Geo-Environment Vulnerability Assessment of Multiple Geohazards Using VWT-AHP: A Case Study of the Pearl River Delta, China

Supplementary Materials

Peng Huang, Xiaoyu Wu, Chuanming Ma * and Aiguo Zhou

School of Environmental Studies, China University of Geosciences, Wuhan 430000, China
* Correspondence: machuanming@cug.edu.cn; Tel.: +86-027-6788-3159

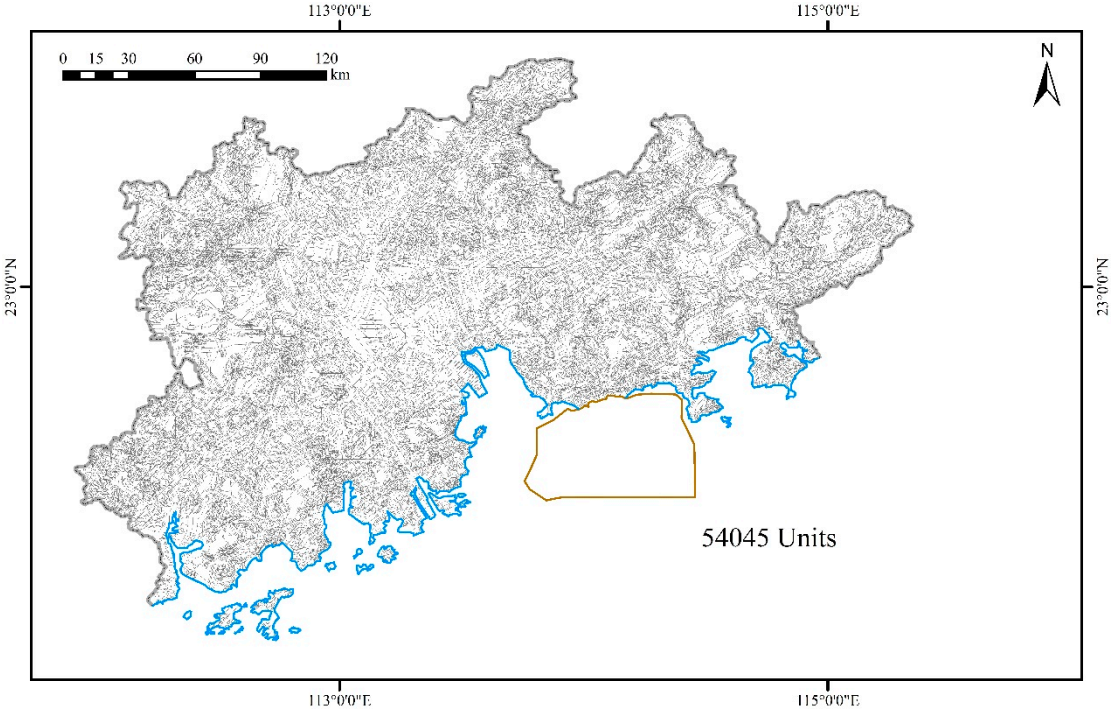

Figure S1 Distribution map of assessment units of landslide and collapse susceptibility

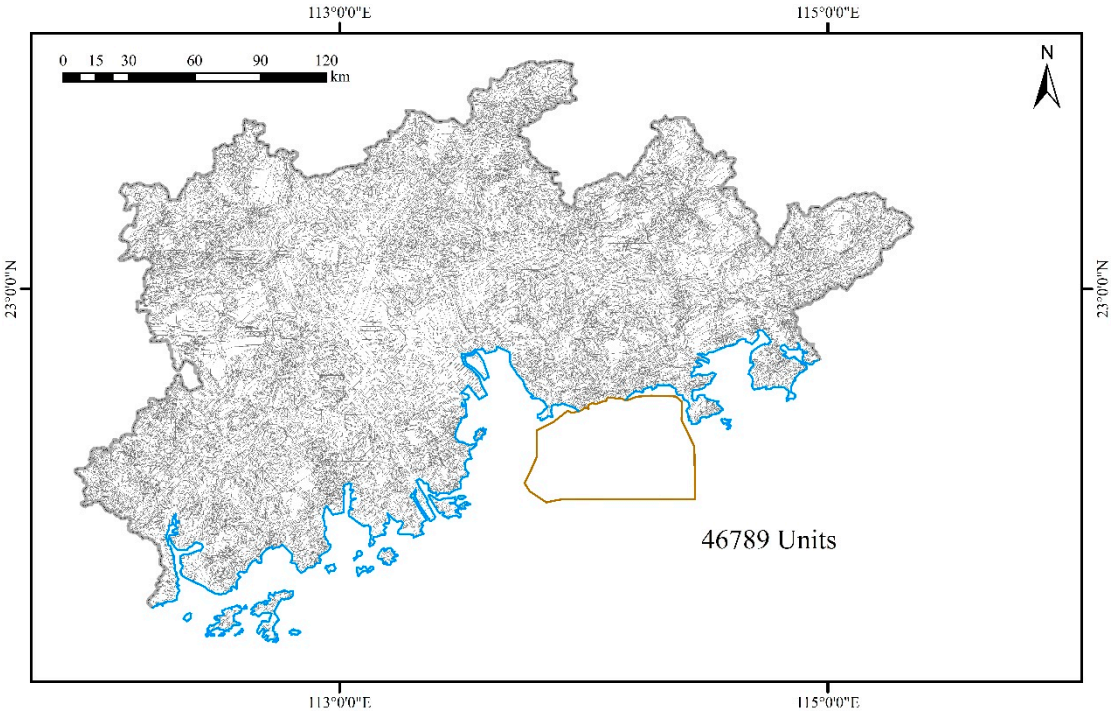

Figure S2 Distribution map of assessment units of debris flow susceptibility

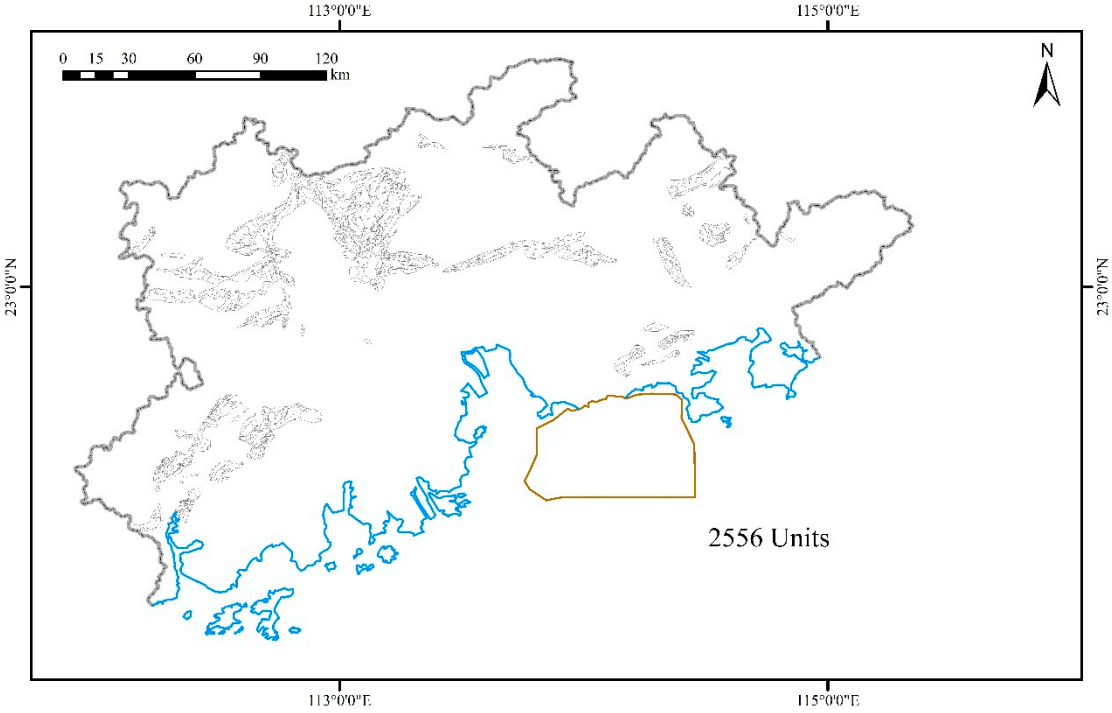

Figure S3 Distribution map of assessment units of karst collapse susceptibility

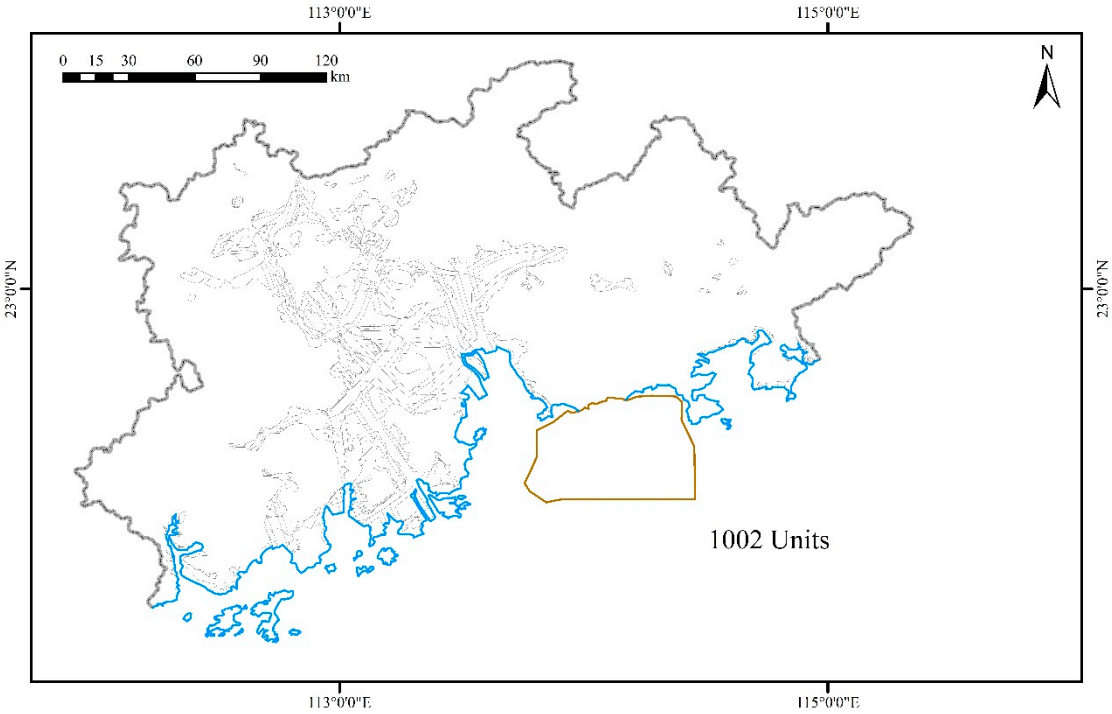

Figure S4 Distribution map of assessment units of ground subsidence susceptibility

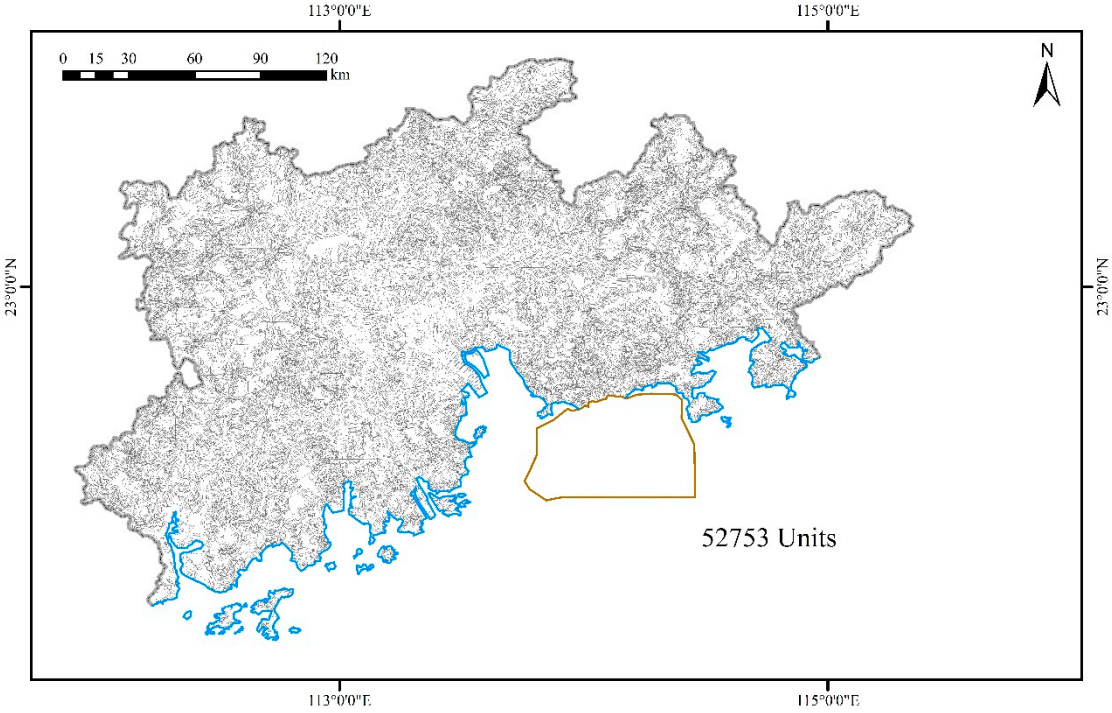

Figure S5 Distribution map of assessment units of soil erosion susceptibility

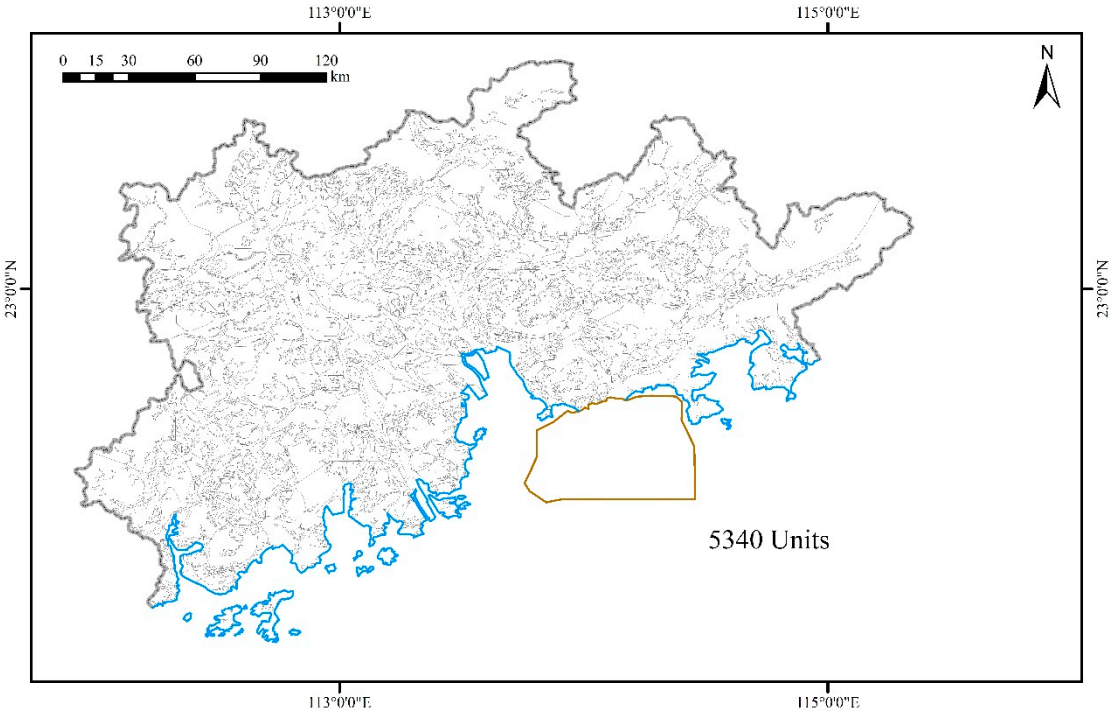

Figure S6 Distribution map of assessment units of sea water intrusion susceptibility

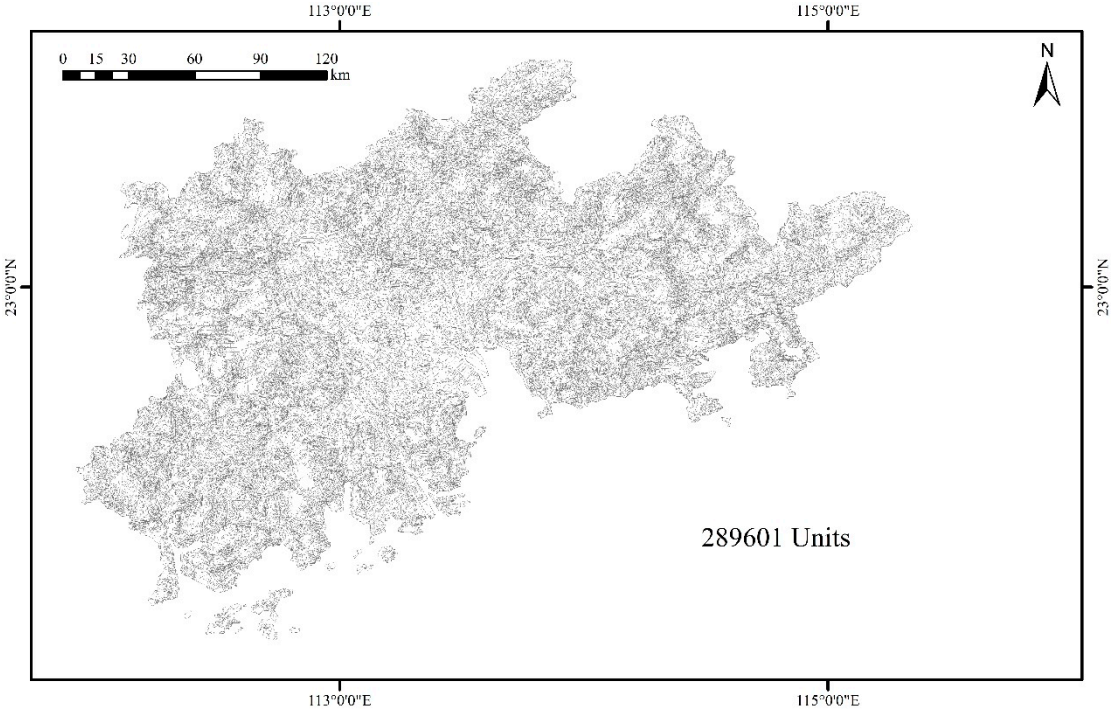

Figure S7 Distribution map of assessment units of geo-environment vulnerability

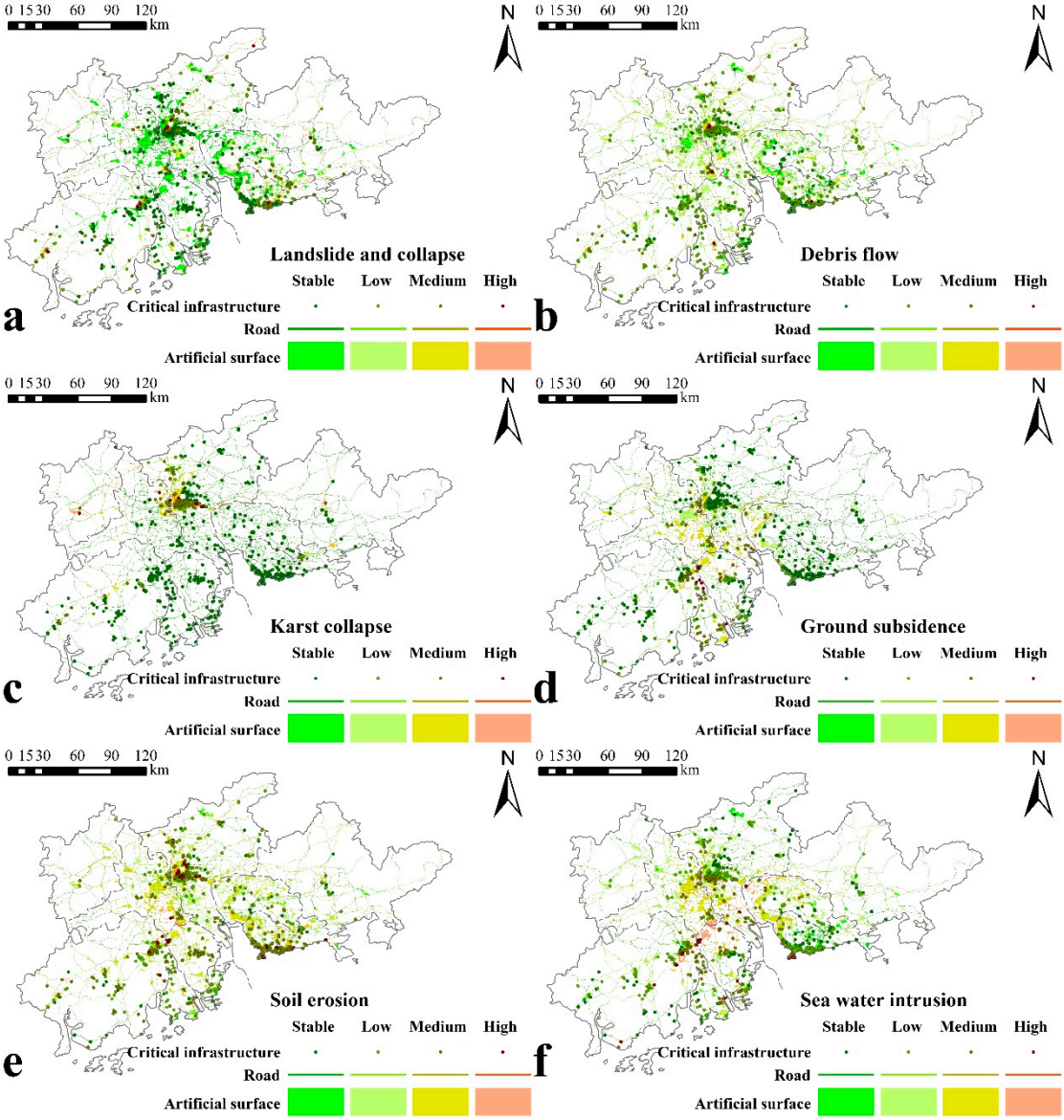

Figure S8 Distribution of critical infrastructures, roads, and artificial surfaces in different susceptibility areas (a) landslide and collapse (b) debris flow (c) karst collapse (d) ground subsidence (e) soil erosion (f) sea water intrusion

Table S1 Judgment matrix and constant weights of each indicator for landslide and collapse susceptibility

Indicator	B_{11}	B_{12}	B_{13}	B_{14}	B_{15}	B_{16}	B_{17}	Constant weight
B_{11}		1	1/3	2	1	2	1/2	0.1265
B_{12}			1/2	1	1	2	1/2	0.1170
B_{13}				2	2	3	1	0.2427
B_{14}					1	2	1/2	0.1080
B_{15}						2	1/2	0.1170
B_{16}							1/3	0.0640
B_{17}								0.2249
CI=0.0120								

Table S2 Judgment matrix and constant weights of each indicator for debris flow susceptibility

Indicator	B_{11}	B_{22}	B_{23}	B_{24}	B_{25}	B_{26}	B_{27}	B_{28}	Constant weight
B_{21}		1	1/2	1/2	1	1/3	1/3	1/3	0.0634
B_{22}			1/2	1	1	1/2	1/3	1/3	0.0739
B_{23}				1	1	1	1/2	1/2	0.1143
B_{24}					1	2	1/2	1/2	0.1233
B_{25}						1/2	1/2	1/2	0.0886
B_{26}							1	1	0.1487
B_{27}								1	0.1939

B_{28}	0.1939
CI=0.0260	

Table S3 Judgment matrix and constant weights of each indicator for karst collapse susceptibility

Indicator	B_{31}	B_{32}	B_{33}	B_{34}	B_{35}	Constant weight
B_{31}		1	3	3	1	0.2794
B_{32}			3	3	1	0.2794
B_{33}				1	1/2	0.1011
B_{34}					1/2	0.1011
B_{35}						0.2392
CI=0.0059						

Table S4 Judgment matrix and constant weights of each indicator for ground subsidence susceptibility

Indicator	B_{41}	B_{42}	B_{43}	B_{44}	Constant weight
B_{41}		1	3	2	0.3564
B_{42}			2	2	0.3257
B_{43}				1/2	0.1243
B_{44}					0.1936
CI=0.0172					

Table S5 Judgment matrix and constant weights of each indicator for soil erosion susceptibility

Indicator	B_{51}	B_{52}	B_{53}	B_{54}	B_{55}	B_{56}	Constant weight
B_{51}		1	1/3	1/3	1/2	1	0.0905
B_{52}			1/3	1/3	1/2	1	0.0905
B_{53}				1	2	3	0.2839
B_{54}					2	3	0.2839
B_{55}						1	0.1484
B_{56}							0.1028
CI=0.0072							

Table S6 Judgment matrix and constant weights of each indicator for sea water intrusion susceptibility

Indicator	B_{61}	B_{62}	B_{63}	B_{64}	Constant weight
B_{61}		1/2	1/3	1/2	0.1223
B_{62}			1/2	1	0.2270
B_{63}				2	0.4236
B_{64}					0.2270
CI=0.0039					

Table S7 Variable weights of each indicator for landslide and collapse susceptibility

Unit	x_1	x_2	x_3	x_4	x_5	x_6	x_7	w'_1	w'_2	w'_3	w'_4	w'_5	w'_6	w'_7	*CPI*
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1265	0.1265	0.2427	0.1080	0.1170	0.0640	0.2249	0.1000
2	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1287	0.1190	0.2469	0.1098	0.1190	0.0479	0.2288	0.1096
3	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1302	0.1204	0.2498	0.0818	0.1204	0.0659	0.2315	0.1164
……															
54043	0.9	0.7	0.9	0.9	0.7	0.9	0.7	0.1527	0.0884	0.2929	0.1303	0.0884	0.0772	0.1700	0.8306
54044	0.9	0.7	0.9	0.9	0.9	0.7	0.7	0.1491	0.0864	0.2861	0.1273	0.1379	0.0472	0.1660	0.8401
54045	0.9	0.7	0.9	0.9	0.9	0.9	0.7	0.1450	0.0840	0.2782	0.1238	0.1341	0.0734	0.1615	0.8509
w_1=0.1265		w_2=0.1170		w_3=0.2427		w_4=0.1080		w_5=0.1170		w_6=0.0640		w_7=0.2249			

Table S8 Variable weights of each indicator for debris flow susceptibility

Unit	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	w'_1	w'_2	w'_3	w'_4	w'_5	w'_6	w'_7	w'_8	*CPI*

1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0634	0.0739	0.1143	0.1233	0.0886	0.1487	0.1939	0.1939	0.1000
2	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0474	0.0752	0.1163	0.1254	0.0901	0.1512	0.1972	0.1972	0.1095
3	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0647	0.0554	0.1166	0.1258	0.0904	0.1517	0.1978	0.1978	0.1111
……																	
46787	0.7	0.7	0.7	0.9	0.1	0.9	0.9	0.9	0.0454	0.0530	0.0819	0.1411	0.0648	0.1701	0.2219	0.2219	0.8121
46788	0.7	0.3	0.9	0.9	0.7	0.9	0.9	0.7	0.0478	0.0417	0.1375	0.1483	0.0667	0.1788	0.2332	0.1460	0.8228
46789	0.3	0.7	0.9	0.9	0.7	0.9	0.9	0.7	0.0357	0.0556	0.1372	0.1480	0.0666	0.1785	0.2327	0.1458	0.8250

w_1=0.0634 w_2=0.0739 w_3=0.1143 w_4=0.1233 w_5=0.0886 w_6=0.1487 w_7=0.1939 w_8=0.1939

Table S9 Variable weights of each indicator for karst collapse susceptibility

Unit	x_1	x_2	x_3	x_4	x_5	w'_1	w'_2	w'_3	w'_4	w'_5	***CPI***
1	0.1	0.1	0.1	0.1	0.1	0.2793	0.2793	0.1011	0.1011	0.2392	0.1000
2	0.1	0.1	0.1	0.3	0.1	0.2870	0.2870	0.1039	0.0764	0.2457	0.1153

3	0.1	0.1	0.3	0.3	0.1	0.2951	0.2951	0.0785	0.0785	0.2527	0.1314
……											
2554	0.7	0.7	0.1	0.7	0.3	0.2965	0.2965	0.1094	0.1073	0.1904	0.5582
2555	0.7	0.7	0.1	0.1	0.7	0.2782	0.2782	0.1027	0.1027	0.2382	0.5768
2556	0.7	0.7	0.1	0.7	0.7	0.2788	0.2788	0.1029	0.1009	0.2387	0.6383
w_1=0.2794			w_2=0.2794		w_3=0.1011		w_4=0.1011		w_5=0.2392		

Table S10 Variable weights of each indicator for ground subsidence susceptibility

Unit	x_1	x_2	x_3	x_4	w'_1	w'_2	w'_3	w'_4	***CPI***
1	0.1	0.1	0.1	0.1	0.3564	0.3257	0.1243	0.1936	0.1000
2	0.1	0.1	0.3	0.1	0.3685	0.3368	0.0945	0.2002	0.1189
3	0.1	0.1	0.1	0.3	0.3756	0.3433	0.1310	0.1501	0.1300
……									

1000	0.7	0.7	0.1	0.7	0.3555	0.3249	0.1265	0.1931	0.6241
1001	0.7	0.7	0.3	0.7	0.3678	0.3361	0.0962	0.1998	0.6615
1002	0.7	0.7	0.7	0.7	0.3564	0.3257	0.1243	0.1936	0.7000
w_1=0.3564		w_2=0.3257		w_3=0.1243		w_4=0.1936			

Table S11 Variable weights of each indicator for soil erosion susceptibility

Unit	x_1	x_2	x_3	x_4	x_5	x_6	w'_1	w'_2	w'_3	w'_4	w'_5	w'_6	***CPI***
1	0.1	0.1	0.1	0.1	0.1	0.1	0.0905	0.0905	0.2839	0.2839	0.1484	0.1028	0.1000
2	0.1	0.3	0.1	0.1	0.1	0.1	0.0927	0.0682	0.2909	0.2909	0.1520	0.1053	0.1136
3	0.1	0.1	0.1	0.1	0.1	0.3	0.0930	0.0930	0.2918	0.2918	0.1525	0.0777	0.1155
……													
52751	0.7	0.9	0.9	0.9	0.7	0.3	0.0662	0.1057	0.3316	0.3316	0.1086	0.0564	0.8312
52752	0.3	0.9	0.9	0.9	0.9	0.3	0.0474	0.1008	0.3163	0.3163	0.1653	0.0538	0.8393

52753	0.7	0.9	0.9	0.9	0.9	0.3	0.0622	0.0993	0.3114	0.3114	0.1628	0.0530	0.8558
w_1=0.0905		w_2=0.0905		w_3=0.2839		w_4=0.2839		w_5=0.1484		w_6=0.1028			

Table S12 Variable weights of each indicator for sea water susceptibility

Unit	x_1	x_2	x_3	x_4	w'_1	w'_2	w'_3	w'_4	***CPI***
1	0.1	0.1	0.1	0.1	0.1223	0.2270	0.4236	0.2270	0.1000
2	0.3	0.1	0.1	0.1	0.0930	0.2346	0.4378	0.2346	0.1186
3	0.1	0.3	0.1	0.1	0.1301	0.1776	0.4507	0.2415	0.1355
……									
5338	0.9	0.3	0.9	0.7	0.1539	0.1342	0.5330	0.1789	0.7837
5339	0.9	0.9	0.7	0.7	0.1616	0.2999	0.3506	0.1879	0.7923
5340	0.9	0.9	0.9	0.7	0.1336	0.2481	0.4629	0.1554	0.8689
w_1=0.3564		w_2=0.3257		w_3=0.1243		w_4=0.1936			

Table S13 Distribution of critical infrastructures, roads, and artificial surfaces in different susceptibility areas

Geo-hazard		Stable	Low	Medium	High
Landslide and collapse	Critical infrastructure	533	129	122	13
	Road (km)	20061.09	6075.53	3998.62	1139.11
	Artificial surface (km^2)	1912.45	342.03	195.20	30.08
Debris flow	Critical infrastructure	154	560	76	7
	Road (km)	7927.67	20370.11	2579.86	396.71
	Artificial surface (km^2)	581.77	1683.83	193.33	20.83
Karst collapse	Critical infrastructure	584	64	134	15
	Road (km)	25520.01	1635.63	3547.43	571.28
	Artificial surface (km^2)	1982.90	100.12	337.70	59.04
Ground subsidence	Critical infrastructure	461	205	122	9

	Road (km)	20940.59	5132.19	4946.04	255.53
	Artificial surface (km^2)	1306.11	619.67	535.96	18.01
Soil erosion	Critical infrastructure	55	380	309	53
	Road (km)	4749.97	17506.76	8273.81	743.81
	Artificial surface (km^2)	112.39	1018.23	1219.19	129.94
Sea water intrusion	Critical infrastructure	165	392	207	33
	Road (km)	8639.36	14594.27	6744.59	1296.13
	Artificial surface (km^2)	279.08	1129.18	904.49	167.02