Supplementary Section 5.1.1 Environmental capacity

(1) Weights of environmental capacity sub-indices

Table S1 reports the weights of the environmental capacity sub-indices.

Table S1. Weights of the environmental capacity sub-indices.

Sub-index	Surface Water Environmental Capacity	Atmospheric Environmental Capacity	Carbon Fixation
Weight	0.3	0.5	0.2

(2) Assessment and evaluation method

1) Surface water environmental capacity

① Absolute capacity of the single index of surface water

According to the standard limit value of each index of surface water and the measured background value of the surface water index concentration, the calculation formula for the absolute capacity of the single index of surface water is expressed in Formula S1:

$$\mathrm{Q_1 = WS_1 - B_1} \tag{S1}$$

where Q_1 is the absolute capacity of the single index of surface water; WS_1 is the standard concentration limit of surface water; and B_1 is the background concentration of the surface water index;

② Surface water capacity index

The surface water capacity index was comprehensively calculated through the absolute capacity of the single index of surface water and the standard limit value of the corresponding index. It was formulated using:

$$q_{1i} = \frac{Q_{1i}}{WS_{1i}}, \quad i = (1,2,\ldots.,\ n) \tag{S2}$$

$$\mathrm{q_1} = \sum_{i=1}^{n} q_{1i} \tag{S3}$$

where q_{1i} is the absolute capacity of the single index of surface water; Q_{1i} is the absolute capacity of the single index and standard limit of the single index of surface water; WS_{1i} is the single index capacity index of surface water; and q_1 is the surface water capacity index.

2) Atmospheric environmental capacity

The atmospheric environmental capacity was evaluated and assessed according to the ambient air quality standards and relevant evaluation documents.

① Absolute capacity of the atmospheric single index

Based on the ambient air quality standards and the measured background value of the atmospheric index concentration, the calculation formula for the atmospheric single index absolute capacity is expressed in Formula S4:

$$\mathrm{Q}_2 = \mathrm{WS}_2 - \mathrm{B}_2 \tag{S4}$$

where Q_2 is the absolute capacity of the single index of the atmosphere; WS_2 is the concentration limit of the pollutant index in the ambient air Class II area; and B_2 is the background concentration of the pollutant index;

② Atmospheric capacity

Through the absolute capacity of the single atmospheric index and the concentration limit of the corresponding index, the atmospheric capacity index was comprehensively calculated as follows:

$$q_{2j} = \frac{Q_{2j}}{WS_{2j}},\ j = 1, 2......n \tag{S5}$$

$$\mathrm{q}_2 = \sum_{j=1}^{n} q_{2j} \tag{S6}$$

where q_{2j} is the absolute capacity of the single index; $Q_{2\mathrm{j}}$ is the atmospheric single index of the capacity index ; $\mathrm{WS}_{2\mathrm{j}}$ is the concentration limit of the single index; and j is the atmospheric capacity index.

3) Carbon absorption

The development of the oil shale in situ mining area has changed the type of land use in the mining area, causing a reduction in the carbon storage of farmland vegetation.

The ecological restoration and carbon sink increase in the mining area have become the focus of researchers. Therefore, it is important to establish a calculation model for the total carbon fixation of forest land and cultivated land.

① Calculation model of forest carbon fixation

The total fixed CO_2 of forest land is estimated by the total carbon content in the annual net growth biomass of forest trees, and the formula is as follows:

$$\mathrm{E}_{\beta} = \sum_{i=1}^{n} V_1 \times \rho_i / R_i \times \mathrm{f}_i \times \Delta V \times \frac{44}{12} \tag{S7}$$

where E_β refers to the total fixed CO_2 of forest land, kg; V_i refers to the volume of forest trees, m^3; ρ_i refers to trunk density, kg/m^3; R_i refers to the proportion of trunk biomass in the total forest biomass; f_i- refers to the carbon content of trees; and 44/12 refers to the conversion coefficient between C and CO_2;

② Calculation model of cultivated land carbon fixation

Cultivated land assimilates carbon in the atmosphere into organic carbon and fixes it in plants, mainly through crop photosynthesis. The model calculation formula for carbon fixed by vegetation is as follows:

$$\mathrm{C}_d = \sum_{i=1}^{n} C_{d_i} = \sum_{i=1}^{n} \tag{S8}$$

$$\left[C_i \times P_i \times (1-V_i) \times (1+R_i)\right] / H_i \times \frac{44}{12} \tag{S9}$$

where C_d is the total CO_2 uptake during a crop-growth period (photosynthesis respiration), kg; C_{di} is the CO_2 absorption capacity of Class i crops, kg; C_i refers to the carbon content of Class i crops; P_i refers to the output of Class i crops, kg; V_i refers to the moisture content of the fruits of Class i crops; R_i is the root shoot ratio of Class i crops; H_i is the economic coefficient of Class i crops; and 44/12 refers to the conversion coefficient between C and CO_2, that is, the ratio of CO_2 molecular weight and C molecular weight.

The calculation formula for total CO_2 emissions from agricultural land is as follows:

$$\mathrm{C}_r = \sum_{i=1}^{n} A_i \times \delta_i \times \frac{44}{12} \tag{S10}$$

where C_r refers to the total amount of CO_2 released from agricultural land, kg; A_i is the total amount of various carbon sources, kg; and δ_i is the carbon emission coefficient of various carbon sources.

With reference to the fourth assessment report of the IPCC, the formula for converting CH_4 emissions into a CO_2 equivalent is as follows:

$$C_{\delta} = S \times \varphi \times 25 \tag{S11}$$

where C_δ refers to the CO_2 equivalent of the same warming effect excluded by the paddy field considering CH_4 release, kg; S is the rice-field planting area, hm^2; φ refers to the CH_4 gas emission coefficient, which is 215.5 kg/hm^2 as the value in the emission list and i; and 25 refers to the conversion coefficient between CH_4 and the equivalent CO_2.

To sum up, the difference between the total amount of CO2 absorbed by agricultural land and the total amount of CO_2 emitted is the fixed total amount of CO_2. The formula is as follows:

$$E_d = C_d - C_r - C_{\delta} \tag{S12}$$

where E_d is the total amount of CO_2 that agricultural land can absorb from the atmosphere in a year, kg; C_d refers to the total amount of CO_2 absorbed during the growth period of crops, kg; C_r refers to the total amount of CO_2 released from agricultural land, kg; and C_δ refers to the CO_2 equivalent of the same warming effect excluded in consideration of CH_4 release from rice fields, kg;

③ Calculation model of total carbon fixation

The sum of carbon fixation amount of forest land and cultivated land is the total carbon fixation amount, and the formula is as follows:

$$E = E_d + E_{\beta} \tag{S13}$$

4) Evaluation values of the sub-indices of environmental capacity

The assessment values of the two sub-indices of environmental capacity are shown in Table S2.

Table S2. Grading of sub-index assessment values.

Sub-index	Company	Assessment Value		
		80-100	60-80	0-60
Surface water environmental capacity	—	$0.5i<q_1\leq i$	$0<q_1\leq 0.5i$	$q_1\leq 0$
Atmospheric environmental capacity	—	$0.5j<q_2\leq j$	$0<q_2\leq 0.5i$	$q_2\leq 0$
Carbon fixation	Kg/hm^2	≥50000	20000-50000	≤20000

Supplementary Section 5.1.2 Groundwater risk and prevention

(1) Sub-index weights of groundwater risk and prevention

Table S3 reports the sub-index weights of groundwater risk and prevention.

Table S3. Sub-index weights of groundwater risk and prevention.

Sub-index	Groundwater Risk Potential	Groundwater Risk Prevention
Weight	0.7	0.3

(2) Assessment and evaluation method

1) Groundwater risk potential

We identified the possible groundwater risk caused by oil shale mining and calculated the assessment scores according to the level of groundwater risk potential.

① Hazard identification of substances

It is mainly expressed by the ratio of the quantity of hazardous substances to the critical quantity (Q). When $Q < 1$, the environmental risk potential is *I*; when $Q \geq 1$, the Q value is divided into (1) $1 \leq Q < 10$; (2) $10 \leq Q < 100$; and (3) $Q \geq 100$;

② Hazard identification of production system

It was expressed by the industry and production process (M). Generally, M is divided into (1) M1: $M > 20$; (2) M2: $10 < M \leq 20$; (3) M3: $5 < M \leq 10$; and (4) M4: $M = 5$. For oil shale mining projects, M is usually taken as 10;

③ The hazard of hazardous substances and process systems is often determined by the ratio of the quantity of hazardous substances to the critical quantity of the industry and production processes, as shown in Table S4:

Table S4. Hazard-grade judgment of hazardous substances and process systems (P).

Ratio of Quantity of Hazardous Substances to Critical Quantity	Industry and Production Process（M）

(Q)	M1	M2	M3	M4
Q≥100	P1	P1	P2	P3
10≤Q<100	P1	P2	P3	P4
1≤Q<10	P2	P3	P4	P4

④ Finally, the groundwater environmental risk potential was determined by the risk of hazardous substances, process systems, and groundwater environmental sensitivity.

Table S5. Division of environmental risk potential of construction projects.

Environmental Sensitivity (*E*)	Hazards of Hazardous Substances and Process Systems (*P*)			
	Extremely Harmful (*P*1)	High Hazard (*P*2)	Moderately Hazardous (*P*3)	Mild Hazard (*P*4)
Environmental highly sensitive area (E1)	IV^+	IV	III	III
Environmental moderately sensitive area (E2)	IV	III	III	II
Environmental low-sensitive area (E3)	III	III	II	I
Note: IV^+ is extremely high environmental risk				

2) Groundwater risk prevention

The evaluation was mainly carried out from source control, zoning prevention and control, and groundwater monitoring, as well as the management and emergency response measures. During the mining process, the mining personnel and experts evaluated the risk prevention and obtained the assessment score of groundwater risk prevention according to the evaluation grade.

3) Sub-index assessment value of groundwater risk and prevention

The assessment values of two sub-indices of groundwater risk and prevention are shown in Table S6.

Table S6. Classification of assessment values of groundwater risk and prevention sub-indices.

Sub-index	Assessment Value				
	90—100	80—90	60—80	40—60	0-40

Groundwater risk potential classification	I	II	III	IV	IV^{+}
Groundwater risk prevention level	Excellent	Good	Common	Poor	Bad

Supplementary Section 5.1.3 Cleaner production

(1) Weight of cleaner production sub-indices

Table S7 reports the adjusted sub-index weights of cleaner production based on "The Cleaner Production Evaluation Index System for Oil and Gas Exploitation Industry (Trial)" issued by the National Development and Reform Commission of China and the characteristics of oil shale exploitation.

Table S7. Weights of cleaner production sub-indices.

Sub-indicators	Comprehensive Energy Consumption Per Unit Product	Characteristics of Production Equipment	Waste Oil Recovery Rate	Wastewater Compliance Rate	Production Management System	Carbon Emissions
Weight	0.21	0.21	0.16	0.16	0.1	0.16

(2) Assessment and evaluation method

Table S8. Carbon emission factors corresponding to different energy sources.

Energy Category	Carbon Emission Factor
Raw coal ($kgCO_{2e}/kg$)	2.63

Diesel (kgCO_{2e}/kg)	3.20
Electricity (t/MWh)	1.0069
Water (kgCO_{2e}/kg)	2.12×10^{-4}
CH_4 escape (m^3/t)	3.18
CO_2 escape (m^3/t)	2.93

Table S9 reports the assessment values of the six sub-indices of cleaner production.

Table S9. Classification of the assessment value of the cleaner production sub-indices.

Index	Units	Assessment Score				
		90—100	80—90	60—80	40—60	0-40
Comprehensive energy consumption per unit product	Kg/t	≥35	20-35	10-20	5-10	≤5
Characteristics of production equipment	/	Advanced equipment rate≥30%	Advanced equipment rate≥20%	Advanced equipment rate≤20%	Routine	Backward
Waste oil recovery rate	%	100	80-100	60-80	0-60	0
Up to	%	100	80-100	60-80	0-60	0

standard discharge rate of wastewater						
Production management system	/	Comply with national specifications	80% Comply with national specifications	60% Comply with national specifications	50% Comply with national specifications	No system
Carbon emissions	tCO_2/t Shale oil	≤1	1-3	3-5	5-10	≥10

Supplementary Section 5.1.4 Pollution control

(1) Sub-index weights of the pollution index

Table S10 reports the weights of the pollution index sub-indicators.

Table S10. Pollution control sub-index weights.

Sub-indicators	Water Pollution Control	Air Pollution Control	Solid Waste Disposal	Carbon Reduction Performance
Weight	0.45	0.25	0.2	0.1

(2) Assessment and evaluation methods

5) Assessment value of pollution control sub-indices

Table S11 reports the classification of the pollution control sub-indicators.

Table S11. Classification of assessment values of pollution control sub-indicators.

Sub-indicator	Explain	Assessment Value				
		90-100	80-90	60-80	40-60	0-40
Water pollution control	Compliance rate (%)	80-100	70-80	60-70	40-60	0-40
Air pollution control	Compliance rate (%)	80-100	70-80	60-70	40-60	0-40
Solid waste disposal	Compliance rate (%)	80-100	70-80	60-70	40-60	0-40
Carbon reduction performance	(%)	≥50%	25-50%	0-25%	0--25%	≤-25%

Supplementary Section 5.1.5 Process control

(1) Process control sub-index weights

Table S12 presents the weights of the process control sub-indicators.

Table S12. Weights of process control sub-indicators.

Sub-indicators	Monitoring Management	Device Management	Decommissioning Control
Weight	0.6	0.1	0.3

(2) Assessment and evaluation methods

Table S13 reports the grading of the process control sub-indicators.

Table S13. Grading of process control assessment values.

Sub-indicators	Assessment Value				
	90-100	80-90	60-80	40-60	0-40
Monitoring management	Excellent	Good	Common	Poor	Difference
Device management	Excellent	Good	Common	Poor	Difference
Decommissioning control	Excellent	Good	Common	Poor	Difference

Supplementary Section 6 Calculation of comprehensive evaluation mode

Supplementary Section 6.1 Hydrogeology (C1)

(1) Distance between groundwater and reservoir (m1): the distance between the groundwater and the reservoir in the oil shale mining area of Fuyu City, Jilin Province, is 200 m, and the assessment score for m1 is 100;

(2) Aquifer permeability (m2): The permeability of the mining area is 0.0101 m/d, and the assessment score for m2 is 70.

The hydrogeological evaluation model is determined as $P_{C1} = 0.6 \times m1 + 0.4 \times m2 = 88$.

Supplementary Section 6.2 Engineering Geology (C2)

(1) Fault distance (m1): The fault distance of the oil shale in situ mining area is 7 km, and the assessment score for m1 is 68;

(2) Rock quality index (RQD) (m2): The RQD is 83%, and the assessment score for m2 is 81.4;

(3) Rock elastic modulus (m3): The compressive strength is 20M Pa, the elastic modulus is 3×10^4 Mpa, and the assessment score for m3 is 72.2;

(4) Rock porosity (m4): The porosity of the mining area is 4.335%, and the assessment score for m4 is 88.6.

The hydrogeological evaluation model is determined as $P_{C2} = 0.3 \times m1 + 0.3 \times m2 + 0.2 \times m3 + 0.2 \times m4 = 77$.

Supplementary Section 6.3 Ecological sensitivity (C3)

The ecological sensitivity parameters are calculated based on the guideline "Technical Specification for Ecological Environment Assessment" (HJ 192-2015).

(1) Biological abundance index (m1): We used the formula m1 = Abio×(0.35 × Forest+0.21 × Grassland + 0.28 × Water area + 0.11 × Cultivated land + 0.04 × Construction land + 0.01 × Unutilized land/area, where A_{bio} is a normalization coefficient, with a reference value of 511.2642131067. The calculated assessment score for m1 of the biological abundance index is determined as 59.1;

(2) Vegetation coverage index (m2): As the Changchunling oil shale mining area in Fuyu City lacks satellite imagery maps, vegetation coverage was used instead of evaluating the vegetation status in the mining area. In particular, we used vegetation coverage rate = (grassland + cultivated land + forest land) / regional area. The vegetation coverage index assessment score for m2 is determined as 44.5;

(3) Water network density index (m3): We replaced the water network density index with the water density index, where water density index = A_{wde} × Water body area / total area of the area, where A_{bio} is the normalization coefficient of the water density index.

Due to the zero-water area in the mining area, the water network density index is 0;

(4) Land Stress Index (m4): We used Land Stress Index = A_{ero} × (0.4 × Severe erosion area + 0.2 × Moderate erosion area + 0.2 × Construction land area + 0.2 × Other land coercion) / regional area, where A_{ero} is the normalization coefficient of the land stress index. The assessment score for m3 of the land stress index is calculated as 26.2.

In addition, we used Ecological Environment Index (EI) = 0.39 × $M_{biology}$ + 0.28 × $M_{vegetation}$ + 0.16 × $M_{water\ network}$ + 0.17 × (100 - M_{land}) = 48.1.

Therefore, the final calculated ecologically sensitive P_{C3} is 48.1.

Supplementary Section 6.4 Environmental Geological Risks and Prevention (D2)

① Surface deformation (m1): There is no significant deformation on the surface of the mining area. The assessment score for m1 is 80;

② Secondary Disaster Risk (m2): The Jilin Provincial Bureau of Geology and Mineral Resources has conducted a detailed exploration of the engineering geological conditions in the mining area, providing a reliable basis for the preliminary design, construction drawing design, and engineering construction. This ensures the smooth implementation of the project. The assessment score for m2 is 90;

③ Geological risk prevention (m3): Based on the detailed exploration of the engineering geological conditions of the mining area, a full understanding of the terrain and geomorphic conditions of the construction area, and the continuous development of new technologies and processes to improve and enhance the technical level. The assessment score for m3 is determined as 80.

The final environmental geological risk and prevention evaluation model is derived as

$P_{D2} = 0.5 \times m1 + 0.3 \times m2 + 0.2 \times m3 = 83$.

Supplementary Section 6.5 Other environmental risks and prevention (D3)

Surface water environmental risk (m1): According to the Surface Water Functional Zone of Jilin Province (DB22/388-2004), the surface of this area (the main stream of the Songhua River, the Ningjiang section, and the Songlin section) is subject to the Class III water body standard, and the Xidazuizi section is subject to the Class IV water body standard. We also refer to the Class III water quality standard in the Environmental Quality Standards for Surface Water (GB3838-2002). The assessment score for m1 is 75.

Soil environmental risk (m2): According to the "Soil Environmental Quality Construction Land Soil Pollution Risk Control Standard (Trial)" (GB36600-2018), the assessment score for m1 is 75.

Atmospheric environmental risk (m3): According to the "Environmental Air Quality Standards" (GB3095-2012), the environmental air function of the mining area is classified as a Class II area. The assessment score for m3 is 80.

Environmental risk prevention (m4): The mining area adopts corresponding measures to meet the requirements of relevant national environmental protection standards for pollutants, such as sewage, waste residue, and noise, and purifies and reuses these pollutants in designated locations. The project construction process adheres to the principle of "three simultaneities", that is, environmental governance measures are designed, constructed, and put into operation in parallel with the main construction project to ensure that pollutants are discharged up to standards. The assessment score for m4 is determined as 85.

Other environmental risks and prevention evaluation models are derived as $P_{D3} = 0.2 \times m1 + 0.4 \times m2 + 0.2 \times m3 + 0.2 \times m4 = 78$.

Supplementary Materials S1

Questionnaire for weight calculation of environmental impact assessment for oil shale mining

Enterprise :_________________ Position/Title :__________

Name :_________________ Filling date :__________

Contact person: Boyue Liu liuboyue@tcu.edu.cn

Evaluation criteria

the three-scale method

scale	meaning
1	Two elements (X, Y) have equal importance to a certain attribute
2	Comparing two elements, one element (X) is more important than the other element (Y)
0	Comparing two elements, one element (X) is not as important as the other element (Y)

Note: There is no primary or secondary relationship between the evaluation of secondary and tertiary indicators, and experts do not need to consider evaluating the indicators in order.

1. Differences in importance between secondary indicators

Do you think the importance of X relative to Y in the comprehensive evaluation model (A) for in-situ oil shale mining environment?

Comparative factors		How important is it?		
X	Y	0	1	2
Environmental site selection (B1)	Environmental risk (B2)	□	□	□
Environmental site selection (B1)	Environmental governance (B3)	□	□	□
Environmental risk (B2)	Environmental governance (B3)	□	□	□
Explanation	**Please mark "√" in the □ column.**			

2. Differences in importance between tertiary indicators

(1) In terms of environmental site selection (B1), do you think the importance of X relative to Y is?

Comparative factors		How important is it?		
X	Y	0	1	2
Hydrogeology (C1)	Engineering geology (C2)	□	□	□
Hydrogeology (C1)	Ecologically sensitive (C3)	□	□	□
Hydrogeology (C1)	Environmental capacity (C4)	□	□	□
Engineering geology (C2)	Ecologically sensitive (C3)	□	□	□
Engineering geology (C2)	Environmental capacity (C4)	□	□	□
Ecologically sensitive (C3)	Environmental capacity (C4)	□	□	□
Explanation	**Please mark "√" in the □ column.**			

(2) In terms of Environmental risk (B2), do you think the importance of X relative to Y is?

Comparative factors	How important is it?

X	Y	0	1	2
Groundwater risk and prevention (D1)	Environmental geological risk and prevention (D2)	□	□	□
Groundwater risk and prevention (D1)	Other environmental risks and prevention (D3)	□	□	□
Environmental geological risk and prevention (D2)	Other environmental risks and prevention (D3)	□	□	□
Explanation	**Please mark "√" in the □ column.**			

(3) In terms of Environmental governance (B3), do you think the importance of X relative to Y is?

Comparative factors		**How important is it?**		
X	Y	0	1	2
Cleaner production (E1)	Pollution control (E2)	□	□	□
Cleaner production (E1)	Process control (E3)	□	□	□
Pollution control (E2)	Process control (E3)	□	□	□
Explanation	**Please mark "√" in the □ column.**			

Supplementary Materials S2

The scoring results of the expert survey questionnaire

Table S14. Differences in Importance of Secondary Indicators in Relative Target Layer.

Experts	Enterprise	Post	The Importance of X Relative to Y		
			B1 Relative to B2	B1 Relative to B3	B2 Relative to B3
Honghan Vhen	China University of Geosciences	Professor	2	2	1
Sen Guo	Ministry of Ecology and Environment	Senior engineer	1	1	1
Xingchun Li	Safety and Environmental Protection Institute	Professor of engineering	1	2	1
Jianjun Liang	Chongqing University	Associate professor	1	2	1
Linzuo Liang	China National Petroleum Corporation	Senior engineer	2	1	0
Yufeng Ma	Changqing Oilfield Branch	Section chief	2	2	2
Jiayou Mei	CNOOC Environmental Protection Company	Professor of engineering	1	2	0
Fanwei Meng	East China Environmental Geotechnical Branch	Senior engineer	1	2	2
Miao Ning	Environmental Planning Institute of the Ministry of Ecology and Environment	Deputy director	2	1	0
Zhihe Tang	China Petroleum Safety and Environmental Protection Technology Research Institute	Director	0	0	1

Shanbin Tu	PetroChina Southwest Oil and Gas Field Branch	Deputy office	2	2	2
Ligang Wang	Kunlun Project	Deputy chief engineer	2	1	1
Dasong Xing	Fushun Mining Group Co. Ltd.	Deputy director	2	2	2
Tao Yu	China Petroleum Exploration and Production Branch	Senior executive	2	2	2
Fuqin Zhang	China Petroleum Planning and Engineering Institute	Deputy chief engineer	1	2	2

Table S15. Differences in Importance of Third-Level Indicators for Relative Environmental Site Selection.

Experts	Enterprise	Post	The Importance of X Relative to Y					
			C1 Relative to C2	C1 Relative to C3	C1 Relative to C4	C2 Relative to C3	C2 Relative to C4	C3 Relative to C4
Honghan Vhen	China University of Geosciences	Professor	2	2	2	0	1	2
Sen Guo	Ministry of Ecology and Environment	Senior engineer	0	1	1	1	1	1
Xingchun Li	Safety and Environmental Protection Institute	Professor of engineering	1	2	1	2	1	0
Jianjun Liang	Chongqing University	Associate professor	0	0	1	1	2	2
Linzuo Liang	China National	Senior engineer	1	0	2	0	2	2

	Petroleum Corporation							
Yufeng Ma	Changqing Oilfield Branch	Section chief	1	1	1	1	1	1
Jiayou Mei	CNOOC Environmental Protection Company	Professor of engineering	0	0	2	2	0	2
Fanwei Meng	East China Environmental Geotechnical Branch	Senior engineer	0	0	0	1	2	2
Miao Ning	Environmental Planning Institute of the Ministry of Ecology and Environment	Deputy director	1	1	1	1	1	1
Zhihe Tang	China Petroleum Safety and Environmental Protection Technology Research Institute	Director	1	0	0	0	0	2
Shanbin Tu	PetroChina Southwest Oil and Gas Field Branch	Deputy office	1	1	1	0	0	2

Ligang Wang	Kunlun Project	Deputy chief engineer	1	2	0	1	0	1
Dasong Xing	Fushun Mining Group Co. Ltd.	Deputy director	0	2	2	2	2	2
Tao Yu	China Petroleum Exploration and Production Branch	Senior executive	1	0	1	0	1	0
Fuqin Zhang	China Petroleum Planning and Engineering Institute	Deputy chief engineer	1	1	0	2	0	0

Table S16. Differences in the Importance of Third-Level Indicators of Relative Environmental Risk.

Experts	Enterprise	Post	The Importance of X Relative to Y		
			D1 Relative to D2	D1 Relative to D3	D2 Relative to D3
Honghan Vhen	China University of Geosciences	Professor	2	2	0
Sen Guo	Ministry of Ecology and Environment	Senior engineer	1	1	2
Xingchun Li	Safety and Environmental Protection Institute	Professor of engineering	1	2	2

Jianjun Liang	Chongqing University	Associate professor	1	0	0
Linzuo Liang	China National Petroleum Corporation	Senior engineer	1	2	2
Yufeng Ma	Changqing Oilfield Branch	Section chief	2	2	2
Jiayou Mei	CNOOC Environmental Protection Company	Professor of engineering	0	2	2
Fanwei Meng	East China Environmental Geotechnical Branch	Senior engineer	1	1	1
Miao Ning	Environmental Planning Institute of the Ministry of Ecology and Environment	Deputy director	1	2	2
Zhihe Tang	China Petroleum Safety and Environmental Protection Technology Research Institute	Director	2	2	2
Shanbin Tu	PetroChina Southwest Oil and Gas Field Branch	Deputy office	2	1	0
Ligang Wang	Kunlun Project	Deputy chief engineer	2	2	0
Dasong Xing	Fushun Mining Group Co. Ltd.	Deputy director	0	2	2
Tao Yu	China Petroleum Exploration and Production Branch	Senior executive	1	1	1
Fuqin Zhang	China Petroleum Planning and Engineering Institute	Deputy chief engineer	1	1	1

Table S17. Differences in Importance of Third-Level Indicators for Relative Environmental Governance.

Experts	Enterprise	Post	The Importance of X Relative to Y

			E1 Relative to E2	E1 Relative to E3	E2 Relative to E3
Honghan Vhen	China University of Geosciences	Professor	1	1	0
Sen Guo	Ministry of Ecology and Environment	Senior engineer	1	1	2
Xingchun Li	Safety and Environmental Protection Institute	Professor of engineering	1	1	2
Jianjun Liang	Chongqing University	Associate professor	1	1	1
Linzuo Liang	China National Petroleum Corporation	Senior engineer	0	1	2
Yufeng Ma	Changqing Oilfield Branch	Section chief	2	0	1
Jiayou Mei	CNOOC Environmental Protection Company	Professor of engineering	2	0	0
Fanwei Meng	East China Environmental Geotechnical Branch	Senior engineer	2	2	0
Miao Ning	Environmental Planning Institute of the Ministry of Ecology and Environment	Deputy director	1	1	1
Zhihe Tang	China Petroleum Safety and Environmental Protection Technology Research Institute	Director	2	1	0
Shanbin Tu	PetroChina Southwest Oil and Gas Field Branch	Deputy office	2	2	0
Ligang Wang	Kunlun Project	Deputy chief engineer	1	2	0
Dasong Xing	Fushun Mining Group Co. Ltd.	Deputy director	2	0	0

Tao Yu	China Petroleum Exploration and Production Branch	Senior executive	2	2	1
Fuqin Zhang	China Petroleum Planning and Engineering Institute	Deputy chief engineer	2	2	0