

## Supplementary Material

### Vegetation Dynamics and Driving Mechanisms Considering Time-Lag and Accumulation Effects: A Case Study of Hubao–Egyu Urban Agglomeration

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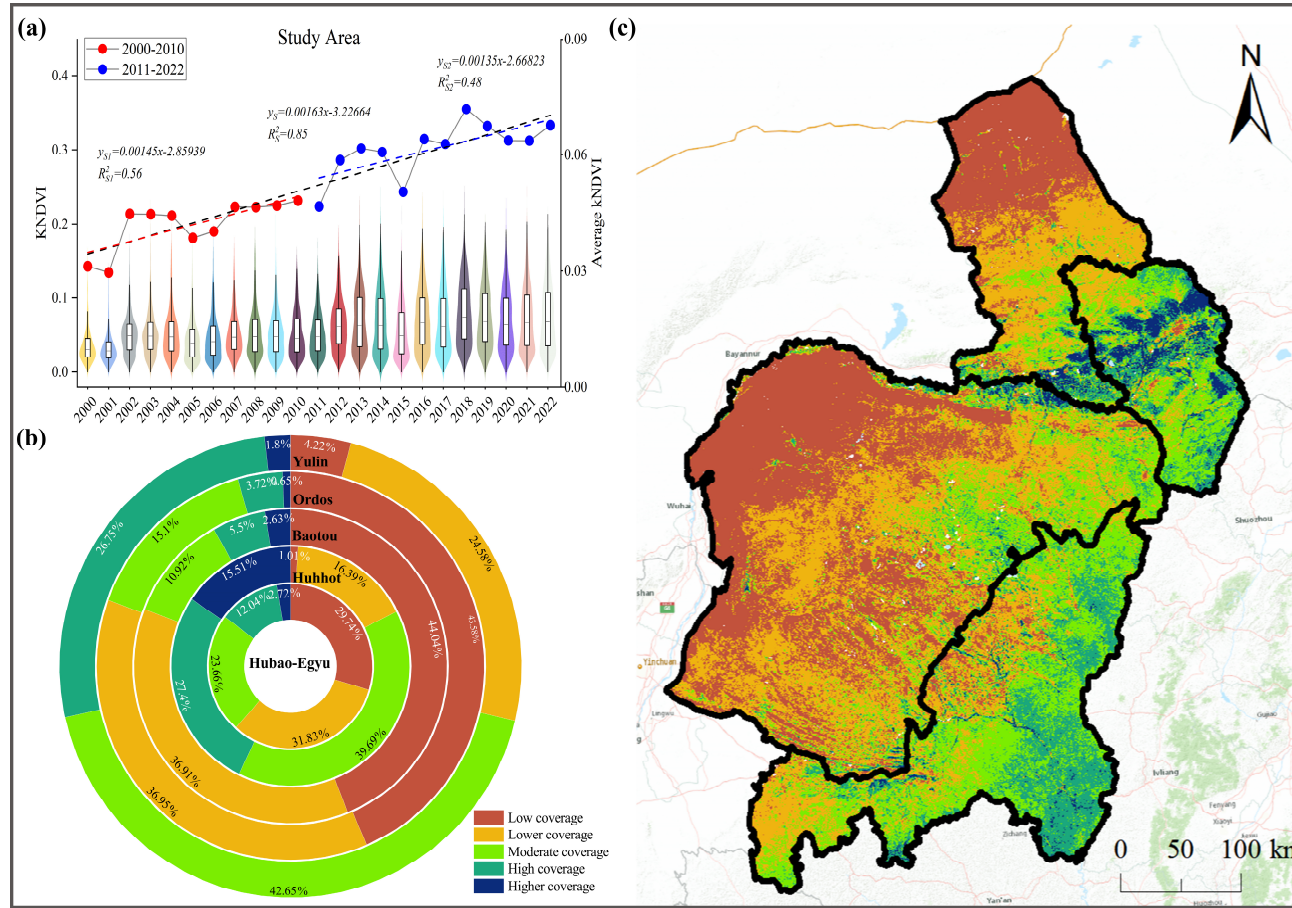
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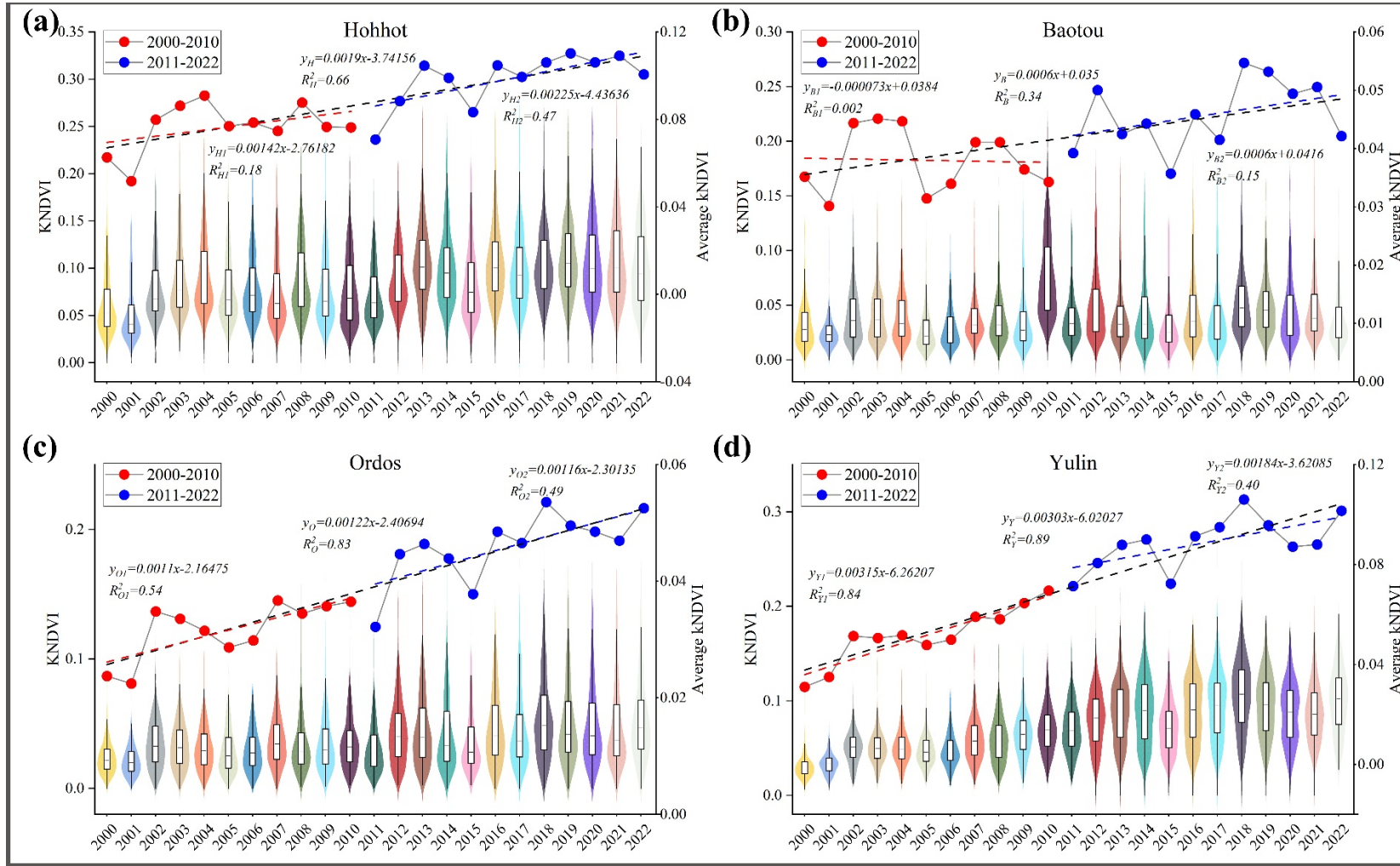
Data are available from the author below, upon reasonable request.

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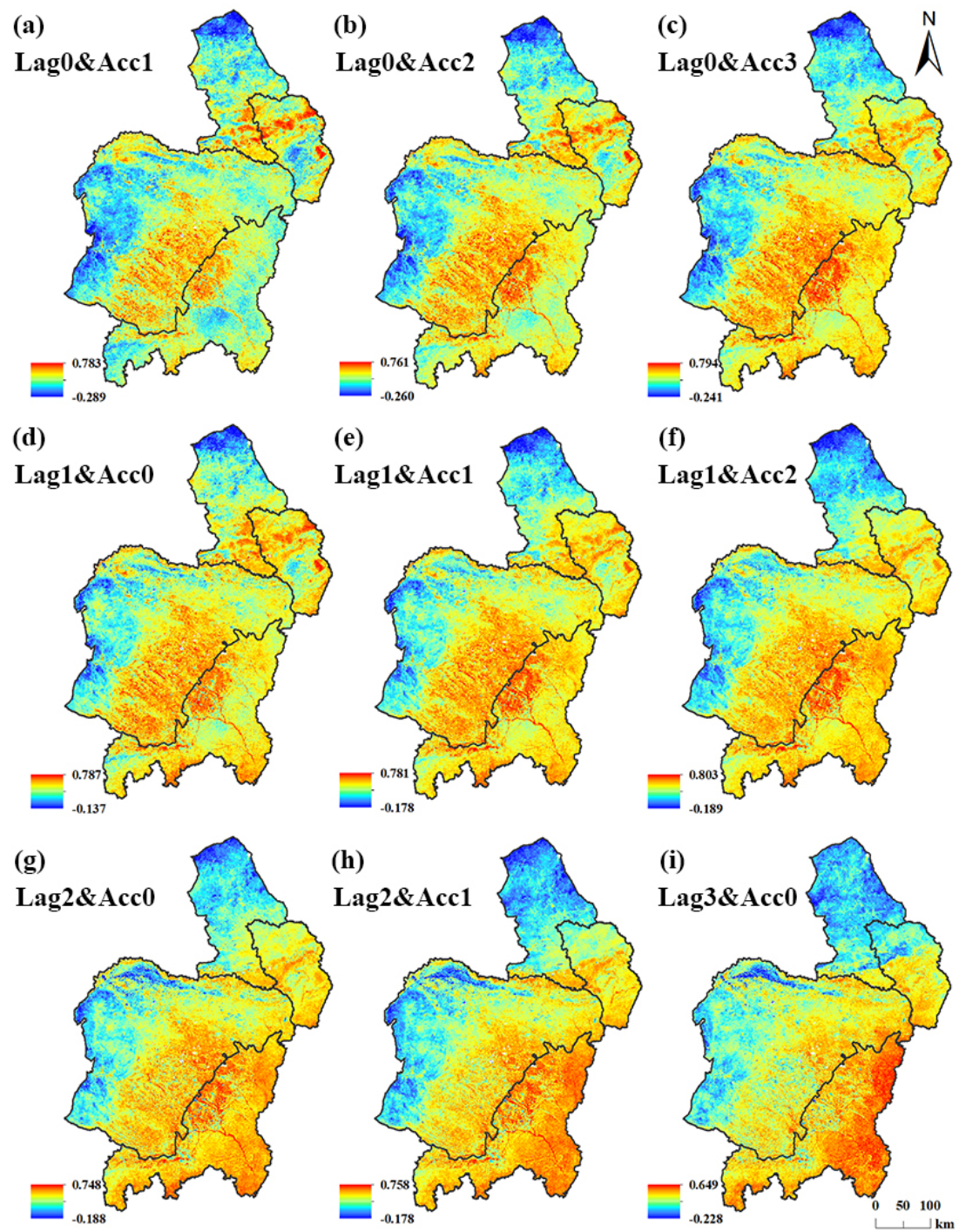


**Figure S1.** Temporal variation characteristics of kNDVI in HBEY (a). The red and blue dots in the figure represent the average kNDVI, and the violin plot shows the distribution of kNDVI in a given year. The whisker of the violin diagram represents the data range, and the upper boundary, horizontal line, and lower boundary of the box part represent the upper, median, and lower quartile of the data, respectively. The width of the violin map reflects the data density at that location. According to the natural break method, the average kNDVI during 2000-2022 is divided into five levels, the scale map is (b) and the spatial distribution map is (c).



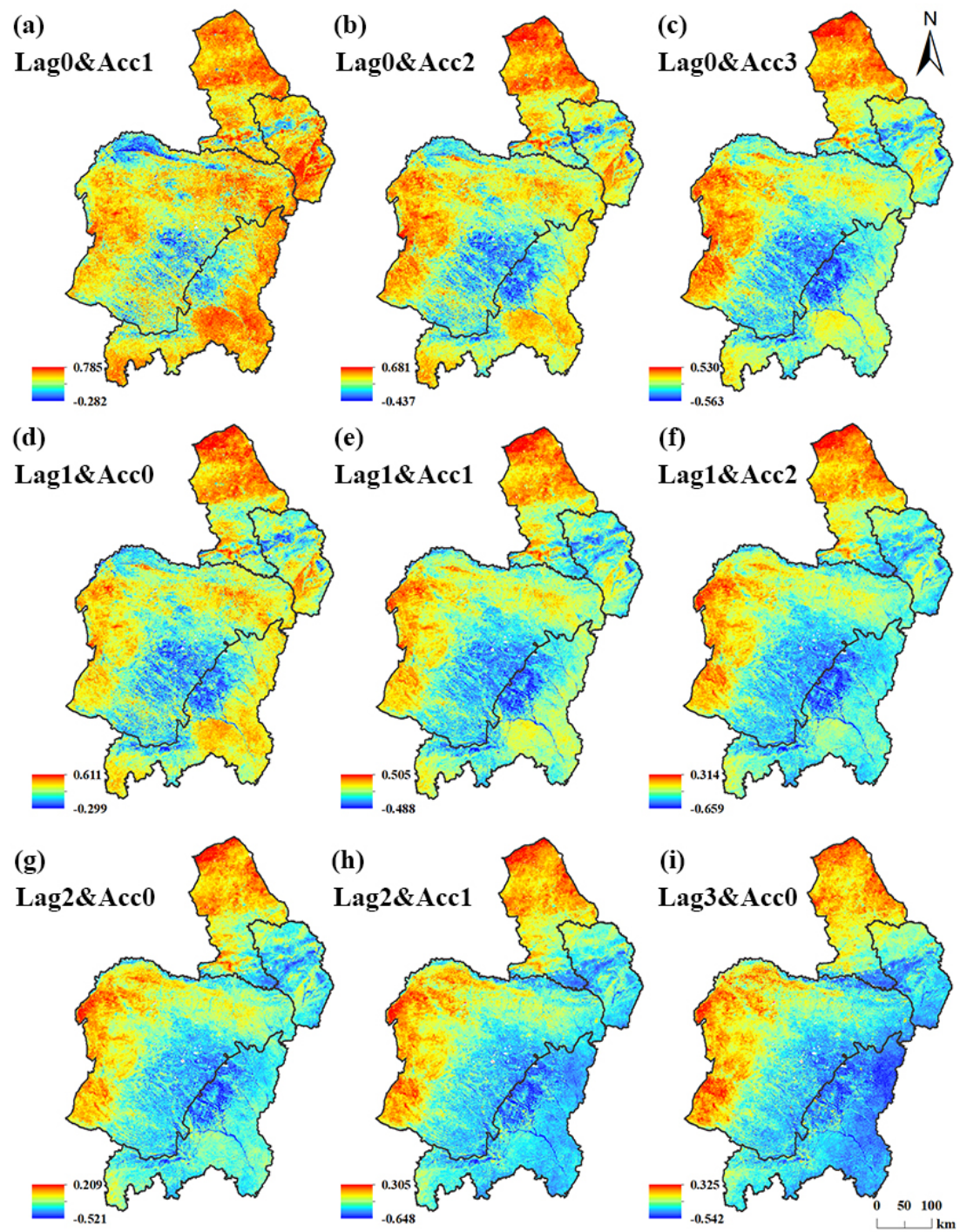
**Figure S2.** Temporal variation of kNDVI in (a) Hohhot, (b) Baotou, (c) Ordos and (d) Yulin.



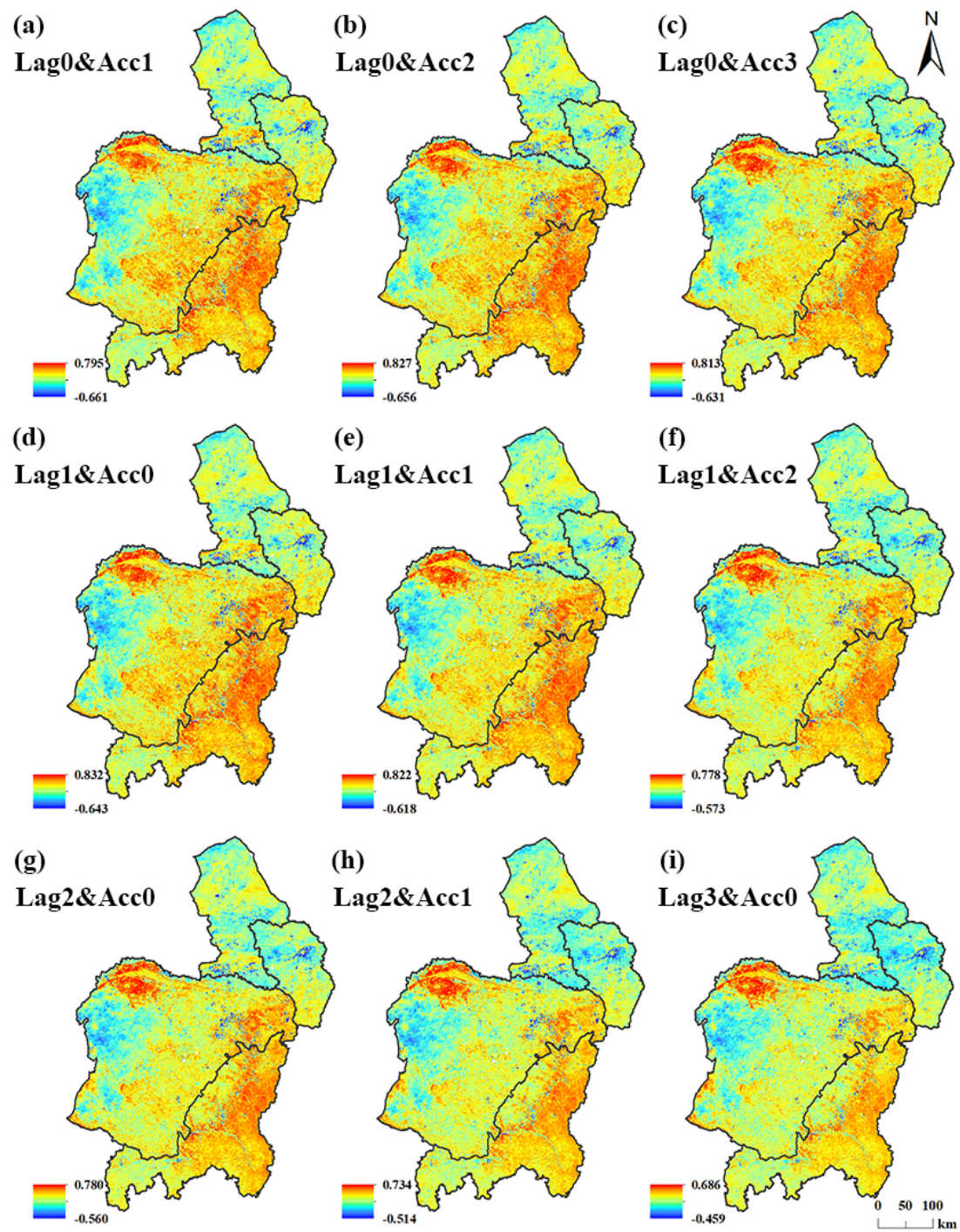


**Figure S3.** Second-order partial correlation coefficient between kNDVI and temperature under different combination of time-lag and accumulation effect.



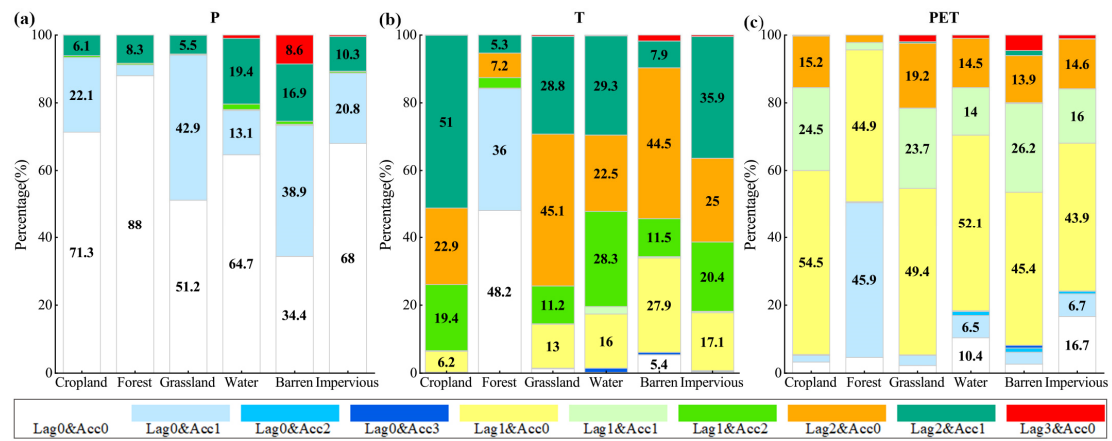


**Figure S4.** Second-order partial correlation coefficient between kNDVI and precipitation under different combination of time-lag and accumulation effect.

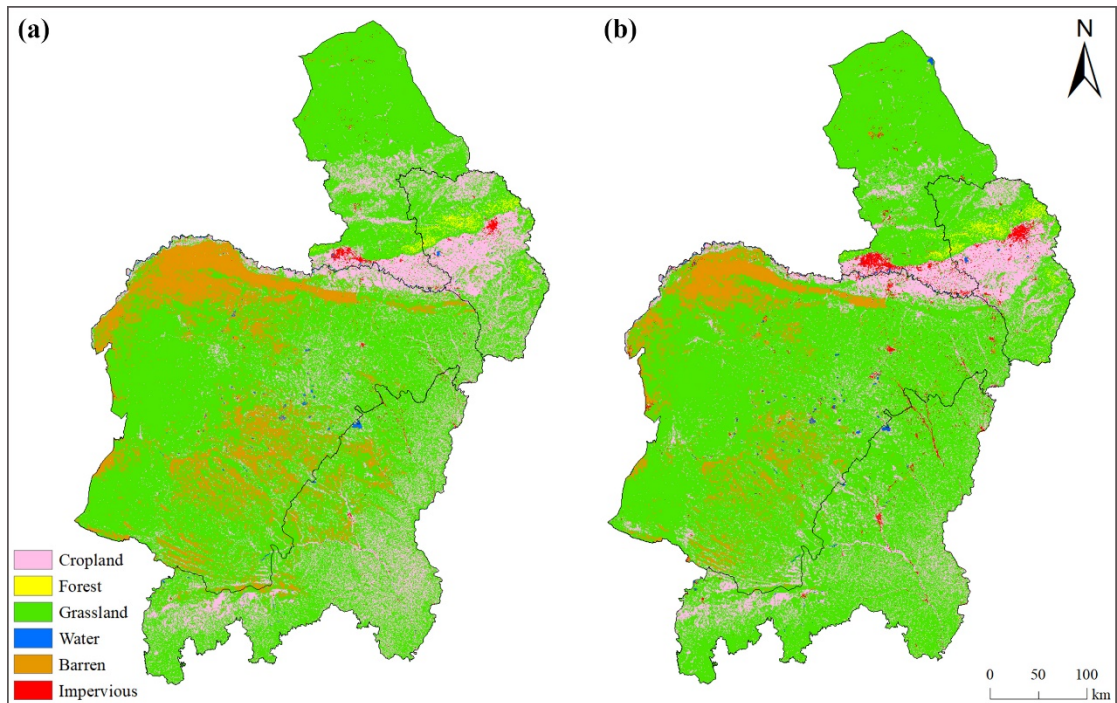


**Figure S5.** Second-order partial correlation coefficient between kNDVI and potential evapotranspiration under different combination of time-lag and accumulation effect.





**Figure S6.** Area proportion of temporal effects of vegetation on each land use type. The histogram legend colors of each effect are the same as in Figure 5.



**Figure S7.** Land use of Hubao-Egyu urban agglomeration in 2000(a) and 2022(b).



**Table S1.** Overview of the data and indicators. Topographic data and Administrative Boundary data were accessed on 15 July 2022. In addition, in order to meet the requirements of partial correlation analysis, we resampled kNDVI data to 1km by bilinear interpolation.

Categories	Derived Indicators	Units	Resolution	Resource
Vegetation Data	kNDVI	/	250m	<a href="https://earthengine.google.com/">https://earthengine.google.com/</a>
Meteorological Data	Temperature	°C	1000m	<a href="https://data.tpd.cn/">https://data.tpd.cn/</a>
	Precipitation	mm	1000m	<a href="https://data.tpd.cn/">https://data.tpd.cn/</a>
	PET	mm	1000m	<a href="https://data.tpd.cn/">https://data.tpd.cn/</a>
	LULC	/	30m	<a href="https://earthengine.google.com/">https://earthengine.google.com/</a>
Topographic Data	Elevation	m	90m	<a href="https://earthengine.google.com/">https://earthengine.google.com/</a>
Administrative Boundary	/	/	/	<a href="https://www.resdc.cn/">https://www.resdc.cn/</a>

**Table S2.** The grading criteria for trends. When  $Z > 1.96$  and  $2.58$ , the representative trend passes 95% and 99% significance tests, respectively.

Growing Trend	Slope	Z	Abbreviation
Extremely Significant Degradation	Slope < 0	$ Z  > 2.58$	ESD
Significant Degradation	Slope < 0	$1.96 <  Z  < 2.58$	SID
Stable	/	$ Z  < 1.96$	STA
Significant Improvement	Slope > 0	$1.96 <  Z  < 2.58$	SII
Extremely Significant Improvement	Slope > 0	$ Z  > 2.58$	ESI

**Table S3.** Driving scenarios for quantifying the contribution on vegetation. GCH refers to the greening caused by climate change and human activity while BCH represents browning. Similarly, GCC, GHA, BCC and BHA represent greening or browning of vegetation caused by climate change and human activity respectively.

Slope( $kNDVI_{obs}$ )	Slope( $kNDVI_{CC}$ )	Slope( $kNDVI_{HA}$ )	Contribution Rate		Scenarios
			CC	HA	
>0	>0	>0	$\frac{S(kNDVI_{CC})}{S(kNDVI_{obs})}$	$\frac{S(kNDVI_{HA})}{S(kNDVI_{obs})}$	GCH
	>0	<0	100	0	GCC
	<0	>0	0	100	GHA
<0	<0	<0	$\frac{S(kNDVI_{CC})}{S(kNDVI_{obs})}$	$\frac{S(kNDVI_{HA})}{S(kNDVI_{obs})}$	BCH
	<0	>0	100	0	BCC
	>0	<0	0	100	BHA

**Table S4.** The lag and accumulation effects of vegetation on climate factors in different land use types, including the statistics of the proportion of four scenarios.

Land use	P				T				PET			
	No	Lag	Acc	LagAcc	No	Lag	Acc	LagAcc	No	Lag	Acc	LagAcc
Cropland	71.29	0.02	22.06	6.63	0.1	29.1	0.15	70.65	3.29	69.99	2.21	24.51
Forest	88.03	0	3.19	8.78	48.17	43.24	0	8.59	4.63	47.1	46.14	2.13
Grassland	51.24	0.08	42.89	5.79	1.29	58.49	0.16	40.06	2.25	70.53	3.14	24.08
Water	64.64	0.97	13.08	21.31	0.24	38.74	1.21	59.81	10.41	67.55	7.99	14.05
Barren	34.41	8.72	39.03	17.84	5.41	74.14	0.68	19.77	2.64	63.88	5.58	27.9
Impervious	68	0.47	20.8	10.73	0.43	42.58	0.28	56.71	16.69	59.59	7.54	16.18
Hubao-Egyu	53.55	0.69	38.87	6.89	1.68	54.79	0.2	43.33	2.68	69.65	3.52	24.15

**Table S5.** Contribution rate of CC (climate change) and HA (human activity) of vary land type under four temporal effects.

	CC				HA			
	No	Lag	Acc	LagAcc	No	Lag	Acc	LagAcc
Cropland	39.31	44.54	41.06	47.06	60.69	55.46	58.94	52.94
Forest	49.86	51.50	51.67	54.26	50.14	48.50	48.33	45.74
Grassland	42.59	48.38	44.71	49.12	57.41	51.62	55.29	50.88
Water	21.20	30.37	27.34	24.77	78.80	69.63	72.66	75.23
Barren	28.03	38.29	30.64	38.47	71.97	61.71	69.36	61.53
Impervious	36.48	40.11	38.12	42.71	63.52	59.89	61.88	57.29

**Table S6.** The lag and accumulation periods of vegetation on climate factors in different land use types.

Land use	P		T		PET	
	Lag_Days	Acc_Days	Lag_Days	Acc_Days	Lag_Days	Acc_Days
Cropland	0.128	0.287	1.737	0.905	1.102	0.271
Forest	0.171	0.125	0.644	0.117	0.514	0.487
Grassland	0.116	0.49	1.733	0.517	1.181	0.275
Barren	0.606	0.58	1.499	0.332	1.163	0.367
Hubao-Egyu	0.155	0.462	1.708	0.565	1.16	0.282