remote sensing

Supplementary Materials:

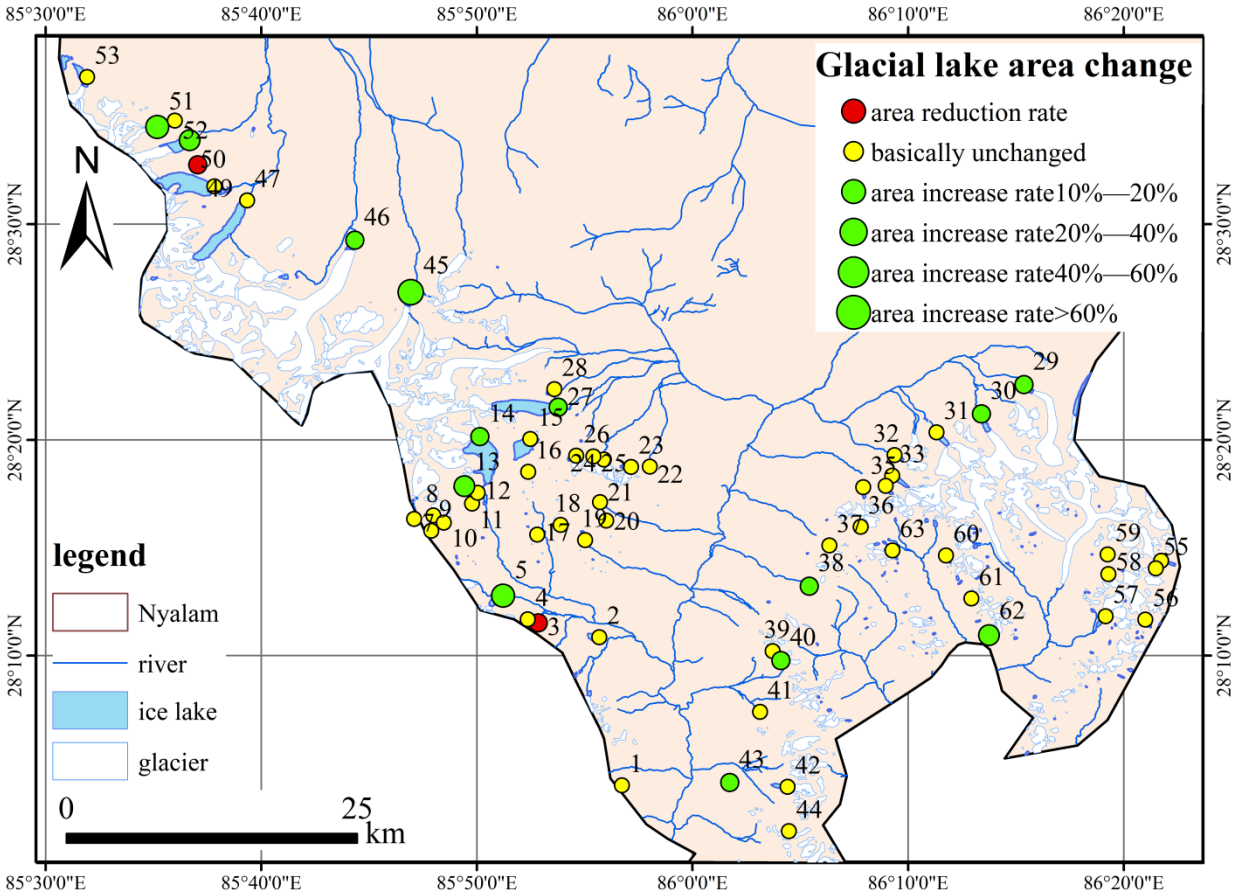

Figure S1. Glacial lake area change.

Table S1. Glacial lake change Information.

No.	Name	Catchment	Mountain	Latitude (N)	Longitude (E)	Elevation (m)	Classification	Area in 2020 (km²)	Area in 2010 (km²)	Area in 2000 (km²)	Area in 1990 (km²)	Area increase (%)
1		Chongduipu	Central Himalaya	28°03.97′	85°56.70′	4540	Cirque lake	0.041	0.037	0.063	0.069	-0.406
2	Daroco	Chongduipu	Central Himalaya	28°11.00′	85°55.46′	4340	Glacial erosion lake	0.445	0.451	0.512	0.516	-0.138
3		Chongduipu	Central Himalaya	28°11.65′	85°52.91′	4620	Moraine dammed lake	0.017	0.031	0.045	0.052	-0.673
4		Chongduipu	Central Himalaya	28°11.76′	85°52.41′	4620	Moraine dammed lake	0.061	0.053	0.069	0.072	-0.153
5	Jialongco	Chongduipu	Central Himalaya	28°12.85′	85°51.07′	4410	Moraine dammed lake	0.629	0.541	0.213	0.154	3.084
6		Chongduipu	Central Himalaya	28°13.53′	85°48.24′	4740	Moraine dammed lake	0.035	0.032	0.054	0.056	-0.375
7		Chongduipu	Central Himalaya	28°16.35′	85°46.96′	5300	Moraine dammed lake	0.073	0.069	0.079	0.078	-0.064
8		Chongduipu	Central Himalaya	28°16.57′	85°47.90′	5380	Moraine dammed lake	0.039	0.036	0.034	0.030	0.3

9		Chongduipu	Central Himalaya	28°14.43′	85°49.52′	5060	U-type valley lake	0.051	0.051	0.051	0.051	0
10		Chongduipu	Central Himalaya	28°14.77′	85°48.96′	5100	U-type valley lake	0.049	0.048	0.048	0.048	0.021
11		Chongduipu	Central Himalaya	28°17.24′	85°49.59′	5060	Lateral moraine lake	0.079	0.073	0.066	0.072	0.097
12		Chongduipu	Central Himalaya	28°17.68′	85°49.78′	5035	Moraine dammed lake	0.257	0.206	0.222	0.229	0.122
13	KungCo	Chongduipu	Central Himalaya	28°17.96′	85°49.38′	5120	Moraine dammed lake	0.261	0.234	0.213	0.106	1.462
14	Boqu	Chongduipu	Central Himalaya	28°18.73′	85°50.44′	5070	Moraine dammed lake	5.254	4.713	3.138	2.149	1.445
15	GongCo	Chongduipu	Central Himalaya	28°19.81′	85°52.16′	5170	Glacial erosion lake	2.012	2.080	2.216	2.293	-0.123
16		Chongduipu	Central Himalaya	28°18.63′	85°52.30′	5300	U-type valley lake	0.038	0.036	0.036	0.035	0.086
17		Chongduipu	Central Himalaya	28°15.70′	85°52.67′	5220	Cirque lake	0.034	0.034	0.036	0.038	-0.105
18		Chongduipu	Central Himalaya	28°16.15′	85°53.86′	5260	U-type valley lake	0.038	0.040	0.058	0.061	-0.377
19		Karupu	Central Himalaya	28°15.61′	85°54.85′	5105	U-type valley lake	0.325	0.329	0.322	0.333	-0.024
20		Gongbadang	Central Himalaya	28°16.35′	85°55.81′	5300	U-type valley lake	0.054	0.054	0.063	0.061	-0.115
21		Gongbadang	Central Himalaya	28°17.23′	85°55.55′	5109	Cirque lake	0.229	0.243	0.201	0.226	0.013
22		Keyapu	Central Himalaya	28°18.90′	85°57.89′	5140	Moraine dammed lake	0.082	0.085	0.082	0.078	0.051
23		Keyapu	Central Himalaya	28°18.88′	85°56.85′	5200	Moraine dammed lake	0.319	0.311	0.308	0.327	-0.024
24		Keyapu	Central Himalaya	28°19.30′	85°55.79′	5320	Moraine dammed lake	0.084	0.105	0.092	0.101	-0.168
25		Keyapu	Central Himalaya	28°19.43′	85°55.47′	5340	Moraine dammed lake	0.094	0.071	0.074	0.081	0.16
26		Keyapu	Central Himalaya	28°19.47′	85°54.46′	5220	Moraine dammed lake	0.131	0.113	0.133	0.137	-0.044
27	GangxiCo	Keyapu	Central Himalaya	28°21.59′	85°53.12′	5210	Moraine dammed lake	4.635	4.547	3.306	2.579	0.797
28	YinraCo	Keyapu	Central Himalaya	28°22.35′	85°53.46′	5240	Moraine dammed lake	0.257	0.232	0.246	0.253	0.016
29		Rujiapu	Central Himalaya	28°22.68′	85°15.71′	5570	Moraine dammed lake	0.236	0.209	0.192	0.121	0.95
30		Rujiapu	Central Himalaya	28°21.11′	86°13.49′	5350	Moraine dammed lake	0.535	0.463	0.375	0.287	0.864
31		Rujiapu	Central Himalaya	28°20.34′	86°11.42′	5440	Moraine dammed lake	0.514	0.519	0.534	0.561	-0.084
32		Rujiapu	Central Himalaya	28°19.16′	86°09.52′	5580	Moraine dammed lake	0.189	0.021	0.196	0.193	-0.021
33		Tajilingpu	Central Himalaya	28°18.23′	86°09.40′	5320	Moraine dammed lake	0.532	0.506	0.501	0.554	-0.04
34		Tajilingpu	Central Himalaya	28°17.59′	86°09.11′	5360	Moraine dammed lake	0.147	0.135	0.129	0.137	0.073
35		Tajilingpu	Central Himalaya	28°17.49′	86°07.90′	5250	Moraine dammed lake	0.199	0.214	0.205	0.194	0.026
36		Duokapu	Central Himalaya	28°16.05′	86°07.61′	5540	Moraine dammed lake	0.025	0.026	0.024	0.022	0.136
37		Duokapu	Central Himalaya	28°15.08′	86°06.18′	5220	Moraine dammed lake	0.141	0.127	0.133	0.135	0.044
38		Yanggongpu	Central Himalaya	28°12.47′	86°03.46′	4980	Cirque lake	0.100	0.111	0.066	0.051	0.961
39		Wuming	Central Himalaya	28°10.17′	86°03.55′	5180	Moraine dammed lake	0.040	0.038	0.037	0.039	0.026
40		Wuming	Central Himalaya	28°09.82′	86°04.00′	5140	Moraine dammed lake	0.009	0.008	0.006	0.005	0.8

41	Wuming	Central Himalaya	28°09.71′	86°04.20′	5160	Moraine dammed lake	0.012	0.011	0.011	0.009	0.333
42	Wuming	Central Himalaya	28°07.43′	86°03.16′	4380	Moraine dammed lake	0.008	0.006	0.007	0.007	0.143
43	Zhangzangpu	Central Himalaya	28°04.62′	86°03.91′	4720	Moraine dammed lake	0.266	0.260	0.184	0.117	1.274
44	Zhangzangpu	Central Himalaya	28°04.08′	86°01.72′	4500	Cirque lake	0.042	0.042	0.042	0.042	0
45	Sunkexi river	Central Himalaya	28 26.58	85 46.94	5580	Moraine dammed lake	0.452	0.273	0.184	0.096	3.708
46	Sunkexi river	Central Himalaya	28 28.91	85 44.17	5340	supraglacial lake	0.379	0.214	0.241	0.204	0.858
47	Sunkexi river	Central Himalaya	28 29.43	85 38.34	5280	Moraine dammed lake	4.739	4.772	4.665	4.636	0.022
48	Sunkexi river	Central Himalaya	28 32.36	85 36.58	5365	Moraine dammed lake	5.217	5.067	5.049	4.903	0.064
49	Sunkexi river	Central Himalaya	28 32.73	85 36.98	5440	Moraine dammed lake	0.051	0.193	0.162	0.164	-0.689
50	Sunkexi river	Central Himalaya	28 33.75	85 35.55	5360	Moraine dammed lake	1.357	0.809	0.679	0.539	1.518
51	Sunkexi river	Central Himalaya	28 34.52	85 35.19	5450	Moraine dammed lake	0.212	0.096	0.122	0.051	3.157
52	Sunkexi river	Central Himalaya	28 34.67	85 35.76	5420	Moraine dammed lake	0.242	0.255	0.228	0.235	0.03
53	Sunkexi river	Central Himalaya	28 36.55	85 31.67	5100	Moraine dammed lake	0.983	0.882	0.797	0.741	0.327
54	Kidibu Khola	Central Himalaya	28 14.26	86 22.17	5310	Moraine dammed lake	0.262	0.249	0.235	0.223	0.175
55	Kidibu Khola	Central Himalaya	28 14.10	86 21.38	5400	Moraine dammed lake	0.078	0.078	0.079	0.075	0.04
56	Kidibu Khola	Central Himalaya	28 11.53	86 20.96	5315	Moraine dammed lake	0.189	0.176	0.186	0.200	-0.055
57	Kidibu Khola	Central Himalaya	28 11.47	86 18.81	5290	Moraine dammed lake	0.248	0.245	0.271	0.252	-0.016
58	Kidibu Khola	Central Himalaya	28 13.70	86 19.28	5255	Moraine dammed lake	0.066	0.064	0.069	0.067	-0.015
59	Kidibu Khola	Central Himalaya	28 13.69	86 19.21	5365	Moraine dammed lake	0.205	0.219	0.239	0.216	-0.051
60	Kidibu Khola	Central Himalaya	28 14.72	86 11.68	5310	Moraine dammed lake	0.148	0.161	0.153	0.182	-0.187
61	Kidibu Khola	Central Himalaya	28 12.63	86 12.82	5400	Moraine dammed lake	0.042	0.041	0.045	0.051	-0.176
62	Kidibu Khola	Central Himalaya	28 10.96	86 13.53	5170	Moraine dammed lake	0.092	0.089	0.061	0.031	1.968
63	Kidibu Khola	Central Himalaya	86 09.033	28 14.96	5335	Moraine dammed lake	0.119	0.119	0.109	0.104	0.144

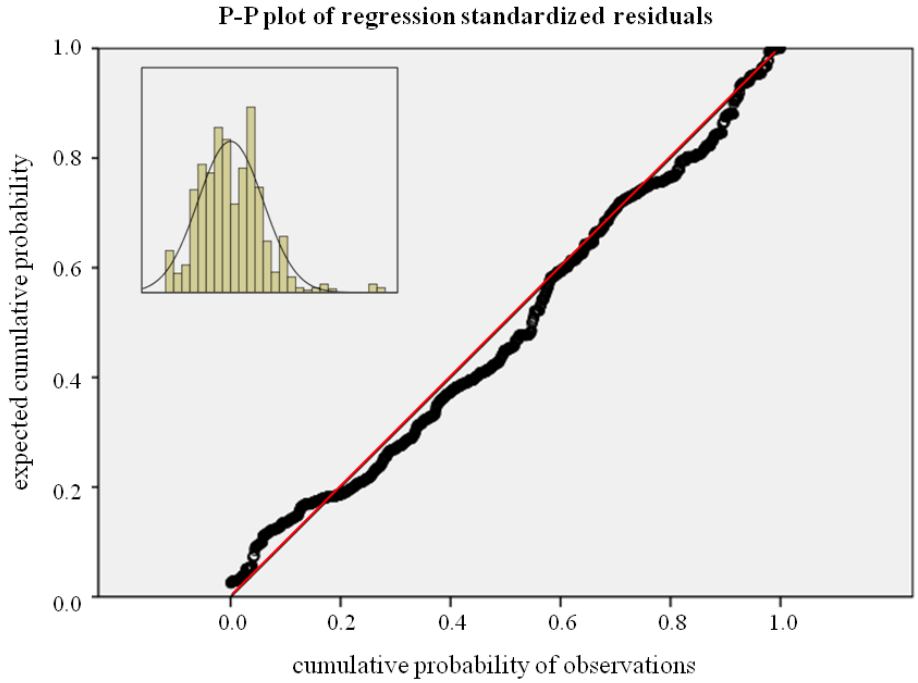

Figure S2. Standard P-P plot of regression standardized residuals.

Table S2. Since the 20th century, the outburst of the Glacier Lake in Nyalam County, Tibet, China.

No.	Location	Latitude	Longitude	Name	Collapse Date	Altitude/m
1	Nyalam	28.29	86.13	Taraco	1935.8.28	5250
2	Nyalam	28.08	86.07	Cirenmaco	1964	4660
3	Nyalam	28.08	86.07	Cirenmaco	1981.7.11	4660
4	Nyalam	28.21	85.85	Jialongco	2002.5.23	4410
5	Nyalam	28.21	85.85	Jialongco	2002.6.29	4410
6	Nyalam	28.08	86.06	Cirenmaco	2016.7.5	4610
7	Nyalam	28.21	85.85	Jialongco	2020.6.26	4410
8	Nyalam	28.18	85.93	DareCo		4340

The accuracy evaluation of the confusion matrix is mainly used to compare the classification results with the actual measured values. The accuracy of the classification results can be displayed in a confusion matrix. Each column represents the predicted value, that is, the glacial lake extracted in this paper, and each row represents the actual value, that is, the glacial lake in the HMA Glacial Lake Inventory (Hi-MAG) database. In the table S3, 1 refers to the grid pixel value of the non-glacial lake type in the study area, and 2 refers to the grid pixel value of the glacial lake type in the study area. By comparing the position and classification of each measured pixel with the corresponding position and classification results in the classified image, the Kappa coefficient finally obtained by calculation is 0.90.

Data set：Annual 30-meter Dataset for Glacial Lakes in High Mountain Asia from 2008 to 2017 (DOI:10.5194/essd-2020-57)

Table S3. The Confusion Matrix for the extraction accuracy of Glacial Lake.

Forecast Grid	**Reference Grid**		
	1	**2**	**Sum**
1	62615	141	62756
2	86	618	704
Sum	62701	759	63360
Producer Accuracy	99.86%	81.42%	
User Accuracy	99.78%	87.78%	
		Kappa Coefficient	0.898260375