

Supplementary Materials

Table S1. The study area and the covering countries around continents

Continents	Dryland areas ($\times 10^4$ km ²)	Countries	Dryland areas ($\times 10^4$ km ²) (excluded countries with dryland area less than 0.02 million km ²)	Countries (excluded countries with dryland area less than 0.02 million km ²)
Asia	1445.9	29	1441.4	20
Africa	1534.2	41	1528.6	29
South America	246.3	13	244.6	8
North America	339.5	8	338.4	3
Europe	23.8	4	22.4	1
Oceania	538.7	2	538.7	1
Global	4128.4	97	4114.1	62

Table S2. The 37 land cover categories in CCILI dataset and their re-groups

Regrouped land covers	Ecological level	Land cover categories in LCCS system
Farmland	5	Cropland, rainfed
		Cropland, rainfed-Herbaceous cover
		Cropland, rainfed-Tree or shrub cover
		Cropland, irrigated or post-flooding
		Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)
		Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)
Forest	2	Tree cover, broadleaved, evergreen, closed to open (>15%)
		Tree cover, broadleaved, deciduous, closed to open (>15%)
		Tree cover, broadleaved, deciduous, closed to open (>15%)-Tree cover, broadleaved, deciduous, closed
		Tree cover, broadleaved, deciduous, closed to open (>15%)-Tree cover, broadleaved, deciduous, open
		Tree cover, needleleaved, evergreen, closed to open (>15%)
		Tree cover, needleleaved, evergreen, closed to open (>15%)-Tree cover, needleleaved, evergreen, closed

		(>40%) Tree cover, needleleaved, evergreen, closed to open (>15%)-Tree cover, needleleaved, evergreen, open (15~40%) Tree cover, needleleaved, deciduous, closed to open (>15%) Tree cover, needleleaved, deciduous, closed to open (>15%)-Tree cover, needleleaved, deciduous, closed (>40%) Tree cover, needleleaved, deciduous, closed to open (>15%)-Tree cover, needleleaved, deciduous, open Tree cover, mixed leaf type (broadleaved and needleleaved) Mosaic tree and shrub (>50%) / herbaceous cover (<50%) Tree cover, flooded, fresh or brackish water Tree cover, flooded, saline water
Grassland	4	Mosaic herbaceous cover (>50%) / tree and shrub (<50%) Grassland
Shrub	3	Shrubland Shrubland-Evergreen shrubland Shrubland-Deciduous shrubland
Wetland	1	Shrub or herbaceous cover, flooded, fresh/saline/brackish water Water bodies
Urban area	5	Urban areas
Bare	5	Bare areas Bare areas-Consolidated bare areas Bare areas-Unconsolidated bare areas
Others	5	Lichens and mosses Sparse vegetation (tree, shrub, herbaceous cover) (<15%) Sparse vegetation (tree, shrub, herbaceous cover) (<15%)-Sparse tree (<15%) Sparse vegetation (tree, shrub, herbaceous cover) (<15%)-Sparse shrub (<15%) Sparse vegetation (tree, shrub, herbaceous cover) (<15%)-Sparse herbaceous cover (<15%) Permanent snow and ice

Table S3. The transition matrix (%) of eight land cover categories (1992–2020)

1992\2020	Farmland	Forest	Grassland	Shrub	Wetland	Urban area	Bare	Others
Farmland	-	1.98	2.14	0.59	0.10	1.84	0.45	0.54
Forest	1.68	-	1.38	3.71	0.20	0.07	0.10	0.44
Grassland	6.02	1.88	-	0.50	0.14	0.57	2.71	9.02
Shrub	2.95	4.38	1.14	-	0.05	0.51	0.22	0.42
Wetland	0.10	0.20	0.13	0.05	-	0.02	1.91	0.11
Urban area	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
Bare	2.09	0.05	9.09	0.03	0.30	0.51	-	15.19
Others	3.36	0.51	15.28	0.17	0.05	0.14	5.00	-

Table S4. The CRs in 37 land cover categories (1992–2020)

37 original land cover categories in LCCS system	Percentage in 1992(%)	Percentage in 2020(%)	CR (%)
Cropland, rainfed	3.93	3.98	1.42
Cropland, rainfed-Herbaceous cover	2.83	3.04	7.65
Cropland, rainfed-Tree or shrub cover	0.08	0.08	2.82
Cropland, irrigated or post-flooding	1.92	2.01	4.94
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	1.18	1.26	6.21
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	1.34	1.33	-0.49
Tree cover, broadleaved, evergreen, closed to open (>15%)	0.29	0.30	4.07
Tree cover, broadleaved, deciduous, closed to open (>15%)	0.76	0.73	-3.19
Tree cover, broadleaved, deciduous, closed to open (>15%)-Tree cover, broadleaved, deciduous, closed (>40%)	0.18	0.17	-4.75

Tree cover, broadleaved, deciduous, closed to open (>15%)-Tree cover, broadleaved, deciduous, open (15~40%)	1.01	1.03	1.84
Tree cover, needleleaved, evergreen, closed to open (>15%)	0.72	0.70	-1.67
Tree cover, needleleaved, evergreen, closed to open (>15%)-Tree cover, needleleaved, evergreen, closed (>40%)	0.04	0.04	-4.82
Tree cover, needleleaved, evergreen, closed to open (>15%)-Tree cover, needleleaved, evergreen, open (15~40%)	0.00	0.00	0.00
Tree cover, needleleaved, deciduous, closed to open (>15%)	0.10	0.11	16.17
Tree cover, needleleaved, deciduous, closed to open (>15%)-Tree cover, needleleaved, deciduous, closed (>40%)	0.00	0.00	0.00
Tree cover, needleleaved, deciduous, closed to open (>15%)-Tree cover, needleleaved, deciduous, open (15~40%)	0.00	0.00	0.00
Tree cover, mixed leaf type (broadleaved and needleleaved)	0.15	0.15	-1.31
Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	1.17	1.24	6.08
Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	0.73	0.69	-4.76
Shrubland	13.37	13.15	-1.63
Shrubland-Evergreen shrubland	0.00	0.00	4.42
Shrubland-Deciduous shrubland	1.76	1.74	-0.94
Grassland	13.27	13.73	3.44
Lichens and mosses	0.001206	0.001201	-0.38
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	11.96	12.13	1.39
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)-Sparse tree (<15%)	0.00	0.00	1.56
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)-Sparse shrub (<15%)	0.09	0.08	-8.78
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)-Sparse herbaceous cover (<15%)	0.67	0.57	-14.46
Tree cover, flooded, fresh or brackish water	0.01	0.01	7.91
Tree cover, flooded, saline water	0.02	0.03	10.72
Shrub or herbaceous cover, flooded, fresh/saline/brackish water	0.53	0.53	0.42
Urban areas	0.08	0.27	228.18
Bare areas	40.65	39.79	-2.11
Bare areas-Consolidated bare areas	0.17	0.17	-1.16
Bare areas-Unconsolidated bare areas	0.21	0.22	2.50
Water bodies	0.61	0.53	-14.20
Permanent snow and ice	0.17	0.17	0.00

Table S5. Top eight land cover transitions from 1992 to 2020(%)

Land cover transitions	Percentage (%)
Bare areas -> Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	13.91
Sparse vegetation (tree, shrub, herbaceous cover) (<15%) -> Grassland	13.81
Bare areas -> Grassland	8.47
Grassland -> Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	7.78
Sparse vegetation (tree, shrub, herbaceous cover) (<15%) -> Bare areas	4.67
Grassland -> Bare areas	2.29
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)-Sparse herbaceous cover (<15%) -> Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	2.26
Water bodies -> Bare areas	1.73

Table S6. Net change areas ($\times 10^4$ km²) of 8 land cover categories in continents

Land covers	Asia	Africa	South America	North America	Europe	Oceania	Global
Farmland	8.74	8.07	1.40	1.98	-0.13	2.22	22.29
Forest	0.66	3.84	-3.30	-0.07	0.19	2.35	3.66
Grassland	10.45	-0.71	0.57	-1.48	-0.03	12.78	21.58
Shrub	-0.57	-5.26	1.39	-2.45	0.00	-5.13	-12.01
Wetland	-4.38	0.12	-0.04	0.00	0.04	-0.10	-4.36
Urban area	5.54	1.33	0.39	1.89	0.28	0.05	9.49
Bare	-22.66	-14.39	-2.30	0.08	-0.03	-4.50	-43.79
Others	2.22	6.98	1.90	0.05	-0.33	-7.69	3.14

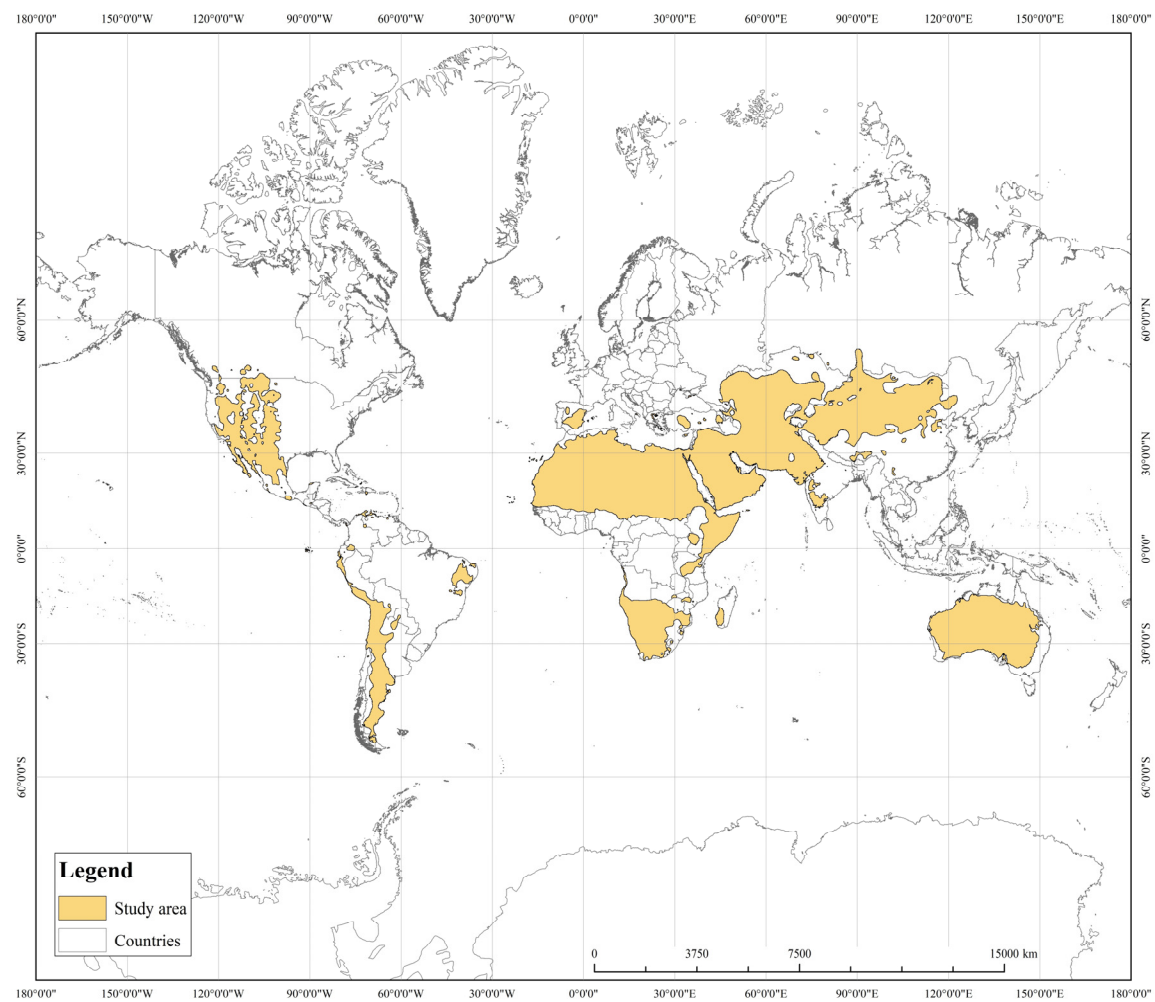


Figure S1. The study area