Taizi River

river health report card

2011

What is river health?

The concept of "river health" incorporates ecological and human values. A "healthy" river is one which has retained its ecosystem integrity. The health of a river depends on its ability to maintain its structure and function, to recover after disturbance, to support local biota (including human communities), and to maintain key processes, like sediment transport, nutrient cycling and energy exchange.

River health is important. Healthy rivers provide water for drinking, agriculture, and industry; fish and other produce for consumption; the assimilation of waste products; buffers against flooding; and recreational opportunities. As rivers become unhealthy, they lose their capacity to provide these valuable goods and services.

Assessing river health

Maintaining and improving river health requires an accurate assessment of the current ecological state of river ecosystems. This process can:

- Identify rivers that are in poor health, or at risk
- Identify the likely causes of poor health
- Help prioritise funding for river restoration, and guide effective management actions
- Assess the effectiveness of management actions
- Allow for reporting on river health

Background to this document

This document has been prepared as part of the River Health and Environmental Flow in China Project. The work described was funded by:

- The Australia-China Environment Development Partnership.
- The China Special Science and Technology Program on Water Pollution, Control and Treatment

This document summarises the results of a pilot river health study in the Taizi River catchment including:

- The basic river health science behind the study
- An assessment of the health of the waterways of the catchment
- Recommendations for future monitoring programs

Introduction to the catchment

The Taizi River catchment forms part of the Liao River basin, located in China's northeast. The catchment, located in the middle of Liaoning Province, has been an important industrial area since the 1950s. Key threats to river health include industrial, urban, and rural pollution, clearing of natural vegetation, the construction of in-stream barriers, the alteration of natural river flows, and the riparian extraction of sand and gravel.

Catchment facts

Drainage: 13,900 km^2

River length: 413km

Annual rainfall: 655-955mm

Mean annual runoff: 4.5 billion m^3

Population: 5.5 million

Land use:
57.2% natural forest
0.8% natural grassland
31.9% agriculture
6.9% urban

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Australian Government AusAID

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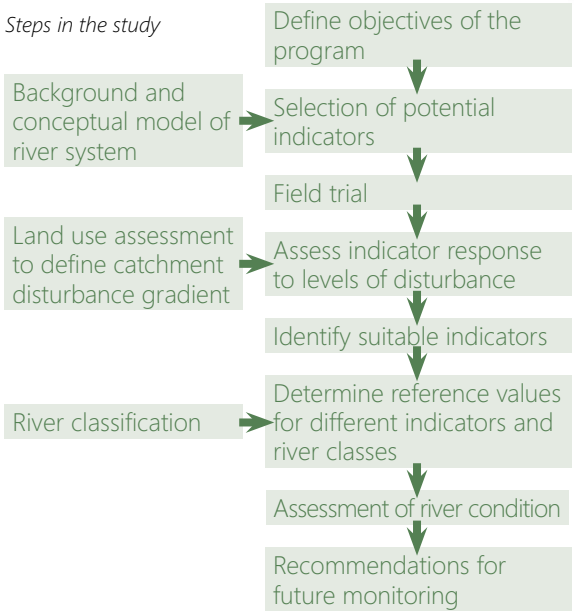
Summary

Methodology

The study aimed to establish a method for selecting suitable indicators of river health, and to make an initial assessment of river health in the catchment. The key steps in this process were:

- Development of conceptual models: to understand the effects of human disturbance on the catchment, and the likely impacts of catchment disturbance on different indicators
- Field trial: involving sampling of 70 sites across the catchment in May 2009. Sampling was carried out for water quality, benthic macroinvertebrates, fish, algae, aquatic and riparian vegetation, and physical form.
- Assess indicators against catchment disturbance: a primary disturbance gradient was generated by assessing land use and land cover upstream of each sampling site. Potential indicators were assessed to see how they varied with changes in levels of disturbance. A secondary water quality disturbance gradient was also used to test the response of biological indicators.
- River classification: rivers across the catchment were classified based on a range of factors, including topography, climate, and hydrology. This allowed for comparisons between similar river reaches and types.
- Establishing reference values: to define what values would amount to a good or a bad score for different indicators across different river classes.
- Scoring sites and indicators: at each site, for each indicator a score from 0 – 1 was assigned, using the reference values as a benchmark. These scores were aggregated to produce scores for different indicator groups and sites.



Key findings and recommendations

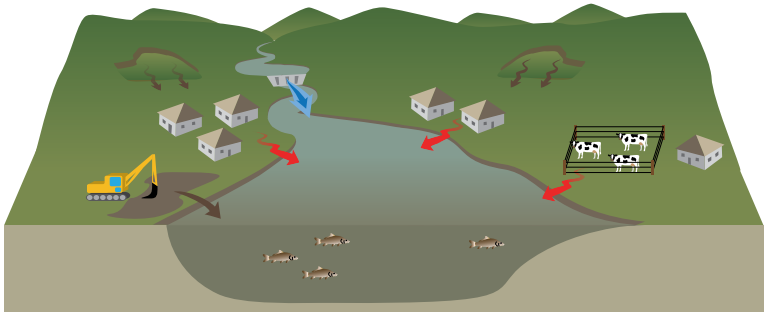
- The study identified a number of indicators which would be suitable for future use in a monitoring program
- The ecological health of the river is better in the highlands than the lowlands
- Indicators of nutrient levels and fish species richness suggest unacceptable levels of ecosystem health across the entire catchment
- Many of the biotic indicators suggest a poorer level of health than do the water quality indicators. This likely reflects the ability of biological indicators to incorporate ecosystem conditions and stresses over a longer timeframe than water quality indicators, which provide a snapshot in time.
- Scores derived during the pilot study should serve as a benchmark for future monitoring and assessment in the catchment. However, scores should be reviewed with each round of monitoring and assessment, particularly to improve the suitability of thresholds adapted from other regions.

Further information

Further information on the project, including detailed technical reports on the Taizi river health assessment, is available at:
http://www.watercentre.org/research/applied-research/acedp

Conceptual diagrams

Highlands



Physical features

Catchment area: 4,557 km^2
Mean altitude: 511 metres
Annual precipitation: 786 – 954 mm

Mean river width: 14.8m
Mean substrate index: 3.6

Human disturbances

- Loss of native vegetation
- Grazing livestock
- Urban development
- In-stream sand mining

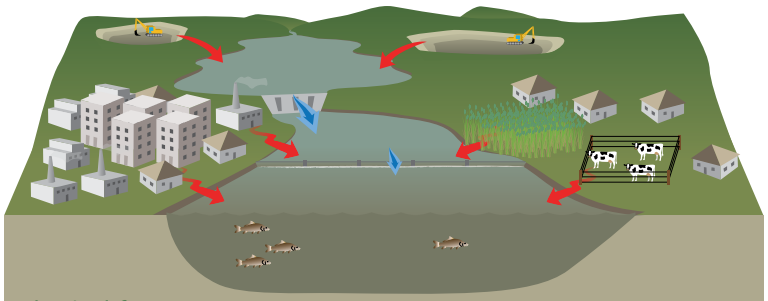
Dominant species

- Fish: *Phoxinus lagowskii* Dybowski, *Phoxinus czekanowskii*
- Macroinvertebrates: *Baetis thermicus*, *Epeorus latifolium*, *Serratella rufa*

Priorities for management*

- Maintain natural habitat
- Protect diversity and biotic integrity of aquatic organisms
- Reduce suspended solids

Midlands



Physical features

Catchment area: 3,896 km^2
Mean altitude: 282 metres
Annual precipitation: 717 – 868 mm

Mean river width: 44.4m
Mean substrate index: 3.4

Human disturbances

- Flow alteration due to dams
- Mining (predominately iron-ore)
- Urbanization
- Point source pollution from factories

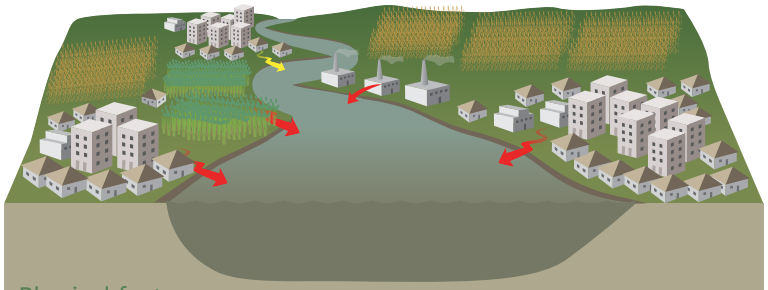
Dominant species

- Fish: *Phoxinus lagowskii* Dybowski, *Abbottina rivularis*
- Macroinvertebrates: *Baetis thermicus*, *Serratella rufa*, *Gammarus* sp.

Priorities for management*

- Reduce nitrogen and phosphorus loads
- Protect ecologically important aquatic organisms

Lowlands



Physical features

Catchment area: 4,749 km^2
Mean altitude: 65 metres
Annual precipitation: 653 - 775 mm

Mean river width: 84 m
Mean substrate index: 2.1

Human disturbances

- Point source pollution from factories
- Diffuse pollution from farmland
- Urbanization

Dominant species

- Fish: almost non-existent
- Macroinvertebrates: *Baetis thermicus*, *Branchiura sowerbyi*

Priorities for management*

- Reduce organic pollutant load
- Protect the most common aquatic organisms
- Improve water quality within national standards

Flow variability
Point source input
Diffuse source input

Nutrients
Sediments
Chemicals

** Note: Priorities for management were developed by the project team based on existing government programs and expert opinion*

Indicator selection

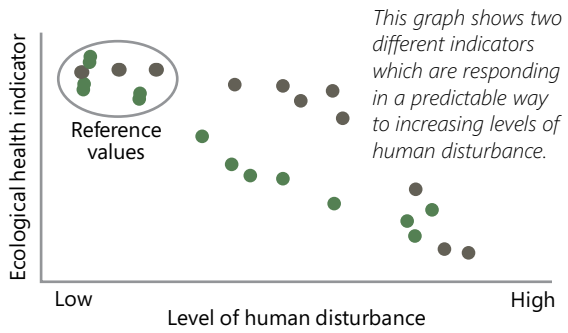
Indicators need to respond predictably to disturbance in the catchment, and changes in river health. Testing a range of indicators to ensure they respond as expected is an important step in developing a river health monitoring program.

In this study, it was necessary to first establish the levels of human disturbance across the catchment. This involved considering known impacts on river health, such as agricultural development and urbanisation. The level of disturbance upstream of each sampling site was determined, to establish a "disturbance gradient". The values for different indicators, at different sites, were then tested against this disturbance gradient – to identify which indicator values changed predictably with changes in disturbance. These indicators were then recommended for use in the monitoring program.

Characteristics of a good indicator

An indicator should:

1. Quantify threats and assets
2. Provide easily interpretable outputs
3. Respond predictably to damage caused by humans but be insensitive to natural variation
4. Relate to appropriate scales
5. Be cost effective to measure
6. Relate to management goals
7. Be scientifically defensible



This graph shows two different indicators which are responding in a predictable way to increasing levels of human disturbance.

Stream classification

Categorising similar types of rivers into groups is crucial for setting appropriate river health reference values, and ensures that comparisons are only made between comparable river systems. This process divides a catchment spatially based on its natural characteristics. The approach is underpinned by the understanding that it is these characteristics which influence aquatic ecosystem structure and function.

Using data on local ecosystems collected during the fieldwork, together with existing information on the geography and hydrology of the region, correlations between aquatic ecosystems and natural geographic factors were identified. As a result of this analysis, altitude (via a digital elevation model) and annual precipitation were chosen as the basis of the river classification in Taizi river catchment. The boundaries for different classes were adjusted to align with subcatchments boundaries. This process resulted in three classes of river in the catchment: highlands, midlands and lowlands.

Targets and thresholds

For each indicator, it was necessary to set reference values as a benchmark against which individual sites can be assessed. These define:

- what is a "good" score - the value expected in a healthy river
- what is a "poor" score - the value that indicates unacceptable or critical river condition

Importantly, different reference values need to be defined for different river types. Reference values were established using expert opinion, together with a combination of:

- Existing Chinese standards (GB3838-2002) and Australian guidelines (ANZECC 2000).
- Values derived for sites in the catchment using data collected in the study.
- Results from national and international studies. The adoption of the last of these options was due to the limited available data from undisturbed sites in the catchment. This approach should be phased out as soon as more local data become available.

At each site, for each indicator a score from 0 – 1 was assigned, using the reference values as a benchmark. Scores ranked along a scale ranging from very good (0.8-1) to critical (0-0.2). Scores were calculated using the following formula:

$$\text{Site indicator score} = 1 - \frac{|\text{Target value - observed value}|}{|\text{Target value - threshold value}|}$$

These scores were then aggregated to produce combined scores for different indicator groups, sites, and regions. In calculating an overall site score, different indicator groups were given different weighting. Macroinvertebrates and fish scores were given the greatest weighting, followed by algal scores. The water quality and nutrient indicator groups were given the lowest weighting, given they are most prone to the affects of short-term fluctuations in river health. In addition, an indicator group was automatically given a "critical" rating if either the dissolved oxygen (for water quality) or the NH_4 (for nutrients) value was in the critical range - due to the significance of these indices for river health.

Potential target values for indicators of aquatic ecosystems in very good condition and potential critical values for indicators representing the threshold at which aquatic ecosystem health collapses

					Basis for values				
Group	**Indicator**	**Region**	**"Very good" Target**	**"Critical" threshold**	**Chinese standards**	**Australian standards**	**Literature**	**Pilot study data**	**Expert opinion**
Water quality	EC (uS/cm)	All	≤400	≥1500		✓			✓
	DO (mg/L)	All	≥7.5	≤2	✓	✓			✓
	Phenols (mg/L)	Midlands and Lowlands	≤0.002	≥0.1	✓				✓
	BOD_5 (mg/L)	Lowlands	≤3	≥10	✓	✓		✓	✓
	COD_{Mn} (mg/L)	Lowlands	≤2	≥15	✓	✓			✓
Nutrients	Total nitrogen (mg/L)	All	≤0.2	≥2	✓	✓			✓
	Total phosphorus (mg/L)	All	≤0.02	≥0.4	✓	✓			✓
	NH_4 (mg/L)	All	≤0.15	≥2	✓	✓		✓	✓
Algae	Algal biotic index	All	7	0				✓	✓
	Algal Berger Parker index	All	≤0.15	≥0.90					✓
Macro invertebrates	Macroinvertebrate family richness	Highlands and Midlands	≥30	0		✓	✓	✓	✓
		Lowlands	≥22	0		✓	✓	✓	✓
	Macroinvertebrate BMWP score	Highlands and Midlands	≥131	0			✓	✓	✓
		Lowlands	≥81	0	✓		✓	✓	✓
	EPT family richness	Highlands	≥15	0		✓	✓	✓	✓
		Midlands	≥10	0		✓	✓	✓	✓
		Lowlands	≥7	0		✓	✓	✓	✓
Fish	Fish species index	All	65	0			✓	✓	✓
	Fish biotic index	All	25	5				✓	✓
	Fish Berger Parker index	All	≤0.15	≥0.90					✓

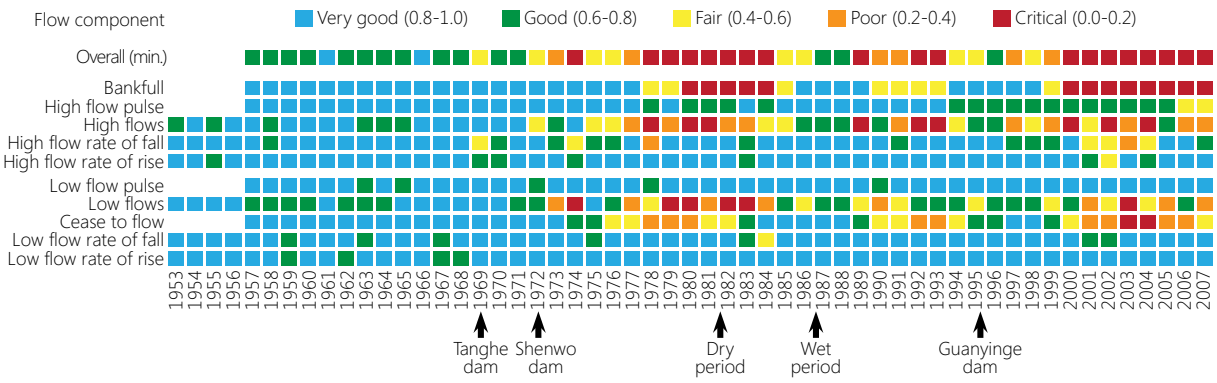
Environmental flows

Environmental flow is the pattern of river flow, or flow regime, which leads to a healthy ecosystem. People benefit from environmental flows because a healthy river ecosystem provides safe drinking water, adequate water for cities, industry and agriculture, favourable conditions for certain animals and plants that people highly value, and rivers that are attractive for recreation and tourism. Environmental flow needs are assessed using a scientific method that relates the flow regime to the level of river health that can be achieved.

In a major river like the Liao system, it is worth undertaking a detailed scientific investigation of the environmental flow needs. To do so, the ecological assets are first defined. Then, through an understanding of the ecological, hydrological and geomorphological character of the assets, the flows required to achieve a certain standard of river health can be determined.

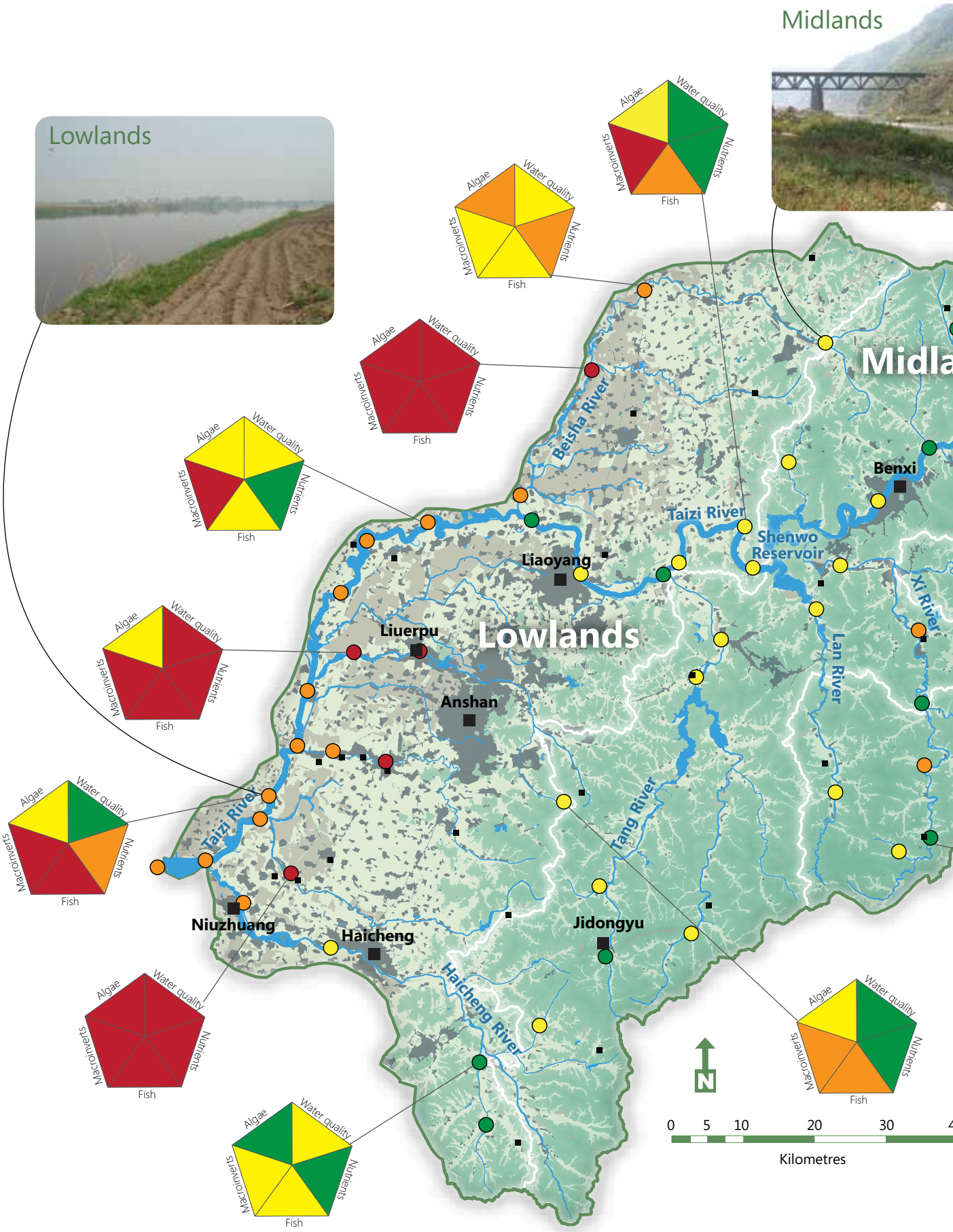
An investigation of the environmental flow needs of the Taizi River identified a number of important ecological assets, and established hydrological objectives that would maintain those assets in a healthy state. These objectives were developed for fish, macroinvertebrates, vegetation and physical form. The extent to which these objectives were met in each year, called the compliance, was then determined. An Index of Flow Health (IFH) was developed to measure the degree of compliance with what was expected for good ecological health. The IFH can be calculated for any year from daily flow records.

Calculation of the IFH produced a comprehensive picture of the pattern of flow health in the Taizi River main stem over the past 50 years. The IFH shows the effect of dams, water extraction, and even dry years and wet years, on environmental flows, and is thus an indicator of changing river health. If river managers decided to implement an environmental flows regime, then the IFH would show an immediate improvement. Of course, river health also depends on human pressures on water quality, riparian vegetation and physical form, and a full assessment of river health should also include these factors, along with direct measures of biological health (such as fish, invertebrates and algae).



IFH score for Liaoyang from 1953 to 2007. The overall score for each year is the minimum score of any component.

Report Card Results

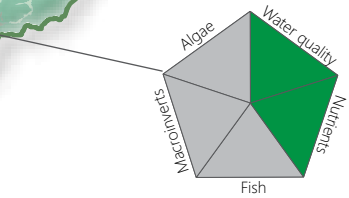


Map legend

- major city (population > 500,000)
- city (population < 500,000)
- Agricultural area
- Irrigated agricultural area
- Natural area
- Urban area
- stream class boundary

Site and indicator health

- Good-very good (0.6-1.0)
- Fair (0.4-0.6)
- Poor (0.2-0.4)
- Critical (0.0-0.2)
- No data/not applicable



What makes up the pentagon?

Each pentagon presents the river health score for each of the 5 different indicator groups sampled at an individual site. The scores for each indicator in a group are aggregated to give a single group score. The group score is indicated by the colour of the relevant section of the pentagon: a section that is green represents a score of 0.6 to 1.0 (good to very) while red indicates a score of 0.0-0.2 (critical).