Post-print: Ecological Functional Zoning of the Wei River Basin

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Abstract

This study takes the Wei River Basin as the research object, establishes a reasonable indicator system based on the current status of the basin' s ecological environment, conducts zoning of the study area using GIS and RS technologies, and formulates corresponding priorities for ecological environmental protection and construction according to the dominant ecological functions or major ecological problems of each functional zone. The results show that the Wei River Basin can be divided into 7 ecological functional zones: Drought prevention and resistance zone; Agricultural planting zone; Animal husbandry development zone; Water source conservation zone; Windbreak and sand fixation zone; Vegetation protection zone; Soil erosion control zone. This study provides a scientific basis for the effective development and utilization of resources and the rational formulation of ecological environmental protection measures in the region.

Full Text

Ecological Function Regionalization in the Weihe River Basin

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Abstract

Ecological function regionalization is the basis for scientific management and sustainable exploitation of natural resources. In this study, the Weihe River Basin was taken as the research object to develop a reasonable index system according to the current ecological environment in the drainage basin, and the GIS and RS means were used to regionalize the study area. Moreover, the emphases of conservation and construction of the ecological environment were worked out based on considering the dominant ecological functions or the main ecological problems in each functional area. The results showed that the Weihe River Basin could be divided into seven ecological functional zones, and the corresponding construction priorities were formulated: Drought prevention and control zone: It should be strictly forbidden to cut down vegetation, and the drought-tolerant vegetation should be advisably cultivated for preventing soil drought; Farming zone: The agricultural structure should be rationally adjusted; Animal husbandry development zone: The advantages of agro-pastoral ecotone should be paid great attention to; Water conservation zone: It was suggested to establish the vegetation protection areas and national forest parks and vigorously develop the water conservation projects; Wind prevention and sand fixation zone: It was suggested to plant sand-fixing plants and prevent land desertification; Vegetation protection zone: It was suggested to protect the existing vegetation, continuously strengthen greening, and reasonably maintain the vegetation resources; Soil erosion control zone: It was suggested to protect and rationally exploit the water and soil resources. The study results could provide a scientific basis for effectively exploiting and utilizing the natural resources and rationally taking some measures to protect the ecological environment in the study area.

Keywords: Weihe River Basin; ecological function regionalization; spatial analysis; ecological environment; construction emphasis

1. Introduction

Ecological function regionalization serves as the foundation for scientific management and sustainable utilization of natural resources. This study focuses on the Weihe River Basin, establishing a comprehensive index system tailored to the basin' s current ecological conditions. By integrating geographic information systems (GIS) and remote sensing (RS) technologies, we conducted a systematic regionalization of the study area. The management priorities for each functional zone were determined based on their dominant ecological functions and primary environmental challenges. The results demonstrate that the Weihe River Basin can be partitioned into seven distinct ecological functional zones, each requiring targeted conservation and development strategies.

2. Study Area and Data

2.1 Study Area

The Weihe River Basin is situated in Shaanxi Province, China, extending between 33°40 -37°18 N and 106°20 -110°37 E [Figure 1: see original paper]. The main river channel spans 818 km, draining a total area of 1.35×10 km². The basin exhibits a continental monsoon climate with significant spatial heterogeneity. The northern region features arid and semi-arid conditions, while the southern area receives relatively abundant precipitation. The basin encompasses diverse landforms, including loess plateaus, hilly terrain, and alluvial plains. Annual average temperatures range from 7.8 to 13.5°C, with precipitation varying between 500–800 mm. The ecological environment is fragile, characterized by severe soil erosion, frequent droughts, and vegetation degradation, necessitating urgent implementation of ecological restoration measures.

2.2 Data Sources

The regionalization framework incorporated multi-source geospatial data: (1) Topographic data: 1:50,000 digital elevation model (DEM); (2) Remote sensing imagery: Landsat TM data for land cover classification; (3) Meteorological data: precipitation and temperature records from 15 meteorological stations spanning 10 years; (4) Soil data: soil type and texture maps; (5) Hydrological data: runoff and sediment discharge measurements; (6) Socioeconomic data: population density and land use statistics. All data were preprocessed and standardized to a unified coordinate system with 30 m spatial resolution.

3. Methods

The ecological function regionalization methodology comprised three principal steps:

First, we constructed a hierarchical evaluation index system encompassing six categories: (1) Climate indices: including precipitation, temperature, and aridity index; (2) Topographic indices: elevation, slope, and relief amplitude; (3) Soil indices: soil erosion modulus, soil type, and nutrient content; (4) Vegetation indices: NDVI, vegetation coverage, and biomass; (5) Hydrological indices: water resource availability and quality; (6) Socioeconomic indices: land use intensity and population pressure. Each indicator was weighted using the analytic hierarchy process (AHP) based on expert consultation.

Second, GIS-based spatial analysis was performed. Single-factor thematic maps were generated and overlaid using weighted sum models:

$$Z = \sum_{i=1}^{n} W_i \times X_i$$

where Z represents the comprehensive ecological function index, W_i denotes

the weight of indicator i, and X_i represents the normalized value of indicator i.

Third, natural breaks classification was applied to delineate functional boundaries, which were subsequently refined through field validation and expert knowledge. The final regionalization scheme identified seven primary ecological functional zones.

4. Results

The regionalization analysis partitioned the Weihe River Basin into seven ecological functional zones [Figure 8: see original paper]:

(1) **Drought Prevention and Control Zone**: Covering 1.13×10 km² (8.35% of the basin), this zone is characterized by low precipitation and high evaporation rates. The dominant ecological function is water resource conservation and drought mitigation. Management should prioritize strict prohibition of vegetation removal and promotion of drought-resistant species.

(2) **Farming Zone**: Spanning 4.01×10 km² (29.68% of the basin), this area contains fertile soils and favorable agricultural conditions. The primary ecological function is food production. Sustainable agricultural practices and rational crop structure adjustment are recommended to balance productivity with environmental protection.

(3) **Animal Husbandry Development Zone**: Encompassing 1.83×10 km² (13.55% of the basin) of high-quality grassland and 2.18×10 km² (16.13%) of moderate-quality pasture, this zone supports important livestock production. The management focus should be on rotational grazing and restoration of degraded grasslands.

(4) **Water Conservation Zone**: This zone covers 1.34×10 km² (9.93% of the basin) and includes critical water source areas. The dominant function is water supply and regulation. Establishing protected areas and implementing afforestation projects are essential for maintaining water security.

(5) **Wind Prevention and Sand Fixation Zone**: Occupying 8.20×10³ km² (6.31% of the basin), this area suffers from severe wind erosion and desertification risks. The ecological function is soil stabilization and sand fixation. Planting sand-binding vegetation and constructing shelterbelts are priority measures.

(6) **Vegetation Protection Zone**: Covering 2.21×10 km² (16.36% of the basin), this zone contains remnant natural forests and shrublands with high biodiversity value. The primary function is biodiversity conservation and habitat provision. Strict protection of existing vegetation and continuous greening efforts are required.

(7) **Soil Erosion Control Zone**: The largest zone at 2.49×10 km² (18.43% of the basin), characterized by severe water erosion on loess slopes. The critical function is sediment retention and erosion control. Comprehensive soil conservation measures, including terracing and reforestation, are urgently needed [Figure 7: see original paper].

5. Discussion

The regionalization results reveal significant spatial heterogeneity in ecological functions across the Weihe River Basin. Each functional zone exhibits distinct environmental challenges requiring targeted management strategies. For drought-prone areas, water-saving technologies and drought-resistant vegetation are crucial. Agricultural zones should optimize planting structures and reduce chemical inputs. Pastoral areas need balanced grazing management to prevent grassland degradation. Water source regions require strict protection policies and ecological compensation mechanisms. Wind-sand zones demand engineering and biological measures for desertification control. Forested areas need conservation-oriented management, while erosion hotspots require integrated watershed management approaches.

The GIS-RS integrated framework provides an effective tool for large-scale ecological regionalization, though uncertainties remain in indicator weighting and boundary delineation. Future research should incorporate dynamic monitoring and climate change scenarios to develop adaptive management strategies.

6. Conclusion

This study successfully regionalized the Weihe River Basin into seven ecological functional zones using a GIS-RS integrated approach. The proposed management priorities for each zone offer a scientific basis for sustainable resource utilization and ecological restoration. Implementation of these zone-specific strategies will enhance the basin' s ecological security and support regional sustainable development. The methodology and results provide valuable reference for similar watershed management initiatives in ecologically fragile regions.

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