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Soil Conservation Dataset Covering National Ecological Barrier Zone at 1-km Resolution (2000–2015)

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Abstract: Ecosystem services are the benefits that ecosystem provides to human beings. As one of the main regulation services provided by the terrestrial ecosystem, soil conservation is an important guarantee to prevent regional land degradation and reduce the frequency of flood disasters, which is often expressed as the value of soil conservation. The national ecological barrier zone (NEBZ), known as "two barriers and three belts", established the national ecological security pattern. Exploring the spatiotemporal distribution of soil conservation in the barrier area is of far-reaching significance for China's ecological civilization construction and sustainable development. Based on the revised universal soil loss equation (RUSLE), the soil conservation dataset (2000–2015) with a resolution of 1 km in NEBZ was quantitatively evaluated using MOD13A2 NDVI, ASTER GDEM, meteorological station data and soil dataset of China, etc. The data is archived in .tif format. The spatial resolution of the data is 1 km, and data size is 168 MB in compress.

Keywords: national ecological barrier zone; ecosystem service; soil conservation; RUSLE model

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.2020.03.19.V1.

1 Introduction

As an important "directional flow service", soil conservation (SC) is the regulation and control capabilities of the ecosystem to prevent soil erosion, and the ability to store and maintain sediment in rivers, lakes, wetlands, and reservoirs[1]. Under the joint influence of climate change and human activities, the risk of global soil erosion is aggravating, and the soil conservation capacity is facing severe challenges[2–3]. As a country with a large population and agriculture, China is also one of the countries with the most severe soil erosion in the world[4]. The in-

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creasingly serious soil erosion is the concentrated manifestation of various ecological problems in China, and poses an acute threat to food security, ecological security, and the sustainable development of the social economy. Therefore, as an important material basis for human survival, more and more attention has been paid to the function of soil conservation that has become a research hotspot in the fields of geography and ecology[5].

In December 2010，the State Council of China launched the national ecological security strategic pattern project, in which the construction framework of “two barriers and three belts” was mentioned. In response to the call of national policy, Fan *et al*.[6] proposed national barrier plan on the basis of national major function oriented zoning. On the basis of ensuring the integrity of counties, Fu *et al*.[7] described the scope of NEBZ and carried out comprehensive assessment of ecosystem services from 2000 to 2010. The geographical regions of NEBZ include the northern sand belt, the ecological barrier of the Qinghai Tibet Plateau, Sichuan Yunnan-loess plateau ecological barrier, the southern hill and mountain belt, and the northeastern forest zone. Quantitative analysis of soil conservation with long time series in the barrier area not only helps to reveal the spatiotemporal distribution and evolution of soil conservation, but also provides theoretical basis for ecological construction and the sustainable development of China. This dataset was evaluated under the support of the national key research and development project. The main purpose of this dataset is to construct the long time series products of soil conservation in NEBZ, to carry out researches on trade-offs and synergies of ecosystem services, and to ensure human rights and well-being. The 1-km spatial resolution_2000-2015_SC product of national barrier zone product is an important output of ecosystem service science in barrier area, and it is also an important digital resource for monitoring and evaluating soil conservation and evolution of ecological environment. In this paper, we aimed to introduce detailed information of the data, the basic principle of the data algorithm and the data results, and make a comparative analysis of the data, so as to evaluate its accuracy.

2 Metadata of the Dataset

The name, short name, authors, geographical region, data age, data resolution, data format, publisher and sharing policy, and related information of the “National ecological barrier zone 1-km resolution soil conservation dataset (2000–2015)”[8] are listed in Table 1.

3 Methods

3.1 Study Area

(1) NDVI data applied a 16-day composite product of MOD13A2 1 km vegetation index from 2000 to 2015[10]. After format conversion, annual maximum value composite, clipping and projection conversion, the annual NDVI of the study area was obtained. This dataset was adopted to calculate the vegetation coverage factor in RUSLE model.
(2) DEM data utilized ASTER global digital elevation model data (ASTER GDEM)[11]. The spatial resolution is 90m. According to the data, ArcGIS10.2 software was used to calculate the slope and slope length.
(3) Monthly climate dataset was downloaded from China meteorological data sharing network[12]. The rainfall data was extracted from it, and the software ANUSPLIN [13] was used for interpolation to obtain the rainfall raster data with a spatial resolution of 1km and was

used to calculate the rainfall erosivity factor in RUSLE model.

Table 1 Metadata summary of the "Soil conservation grid yearly dataset in the national barrier zone of China (2000–2015)"

Items	Description			
Dataset full name	Soil conservation grid yearly dataset in the national barrier zone of China (2000–2015)			
Dataset short name	NBZ_SC_1km_2000-2015			
Authors	Wang, Y. AAS-5036-2020, School of Earth Science and Resources, Chang'an University, wangyichangan134@163.com Wang, X. F. AAS-5271-2020, The College of Land Engineering; the Key Laboratory of Shaanxi Land Consolidation Project, Chang'an University, wangxf@chd.edu.cn Yin, L. C. AAS-4914-2020, Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences; University of Chinese Academy of Sciences, yinlichang3064@163.com			
Geographical region	The provinces include Heilongjiang, Jilin, Qinghai, Gansu, Sichuan, Xinjiang, Inner Mongolia, Hebei, Liaoning, Tibet, Ningxia, Yunnan, Guangxi, Guangdong, Guizhou, Hunan, Jiangxi, and Shanxi The northern sand belt (36°45′N–45°06′N, 75°50′E–124°18′E) The ecological barrier of the Qinghai Tibet Plateau (29°40′N–38°10′N, 82°50′E–105°5′E) Sichuan Yunnan-Loess Plateau ecological barrier (24°10′N–38°50′N, 99°05′E–114°25′E) The southern hill and mountain belt (22°45′N–27°10′N, 103°10′E–119°15′E) The northeastern forest zone (40°52′N–53°34′N, 118°48′E–134°22′E)			
Year	2000–2015			
Spatial resolution	1 km	Data format	.tif	
Data size	168 MB (After compression)	Projection coordinate system	WGS_1984_Albers	
Foundations	Ministry of Science and Technology of P. R. China (2018YFC0507300, 2019QZKK0405); Shaanxi Province (2018JM4016)			
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	***Data*** from the Global Change Research Data Publishing &Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (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[9]			
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref			

(4) Soil data was collected from China soil dataset (v1.1) of the harmonized world soil database (HWSD)[14]. Soil types (sand, silt, clay) content and soil organic carbon content were extracted from the data to calculate the soil erodibility factor in RUSLE model. All the above data was uniformly re-sampled to 1 km×1 km, and the projection coordinate system was Albers_ WGS_ 1984.

3.2 RUSLE Model

The revised universal soil loss equation (RUSLE) model[15–16] was adopted to estimate soil conservation in NEBZ. According to the principle of the model, the potential soil erosion (A_p) and actual soil erosion (A_r) of various land use types were calculated under the conditions of bare land, vegetation cover, and other engineering measure situation. The formula of soil conservation (A_c) is as follows:

$$A_c = A_p - A_r = R \times K \times L \times S \times (1 - C \times P) \tag{1}$$

where A_c is the amount of soil conservation per unit area, and the units of A_c, A_p, and A_r refer to $t \cdot km^{-2} \cdot a^{-1}$; R represents the rainfall erosivity factor ($MJ \cdot mm \cdot km^{-2} \cdot h^{-1} \cdot a^{-1}$); K marks soil erodibility factor ($t \cdot km^2 \cdot h \cdot km^{-2} \cdot MJ^{-1} \cdot mm^{-1}$); L and S stand for slope length and slope factor; C means vegetation coverage factor; P indicates conservation support practice factor. The calculation of each factor is as follows:

(1) The empirical equation proposed by Wischmeier *et al.*[16] was applied to calculate rainfall erosivity factor (R). The calculation equation is as follows:

$$R = \sum_{i=1}^{12} \left(1.735 \times 10^{1.5 \lg \frac{p_i^2}{p} - 0.8188} \right) \tag{2}$$

where p marks the annual rainfall (mm), and p_i refers to the average monthly rainfall (mm).

(2) According to different soil particle composition content and organic matter content, the soil erodibility factor (K) was calculated by Williams model[17]. The calculation equation is as follows:

$$\begin{aligned} K = & \left\{ 0.2 + 0.3 \exp\left[-0.0256 SAN \left(1 - \frac{SIL}{100} \right) \right] \right\} \left(\frac{SIL}{CLA + SIL} \right)^{0.3} \\ & \times \left[1 - \frac{0.25 TOC}{TOC + \exp(3.72 - 2.95 TOC)} \right] \times \left[1 - \frac{0.7 SNI}{SNI + \exp(22.9 SNI - 5.51)} \right] \end{aligned} \tag{3}$$

where SAN, SIL, and CLA refer to sand, silt, and clay content (%), respectively. TOC represents organic matter content (%), and $SNI = 1 - SAN/100$.

(3) The slope length factor (L) was calculated with the method proposed by Wischmeier *et al.*[16], and the calculation equation is defined as follows:

$$\begin{aligned} L &= (\lambda / 22.1)^m \\ m &= \frac{\beta}{\beta + 1} \\ \beta &= \frac{\sin\theta / 0.0896}{3.0 \times (\sin\theta)^{0.8} + 0.56} \end{aligned} \tag{4}$$

where λ marks the slope length extracted from DEM; m represents the slope length index, and θ stands for the slope value extracted from DEM.

The slope factor (S) was extracted by the slope equation proposed by Zhang *et al.*[18], and the specific calculation equation is as follows:

$$S = \begin{cases} 10.8 \sin\theta + 0.03 & \theta < 5° \\ 16.8 \sin\theta - 0.50 & 5° \le \theta \le 10° \\ 21.9 \sin\theta - 0.96 & \theta \ge 10° \end{cases} \tag{5}$$

where θ represents the same as equation (4).

(4) C marks the vegetation coverage factor. The calculation equation was proposed by Cai*et al*[19].

$$C=\begin{cases}1 & f=0\\ 0.6508-0.3436\lg f & 0<f\le 78.3\%\\ 0 & f>78.3\%\end{cases} \quad (6)$$

$$f=\frac{NDVI-NDVI_{min}}{NDVI_{max}-NDVI_{min}}$$

where NDVI represents the normalized vegetation index and f means the fraction of vegetation.

(5) The soil and water conservation measure factor (P) was defined as follows[20–21]:

$$P=0.2+0.03\alpha \quad (7)$$

where α refers to the slope index.

4 Data Results and Validation

4.1 Dataset Composition

The NBZ_SC_1km_2000-2015 dataset is the annual soil conservation data of NEBZ in ArcGIS TIFF format from 2000 to 2015. The spatial resolution is 1 km (unit: $t\cdot km^{-2}\cdot a^{-1}$), and the projection coordinate system is WGS_1984_Albers. The total amount of compressed data is 168 MB. After decompressing, the data can be applied in ArcGIS software.

4.2 Data Results

The spatial distribution of soil conservation at 1-km resolution in NEBZ from 2000 to 2015 is displayed in Figure 1. From 2000 to 2015, the average value is 2,996.49 $t\cdot km^{-2}\cdot a^{-1}$ that is higher in the southeast and lower in the northwest. That is, the high-value areas are concentrated in the Sichuan Yunnan-loess plateau ecological barrier and the southern hill and mountain belt, the middle value is distributed in the northeastern forest zone and the southeast of the Qinghai Tibet plateau ecological barrier, while the low-value areas are located in the northwest of the Qinghai Tibet Plateau ecological barrier and the northern sand belt.

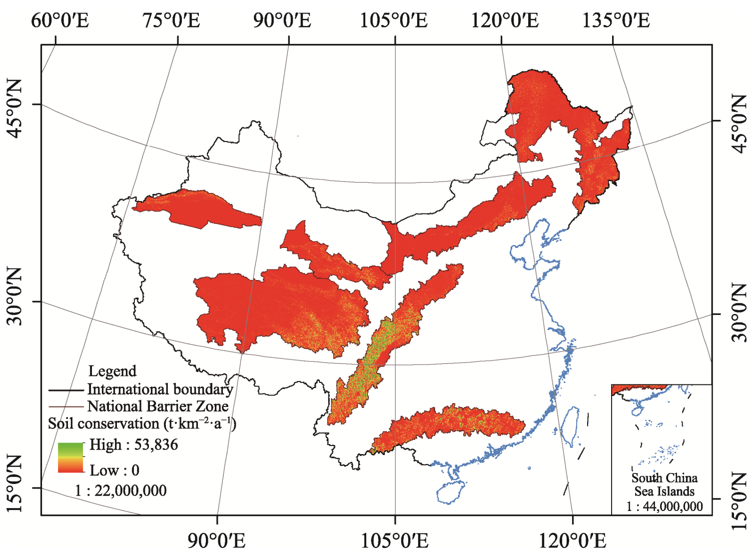

Figure 1 Spatial distribution of soil conservation in the national ecological barrier zone (2015)

From 2000 to 2015, soil conservation increased in most of the study area (84.7%). Apart from some parts of the ecological barrier area of the Qinghai Tibet Plateau, the soil conservation of other sub barriers increased significantly ($p<0.05$), and the regions with higher growth rates were concentrated in the middle part of the Sichuan Yunnan-Loess Plateau ecological barrier.

4.3 Data Validation

By consulting literatures, we compared the similar data (annual soil conservation in different years) in this region to verify and evaluate the accuracy of soil conservation in NEBZ. A total of 17 relevant data (Table 2) were collected, and their quantitative models were all based on RUSLE. No.1–13 are the annual average value of soil conservation in the Three-River Headwaters region of the Qinghai Tibet Plateau ecological barrier from 2000 to 2012[22]. The last four are the annual soil conservation values of the same region in 2000, 2005, 2010, and 2015[23]. The results prove that the absolute value of relative error between the two data fluctuates from 6.98–993.32 $t \cdot km^{-2} \cdot a^{-1}$, and the percentage of relative error is mostly less than 20%. After calculation, the RMSE of this dataset is 431.16, and the overall accuracy is 82.74% (1 minus RMSE divided by the average value of soil conservation simulation data). Therefore, the acquisition of soil conservation results based on this technical process have high correlation with similar data, which can accurately reflect the changing trend of soil conservation in NEBZ in recent years from a macro perspective.

Table 2 Comparative analysis of data validation for soil conservation

No.	Average annual value ($t \cdot km^{-2} \cdot a^{-1}$)	Dataset ($t \cdot km^{-2} \cdot a^{-1}$)	Relative error ($t \cdot km^{-2} \cdot a^{-1}$)	Relative error (%)
1	1,983.47	2,454.37	470.90	19.19
2	1,846.34	2,482.97	636.63	25.64
3	2,169.57	2,326.17	156.59	6.73
4	2,600.55	2,498.71	–101.84	–4.08
5	2,747.47	2,518.09	–229.39	–9.11
6	2,767.06	2,662.07	–104.99	–3.94
7	2,149.98	2,358.90	208.92	8.86
8	3,491.89	2,558.02	–933.87	–36.51
9	2,698.50	2,582.31	–116.19	–4.50
10	3,011.94	2,760.14	–251.80	–9.12
11	3,580.04	2,586.72	–993.32	–38.40
12	2,933.58	2,556.55	–377.03	–14.75
13	2,904.19	2,561.50	–342.69	–13.38
14	2,454.37	2,060.76	–393.61	–19.10
15	2,662.07	2,463.29	–198.78	–8.07
16	2,586.72	2,579.75	–6.98	–0.27
17	2,411.76	2,448.10	36.34	1.48

5 Discussion and Conclusion

The RUSLE model was used to calculate the potential and actual soil erosion, and soil conservation modeling research was carried out, based on remote sensing, meteorology, topography, soil type, and other data. Compared with the existing similar products, the consistency between them is strong, indicating that the dataset has high accuracy and can meet the design goals. The soil conservation dataset of national ecological barrier zone with 1-km spatial resolution from 2000 to 2015 reveals the spatiotemporal distribution of soil conservation in “two barriers and three belts” and the soil conservation benefits of the barrier area in recent years. It can provide reliable basic data and information for the sustainable development of ecosystem in China.

Author Contributions

Wang, Y. designed the overall dataset development, designed the model and algorithm, did the data validation, and wrote this data paper. Wang, X. F. collected and processed the data, and wrote the paper. Yin, L. C. collected and processed the data.

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