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Spatiotemporal Variation Characteristics of Resource and Environmental Pressure in Sichuan Province from the Perspective of Ecological Civilization: Postprint

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Abstract

Based on the footprint family principle, a resource and environmental pressure evaluation index system composed of ecological pressure, greenhouse gas (GHGs) emissions, and water resource pressure was constructed and applied to the evaluation of resource and environmental pressure in Sichuan Province. The results indicate that from 1990 to 2013, the per capita ecological footprint in Sichuan Province increased by 109.57%, while biological carrying capacity remained relatively unchanged, causing ecological pressure to rise from lower-medium (a) to very high (b) level; forestry carbon sink increased by 32.01%, and although GHGs emissions remained at the relatively low (b) level, their emission index increased by 234.97%; water footprint growth was minimal, with water resource pressure at a very low (a) level; the overall provincial resource and environmental pressure rose from very low (a) to lower-medium (a). Spatially, Ganzi and Aba had very low (a) ecological pressure, Guangyuan was upper-medium (b), while the remaining 19 cities (prefectures) including Chengdu, Zigong, and Panzhihua had very high (b) ecological pressure; regarding GHGs emissions status, Panzhihua was very high (b), Neijiang was relatively high (a), Leshan was upper-medium (b), Meishan was lower-medium (a), Ganzi, Ya' an, and Aba served as carbon sinks (a), while the remaining 14 cities (prefectures) including Chengdu, Zigong, and Luzhou all belonged to the relatively low (b) level; for water resource pressure, Zigong, Suining, Meishan, Neijiang, and Ziyang were very high (b), Chengdu was relatively high (a), Luzhou and Dazhou were upper-medium (b), Deyang was lower-medium (a), Yibin and Panzhihua were relatively low (b), while the remaining 10 prefectures (cities) including Ganzi, Aba, and Guang' an were very low (a); regarding resource and environmental pressure status, Aba, Ganzi, Ya' an, and Guangyuan were very low (a), Liangshan and Mianyang were relatively low (b), Guang' an, Bazhong, and

Nanchong were lower-medium (a), Yibin, Deyang, Leshan, and Dazhou were upper-medium (b), Luzhou, Ziyang, and Chengdu were relatively high (a), while Suining, Panzhihua, Meishan, Zigong, and Neijiang were very high (b). The study demonstrates that resource and environmental pressure in Sichuan Province is primarily attributed to high ecological pressure. In future ecological civilization construction, in addition to strictly adhering to the ecological red line for cultivated land to ensure cultivated land productivity, it is also necessary to vigorously develop hydropower to optimize the energy consumption structure, and strengthen forest conservation to enhance carbon sink potential.

Full Text

Spatio-temporal Changes in Resource and Environmental Pressure in Sichuan Province from the Perspective of Eco-civilization

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Abstract: Based on the Footprint Family principle, this study constructed an evaluation index system for resource and environmental pressure composed of ecological pressure, greenhouse gas (GHGs) emissions, and water resource pressure, and applied it to evaluate Sichuan Province. The results show that from 1990–2013, per capita ecological footprint in Sichuan increased by 109.57%, biocapacity changed little, and ecological pressure rose from medium-low (IIa) to very high (IIIb) grade; forestry carbon sequestration increased by 32.01%, GHGs emissions remained at low (Ib) grade but their emission index increased by 234.97%; water footprint grew slowly with very low (Ia) water resource pressure; overall provincial resource and environmental pressure rose from very low (Ia) to medium-low (IIa). Spatially, Ganzi and Aba had very low (Ia) ecological pressure, Guangyuan was medium-high (IIb), and the remaining 19 cities had very high (IIIb) ecological pressure; for GHGs emissions, Panzhihua was very high (IIIb), Neijiang high (IIIa), Leshan medium-high (IIb), Meishan medium-low (IIa), Ganzi, Ya' an and Aba were carbon sinks (Ia), and the other 14 cities were low (Ib); for water resource pressure, Zigong, Suining, Meishan, Neijiang and Ziyang were very high (IIIb), Chengdu high (IIIa), Luzhou and Dazhou medium-high (IIb), Deyang medium-low (IIa), Yibin and Panzhihua low (Ib), and the remaining 10 prefectures very low (Ia); for overall resource and environmental pressure, Aba, Ganzi, Ya' an and Guangyuan were very low (Ia), Liangshan and Mianyang low (Ib), Guang' an, Bazhong and Nanchong medium-low

(IIa), Yibin, Deyang, Leshan and Dazhou medium-high (IIb), Luzhou, Ziyang and Chengdu high (IIIa), and Suining, Panzhihua, Meishan, Zigong and Neijiang very high (IIIb). The study shows that Sichuan' s resource and environmental pressure is mainly attributed to high ecological pressure. Future eco-civilization construction should strictly adhere to cultivated land ecological red lines to ensure productivity, vigorously develop hydropower to optimize energy consumption structure, and strengthen forest conservation to enhance carbon sink potential.

Keywords: Footprint Family; Ecological footprint; Water footprint; Carbon footprint; Eco-civilization; Resource and environmental pressure

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1. Study Area Overview

Sichuan Province is located between 92°21 –108°12 E and 26°03 –34°19 N, covering an area of 48.6×10 km^2 and administering 21 prefecture-level cities and autonomous prefectures. The climate can be divided into three zones: the mid-subtropical humid climate zone of the Sichuan Basin, the subtropical semi-humid climate zone of southwestern Sichuan mountains, and the alpine and plateau cold climate zone of northwestern Sichuan. The topography is complex and diverse, with mountains accounting for 77.1%, hills 12.9%, plains 5.3%, and plateaus 4.7% of the total area. Cultivated land constitutes a very low proportion of provincial land area at only 12.4%, mainly distributed in the basin and low hilly areas, while forest and grassland account for a larger proportion (68.9%), primarily distributed in the surrounding mountainous areas and western high plateaus. The province is rich in flora and fauna resources with diverse vegetation types, hosting nearly 10,000 species of higher plants—ranking second nationally after Yunnan Province. Vertebrates account for over 45% of the national total, with 217 mammal species and 625 bird species, together representing about 53% of the national total. Energy resources are abundant and dominated by hydropower, coal, and natural gas, accounting for 75%, 23.5%, and 1.5% respectively. Hydropower potential exceeds 1×10 kW·h, making it the largest hydropower base in China. Coal reserves total 122.7 t with complete varieties, mainly distributed in southern Sichuan. Natural gas reserves reach 7×10^{12} m^3, accounting for approximately 19% of national reserves. Water resources are plentiful, with 17 rivers covering drainage areas over 10,000 km^2, 325 rivers over 500 km^2, and 1,065 rivers over 100 km^2, earning it the title "Province of a Thousand Rivers." Total water resources amount to approximately 3,489.70 m^3 with per capita availability higher than the national average. Sichuan is also a major population province, with a permanent population of 8,107×10 in 2013, ranking fifth nationally, but its per capita land area is below the national average, creating prominent human-land conflicts.

2. Methods

2.1 Footprint Family Method

Although many new footprint types have emerged, only ecological footprint, carbon footprint, and water footprint have well-defined accounting methods and are thus suitable for inclusion in the Footprint Family. This study adopts the definition by Galli et al. [10–11]: the Footprint Family consists of ecological footprint, carbon footprint, and water footprint, used to assess human demand for biological resources and water resources and the environmental impacts of greenhouse gas (GHGs) emissions.

2.1.1 Ecological Footprint Ecological footprint measures human demand on the biosphere, while biocapacity refers to the total ecological services that biologically productive land and sea areas can provide for human consumption. A positive difference between ecological footprint and biocapacity indicates an ecological deficit, while a negative difference indicates an ecological surplus [13]. Ecological footprint is divided into biomass footprint and energy footprint; ecological deficit can be further classified into hard deficit (ecological deficit with biomass deficit) and soft deficit (ecological deficit but biomass surplus). The formulas are as follows:

$$(i = 1, 2, ..., n; j = 1, 2, 3, 4, 5, 6) \quad (1)$$

$$(j = 1, 2, 3, ..., 6) \quad (2)$$

where ef is ecological footprint (hm²), ec is biocapacity (hm²), c is per capita consumption of the ith consumer product, p is the global average yield of the ith product, r is the equivalence factor, i is the type of consumer product, j is the type of biologically productive area, a is the per capita actual biologically productive area, and y is the yield factor.

The equivalence factors used in this study are taken from the latest results published by the Global Footprint Network [13]: 2.51 for cropland and built-up land, 0.37 for water bodies, 0.46 for grassland, and 1.26 for forest land. The yield factors for cropland and built-up land were obtained by comparing Sichuan' s average annual grain yield with global average yields. Yield factors for other land types were taken as average values from literature [14–16]: 0.34 for grassland, 0.91 for forest land, and 0.81 for water bodies.

2.1.2 Carbon Footprint Carbon footprint represents direct and indirect GHGs emissions from human activities [10–11]. This study adopts the methods recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* and the *Provincial Greenhouse Gas Inventory Guidelines* based on IPCC. Calculation formulas and emission factors are detailed in literature [17–18]. Carbon footprint is expressed in tonnes of CO equivalent (t CO e).

2.1.3 Water Footprint Water footprint consists of direct water footprint (physical water use) and indirect water footprint (virtual water use). Indirect water footprint equals the consumption of a product multiplied by its virtual water content per unit [19-20]:

$$wf = wu + \sum_{i=1}^{n} p_i \times vwfi \quad (i = 1, 2, 3, ..., n) \quad (3)$$

where wf is per capita water footprint (m^3), wu is per capita direct water footprint, p is per capita consumption of the ith product, and vwf is the virtual water content per unit of that product, with values taken from literature [21-22].

2.2 Construction of Resource and Environmental Pressure Evaluation System

Based on the Footprint Family principle, this study proposes a Resource and Environmental Pressure Index (RPI) integrating the Ecological Pressure Index (EPI), GHGs Emission Index (CEI), and Water Resource Pressure Index (WPI). All indices are standardized using the extremum method, with maximum values of 3 and 1 for EPI and WPI, respectively.

Following the authors' previous research [23-24], the Ecological Pressure Index is defined as the ratio of biomass footprint to biocapacity to reflect regional ecological security. The Water Resource Pressure Index is defined as the ratio of regional water footprint to available water resources to reflect water resource pressure status [25]. To evaluate regional contributions to global climate change, this study draws upon the authors' previously proposed per capita GHGs emission index (C), per area GHGs emission index (C), and the comprehensive GHGs Emission Index derived from C and C [17]. C is defined as the ratio of regional per capita carbon footprint to the per capita carbon footprint target for addressing global climate change. C is defined as the ratio of carbon footprint per unit area (carbon footprint density) to the target carbon footprint density for addressing global climate change (with area converted to biologically productive area of biocapacity). Stern [26] proposed 2 t CO e per capita as the target for national emission reduction commitments. According to WWF [27], global biocapacity in 2010 was 120×10 hm^2 (1.7 hm^2 per capita), so the target carbon footprint density for addressing global climate change is 1.18 t · hm ^{2}.

Based on C and C, the regional GHGs Emission Index (CEI) is constructed. To reduce subjective influences, this study employs the objective entropy weight method [4] to determine weights. This method determines weights based on the information content provided by each indicator' s measured values. For m evaluation indicators and n evaluation objects (where n is the number of evaluation years), the process involves: (1) calculating the proportion (r) of the jth indicator value for the ith year to the total value of that indicator,

(2) calculating the entropy value (e) of the jth indicator, (3) calculating the variability coefficient (information redundancy d) of the jth indicator, and (4) calculating the weight (w) of each indicator:

$$(i = 1, 2, 3, ..., m; j = 1, 2, 3, ..., n) \quad (4)$$

The weights for C and C were determined to be 0.5001 and 0.4999, respectively. The GHGs Emission Index is calculated as follows:

$$CEI = \frac{C_p}{C_{p.max}} \times w_p + \frac{C_a}{C_{a.max}} \times w_a \quad (7)$$

where $C.max$ and $C.max$ are the maximum values of global per capita carbon footprint and carbon footprint density, valued at 15 and 20, respectively; w and w are weights.

Based on the three indices (EPI, CEI, WPI), the Resource and Environmental Pressure Index (RPI) is constructed. Weights determined by the entropy method for the three indices in resource and environmental pressure evaluation are 0.3330, 0.3339, and 0.3331 (denoted as w, w_c, w_w), respectively. The RPI is calculated as:

$$RPI = EPI \times w_e + CEI \times w_c + WPI \times w_w$$

Grading criteria for the indices are shown in Table 1.

2.3 Data Sources

Data were primarily obtained from the China Economic and Social Development Statistical Database, websites of the National Bureau of Statistics and Sichuan Provincial Bureau of Statistics, electronic yearbooks, the China Economic Net Industry Database, and the 1991-2014 *Sichuan Statistical Yearbook*, *China Energy Statistical Yearbook*, *China Statistical Yearbook*, *China Rural Statistical Yearbook*, *China Forestry Statistical Yearbook*, and *China Dairy Statistical Yearbook*. Additional missing data were supplemented through industry authorities such as Sichuan Provincial Forestry Department and Agricultural Department.

3. Results

3.1 Temporal Dynamics

3.1.1 Dynamic Analysis of Ecological Footprint, Carbon Footprint, and Water Footprint Per capita ecological footprint in Sichuan Province increased annually from 1.62 hm² in 1990 to 3.39 hm² in 2013, representing a 109.57% increase with an average annual growth rate of 3.27% (Fig. 1 [Figure 1: see original paper]). Per capita energy footprint grew from 0.50 hm² to

1.06 hm^2, while per capita biomass footprint increased from 1.12 hm^2 to 2.32 hm^2. Per capita biocapacity fluctuated between 0.77-0.83 hm^2. Concurrently, per capita ecological deficit increased annually from 0.79 hm^2 to 2.56 hm^2, a 222.93% increase with an average annual growth rate of 5.23%. Per capita biomass deficit increased from 0.29 hm^2 to 1.50 hm^2. The continuous increase in both ecological deficit and biomass deficit indicates that Sichuan’ s ecological demand has exceeded ecosystem carrying capacity, making its development unsustainable. Although the application of advanced agricultural technologies increased the cropland yield factor by 17.71% since 1990, enhancing biocapacity per unit area, population growth (3.47% increase) and cropland reduction (0.86% decrease) during the same period offset these gains.

From 1990–2013, Sichuan’ s carbon footprint showed a clear upward trend (Fig. 2 [Figure 2: see original paper]), rising from 116.8826×10 t to 405.3796×10 t, an increase of 246.83% with an average annual growth rate of 5.56%. Energy consumption carbon footprint grew from 100.7825×10 t to 327.1735×10 t (224.63% increase, 5.25% annually). Carbon footprint from cement production increased from 3.7639×10 t to 56.0748×10 t (1,389.81% increase, 12.46% annually). Agricultural production carbon footprint grew from 42.8216×10 t to 58.2036×10 t (35.92% increase, 1.34% annually). Forestry carbon sequestration increased from 36.4745×10 t to 48.1491×10 t (32.01% increase, 1.21% annually). Waste treatment carbon footprint increased from 5.9892×10 t to 12.0768×10 t (101.64% increase, 3.10% annually).

Per capita carbon footprint increased from 1.49 t in 1990 to 5.00 t in 2013, with the 2013 value being 2.5 times the climate change mitigation target. Throughout 1990–2013, energy consumption accounted for 62.15%-74.73% of total GHGs (excluding forestry carbon sequestration), cement production 2.45%-12.36%, agriculture 12.79%-29.90%, waste treatment 2.41%-3.92%, while forestry carbon sequestration offset 9.86%-23.78% of total GHGs. Energy consumption is thus the primary driver of Sichuan’ s carbon footprint growth, while forestry carbon sequestration can neutralize 10%-24% of provincial GHGs emissions. Although Sichuan’ s per capita carbon footprint is not high compared to other provinces, its GHGs emission growth rate far exceeds that of forestry carbon sequestration, making emission reduction and vegetation conservation critical concerns.

Per capita water footprint in Sichuan increased from 494.92 m^3 in 1990 to 554.02 m^3 in 2013, an 11.94% increase with an average annual growth rate of 0.49% (Fig. 3 [Figure 3: see original paper]). Per capita physical water use increased from 95.98 m^3 to 130.09 m^3 (35.54% increase, 1.33% annually), while per capita virtual water fluctuated and increased from 398.95 m^3 to 423.94 m^3. Per capita available water resources fluctuated and decreased from 3,305.34 m^3 to 3,116.22 m^3 (5.72% decrease, 0.26% annually). With population increasing by 3.47% during the same period, the decline in per capita water resources may be attributed not only to population growth but also to climate warming and drying trends, which warrant attention.

3.1.2 Dynamic Analysis of Resource and Environmental Pressure Based on our results (Fig. 4 [Figure 4: see original paper]), Sichuan' s ecological pressure status from 1990-2013 can be divided into four stages: 1990-1992 at medium-low (IIa), 1993-1996 at medium-high (IIb), 1997-2001 at high (IIIa), and 2002 onward at very high (IIIb) grade. Although GHGs emissions remained at low (Ib) grade, the emission index increased from 0.06 to 0.21, a 234.97% increase. Water resource pressure index fluctuated between 0.14-0.26, remaining at very low (Ia) grade. Overall resource and environmental pressure can be divided into three periods: 1990-1997 at very low (Ia) grade, 1998-2003 at low (Ib) grade, and 2004 onward at medium-low (IIa) grade.

3.2 Spatial Variation

3.2.1 Spatial Difference Analysis of Ecological Footprint, Carbon Footprint, and Water Footprint In 2013, per capita ecological footprint across Sichuan' s prefectures fell into two categories (Table 2): eight prefectures (Nanchong, Ganzi, Suining, Bazhong, Aba, Deyang, Mianyang, and Guangyuan) had relatively low values (<3 hm^2), while the remaining 13 prefectures had higher values (>3.6 hm^2). Panzhihua showed the highest per capita ecological footprint at 15.27 hm^2, with energy footprint reaching 11.47 hm^2, clearly driven by its steel industry and other high-energy-consumption sectors. Per capita biocapacity showed three categories: Aba (5.02 hm^2) and Ganzi (5.94 hm^2) were highest, followed by Ya' an, Guangyuan, and Liangshan (1.21-1.36 hm^2), with other regions lower (0.30-0.88 hm^2). Per capita ecological deficit was highest in Panzhihua, Neijiang, Yibin, Leshan, Meishan, Zigong, and Luzhou (>4 hm^2), followed by Dazhou, Guang' an, Chengdu, Ziyang, Liangshan, Ya' an, and Deyang (2.15-3.97 hm^2), then Mianyang, Suining, Bazhong, Guangyuan, and Nanchong (1.65-1.94 hm^2). Aba and Ganzi showed ecological surpluses of 2.41 hm^2 and 3.71 hm^2, respectively.

In 2013, per capita carbon footprint was highest in Panzhihua, Meishan, Neijiang, and Leshan (9.30-35.31 t). Ya' an, Ganzi, and Aba showed negative per capita carbon footprints (-18.61 to -10.83 t), indicating carbon sink status. Nanchong' s per capita carbon footprint was 1.96 t, below the global climate change mitigation target of 2 t. Other regions showed moderate values (2.68-5.62 t).

Per capita water footprint was highest in Panzhihua, Zigong, Ziyang, Luzhou, Neijiang, and Liangshan (601.65-826.14 m^3), followed by Guang' an, Leshan, Chengdu, Meishan, Deyang, Yibin, Bazhong, and Mianyang (505.81-596.80 m^3), with other regions lower (431.64-498.34 m^3). Physical water use was relatively low in Bazhong, Aba, Suining, Yibin, Ganzi, Nanchong, Dazhou, Luzhou, and Liangshan (47.17-96.83 m^3), but higher in other regions (>100 m^3), reaching 336.09 m^3 in Panzhihua. Virtual water was lower in Ganzi, Suining, Guangyuan, Nanchong, Deyang, and Mianyang (<400 m^3), higher in Liangshan, Ya' an, Luzhou, Ziyang, and Zigong (>500 m^3), and moderate in remaining regions.

Per capita available water resources were highest in Ganzi (48,349 m^3), Aba (42,730 m^3), and Guang' an (10,027 m^3), and lowest in Meishan (607 m^3), Zigong (603 m^3), and Suining (387 m^3). Clearly, available water resources show substantial spatial variation across Sichuan.

3.2.2 Spatial Difference Analysis of Resource and Environmental Pressure Based on our results (Fig. 5 [Figure 5: see original paper]), ecological pressure in 2013 was very low (Ia) in Ganzi and Aba, medium-high (IIb) in Guangyuan, and very high (IIIb) in the remaining 19 prefectures including Chengdu, Zigong, and Panzhihua. For GHGs emissions, Panzhihua was very high (IIIb), Neijiang high (IIIa), Leshan medium-high (IIb), Meishan medium-low (IIa), Ganzi, Ya' an, and Aba were carbon sinks (Ia), and the other 14 prefectures including Chengdu, Zigong, and Luzhou were low (Ib). For water resource pressure, Zigong, Suining, Meishan, Neijiang, and Ziyang showed very high pressure (IIIb), Chengdu high (IIIa), Luzhou and Dazhou medium-high (IIb), Deyang medium-low (IIa), Yibin and Panzhihua low (Ib), and the remaining 10 prefectures including Ganzi, Aba, and Guang' an very low (Ia). Overall resource and environmental pressure fell into three major categories and six sub-categories: very low (Ia) in Aba, Ganzi, Ya' an, and Guangyuan; low (Ib) in Liangshan and Mianyang; medium-low (IIa) in Guang' an, Bazhong, and Nanchong; medium-high (IIb) in Yibin, Deyang, Leshan, and Dazhou; high (IIIa) in Luzhou, Ziyang, and Chengdu; and very high (IIIb) in Suining, Panzhihua, Meishan, Zigong, and Neijiang.

4. Discussion and Conclusion

The essence of eco-civilization construction evaluation is to quantitatively measure the achievement degree of building a resource-saving and environment-friendly society. Assessment of resource and environmental pressure provides the fundamental basis for regional eco-civilization construction decision-making. Based on Footprint Family theory and considering regional ecological pressure, resource constraints on socio-economic development, and environmental protection, this study constructed a Resource and Environmental Pressure Index comprising ecological pressure index, GHGs emission index, and water resource pressure index. Empirical research in Sichuan demonstrates that this method overcomes the limitation of single indicators that cannot comprehensively reflect human impacts on ecological environments, while also addressing the shortcomings of multi-indicator comprehensive evaluations that are heavily influenced by subjective factors. The evaluation system proves applicable to multi-scale provincial and municipal studies with good spatial and temporal comparability. Future research will explore social footprint assessment methods to enrich and expand the Footprint Family evaluation indicator system, and revise relevant indicators and parameters through more empirical studies to provide scientifically effective evaluation methods for comprehensive assessment of regional eco-civilization construction.

Applying the Footprint Family-based resource and environmental pressure evaluation system to assess Sichuan Province from 1990-2013 yields the following main conclusions:

1) From 1990-2013, Sichuan' s per capita ecological footprint increased at an average annual rate of 3.27%, while biocapacity remained relatively stable, causing the ecological pressure index to rise substantially. Ecological pressure changes can be divided into four stages: 1990-1992 at medium-low (IIa), 1993-1996 at medium-high (IIb), 1997-2001 at high (IIIa), and 2002 onward at very high (IIIb) grade. Spatially, ecological pressure was very low (Ia) in Ganzi and Aba, medium-high (IIb) in Guangyuan, and very high (IIIb) in the remaining 19 prefectures.
2) Since 1990, provincial forestry carbon sequestration increased by 32.01%. Although provincial GHGs emissions remained at low (Ic) level, the GHGs emission index increased by 234.97%. Spatially, Panzhihua showed very high (IIIb) GHGs emissions, Neijiang high (IIIa), Leshan medium-high (IIb), Meishan medium-low (IIa), Ganzi, Ya' an, and Aba were carbon sinks (Ia), and the remaining 14 prefectures including Chengdu, Zigong, and Luzhou were low (Ib).
3) Sichuan' s water footprint grew slowly from 1990-2013, with abundant available water resources resulting in very low (Ia) water resource pressure, though the declining trend in available water resources cannot be ignored. Spatially, water resource pressure was very high (IIIb) in Zigong, Suining, Meishan, Neijiang, and Ziyang; high (IIIa) in Chengdu; medium-high (IIb) in Luzhou and Dazhou; medium-low (IIa) in Deyang; low (Ib) in Yibin and Panzhihua; and very low (Ia) in the remaining 10 prefectures including Ganzi, Aba, and Guang' an.
4) Overall resource and environmental pressure can be divided into three periods: 1990-1997 at very low (Ia) grade, 1998-2003 rising to low (Ib) grade, and 2004 onward continuing to medium-low (IIa) grade. Spatially, pressure was very low (Ia) in Aba, Ganzi, Ya' an, and Guangyuan; low (Ib) in Liangshan and Mianyang; medium-low (IIa) in Guang'an, Bazhong, and Nanchong; medium-high (IIb) in Yibin, Deyang, Leshan, and Dazhou; high (IIIa) in Luzhou, Ziyang, and Chengdu; and very high (IIIb) in Suining, Panzhihua, Meishan, Zigong, and Neijiang.
5) Sichuan' s resource and environmental pressure is primarily attributed to high ecological pressure. Future eco-civilization construction should strictly adhere to cultivated land ecological red lines to ensure productivity, vigorously develop hydropower to optimize energy consumption structure, and strengthen forest conservation to enhance carbon sink potential.

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