Coastal and Estuarine Restoration in China

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OUTLINE

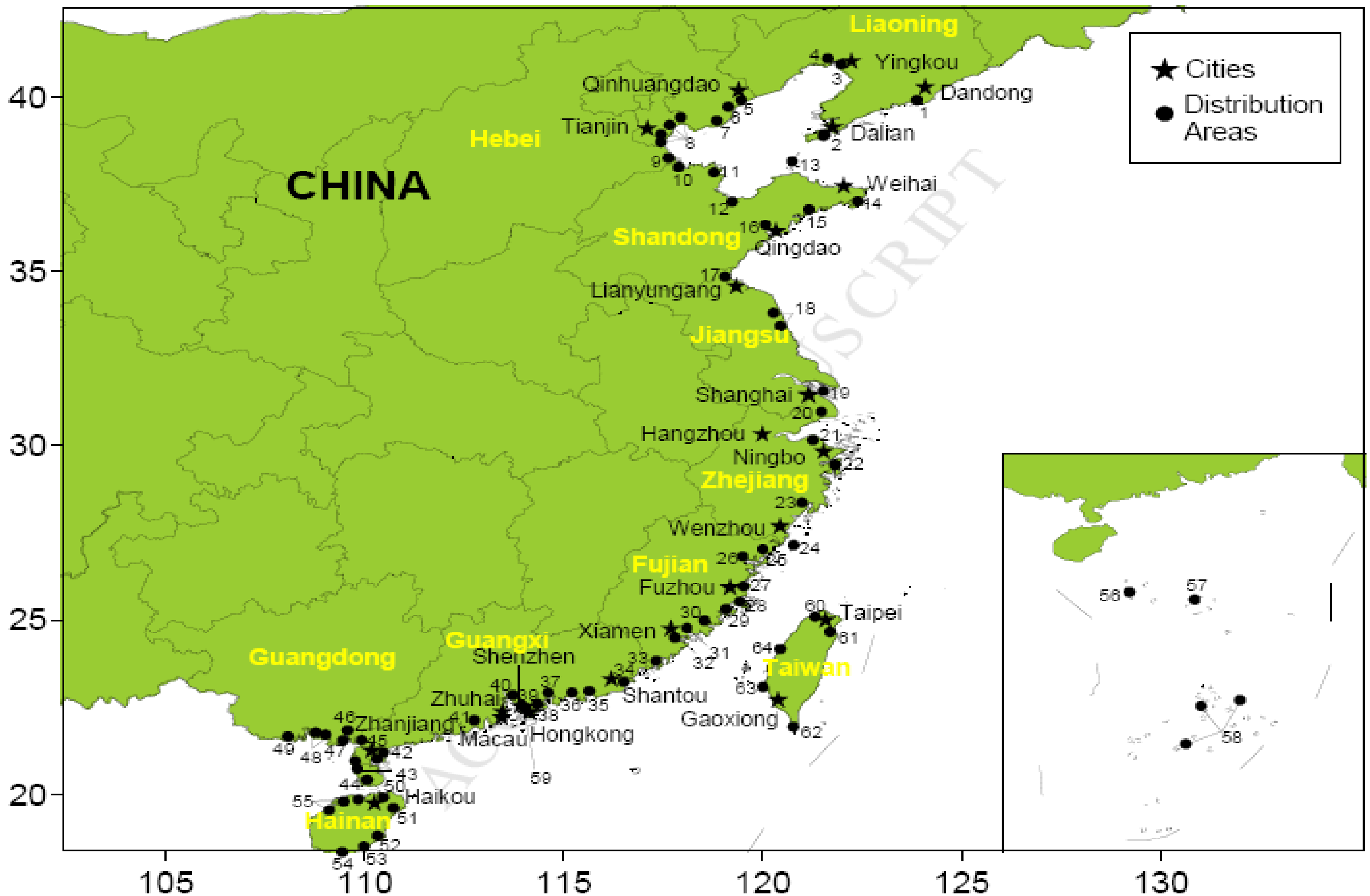
Part 1:Coastal Restoration in China

- Wetland in China
- Coastal restoration in China

Part 2: Research for coastal restoration 1.

- Coastal restoration in general
- Sediment transport
  - . Water quality
  - . Beach erosion （nourishment）

Distribution of main coastal wetlands in China (Ting-ting Jiang et al.(2014)



Characteristics of China's wetlands

Multiple types

31 types of wetlands & 9 types of artificial wetlands

Large area.

Area : about 65.94 million hectares, 10% of the world Wetland

Coastal Wetland: 10.85% of the total wetlands (SFA, 2014).

Wide distribution.

Obvious regional variation.

Abundant biological diversity.

2276 species of advanced plants,

724 species of wild animals

Problem of Wetlands

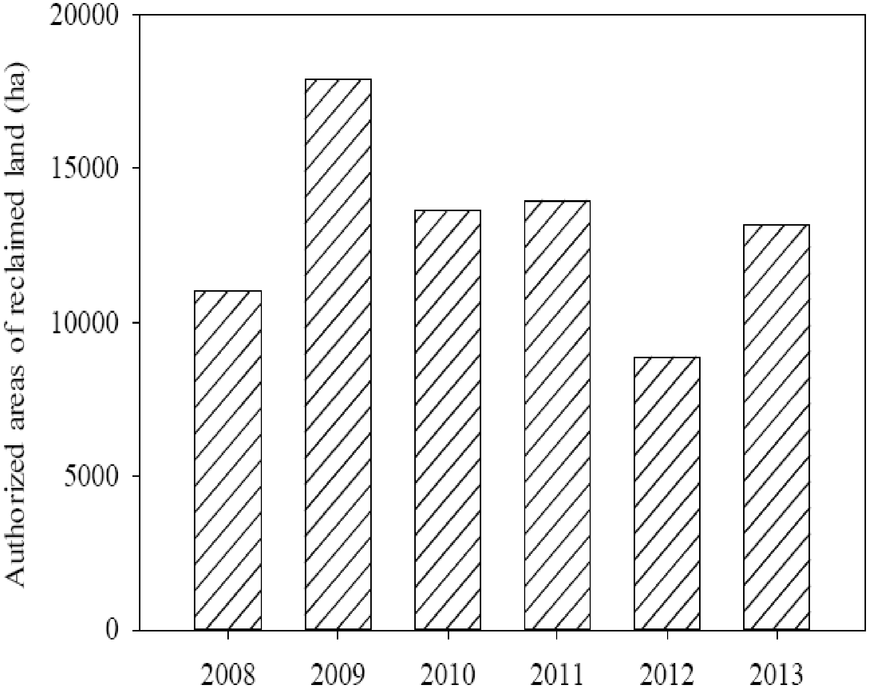
-Decrease of wetland area

-Coastal erosion and sea-level rising

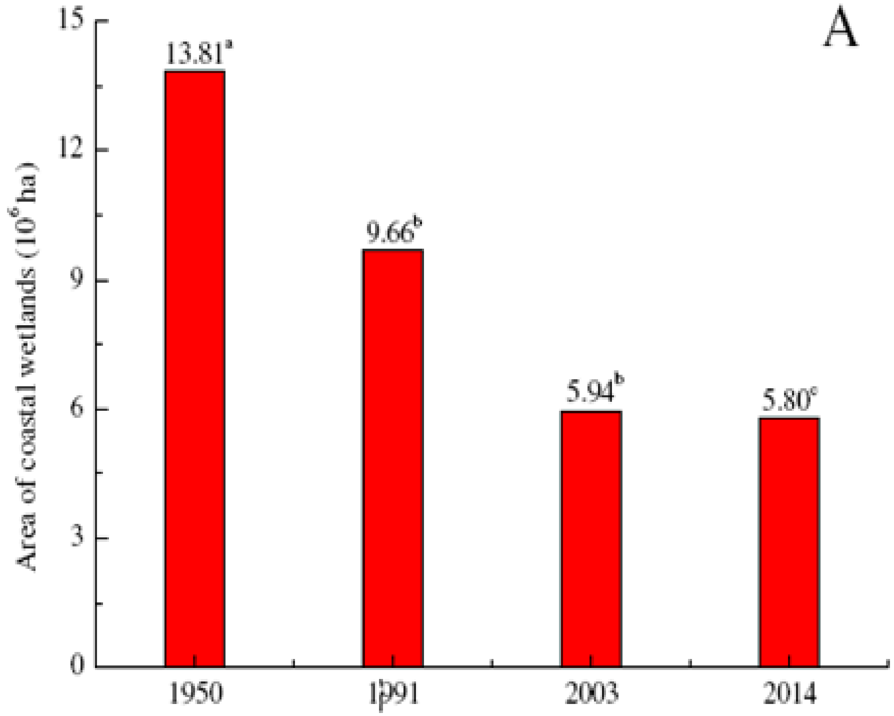
-Serious environmental pollution

-Damaged biological diversity

In China, 23% of freshwater swamps, 16% of lakes, 15% of rivers and 51% of coastal wetlands disappeared over the past 50years, due to reclamation and urbanization (An et al., 2007).

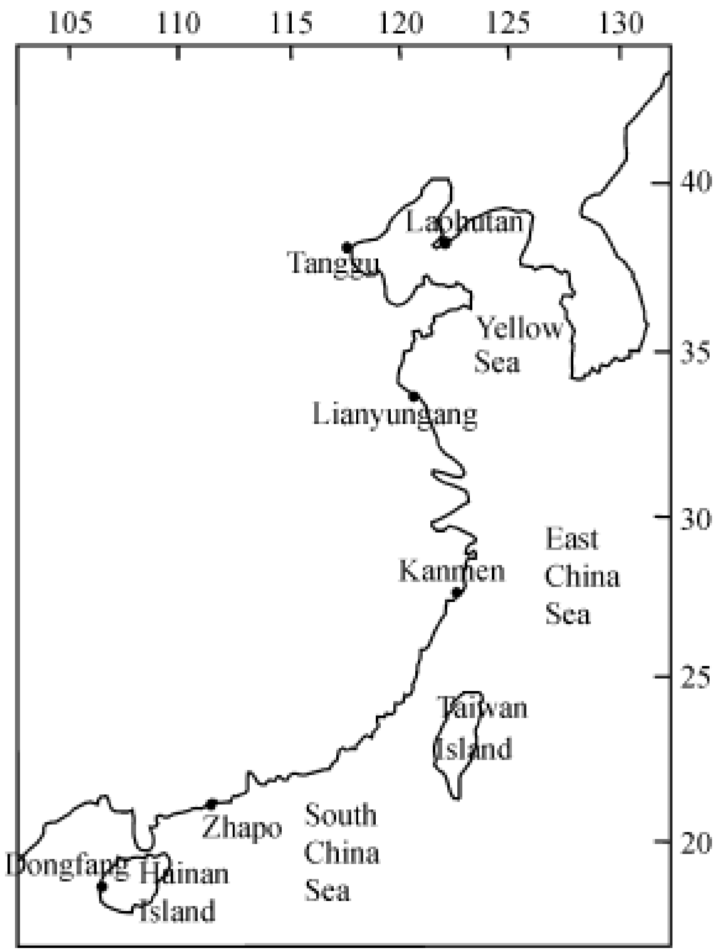


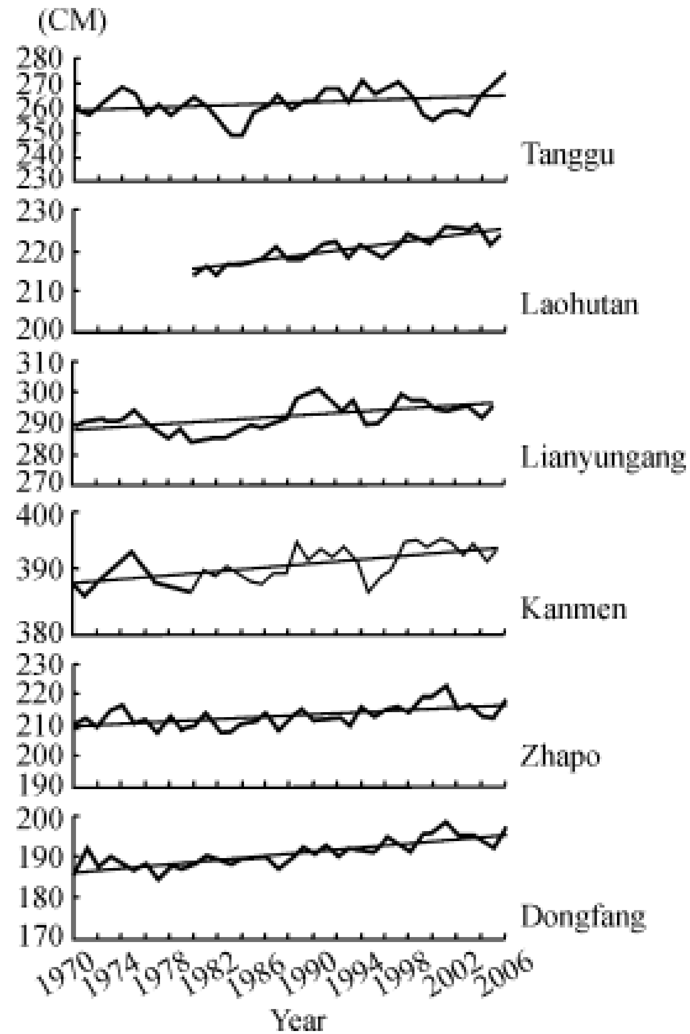
Authorized acreages of reclaimed wetland in China (data from SOA).



Past and present areas of the coastal wetlands Zhigao Sun(2015)

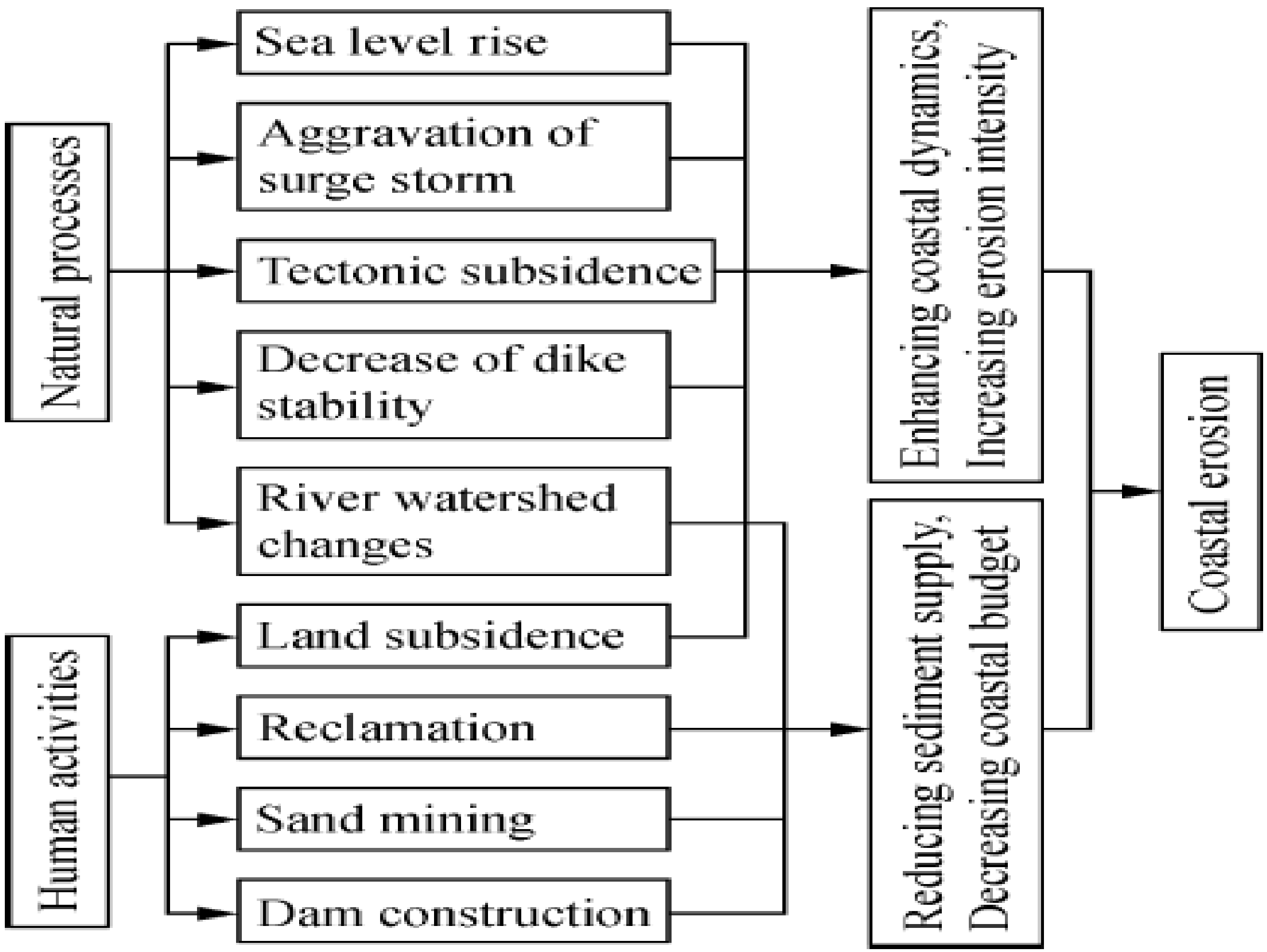
Sea level changes from 1970 to 2006 from observation stations along the coast of China (Feng Cai et al. (2014))





Man causes of coastal erosion

(Feng Cai et al. (2014))



Wetland restoration projects

- the first wetland restoration projects started in the early 1990s.
- More than 200 programs have been aided financially to protect current natural wetlands, restore damaged wetlands and create wetlands that have been lost
- The "863" Environmental Action Plan funded 36 projects during 2000–2005, which aimed at restoring water quality of natural lakes and rivers, and improving pollution purification capacity of urban wetlands (SEPAC, 2005).
- Another 53 large programs will be conducted to restore and create an additional 14,000 km2 of wetlands by 2030 (An et al., 2007).

Coastal wetlands Conservation History

(Zhigao Sun et al. 2015)

- **Un-protection stage (1950s–1970s)**
- **General attention stage (1980s–1991)**
- **Special attention stage (1992–2002)**
- **Effective protection stage (2003–2010)**
- **Overall implementation stage (2011–present)**

Conservation Achievements

(Zhigao Sun et al. 2015)

1. Coastal wetlands conservation and restoration

- Eleventh 5-Year Plan (2006–2010)
- Twelfth 5-year Plan (2011–2015)

2. Coastal wetlands nature reserve construction

- 15 Coastal wetlands listed in Ramsar Convention

3. Coastal wetlands survey and monitoring

- First national wetland resources survey: 1995-2003
- Second national wetland resources survey: 2009-2013

4. Scientific research of coastal wetlands

Many national wetland research institutions

- Wetland Research Center of SFA,
- Plateau Wetlands Research Center
- Wetland Protection & Restoration Technology Center

Many important national projects focused on wetland

5. Coastal wetland management policy and legislation
6. Public participation of coastal wetland conservation
7. International cooperation in coastal wetlands conservation

Ramsar Convention on Wetlands (joined in 1992)
WWFN (국제야생보호기금),
Wetlands International (WI),
European Union (EU),
United Nations Development Program (UNDP),
Global Environment Facility (지구환경기금),
International Union for Conservation of Nature (국제자연보호연맹)
Etc.

Example of Restoration

Inland Wetland (river & lake side)

Beijing Area, Taihu Area, etc.

Coastal Wetland

Mangroves Restoration

Southern Provinces

Estuary, River Delta

Yellow River, Yangtze River, Perl River

Ports & municipal area

Tianjin, Xiamen, Lianyungang, etc.

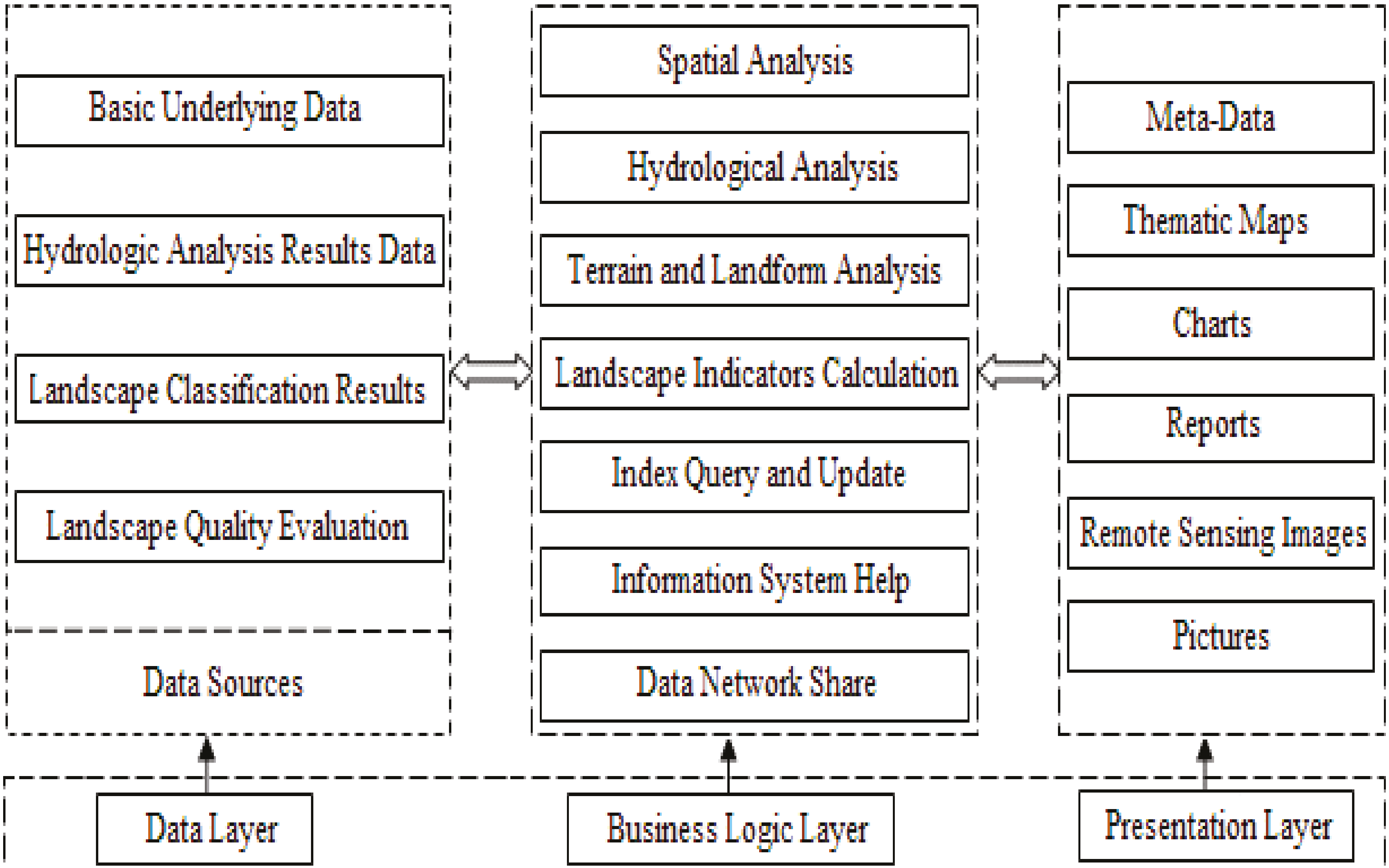
Beach Nourishment

Mangroves Restoration

- A relatively complete system of mangrove restoration technologies has been established and is widely used in southern coastal areas
- Since the 1980s, many mangrove restoration programs and practices have been launched in Southern Provinces such as Zhejiang, Fujian, Guangdong, Guangxi and Hainan.
- The mangrove area in China has consequently increased from 14,877 ha in 1997 to 23,081.5 ha in 2008 (Chen et al., 2009).

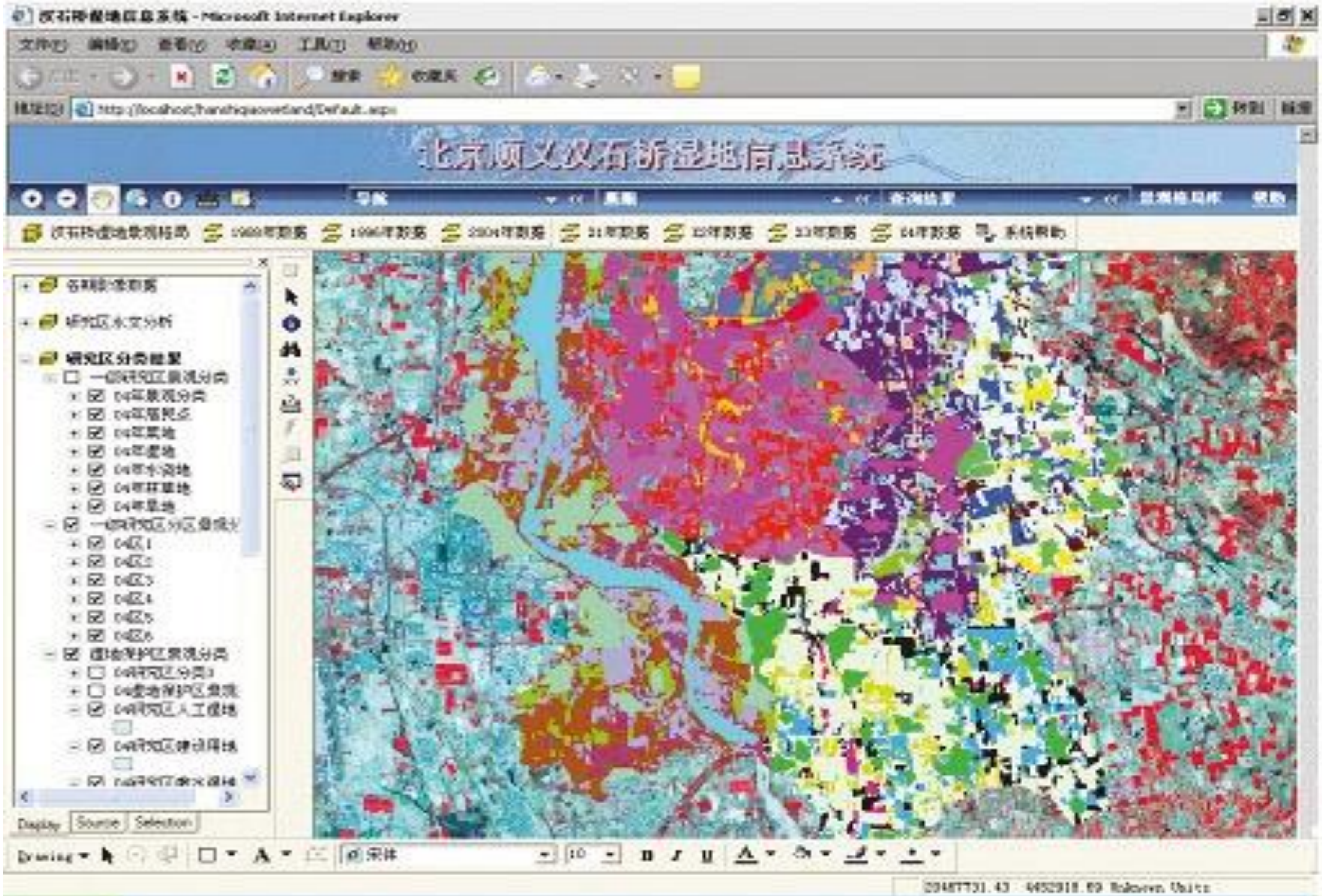
Structure of Beijing Hanshiqiao wetland information system

Shiwei Dong et al. 2011

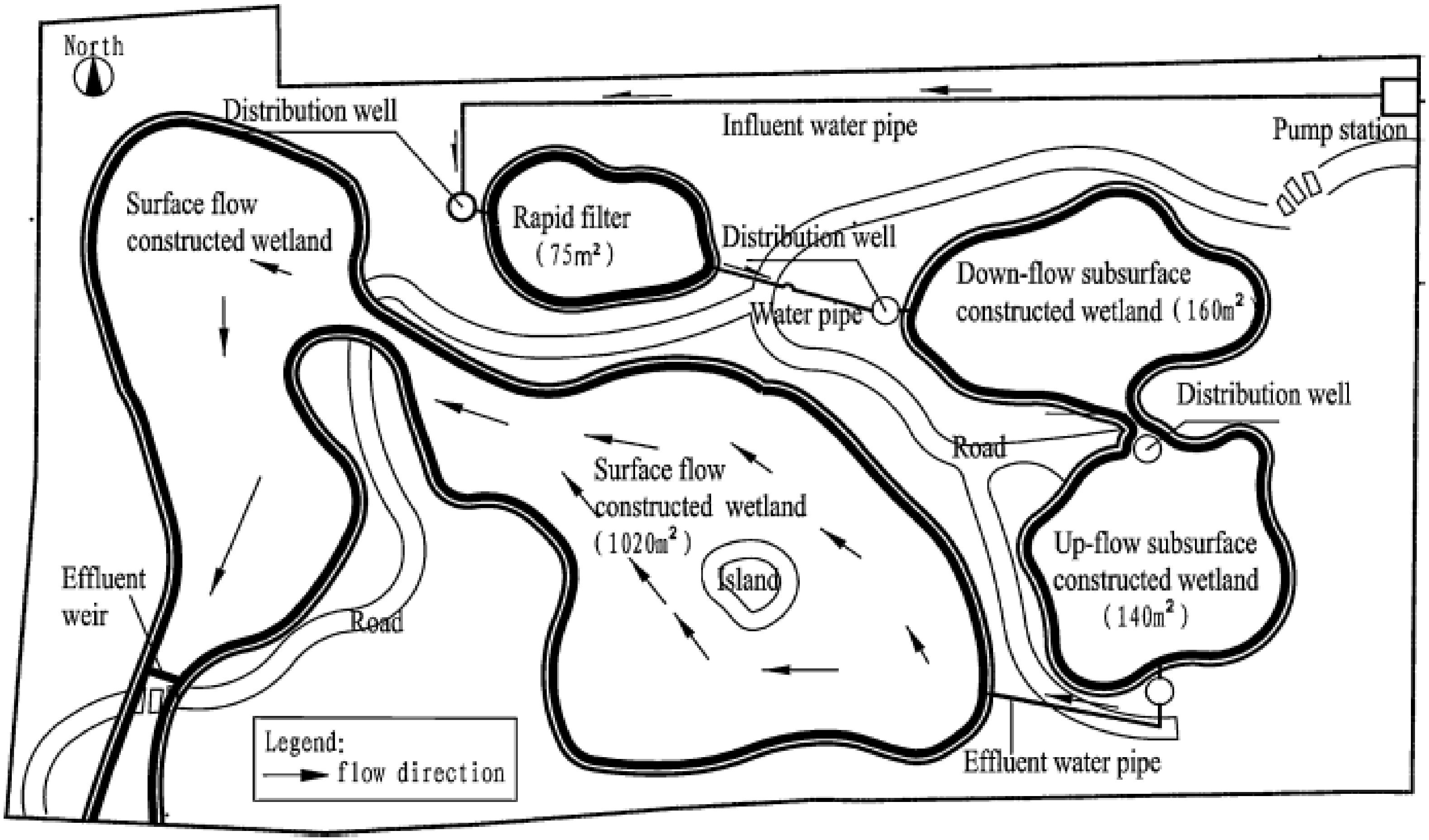


Beijing Hanshiqiao wetland network information system interface

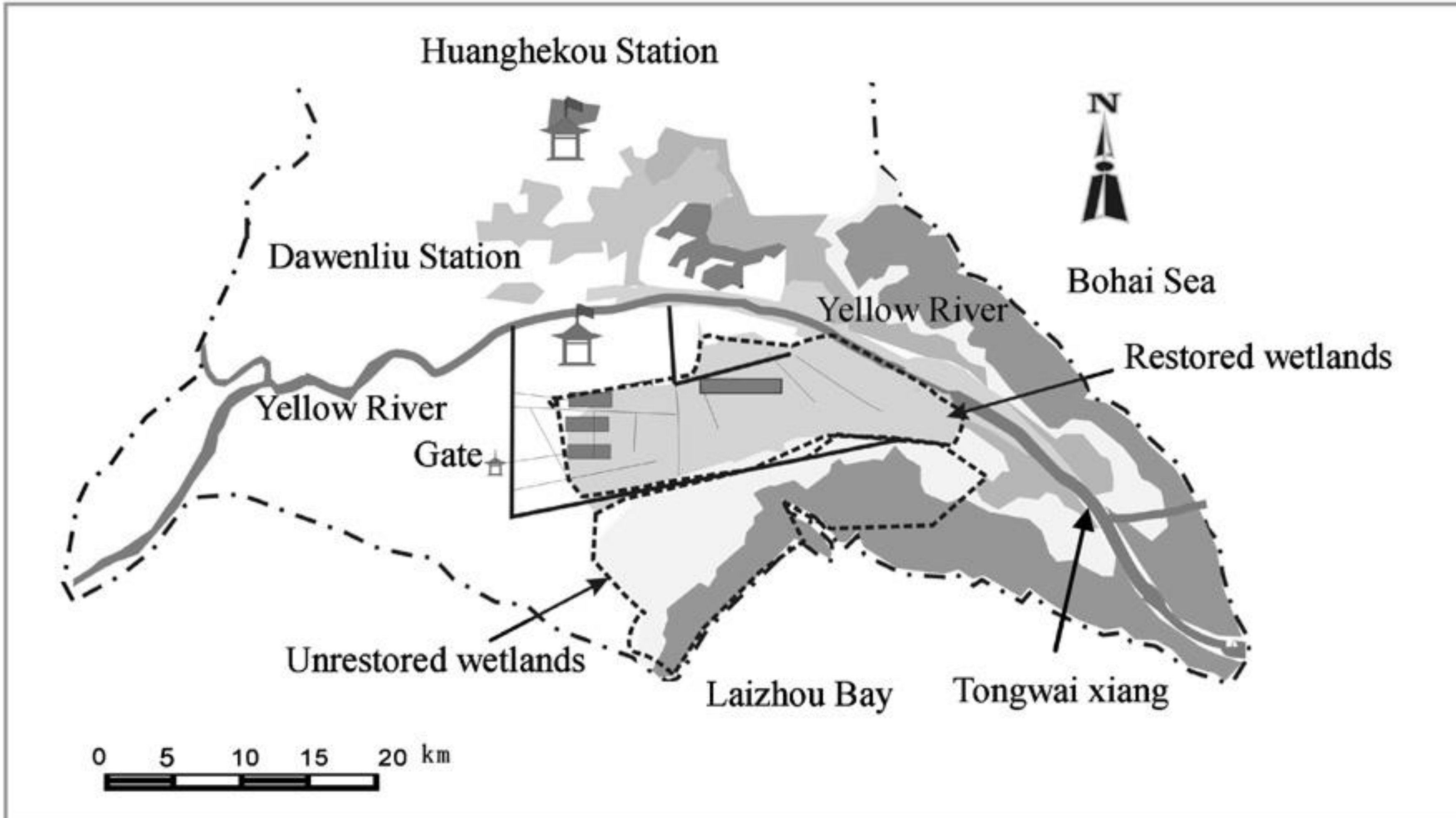
Shiwei Dong et al. 2011



Zhijiashe four-stage constructed wet-land system (Haifeng Jia et al. (2014))



Restoration of wetlands in the Yellow River Delta Wei Yang et al. 2011

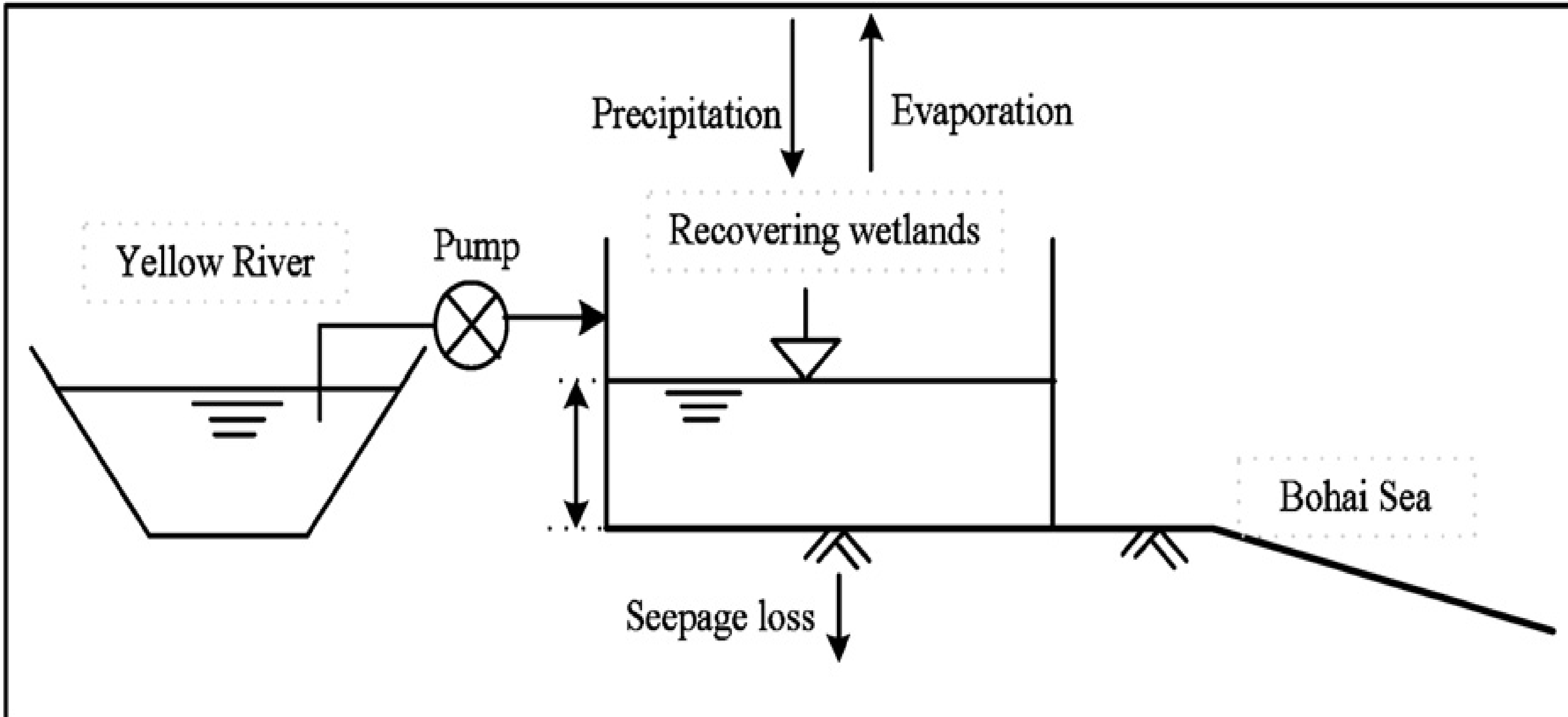


- In 2002, the government spent one hundred million yuan on the restoration of the Yellow River Delta wetland.
- During the project, water from the Yellow River was diverted into the wetland to improve surface runoff circulation and irrigation conditions and the ecological environment.
- After restoration, water quality improved, with reduced nitrogen and total phosphorus content (Cui et al. (2009)).

The quality of soil also improved, with reduced salinity and increased organic matter accumulation

The vegetation of wetlands improved greatly after several years of restoration

Water allocated from the Yellow River to the recovering wetlands Wei Yang wt al. 2011



Simulation for wetland utilization & protection based on system dynamic model

A system dynamic model for wetland management to find a balance between economic development and wetland protection in Tianjin Area based on the analysis of 24 indexes and five subsystems

The statistical data in Tianjin from 1990 to 2008 to verify the model.

Selected six typical models for scenario simulation in 2010, 2030 and 2050.

Suggested that ecological protection, population control and industrial structure adjustment are sustainable approaches

Beach Nourishment

Together with dunes and associated water bodies, the beach and tidal flats provide valuable habitat.

Sand dunes can serve as a natural buffer against high waves, preventing or delaying the intrusion of water and sedimentation

As compared with other hard engineering measures, dune nourishments and/or reconstructions are more preferred in a more demanding society.

Experiments to find the best possible way to build sand dunes that should be both economically, as well as ecologically, feasible.

Integrated coastal management(ICM)

About 12% of China's coast line has now come under the ICM governance framework to address the environmental and management challenges.

The ICM indicators in terms of governance, environment and socioeconomic aspects were designed for quantitatively evaluating the ICM performance over a 9-year period from 2004 to 2012.

The results showed that ICM performance based on governance, coastal environment and socio-economic aspects in the three improved, indicating that the ICM approach can be effective in promoting the overall sustainability of China's coastal cities

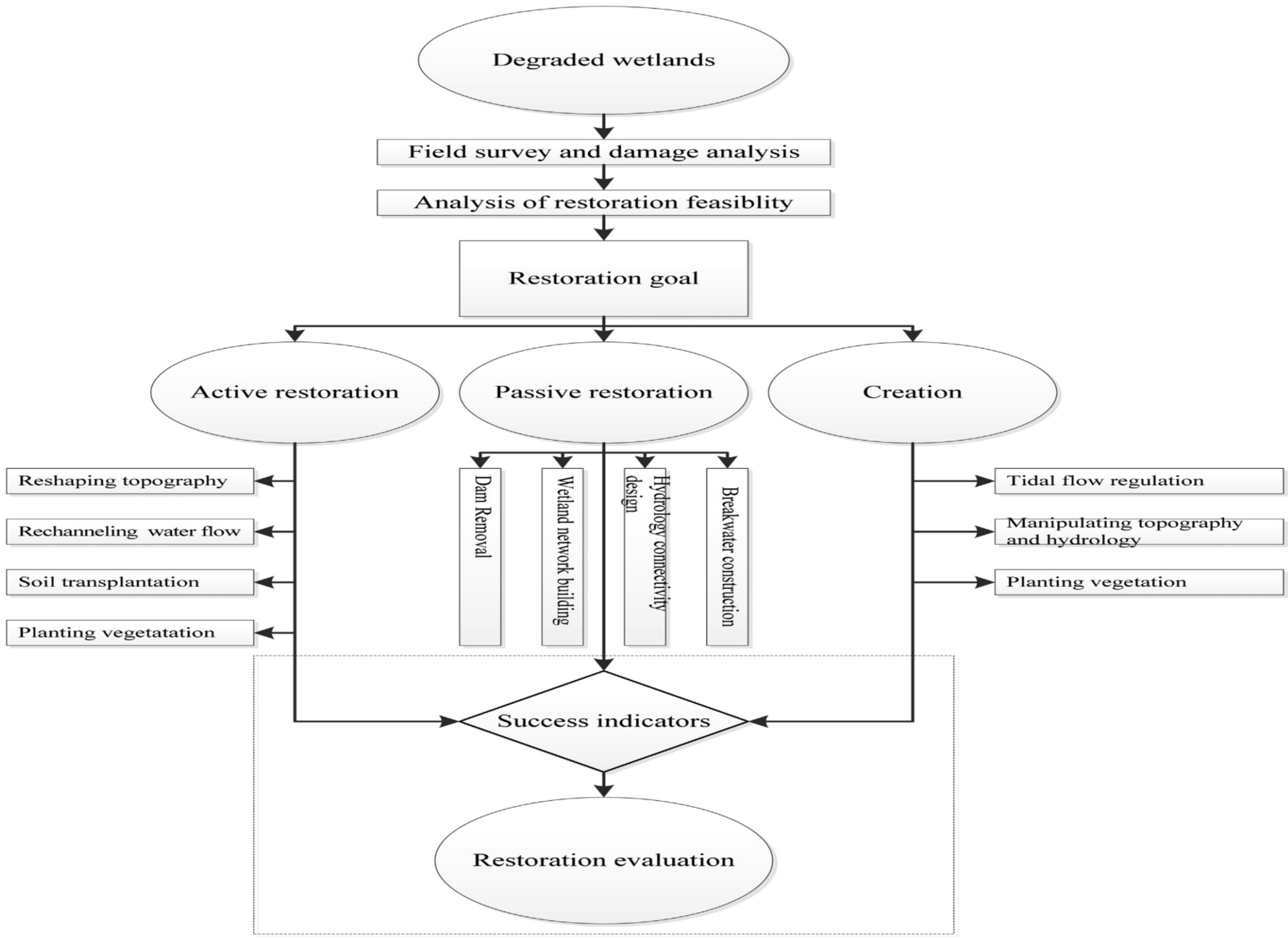
3 studied ICM sites & eight other ICM cities

Guanqiong Ye et al. 2015

- **Mangrove restoration in Quanzhou bay**
- **Bay ecosystem restoration in Wuyuan Bay of Xiamen**
- **Eutrophic semi-enclosed bay restoration in Xiamen western waters)**

Coastal wetland restoration.

Qingqing Zhaoa et al. (2015)



Barriers for success

-More comprehensive insights into ecological, socio-economic, political factors are necessary for setting-up clear project objectives and targets;
- More attention should be paid to ecological functions in order to restore the ecosystem vs values and benefits
- More scientific processes need to be conducted to evaluate the causes for ecosystem degradation and predict the probability for natural recovery
-Degradation causes diagnosis, restoration technology & methods, monitoring strategies and techniques, assessment and evaluation, adaptive management and results dissemination should be all emphasized during the restoration efforts.
- Problems of Overlapping Jurisdiction

Authorities responsible for coastal wetland protecting in China

- State Oceanic Administration (SOA) .
- Ministry of Environmental Protection (MEP)
- State Forestry Administration (SFA)
- State Fishery Administration
- Ministry of Agriculture
- Ministry of Transport

On March 2, 2010, MEP and SOA signed the "Framework Agreement on Setting up the Cooperation Working Mechanism on Improving Ocean Environment Protection Communication"

to solve the Problems of Overlapping Jurisdiction

Part 2: Research for sustainable coastal development and management

Problems of Coastal Area

- Increasing concern about the long-term effects of changes in natural environmental forcing (wave, mean sea level, storm surge frequency, etc) as well as of human activities(coastal construction, channel dredging, sand mining etc) on estuarine environments.

I). Port and harbors

II). Tidal inlets, river mouths, estuaries and bays

III). Beach (Most sandy beaches are eroding)

Research for coastal restoration

Comprehensive and systematic scientific research, an integrated discipline, restoration and management should be carried out for the sustainable development of coastal wetlands.

. Physical, hydrological, sedimentary
. Chemical
. Biological
. Engineering
. Socio-economic

Water, Soil, Biota : 3 basic elements of wetland

Water

Chemistry of water: water pollution

Movement of water: flow, water level

Soil(Sediment)

Chemistry of soil

Movement of Sediment: sediment transport, morphology change

Biota

Adaptation of plants and animals

Biodiversity

- **Observation, Analysis and Prediction of basic elements &**

=> **Prediction of the response of Coastal Restoration on ecological functions**

Research for the success of coastal restoration project

1) Understanding of wet-land/beach functions

2). Understanding of the coastal processes, mechanisms, causes of degradation

3) Understanding of self-restoring capacities of coastal waters

4). Long-term prediction modeling

5) Restoration technology and method

Obstacles

- Coastal waters: highly coupled system of water, sediment, chemistry, biology …
- Swash-zone hydrodynamics and morpho-dynamics are difficult to simulate using conventional modeling techniques
- Long-term monitoring is difficult and expensive

Monitoring of water, sediment and biota

-Fundamental databases should be established using in situ. data & remote sensing data

-Developments in restoration and monitoring technology are required to ensure long-term sustainability.

- **Monitoring program for Pre-construction, construction and after construction**

Coastal Monitoring Program

i). Coastal development

For proper plan of coastal development & design of coastal structures and implementation

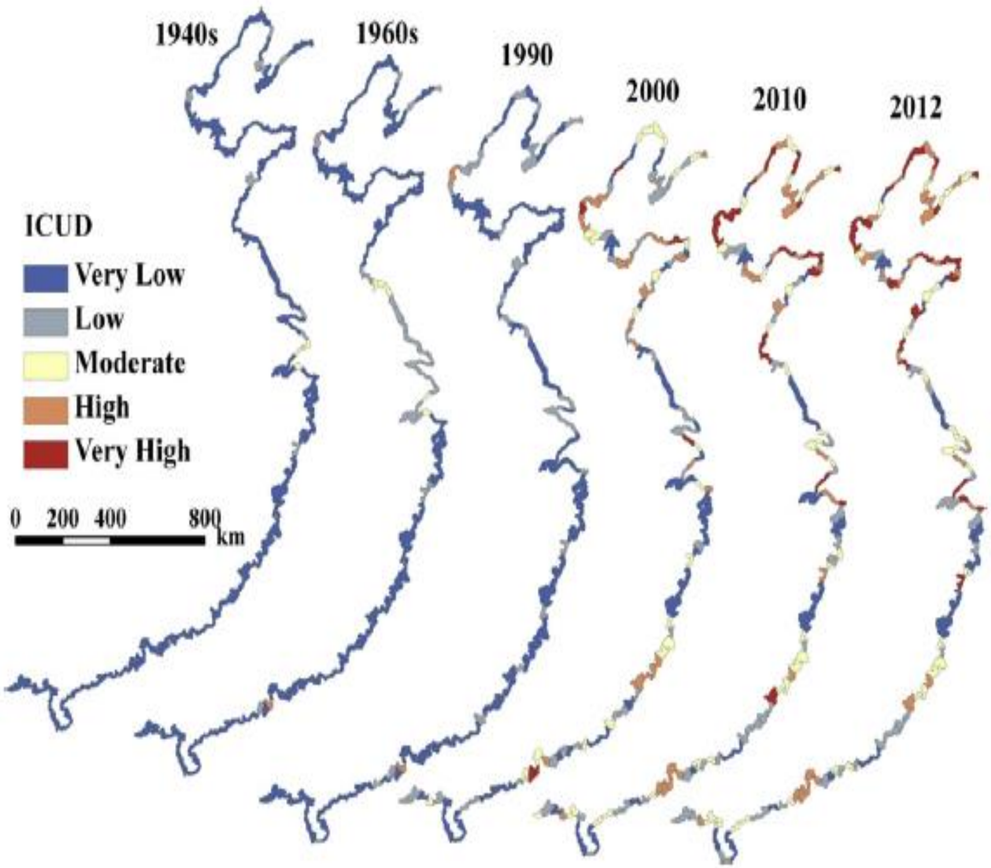
. Pre-construction coastal monitoring
. Post-construction coastal monitoring
. Base-line monitoring

ii). Coastal Restoration and coastal protection

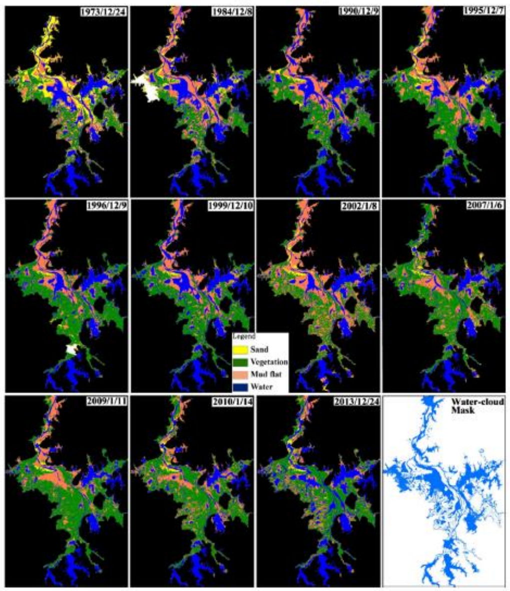
–For the evaluate of the success of coastal restoration and proper afterward management

-For the proper method of beach protection and beach management.

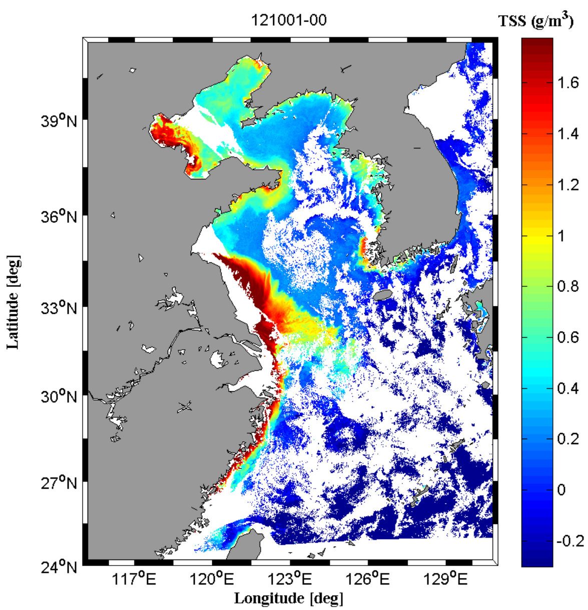
Example of application of Remote Sensing



Spatio-temporal *characteristics of the coastline utilizati*on degree over the 70 years using LANDSAT data (Ting Wu(2014))



Example of Application of RS Wetland Change of Poyang Lake



Example of GOCI Data 2012-10-01 01:00

Sediment Transport Modeling

(Interaction between **Water** and **Soil**)

Lots of impacts of Sediment Transport on ecological functions of coastal area

- Environmental and Ecosystem at muddy coast with transport of fine cohesive sediment (pollutants stick to sediment and move together)
- Beach erosion and morphology change at sandy coast with transport of sand at swash-zone

=> Impacts of **Biology**

Fluid motion from Eq. of motion

$$\overbrace{\rho\Big(\underbrace{\frac{\partial u}{\partial t}}_{\substack{\text{Unsteady}\\ \text{acceleration}}} + \underbrace{u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}}_{\substack{\text{Convective}\\ \text{acceleration}}}\Big)}^{\text{Inertia (per volume)}} = \underbrace{\rho g_x}_{\substack{\text{Gravity}\\ \text{force}}} - \underbrace{\frac{\partial p}{\partial x}}_{\substack{\text{Pressure}\\ \text{gradient}}} + \underbrace{\mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right)}_{\text{Viscosity}}$$

$$(u, w, p) = (\overline{u} + \tilde{u} + u', \overline{w} + \tilde{w} + w', \overline{p} + \tilde{p} + p')$$

Two Approaches:

i) . From time averaged Eq. of motion

=> Mean flow information(current and tide

From energy eq. => wave spectrum

ii). Both mean flow & waves from eq. of motion

Hydro- & sediment dynamics at Surf-zone and Swash-zone

Conventional wave-averaged model
(ex. Delft3D, Mike System, Telemac model..)
-Coupling among wave, flow & sediment
-Not applicable for Swash-zone

Need to develop. of working model for swash-zone (Wave-resolving model)
- Trade off : Accuracy, Computation Time
- Preparation of Input information

Development of Long-term Morphology Prediction System

- For the proper protection of coastal erosion and proper coastal-zone management, t**here is a need to develop a practical system to predict long-term morphology change.**

1). Reliable sediment transport model
2). Proper preparation input parameters
3). Proper long-term input forcing terms
4). Long-term simulation system that can be used in reasonable computation time
5). Proper consideration of te impacts of climate change(?)

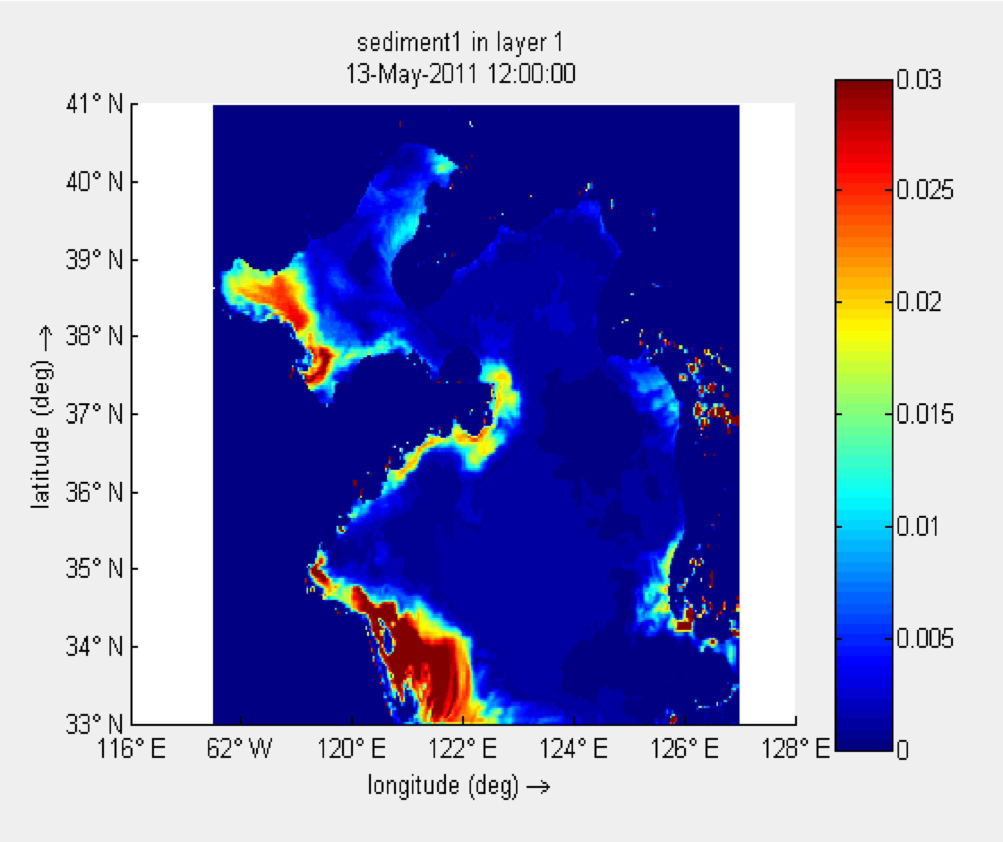
Fine cohesive sediment transport

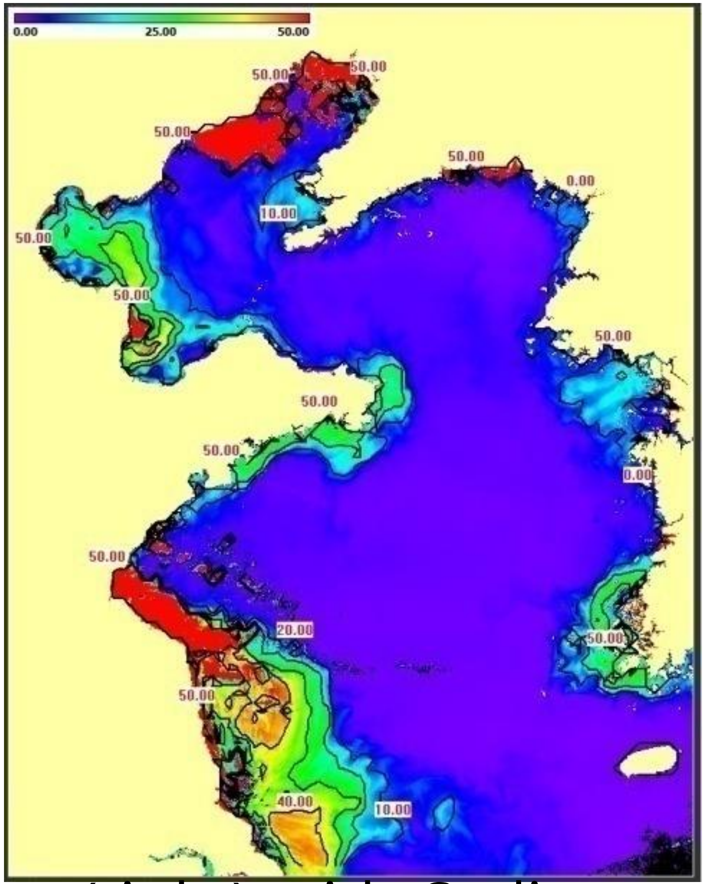
- Pollutants move together with fine cohesive sediment
- Prediction of five cohesive sediment is important to water quality & ecosystem modeling
- Proper estimation of vertical sediment flux as well as flocculation and consolidation processes are difficult to predict

$\Rightarrow$Require field observation data

Preparation of input parameters using GOCI data (inverse method) to development working prediction system for major estuaries of the Yellow Sea

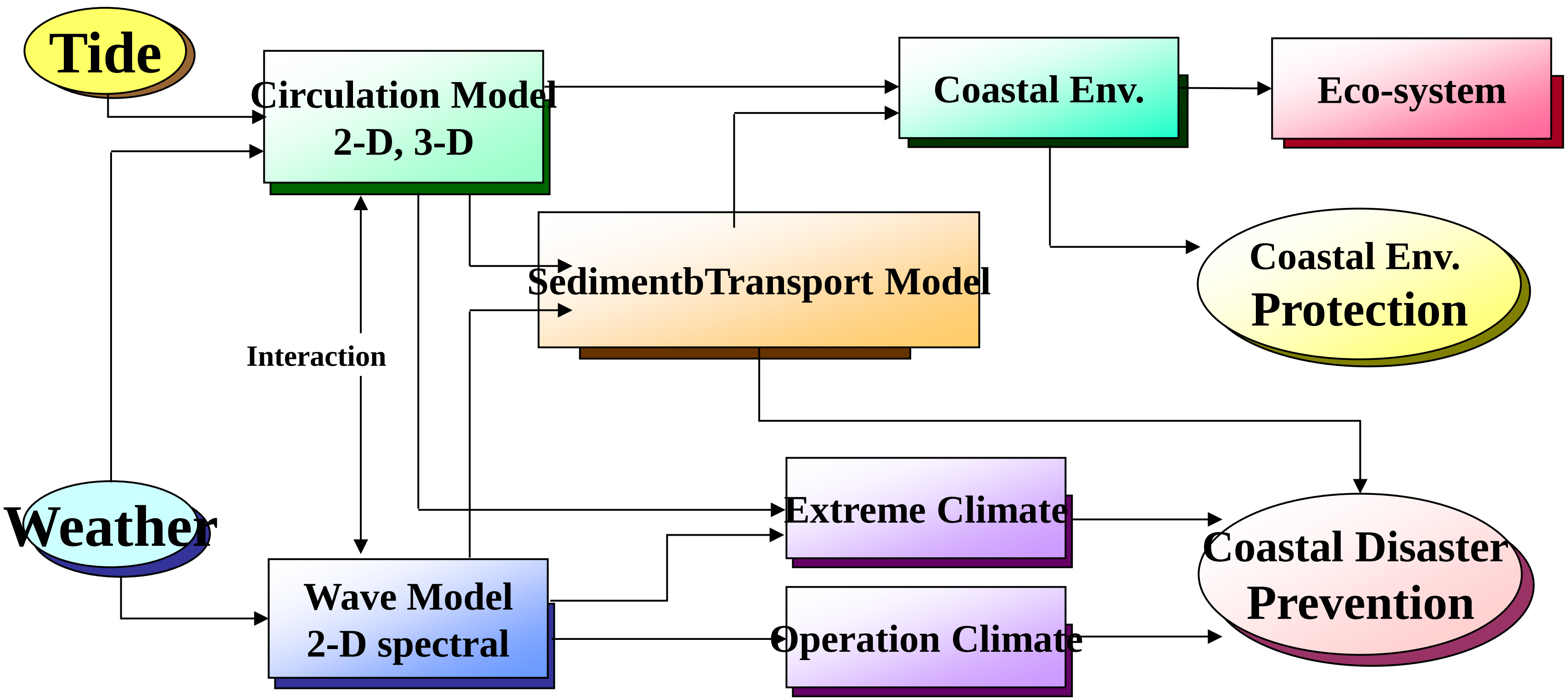
Example of Sediment Transport Prediction using Delft 3D model





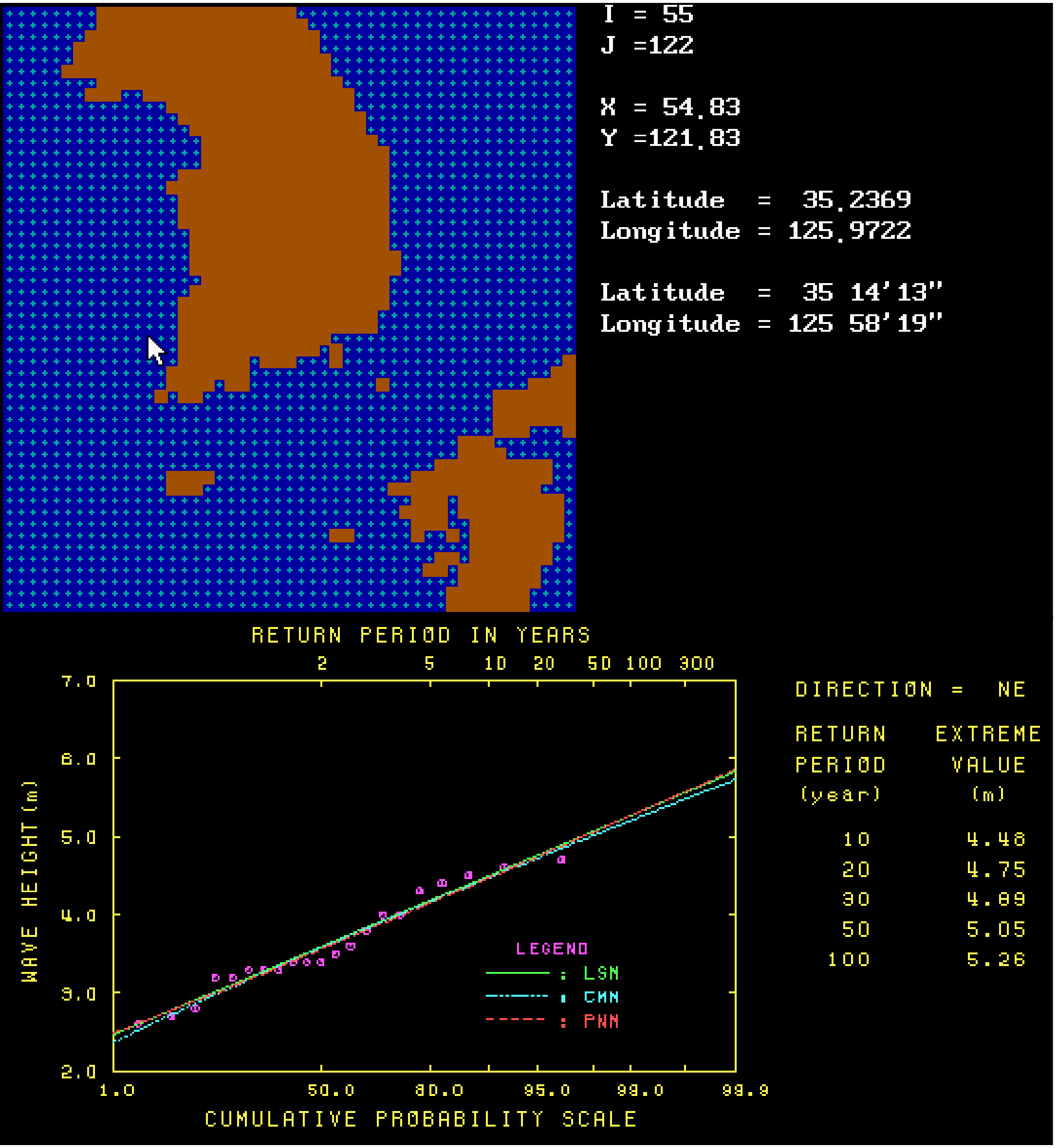
Comparison of GOCI satellite data (right) with Sediment Model Output (left)

Coastal Hazard Reduction & Env. Conservation



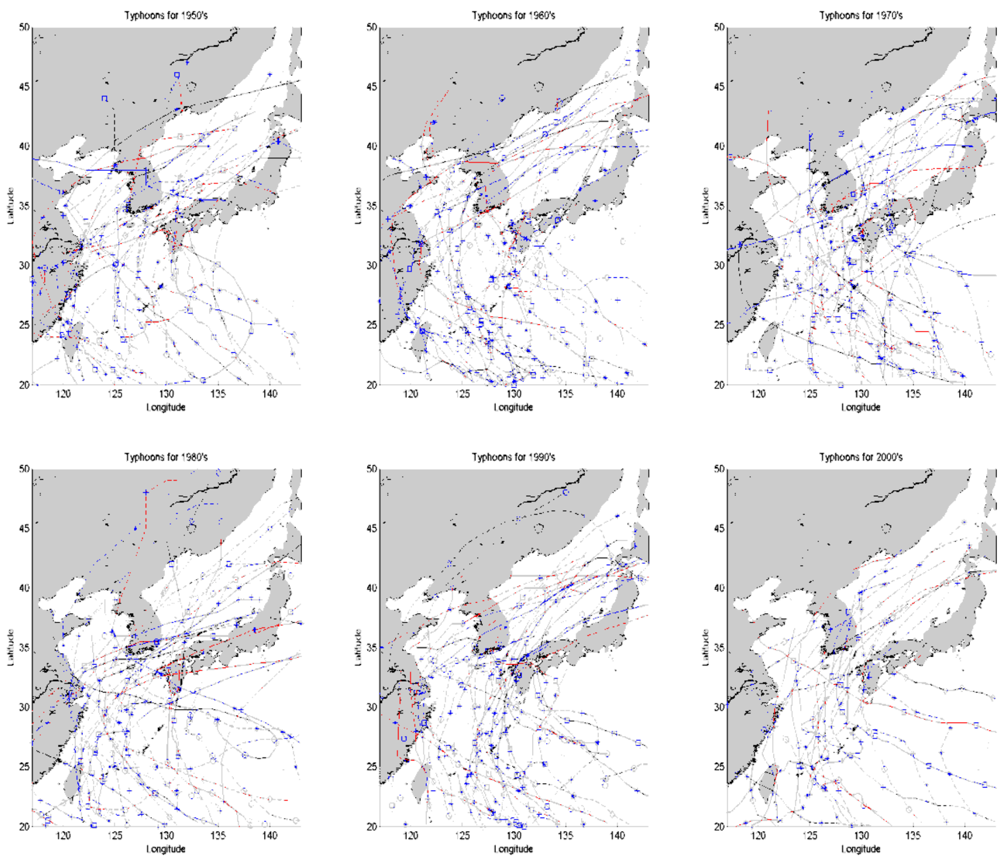
Primary Information: Weather(wind, air pressure)
Tide(elevation, current)
Secondary Information: Wave, Storm Surge
Engineering Application:Design, Management….

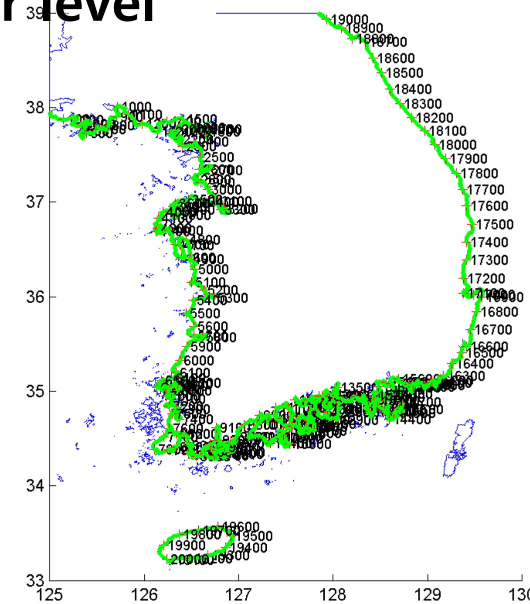
Extreme analysis with directions at a grid point

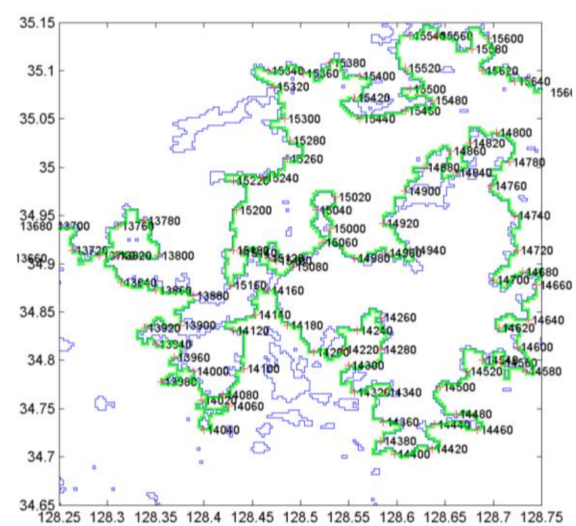


Dir	Return Period(year)				
	10.0	20.0	30.0	50.0	100.0
N	2.0	2.6	3.0	3.5	4.3
NNE	2.0	2.5	2.7	3.1	3.5
NE	2.0	2.3	2.4	2.6	2.8
ENE	2.1	2.3	2.5	2.7	2.9
E	2.4	2.9	3.1	3.4	3.8
ESE	2.4	2.8	3.1	3.4	3.8
SE	2.3	2.8	3.0	3.3	3.7
SSE	2.3	2.7	2.9	3.2	3.5
S	2.6	3.2	3.5	3.9	4.4
SSW	3.6	4.6	5.1	5.9	6.8
SW	3.3	4.1	4.6	5.3	6.2
WSW	2.8	3.5	4.0	4.6	5.4
W	2.7	3.5	4.0	4.7	5.6
WNW	2.1	2.6	2.9	3.3	3.8
NW	1.7	2.3	2.6	3.0	3.7
NNW	1.7	2.2	2.5	3.0	3.6
TOT	3.8	4.6	5.3	5.8	6.9

Simulation of storm surge for 201 typhoons using FVCOM and estimation of design water level for every 300 meter grids along the coast







Conclusion

- **Coastal wetlands are seriously threatened by natural and anthropogenic factors and lots of Coastal Restoration Programs have been and are being implemented in China.**
- **The experiences, technology developments and lessons gained in China would be helpful in planning, designing and implementing similar programs in Korea**
- **Proper monitoring and inter-disciplinary scientific research is necessary for the sustainable development of coastal wetlands.**