

Supplementary Materials

A pixel level evaluation of five multitemporal global gridded population datasets: a case study in Sweden, 1990-2015

Population and Environment

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Table A1 Comparison statistics for cell by cell comparison by dataset and year

Dataset	Year	%MAE	%RMSE	Pearson's r	Percent correct		
					Total	Populated	Unpopulated
GHS-POP	1990	0.76	6.15	0.81	76.3	21.6	95.4
	2000	0.75	6.06	0.83	77.1	24.3	95.3
	2015	0.72	5.84	0.85	81.3	28.9	96.4
GPWv4	2000	1.29	9.61	0.65	18.9	99.8	3.8
	2005	1.28	9.56	0.66	18.8	99.8	3.8
	2010	1.26	9.41	0.68	18.6	99.8	3.8
	2015	1.25	9.57	0.68	16.7	99.9	3.8
GPWv4, UN WPP-adjusted	2000	1.3	9.6	0.65	18.9	99.8	3.8
	2005	1.28	9.56	0.66	18.8	99.8	3.8
	2010	1.26	9.41	0.68	18.6	99.8	3.8
	2015	1.25	9.57	0.68	16.7	99.9	3.8
GRUMP	1990	1.47	10.97	0.45	18.5	99.3	3.6
	1995	1.44	11.05	0.45	18.6	99.3	3.6
	2000	1.43	11.25	0.46	18.6	99.3	3.6
GRUMP, UN WPP-adjusted	1990	1.45	10.97	0.45	18.5	99.3	3.6
	1995	1.44	11.05	0.45	18.6	99.3	3.6
	2000	1.43	11.25	0.46	18.6	99.3	3.6
LandScan	2000	1.13	10.5	0.61	63.6	86.8	59.3
	2005	0.87	8.97	0.71	84.6	74.3	86.5
	2010	0.81	8.61	0.74	87.8	66.7	91.7
	2015	0.77	8.62	0.75	88.5	69.7	91.4
WorldPop	2000	0.89	7.56	0.81	18.2	99.9	3
	2005	0.88	7.38	0.81	18.1	99.9	3
	2010	0.85	7.43	0.82	17.9	99.9	3
	2015	0.75	7.29	0.83	16	99.9	2.9

Table A2 Comparison statistics for cell by cell comparison by dataset, year and population density for three density cutoffs

Dataset	Year	Density	Average population density for Sweden: 22 people/km ²				Average global population density: 50 people/km ²				Average of average country population density: 382 people/km ²			
			%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct
GHS-POP	1990	High	0.62	1.54	0.82	53.1	0.57	1.12	0.8	76.3	0.45	0.68	0.74	98.1
		Low	1.88	10.14	0.05	11.5	1.69	7.7	0.09	14.3	1.42	5.86	0.39	18.6
		Zero	-	-	-	95.4	-	-	-	95.4	-	-	-	95.4
	2000	High	0.59	1.51	0.84	56.2	0.54	1.11	0.83	78.1	0.43	0.67	0.78	98.4
		Low	2.07	11.69	0.04	13.8	1.79	8.35	0.08	16.8	1.43	5.78	0.36	21.4
		Zero	-	-	-	95.3	-	-	-	95.3	-	-	-	95.3
	2015	High	0.57	1.45	0.86	59.6	0.52	1.07	0.85	80	0.41	0.65	0.83	98.7
		Low	2.11	11.35	0.05	16.6	1.84	8.5	0.08	20.2	1.44	5.74	0.35	25.5
		Zero	-	-	-	96.4	-	-	-	96.4	-	-	-	96.4
GPWv4	2000	High	0.79	2.31	0.69	100	0.77	1.7	0.69	100	0.73	1.07	0.68	100
		Low	2.77	10.23	0.06	99.8	1.94	6.59	0.07	99.8	1.4	4.2	0.17	99.8
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
	2005	High	0.79	2.29	0.69	99.9	0.76	1.69	0.69	100	0.72	1.06	0.68	100
		Low	2.86	10.67	0.05	99.8	2.02	7.13	0.08	99.8	1.43	4.33	0.17	99.8
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
	2010	High	0.78	2.24	0.71	99.9	0.75	1.66	0.71	100	0.71	1.04	0.7	100
		Low	2.94	11.37	0.06	99.8	2.08	7.5	0.08	99.8	1.45	4.53	0.18	99.8
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
	2015	High	0.78	2.27	0.71	100	0.75	1.69	0.71	100	0.71	1.06	0.69	100

Dataset	Year	Density	Average population density for Sweden: 22 people/km ²				Average global population density: 50 people/km ²				Average of average country population density: 382 people/km ²			
			%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct
GPWv4, UN WPP- adjusted		Low	2.62	9.85	0.05	99.8	1.92	6.76	0.07	99.9	1.39	4.25	0.18	99.9
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
		High	0.79	2.3	0.69	100	0.77	1.7	0.69	100	0.73	1.07	0.68	100
	2000	Low	2.83	10.42	0.06	99.8	1.98	6.72	0.07	99.8	1.41	4.27	0.17	99.8
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
		High	0.79	2.29	0.69	99.9	0.76	1.69	0.69	100	0.72	1.06	0.68	100
	2005	Low	2.85	10.65	0.05	99.8	2.02	7.12	0.08	99.8	1.42	4.32	0.17	99.8
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
		High	0.78	2.24	0.71	99.9	0.75	1.66	0.71	100	0.71	1.04	0.7	100
	2010	Low	2.93	11.33	0.06	99.8	2.07	7.47	0.08	99.8	1.45	4.52	0.18	99.8
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
		High	0.78	2.28	0.71	100	0.75	1.69	0.71	100	0.71	1.06	0.69	100
	2015	Low	2.61	9.82	0.05	99.8	1.92	6.74	0.07	99.9	1.39	4.24	0.18	99.9
		Zero	-	-	-	3.8	-	-	-	3.8	-	-	-	3.8
		High	0.88	2.66	0.48	99.5	0.84	1.95	0.47	99.5	0.84	1.24	0.43	99.6
GRUMP	1990	Low	3.34	9.64	0.08	99.2	2.38	6.58	0.12	99.3	1.57	4.13	0.18	99.3
		Zero	-	-	-	3.6	-	-	-	3.6	-	-	-	3.6
		High	0.88	2.7	0.48	99.5	0.84	1.99	0.47	99.5	0.83	1.26	0.43	99.7
	1995	Low	3.39	10.37	0.08	99.2	2.39	6.9	0.11	99.2	1.57	4.26	0.17	99.3
		Zero	-	-	-	3.6	-	-	-	3.6	-	-	-	3.6
		High	0.88	2.74	0.49	99.5	0.84	2.02	0.48	99.5	0.83	1.28	0.44	99.7
	2000	High	0.88	2.74	0.49	99.5	0.84	2.02	0.48	99.5	0.83	1.28	0.44	99.7

Dataset	Year	Density	Average population density for Sweden: 22 people/km ²				Average global population density: 50 people/km ²				Average of average country population density: 382 people/km ²			
			%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct
GRUMP, UN WPP- adjusted		Low	3.41	10.69	0.08	99.2	2.41	7.09	0.11	99.2	1.58	4.39	0.18	99.3
		Zero	-	-	-	3.6	-	-	-	3.6	-	-	-	3.6
		High	0.88	2.66	0.48	99.5	0.85	1.95	0.47	99.5	0.84	1.25	0.43	99.6
	1990	Low	3.24	9.37	0.08	99.2	2.31	6.39	0.12	99.3	1.54	4.02	0.18	99.3
		Zero	-	-	-	3.6	-	-	-	3.6	-	-	-	3.6
		High	0.88	2.7	0.48	99.5	0.84	1.99	0.47	99.5	0.83	1.26	0.43	99.7
	1995	Low	3.38	10.36	0.08	99.2	2.39	6.89	0.11	99.2	1.57	4.25	0.17	99.3
		Zero	-	-	-	3.6	-	-	-	3.6	-	-	-	3.6
		High	0.88	2.74	0.49	99.5	0.84	2.02	0.48	99.5	0.83	1.28	0.44	99.7
	2000	Low	3.41	10.68	0.08	99.2	2.41	7.08	0.11	99.2	1.58	4.38	0.18	99.3
		Zero	-	-	-	3.6	-	-	-	3.6	-	-	-	3.6
		High	0.84	2.48	0.62	90.8	0.8	1.81	0.6	92.1	0.7	1.1	0.52	94.6
	2005	Low	2.45	15.58	0.03	84.5	1.94	10.49	0.05	85.7	1.63	7.06	0.19	86.4
		Zero	-	-	-	59.3	-	-	-	59.3	-	-	-	59.3
		High	0.69	2.18	0.7	88.3	0.65	1.61	0.68	94.2	0.55	1	0.57	100
LandScan	2000	Low	2.16	10.23	0.04	66.1	1.77	7.13	0.09	69.9	1.47	4.92	0.44	72.8
		Zero	-	-	-	86.5	-	-	-	86.5	-	-	-	86.5
		High	0.66	2.1	0.73	85.1	0.62	1.55	0.71	92.8	0.52	0.95	0.63	99.9
	2010	Low	1.98	10.17	0.05	55.8	1.68	6.88	0.11	60.7	1.42	4.99	0.47	64.7
		Zero	-	-	-	91.7	-	-	-	91.7	-	-	-	91.7
		High	0.64	2.1	0.74	84.9	0.6	1.55	0.72	92.8	0.5	0.96	0.64	99.8

Dataset	Year	Density	Average population density for Sweden: 22 people/km ²				Average global population density: 50 people/km ²				Average of average country population density: 382 people/km ²			
			%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct	%MAE	%RMSE	Pearson's r	Percent correct
WorldPop		Low	1.77	8.27	0.04	58.5	1.56	6.26	0.1	63.4	1.35	4.59	0.49	67.5
		Zero	-	-	-	91.4	-	-	-	91.4	-	-	-	91.4
		High	0.61	1.81	0.82	99.9	0.58	1.33	0.81	99.9	0.52	0.83	0.77	99.9
	2000	Low	2.13	9.72	0.05	99.9	1.61	6.23	0.09	99.9	1.24	4.18	0.31	99.9
		Zero	-	-	-	3	-	-	-	3	-	-	-	3
		High	0.6	1.76	0.83	99.9	0.57	1.3	0.82	99.9	0.51	0.81	0.78	99.9
	2005	Low	2.1	9.56	0.05	99.9	1.6	6.28	0.09	99.9	1.23	4.19	0.33	99.9
		Zero	-	-	-	3	-	-	-	3	-	-	-	3
		High	0.59	1.77	0.83	99.9	0.56	1.3	0.82	99.9	0.5	0.81	0.78	99.9
	2010	Low	2.1	10.59	0.04	99.9	1.61	6.95	0.08	99.9	1.23	4.43	0.32	99.9
		Zero	-	-	-	3	-	-	-	3	-	-	-	3
		High	0.55	1.73	0.84	99.9	0.52	1.27	0.83	99.9	0.45	0.78	0.79	99.9
	2015	Low	1.56	9.13	0.03	100	1.33	6.62	0.07	99.9	1.12	4.42	0.35	99.9
		Zero	-	-	-	2.9	-	-	-	2.9	-	-	-	2.9
		High	0.55	1.73	0.84	99.9	0.52	1.27	0.83	99.9	0.45	0.78	0.79	99.9

Table A3 Comparison statistics for cell by cell comparison by dataset, year and population change

Dataset (reference year)	Year	Change	All cells						Only known populated cells			
			%MAE	%RMSE	Pearson's r	Percent correct			%MAE	%RMSE	Pearson's r	Percentage populated correct
						Total	Populated	Un- populated				
GHS-POP (1990)	2000	Decline	0.8	3.11	0.75	36.2	26.5	93.2	0.78	2.83	0.76	26.5
		Growth	0.62	2.7	0.87	26	26	-	0.62	2.7	0.87	26
		Stable	4.54	87.34	0.23	91.5	12.3	95.4	1.7	10.12	0.39	12.3
	2015	Decline	0.92	4.15	0.72	53.1	29.2	92.2	0.86	3.14	0.73	29.2
		Growth	0.58	2.34	0.88	29.9	29.9	-	0.58	2.34	0.88	29.9
		Stable	7.49	151.25	0.16	95.3	17.6	96.7	1.62	9.61	0.3	17.6
GPWv4 (2000)	2005	Decline	0.93	3.51	0.65	84.4	99.9	0.6	0.89	3.21	0.65	99.9
		Growth	0.83	3.23	0.7	99.8	99.8	-	0.83	3.23	0.7	99.8
		Stable	13.15	72.85	0.28	8.2	99.8	3.9	1.87	6.69	0.56	99.8
	2010	Decline	1.01	4.29	0.67	72.5	99.9	0.5	0.92	3.6	0.67	99.9
		Growth	0.84	3.21	0.72	99.8	99.8	-	0.84	3.21	0.72	99.8
		Stable	27.27	156.3	0.07	6.1	99.9	3.9	2.05	6.77	0.18	99.9
	2015	Decline	1.08	4.51	0.66	56.9	99.9	0.4	0.91	3.3	0.68	99.9
		Growth	0.83	3.23	0.71	99.9	99.9	-	0.83	3.23	0.71	99.9
		Stable	33.88	201.54	0.09	5	99.9	3.9	1.51	4.8	0.39	99.9
GPWv4, UN WPP-adjusted (2000)	2005	Decline	0.93	3.51	0.65	84.4	99.9	0.6	0.89	3.21	0.65	99.9
		Growth	0.83	3.23	0.7	99.8	99.8	-	0.83	3.23	0.7	99.8
		Stable	13.12	72.7	0.28	8.2	99.8	3.9	1.87	6.68	0.56	99.8
	2010	Decline	1.01	4.29	0.67	72.5	99.9	0.5	0.92	3.6	0.67	99.9

Dataset (reference year)	Year	Change	All cells						Only known populated cells			
			%MAE	%RMSE	Pearson's r	Percent correct			%MAE	%RMSE	Pearson's r	Percentage populated correct
						Total	Populated	Un- populated				
	2015	Growth	0.84	3.22	0.72	99.8	99.8	-	0.84	3.22	0.72	99.8
		Stable	27.17	155.75	0.07	6.1	99.9	3.9	2.04	6.75	0.18	99.9
		Decline	1.08	4.5	0.66	56.9	99.9	0.4	0.91	3.3	0.68	99.9
		Growth	0.83	3.24	0.71	99.9	99.9	-	0.83	3.24	0.71	99.9
		Stable	33.76	200.87	0.09	5	99.9	3.9	1.51	4.8	0.39	99.9
GRUMP (1990)	1995	Decline	1.01	3.51	0.41	88.7	99.4	0.9	0.99	3.3	0.41	99.4
		Growth	0.95	4.03	0.51	99.2	99.2	-	0.95	4.03	0.51	99.2
		Stable	13.82	68.57	0.09	8.1	99.2	3.6	2.18	7.13	0.17	99.2
	2000	Decline	1.07	3.81	0.33	82.9	99.4	1	1.03	3.45	0.33	99.4
		Growth	0.95	4.29	0.53	99.1	99.1	-	0.95	4.29	0.53	99.1
		Stable	20.04	104.3	0.13	6.5	99.3	3.6	2.17	7.33	0.3	99.3
GRUMP, UN WPP-adjusted (1990)	1995	Decline	1.01	3.51	0.41	88.7	99.4	0.9	0.99	3.3	0.41	99.4
		Growth	0.95	4.03	0.51	99.2	99.2	-	0.95	4.03	0.51	99.2
		Stable	13.81	68.5	0.09	8.1	99.2	3.6	2.18	7.12	0.17	99.2
	2000	Decline	1.07	3.81	0.33	82.9	99.4	1	1.03	3.45	0.33	99.4
		Growth	0.95	4.29	0.53	99.1	99.1	-	0.95	4.29	0.53	99.1
		Stable	20.02	104.2	0.13	6.5	99.3	3.6	2.17	7.32	0.3	99.3
LandScan (2000)	2005	Decline	0.77	3.27	0.7	74.2	78.1	52.8	0.75	2.98	0.7	78.1
		Growth	0.73	3.11	0.71	76.2	76.2	-	0.73	3.11	0.71	76.2
		Stable	4.53	52.93	0.34	86	65.9	86.9	1.51	6.76	0.52	65.9

Dataset (reference year)	All cells								Only known populated cells			
	Year	Change	%MAE	%RMSE	Pearson's r	Percent correct			%MAE	%RMSE	Pearson's r	Percentage populated correct
						Total	Populated	Un- populated				
	2010	Decline	0.82	3.84	0.74	67.7	70.2	60.9	0.77	3.23	0.75	70.2
		Growth	0.69	3.07	0.73	66.9	66.9	-	0.69	3.07	0.73	66.9
		Stable	5.96	80.66	0.27	91.7	54.5	92.6	1.4	5.02	0.55	54.5
	2015	Decline	0.82	4.18	0.73	67.7	73.8	59.6	0.74	3.08	0.74	73.8
		Growth	0.65	2.96	0.76	67.8	67.8	-	0.65	2.96	0.76	67.8
		Stable	6.63	102.31	0.4	92.5	62.4	92.9	1.15	3.92	0.76	62.4
WorldPop (2000)	2005	Decline	0.71	2.8	0.8	84.5	99.9	0.1	0.68	2.54	0.8	99.9
		Growth	0.63	2.46	0.84	99.9	99.9	-	0.63	2.46	0.84	99.9
		Stable	6.81	52.24	0.28	7.4	100	3	1.39	5.84	0.48	100
	2010	Decline	0.76	3.27	0.8	72.5	100	0.1	0.69	2.71	0.81	100
		Growth	0.63	2.62	0.84	99.9	99.9	-	0.63	2.62	0.84	99.9
		Stable	13.39	108.01	0.15	5.3	100	3.1	1.49	6.79	0.3	100
	2015	Decline	0.76	3.49	0.8	56.8	100	0.1	0.65	2.52	0.81	100
		Growth	0.57	2.46	0.85	99.9	99.9	-	0.57	2.46	0.85	99.9
		Stable	13.34	149.87	0.14	4.2	100	3.1	0.98	4.08	0.45	100

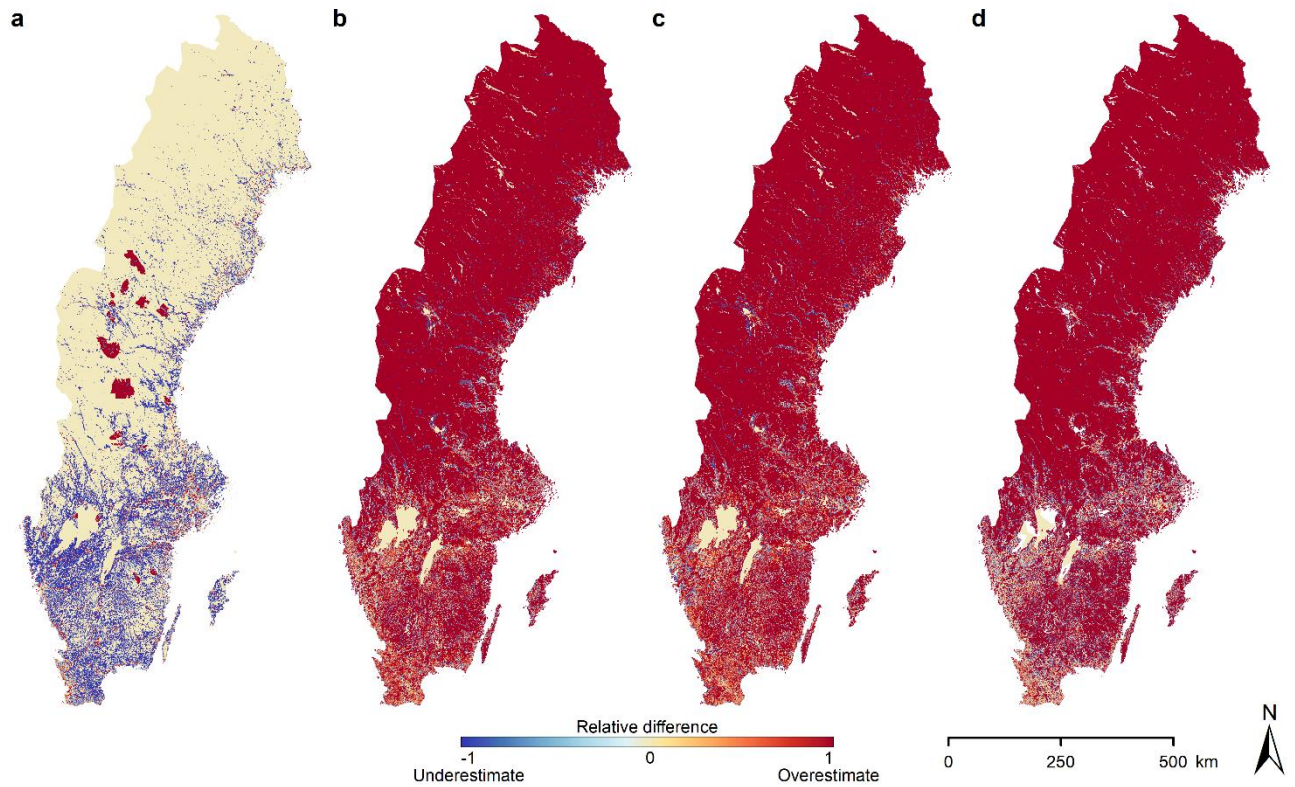


Fig. A1 Relative differences between candidate populations and the known population.

(a) GHS-POP 2015, (b) GPWv4 2015, (c) GRUMP 2000, (d) WorldPop 2015. GPWv4 and GRUMP UN WPP-adjusted have been excluded because the distribution was very similar to that of the unadjusted datasets.