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Ecological Co-management of Water and Nutrients in Natural and Cultivated Wetlands of Sanjiang Plain



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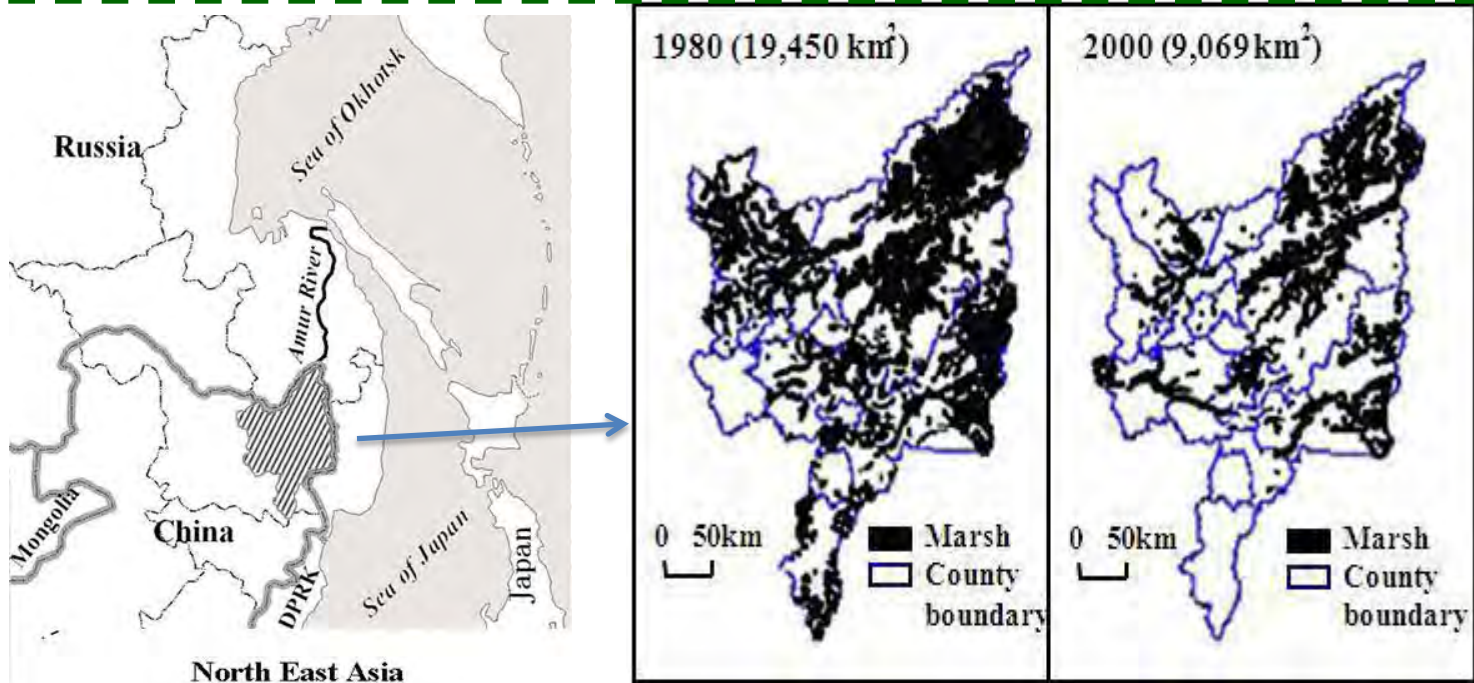




Outline

- **Natural wetlands in Sanjiang Plain**
 - ✓ Wetland loss
 - ✓ Wetland-loss induced change
 - ✓ Wetland protection
- **Rice cultivation in Sanjiang Plain**
- **Co-management of natural and cultivated wetlands**

Wetland loss





Wetland loss-induced changes

- **Hydrology**
- **Climate**
- **Soil**

Intensive water management



- ✓ Surface water diversion
- ✓ Surface water drainage
- ✓ Ground water irrigation

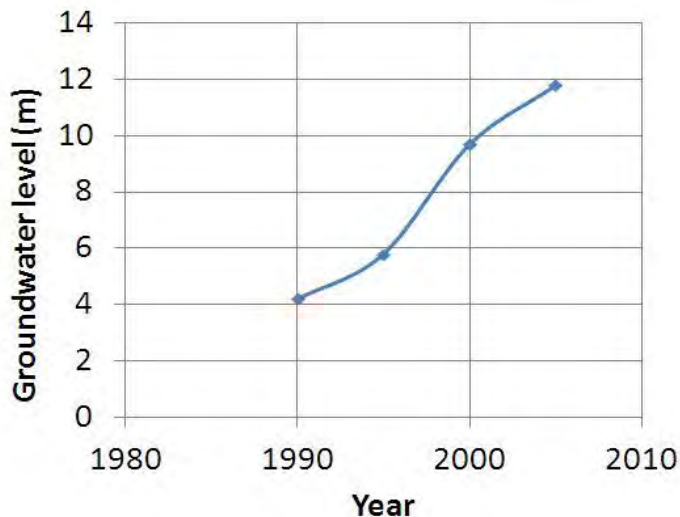




Intensive water management dries Sanjiang Plain

Year	Area (km ²)	Depth/yr (m/yr)	Volume/yr (billion m ³ /yr)
1949	3.4 x 10000	0.25	8.5
2005	0.81 x 10000	0.25	2.0

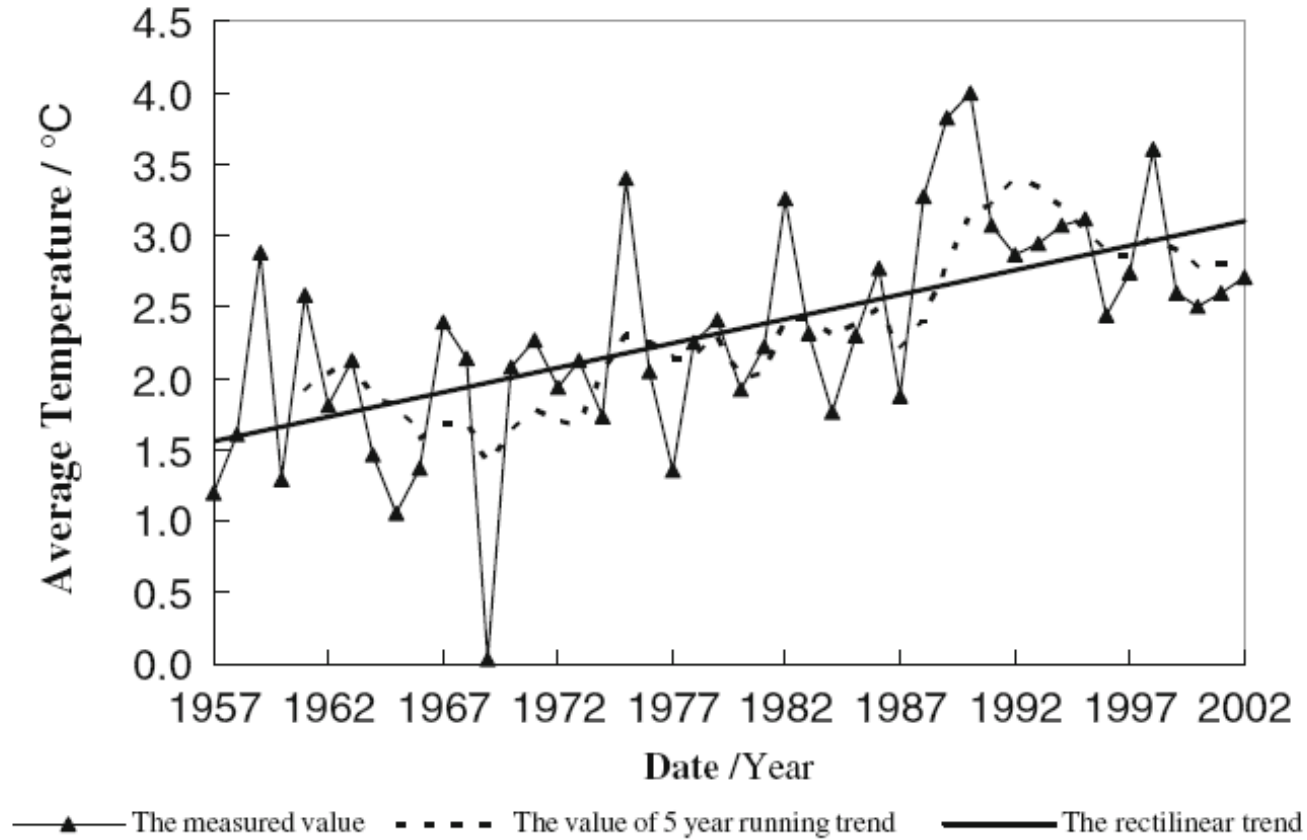
Great loss of wetlands causes greatly loss (diversion) of surface water



The rapid increase of groundwater-based rice cultivation since 1990, causes greatly lowered groundwater level in <20 years (adopted from Liu, 2007).



Dried Sanjiang Plain contributes to a warmer climate



Temperature change in the Jiansanjiang area (Zhou et al., 2009)

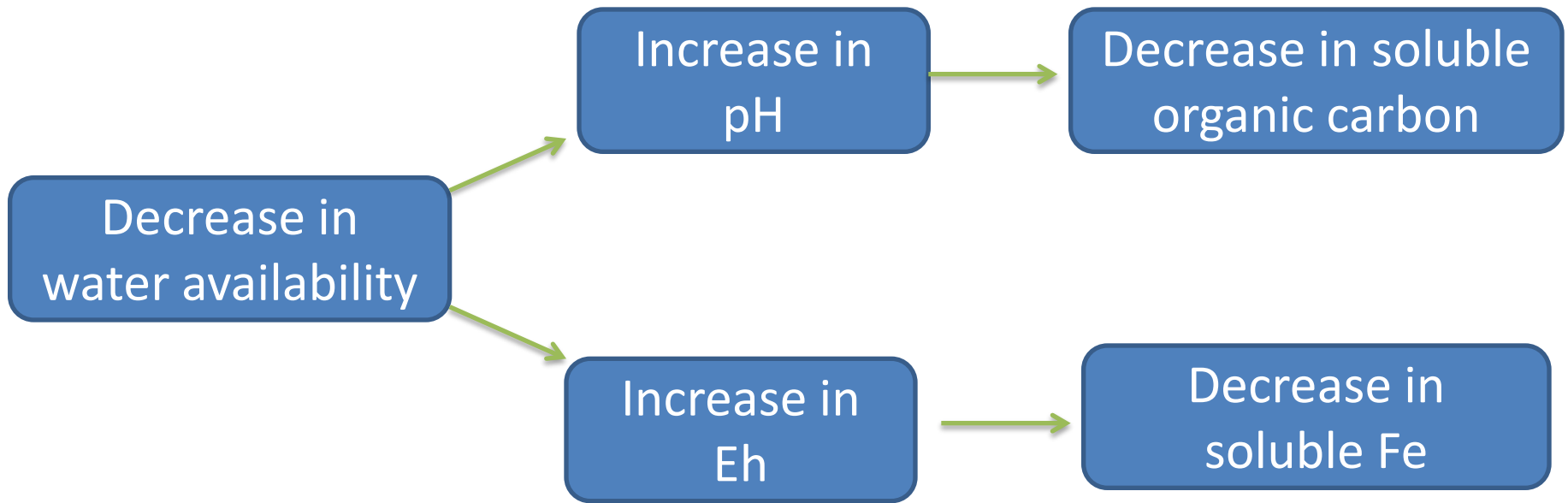


Wetland loss-induced changes

- Hydrology
- Climate
- **Soil**
 - Soil chemistry
 - wetland sustainability
 - Carbon sequestration



Water change promotes wetland soil chemical change



The decrease in water availability in wetland soil is the primary factor to promote wetland soil chemical change



Wetland isolation causes wetland degradation

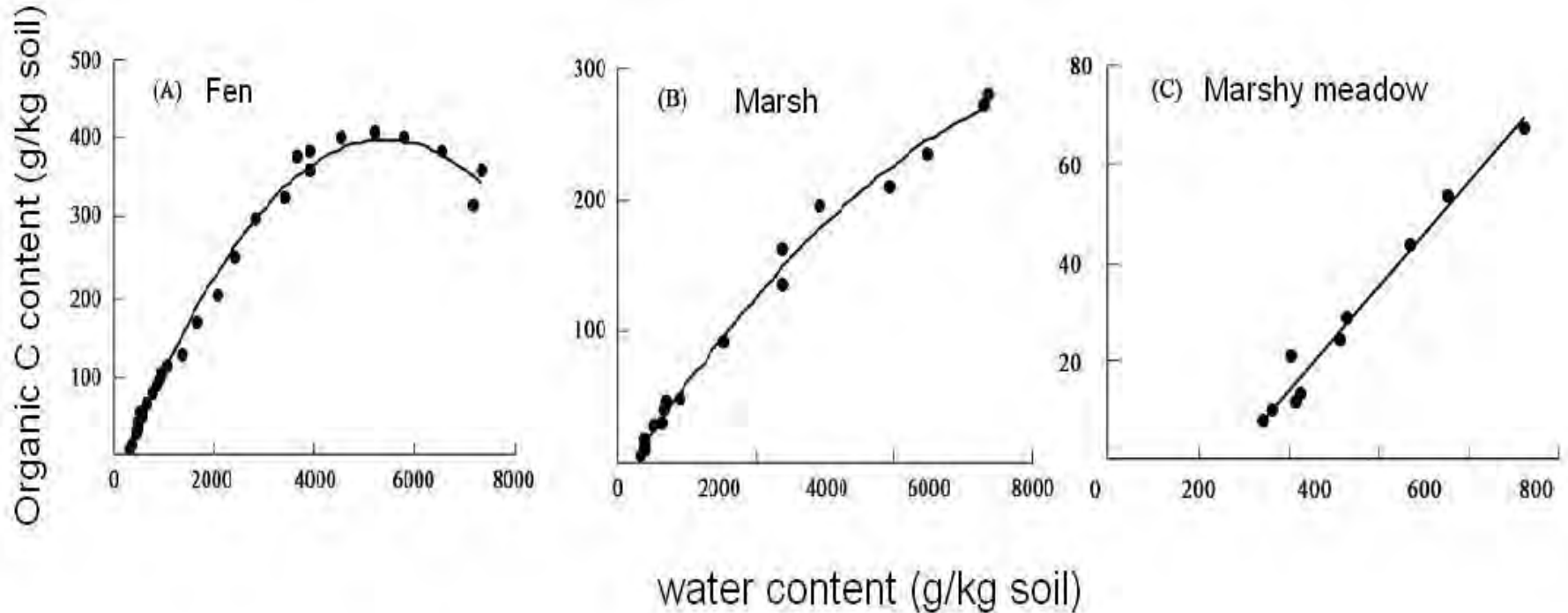
landscape changes of the protected Honghe wetland zone
(km², established in 1984) (Bian, 2006)

Year	water	Marsh	Forest	Grass	crops	Roads, etc.
1967	1.17	187.2	29.9		0	0
1985	1.13	180.7	36.5		0	0
1993	0.3	149.6	58.4	4.2	5.2	0.74
2004	0.3	147.6	58.4	4.2	7.2	0.74

A primary cause for wetland degradation: water shortage due to cut off upstream water input and drainage of downstream water



Lowered water availability lowers carbon sequestration in wetland soils



In a wide range of water availability, a decrease in water content lowers organic carbon content in three typical wetland soils of Sanjiang Plain (Tong et al., 2005)



Wetland protection

- **To establish more wetland protection zones**
 - ✓ In 2011, Qixinghe and Zhenbaodao wetland protection zones (Jiansangjiang area) are listed as internationally important wetlands.
- **To expand/restore more riparian wetlands**
 - ✓ Easier to restore and easier to sustain



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- Natural wetlands in Sanjiang Plain
- **Rice cultivation in Sanjiang Plain**
- **Co-management of natural and cultivated wetlands**



Rice cultivation in Sanjiang Plain

Year	Sanjiang Plain (M ha)	Heilongjiang Province (M ha)
1990	0.22	0.76
2000	1.04	1.60
2010	1.80-2.20*	2.97

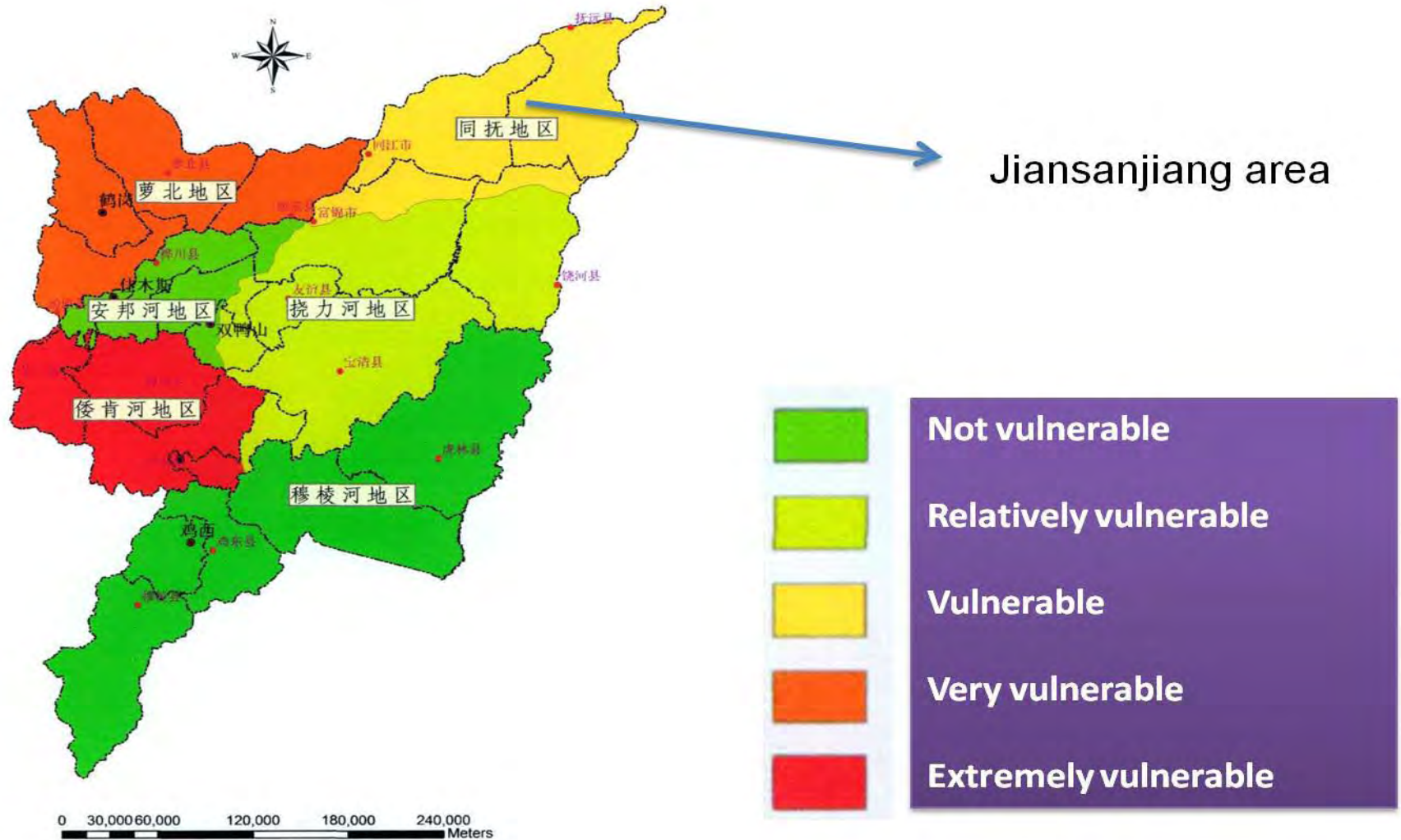
*Estimated



Rice cultivation heavily relies on groundwater

- >50% of agricultural fields in Sanjiang Plain for rice cultivation in 2010.
- >70% of rice cultivation relied on groundwater in 2010

Groundwater vulnerability in Sanjiang Plain (Liu, 2007)





Outline

- Natural wetlands in Sanjiang Plain
- Rice cultivation in Sanjiang Plain
- **Co-management of natural and cultivated wetlands**
- ✓ **Surface water-based rice cultivation**
- ✓ **Ecological pollution control in rice cultivation**



Surface water-based irrigation system in Sanjiang Plain

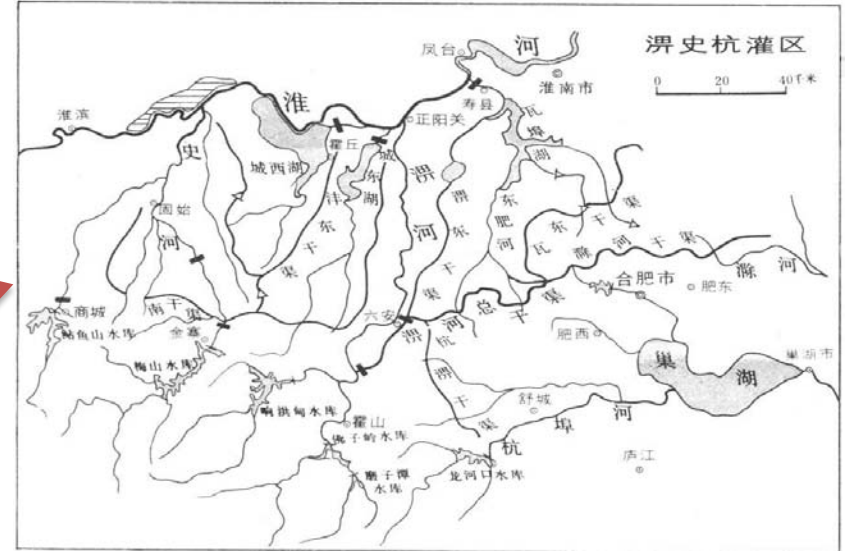
- ✓ **Status: to be significantly expanded and re-constructed with better coordination in surface water use across the whole Sanjiang Plain**

Approaches

1. Increase surface water utilization efficiencies within watersheds
2. Diversion of surface water from big rivers
3. Creation/restoration of wetland-based aquatic environments

A good example: Pi-Shi-Hang irrigation system, China

Main watersheds of China



To control floods for area of 1.4 Mha

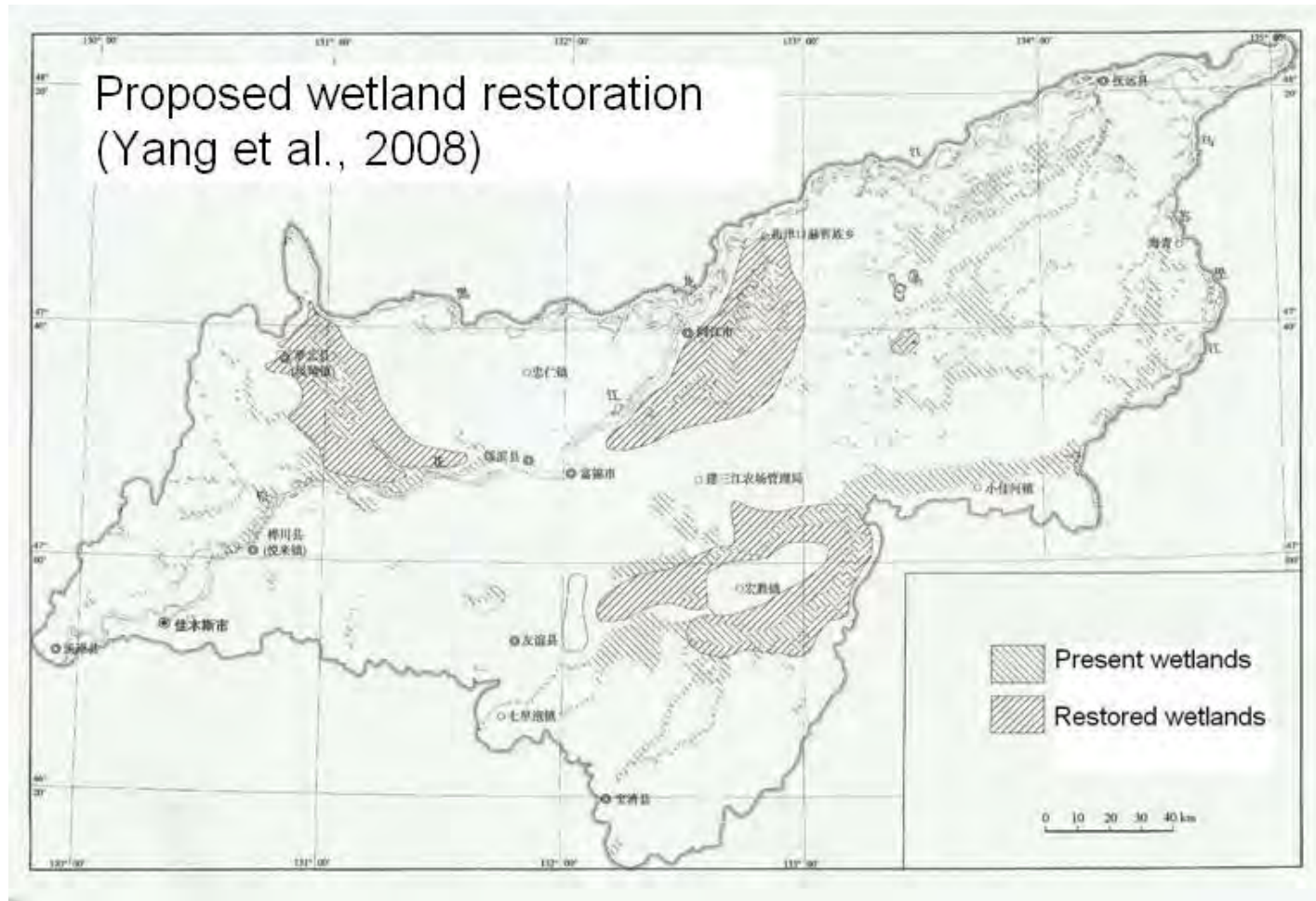
To irrigate fields of 0.67 Mha



Trends in rice cultivation in the Jiansanjiang region

- 1. Rice cultivation increased from 0.51 M ha in 2010 to 0.57 M ha in 2011 (occupying 78% cultivated soils) , through re-conversion previous upland fields**
- 2. Diversion and irrigation projects under construction to supply surface water for 80% of rice cultivation**
- 3. Groundwater environment is expected to be improved**

Wetland restoration to facilitate irrigation and flood control in Sanjiang Plain



Where : old river channels; recently converted wetlands; riparian wetlands

How much: up to 0.4 M ha

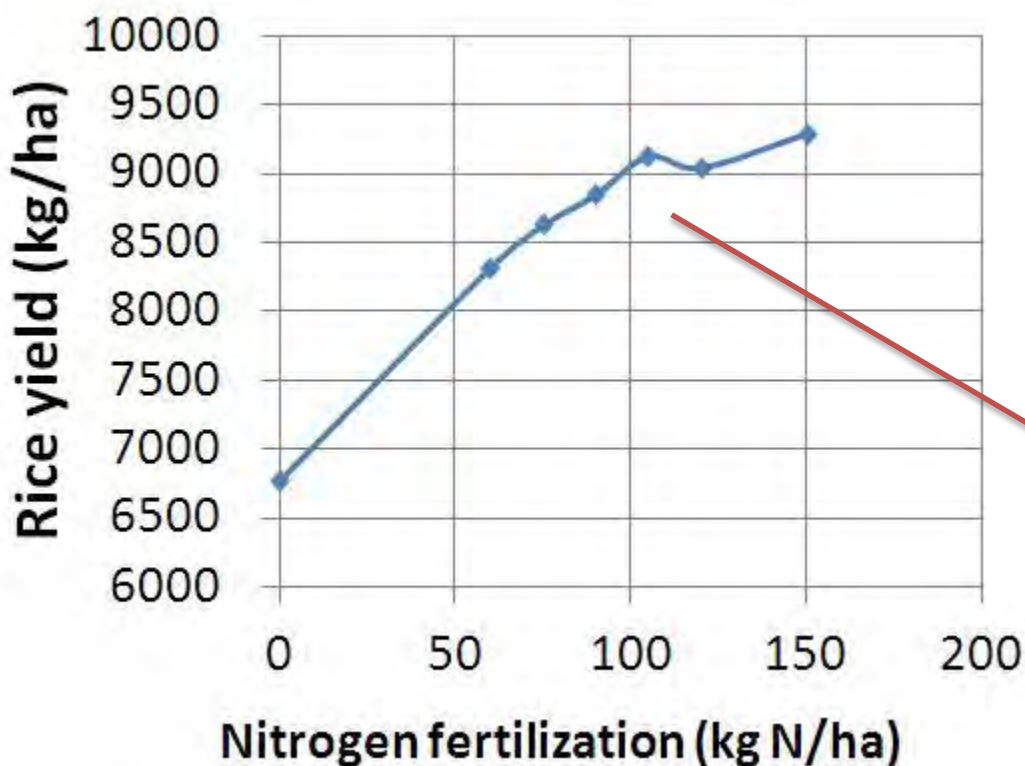


Outline

- Natural wetlands in Sanjiang Plain
- Rice cultivation in Sanjiang Plain
- Co-management of natural and cultivated wetlands
- ✓ Surface water-based rice cultivation
- ✓ **Ecological pollution control in rice cultivation**
 - Fertilizer
 - Pesticides and herbicides
 - Residual biomass
 - Runoff

Ecology and economy in nitrogen fertilization

Rice yield affected by nitrogen fertilization in Sanjiang Plain (Jiang, 2011)



Nitrogen over-fertilization (typically around 150 kg N/ha) is common in rice cultivation in Sanjiang Plain.

Nitrogen fertilization around 100 kg N/ha is economically and ecologically feasible



Nitrate pollution in drinking water

- Nitrate in drinking water from three national farms of the Jiansanjiang area (Li, 2007)

Farm	NO ₃ -N (mg/L)
859 national farm	23.6*
Shengli national farm	27.3
Qixing national Farm	28.8

*The level of naturally occurring nitrate is typically < 5 mg N/L; The level of nitrate for drinking water recommended by WHO is <10 mg N/L



Residual biomass treatment

- On-site burning
- Electricity generation
- Recycling to improve soil productivity



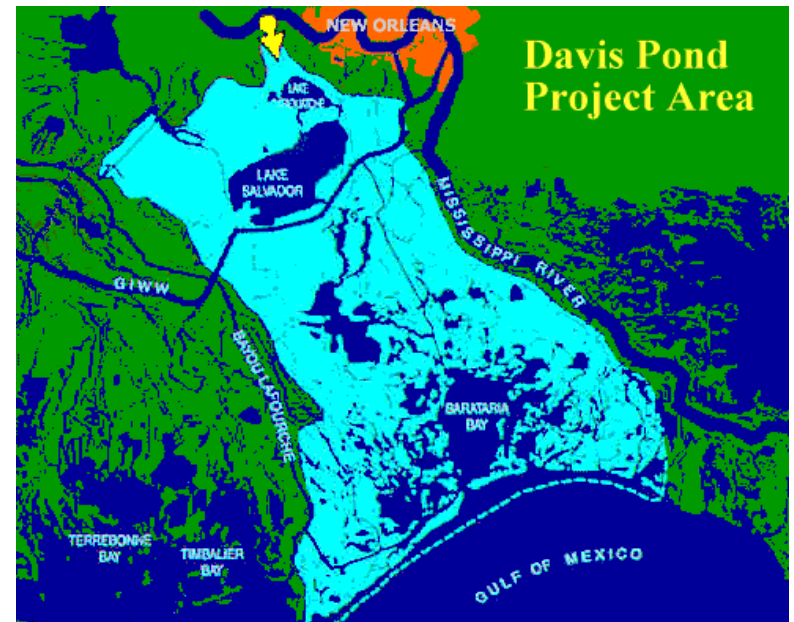
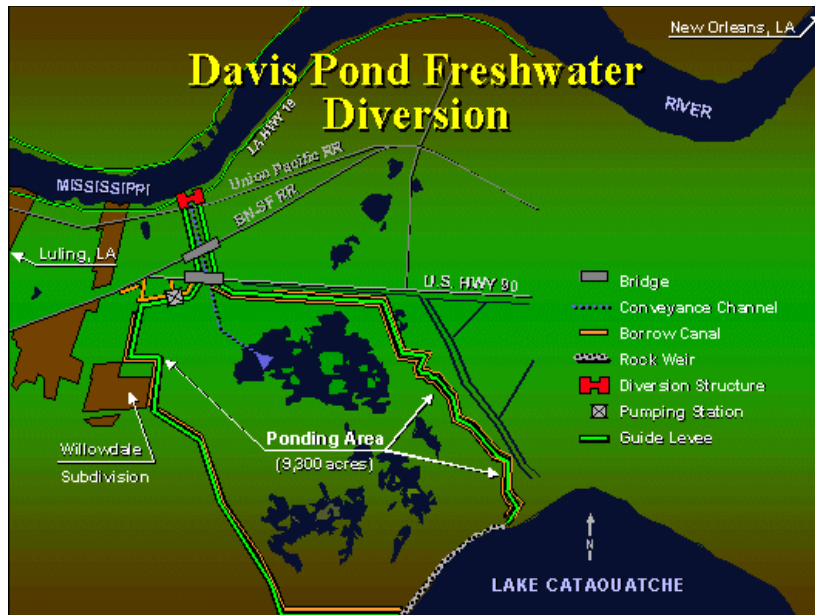


Agricultural runoff treatment

- **Treatment by wetlands**
 - ✓ To provide nutrients for wetland plants
 - ✓ To reduce nonpoint pollution

Diverting Mississippi river water to wetlands

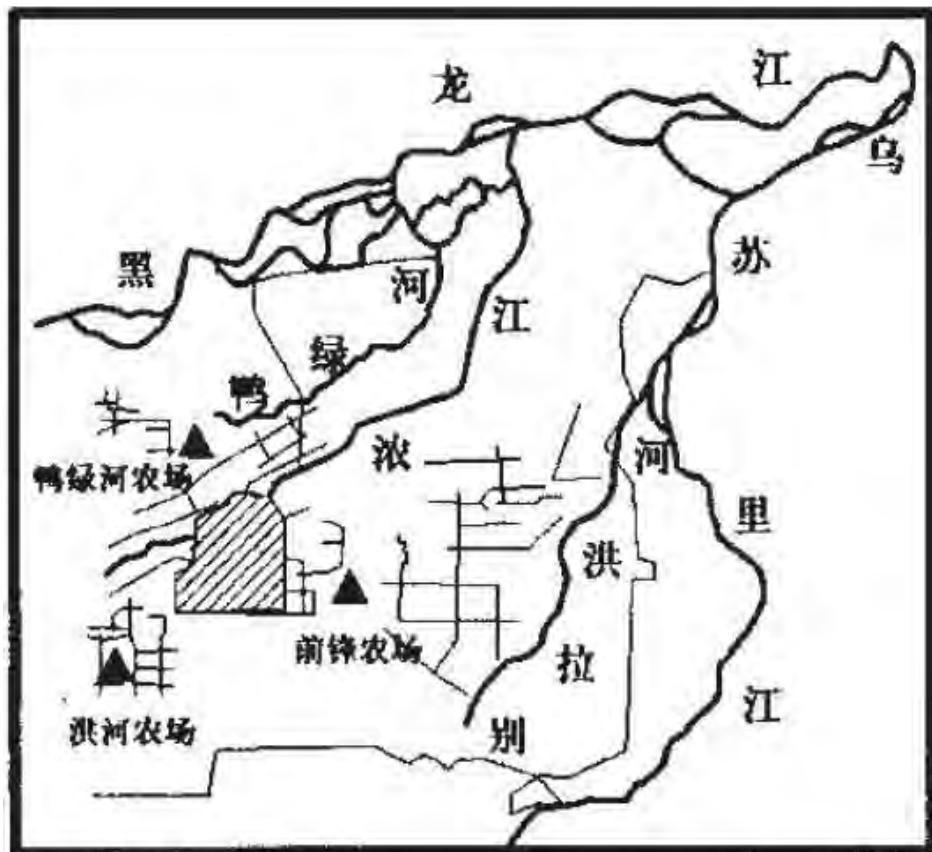
● Water diversion in Mississippi River Delta, USA



Two main purposes (Carpenter et al., 2007):

- ✓ To supply mineral nutrients and sediments to wetlands
- ✓ To lessen nitrogen loading to the Mississippi River estuary

Water diversion to Sanjiang wetlands



-  Honghe wetland
-  National farm
-  River
-  Drainage channel

Water diversion to the Honghe wetland protection zone

✓ 0.1 billion tons/yr surface water is needed

✓ Surface water input is especially needed during dry years, and is possible with the available water control system

✓ Special attention is needed on ecological risks of pesticides and herbicides



Summary

- **Groundwater-supported rice cultivation will ultimately endanger the sustainability of both natural wetlands and rice cultivation in Sanjiang Plain**
- **Expansion and re-construction the Sanjiang irrigation system to a surface water-based one is essential to sustain rice cultivation and protect natural wetlands in Sanjiang Plain**
- **Input of surface water/agricultural runoff will enhance the sustainability of natural wetlands in Sanjiang Plain**

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