

Supplementary Information

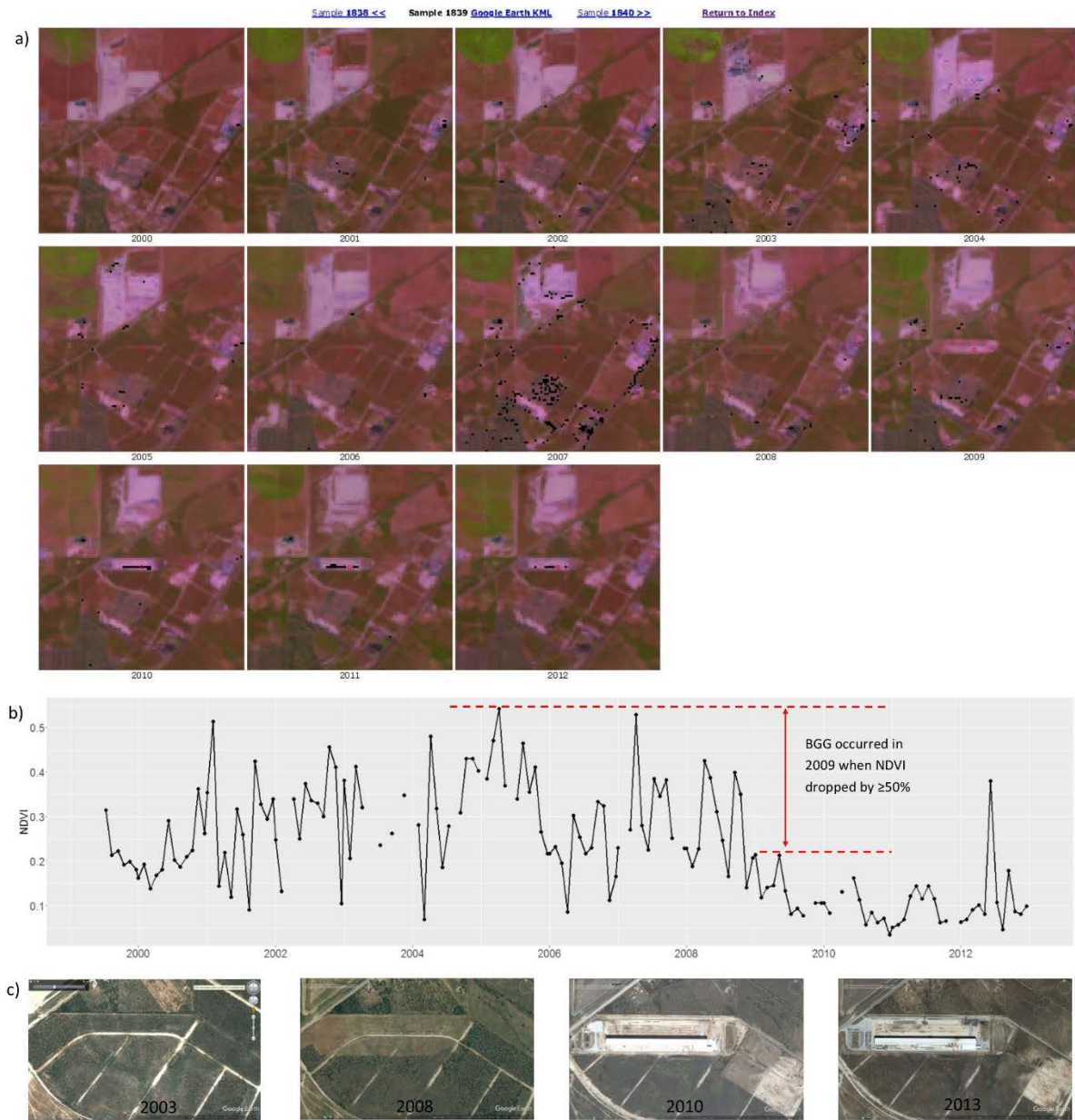


Fig. S1. Attribution of LCLU outcomes of bare ground gain sample and interpretation of change year: a) Landsat time series of a $\sim 9 \times 9$ km block (303×303 Landsat pixels) centered at a gain sample pixel (31.50° N 100.39° W) as shown in red square suggested bare ground gain occurred

in 2009; b) NDVI 32-day time series of the sample pixel for 1999-2012 demonstrated vegetation lost by over 50% starting at 2009 and lasting for at least three years; c) Screenshots taken from Google Earth confirmed our interpretation on change year with an attribution of bare ground gain as commercial/residential built-up area. Landsat images are false color composites of Shortwave Infrared (SWIR 1.55-1.75 μm), Near-Infrared (NIR 0.77-0.90 μm) and Red (0.63-0.69 μm) bands. NDVI sequences were extracted from Landsat 7 collection 1 tier 1 32-day NDVI composite available on Google Earth Engine.

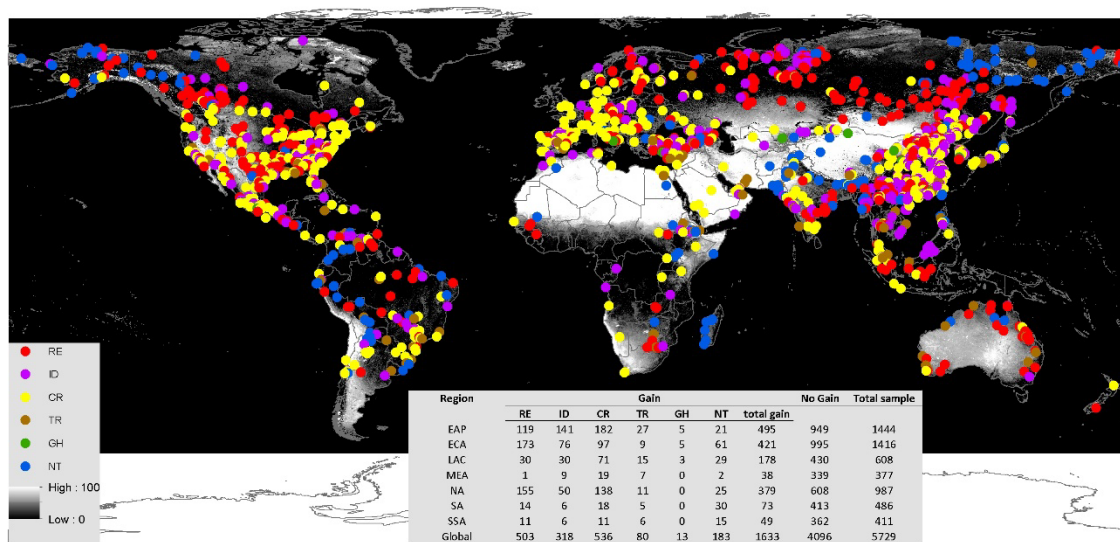


Fig. S2. Spatial distribution of LCLU outcomes of sample pixels. The inset table summarizes the sample counts by region (2 sample pixels of bare ground gain and 19 of no gain not counted due to out of the continental boundaries). Background layer ranging from 80° N to 60° S except Greenland is percent bare ground cover that is per pixel the median value of percent bare ground cover in the last three years (2010, 2011, and 2012). RE denotes resource extraction; ID denotes

infrastructural development; CR denotes commercial/residential built-up area; TR denotes transitional bare ground gain; GH denotes greenhouses; NT denotes natural bare ground gain, thereafter.

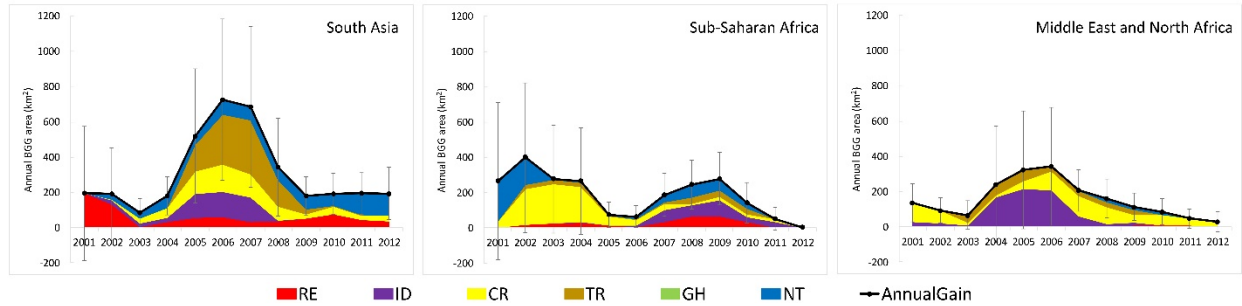


Fig. S3. Temporal bare ground gain areas in three regions (South Asia, Sub-Saharan Africa, Middle East and North Africa) that were excluded from panel analysis for high uncertainty.

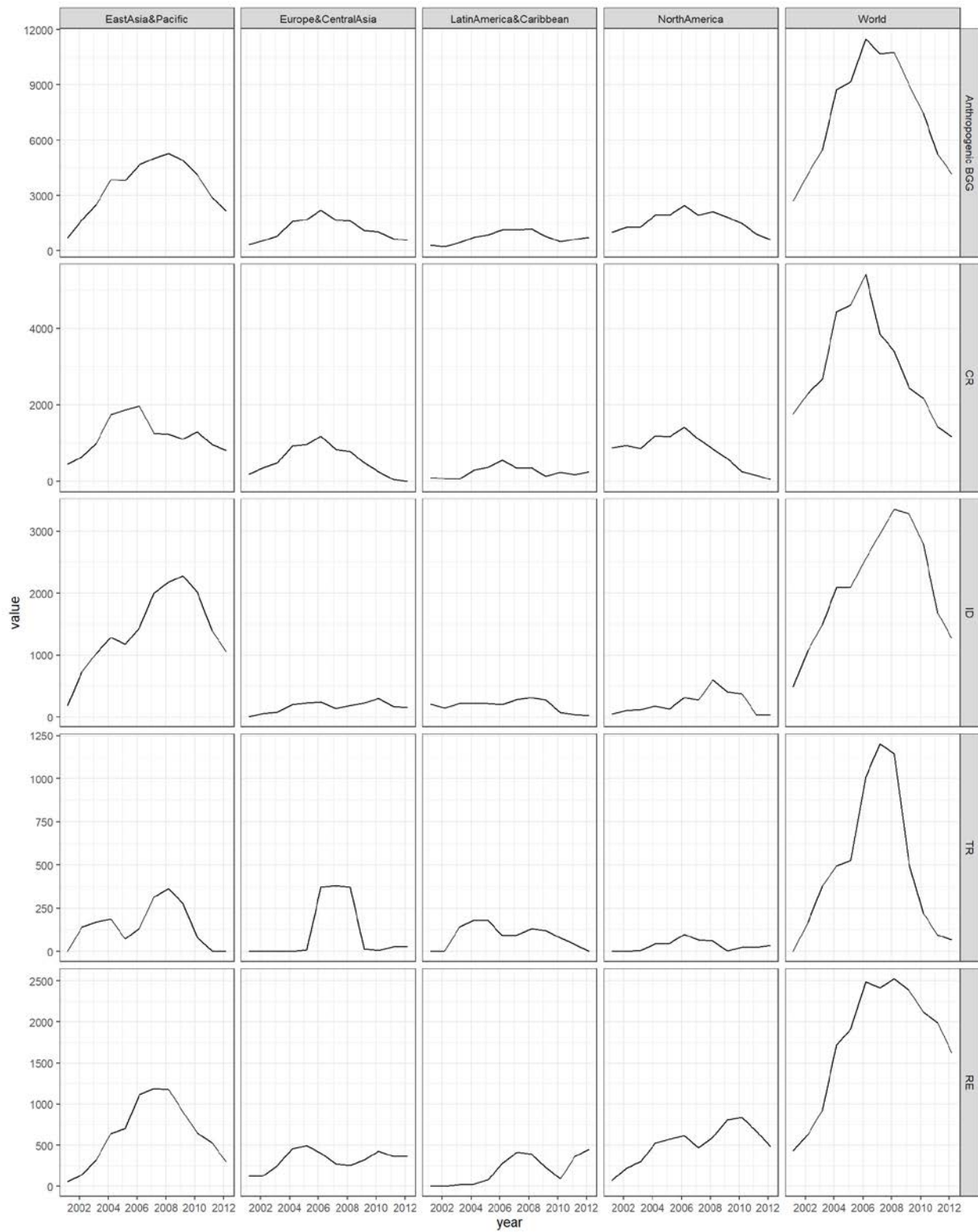


Fig. S4. Temporal anthropogenic bare ground gain, commercial/residential built-up area, infrastructure development, transitional bare ground gain and resource extraction (unit: km²) at global and regional level.

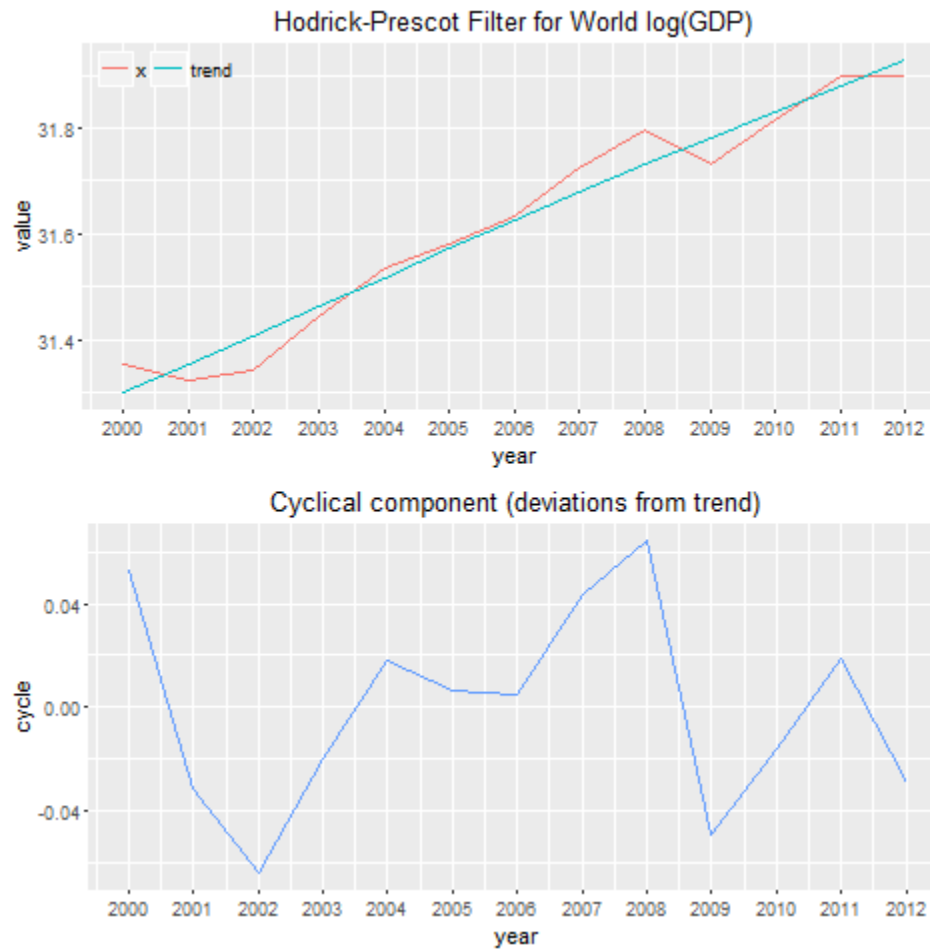


Fig. S5. Time sequences of natural log GDP (red), growth trend and cyclical component decomposed by Hodrick-Prescott Filter ($\lambda=100$).

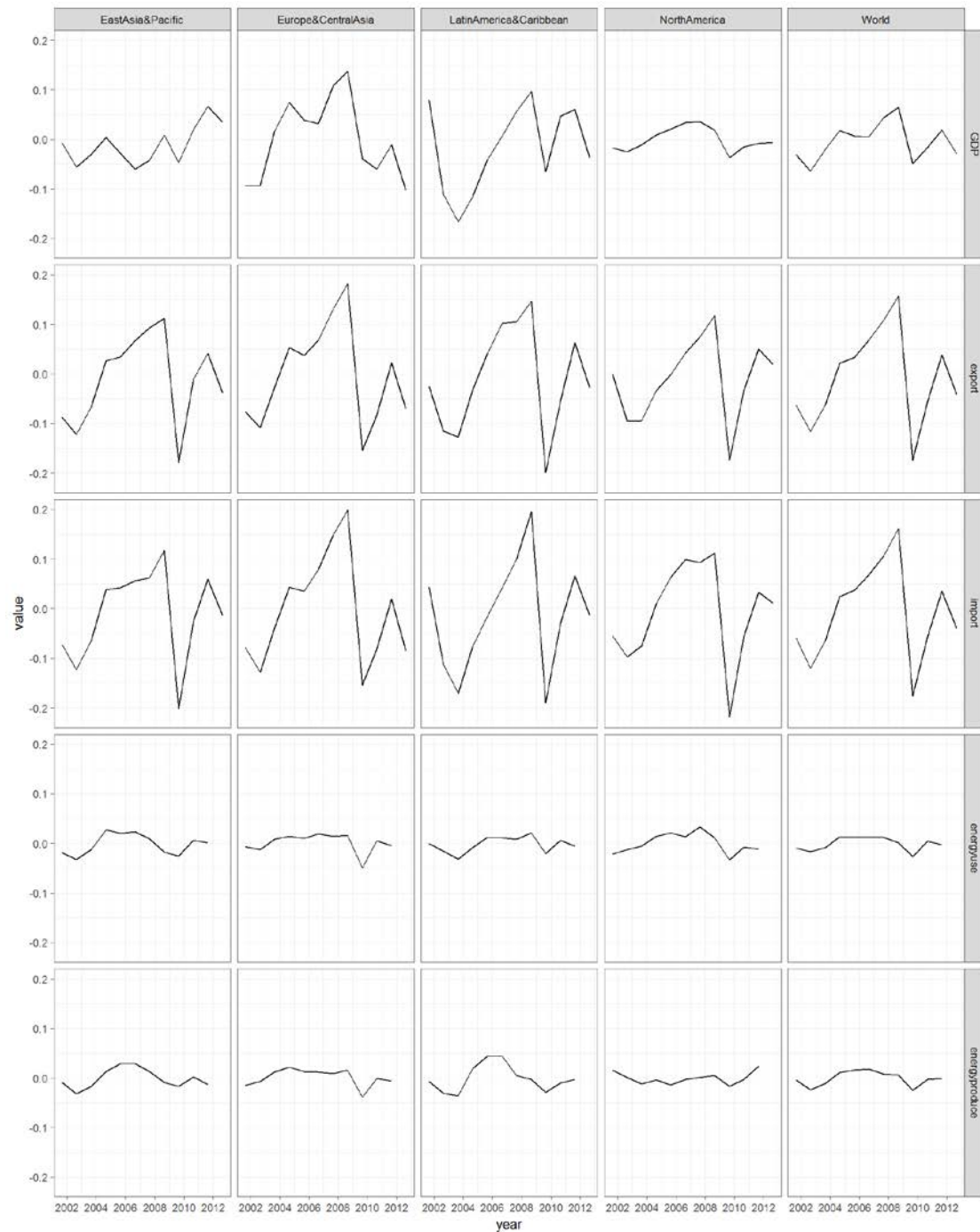


Fig.S6. De-trended economic variables showing economic fluctuations at global and regional scale in 2001-2012. All economic variables are after natural logarithm and de-trended, and therefore unitless.

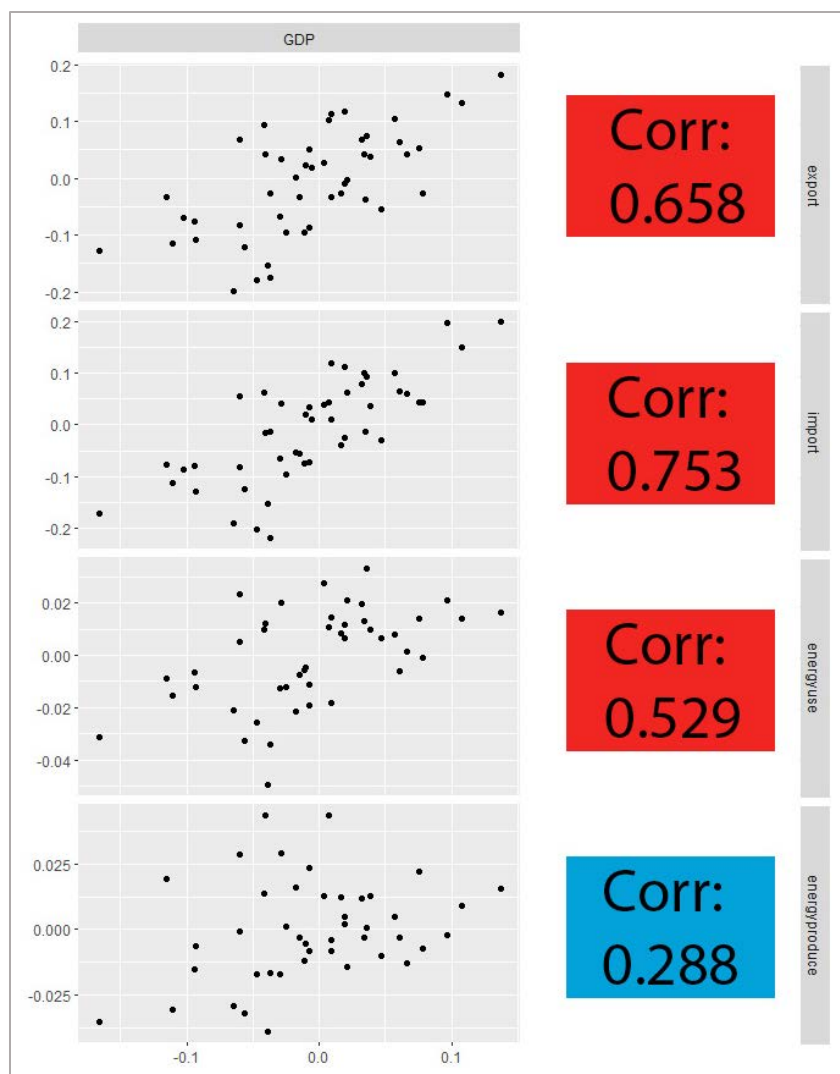


Fig. S7. Pearson correlation tests of pooled GDP and merchandise exports, merchandise imports, energy use and energy production, respectively. All economic variables are after natural logarithm and de-trended, and therefore unitless. Scatter plots on the left and correlation coefficients on the right with significant levels colored in red ($p < 0.001$) and blue ($p < 0.1$).

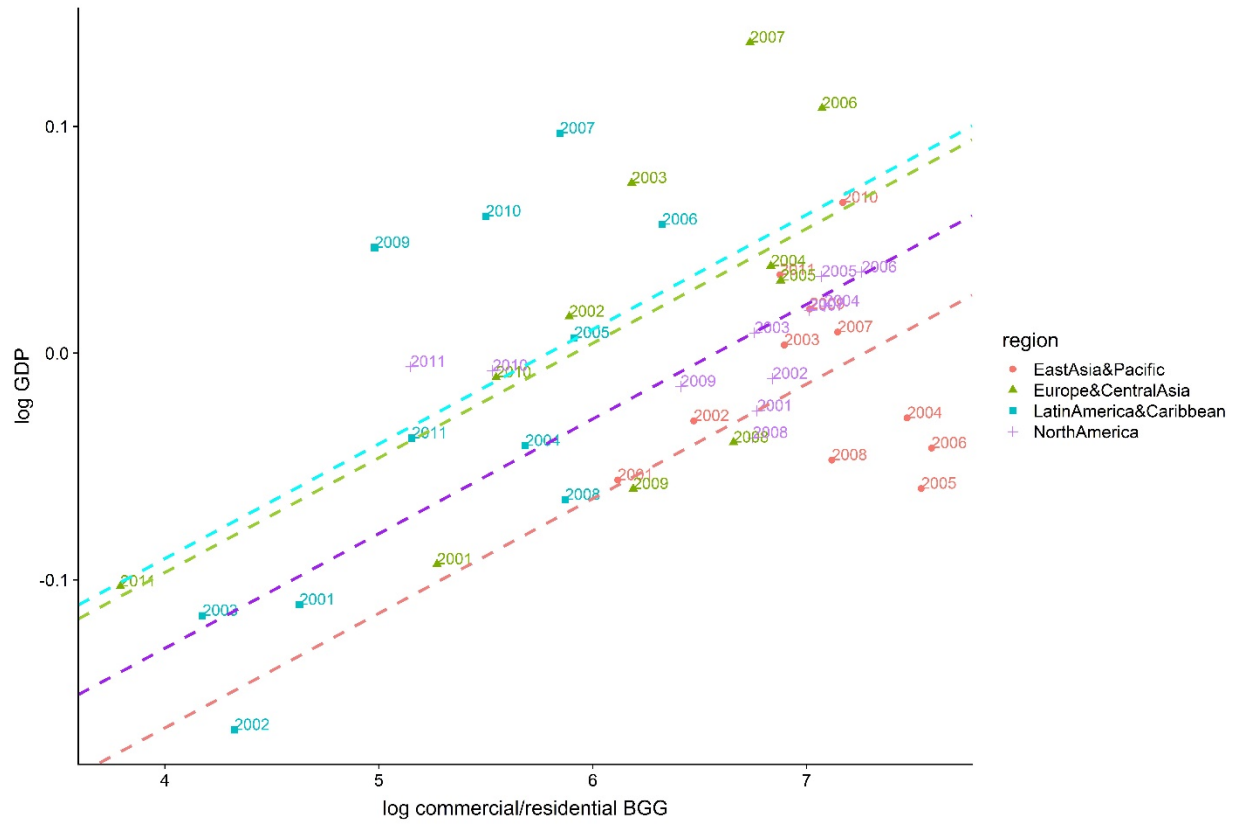


Fig. S8. De-trended GDP (natural log) versus one-year lagged bare ground gain of commercial/residential built-up area (natural log). The labeled year t besides each point denotes bare ground gain in year t and GDP in year $t+1$. Panel regressions shown in dash lines.

Table S1. Sample distribution by change time and region

Year	EAP	ECA	LAC	MEA	NA	SA	SSA	Global
2001	13	5	4	5	10	1	1	39
2002	30	26	11	1	27	0	2	97
2003	43	35	5	0	39	7	7	136
2004	39	47	11	4	42	2	5	150
2005	48	56	24	3	51	12	5	199
2006	65	48	24	6	60	15	2	220
2007	73	57	30	7	56	14	7	244
2008	57	56	31	6	34	5	13	202
2009	49	41	15	3	31	6	3	148
2010	46	26	12	2	16	5	4	111
2011	24	17	4	1	12	3	0	61
2012	8	7	7	0	1	3	0	26

Table S2. Temporal bare ground gain and LCLU outcomes (km²) at global and regional scale

region	year	Sum	RE	ID	CR	TR	NT	GH
Global	2001	3118	433	486	1768	0	431	0
Global	2002	4522	635	1079	2299	169	340	0
Global	2003	5635	929	1487	2666	378	175	0
Global	2004	8894	1720	2091	4429	494	157	3
Global	2005	9404	1917	2096	4617	526	240	7
Global	2006	11878	2488	2560	5417	1008	398	7
Global	2007	11330	2415	2955	3849	1202	640	268
Global	2008	11485	2525	3357	3396	1147	706	355
Global	2009	9710	2388	3283	2443	508	705	385
Global	2010	7989	2121	2792	2171	222	543	141
Global	2011	5838	1988	1681	1435	96	588	50
Global	2012	4772	1624	1268	1171	65	614	30
EAP	2001	767	53	188	453	0	73	0
EAP	2002	1713	139	730	647	141	56	0
EAP	2003	2548	318	1033	988	169	41	0
EAP	2004	3888	645	1284	1754	185	19	0
EAP	2005	3834	703	1169	1874	73	16	0
EAP	2006	4714	1122	1446	1967	133	46	0
EAP	2007	5182	1193	1997	1268	315	173	236
EAP	2008	5454	1181	2174	1234	362	176	327
EAP	2009	5109	907	2276	1112	279	208	327
EAP	2010	4208	653	2016	1298	81	69	91
EAP	2011	2989	530	1399	968	5	87	0
EAP	2012	2193	294	1052	808	0	38	0
ECA	2001	360	120	10	195	0	36	0
ECA	2002	574	128	59	361	0	26	0
ECA	2003	856	256	78	484	0	38	0
ECA	2004	1626	458	203	928	0	38	0
ECA	2005	1781	494	226	971	10	79	0
ECA	2006	2295	403	243	1178	373	98	0
ECA	2007	1764	271	140	842	381	105	26
ECA	2008	1761	256	185	779	371	144	26
ECA	2009	1225	322	221	487	14	126	55
ECA	2010	1139	426	293	257	5	108	50
ECA	2011	693	365	173	44	26	36	50
ECA	2012	603	363	151	0	30	29	30
LAC	2001	399	0	207	102	0	90	0
LAC	2002	287	0	147	76	4	60	0
LAC	2003	491	22	221	65	140	43	0

LAC	2004	735	27	226	294	179	6	3
LAC	2005	924	79	220	370	178	70	7
LAC	2006	1241	280	203	558	93	100	7
LAC	2007	1266	415	279	346	96	122	7
LAC	2008	1271	390	311	355	133	80	3
LAC	2009	878	229	271	146	121	109	3
LAC	2010	699	90	73	245	79	212	0
LAC	2011	955	363	39	173	39	340	0
LAC	2012	1160	452	30	256	0	422	0
NA	2001	996	65	53	870	0	7	0
NA	2002	1269	218	102	935	0	14	0
NA	2003	1310	303	125	859	6	16	0
NA	2004	1959	527	180	1191	42	18	0
NA	2005	1946	574	129	1176	47	20	0
NA	2006	2496	615	313	1418	98	52	0
NA	2007	2039	470	274	1111	66	118	0
NA	2008	2249	598	597	852	62	141	0
NA	2009	1928	804	405	609	4	106	0
NA	2010	1524	836	378	253	23	34	0
NA	2011	908	674	39	172	23	0	0
NA	2012	595	481	35	44	35	0	0

Table S3. List of dependent economic variables

Explanatory variables	Description from the World Bank
GDP	The sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products in current U.S. dollars.
Merchandise imports	The c.i.f. (cost, insurance and freight included) value of goods received from the rest of the world valued in current U.S. dollars.
Merchandise exports	The f.o.b (free on board) value of goods provided to the rest of the world valued in current U.S. dollars.
Energy use	Use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport, all converted into oil equivalents.
Energy production	Forms of primary energy--petroleum (crude oil, natural gas liquids, and oil from nonconventional sources), natural gas, solid fuels (coal, lignite, and other derived fuels), and combustible renewables and waste--and primary electricity, all converted into oil equivalents.

Table S4. Fixed effect regressions of economic variables on the coincident sequences of different compositions of LCLU outcomes of bare ground gain (2001-2012).

	GDP	Imports	Exports	Energy Use	Energy Produce
	coincident	coincident	coincident	coincident	coincident
Anthropogenic BGG	0.049*** (0.017)	0.090*** (0.026)	0.089*** (0.024)	0.018*** (0.005)	0.016*** (0.006)
N	48	48	48	44	44
R-sq	0.17	0.22	0.25	0.24	0.17
F statistic	8.67	11.83	14.33	12.48	8.10
ID + CR + TR	0.033** (0.013)	0.053** (0.022)	0.050** (0.020)	0.016*** (0.005)	0.012** (0.005)
N	48	48	48	44	44
R-sq	0.13	0.12	0.13	0.22	0.12
F statistic	6.25	5.96	6.33	11.14	5.13
ID + CR	0.033** (0.013)	0.048** (0.022)	0.044** (0.020)	0.016*** (0.005)	0.012** (0.005)
N	48	48	48	44	44
R-sq	0.12	0.10	0.10	0.23	0.12
F statistic	5.97	4.88	4.85	11.72	5.16
CR	0.027** (0.011)	0.044** (0.019)	0.040** (0.017)	0.014*** (0.004)	0.013** (0.004)
N	47	47	47	44	44
R-sq	0.12	0.12	0.12	0.29	0.22
F statistic	5.98	5.70	5.56	15.59	11.10
ID	0.011 (0.011)	0.018 (0.018)	0.018 (0.017)	0.005 (0.004)	0.001 (0.004)
N	48	48	48	44	44
R-sq	0.02	0.02	0.03	0.04	0.00
F statistic	0.94	0.93	1.18	1.61	0.12
RE	0.028** (0.011)	0.051*** (0.018)	0.043** (0.016)	0.009** (0.003)	0.004 (0.004)
N	46	46	46	42	42
R-sq	0.14	0.17	0.14	0.15	0.04
F statistic	6.89	8.23	6.83	6.75	1.40

Notes: *** Significant at the p<0.01 level. ** Significant at the p<0.05 level. * Significant at the p<0.1 level.

Table S5. Fixed effect regressions of economic variables on the coincident sequences or 1yr-lagged sequences of different compositions of LCLU outcomes of bare ground gain (2001-2010).

Notes: *** Significant at the $p < 0.01$ level. ** Significant at the $p < 0.05$ level. * Significant at the $p < 0.1$ level.

	GDP			Merchandise Imports		Merchandise Exports		Energy Use		Energy Production	
	coincident	lag (1)		coincident	lag (1)	coincident	lag (1)	coincident	lag (1)	coincident	lag (1)
Anthropogenic BGG	0.053***	0.064***		0.108***	0.097***	0.110***	0.088***	0.018***	0.013**	0.018***	0.011*
	(0.018)	(0.016)		(0.030)	(0.032)	(0.026)	(0.030)	(0.006)	(0.006)	(0.006)	(0.006)
	40	36		40	36	40	36	40	36	40	36
	R-sq	0.34		0.27	0.22	0.33	0.22	0.23	0.13	0.22	0.09
F statistic	8.42	16.00		13.13	8.96	17.57	8.56	10.75	4.48	9.61	3.01
ID + CR + TR	0.057***	0.066***		0.120***	0.104***	0.120***	0.096***	0.019***	0.013*	0.020***	0.013*
	(0.019)	(0.018)		(0.030)	(0.035)	(0.027)	(0.032)	(0.006)	(0.007)	(0.006)	(0.007)
	40	36		40	36	40	36	40	36	40	36
	R-sq	0.21	0.31		0.22	0.22	0.37	0.23	0.24	0.12	0.24
F statistic	9.27	14.01		15.42	8.86	20.13	9.00	11.24	4.06	11.25	3.70
ID + CR	0.063***	0.070***		0.129***	0.114***	0.128***	0.104***	0.022***	0.016**	0.022***	0.014*
	(0.020)	(0.019)		(0.033)	(0.038)	(0.030)	(0.035)	(0.006)	(0.007)	(0.006)	(0.007)
	40	36		40	36	40	36	40	36	40	36
	R-sq	0.22	0.30		0.30	0.23	0.36	0.23	0.27	0.14	0.27
F statistic	10.03	13.27		15.36	9.16	19.51	9.07	12.64	5.06	13.08	3.39
CR	0.058***	0.068***		0.114***	0.117***	0.111***	0.105***	0.021***	0.017***	0.023***	0.015***
	(0.016)	(0.016)		(0.026)	(0.031)	(0.023)	(0.028)	(0.005)	(0.006)	(0.004)	(0.006)
	40	36		40	36	40	36	40	36	40	36
	R-sq	0.29	0.38		0.36	0.32	0.41	0.31	0.38	0.22	0.45
F statistic	14.03	18.69		20.01	14.76	24.21	13.74	21.36	8.50	28.07	5.49
ID	0.020	0.025*		0.037	0.031	0.038*	0.032	0.005	0.004	0.004	0.003
	(0.014)	(0.014)		(0.024)	(0.027)	(0.032)	(0.024)	(0.004)	(0.005)	(0.004)	(0.005)
	40	36		40	36	40	36	40	36	40	36
	R-sq	0.06	0.09		0.06	0.04	0.08	0.05	0.03	0.02	0.02
F statistic	2.12	3.04		2.42	1.38	3.15	1.75	1.19	0.66	0.63	0.39
RE	0.031***	0.025**		0.053**	0.039*	0.045**	0.029	0.010**	0.005	0.005	-0.002
	(0.011)	(0.010)		(0.020)	(0.022)	(0.019)	(0.020)	(0.004)	(0.004)	(0.004)	(0.004)
	38	34		38	34	38	34	38	34	38	34
	R-sq	0.19	0.17		0.17	0.099	0.15	0.07	0.18	0.05	0.04
F statistic	7.93	6.02		6.87	3.19	5.79	2.06	7.31	1.54	1.36	0.34

