Supplementary information

Fig. S1 – The following figure provides a regional aggregation of urban centre exposure instance totals to cumulative chronic flooding. Plots are illustrated in (a), with (b) including a total count of centres within each region by size class in addition to their respective total population and GDP. Note the population axis labels are not standardised, rather the plot highlights the shifting distributions between income groups across centre classes.

a)

Distribution of population and exposure by region and urban centre class
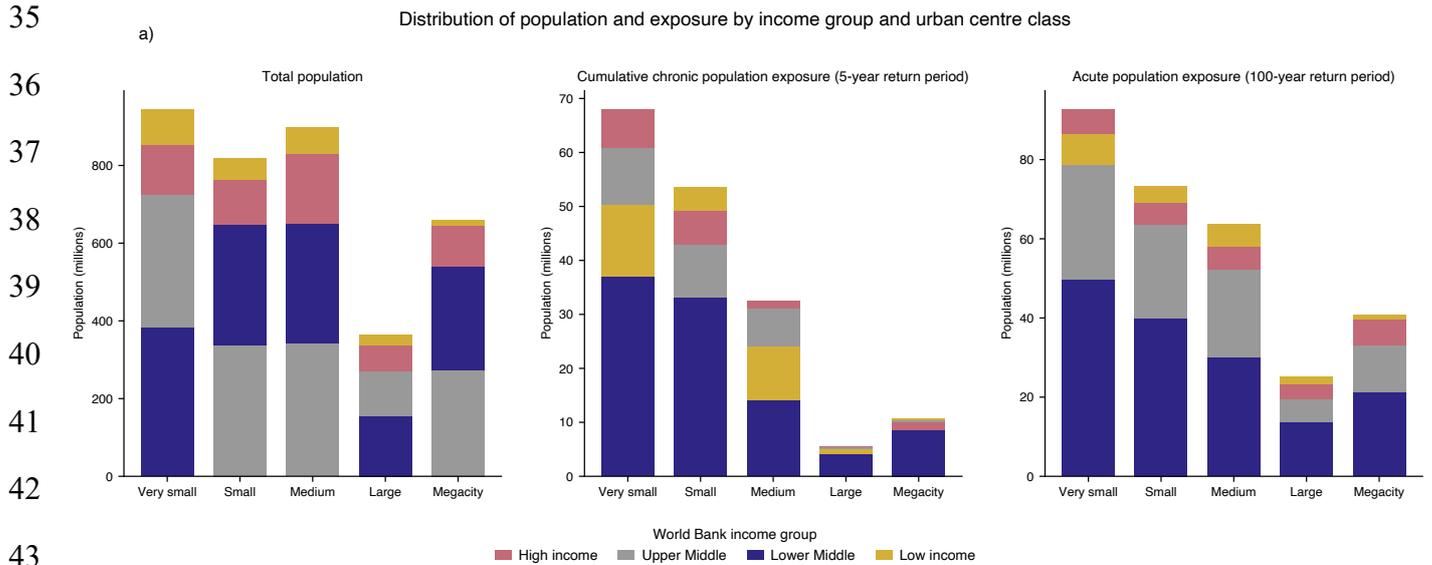
b)
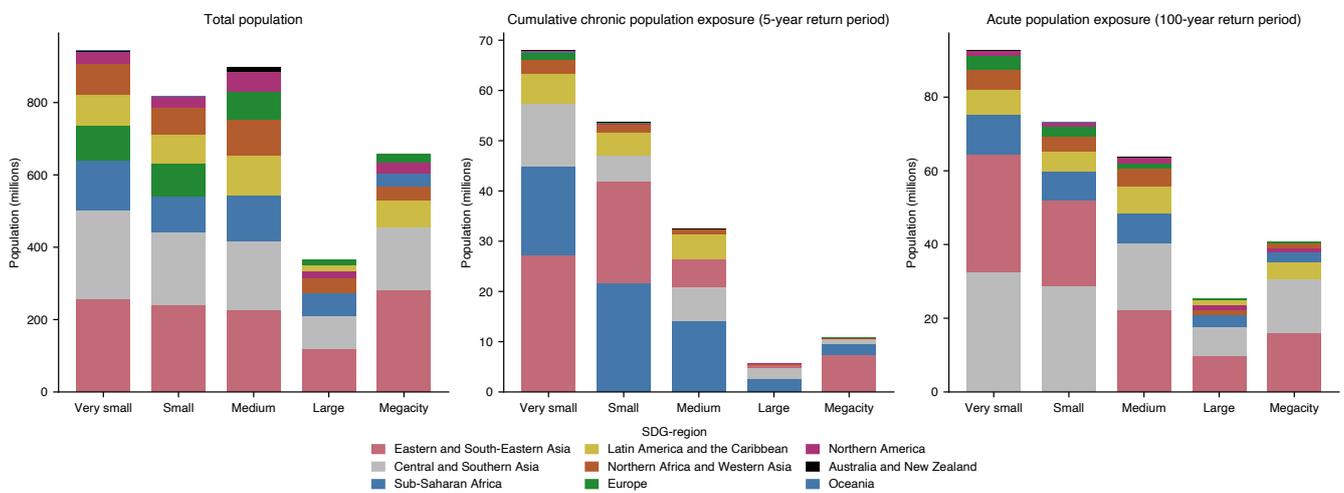
Sustainable development goal region	Urban centre size	Total urban centre count	Total population (urban centres)	Total flooded centres (count)	Cumulative chronic population exposure	Cumulative chronic economic exposure
Australia and New Zealand	Large	NaN	NaN	NaN	NaN	NaN
Australia and New Zealand	Megacity	NaN	NaN	NaN	NaN	NaN
Australia and New Zealand	Very small	35	3,332,876	22	20,529	870,572,783
Australia and New Zealand	Medium	5	12,723,282	5	20,358	844,035,603
Australia and New Zealand	Small	4	1,996,515	4	7,527	338,688,643
Central and Southern Asia	Very small	2346	244,352,584	1,682	12,445,972	59,370,583,121
Central and Southern Asia	Medium	92	188,931,601	90	6,725,712	46,736,395,185
Central and Southern Asia	Small	436	199,405,937	381	5,004,121	26,939,921,723
Central and Southern Asia	Large	13	90,605,973	13	2,063,132	14,664,601,578
Central and Southern Asia	Megacity	8	174,456,553	8	882,153	9,945,221,892
Eastern and South-Eastern Asia	Very small	2466	257,430,109	1,759	27,166,401	226,816,170,417
Eastern and South-Eastern Asia	Small	510	241,376,196	455	20,432,562	402,628,969,343
Eastern and South-Eastern Asia	Megacity	12	282,039,992	12	7,415,834	143,046,285,123
Eastern and South-Eastern Asia	Medium	112	227,296,717	109	5,608,812	162,121,772,732
Eastern and South-Eastern Asia	Large	17	118,823,834	17	591,394	12,194,531,801
Europe	Very small	928	95,350,932	139	1,398,152	44,481,770,295
Europe	Medium	42	78,527,167	17	58,065	1,753,268,591
Europe	Small	191	88,273,674	56	56,216	1,506,000,637
Europe	Megacity	2	24,788,572	1	11,243	607,465,094
Europe	Large	2	15,006,156	1	118	5,573,817
Latin America and the Caribbean	Very small	851	86,122,166	531	6,100,994	103,414,746,051
Latin America and the Caribbean	Medium	54	111,317,039	51	4,980,480	66,943,608,190
Latin America and the Caribbean	Small	177	81,667,702	137	4,678,011	26,730,266,609
Latin America and the Caribbean	Megacity	5	72,540,531	5	189,661	4,125,533,338
Latin America and the Caribbean	Large	2	16,484,646	2	113,394	2,329,776,184
Northern Africa and Western Asia	Very small	826	85,170,144	397	2,712,603	21,361,201,424
Northern Africa and Western Asia	Small	154	73,499,190	118	1,471,357	13,128,946,850
Northern Africa and Western Asia	Medium	50	98,096,662	47	861,969	12,130,020,351
Northern Africa and Western Asia	Large	6	41,641,719	6	105,409	1,414,744,576
Northern Africa and Western Asia	Megacity	2	39,436,155	2	32,542	585,784,063
Northern America	Small	62	29,032,302	20	275,948	15,141,365,962
Northern America	Very small	306	32,017,410	70	201,154	13,350,875,582
Northern America	Megacity	2	27,668,266	2	133,562	11,109,520,656
Northern America	Medium	25	53,540,876	16	47,169	3,416,856,872
Northern America	Large	3	16,614,303	2	3,501	193,950,926
Oceania	Medium	NaN	NaN	NaN	NaN	NaN
Oceania	Large	NaN	NaN	NaN	NaN	NaN
Oceania	Megacity	NaN	NaN	NaN	NaN	NaN
Oceania	Very small	17	1,672,683	17	266,142	1,258,693,833
Oceania	Small	1	442,162	1	113,122	1,225,543,448
Sub-Saharan Africa	Small	225	101,781,298	208	21,572,497	99,702,485,311
Sub-Saharan Africa	Very small	1363	139,422,875	988	17,706,183	63,836,863,012
Sub-Saharan Africa	Medium	57	127,088,244	54	14,155,762	44,959,947,119
Sub-Saharan Africa	Large	10	65,322,820	10	2,725,737	13,967,196,699
Sub-Saharan Africa	Megacity	3	37,460,301	3	2,087,838	17,382,653,048

Fig. S2 – The following figure provides an income group aggregation of urban centre exposure instance totals to cumulative chronic flooding. Plots are illustrated in (a), with (b) including total count of centres within each region by size class in addition to their respective total population and GDP. Note the population axis labels are not standardised, rather the plot highlights the shifting distributions between income groups across centre classes.

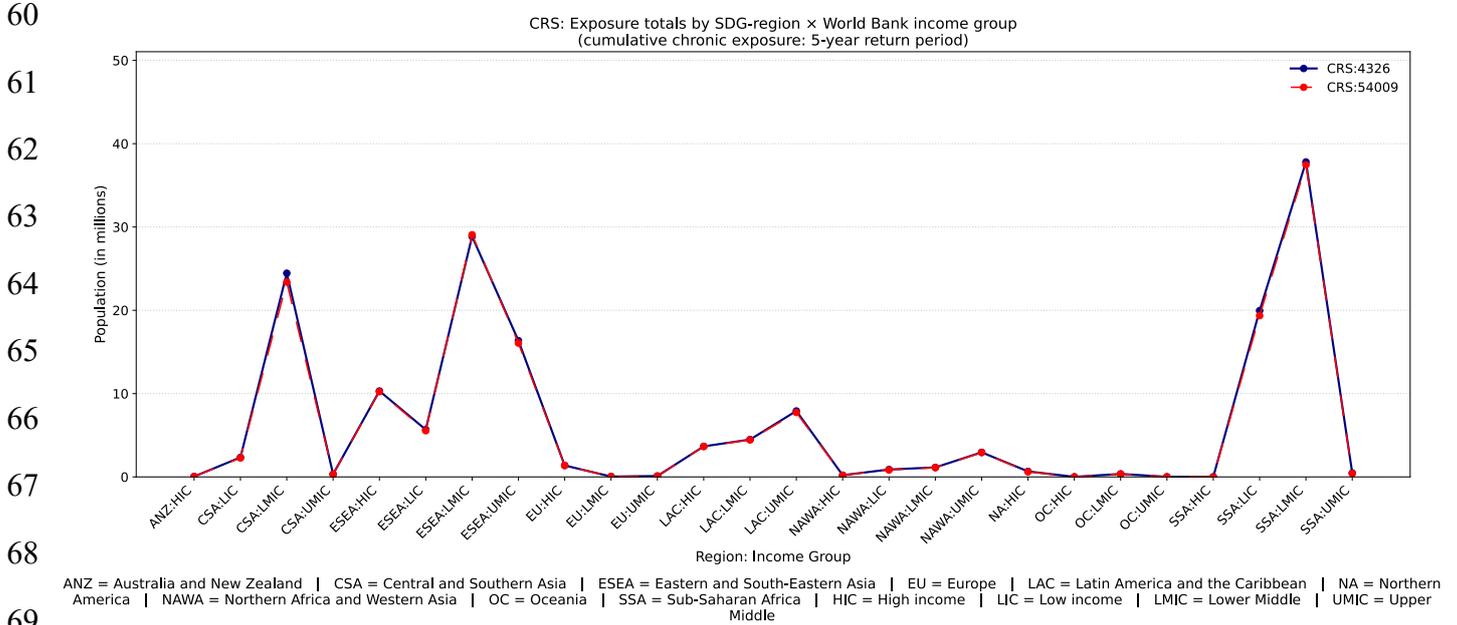a) Distribution of population and exposure by income group and urban centre class

World Bank income group: High income, Upper Middle, Lower Middle, Low income

b)

World Bank development group	Urban centre size	Total urban centre count	Total population (urban centres)	Total flooded centres	Cumulatve chronic population exposure
Low income	Megacity	1	12,944,300	1	295,778
Low income	Large	4	25,822,276	4	996,469
Low income	Small	123	54,175,649	104	4,403,003
Low income	Medium	30	69,099,639	30	9,898,538
Low income	Very small	892	91,074,225	645	13,274,287
Lower Middle	Large	23	154,488,143	23	4,113,806
Lower Middle	Megacity	13	264,673,175	13	8,545,572
Lower Middle	Medium	150	309,226,614	141	14,198,533
Lower Middle	Small	685	310,456,683	606	33,200,222
Lower Middle	Very small	3722	384,510,603	2600	37,091,824
Upper Middle	Large	16	115,445,056	16	350,139
Upper Middle	Megacity	14	274,633,887	13	495,201
Upper Middle	Medium	171	341,332,482	161	7,031,873
Upper Middle	Small	699	336,639,351	563	9,679,868
Upper Middle	Very small	3280	339,974,530	2053	10,582,792
High income	Large	10	68,743,976	8	142,272
High income	Medium	86	177,862,853	57	1,329,383
High income	Megacity	6	106,139,007	6	1,416,284
High income	Small	253	116,203,293	107	6,328,269
High income	Very small	1244	129,312,422	307	7,069,228

57 Fig. S3 – The line plot identifies exposure trends for cumulative chronic flooding

58 because of differences between calculating urban centre population exposure when
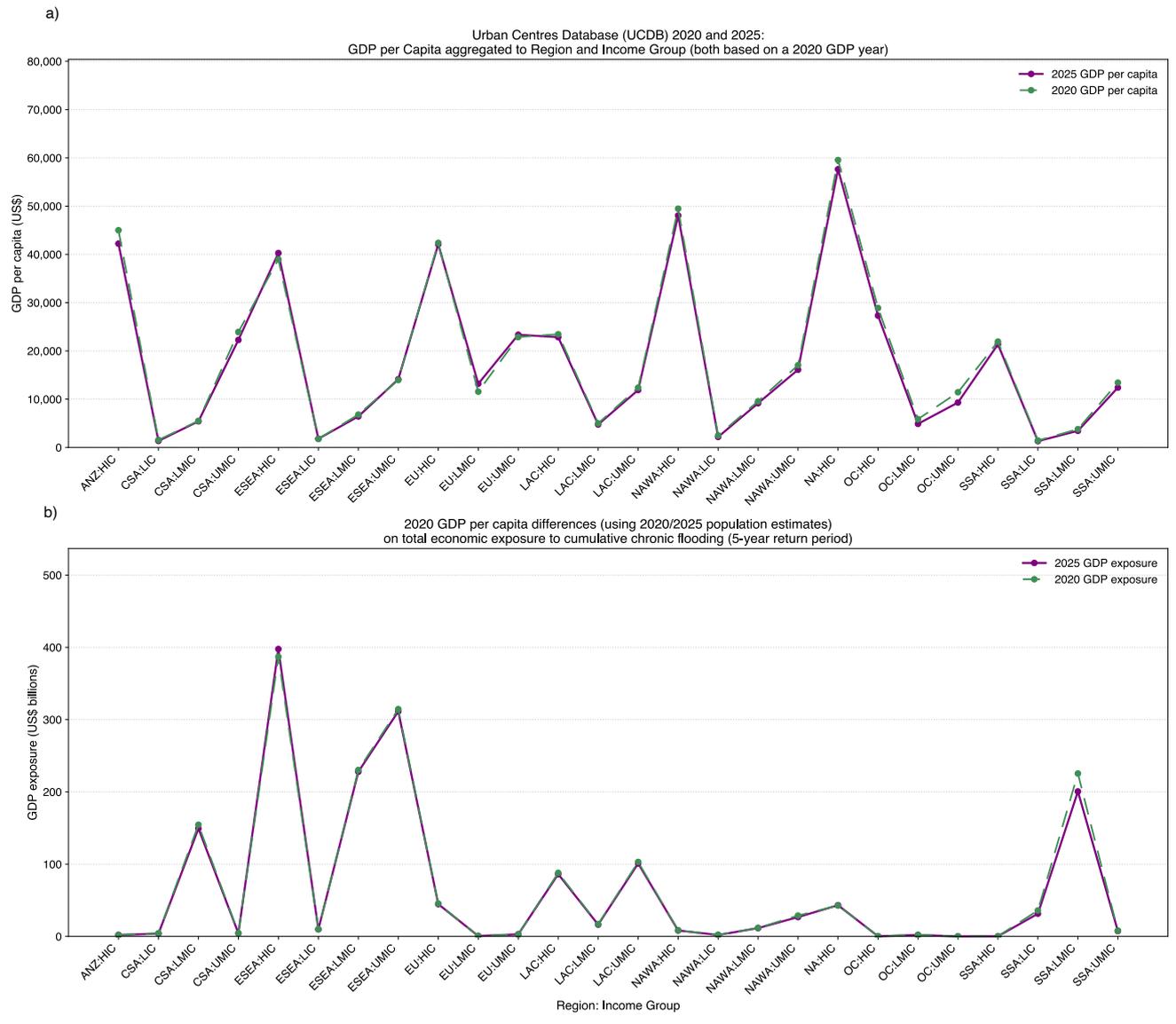
59 using GHS-POP CRS:54009 and GHS-POP CRS:4326.

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CRS: Exposure totals by SDG-region × World Bank income group
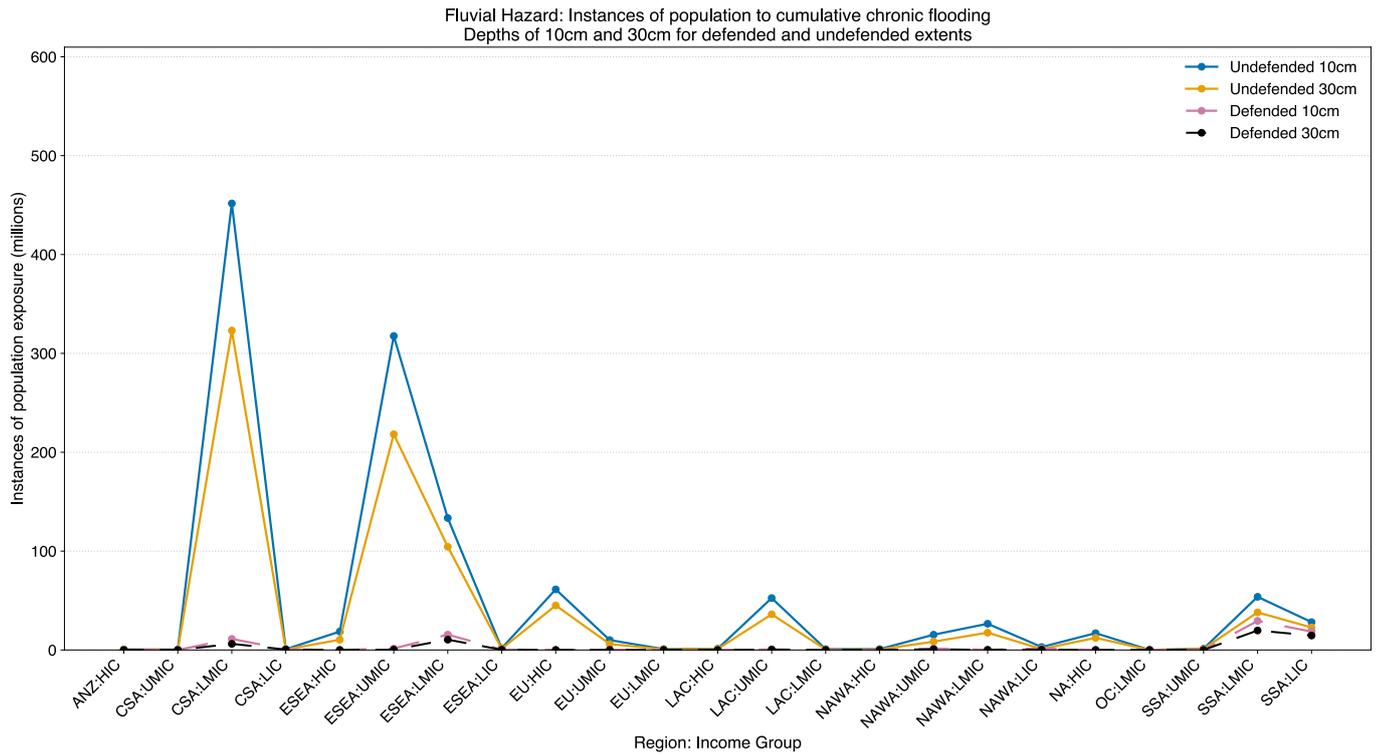(cumulative chronic exposure: 5-year return period)

ANZ = Australia and New Zealand | CSA = Central and Southern Asia | ESEA = Eastern and South-Eastern Asia | EU = Europe | LAC = Latin America and the Caribbean | NA = Northern America | NAWA = Northern Africa and Western Asia | OC = Oceania | SSA = Sub-Saharan Africa | HIC = High income | LIC = Low income | LMIC = Lower Middle | UMIC = Upper Middle

71 Fig. S4 – Plot (a) illustrates the difference in the 2020 GDP per capita when applying

72 it to the 2020 UCDB epoch boundary, or the 2025 UCDB epoch boundary GDP,

73 (aggregated by region: income group). The lower number of total urban centres in

74 2020 predominately drives these changes. A slightly lower 2025 GDP per capita

75 estimate is a result of a larger population in UCDB 2025 than in 2020, when applied

76 on the same 2020 GDP total. The second plot (b) shows how this affects economic

77 exposure totals to cumulative chronic flooding. Item (c) provides summary totals of the

78 differences to plot (a). Trends remain the same, though there are slight under

79 predictions in some regions using the 2025 population totals.

a)

Urban Centres Database (UCDB) 2020 and 2025:
GDP per Capita aggregated to Region and Income Group (both based on a 2020 GDP year)

Legend: 2025 GDP per capita; 2020 GDP per capita

Y-axis: GDP per capita (US$)

b)

2020 GDP per capita differences (using 2020/2025 population estimates)
on total economic exposure to cumulative chronic flooding (5-year return period)

Legend: 2025 GDP exposure; 2020 GDP exposure

Y-axis: GDP exposure (US$ billions)

X-axis: Region: Income Group

ANZ = Australia and New Zealand I CSA = Central and Southern Asia I ESEA = Eastern and South-Eastern Asia I EU = Europe I LAC = Latin America and the Caribbean I NA = Northern America I NAWA = Northern Africa and Western Asia I OC = Oceania I SSA = Sub-Saharan Africa I HIC = High income I LIC = Low income I LMIC = Lower Middle I UMIC = Upper Middle

c)

UCDB datasets	GDP (US$)	Population
2020	68,354,571,742,808	3,489,624,819
2025	68,837,560,354,969	3,682,758,164
count difference (2020 to 2025)	482,988,612,162	193,133,345
% similarity (2020 to 2025)	99	95

Fig. S5 – Plots the differences across regions and income groups when comparing defended and undefended fluvial instances of population exposure. Notably, significant increase is in the highly populated areas of Central South Asia and East and South-Eastern Asia. Relatively Europe sees the greatest increases in exposure, and Sub-Saharan Africa maintains the region where totals differ the least.

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Fig. S6 – (a) Plots the difference in instances of population exposure to cumulative chronic flooding when applying a 10cm and 30cm depth threshold to fluvial pluvial and coastal (defended) hazard. Pluvial registers the greatest increase, equivalent to 329 million (564%) (b). These increases are greatest in Central and South Asia and East and South-Eastern Asia. Though many poorer regions see large increases in exposure estimates.

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a)

Cumulative chronic flooding: Instances of population exposure by flood type and depth
(fluvial, coastal at 10cm and 30cm for 5-year return period)

b)

Cumulative chronic flooding: Instances of population exposure by flood type and depth
(pluvial at 10cm and 30cm for 5-year return period)

ANZ = Australia and New Zealand I CSA = Central and Southern Asia I ESEA = Eastern and South-Eastern Asia I EU = Europe I LAC = Latin America and the Caribbean I NA = Northern America I NAWA = Northern Africa and Western Asia I OC = Oceania I SSA = Sub-Saharan Africa I HIC = High income I LIC = Low income I LMIC = Lower Middle I UMIC = Upper Middle
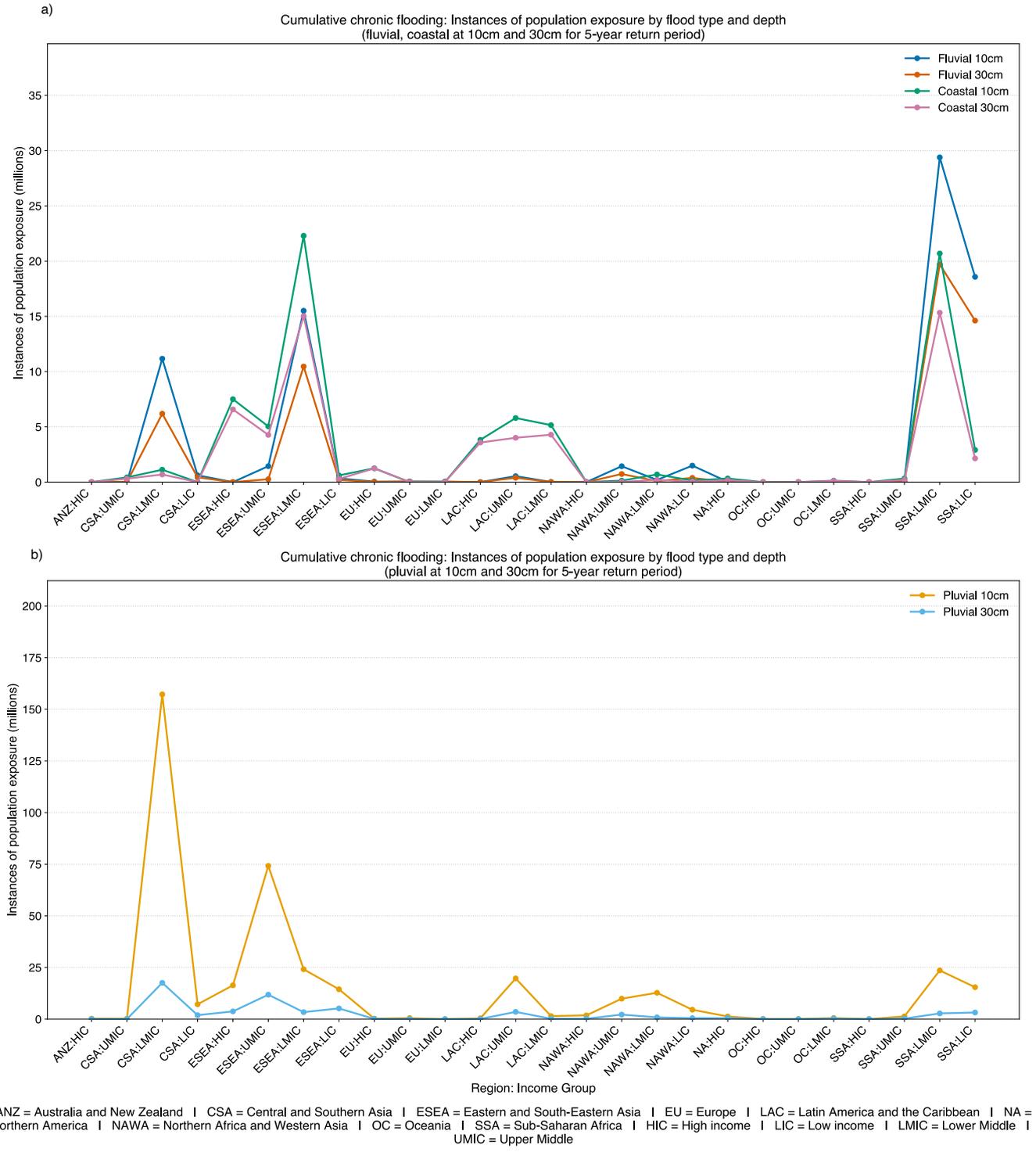
Fig. S7 – Plots the difference in instances of population exposure to cumulative chronic flooding in plot (a) with global totals in item (c), and acute exposure (b) when using a multi-hazard or combined hazard approach to compute inundation extent and subsequent exposure estimates.
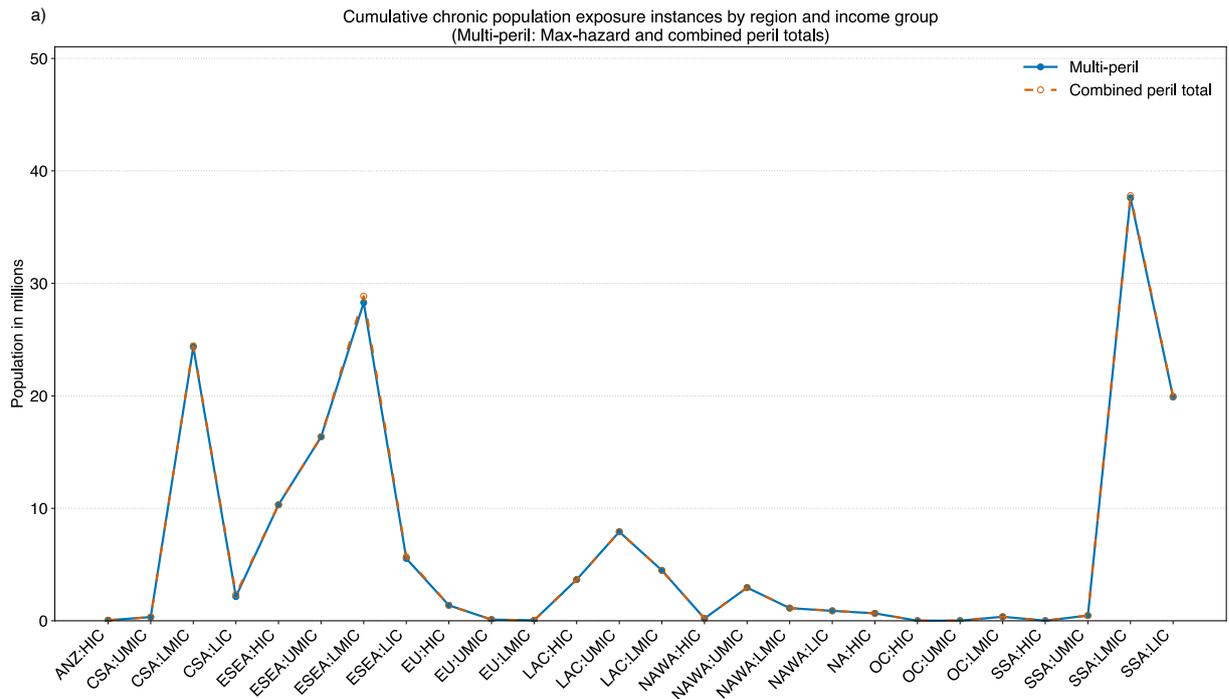
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a)

Cumulative chronic population exposure instances by region and income group
(Multi-peril: Max-hazard and combined peril totals)

b)

Acute population exposure instances by region and income group
(Multi-peril: Max-hazard and combined peril totals)
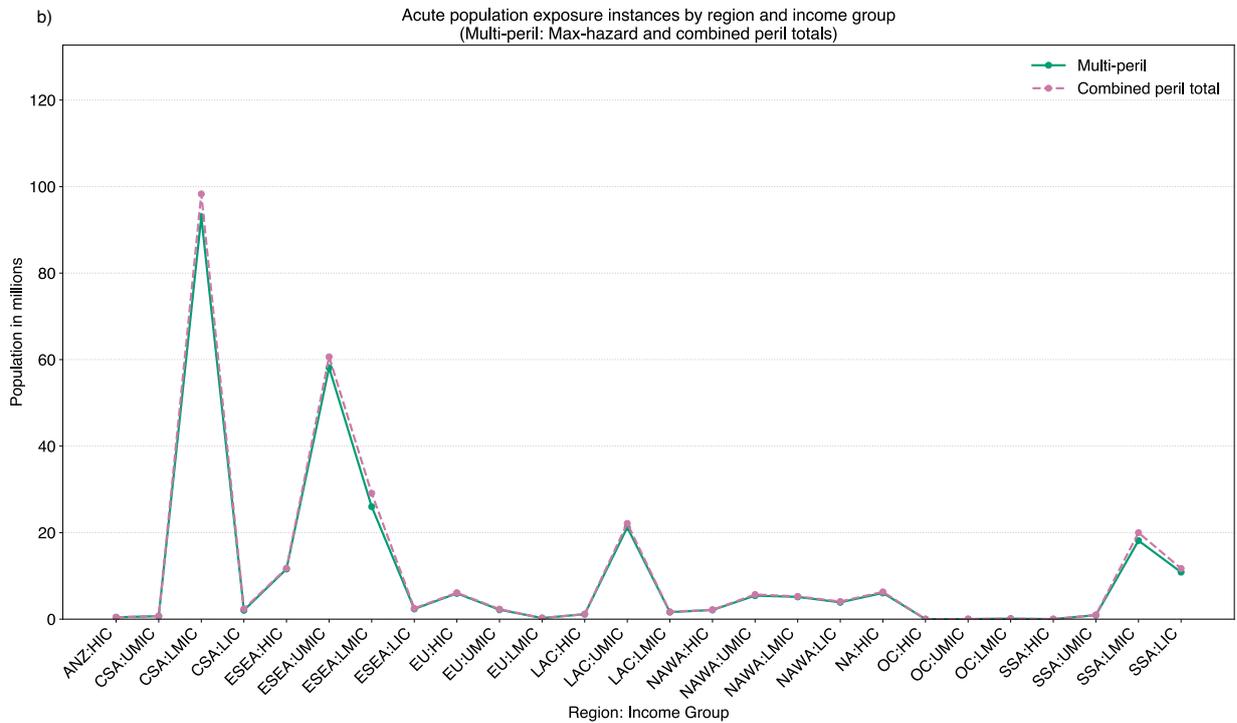
ANZ = Australia and New Zealand | CSA = Central and Southern Asia | ESEA = Eastern and South-Eastern Asia | EU = Europe | LAC = Latin America and the Caribbean |
NA = Northern America | NAWA = Northern Africa and Western Asia | OC = Oceania | SSA = Sub-Saharan Africa | HIC = High income | LIC = Low income | LMIC =
Lower Middle | UMIC = Upper Middle

c)

Cumulative chronic exposure instances

Multi-peril total (millions)	Combined-peril total (millions)	Difference (millions)
169.1	170.4	1.3