Decision Support System of River Restoration Adaptive Management

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- Project Overview
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I. Project overview

Research Objectives

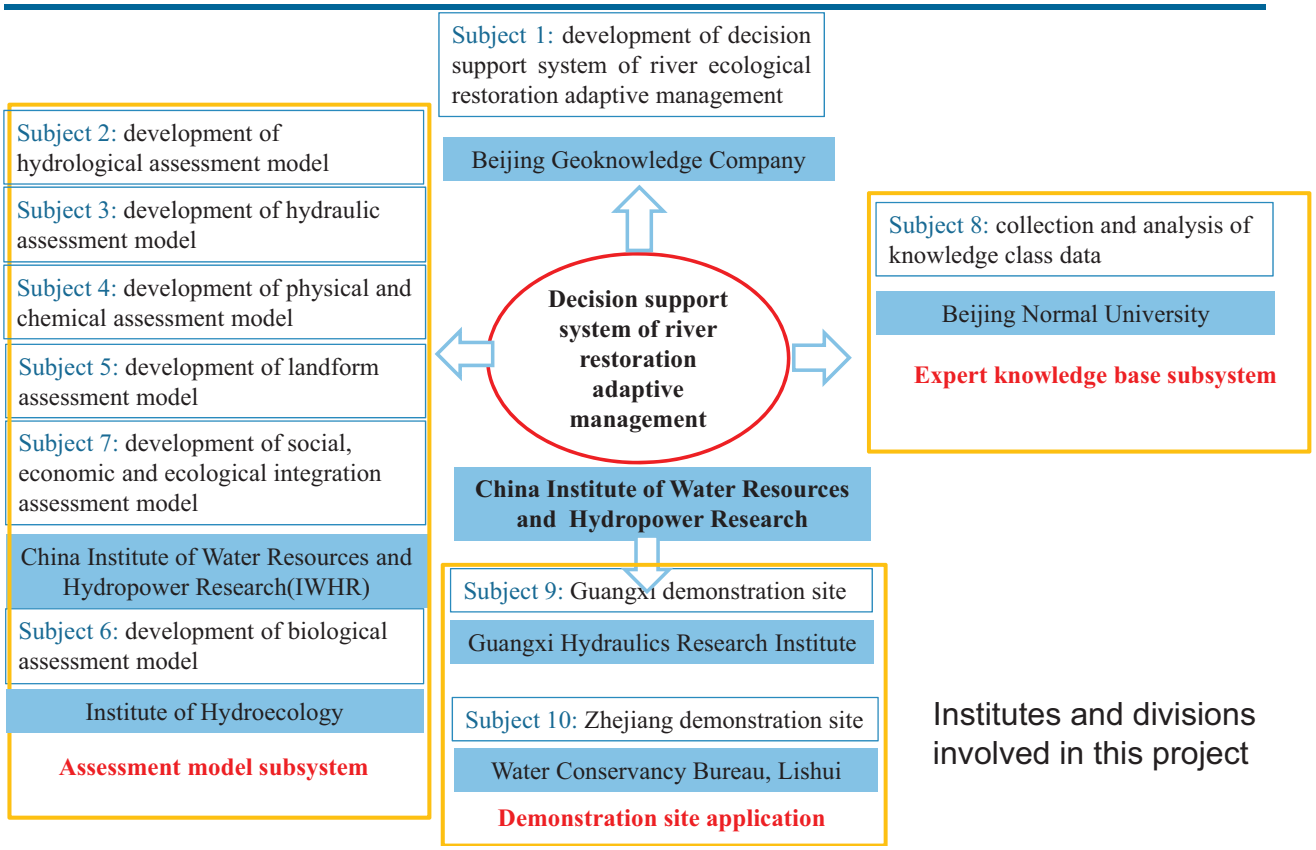
■With 3S technology(GIS, RS, GPS), the decision support system of river restoration adaptive management(DSSRRAM) is developed.

■It includes main system, multi-level database subsystem, multi-factor assessment model subsystem, and expert knowledge base subsystem.

■It could provide decision support for the phases of planning, design, implementation and post-assessment during the process of river restoration project.

■This system is applied in two demonstration sites, Oujiang river in Zhejiang and Lijiang River in Guangxi.

I. Project overview

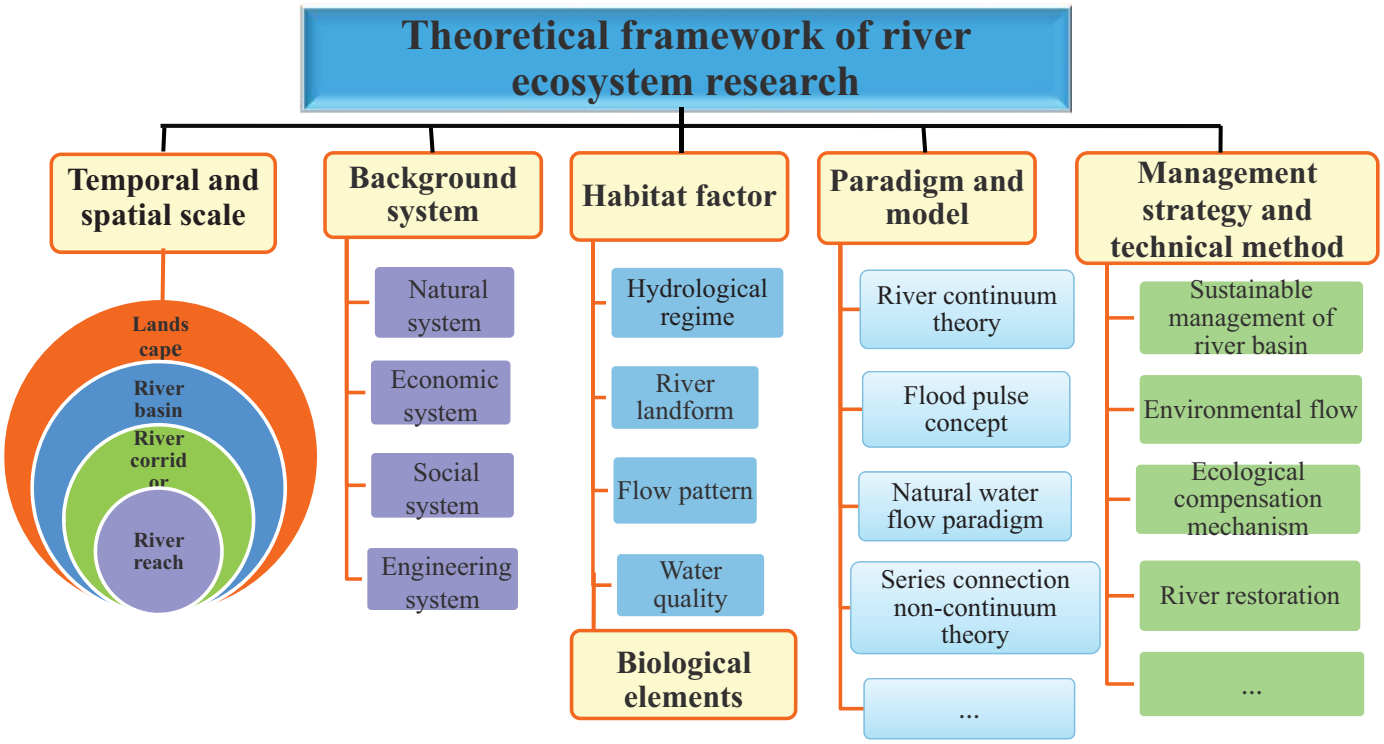


Institutes and divisions involved in this project

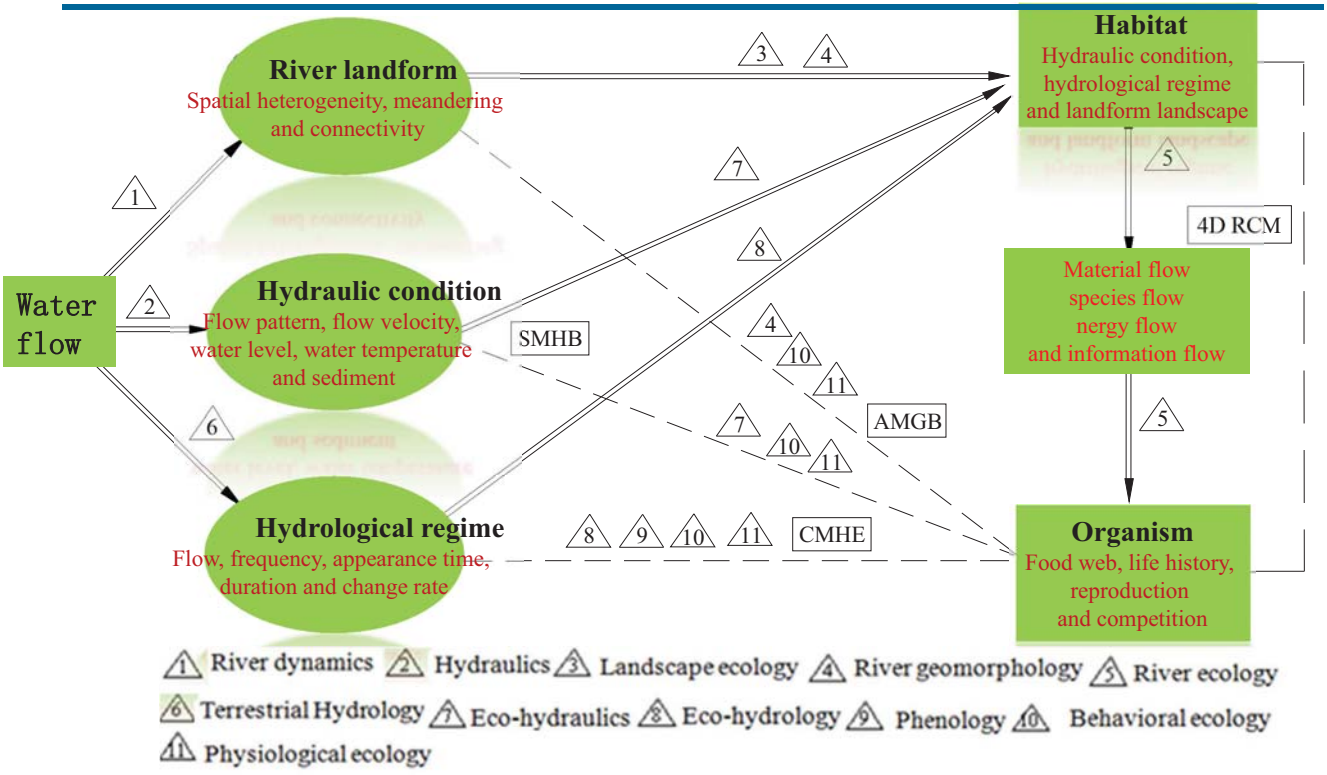
II. Project research results

- **Theoretical framework of river ecosystem**
- **Holistic conceptual model of river ecosystem structure and function**
- **Multi-factor assessment model system based on river ecological status classification system:**
  - Hydrological assessment
  - Hydraulics assessment
  - Physical and chemical assessment
  - Landform assessment
  - Biological assessment
  - Socioeconomic benefit assessment
- **Negative feedback regulation mechanism of river restoration**
- **Platform development of decision support system of river restoration adaptive management**

Research result-1. Theoretical framework of river ecosystem research



Research result-2. Holistic conceptual model of river ecosystem structure and function



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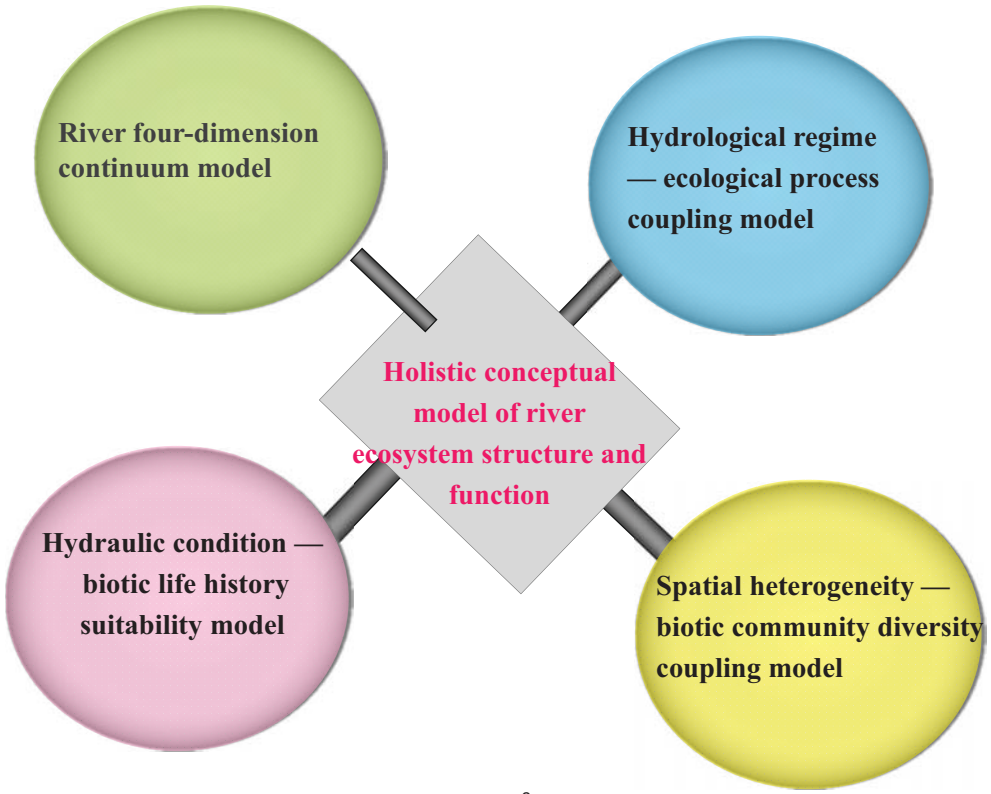
Research result-2. Holistic conceptual model of river ecosystem structure and function



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Research result-3. Multi-factor assessment model system based on river ecological status classification system

River ecological status classification system(RESCS)

Ecological element		Biological quality			Hydrological regime		Physical chemistry			River landform		
No.		1			2		3			4		
Index		Abundance	Biomass	Age structure	Ecological basic flow	Hydrological process	General situation	Water quality	Water temperature	Continuity	Connectivity	Landscape pattern
		a			b	c	d	e	f	g	h	i
Excellent	1	1.a.1			2.b.1	2.c.1	3.d.1	3.e.1	3.f.1	4.g.1	4.h.1	4.i.1
Good	2	1.a.2			2.b.2	2.c.2	3.d.2	3.e.2	3.f.2	4.g.2	4.h.2	4.i.2
Medium	3	1.a.3			2.b.3	2.c.3	3.d.3	3.e.3	3.f.3	4.g.3	4.h.3	4.i.3
Poor	4	1.a.4			2.b.4	2.c.4	3.d.4	3.e.4	3.f.4	4.g.4	4.h.4	4.i.4

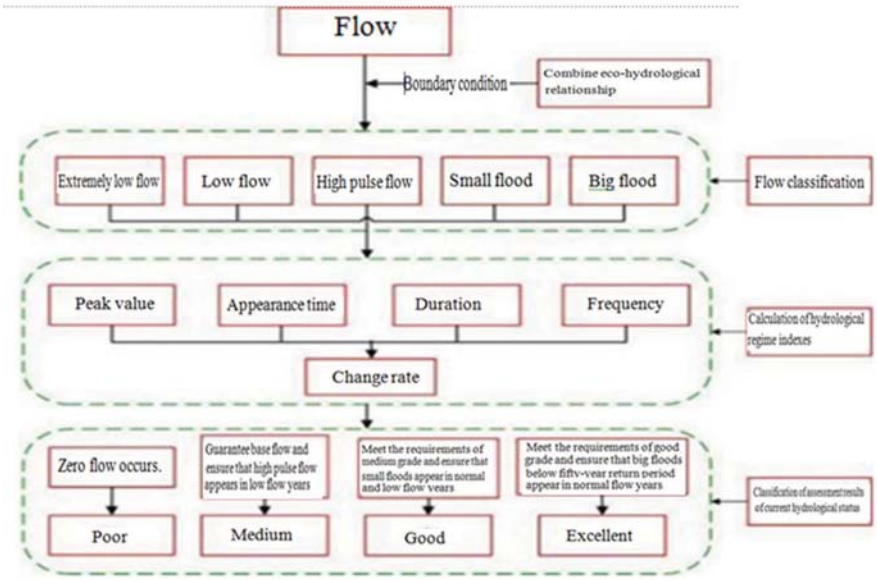
Element layer
4 elements

Index layer
11 indexes

Grade layer
4 grades

(1)Multi-factor assessment model system-*hydrological assessment*

Hydrological assessment index based on five kinds of environmental water flow components and five hydrological elements



Flow chart of hydrological assessment

(2) Multi-factor assessment model system-*hydraulic assessment*

➢ Hydraulic assessment factors

- ✓ **Water flow characteristic quantity** — *flow velocity, flow velocity gradient, special flow pattern, flow and sediment concentration.*
- ✓ **River channel characteristic quantity** — *Water depth, water surface width, wetted perimeter rate, wetted cross section area, sediment type, etc.*
- ✓ **Dimensionless quantity** — *Froude number (Fr) and Reynolds number (Re).*

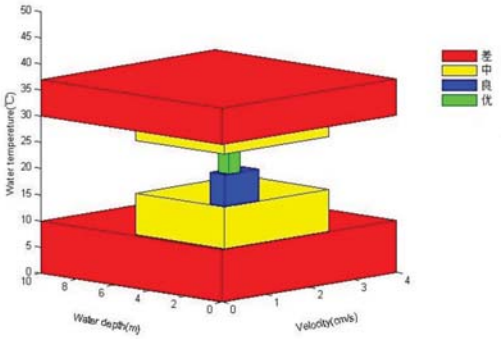
➢ Assessment methods

Hydrodynamic model —1D, 2D, 3D, 1-2D and1-3D
Habitat model

➢ Assessment results

Temporal and spatial distribution of hydraulic factors under different water flow conditions;

Fitness curve of biological and hydraulic factors



Hydraulic assessment classification

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(3) Multi-factor assessment model system- *physical and chemical assessment*

➢ Assessment factors

COD, NH_3-N, TP, TN, heavy metal, water temperature, etc.

➢ Assessment bases and standards

Environmental quality standards for surface water (GB3838-2002), water quality standard for fishery as well as water environment functional area objectives

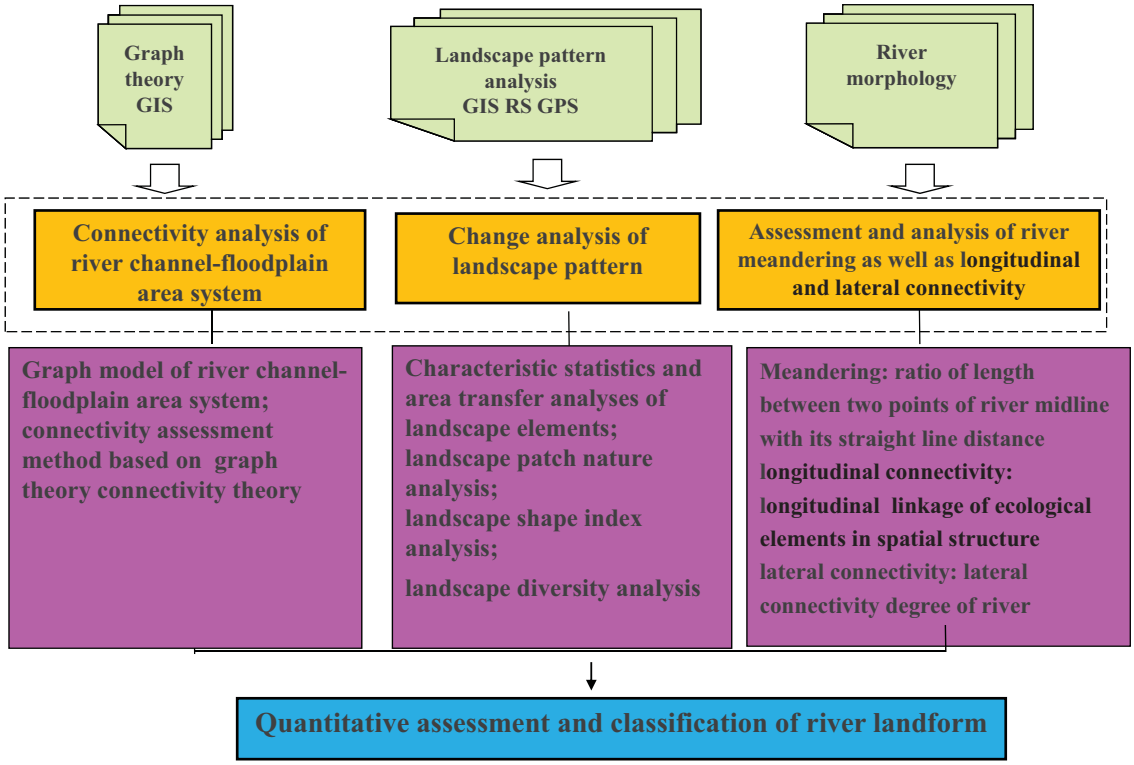
➢ Assessment results

Comprehensive water quality category, functional area water quality compliance rate and main pollution factors

Grade	Water quality requirements
Excellent	Superior to Class II (including Class II)
Good	Function area water quality reaches the standards (Class III)
Medium	Function area water quality compliance rate exceeds 60%.
Poor	Function area water quality compliance rate is lower than 60%.

Physical and chemical assessment classification

(4) Multi-factor assessment model system- *landform assessment*



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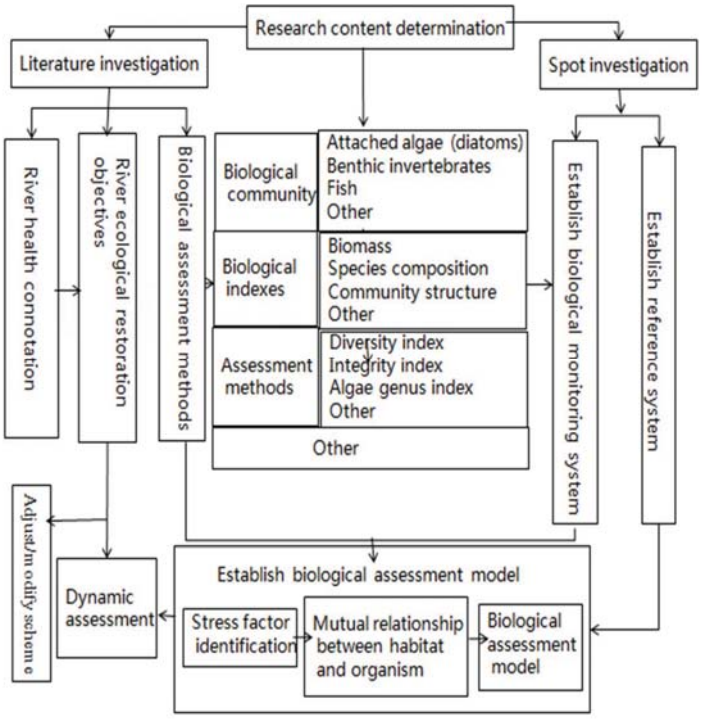
(5) Multi-factor assessment model system- *biological assessment*



Biological assessment flow chart

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Biological assessment methods

Model prediction method and comprehensive index assessment method

Biological assessment indices

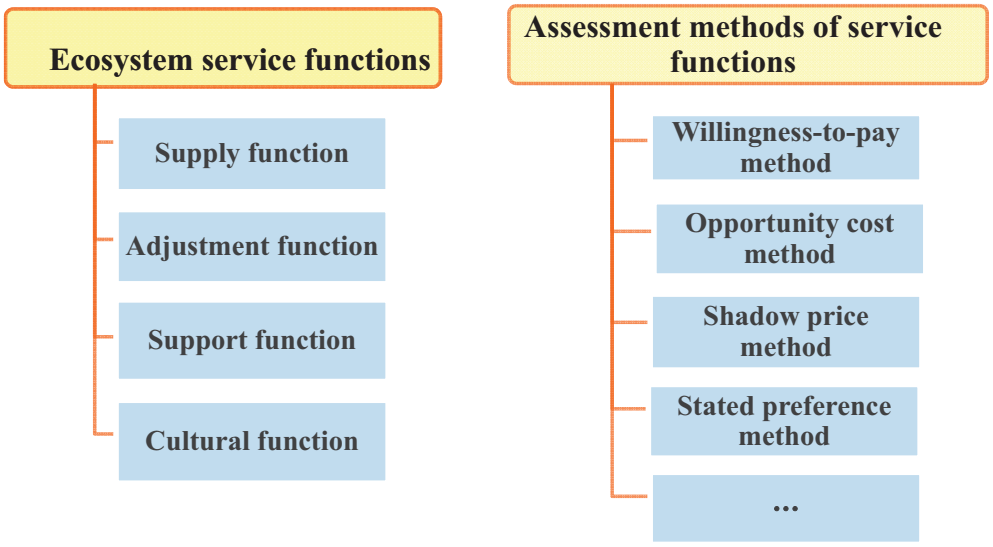
Zoobenthos:
Integrity index IBI and percentage mode similarity index PMA

Fish:
Dominant species, community similarity, diversity index and biotic integrity index

Biological assessment classification

Biotic integrity grade	IBI values
Very good	53-60
Good	43-52
General	33-42
Poor	23-32
Very poor	13-22

(6) Multi-factor assessment model system- *social, economic and ecological benefit assessment*



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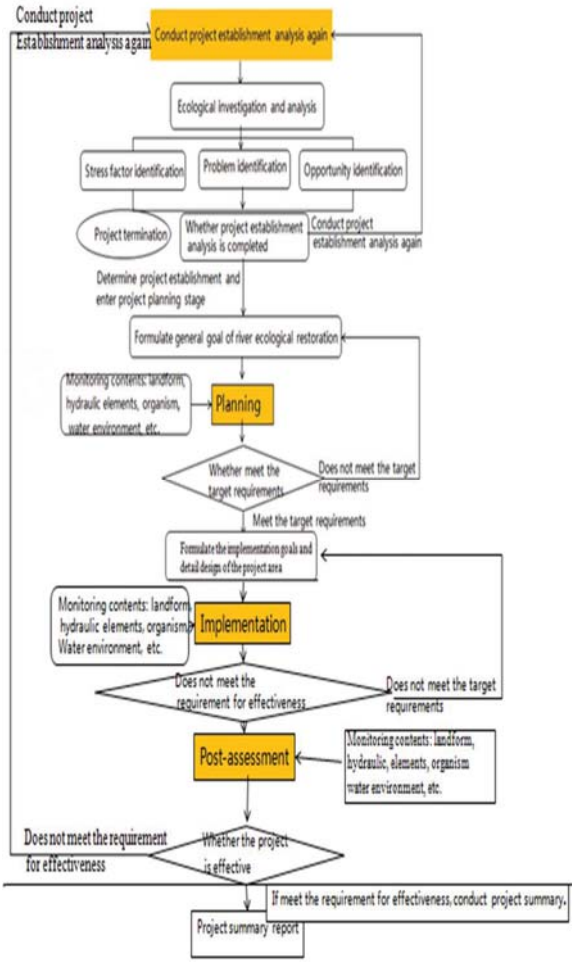

Research result-4. Negative feedback regulation mechanism of river restoration

■Set the river restoration target;

■Conduct trend assessment for different stages ;

■Compare the difference between assessment result and the preset target;

■Adjust the restoration measures, gradually reduce the difference and finally achieve the preset objective;

■Repeat the cycle, thereby forming the negative feedback regulation mechanism.

Schematic diagram of negative feedback regulation mechanism of river restoration

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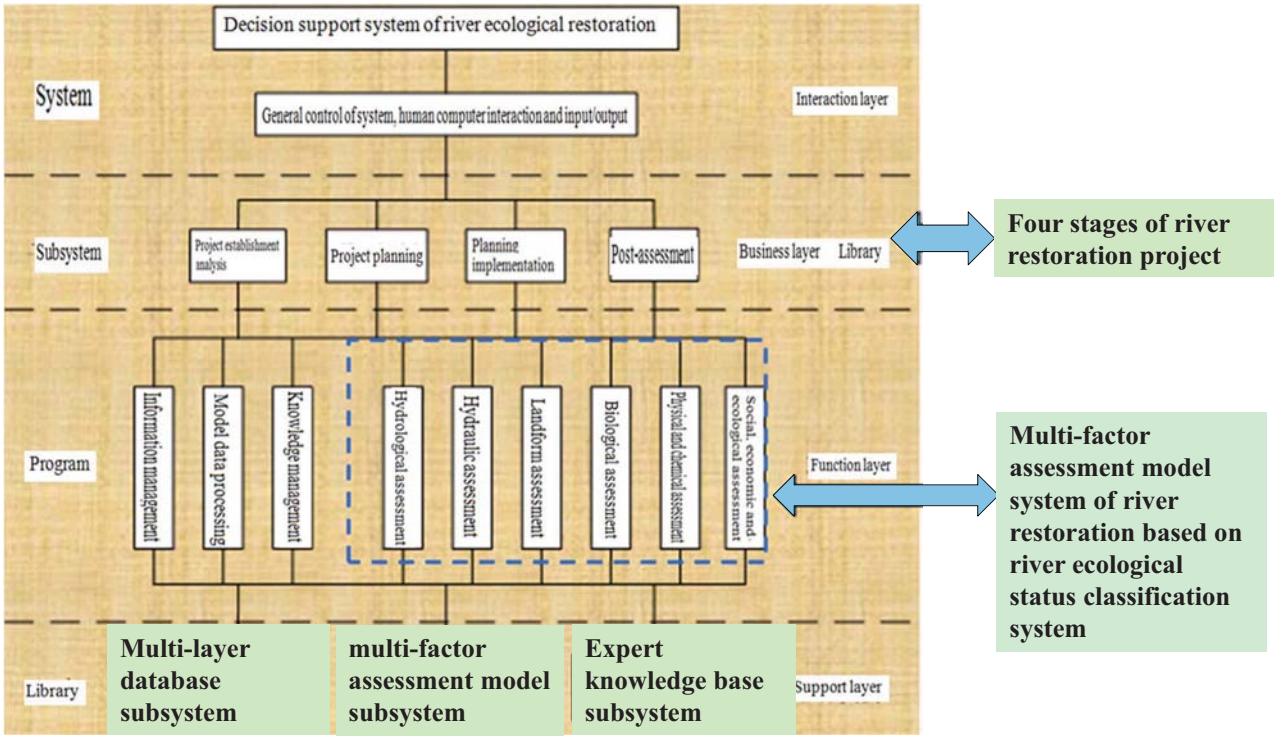
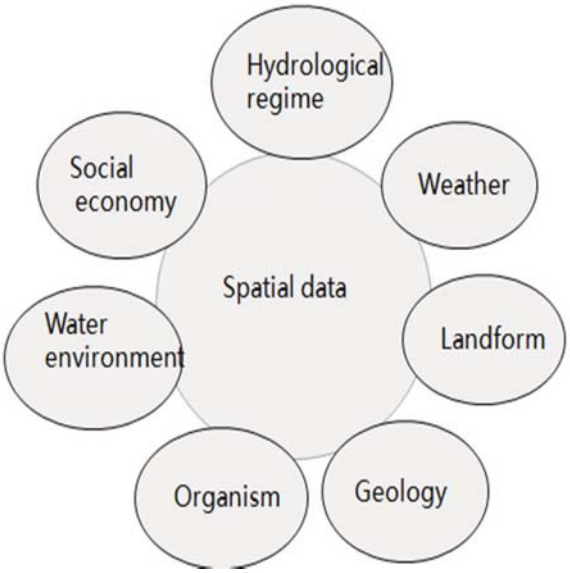
Research result-5. Platform development of decision support system of river restoration adaptive management

Structure chart of decision support system of river restoration adaptive management



Research result-5. Platform development of decision support system of river restoration adaptive management

■ Multi-layer database subsystem



■ Provide sufficient data foundation for the whole process of river restoration project;

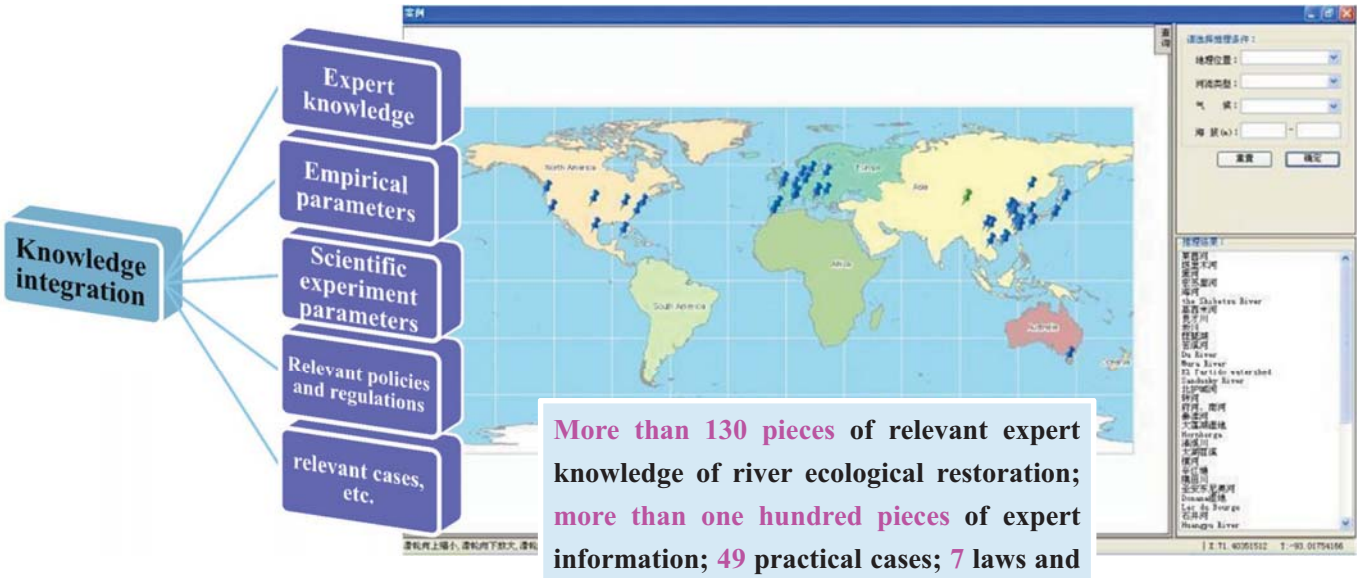
■ By making use of modern information technology, establish data acquisition, reorganization, mining and processing mechanisms and achieve the integrated management of multi-level and various types of professional data;

■ Integrate and show the data of different categories, different periods and different formats through GIS platform.

Research result-5. Platform development of decision support system of river ecological restoration adaptive management

■ Expert knowledge base subsystem

Structurize the relevant river ecological restoration project case information and display it with spatial coordinates as the frame and case attribute as the basis.



More than 130 pieces of relevant expert knowledge of river ecological restoration; more than one hundred pieces of expert information; 49 practical cases; 7 laws and regulations.

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Ⅲ Application— *take Oujiang River as an example*

1. System interface

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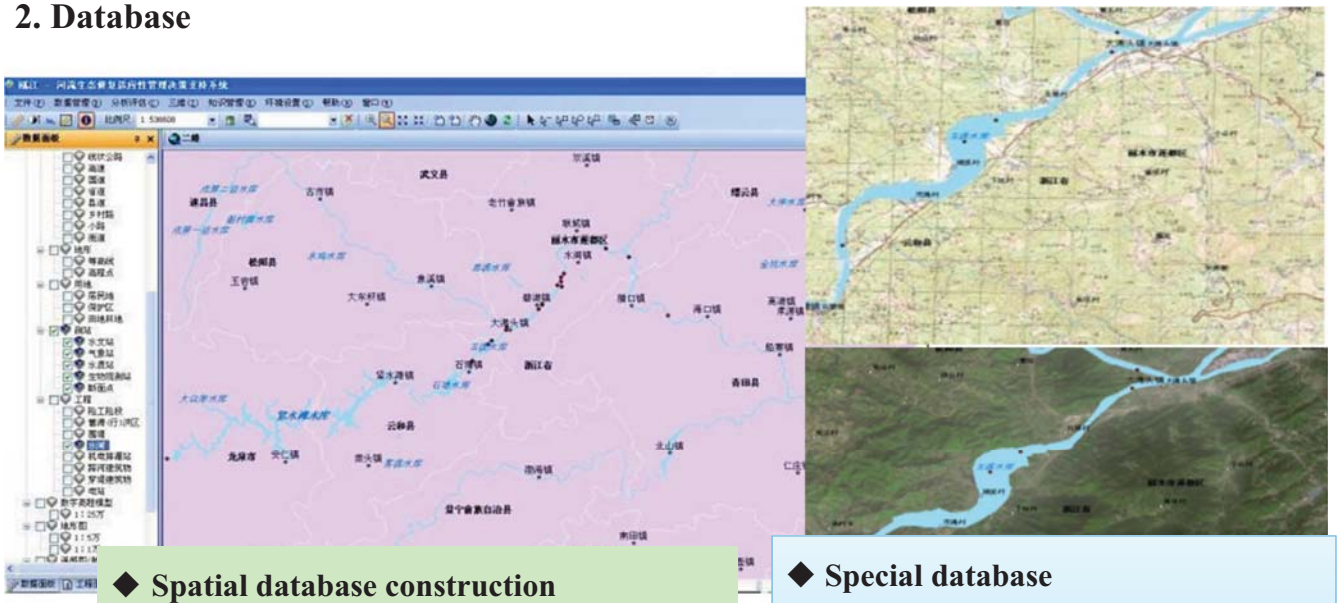
Ⅲ Application— *take Oujiang River as an example*

2. Database



◆ **Spatial database construction**

Digital elevation model (DEM), digital raster graph (DRG), digital orthophoto map (DOM) and other spatial data sets

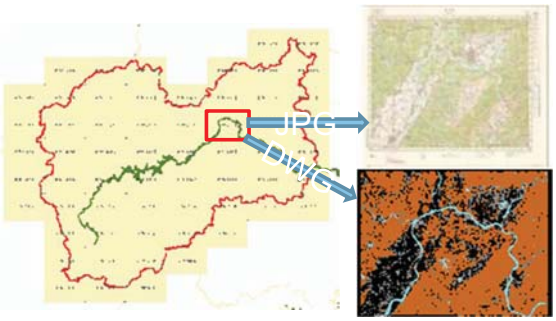
◆ **Special database**

Geographical information of each observation station and cross section as well as actually measured hydrological regime and water quality information of each observation station

Ⅲ Application— *take Oujiang River as an example*

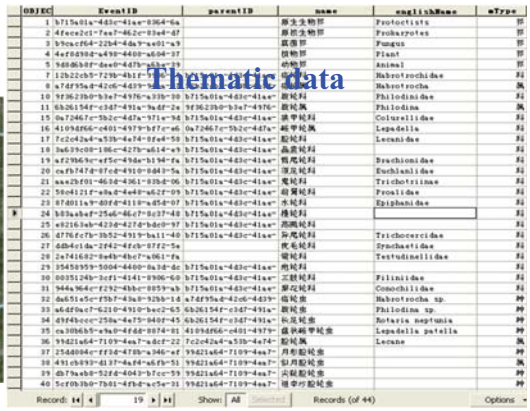
3. Import data

Basic geographical data



Remote sensing image data

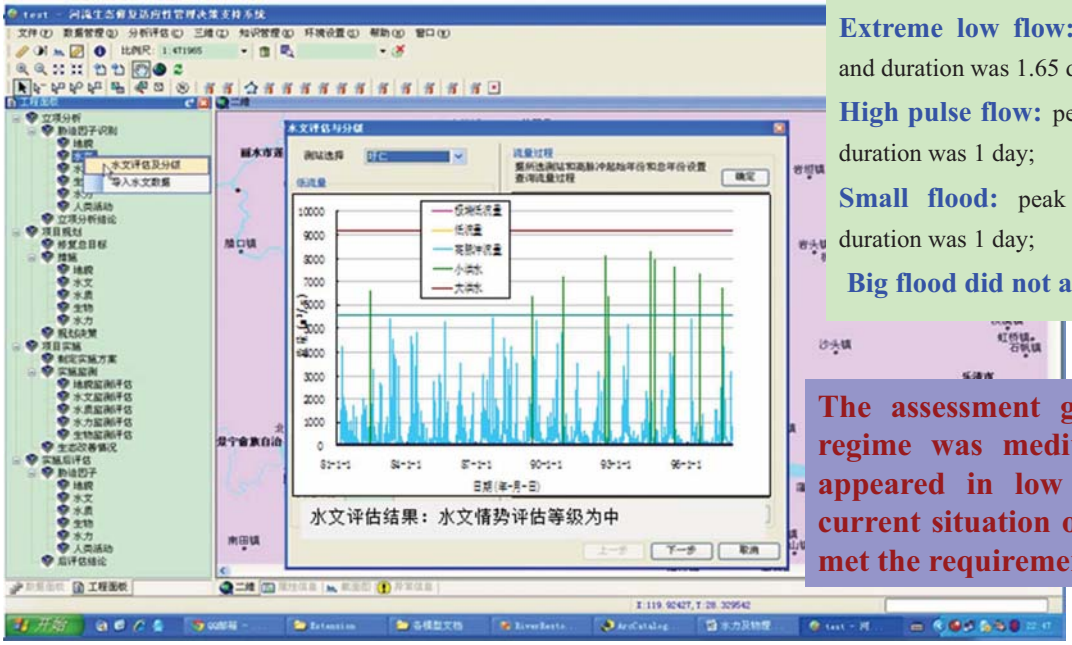
Thematic data



Ⅲ Application— *take Oujiang River as an example*

4. Ecological element assessment and classification

Hydrological assessment



Current situation of hydrological regime (1981-1996)

Extreme low flow: peak value was 42.98m^3/s and duration was 1.65 days;

High pulse flow: peak value was 4,860 m^3/s and duration was 1 day;

Small flood: peak value was 7,281m^3/s and duration was 1 day;

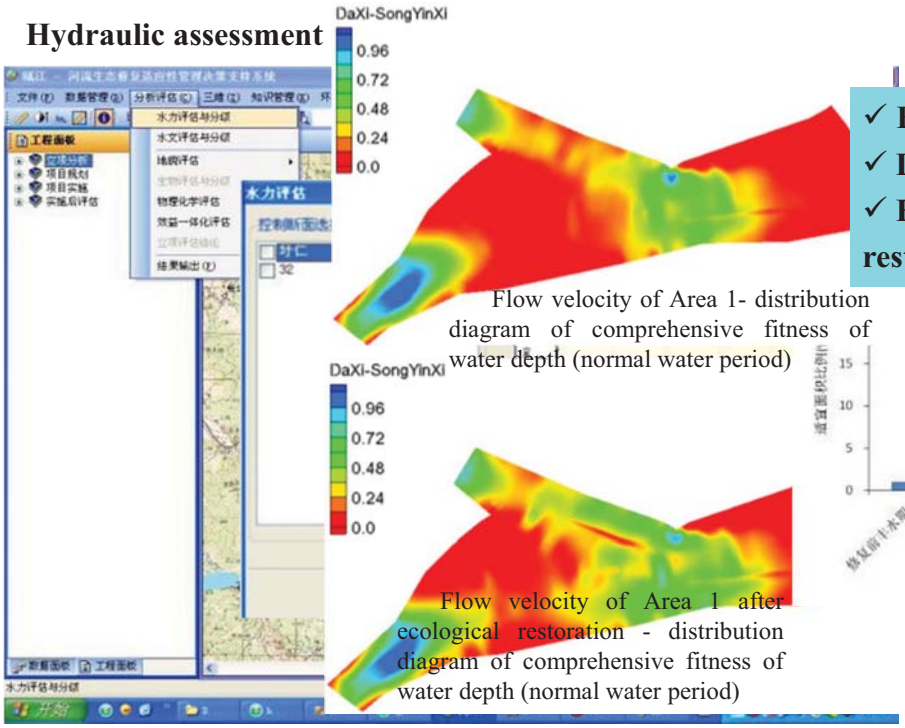
Big flood did not appear.

The assessment grade of hydrological regime was medium: high pulse flow appeared in low flow years and the current situation of hydrological regime met the requirements of base flow.

Ⅲ Application— *take Oujiang River as an example*

4. Ecological element assessment and classification

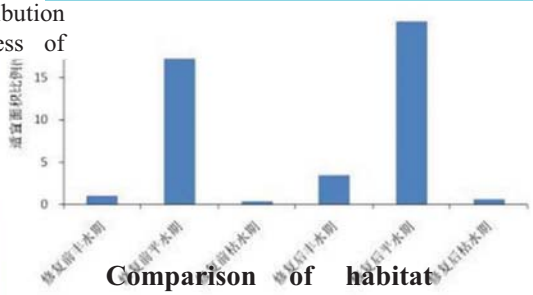
Hydraulic assessment



Flow velocity of Area 1- distribution diagram of comprehensive fitness of water depth (normal water period)

Flow velocity of Area 1 after ecological restoration - distribution diagram of comprehensive fitness of water depth (normal water period)

- ✓ **Ban sand mining activities**
- ✓ **Dredge river**
- ✓ **Have important significance for restoring biotic habitat**



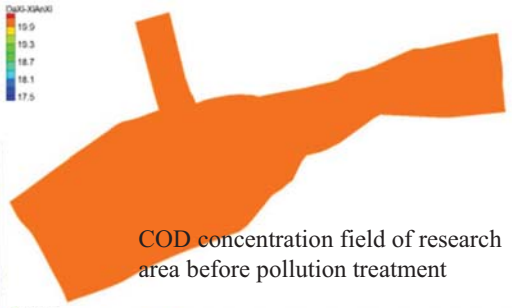
Comparison of habitat suitability area before and after ecological restoration

17.25% ⇨ 21.64%

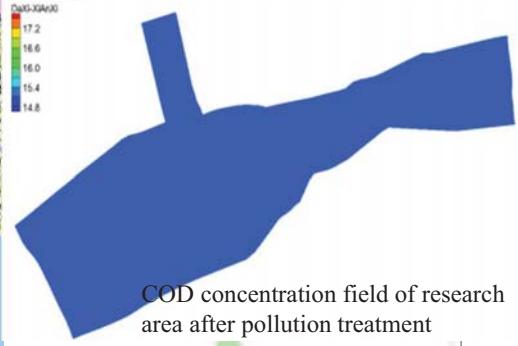
Ⅲ Application— *take Oujiang River as an example*

4. Ecological element assessment and classification

Physical and chemical assessment



COD concentration field of research area before pollution treatment



COD concentration field of research area after pollution treatment

Except **Lishui Xiahe cross section (Class IV)**, the annual average values of other cross sections of Oujiang River trunk stream all **reached Class II standards**, and the main overproof items of Lishui Xiahe cross section were **BOD_5, DO and petroleum**.

At present, the water environment quality of the research area is good, basically meeting the requirements of aquatic organisms. If the pollution treatment can be strengthened continuously, the physical and chemical classification may be improved from good to excellent, more suitable for aquatic organisms to inhabit.

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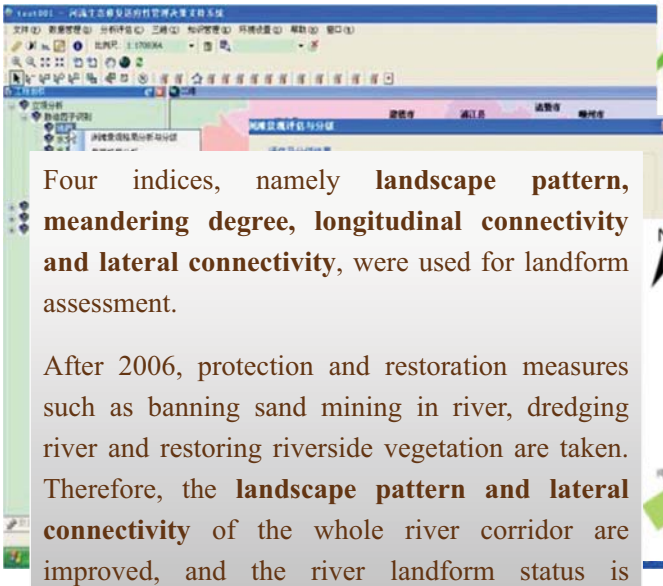
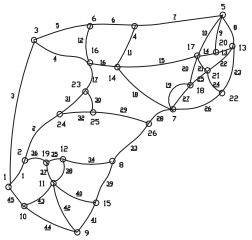
Ⅲ Application— *take Oujiang River as an example*

4. Ecological element assessment and classification

Landform assessment

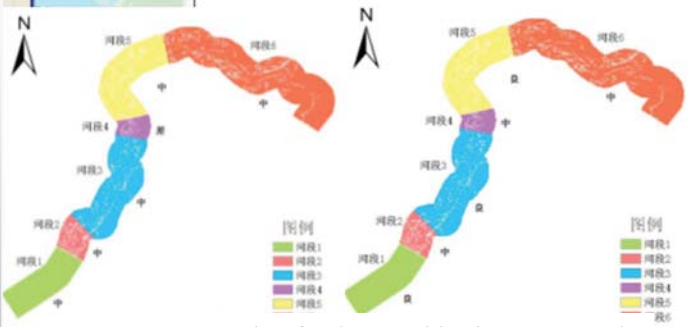




Connectivity status graph and graph model when water level is 48.5m

Four indices, namely **landscape pattern, meandering degree, longitudinal connectivity and lateral connectivity**, were used for landform assessment.

After 2006, protection and restoration measures such as banning sand mining in river, dredging river and restoring riverside vegetation are taken. Therefore, the **landscape pattern and lateral connectivity** of the whole river corridor are improved, and the river landform status is **restored from medium to good**.



Assessment results of Kaitan-Yuxi landscape pattern in Oujiang River in 2004 and 2009

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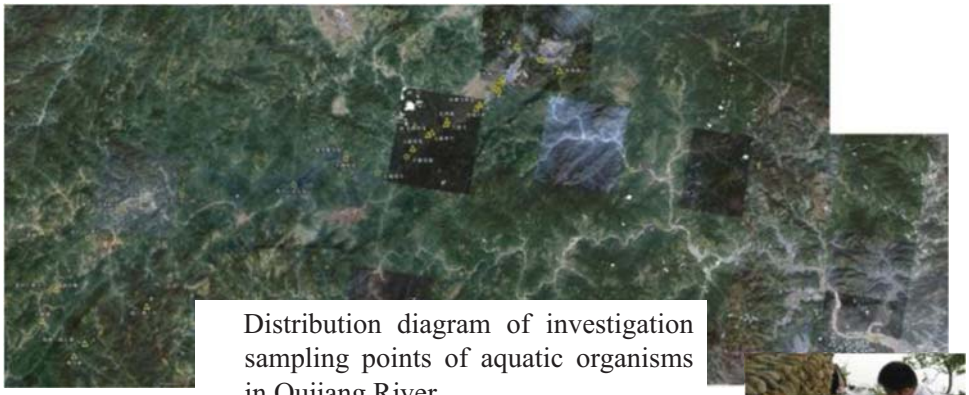
Ⅲ Application— *take Oujiang River as an example*

4. Ecological element assessment and classification

Biological assessment



Distribution diagram of investigation sampling points of aquatic organisms in Oujiang River

Assessment indexes of fish in each sampling point of Oujiang River

Index	Chatian Town	Longquan	Dagangtou	Lishui	Haikou Town
Shannon-Wiener Index Hn′	2.464,7	2.352,0	1.948,5	2.444,2	2.324,8
Shannon-Wiener Index Hw′	2.444,8	2.625,9	1.459,6	2.509,8	2.147,6
Pielon Index J′	0.739,7	0.750,1	0.650,4	0.693,1	0.820,6
Species Richness Index D	4.756,2	3.69	3.522,7	5.726,3	3.199,6
IBI Value	42	34	24	38	36

Ⅲ Application— *take Oujiang River as an example*

Social, economic and ecological assessment

Identification of service functions of ecosystem in Oujiang River

Supply function	Animal and plant products	Domestic water	Agricultural irrigation	Industrial water	Hydroelectric power generation	Waterway transport
	√	√	√	√	√	√
Support function	Hydrological cycle balance	Geological natural evolution	Nutrient transport	Biodiversity	Groundwater recharge	Sand flushing desilting
	√	√	√	√	√	√
Adjustment function	Climate regulation	Dilution and purification	Flood storage			
	√	√	√			
Cultural function	Landscape effect	Entertainment tourism	Aesthetic enjoyment			
	√	√	√			

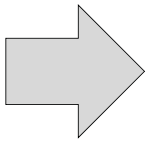
The ecological protection and restoration effect of the river was reflected in the increased benefits ,RMB 8.13 billion Yuan.

The minimum value of the wetland restoration benefits of Oujiang River demonstration site calculated by wetland restoration cost method was RMB 1.85 million Yuan/year.

Ⅲ Application— *take Oujiang River as an example*

Assessment conclusions

	Hydrological regime	Physical chemistry	Hydraulic condition	Landform	Organism
Excellent					
Good					
Medium					
Poor					



	Hydrological regime	Physical chemistry	Hydraulic condition	Landform	Organism
Excellent					
Good					
Medium					
Poor					

Social, economic and ecological benefits of demonstration segment: 12.3 (RMB 100 million Yuan)

Before planning implementation

Social, economic and ecological benefits of demonstration segment: 33 (RMB 100 million Yuan)

After planning was implemented partially

After the planning was implemented partially, the grades of physical chemistry, hydraulic condition and landform in the classification system were improved, the grades of hydrological regime and organism unchanged, and the social, economic and ecological benefits increased significantly.

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Ⅳ. Conclusion

- The decision support system of river restoration adaptive management(DSSRRAM) plays a role during planning and implementation phases of Oujiang River.
- The system could be updated with the progress of information technology, the progress in the field of river restoration theory and technology.
- This system is so complicated that it is difficult for non-professionals to utilize it efficiently, which will be simplified in future so that it could be popularized.
- At present, the system is just be applied in South China area, which should be modified when applied in other area because of the different characteristics of ecological elements.

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Thank you for your attention!