

Table S1. Land-cover stability and major land-cover transitions in Xinjiang during 2001 – 2020.

Conversion type	Code	Pixels	Proportion	Ecological implication
Bare land → Grassland	12→7	94,919	63.10%	Grazing retirement, desert grassland recovery
Grassland → Cropland	7→9	943	0.60%	Agricultural expansion
Cropland → Grassland	9→7	196	0.10%	Grain for Green
Bare land → Cropland	12→9	7,779	5.20%	Desert reclamation
Bare land → Shrubland	12→6	5,053	3.40%	Shrubland recovery
Grassland → Shrubland	7→6	58	0.00%*	Shrubland recovery
Water → Wetland	13→8	41,409	27.50%	Ecological water conveyance
Total conversion		150,357	3.60%	
Stable pixels		4,061,487	96.40%	

Table S2. Partial and first-difference correlations among NDVI, CO₂, WUE, and climatic variables.

Test	Variable pair	Controlling for	r	p	n
First-order partial	NDVI—CO ₂	Precipitation	+0.772	0.0001	20
	WUE—CO ₂	Precipitation	+0.908	<0.0001	20
Second-order partial	NDVI—CO ₂	Precipitation + Temperature	+0.771	0.0002	20
	WUE—CO ₂	Precipitation + Temperature	+0.904	<0.0001	20
First-difference	Δ NDVI—Δ CO ₂	—	+0.429	0.067	19
	Δ WUE—Δ CO ₂	—	−0.176	0.471	19
	Δ WUE—Δ CO ₂	Δ Precipitation	+0.040	0.875	19

Table S2. Partial and first-difference correlations among NDVI, CO₂, WUE, and climatic variables.

Zone	α (CO ₂ → WUE)	β (WUE → NDVI)	ACME	ACME 95% CI	Significant
<50 mm	+0.0031	+0.0257	+8.1 × 10 ^{−5}	[−2.4 × 10 ^{−5} , +2.6 × 10 ^{−4}]	No
50 – 100 mm	+0.0138	+0.0020	+2.7 × 10 ^{−5}	[−1.6 × 10 ^{−4} , +2.5 × 10 ^{−4}]	No
100 – 200 mm	+0.0089	−0.0105	−9.4 × 10 ^{−5}	[−6.5 × 10 ^{−4} , +5.8 × 10 ^{−4}]	No
200 – 400 mm	+0.0040	+0.0896	+3.6 × 10 ^{−4}	[−8.0 × 10 ^{−5} , +9.6 × 10 ^{−4}]	No
>400 mm	+0.0015	+0.1571	+2.4 × 10 ^{−4}	[+7.5 × 10 ^{−5} , ...]	Yes

Table S4. Maximum light use efficiency (LUE_{max}) by vegetation type.

Vegetation type	LUE _{max} (gC/MJ)
Evergreen needleleaf forest	0.389
Deciduous needleleaf forest	0.485
Deciduous broadleaf forest	0.692
Mixed forest	0.475
Shrubland	0.429
Grassland	0.542
Cropland	0.542
Wetland	0.542
Bare land	0.389

Table S5. IGBP Classification Reclassification Scheme

New code	Category	Original IGBP types
1	Evergreen Needleleaf Forest	Evergreen Needleleaf Forest
2	Evergreen Broadleaf Forest	Evergreen Broadleaf Forest
3	Deciduous Needleleaf Forest	Deciduous Needleleaf Forest
4	Deciduous Broadleaf Forest	Deciduous Broadleaf Forest
5	Mixed Forest	Mixed Forest
6	Shrubland	Closed Shrublands, Open Shrublands
7	Grassland	Woody Savannas, Savannas, Grasslands
8	Wetland	Permanent Wetlands
9	Cropland	Croplands, Cropland/Natural Vegetation Mosaic
10	Built-up Land	Urban and Built-up
11	Snow and Ice	Permanent Snow and Ice
12	Bare Land	Barren or Sparsely Vegetated
13	Water Body	Lakes, Reservoirs, Rivers

Table S6 Analysis of precipitation intervals

Precipitation interval	Pixel count	r median	r mean	Standard deviation	Positive correlation proportion (%)
<50 mm	287	0.197	0.185	0.296	77.7
50–100 mm	605	0.284	0.293	0.340	80.8
100–200 mm	1,438	0.229	0.250	0.302	79.1
200–400 mm	1,260	0.340	0.327	0.311	84.1
>400 mm	1,995	0.240	0.226	0.300	76.3