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Yearly Spatial Dataset Development of Ecological Risk Assessment for the Qinghai-Xizang Plateau (1 km, 2000–2020)

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Abstract: Ecological risk assessment helps identify and quantify potential risks and threats to ecosystems, as well as evaluate impact of human activities or natural changes on ecosystem health, functions and services. In developing the dataset, a comprehensive assessment framework for ecosystem health and services was established by integrating model algorithms such as the CASA model, the revised universal soil loss equation (RUSLE), and the InVEST model, together with multi-source data including land use, NDVI, soil type, annual precipitation, and mean annual temperature. This framework enables a holistic evaluation of ecosystem health and ecosystem services. Based on calculations of indicators related to ecosystem organization, quality, and services, an annual ecological risk assessment dataset was produced for the period 2000–2020. The results indicate that the ecological risk index of the Qinghai-Xizang Plateau exhibits an overall fluctuating trend over time and gradually increases from the southeast to northwest in spatial distribution. Low-risk areas are mainly concentrated in Garzê and Ngawa, near Yunnan and Guizhou, whereas high-risk areas are predominantly distributed in Nagqu and the northern Xizang region bordering Xinjiang. The dataset is archived in .tif data format, with a spatial resolution of 1 km, and consists of 21 data files with the data size of 485 MB (compressed into one file with 155 MB).

Keywords: Qinghai-Xizang Plateau; ecological risk; ecosystem health; ecosystem services

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2025.06.01.V1.

1 Introduction

With the acceleration of socio-economic development, coupled with climate change and intensified human activities, ecosystems are under greater pressure. To address the resulting ecological risks, the China's government has launched a series of ecological restoration

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[2] Xia, Y. Q., Wang, H., Tang, B. T., *et al*. Yearly spatial dataset of ecological risk assessment for the Qinghai-Xizang Plateau (1 km, 2000–2020) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2025. https://doi.org/10.3974/geodb.2025.06.01.V1.

programs, including the Grain-for-Green Program and the Grazing Withdrawal Program, which have achieved remarkable results[1,2]. The Qinghai-Xizang Plateau is an important ecological barrier in China and a typical region characterized by ecological vulnerability and underdeveloped economic conditions[3]. To gain a comprehensive understanding the current ecological and environmental conditions of the Qinghai-Xizang Plateau, the China's government launched the Second Scientific Expedition to the Qinghai-Xizang Plateau in 2017, aiming to provide a scientific basis for future ecological restoration and conservation in the region. Therefore, assessing ecological risks across Qinghai-Xizang Plateau can effectively identify regions in need of subsequent restoration and protection, determine their prioritization, and offer important guidance for the sustainable development of regional ecological construction.

At present, research on the identification and early warning of ecological risks mainly focuses on ecosystems themselves. On the one hand, ecologically fragile areas are identified based on ecosystem structure and its spatial patterns[4,5]. For example, some studies select indicators of ecosystem organization or quality, such as landscape diversity, landscape fragmentation to assess regional ecological risks[6]. On the other hand, a series of ecological indicators simulating different ecological processes are used to identify potential degradation risk areas[7,8]. For example, regions with medium to low or declining ecosystem productivity or ecosystem services are identified as high-risk or degraded areas[9]. Although existing studies can indicate the approximate locations where ecological risks may occur, differences remain in scholars' understanding of the conceptual connotations of ecological risk, and there is still no unified evaluation methodology. Therefore, it is important to develop an ecological risk assessment framework that not only reflects the spatiotemporal variation patterns of ecological risk, but also incorporates ecological processes and their driving factors. Such a framework is crucial for identifying and providing early warning of regional ecological risks, and warranting further in-depth research.

This paper constructs a comprehensive assessment framework for ecosystem health and ecosystem services, integrating ecosystem organization, quality and services from the perspectives of ecosystems and human interests. It helps identify and quantify the potential risks and threats faced by the Qinghai-Xizang Plateau region, and assists decision-makers in formulating scientific and effective ecological protection and sustainable development policies.

2 Metadata of the Dataset

The metadata of the Yearly spatial dataset of ecological risk assessment for the Qinghai-Xizang Plateau (1 km, 2000–2020)[10] is summarized in Table 1. It includes the dataset's full name, short name, authors, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy.

3 Methods

3.1 Data Sources

The spatial extent and boundary data of the Qinghai-Xizang Plateau were derived from the Datasets of the boundary and area of the Qinghai-Xizang Plateau published by Zhang, *et al*[12]. Land use data for 2000–2020 were obtained from the European Space Agency, with a spatial resolution of 300 m[1]. Meteorological data were sourced from the National Meteorological Science Data Center and include mean annual temperature, annual precipitation,

[1] European Space Agency (ESA). https://essd.copernicus.org/articles/15/1465/2023/essd-15-1465-2023-assets.html.

Table 1 Metadata summary of the Yearly spatial dataset of ecological risk assessment for the Qinghai-Xizang Plateau (1 km, 2000–2020)

Items	Description
Dataset full name	Yearly spatial dataset of ecological risk assessment for the Qinghai-Xizang Plateau (1 km, 2000–2020)
Dataset short name	ER2000-2020
Authors	Xia, Y. Q., School of Geography and Tourism, Shaanxi Normal University, yq_xia@snnu.edu.cn Wang, H., School of Geography and Tourism, Shaanxi Normal University, foreva@snnu.edu.cn Tang, B. T., School of Geography and Tourism, Shaanxi Normal University; Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, tangbutian@snnu.edu.cn Hui, L., School of Geography and Tourism, Shaanxi Normal University, 2002huile@snnu.edu.cn Han, B. Y., School of Geography and Tourism, Shaanxi Normal University, byhan@snnu.edu.cn
Geographical region	Qinghai-Xizang Plateau
Year	2000–2020
Temporal resolution	Year
Spatial resolution	1 km
Data format	.tif
Data size	155 MB (after compression)
Data files	Annual ecological risk assessment results data for the Qinghai-Xizang Plateau (2000–2020)
Foundation	Ministry of Science and Technology of P. R. China (2019QZKK0403)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the "ten percent principal" should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[11]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

and solar radiation for the period 2000–2020[2]. DEM data were obtained from the Geospatial Data Cloud[3], with a spatial resolution of 90 m. NDVI data for 2000–2020 were derived from the MOD13Q1 16-day composite product[4], with a spatial resolution of 250 m. Soil type data for 2000–2020 were obtained from the National Cryosphere Desert Data Center[5], with a spatial resolution of 30 m. Based on these datasets, landscape indices, net primary productivity (NPP), water yield, soil retention, and habitat quality services of the Qinghai-Xizang Plateau were calculated to quantify ecosystem organization, quality, and services, thereby enabling the annual ecological risk assessment for the period 2000–2020.

3.2 Algorithm

(1) Ecosystem organization

Ecosystem organization is derived from the coupling of ecological processes and spatial patterns in landscape ecology, and is primarily calculated using landscape indices such as landscape heterogeneity and landscape connectivity[13]. The ecosystem organization index was calculated using a weighted coefficient model. Considering that landscape heterogeneity and landscape connectivity are equally important components of the organization index, each was assigned a weight of 0.35. Forest and grassland, as important land cover types

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2 National Meteorological Science Data Center. http://data.cma.cn.

3 Geospatial Data Cloud. http://www.gscloud.cn.

4 Resource and Environmental Science Data Platform. http://www.resdc.cn/.

5 National Cryosphere Desert Data Center. http://www.ncdc.an.cn/portal.

influencing the regional environment, were assigned a combined weight of 0.30[14]. The specific Equation is as follows:

$$EO = 0.35 \times LC + 0.35 \times LH + 0.30 \times IC \tag{1}$$

$$= 0.1 \times AWMPFD + 0.25 \times FN_1 + 0.15 \times SHDI \times 0.1 \times MSIDI + 0.1 \times CONT + 0.1 \times FN_2 + 0.05 \times CONNECT_1 + 0.1 \times FN_3 + 0.05 \times CONNECT_2$$

where EO represents ecosystem organization; LC represents landscape connectivity; LH represents landscape heterogeneity; IC represents important land patches. $AWMPFD$ represents the area-weighted mean patch fractal dimension index; FN_1 represents landscape fragmentation index; $SHDI$ represents the Shannon's diversity index; $MSIDI$ represents the modified Simpson's diversity index; $CONT$ represents the landscape contagion index; FN_2 and FN_3 represent the landscape fragmentation indices of forest and grassland, respectively; and $CONNECT_1$ and $CONNECT_2$ represent the patch connect index of forest and grassland, respectively.

(2) Ecosystem quality

Ecosystem quality refers to the condition of terrestrial ecosystems and is closely related to regional vegetation and its productivity[15]. NPP represents the net amount of carbon fixed by plants through photosynthesis. As an important component of the terrestrial carbon cycle, carbon sequestration serves as a core indicator for assessing ecosystem quality[16,17]. NPP data calculated using the CASA model were employed to characterize carbon sequestration services, and the normalized NPP values were used to represent ecosystem quality. The specific Equations are as follows:

$$EQ = NPP(x,t) = APAR(x,t) \times \varepsilon(x,t) \tag{2}$$

$$APAR(x,t) = SOL(x,t) \times 0.5 \times FPAR(x,t) \tag{3}$$

$$X_{Nor} = \frac{X_i - X_{min}}{X_{max} - X_{min}} \tag{4}$$

where x represents the spatial location; t represents time; $NPP(x,t)$, $APAR(x,t)$ and $\varepsilon(x,t)$ refer to the net primary productivity of vegetation (g C/m^2), the photosynthetically active radiation (MJ/m^2), and the actual light energy utilization (g C/MJ) at location x and time t, respectively; $SOL(x,t)$ and $FPAR(x,t)$ represent the total solar radiation (MJ/m^2) and the fraction of the incident photosynthetic effective radiation at location x and time t, respectively. The constant 0.5 represents that the proportion of effective solar radiation utilized for vegetation photosynthesis (wavelength 0.4–0.7 μm) accounts for the total solar radiation[18]. X_{Nor} represents the normalized NPP value, while X_i represents the original NPP value; X_{min} and X_{max} are the minimum and maximum values of the original NPP dataset, respectively.

(3) Ecosystem services

Ecosystem services refer to the ecological functions and processes that contribute to human survival and well-being[19]. A sustained and stable supply of ecosystem services can effectively support the sustainable development of human society[20,21]. By integrating water yield, soil retention, and habitat provision, an ecosystem services index was constructed to characterize the supply level of ecosystem services on the Qinghai-Xizang Plateau[22,23]. Water yield, soil retention, and habitat provision were estimated using the water balance method, the Revised Universal Soil Loss Equation (RUSLE), and the InVEST model, respectively. The specific Equations are as follows:

$$WY = P - ET = \frac{P\left(1 + \omega \frac{P \times ET}{P}\right)}{1 + \omega \frac{P \times ET}{P} + \left(\frac{P \times ET}{P}\right)^{-1}} \tag{5}$$

$$SC = A_p - A_m = R \times K \times LS \times (1 - C \times P) \tag{6}$$

$$B_{xj} = H_j \left(1 - \left(\frac{D_{xj}^z}{D_{xj}^z + k^z} \right) \right) \tag{7}$$

$$ES = WY + SC + HP \tag{8}$$

where in Equation 5, WY, P and ET represent the annual water yield (mm), annual precipitation (mm), and actual evapotranspiration (mm), respectively; ω represents the water consumption coefficient of vegetation. In Equation 6, SC, A_p, and A_m represent soil conservation, potential soil erosion, and actual soil erosion (t hm^{-2} yr^{-1}), respectively. R represents the rainfall erosivity factor (MJ mm hm^{-2} h^{-1} yr^{-1}); S represents the slope factor; L represents the slope length factor; K represents the soil erodibility factor (t hm^{2} h hm^{-2} MJ^{-1} mm^{-1}); C represents the vegetation cover and management factor; P represents the soil and water conservation factor. In Equation 7, B_{xj} represents the quality of habitat of the grid cell x in a given habitat type j; H_j represents the habitat suitability of that habitat type j; D_{xj} represents the habitat degradation degree of the grid cell x in a given habitat type j; z represents the normalization constant; k represents the half-saturation constant. In Equation 8, ES represents ecosystem services; WY, SC and HP represent the normalized values of water yield, soil conservation, and habitat provision services, respectively.

(4) Ecological risk index

Ecosystem organization, quality, and services are 3 equally important dimensions in evaluating ecological risk. To effectively balance these dimensions, an ecological risk index was constructed based on previous studies[24,25]:

$$ER = \sqrt[3]{EO \times EQ \times ES} \tag{9}$$

where ER represents the ecological risk index; EO represents the ecosystem organization; EQ represents the ecosystem quality; ES represents the ecosystem services.

4 Data Results

4.1 Dataset Composition

The Yearly spatial dataset of ecological risk assessment for the Qinghai-Xizang Plateau (1 km, 2000–2020) is archived in .tif format and contains ecological risk assessment results for 21 years, covering the period from 2000 to 2020. The spatial resolution is 1 km. The smaller the value of the ecological risk data, the higher the ecological risk, and the missing data is set to –9999.

4.2 Data Results

4.2.1 Temporal Distribution Characteristics of Ecological Risk

The ecological risk index of the Qinghai-Xizang Plateau generally shows fluctuations trend, with overall changes being relatively minor. In particular, ecological risk declined significantly in 2002 and 2010, indicating improvements in regional ecological conditions, followed by a gradual increase in ecological risk (Figure 1).

4.2.2 Spatial Distribution Characteristics of Ecological Risk

The ecological risk index shows a gradual increase from southeast to northwest. Low-risk areas are mainly concentrated in Garzê and Ngawa, adjacent to Yunnan and Guizhou,

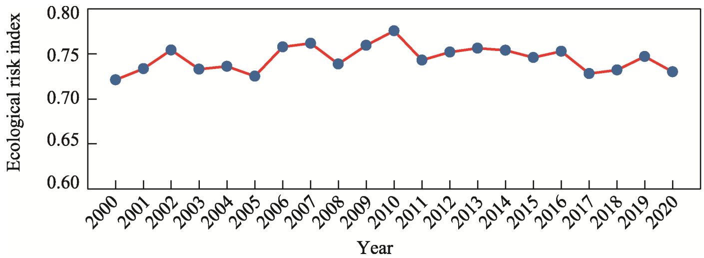

Figure 1 Changes in the average annual ecological risk index (2000–2020)

whereas high-risk areas are primarily distributed in Nagqu City and the northern Xizang region near Xinjiang (Figure 2). Overall, ecological risk in the region exhibits a decreasing trend (decrease: 55.3%, increase: 44.7%). Areas with significant increases are mainly located in the southern Qinghai-Xizang Plateau, including Shigatse, Lhoka, and Nyingchi, covering 12.81% of the total area. In contrast, areas with significant decreases are concentrated in the northern and eastern Qinghai-Xizang Plateau, such as Jiuquan and Hotan (Figure 3).

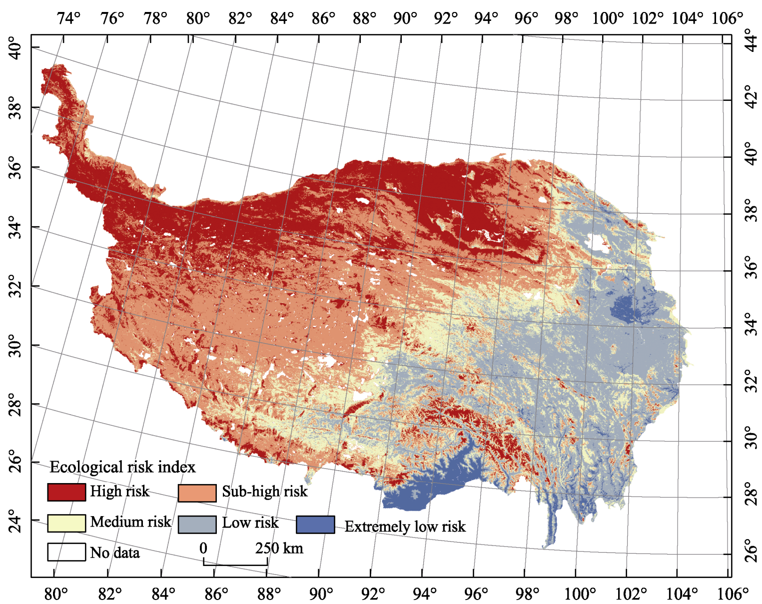

Figure 2 Map of the spatial distribution of ecological risk index from 2000 to 2020

5 Discussion and Conclusion

Compared with existing ecological risk assessment approaches, this dataset establishes an assessment framework from the dual perspectives of ecosystem health and ecosystem services, using 3 indicators: ecosystem organization, quality, and services. Continuous data were applied for quantification and analysis, enabling the identification of ecological risk patterns in the region from a spatiotemporal perspective, and providing theoretical support for ecological protection efforts aimed at safeguarding ecological security.

Based on the region's typical characteristics, this dataset selects and quantifies 3 ecosystem services of the Qinghai-Xizang Plateau—water yield, soil retention, and habitat provision, and adopts net primary productivity as the indicator for ecosystem quality.

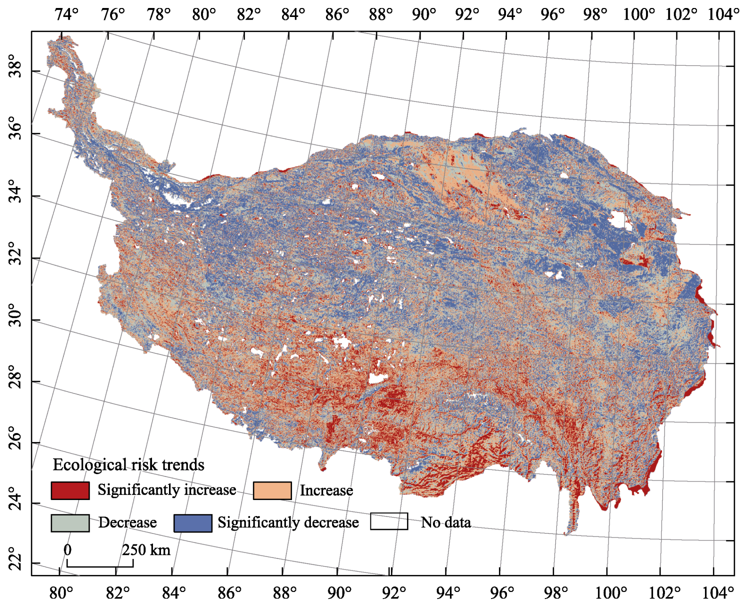

Figure 3 Map of the trend of ecological risk index from 2000 to 2020

However, given the vast expanse of the Qinghai-Xizang Plateau and the pronounced heterogeneity of natural environments across subregions, the ecological functions performed vary accordingly. Therefore, future research should refine the assessment for different subregions by incorporating more region-specific ecosystem services, as well as structural and quality indicators, into the assessment framework, thereby providing a more scientific and rational theoretical basis for local ecological risk identification and prevention. Due to the plateau's unique geographical environment, data sources and accuracy remain relatively limited, future studies should integrate more diverse data types and conduct targeted field surveys to promptly validate and adjust the assessment results.

Author Contributions

Wang, H. conducted the overall design of the dataset development. Xia, Y. Q. and Tang, B. T. collected and processed the relevant remote sensing data, and performed simulations and calculations based on the models. Hui, L. and Han, B. Y. assisted in data processing and model calculations. Xia, Y. Q. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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