XVIII World Water Congress
International Water Resources Association (IWRA)

Scenario analysis of different empowerment methods for assessing the ecological restoration potential of watersheds

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XVIII WORLD WATER CONGRESS
Water for All
Harmony between Humans and Nature
第18届 世界水资源大会
水与万物:
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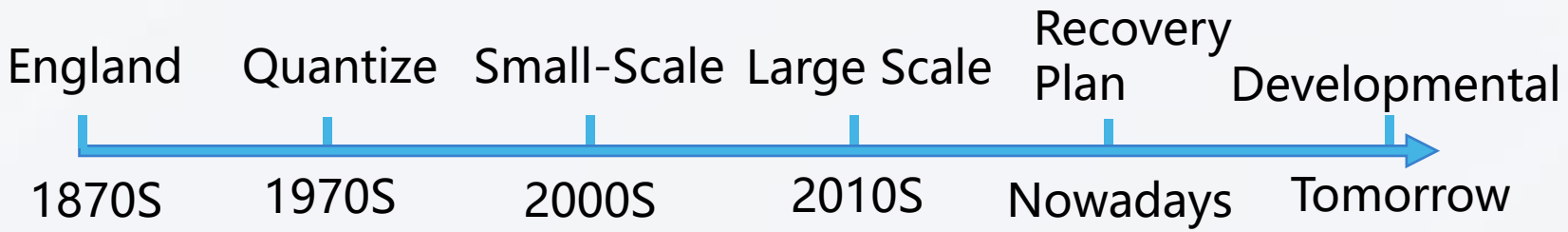
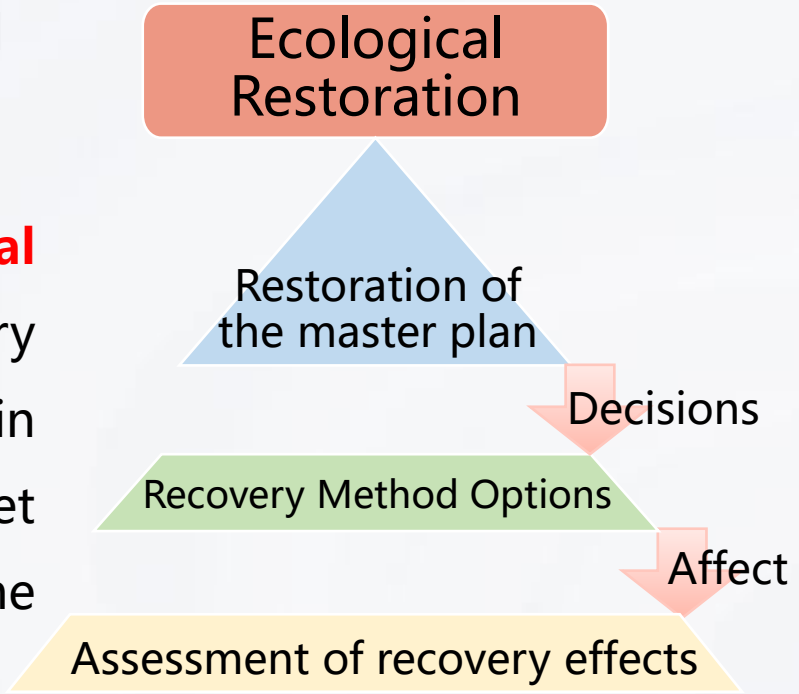
1) Overview of ecological restoration potential assessment





Ecological restoration potential assessment is **a branch of ecological restoration science**, ecological restoration science has a long history of development, the earliest can be traced back to the 19th century in England, and ecological restoration potential assessment is to meet the needs of **strategic planning** and the development of the emerging disciplines.

- The assessment of ecological restoration potential **is the top-level design of restoration ecology**, which plays a crucial role in the selection of subsequent restoration methods and the effectiveness of restoration.

1) Ecological restoration potential step

Methodological steps for assessing ecological restoration potential

According to existing relevant studies, the steps for assessing ecological restoration potential are mainly a **four-step framework**.

The four-step framework

① Comprehensive survey
- Ecological problems in the watershed were identified after a **comprehensive survey and study** of the watershed.

② Selection of indicators
- The synthesis of the findings and the balance of interests of all parties to **select a suitable system of assessment indicators**.

③ Scientific empowerment
- Selection of **scientifically appropriate weighting methods** for different indicator selection scenarios.

④ Potential assessment
- The ecological restoration potential scores for each area were synthesized to **determine a preferred list** of restoration areas.

In step ③ Different empowerment methods have different application scenarios

1) Weighting analysis methods

Introduction to the empowerment methodology

The current empowerment methods that are often used in evaluation fall **into two main camps**. One is **the subjective empowerment method** and the other is **the objective empowerment method**.

Subjective Empowerment Method

e.g. AHP
G1
DEMATEL
……and so on

Advantages are that they are not constrained by the completeness of the data and can be analyzed in the context of the actual problem.

Disadvantage is that it tends to be highly subjective and arbitrary, increasing the burden on decision analysts.

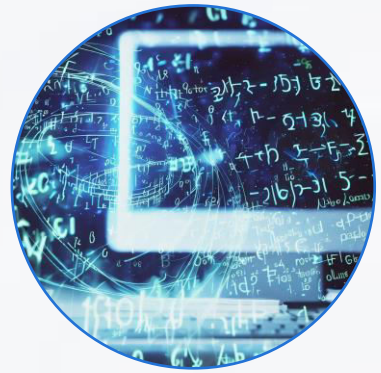
Different methods of empowerment have their own **advantages and disadvantages**, but most importantly:

fitting

There is **no best method** of empowerment only **the most appropriate one**.

Objective Empowerment Method

e.g. Entropy Weighting
PCA
Mean Squared Error
……and so on



Advantages are easy to operationalize, strongly grounded in mathematical theory and do not increase the burden on decision makers

Disadvantage is that it is constrained by the adequacy of the data, and it can happen that the weighting results are skewed and not robust enough

2) Technical Flow Chart

Technical flow of this article

Conducted field surveys to determine the ecological condition of the regions and obtained data

Selection of indicators as needed to formulate the data situation

Assign each case separately using different assignment methods

Evaluate the results using different weights to get a preferred list of restoration areas

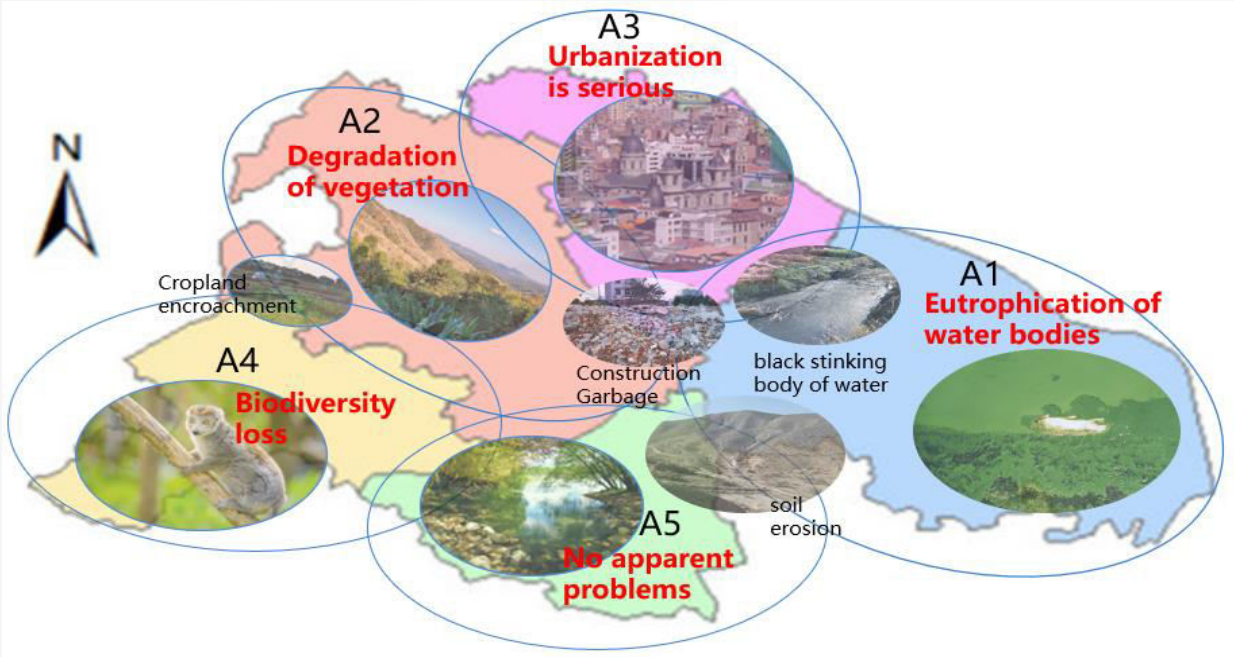
Comparison of evaluation results with survey findings

Analysis of the causes of the results

Survey of regional ecological issues

The previous survey found that there are **many ecological problems** in the Xiaonanhai watershed, and several ecological problems often exist in one area.

The Xiaonanhai watershed is divided into **five assessment units** (denoted by A1 to A5) and the areas are represented by the **most significant problems** in each area.



2) Indicator selection and scenario modeling

Selection of indicators

Four sets of indicators with **different amounts of data** were developed for separate assignments, oriented to **the main issues** of the evaluation region.

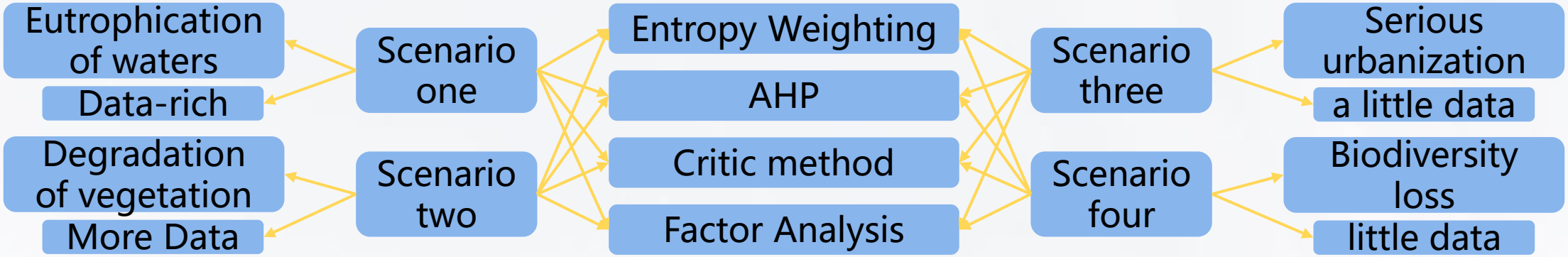
Biodiversity loss
Vegetation cover index
Vegetation Diversity Index
Aquatic Biodiversity Index

Serious urbanization
Heavy Metal Pollution Index
COD
Number of industrial enterprises in region
Waste water per unit of industrial output
Water quality level

Degradation of vegetation
Vegetation cover index
Soil water content
Vegetation Diversity Index
GDP
Fertilizer use per unit area
Heavy Metal Pollution Index
Basic farmland area

Eutrophication of waters
TN
TP
COD
Chlorophyll-a
Nitrite
Ammonia Nitrogen
DO
Fertilizer use per unit area
Self-purifying capacity of rivers

Comparison of weights in four simulation scenarios



3) Simulation results

Scenario one

Data-rich

Indicator	Factor analysis method of empowerment	Critic method empowerment	Entropy weight method of empowerment	AHP method of empowerment
C1	11.84%	11.87%	14.94%	28.62%
C2	12.07%	8.04%	9.93%	15.77%
C3	10.41%	8.00%	10.18%	8.59%
C4	11.96%	8.51%	10.70%	3.27%
C5	12.48%	8.29%	11.26%	2.21%
C6	11.03%	13.88%	20.36%	20.76%
C7	12.53%	13.78%	6.53%	10.87%
C8	7.78%	10.24%	9.04%	4.07%
C9	9.89%	17.38%	7.05%	5.84%
Region	**Regional Rankings**			
A1	1	2	2	2
A2	3	3	1	1
A3	4	4	4	4
A4	2	1	3	3
A5	5	5	5	5

Scenario two

More Data

Indicator	Factor analysis method of empowerment	Critic method empowerment	Entropy weight method of empowerment	AHP method of empowerment
C10	12.43%	13.47%	13.57%	34.73%
C11	9.61%	15.00%	11.19%	25.13%
C12	21.43%	12.10%	12.87%	15.22%
C13	13.66%	16.34%	21.23%	7.15%
C8	21.88%	12.08%	12.61%	10.41%
C14	0.41%	19.10%	16.31%	2.87%
C15	20.58%	11.91%	12.21%	4.48%
Region	**Regional Rankings**			
A1	1	1	2	1
A2	2	2	1	2
A3	3	4	4	3
A4	5	3	3	5
A5	4	5	5	4

When there is **data-rich (Scenario I), the factor analysis method** is the best for empowerment. When there is **more data (Scenario II), the entropy weight method** is the best. When there is **less data (scenario III), the Critic method** is the best for empowerment. When there is **very little data (Scenario IV), the AHP method** of empowerment works best.

Scenario three

A little data

Indicator	Factor analysis method of empowerment	Critic method empowerment	Entropy weight method of empowerment	AHP method of empowerment
C14	21.87%	16.88%	21.77%	17.43%
C3	15.89%	27.75%	19.06%	24.82%
C16	15.94%	27.65%	20.93%	9.84%
C17	21.94%	12.71%	15.14%	41.53%
C18	24.37%	15.00%	23.09%	6.38%
Region	**Regional Rankings**			
A1	4	4	4	3
A2	3	3	3	4
A3	2	1	2	2
A4	1	2	1	1
A5	5	5	5	5

Scenario four

little data

Indicator	Factor analysis method of empowerment	Critic method empowerment	Entropy weight method of empowerment	AHP method of empowerment
C10	31.73%	29.34%	34.42%	16.37%
C12	31.23%	29.10%	32.90%	29.72%
C19	37.04%	41.55%	32.67%	53.89%
Region	**Regional Rankings**			
A1	1	1	1	3
A2	2	2	2	2
A3	4	5	4	4
A4	3	3	3	1
A5	5	4	5	5

3) Final conclusions

In the assessment of ecological restoration potential, a systematic analysis of the empowerment methods applied under various scenarios was carried out to obtain the results of the empowerment analysis.

Hierarchical analysis results are intuitive and applicable in the assessment of ecological restoration potential in cases where there is very little data, and the number of recommended indicators is **under 4.**

Suggested number of indicators **<4**

The Critic method is suitable for use when there is little data to assess the indicators, when the indicators are objectively measurable and have a low degree of homogenization, and when the number of recommended indicators is **4 to 6.**

Suggested number of indicators **4~6**

The entropy weight method is suitable for the assessment of more data of indicators, and the independence of the content of indicator characterization is stronger, when the number of indicators is **6 to 8.**

Suggested number of indicators **6~8**

Factor analysis is suitable for use when assessment data are abundant and the number of indicators is **8 or more**, while redundant indicator systems can be streamlined using factor analysis.

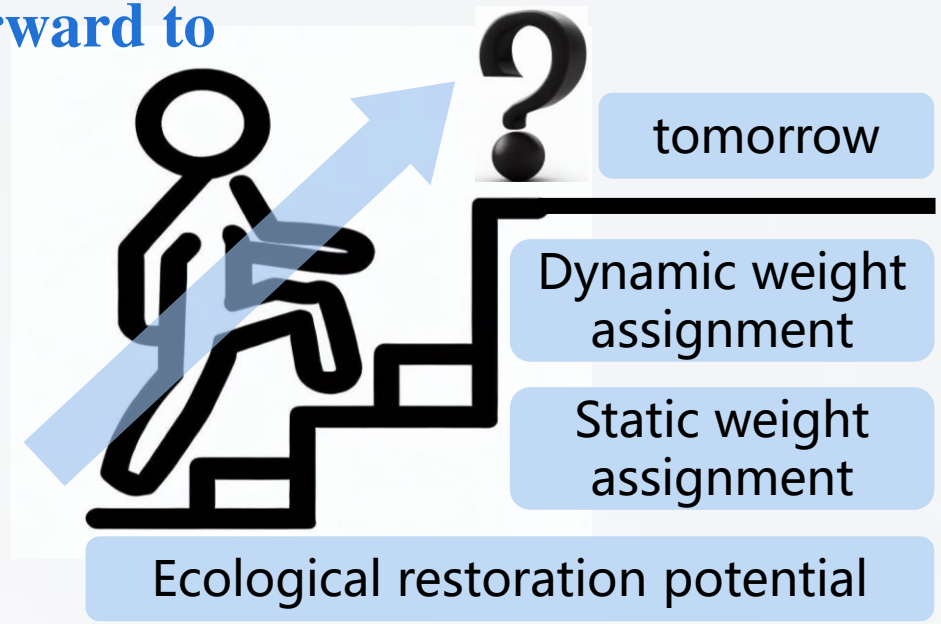
Suggested number of indicators **>8**

4) Summarizing and looking forward

Summarize

Although the assessment of ecological restoration potential can quickly and effectively obtain a list of preferred areas for restoration, its methodological system is generally relatively new and there are still many imperfections. However, as scholars gradually refine their research, ecological restoration potential assessment will be **more accurate, efficient and convenient in the future**.

Look forward to



Efficiently

Convenient

accurate

Thanks for your listening!