soil area;
(3) Sanded area; (4) Dry farming lands


The shortage of water resources is the crux of the three curses now plaguing the River Valley.


River Water Pollution
Pollution with black color

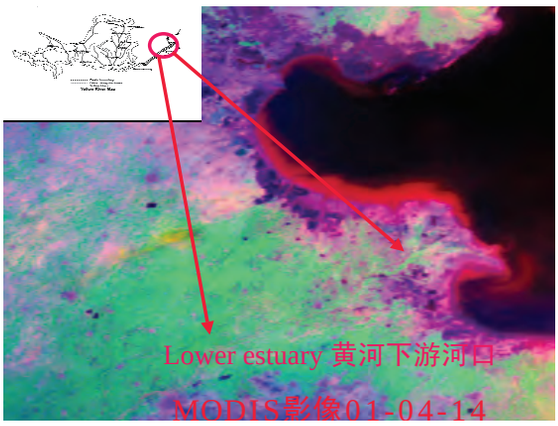

Serious pollution of water resources resulting a degradation of water quality

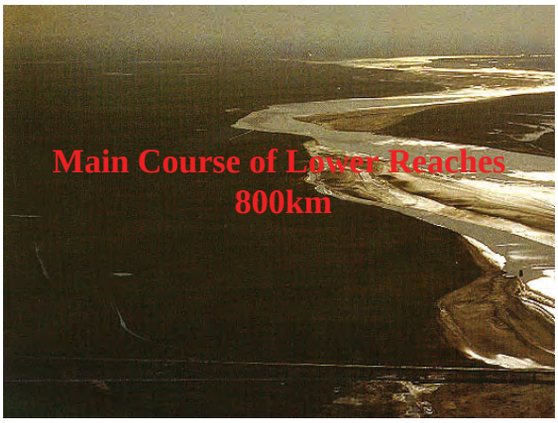

Garbage Wasted Pollution
（晋陕峡谷地区）

1.2.3. Problems in lower reaches

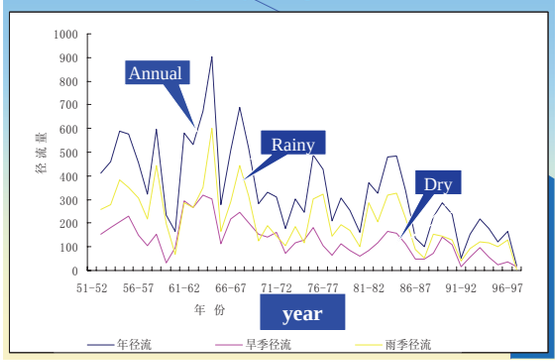
Major problems:

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





Actual Measurement of Diminished Runoff in Lower Yellow River at Lijin Hydrological Station, 1950s-1990s



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)

The Water Vulnerability: Influencing Factors

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%

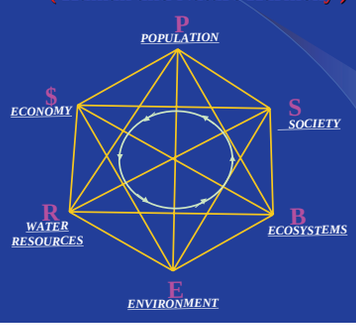
3. Discussions:

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)

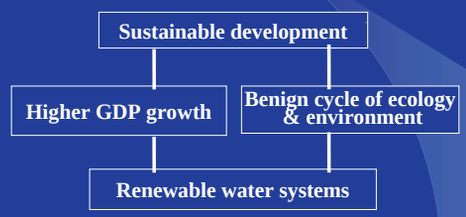


A DEDUCTIVE MATRIX:
30 子系统相互演绎矩阵

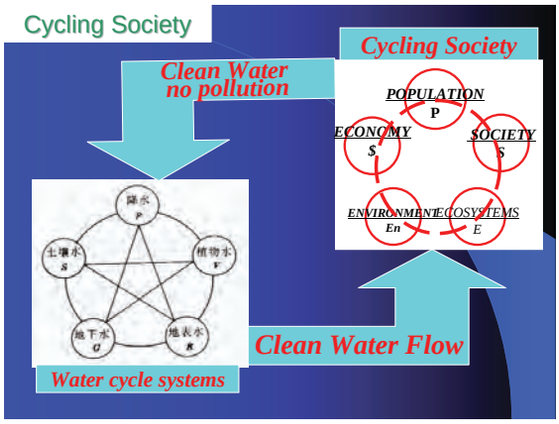
		P	$	S	R	B	E
人口	P	1	P/$	P/S	P/R	P/B	P/E
经济	$	$/P	1	$/S	$/R	$/B	$/E
社会	S	S/P	S/$	1	S/R	S/B	S/E
水源	R	R/P	R/$	R/S	1	R/B	R/E
生态	B	B/P	B/$	B/S	B/R	1	B/E
环境	E	E/P	E/$	E/S	E/R	E/B	1

More coupling subsystems can be taken for study

HARMONIOUS DEVELOPMENT



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"

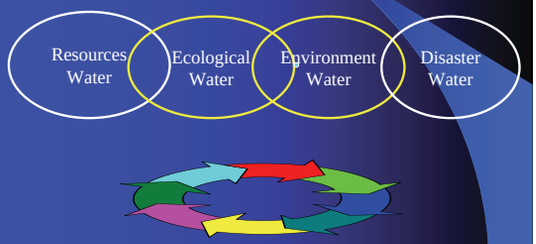
- The balance of ecosystem is a hard base for sustainable development as water is one of the most key factors for the eco-environment and the socio-economy at basin and regional levels.

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
- Resourcefulization, incl. marginal waters
- Recharging groundwater against overdraft
- Reallocating 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

strong / weak = (m / mm) / (min / 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