

Supporting Information

Assessing Representative CCUS Layouts for China's Power Sector towards Carbon Neutrality

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Table S7 Terrain penalty matrix (in part) caused by rivers.

Figure S1 Six major regions of China.

Figure S2 Schematic diagrams of terrain penalty matrix caused by rivers.

25 **1. Information about 6 major regions and 34 provincial-level administrative**
26 **regions of China.**

27 **Table S1**

28 Abbreviations of provinces.

Annotation	Province	Abbreviation	Annotation	Province	Abbreviation
North China	Beijing	BEIJ	East China	Shanghai	SHAN
	Tianjin	TIAN		Jiangsu	JINU
	Hebei	HEBE		Zhejiang	ZHEJ
	Shanxi	SHNX		Anhui	ANHU
	Inner Mongolia	NEMO		Fujian	FUJI
Northeast China	Liaoning	LIAO	South Central China	Jiangxi	JINX
	Jilin	JILI		Shandong	SHAD
	Heilongjiang	HEIL		Henan	HENA
Southwest China	Chongqing	CHON	South Central China	Hubei	HUBE
	Sichuan	SICH		Hunan	HUNA
	Guizhou	GUIZ		Guangdong	GUAD
	Yunnan	YUNN		Guangxi	GUAX
Northwest China	Shaanxi	SHAA	No data	Hainan	HAIN
	Gansu	GANS		Xizang	TIBE
	Qinghai	QING		Hongkong	HK
	Ningxia	NINX		Macao	MACAO
	Xinjiang	XING		Taiwan	TAIWAN

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32 **Figure S1 Six major regions of China.** Note: no data for Xizang, Hongkong, Macao and Taiwan.

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34 **2. Interpretation of results from China TIMES model**

35 **2.1. Emission pathways**

36 China's fair carbon budget is determined based on different effort-sharing
 37 principles,^{1, 2} which are grouped into the IPCC AR5 (the Fifth Assessment Report of
 38 the Intergovernmental Panel on Climate Change) categories. The carbon budget of 290
 39 Gt in 2010-2050 used in this study has also been applied in other research, thus ensuring
 40 its reasonability.^{3, 4} China announced to achieve carbon neutrality before 2060, but it is
 41 not clear whether the emission scope is limited to CO₂ or includes full greenhouse gases
 42 (GHG). Taking this into consideration, we assume a relative low level of CO₂ emissions
 43 of 0.5 Gt in 2050 referring research from other scholars around the world. China TIMES
 44 mainly pays attention to energy-related CO₂ emissions. If the carbon neutrality goal
 45 only aims at CO₂, it is much likely to be achieved by 2060 considering average
 46 reduction of 0.5 Gt CO₂ per year (shown in Fig.2a) and a low level of CO₂ emissions
 47 in 2050. If the emission scope includes full GHG, China may still achieve carbon
 48 neutrality by 2060 with the assumption that process-based CO₂ emissions and non-CO₂

49 GHG emissions can be offset by negative emissions from LULUCF (Land use, land use
50 change and forestry).⁵ Therefore, the emission pathways of this study meet the
51 requirement of China's carbon neutrality with a high probability.

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53 **2.2. Energy system transition and CCUS deployment**

54 Under the same carbon budget of 290 Gt in 2010-2050 and CO₂ emissions of 0.5
55 Gt in 2050, three representative energy transition roadmaps (i.e., portfolios of fuels and
56 technology) are proposed with the minimization of the total discount cost. Considering
57 the uncertainty of CCUS prospect resulting from technology competition, different
58 capacity constraints are applied to generate three levels of CCUS deployment (i.e., total
59 installed capacity of CCUS) corresponding to three roadmaps, as is shown in Fig.2b.

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62 **3. Scenario representation**

63 The mix integer linear programming (MILP) for CCUS SSM under S1~S9 are
64 distinguished by setting CO₂ capture target T and the maximum transportation distance
65 l_{max} to different values, as shown in Table S2. Three specific values of T are determined
66 by China TIMES model, corresponding to three representative CCUS deployment.

67 **Table S2**

68 Scenario representation.

	$l_{max} = 100 \text{ km}$	$l_{max} = 300 \text{ km}$	$l_{max} = 800 \text{ km}$
$T = 0.4 \text{ Gt}$	S1	S2	S3
$T = 1.1 \text{ Gt}$	S4	S5	S6
$T = 1.7 \text{ Gt}$	S7	S8	S9

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70 4. Data for emission sources and storage sites

71 Information about emission sources and storage sites are provided in Table S3.

Table S3

Data for emission sources.⁶

Province	Plant name	Number of units	Capacity (MW)	Heat rate (Btu/kWh)	Emission factor (kg CO ₂ /TJ)
ANHU	Anhui Bengbu power station	2	660	8272.00	94600.00
	Anhui Hwasu power station	2	300	9572.20	96100.00
	Anhui Xuancheng power station	1	660	8272.00	94600.00
	CPI Pingwei power station	2	1000	8272.00	94600.00
	Fuyang Haoyuan cogen power station	2	40	10326.00	96100.00
	Hefei Lujiang power station	2	660	8272.00	96100.00
	Hefei power station	1	630	8272.00	94600.00
	Huadian Lu'an power station	2	660	8272.00	94600.00
	Huadian Wuhu power station	1	1000	8272.00	94600.00
	Huaibei Hushan power station	2	660	8409.00	94600.00
	Huaibei Linhuan power station	2	330	9572.20	94600.00
	Huaibei Pingshan power station	2	660	8272.00	96100.00
	Huainan Fengtai power station	2	660	8272.00	94600.00
	Huainan Guqiao power station	2	330	9572.20	94600.00
	Huainan Tianji power station	2	660	8272.00	96100.00
	Lixin Banji power station	2	1000	8272.00	96100.00
	Shanying Mill Ma'anshan power station	2	65, 50	10442.40	96100.00
	Shenhua Anqing power station	2	1000	8272.00	94600.00

	Sinopec Anqing power station	1	50	10442.40	96100.00
	Suzhou Huiyuan power station	2	350	9249.90	96100.00
	Suzhou Qianyingzi power station	2	350	9572.20	96100.00
	Tongling Wanneng power station	2	1000	8272.00	94600.00
	WEnergy Ma'anshan Power Station	2	660	8272.00	94600.00
	Wuhu Zhongdian power station	2	660	9099.20, 8272.00	94600.00
CHON	Anwen Songzao power station	2	660	8409.00	96100.00
	Baitao cogen power station	2	50	10442.40	96100.00
	Chongqing Longqiao power station	3	300, 50*2	9572.20, 10442.40*2	96100.00
	Chongqing Nine Dragons Cogen power station	1	105	10442.40	96100.00
	Chongqing Qineng power station	2	330	9572.20	94600.00
	Chongqing Shizhu power station	2	350	9249.90	96100.00
	Chongqing Shuanghuai power station	2	660	8272.00	94600.00
	Huadian Fengjie power station	2	600	8409.00	94600.00
	Shenhua Wanzhou power station	2	1000	8272.00	96100.00
	Shuijiang Zutuan power station	1	350	9249.90	96100.00
FUJI	Fujian Hongshan power station	4	600*2, 1000*2	8409.00*2, 8272.00*2	94600.00
	Fujian Jinnan Cogen power station	2	30	10326.00	96100.00
	Hang Hau Longyan power station	1	300	10442.40	94600.00
	Huadian Shaowu power station	2	660	8272.00	96100.00
	Huaneng Fuzhou power station	2	660	9099.20	94600.00
	Huaneng Luoyuan power station	2	660	8272.00	96100.00
	Meizhou Wan power station	2	1000	8272.00	94600.00
	Nanpu Quanzhou power station	2	670	8409.00	94600.00
	Yong'an power station	2	300	10442.40, 9572.20	98300.00
	Zhangping power station	2	300	9572.20	98300.00

GANS	Datang 803 power station	2	300	9572.20	96100.00
	Gansu Baiyin power station	2	350	9249.90	96100.00
	Gansu Chongxin power station	2	660	9249.90, 8409.00	96100.00
	GEPIC Jinchang power station	2	330	9572.20	94600.00
	Guodian Jiuquan power station	2	330	9572.20	96100.00
	Guodian Yuzhong power station	1	350	9249.90	96100.00
	Huaneng Pingliang power station	2	600	9249.90	94600.00
	Jiayuguan Aluminum power station	4	350	9249.90	96100.00
	Jisco-1 power station	2	41.5	10326.00	96100.00
	Jisco-2 power station	2	350	9249.90	96100.00
	Lanzhou Fanjiaping power station	2	330	9572.20	96100.00
	Wuwei Cogen power station	2	350	9249.90	96100.00
	Baosteel Zhanjiang power station	2	350	9572.20	94600.00
	Chaozhou Sanbaimen power station	1	1000	9099.20	94600.00
	Datang Leizhou power station	2	1000	8272.00	96100.00
GUAD	Guangdong Huilai power station	2	1000	8272.00	94600.00
	Guangdong Huizhou Pinghai power station	2	1000	9099.20, 8272.00	96100.00
	Guangdong Shaoguan power station	2	600	8272.00	98300.00
	Guangdong Zhongshan power station	2	300	9572.20	96100.00
	Guangzhou Lixin power station	2	330	9572.20	96100.00
	Guodian Guangdong Zhaoqing Dawang power station	2	350	9249.90	96100.00
	Guohua Taishan power station	2	1000	8272.00	94600.00
	Heshuyuan power station	2	300	9572.20	94600.00
	Huadian Nanxiong power station	2	350	9249.90	96100.00
	Huaneng Haimen power station	3	1036	9099.20, 8272.00*2	94600.00
	Huizhou Cogen power station	2	330	10442.40	94600.00

	Lufeng Jiahuwan power station	2	1000	8272.00	96100.00
	Maoming Zhenneng power station	1	600	8409.00	94600.00
	Nanhai Foshan-2 power station	2	330	10442.40	94600.00
	Pingshi power station	1	300	10442.40	98300.00
	Sanshui Hengyi power station	2	600	8409.00	96100.00
	Shanwei Haifeng CCS power station	2	1050	8272.00	96100.00
	Shanwei Honghaiwan power station	2	660	8272.00	94600.00
	Shaoguan Wastecoal power station	2	350	9572.20	94600.00
	Yangxi Zhujiang power station	3	660*2, 1240	8272.00	96100.00*2, 94600.00
	Yudean Dabu power station	2	600	8272.00	96100.00
	Yunfu power station	2	300	10442.40	98300.00
	Zhanjiang Aoliyou power station	2	600	8702.00	94600.00
GUAX	Baise Smelter power station	2	350	9249.90	96100.00
	Datang Heshan power station	1	670	8409.00	98300.00
	Fangchenggang Qisha power station	2	660	8272.00	94600.00
	Guangxi Hualei power station	3	350	9249.90	96100.00
	Guangxi Luzhai power station	2	350	9249.90	96100.00
	Guodian Nanning power station	2	660	8409.00	98300.00
	Hezhou power station	2	1045	8272.00	94600.00
	Jingxi Xinfia Aluminum power station	1	360	9249.90	96100.00
	SDIC Qinzhou power station	2	1050	8272.00	94600.00
GUIZ	CR Liuzhi power station	2	660	8409.00	96100.00
	Guizhou Fa'er power station	1	600	9572.20	96100.00
	Guodian Duyun power station	2	600	8409.00	94600.00
	Jinsha Chayuan power station	2	660	8409.00	96100.00
	Panbei power station	2	300	9572.20	94600.00
	Panxian-1 power station	2	660	8409.00	94600.00
	Pu'an power station	2	660	8409.00	96100.00

	Qianxi power station	1	660	8409.00	96100.00
	Qingshuihe captive power station	2	350	9249.90	96100.00
	CPI Suiyang power station	2	150	10326.00	96100.00
	Tangzhai power station	2	600	8409.00	98300.00
	Tongzi power station	2	600	8409.00	98300.00
	Xingyi power station	2	600	8409.00	98300.00
	Xingyi Zhengluwan power station	1	350	9249.90	96100.00
	Xishui Erlang power station	2	660	8702.00	96100.00
	Zhenfeng power station	2	350	9249.90	96100.00
	Guodian Zhijin power station	2	660	8409.00	96100.00
HAIN	Hainan Southwest power station	2	350	9249.90	96100.00
	Huaneng Hainan East power station	2	350	9249.90	96100.00
HEBE	Baoding Northwest Suberb power station	2	350	9249.90	96100.00
	Cangzhou Bohai power station	2	350	9572.20	96100.00
	Cangzhou Yundong Cogen power station	1	350	9249.90	96100.00
	Chengde Shangbancheng power station	2	350	9249.90	101000.00
	China Resources Caofeidian power station	2	1000	8272.00	94600.00
	Datang Matou power station	2	300	10442.40	96450.00
	Datang Qingyuan power station	2	300	9572.20	96100.00
	Datang Wu'an power station	2	300	9572.20	94600.00
	Datang Yuxian power station	2	660	8272.00	96100.00
	Guodian Langfang power station	2	350	9249.90	96100.00
	Handan Eastern Outskirt Cogen Power Station	2	350	9249.90	96100.00
	Huadian Luhua power station	2	330	9572.20	98300.00
	Huaneng Shang'an power station	1	620	9249.90	94600.00
	Jingneng Qinhuangdao power station	2	350	9249.90	96100.00
	Jingneng Zhuozhou power station	2	350	9249.90	96100.00
	Kailuan Guye power station	2	300	9572.20	94600.00

	Luanhe power station	1	330	9572.20	94600.00
	Mancheng Mill power station	4	30*2, 35*2	10442.40	96100.00
	Renqiu power station	2	350	9249.90	94600.00
	Shahe power station	2	600	8409.00	94600.00
	Shijiazhuang Liangcun power station	2	330	9572.20	94600.00
	Datang Tangshan Beijiao power station	2	350	9249.90	96100.00
	Tangshan Sanyou Cogen power station	1	30	10442.40	96100.00
	Tangshan West power station	2	350	9249.90	96100.00
	Xingtai Cogen power station	2	350	9249.90	96100.00
	Xuanhua power station	2	300	10442.40	96100.00
	Zhangjiakou ZTP power station	1	300	10442.40	94600.00
	Zunhua-2 power station	2	350	9249.90	94600.00
HEIL	Anda Cogen power station	2	50	10442.40	96100.00
	Daqing Oil Central power station	1	300	9572.20	101000.00
	Datang Harbin power station	2	300	10442.40	101000.00
	Datang Suihua power station	2	350	9249.90	101000.00
	Guodian Pingnan power station	2	350	9249.90	96100.00
	Huadian Fulaerji power station	1	350	9249.90	96100.00
	Huadian Harbin-1 power station	1	350	9572.20	94600.00
	Huaneng Daqing power station	2	350	9249.90	96100.00
	Huaneng Yichun power station	2	350	9249.90	96100.00
	Jiamusi Zhongheng Cogen power station	2	75, 50	10326.00	96100.00
	Jixi power station	2	300	9572.20	94600.00
	Linkou Cogen power station	1	50	10442.40	96100.00
	Mudanjiang-2 power station	2	300	10442.40,	94600.00
				9572.20	
	Shenhua Baoqing power station	1	600	8409.00	101000.00
	Yipin Captive power station	3	35	10326.00	96100.00
HENA	CPI Minsheng power station	2	350	9249.90	96100.00

Datang Gongyi power station	2	660	8272.00	96100.00
Datang Linzhou power station	2	350	9249.90	94600.00
Datang Sanmenxia power station	1	1000	8272.00	94600.00
Dengfeng-2 power station	2	630	8409.00	94600.00
Henan Heqi power station	2	660	8272.00	94600.00
Henan Mengdian power station	2	300	9572.20	98300.00
Henan Shenhua power station	1	600	8409.00	94600.00
Henan Xin'an power station	2	300	10442.40, 9572.20	94600.00
Henan Xinmi power station	2	1030	8272.00	96100.00
Henan Xinzhenyi power station	2	660	8272.00	96100.00
Huadian Luohe power station	1	330	10442.40	96100.00
Huaneng Luoyang power station	2	350	9249.90	96100.00
Huaneng Mianchi power station	2	350	9249.90	96100.00
Huaneng Qinbei power station	2	1000	8272.00	96100.00
Jiaozuo Aluminum power station	2	350	9572.20	98300.00
Jiaozuo Bo'ai power station	2	660	8272.00	96100.00
Jiaozuo Danhe power station	2	1000	8272.00	96100.00
Luoyang Mengjin power station	2	600	8409.00	94600.00
Pingdingshan Luyang power station	2	1030	9099.20	94600.00
Puyang Longfeng power station	2	600	8272.00	96100.00
Qudong power station	2	330	9572.20	96100.00
SDIC Neixiang power station	1	1000	8272.00	96100.00
Shenhua Jiaozuo power station	2	660	8272.00	98300.00
Xingyang Integration power station	2	630	9249.90	98300.00
Yichuan Longquan Kim Hyung power station	2	660	8272.00	94600.00
Zhengzhou Xinli power station	1	660	8272.00	94600.00
Zhoukou Longda power station	2	660	8272.00	96100.00
Zhumadian-3 power station	2	330	9572.20	96100.00

HUBE	CPI Dabieshan power station	1	660	8409.00	94600.00
	Hanchuan power station	2	1000	8272.00	96100.00
	Huadian Jiangling power station	2	660	8272.00	96100.00
	Huadian Xisaishan power station	2	680	9099.20, 8272.00	94600.00
	Huaneng Jingmen power station	2	350	9249.90	96100.00
	Huaneng Yingcheng power station	2	50, 350	10090.80, 9249.90	94600.00
	Huangshi power station	1	330	10442.40	96100.00
	Hubei Ezhou power station	2	1000	8272.00	96100.00
	Long Chen Paper Jingzhou captive power station	3	35	10326.00	96100.00
	Puqi Xianning power station	2	1000	8272.00	94600.00
	Qingshan power station	2	350	9572.20	98300.00
	Shiyan Cogen power station	2	350	9249.90	96100.00
	Yangjiachang Town Cogen power station	2	60	10326.00	96100.00
	Yichang Xiaoting power station	2	350	9249.90	96100.00
	Datang Zhuzhou-2 power station	2	630	8409.00	96100.00
HUNA	Guodian Baoqing power station	2	660	8409.00	94600.00
	Huadian Changde power station	2	660	8272.00	96100.00
	Huaneng Yueyang power station	2	600	8272.00	98300.00
	Yueyang Paper Mill power station	2	50	11312.60	96100.00
	Alashan Left Qi Wusitai power station	1	300	10326.00	96100.00
NEMO	Baotou Aluminum power station	4	330*2, 350*2	9572.20*2, 9249.90*2	96100.00
	Bayanhaote Cogen power station	2	330	9572.20	96100.00
	Bayanhua Jinshan power station	2	600	9572.20	101000.00
	Beijing Energy Wujianfang power station	2	660	8272.00	96100.00
	Bulian power station	2	660	8272.00	94600.00
	Chuangyuan Smelter power station	2	330	9572.20	101000.00

CPI Chifeng Daban power station	2	600	8702.00	101000.00
CPI Chifeng New City Region power station	1	300	9572.20	101000.00
CPI Chifeng New City Region power station	1	300	9572.20	101000.00
CR Xiwu Qi Wujianfang power station	2	660	8272.00	101000.00
Daihai power station	2	600	8702.00	94600.00
Datang Tuoketuo power station	2	660	8272.00	94600.00
Datang Xilinhaote power station	1	660	8272.00	96100.00
Guohua Hulunbeier power station	2	600	9249.90	101000.00
Guyang Jinshan Cogen power station	1	350	9249.90	96100.00
Hohhot Jinshan power station	2	300	10442.40	96100.00
Hongjun Aluminum power station	1	350	9572.20	94600.00
Huadian Baotou Tuyou power station	2	660	8409.00	96100.00
Huadian Zhunger Dalu Waste Coal power station	2	300	9572.20	94600.00
Huaneng Helin power station	2	600	8409.00	94600.00
Huaneng Hohhot power station	2	350	10090.80	94600.00
Huaneng Manzhouli Dalaihu power station	2	200	10326.00	96100.00
Huaneng Shangdu power station	2	660	8409.00	101000.00
Huaneng Yimin power station	2	600	9249.90	101000.00
Huaneng Zhunger Weijiamao power station	2	660	8409.00	96100.00
Huolinhe Zhanute power station	3	660	8409.00	101000.00
Inner Hangjin power station	2	330	9572.20	94600.00
Inner Mongolia Xilin power station	2	350	9249.90	101000.00
Inner Mongolia Xing'an power station	2	340	9572.20	101000.00
Jingmei Wuhai Jinghai Waste Coal power station	2	330	10442.40	94600.00
Jingneng Energy Jining power station	2	350	9249.90	96100.00
Jingneng Energy Shuangxin power station	2	350	9249.90	94600.00
Jingtai Zhunge'er Suancigou power station	2	300	10442.40	94600.00
Jiyuan Cogen power station	2	36	10326.00	101000.00

JINU	Kangbashi power station	2	350	9249.90	96100.00
	Keyouzhongqi power station	1	330	10442.40	96100.00
	Lianyuan Cogen power station	2	50	10442.40	96100.00
	Mengtai Beijiao power station	2	330	9572.20	94600.00
	Ordos Junzheng power station	2	330	9572.20	94600.00
	Ordos Power Qipanjing power station	2	330	10442.40	96100.00
	Ordos Resources Qipanjing power station	2	330	9465.50	96100.00
	Salaqi power station	2	300	9572.20	94600.00
	SGCC Ewenki power station	2	600	8409.00	101000.00
	Shengle Cogen power station	2	350	9249.90	96100.00
	Shenhua Zhunneng power station	2	330	9572.20	94600.00
	United Laboratories Linhe power station	2	300	9572.20	94600.00
	Xinghe Cogen power station	2	350	9572.20	96100.00
	Zhongtian Hechuang Ordos power station	3	135*2, 30	10442.40	96100.00
	CPI Changshu-1 power station	2	1000	8272.00	94600.00
	CPI Binhai power station	2	1000	8272.00	96100.00
	Datang Nanjing Xiaguan-3 power station	2	660	9099.20	94600.00
	Datun Mine power station	2	350	9249.90	98300.00
	Guodian Suqian power station	2	660	8272.00	96100.00
	Guodian Taizhou power station	2	1000	8272.00	94600.00
	Guohua Xuzhou power station	2	1000	8272.00	96450.00
	Hongyang Lianyungang power station	3	40	10442.40	96100.00
	Huadian Jurong power station	4	1000	8272.00	94600.00*2, 96100.00*2
	Huadian Wangting power station	1	660	9099.20	94600.00
	Huaiyin power station	1	350	9572.20	94600.00
	Huaneng Jinling power station	1	1030	9099.20	94600.00
	Huaneng Nanjing Chemical Industrial Park power station	2	50	10442.40	96100.00
	Jianbi power station	2	1000	8272.00	94600.00

	Jiangsu Guohua Chenjiagang power station	2	660	8409.00	96100.00
	Jiangsu Guoxin Jingjiang power station	2	660	8272.00	94600.00
	Jiangsu Nanre Thermal power station	2	600	9249.90,	94600.00
				8409.00	
	Jiangsu Nantong power station	2	1000	8272.00	96100.00
	Jiangsu Sheyanggang power station	2	660	8272.00	96100.00
	Lusigang power station	4	660	9099.20	94600.00
	Singpu Chemicals Taixing power station	2	50	10442.40	96100.00
	Xinhai power station	2	1000	8272.00	96100.00
	Xuzhou Huamei power station	2	350	9249.90	94600.00
	Xuzhou Pengcheng power station	2	1000	9099.20	94600.00
	Zhangjiagang Changyuan Cogen power station	2	35	10442.40	96100.00
	Zhangjiagang Shazhou power station	2	1000	8272.00	96100.00
	Zhongneng Polysilicon power station	1	350	9249.90	96100.00
JINX	CPI Xinchang power station	1	700	9099.20	94600.00
	Datang Fuzhou power station	2	1000	8272.00	96100.00
	CPI Fenyi power station	1	660	8272.00	96100.00
	Guixi power station	2	640	8409.00	94600.00
	Guodian Jiujiang power station	1	660	8272.00	96100.00
	Huaneng Anyuan power station	2	660	8272.00	94600.00
	Jingdezhen power station	2	660	8272.00,	96100.00
				9099.20	
	Shenhua Jiujiang power station	2	1052	8272.00	96100.00
JILI	Changchun Southeast power station	2	350	9249.90	94600.00
	Changchun-3 power station	2	80	10442.40	94600.00
	CPI Baicheng power station	2	660	9249.90	101000.00
	Datang Changshan power station	1	660	8409.00	101000.00
	Fanjiatun Kaixuan Cogen power station	2	30	10326.00	96100.00
	Guodian Changchun power station	2	350	9249.90	96100.00

	Guodian Jiangnan power station	2	330	10442.40, 9572.20	94600.00
	Hongyuan Waste Coal Cogen power station	2	30	10326.00	94600.00
	Huaneng Baishan power station	2	330	9572.20	94600.00
	Huaneng Changchun power station	1	350	10090.80	101000.00
	Jilin Yuanyuan Cogen power station	2	50	10442.40	96100.00
	Longhua Baicheng power station	2	200	10442.40	96100.00
	Longhua Yanji power station	2	200	11312.60	96100.00
	Longsheng Cogen power station	2	30	10442.40	96100.00
	Shuangliao West power station	1	660	8409.00	101000.00
	Siping power station	1	350	9572.20	101000.00
	Songhuajiang power station	4	350, 40*2, 50	9572.20, 10442.40*3	101000.00
LIAO	Benxi Cogen power station	2	350	9249.90	96100.00
	Changxing Island Hengli Petrochemical power station	2	60	10442.40	96100.00
	Chaoyang GDP power station	2	350	9249.90	96100.00
	Chaoyang Yanshanhu power station	2	600	8409.00	101000.00
	CNPC Fushun Petrochemical power station	2	100	10442.40	96100.00
	CPI Qinghe power station	2	600	8409.00, 9249.90	101000.00
	Dalian ETDC power station	2	350	9249.90	96100.00
	Dalian Ganjingzi power station	2	300	10442.40	101000.00
	Dandong Jinshan power station	2	300	9572.20	96100.00
	Dangtang Shendong power station	2	350	9249.90	96100.00
	Datang Huludao power station	2	350	9249.90	96100.00
	Diaobingshan power station	2	300	10442.40	94600.00
	Fushun Zhongji power station	2	300	9572.20	94600.00
	Guodian Shenyang power station	2	330	9572.20	96100.00
	Hongyang Nengyuan power station	2	300	10442.40	94600.00

	Huaneng Xianrendao power station	2	50	10442.40	96100.00
	Liaoyang Guocheng power station	2	50	10442.40	96100.00
	Panjin Xinli power station	2	350	9249.90	96100.00
	Suizhong power station	2	1000	9099.20	94600.00
	Sujiatun Jinshan power station	2	220	11312.60	96100.00
NINX	CPI Linhe power station	3	350	9249.90	96100.00
	CPI Ningxia Zaoquan power station	2	660	8272.00	96100.00
	CPI Zhongwei Cogen power station	2	350	9249.90	96100.00
	Guodian Dawukou power station	2	330	10442.40	96100.00
	Guodian Fangjiazhuang power station	2	1000	8272.00	96100.00
	Guohua Ningdong power station	4	330*2, 660*2	10442.40*2, 8272.00*2	94600.00
	Huaneng Daba-4 power station	2	660	8272.00	96100.00
	Ningdong Younglight power station	2	330	9572.20	96100.00
	Huadian Ningxia Lingwu power station	2	1060	9099.20, 8272.00	94600.00
	Ningxia Liupanshan power station	2	330	10442.40	96100.00
	Ningxia Risheng Gaoxin Captive power station	3	30	10326.00	96100.00
	Qingtongxia Aluminum Works power station	2	330	10442.40	96100.00
	Shenery Wuzhong power station	2	350	9249.90	96100.00
	Shuidonggou power station	2	600	8409.00	96100.00
	Xixia Ningxia power station	2	350	9249.90	96100.00
	Yinxing power station	2	660	8272.00	94600.00
	Shenhua Yuanyang Lake power station	4	660*2, 1100*2	9249.90, 8409.00, 8272.00*2	94600.00
QING	CPI Xining power station	2	660	8272.00	96100.00
	Huaneng Xining power station	2	350	9249.90	96100.00
SHAA	Datang Lueyang power station	1	330	9572.20	96100.00

	Datang Yan'an power station	2	350	9249.90	96100.00
	Fugu Qingshuihuan power station	2	1000	8272.00	96100.00
	Fuping Cogen power station	2	350	9249.90	96100.00
	Guodian Baoji-2 power station	2	660	8409.00	96100.00
	Huaneng Qinling power station	2	600	8409.00	94600.00
	Huaneng Weinan cogeneration power station	1	350	9249.90	96100.00
	Huangling waste coal power station	2	300	9572.20	94600.00
	Leilongwan power station	2	1000	8272.00	96100.00
	Linyou Waste Coal power station	2	350	9249.90	94600.00
	Meixin captive power station	2	350	9249.90	96100.00
	Shaanxi Beiyuan power station	4	125	11186.50*2, 10326.00*2	96100.00
	Shaanxi Youser Yulin power station	5	330	9572.20	96100.00
	Shangluo power station	2	660	8272.00	96100.00
	Shenhua Fugu Guojiawan power station	2	300	10442.40	94600.00
	Shenhua Shenmu power station	2	660	8409.00	96100.00
	Xinyuanjianeng Qingshuihuan power station	2	300	9572.20	94600.00
	Huadian Yangling Cogen power station	2	350	9249.90	96100.00
	Yulin Chemical power station	2	300	9465.50	96100.00
	Yulin Hengshan power station	2	1000	8272.00	96100.00
	Yulin Yuheng power station	2	600	8272.00	96100.00
	Yulin Beijiao power station	2	350	9249.90	96100.00
SHAD	Binzhou Heating Supply Center power station	8	60*4, 135*4	11312.60*4, 10326.00*4	96100.00
	CHALCO Shandong Branch Power Station	2	46	10326.00	96100.00
	Chiping Haoji power station	4	350	9249.90	94600.00
	Datang Binzhou power station	2	350	9249.90	94600.00
	Datang Linqing power station	2	350	9249.90	96100.00
	Dongying Coastal power station	2	300	9572.20	96100.00

Dongying Haixin Cogen power station	2	50	10442.40	96100.00
Gaotang power station	1	48	11186.50	96100.00
Guodian Tai'an power station	2	350	9249.90	96100.00
Guohua Shouguang power station	2	1000	8272.00	94600.00
Heze Huarun power station	2	600	8272.00	98300.00
Heze Zhaolou power station	1	300	9572.20	96100.00
Huadian Laizhou power station	4	1039*2,1000*2	8272.00	94600.00
Huadian Shiliquan power station	2	660	8272.00	94600.00
Huadian Zibo power station	2	330	9572.20	94600.00
Huaneng Laiwu power station	2	1000	8272.00	94600.00
Huaneng Yantai Bajiao power station	2	670	8272.00	94600.00
Huangtai power station	2	350	9249.90	98300.00
Linyi Xincheng Jinluo Cogen power station	1	50	10326.00	96100.00
Linyi power station	2	350	9249.90	94600.00
Liyuan Cogen power station	4	350	9249.90	96100.00
Luxi Chemical Cogen power station	5	135*2, 90*3	11186.50*2, 10326.00*3	96100.00
Nanshan Aluminum Donghai power station	3	330	10442.40*2, 9572.20	96100.00
Nanshan Thermal power station	1	150	10442.40	94600.00
Pingyuan Chemical power station	1	50	11186.50	96100.00
Rizhao Iron and Steel Cogen power station	2	330	9572.20	96100.00
Shandong Haihua Weifang 3 power station	1	150	10442.40	96100.00
Shandong Huatai power station	2	135	10442.40	96100.00
Shandong Xingda Cogen power station	3	60, 150*2	10442.40	96100.00
Shengli Dongying power station	1	660	8409.00	94600.00
Taiyang Mill power station	1	50	10442.40	94600.00
Tianyuan Shandong power station	2	300	10442.40, 9572.20	96100.00

	Weihai power station	2	660	9099.20	94600.00
	Weiqiao Aluminum power station	8	330	9572.20	96100.00
	Beihai New Area Heating power station-I	4	60	10442.40	96100.00
	Beihai New Area Heating power station-II	4	330	9572.20	96100.00
	Weiqiao Binteng Textile power station	4	330	9572.20	96100.00
	Weiqiao Binzhou Public Heating power station	4	330	9572.20	96100.00
	Weiqiao Huji power station-I	4	330	9572.20	96100.00
	Weiqiao Huji power station-II	4	330	9572.20	96100.00
	Weiqiao Town Public Heating power station	4	330	9572.20	96100.00
	Weiqiao Yangxin power station	4	330	9572.20	96100.00
	Weiqiao Zanhua power station	3	350	9572.20	96100.00
	Weiqiao Zouping-1 power station	5	660	8272.00	96100.00
	Weiqiao Zouping-7 power station	8	330	9572.20	96100.00
	Xinyuan Aluminum power station	6	660	8272.00	96100.00
	Yellow River Delta power station	3	50*2, 350	10442.40*2, 9572.20	96100.00
	Zaozhuang Bayi power station	1	350	9572.20	94600.00
SHAN	Shanghai Caojing power station	2	1000	9099.20	96100.00
SHNX	Changzhi power station	2	330	9572.20	96100.00
	CPI Shanxi Houma power station	2	300	9572.20	94600.00
	Huadian Shuozhou power station	2	350	9249.90	96100.00
	Huadian Xinzhou Guangyu power station	2	350	9249.90	94600.00
	Huaneng Zuoquan power station	2	631	8272.00	94600.00
	Huozhou power station	2	600	8409.00	94600.00
	Jinneng Guojin power station	2	350	9249.90	94600.00
	Linfen power station	2	300	10442.40, 9572.20	94600.00
	Lingshi Qiguang power station	2	350	9249.90	94600.00
	Lishi power station	2	350	9249.90	94600.00

	Liulin Liansheng power station	2	300	9572.20	96100.00
	Lüliang Pangpangta power station	2	350	9249.90	94600.00
	SDIC Jincheng power station	2	300	9572.20	98300.00
	Shanxi Guofeng power station	2	300	9572.20	94600.00
	Shanxi Guojin power station	2	300	9249.90	94600.00
	Shanxi Hepo power station	2	350	9249.90	96100.00
	Shanxi Ruiguang power station	2	330	9572.20	94600.00
	Shanxi Yaoguang power station	2	200	10442.40	94600.00
	Shanxi Yuguang power station	4	300*2, 350*2	9572.20*2, 9249.90*2	94600.00
	Shendong Hequ power station	2	350	9249.90	94600.00
	Shenhua Hequ power station	2	600	8409.00	96100.00
	CPI Shentou power station	2	660	8409.00	94600.00
	Taiyuan Steel Mill power station	2	300	10442.40	94600.00
	Taiyuan-2 power station	2	330	9572.20	94600.00
	Tongmei Datang power station	2	330	9572.20	94600.00
	Tongmei Shuonan Gangue power station	2	350	9249.90	94600.00
	Tongmei Tashan power station	2	660	8409.00	94600.00
	Tongmei Yongji power station	2	350	9249.90	94600.00
	Tonghua Xuangang power station	2	660	9249.90	94600.00
	Xishan Gujiao power station-II	2	600	8409.00	94600.00
	Xishan Gujiao power station-III	2	660	8409.00	94600.00
	Yanggao power station	2	350	9249.90	94600.00
	Youyu power station	2	330	9572.20	96100.00
	Yuci power station	1	330	10442.40	94600.00
	Yuncheng Gunlü power station	2	80	10442.40	96100.00
	Zhangze Linfen power station	2	300	10442.40, 9572.20	96100.00
SICH	Fuxi power station	2	600	8409.00	94600.00

	Huadian Gongxian power station	2	600	8409.00	98300.00
	Neijiang Baima power station	1	600	8409.00	98300.00
	Panzhihua Works power station	1	330	9572.20	94600.00
TIAN	GreenGen power station	1	250	9033.60	96100.00
	Junliangcheng power station	3	350	10442.40*2, 9249.90	94600.00
	Tianjin Beijiang power station	2	1000	8272.00	96100.00
	Tianjin Guodian Beitang power station	2	350	9249.90	96100.00
	Tianjin Petrolchemical captive power station	2	100	11312.60	96100.00
XING	Aksu Cogen power station	2	350	9249.90	96100.00
	Aksu Xuzhou power station	2	200	10442.40	96100.00
	Aral Xinhua Cogen power station	2	350	9249.90	96100.00
	Beitun Cogen power station	2	135	10442.40	96100.00
	Bole Cogen power station	2	150	10090.80	96100.00
	Changji Fukang power station	2	135	11312.60, 10442.40	96100.00
	CPI Wusu power station	2	300	9572.20	96100.00
	Dananhу power station	2	660	8409.00	96100.00
	Datang Hutubi power station	2	300	9572.20	96100.00
	East Hope Metals Wucaiwan power station	9	350	9572.20	96100.00
	Ganquanbao TBEA power station	2	350	9249.90	96100.00
	Guodian Dananhу power station	2	660	8272.00	96100.00
	Guodian Kuqa power station	2	300	9572.20	94600.00
	Guotai Xinhua Coal Chemical power station	2	350	9249.90	96100.00
	Hefeng power station	2	300	9572.20	96100.00
	Henglian Wucaiwan power station	2	660	8272.00	96100.00
	Hesheng Shanshan power station	2	330	9572.20	96100.00
	Hesheng Shanshan power station	2	350	9249.90	96100.00
	Hongyanchi-1 power station	2	330	9572.20, 94600.00	

			10442.20	
Huadian Changji power station	2	330	9572.20	94600.00
Huadian Kashi power station	2	350	9249.90	96100.00
Huaneng Luntai power station	2	350	9249.90	94600.00
Huawei Hetian power station	2	135	10326.00	96100.00
Huayi Jinlong Cogen power station	2	100	10326.00	96100.00
Xinjiang Jiarun power station	4	350	9572.20*2, 9249.90*2	96100.00
Jinchuan power station	2	135	10326.00	96100.00
Karamay power station	2	350	9249.90	96100.00
Xinjiang Qiya Smelter power station-I	4	360	9249.90	94600.00
Xinjiang Qiya Smelter power station-II	1	360	9249.90	94600.00
SGCC Yili power station Unit 1 (Ili Nangang Cogen power station)	2	135	10442.40	96100.00
Shenhua Guoneng Dananhu Power Plant	2	300	9572.20	96100.00
Shenhua Guoneng Hami power station	4	660	8409.00*2, 8272.00*2	96100.00
Shenhua Yili power station (Xinjiang)	2	350	9249.90	96100.00
Shenneng Korla power station	2	350	9249.90	96100.00
Shihezi Tianhe power station	2	330	9572.20	96100.00
Tianchi Changji Cogen power station	2	350	9249.90	96100.00
Tianchi Energy Zhundong Wucaiwan power station	4	660	8272.00	96100.00
Tianfu North power station	2	660	8272.00	94600.00
Tianfu Shihutan cogen power station	2	50	10326.00	96100.00
Tianfu South power station	2	330	9572.20	96100.00
Tianshan Qitai power station	2	350	9249.90	96100.00
Tianye power station	4	300*2, 330*2	10442.40, 9572.20*3	96100.00
Toksun Mahatma power station	2	300	9572.20	96100.00
Tumxuk power station	4	50*2	10442.40*2	96100.00

			350*2	9249.90*2
	Wucaiwan Bei'er power station	3	660	8272.00 96100.00
	Wujiaqu power station	6	360*4, 1100*2	9249.90*4 8272.00*2 96100.00*4 101000.00*2
	Xinjiang Guoxin Qitai power station	1	660	8409.00 96100.00
	Xinjiang Kingho captive power station	1	60	10326.00 96100.00
	Xinjiang Midong power station	2	300	10442.40 94600.00
	Xinjiang Zhongtai Fukang Metallurgy Power Station	4	150 10442.40	10326.00*3 96100.00
	Xinyou Qitai power station	1	660	8409.00 96100.00
	XPCC Hongxing power station	1	660	8272.00 96100.00
	XPCC Shihezi Cogen power station	6	350*4, 360*2	9572.20*4, 9249.90*2
	Yihua Wucaiwan power station	2	330	9572.20 96100.00
	Yili Yining Cogen power station	2	330	9572.20 96100.00
	Zhongtai Toksun power station	2	330	9572.20 96100.00
	Shenhuo Zhundong power station	4	350	9249.90 96100.00
	Shenhua Zhundong Wucaiwan power station	3	350*2, 660	9249.90*2 8272.00 94600.00
YUNN	Diandong Yuwang power station	1	600	9572.20 98300.00
	Huadian Zhenxiong power station	2	600	8409.00 98300.00
	Weixin power station	2	600	8409.00 98300.00
	Xunjiansi power station	1	300	9572.20 98300.00
ZHEJ	Guohua Zhoushan power station	2	300, 350	10442.40, 9249.90 94600.00
	Huaneng Changxing power station	2	660	8272.00 95350.00
	Huarun Cangnan power station	2	1036	8272.00 94600.00
	Jiaxing Xinjia'aisi Cogen power station	1	50	10326.00 94600.00
	Jiaxing power station	2	1000	8272.00 94600.00
	Juhua Quzhou Complex power station	1	30	10442.40 94600.00

Shaoxing Binhai power station	6	300*2, 57*4	9572.20*2, 10326.00*4	94600.00*2, 96100.00*4
Zhejiang Taizhou-2 power station	2	1000	8272.00	94600.00
Zhejiang Taizhou-1 power station	1	300	10442.40	96100.00
Zheneng Liuheng power station	2	1000	8272.00	94600.00
Zheneng Wenzhou power station	2	660	8272.00	94600.00
Zheneng Yueqing power station	2	660	9099.20	94600.00

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Information for onshore oilfields, deep saline aquifers and coal seams are provided in Table S4, Table S5 and Table S6, respectively.

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Table S4
Data for CO₂ storage potential of China's onshore oilfields.⁷

Oilfield	CO ₂ -EOR (Mt)	Oilfield	CO ₂ -EOR (Mt)
Daqingchangyuan	703.61	Wennan	25.36
Kelamayi	374.82	Tuyuke	24.67
Huanxiling	178.03	Qiuling	23.59
Jing'an	109.25	Jinganbao	23.17
Ansai	106.79	Bonan	21.41
Yushulin	81.83	Ciyutuo	20.26
Shuguang	60.87	Yongle	20.02
Pucheng	60.6	Shuanghe	19.81
Shengtuo	60.49	Yanchang	19.27
Zhaozhou	59.93	Shanshan	18.27
Tahe	58.81	Zaoyuan	18.14
Shixi	53.5	Lengjiapu	17.93
Renqiu	51.39	Qian'an	16.48
Gudao	48.98	Chepaizi	16.28
Chengdao	46.22	Wenjisang	16.19
Niujuanhu	42.66	Gaosheng	15.18

Toutai	36.84	Huoshashan	15.16
Xinglongtai	35.96	Wangguantun	14
Gudong	33.35	Cainan	13.24
Linpan	32.33	Banqiao	13.23
Gasikule	32.28	Xinli	12.9
Tazhong-4	31.24	Hade-4	12.85
Dongxin	30.59	Huatugou	12.56
Wendong	30.4	Wenzhong	12.26
Fuyu	30.08	Chaheji	12.24
Baikouquan	29.4	Fahaniu	12.21
Beidagang	27.58	Xiazijie	12.21
Longhupao	27.57	Binnan	11.78
Chaoyanggou	26.93	Huachi	11.44
Damintun	26.72	Niuju	11.31
Maling	26.41	Liuquan	10.43
Chunhua	26.15	Laojunmiao	10.1
Xinmin	25.93	Qianmiqiao	10

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Table S582 Data for CO₂ storage potential of China's onshore deep saline aquifers.⁸

Onshore basin	Storage potential (Mt)
Tarim	745,800
Ordos	256,500
Bohai Bay	233,300
Songliao	227,800
Junggar	197,100
Hehuai	178,000
Subei	89,900
Erlian	85,000
Sichuan	77,600
Turpan-Hami	54,300
Jianghan-Dongting	52,800
Sanjiang	44,900
Qinshui	29,000
Qaidam	21,500
Hailaer	16,100
Nanxiang	7,500

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Table S6Data for CO₂ storage potential of China's onshore unmineable coalbeds.⁸

Coal-bearing region	Storage potential (Mt)	Coal-bearing region	Storage potential (Mt)	Coal-bearing region	Storage potential (Mt)
Ordos Basin & Hedong-Weibei	4,450	Xuzhou - Huabei	78	Jingyuan - Jingtai	14
Turpan - Hami Basin	2,200	Zhangjiakou	72	Northern Qilian	11
Santang Lake	990	Western Shandong	68	Chengde	11
Eastern Junggar	650	Western Henan	56	Dunhua - Fushun	11
Qinshui Basin	610	Beijing - Tangshan	55	Huayinshan - Yongrong	11
Ili Basin	560	Xuanhua - Weixian	44	Kunming - Kaiyuan	10
Northern Junggar	530	Zhuozi – Helan Mountains	38	Beipiao	8
Southern Junggar	340	Northern Tarim	36	Jinan	7
Sanjiang - Mulinhe	240	Northern Qaidam	30	Fuxin - Zhangwu	7
Datong - Ningwu	160	South Songliao	28	Yilan - Yitong	6
Yanqi Basin	120	Daqing – Wula Mountains	27	Yianbian	5
Huainan	120	Youerdusi	26	Baise Basin	5
Liupanshui	110	Dacheng	25	Eastern Henan	4
Eastern Tarim	100	Middle Qilian	25	Middle Shandong	4
South Sichuan & North Guizhou	79	Eastern Piedmont of 51		Lianyuan - Shaoyang	4
		Taihang Mountains			

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88 **5. Geospatial analysis of terrain impacts on CCUS layouts**

89 **Table S7**

90 Terrain penalty matrix (in part) caused by rivers.

	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
i1	0	0	6	1	1	0	0	2	2	1
i2	0	0	6	1	1	0	0	0	2	1
i3	6	6	0	3	9	10	6	2	0	8
i4	1	1	3	0	2	1	1	1	3	0
i5	1	1	9	2	0	1	1	1	3	0
i6	0	0	10	1	1	0	0	0	6	1
i7	0	0	6	1	1	0	0	0	2	3
i8	2	0	2	1	1	0	0	0	6	1
i9	2	2	0	3	3	6	2	6	0	4
i10	1	1	8	0	0	1	3	1	4	0

91 Penalty matrices of linear terrain features are constructed based on the number of
 92 intersections between the path layer and the terrain layers, which can be solved by
 93 overlay analysis. Since there are 531 emission sources and 106 storage sites in CCUS
 94 SSM, the penalty matrix is a symmetric matrix of order 637 (531 plus 106). In order to
 95 show the specific meaning of the heat maps conveniently and intuitively, the sub-matrix
 96 of order 10 is extracted from the original matrix (Table S7).

97 Taking rivers as an example, the main diagonal elements of the matrix are all 0
 98 because any node cannot be connected to itself. The remaining elements represent the
 99 number of intersections between the paths (connected by the row labels and column
 100 labels) and the rivers. Let the matrix elements be a_{nn} . For example, in Table S7, $a_{13} =$
 101 $a_{31} = 6$, i.e., the candidate transportation route from node 1 to node 3 (i.e., from node
 102 3 to node 1) crosses rivers 6 times.

103 After obtaining the penalty matrix, min-max standardization is employed to
 104 prepare it for visualization by the heat map. Each element is transformed as shown in
 105 the following formula:

$$106 \quad a'_{nn} = \frac{a_{nn} - \min a_{nn}}{\max a_{nn} - \min a_{nn}} \quad (S1)$$

107 where $\min a_{nn}$ and $\max a_{nn}$, according to Table S7, are 0 and 10, respectively. The
 108 standardized penalty matrix is shown in Fig S2.a and corresponding heat map is
 109 depicted as Fig S2.b. The darker the color, the greater the value of the element,
 110 representing more additional cost caused by terrain obstacle on this route.

111 Applying this method to the original matrix, a heat map for overall CCUS layouts
 112 can be obtained. However, it should be noted that the value of $\max a_{nn}$ changes when
 113 it comes to the original matrix of order 637.

a	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
i1	0.00	0.00	0.60	0.10	0.10	0.00	0.00	0.20	0.20	0.10
i2	0.00	0.00	0.60	0.10	0.10	0.00	0.00	0.00	0.20	0.10
i3	0.60	0.60	0.00	0.30	0.90	1.00	0.60	0.20	0.00	0.80
i4	0.10	0.10	0.30	0.00	0.20	0.10	0.10	0.10	0.30	0.00
i5	0.10	0.10	0.90	0.20	0.00	0.10	0.10	0.10	0.30	0.00
i6	0.00	0.00	1.00	0.10	0.10	0.00	0.00	0.00	0.60	0.10
i7	0.00	0.00	0.60	0.10	0.10	0.00	0.00	0.00	0.20	0.30
i8	0.20	0.00	0.20	0.10	0.10	0.00	0.00	0.00	0.60	0.10
i9	0.20	0.20	0.00	0.30	0.30	0.60	0.20	0.60	0.00	0.40
i10	0.10	0.10	0.80	0.00	0.00	0.10	0.30	0.10	0.40	0.00

b	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
i1	0	0	0.6	0.1	0.1	0	0	0.2	0.2	0.1
i2	0	0	0.6	0.1	0.1	0	0	0	0.2	0.1
i3	0.6	0.6	0	0.3	0.9	1	0.6	0.2	0	0.8
i4	0.1	0.1	0.3	0	0.2	0.1	0.1	0.1	0.3	0
i5	0.1	0.1	0.9	0.2	0	0.1	0.1	0.1	0.3	0
i6	0	0	1	0.1	0.1	0	0	0	0.6	0.1
i7	0	0	0.6	0.1	0.1	0	0	0	0.2	0.3
i8	0.2	0	0.2	0.1	0.1	0	0	0	0.6	0.1
i9	0.2	0.2	0	0.3	0.3	0.6	0.2	0.6	0	0.4
i10	0.1	0.1	0.8	0	0	0.1	0.3	0.1	0.4	0

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115 **Figure S2 Schematic diagrams of terrain penalty matrix caused by rivers.** a) Min-
 116 max standardization of original matrix; b) Visualization of standardized matrix.

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