Postprint of Health Assessment of the Yarkand River Based on the Coordinated Development Degree Model

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Abstract

Identifying impact factors that effectively indicate river health status and its changes, and conducting evaluations thereof, is crucial for the eco-hydrological conservation and adaptive management of inland rivers. Taking the Kaqun-Ailike Tamu reach of the Yarkant River as the assessment section, a river health assessment indicator system comprising 23 indicators was established based on the Pressure-State-Response (PSR) model; a river health assessment criterion of "achievable optimal state" was proposed; on this basis, the coordinated development degree theory was introduced into river health assessment, a river health assessment model based on coordinated development degree was established, and evaluation standard grades for coordinated development degree and classification of river health grades were developed. The river health status of the assessment section at the current level (year 2015) was evaluated and analyzed. The results show that: for the Yarkant River assessment section, the total coordinated development degree D_total = 0.495, the comprehensive evaluation index T_total = 0.537, the coordinated development type belongs to the "weakly uncoordinated type" , and the health status belongs to the "sub-healthy" grade, indicating that the health status is in a critical transitional state from healthy to unhealthy, and the river health status is under threat. In future integrated river management, consideration should be given to improving the coordinated development level among the three system elements of pressure-state-response factors, while prioritizing the restoration of corresponding indicator levels under the response factor.

Full Text

Abstract

It is crucial for ecological hydrological conservation and river adaptability management in arid inland river basins to identify and evaluate the factors affecting river health and its changes. The Yarkant River section from Kaqu to Ayrik Tam was selected as a typical study area, where a river health evaluation index system comprising 23 indicators was established based on the pressure-state-response (PSR) model, and corresponding evaluation standards were proposed. The theory of coordinated development degree was introduced to assess river health, and an evaluation model was developed based on this approach. The standard levels for coordinated development evaluation were established and categorized, enabling the assessment and analysis of river health in 2015. The results revealed a coordinated development index of D_total = 0.495 and a comprehensive evaluation index of T_total = 0.537 along the river section, indicating a "slightly uncoordinated" development type and a "sub-health" status. These findings demonstrate that the river' s health is under threat. For future comprehensive river management, the coordinated development level among pressure-state-response factors should be improved, with particular emphasis on enhancing the corresponding index levels under restoration-response factors.

Keywords: coordinated development degree; reachable best standard; PSR model; river health; Yarkant River

3.1 Coordinated Development Degree Model

The coordinated development degree model is a method for evaluating the coordinated development state among multiple systems [17, 28]. This approach has been widely applied in assessing coordinated development among population, economy, and ecological systems [29], urbanization and environment systems [30], and water resource systems [27]. Within the PSR model framework, the coordinated development degree among pressure, state, and response systems can be calculated to reflect the overall health status of the river.

3.8 Coordinated Development Degree Evaluation Model

The coordinated development degree evaluation model assesses the coordinated development state among systems. According to previous research [29, 32], when evaluating coordinated development among pressure, state, and response systems, the coordination degree C and comprehensive evaluation index T are first calculated. The coordination degree C reflects the proximity among systems, with values closer to 1 indicating better coordination. The comprehensive evaluation index T reflects the overall development level of the three systems. The coordinated development degree D is then calculated as:

$$D = C \times \sqrt{T}, \quad T = \alpha f(x) + \beta g(y) + \gamma h(z) \quad (10)$$

where D is the coordinated development degree (0 D 1); T is the comprehensive evaluation index of pressure, state, and response systems, reflecting the overall development level; , , and are weight coefficients (0–0.39), typically set as 1/3 each; and f(x), g(y), and h(z) are the standardized values of pressure, state, and response indicators, respectively.

4 Application and Analysis

4.1 Weight Calculation Using the Analytic Hierarchy Process (AHP) to calculate indicator weights, the judgment matrix was constructed based on expert consultation. The maximum eigenvalue _max = 6.08, and the consistency ratio CR = 0.013 (< 0.1), indicating satisfactory consistency. The weights of pressure, state, and response indicators were determined as shown in Table 5.

4.2 Evaluation Process and Results Based on formulas (8)–(11), the standardized values f(x), g(y), and h(z) for pressure, state, and response indicators were calculated. The comprehensive evaluation functions F(x), G(y), and H(z) were computed using formula (9):

$$F(x) = \sum f(x_i) \times S_i$$
$$G(y) = \sum g(y_i) \times S_i$$
$$H(z) = \sum h(z_i) \times S_i$$

The coordination degree C and comprehensive evaluation index T were then calculated using formula (10), yielding the coordinated development degree D. The evaluation results showed that the response system had the highest standardized value, followed by the state system, with the pressure system being the lowest. This indicates that restoration-response measures have achieved some effects, but pressure factors remain prominent, requiring strengthened management.

The coordinated development degree D_total = 0.495 and comprehensive evaluation index T_total = 0.537 along the Yarkant River section indicate a "slightly uncoordinated" development type and "sub-health" status, suggesting that river health is under threat. Future comprehensive river management should focus on improving the coordinated development level among pressure-state-response factors, with particular emphasis on reducing pressure factors while maintaining response measures.

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Note: Figure translations are in progress. See original paper for figures.