

Supplementary Information for the Article

Urban Growth Prediction along Shared Socioeconomic Pathways (SSPs) for Future Flood Exposure Risk Assessment: A Cross-Continental Analysis of Coastal Cities

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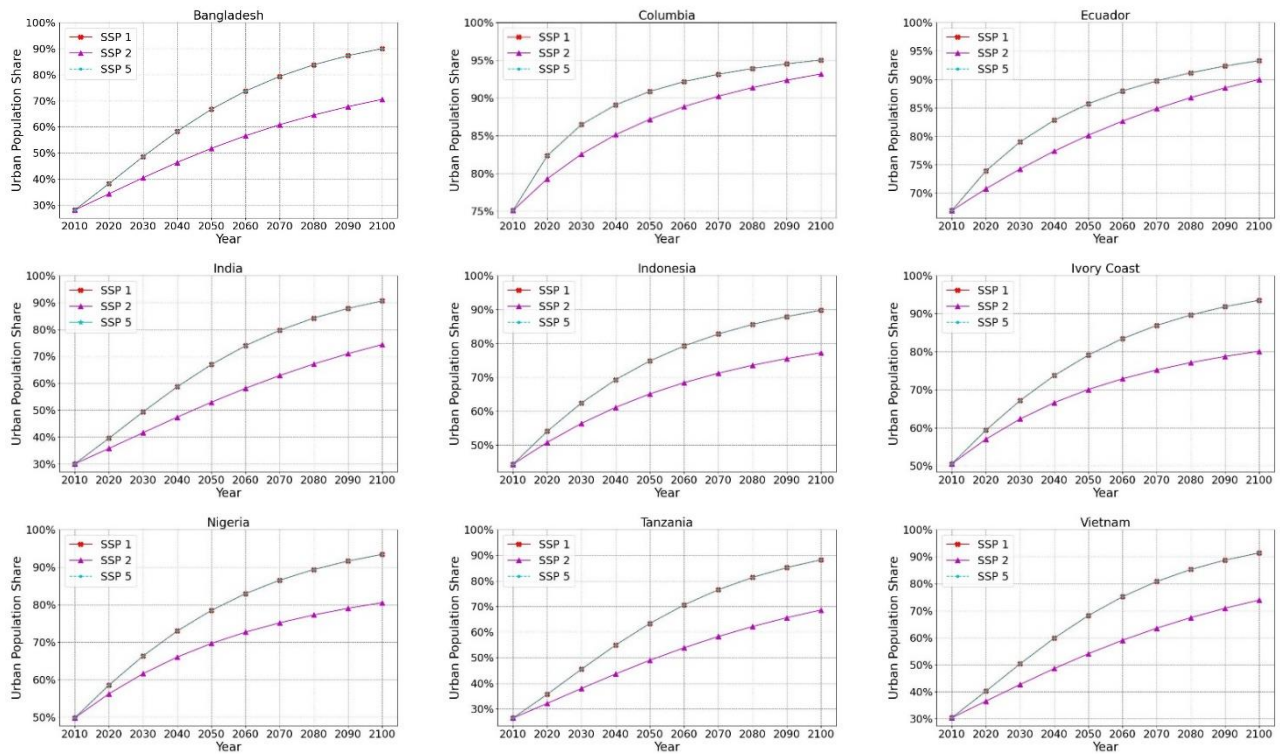
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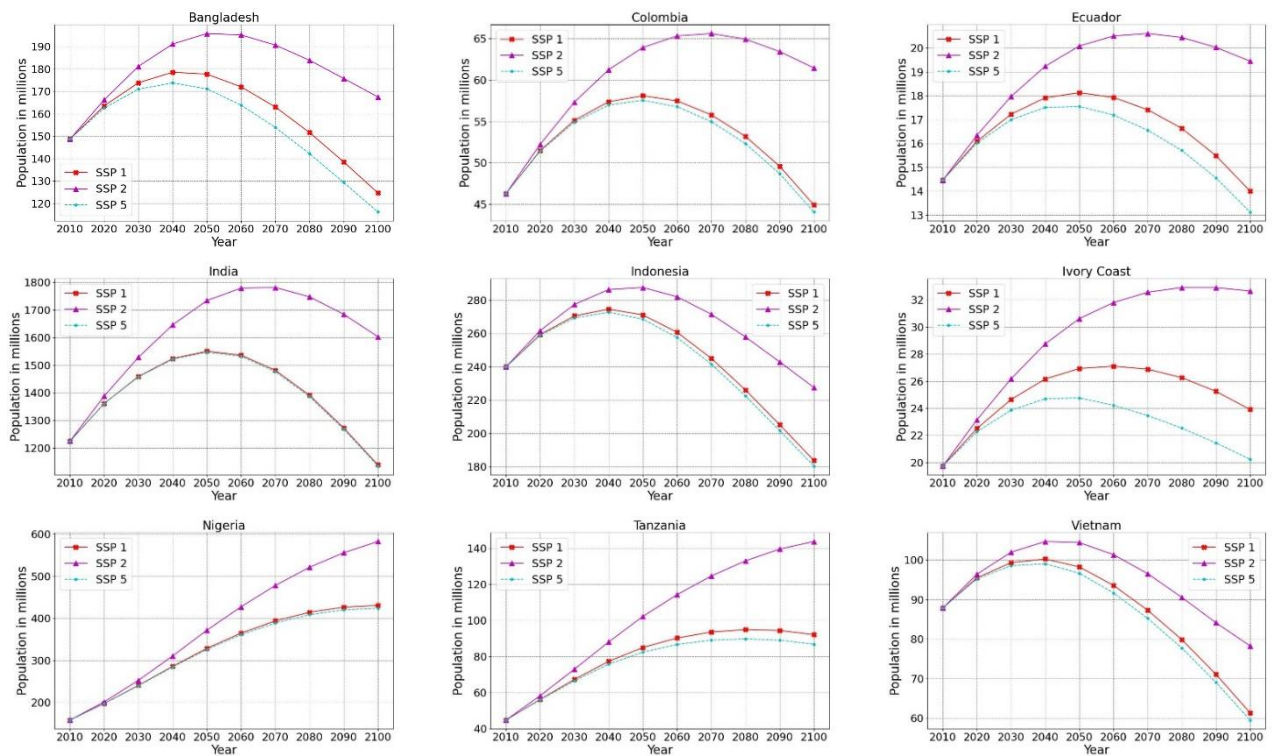
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Supplementary Table 1: Specification and key information on the agglomerations in the case study areas.

Agglomerations (Study areas)	Study area in km ²	Population (Census (C) year, Projection (P) year)	Average annual growth rate (weighted mean in case of multiple administrative units)	Recent flood events	References
Africa					
Abidjan (ABI), Ivory Coast (Autonomous District Abidjan)	2,140	6,321,017 (C 2021)	3.96% (2014-2021)	06/2020, 10/2021, 06/2022, 06/2023	(Brinkhoff , FloodList 2020, Davies 2021, INS 2021, FloodList 2022, Davies 2023)
Dar es Salaam (DAR), Tanzania, (Region)	1,393	5,383,728 (C 2022)	2.12% (2012-2022)	10/2020	(Brinkhoff, NBS , FloodList 2020)
Lagos (LAG), Nigeria (Lagos State and Local Government Areas: Ado-Odo/Ota, Ifo, Sagamu, Odogbolu, Ijebu Ode of Ogun State)	6,213	16,221,700 (P 2022)	2.65% (2006-2022)	10/2019, 06/2020	(Brinkhoff, NBS Nigeria, FloodList 2019, FloodList 2020)
Asia					
Ho Chi Minh City (HCM), Vietnam (Municipality)	2,061	8,993,982 (C 2019)	2.30% (2009-2019)	06/2020, 05/2023, 06/2023	(Brinkhoff, ECHO 2020, General Statistics Office 2020, Tung and Diep 2023, Tung et al. 2023)
Khulna (KHL), Bangladesh (District Khulna subprovinces/ Upazila: Khulna City, Dumuria, Batiaghata, Rupsa, Terokhada, Dighalia, Phultala; Jessore District: Abhaynagar; Narail District: Kalia; Bagerhat District: Fakirhat)	1,904	2,639,852 (C 2022)	1.10% (2011-2022)	05/2020, 05/2021, 10/2022	(Brinkhoff, IFRC 2021, IFRC 2022, IFRC 2023, BBS 2023)
Surabaya (SBY), Indonesia (Regencies: Kota Surabaya, Sidoarjo, Gresik without Pulau Bawean)	2,126	6,268,330 (C 2020)	0.16% (2015-2020)	06/2022	(Brinkhoff, Indonesia Water Portal 2022, BPS 2023)
Surat (STV), India (District Surat without the subdistricts Mahuva, Bardoli, Mandvi, Mangrol; including subdistricts Navsari and Jalalpore of District Navsari)	1,651	5,846,552 (C 2011) *8,065,000 (P 2023)	*4.08%	08/2019, 09/2020, 07/2023	(Director of Census Operations 2012, FloodList 2019, FloodList 2020, ORGI 2021, The Times of India 2023)
* estimated by (Macrotrends.net 2023) based on (United Nations 2023) for “Surat metropolitan area” ≠ study area					
South America					
Barranquilla (BAQ), Colombia (Atlántico Department)	3,316	2,693,665 (P 2020)	2.30% (2015-2020)	11/2020, 11/2022	(Brinkhoff, DANE 2020, Davies 2020, Davies 2022)
Guayaquil (GYE), Ecuador (Cantons: Guayaquil, Nobol, Lomas de Sargentillo, Daule, Samborondón, Milagro, San Jacinto de Yaguachi, Durán, Naranjal)	7,231	2,746,403 (C 2022)	1.68% (2010-2022)	01/2016, 03-05 /2023	(Brinkhoff, NEC, Masoero 2016, IFRC 2023)



Supplementary Figure 1. Projected urban population share from the IIASA SSP database (Version 2) at national scale until 2100.



Supplementary Figure 2. Projected population development from the IIASA SSP database (Version 2) at national scale until 2100.

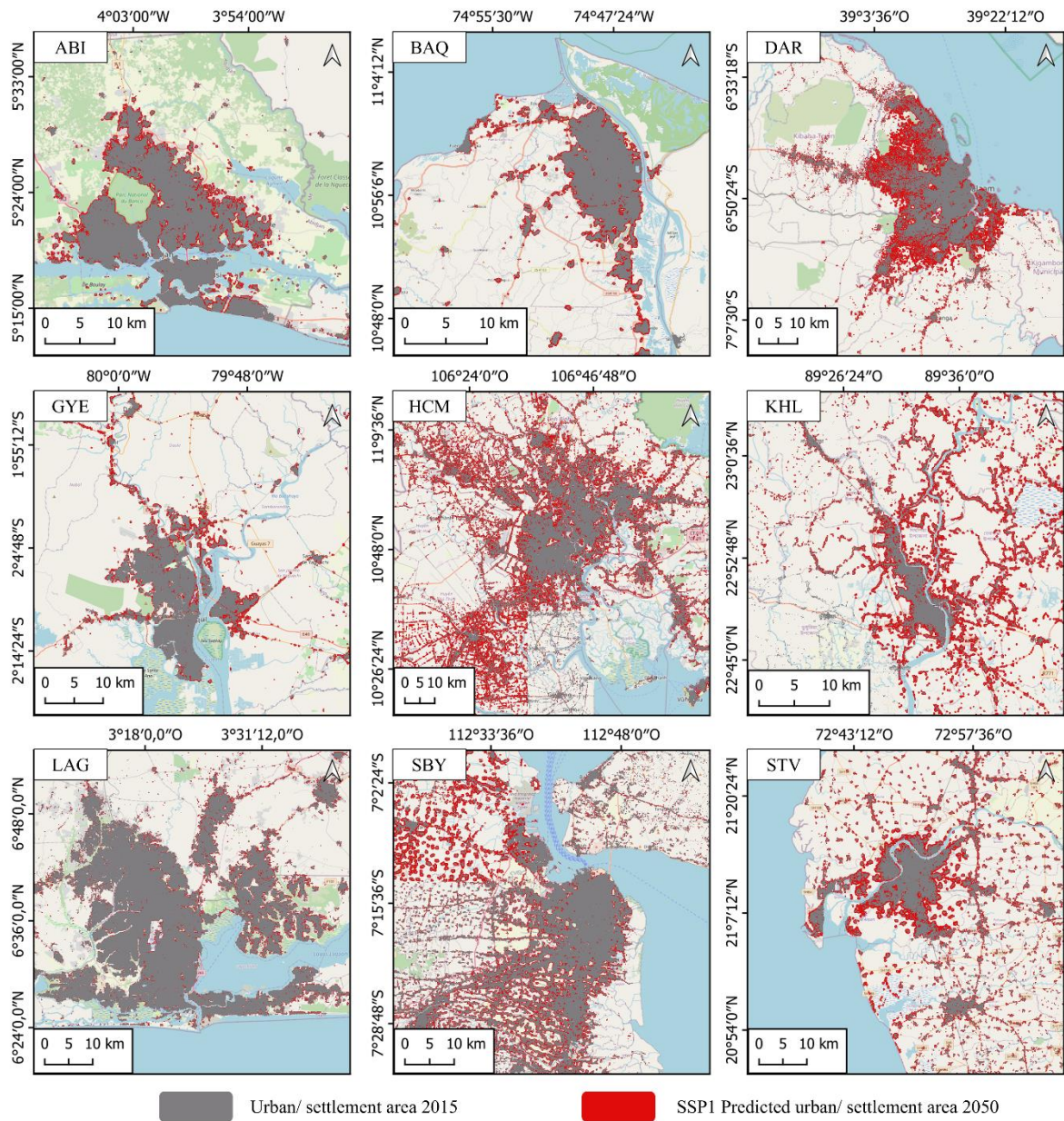
Supplementary Table 2. Modification Factors for Breed and Spread coefficients of the SLEUTH model in for the three different urban growth scenarios SSP1, SSP2 and SSP5 of the nine cities

	SSP1	SSP2	SSP5
Abidjan	97%	100%	80%
Barranquilla	79%	100%	76%
Dar es Salaam	109%	100%	105%
Guayaquil	86%	100%	77%
Ho-Chi-Minh City	135%	100%	131%
Khulna	128%	100%	120%
Lagos	99%	100%	97%
Surabaya	118%	100%	115%
Surat	121%	100%	120%

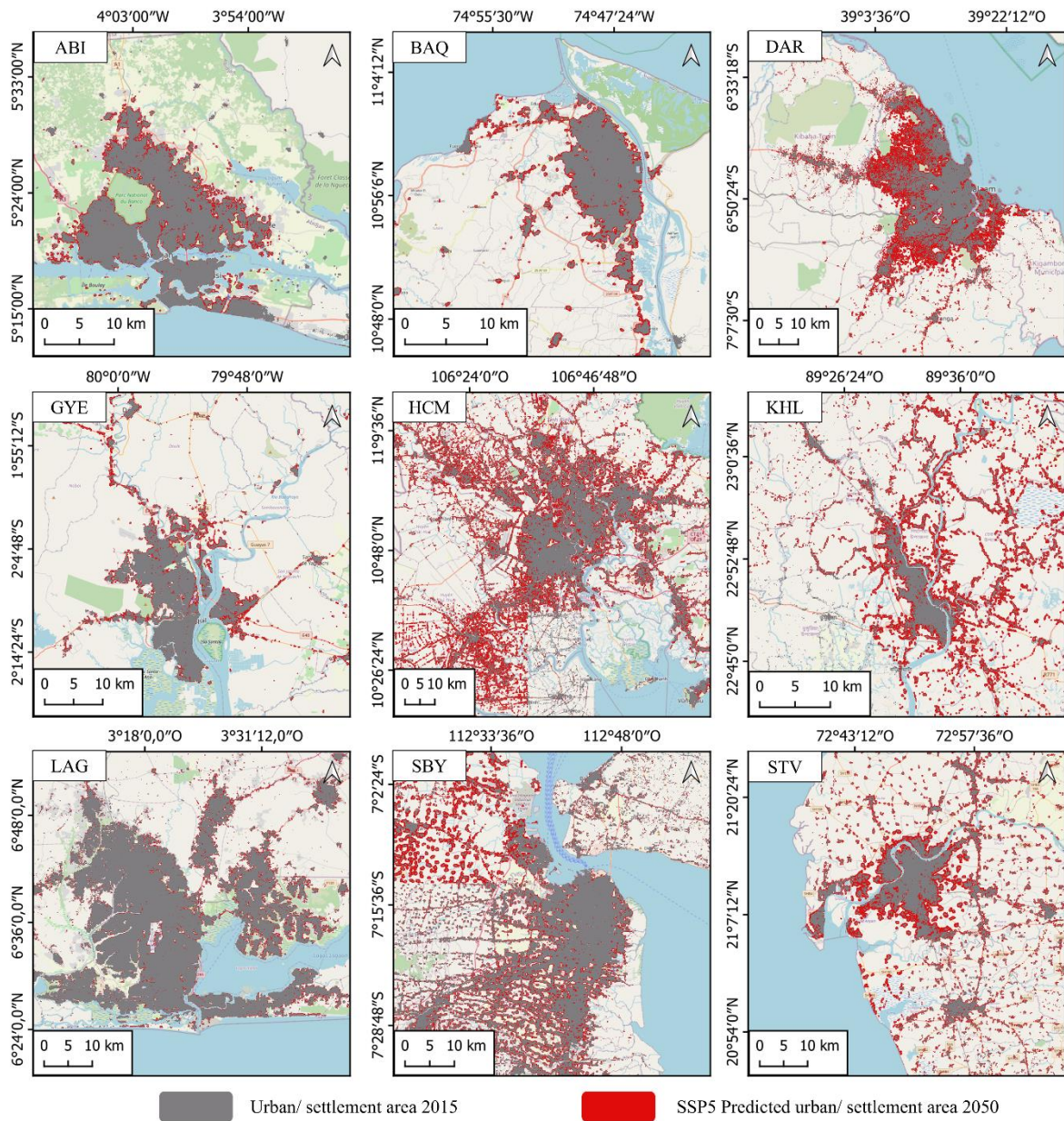
Supplementary Table 3. Breed and Spread coefficients of the SLEUTH model in for the three different urban growth scenarios SSP1, SSP2 and SSP5 for the 95 urban and rural tiles of the nine cities

Tile	Coeff.	SSP1	SSP2	SSP5	Tile	Coeff.	SSP1	SSP2	SSP5
Abidjan					Ho-Chi-Minh City				
Urban	Breed	90	92	74	Urban	Breed	80	59	77
	Spread	41	42	34		Spread	91	67	88
Rural_0_0	Breed	68	70	56	Rural_0_0	Breed	45	33	43
	Spread	21	22	18		Spread	42	31	41
Rural_0_1	Breed	18	18	14	Rural_0_1	Breed	24	18	24
	Spread	18	18	14		Spread	100	89	100
Rural_0_2	Breed	23	24	19	Rural_0_2	Breed	16	12	16
	Spread	18	18	14		Spread	42	31	41
Rural_1_0	Breed	29	30	24	Rural_1_0	Breed	20	15	20
	Spread	18	18	14		Spread	31	23	30
Rural_1_1	Breed	3	3	2	Rural_1_1	Breed	100	78	100
	Spread	19	20	16		Spread	42	31	41
Rural_1_2	Breed	15	15	12	Rural_1_2	Breed	100	81	100
	Spread	15	15	12		Spread	32	24	32
Barranquilla					Rural_2_0	Breed	24	24	24
Urban	Breed	4	5	4		Spread	62	46	60
	Spread	42	53	40	Rural_2_1	Breed	100	99	100
Rural_0_0	Breed	71	90	69		Spread	9	7	9
	Spread	1	1	1	Rural_2_2	Breed	3	2	3
Rural_0_1	Breed	14	18	14		Spread	43	32	42
	Spread	32	40	31	Khulna				
Rural_0_2	Breed	1	1	1	Urban	Breed	3	2	2
	Spread	1	1	1		Spread	49	38	46
Rural_1_0	Breed	21	27	21	Rural_0_0	Breed	100	92	100
	Spread	1	1	1		Spread	35	27	32

Rural_1_1	Breed	7	9	7
	Spread	45	57	43
Rural_1_2	Breed	1	1	1
	Spread	4	5	4
Rural_2_0	Breed	12	15	11
	Spread	12	15	11
Rural_2_1	Breed	24	30	23
	Spread	1	1	1
Rural_2_2	Breed	64	81	62
	Spread	1	1	1
Dar es Salaam				
Urban	Breed	88	81	85
	Spread	64	59	62
Rural_0_0	Breed	5	5	5
	Spread	20	18	19
Rural_0_1	Breed	1	1	1
	Spread	87	80	84
Rural_1_0	Breed	75	69	72
	Spread	37	34	36
Rural_1_1	Breed	46	42	44
	Spread	16	15	16
Guayaquil				
Urban	Breed	83	97	75
	Spread	53	62	48
Rural_0_0	Breed	10	12	9
	Spread	71	83	64
Rural_0_1	Breed	8	9	7
	Spread	25	29	22
Rural_0_2	Breed	17	20	15
	Spread	67	78	60
Rural_1_0	Breed	15	18	14
	Spread	41	48	37
Rural_1_1	Breed	44	51	39
	Spread	39	46	35
Rural_1_2	Breed	22	26	20
	Spread	35	41	32
Rural_2_0	Breed	5	6	5
	Spread	17	20	15
Rural_2_1	Breed	13	15	12
	Spread	8	9	7
Rural_2_2	Breed	28	33	25
	Spread	38	44	34
Rural_0_1	Breed	35	27	32
	Spread	42	33	40
Rural_1_0	Breed	76	59	71
	Spread	3	2	2
Rural_1_1	Breed	87	68	82
	Spread	45	35	42
Lagos				
Urban_0_0	Breed	35	35	34
	Spread	50	51	50
Urban_0_1	Breed	77	78	76
	Spread	63	64	62
Rural_0_0	Breed	18	18	18
	Spread	16	16	16
Rural_0_1	Breed	72	73	71
	Spread	28	28	27
Rural_0_2	Breed	79	80	78
	Spread	13	13	13
Rural_1_0	Breed	52	53	52
	Spread	20	20	19
Rural_1_1	Breed	76	77	75
	Spread	28	28	27
Rural_1_2	Breed	80	81	79
	Spread	7	7	7
Surabaya				
Urban	Breed	79	67	77
	Spread	44	37	43
Rural_0_0	Breed	21	18	21
	Spread	94	80	92
Rural_0_1	Breed	100	91	100
	Spread	24	20	23
Rural_1_0	Breed	100	87	100
	Spread	21	18	21
Rural_1_1	Breed	28	24	28
	Spread	22	19	22
Surat				
Urban	Breed	4	3	4
	Spread	87	72	86
Rural_0_0	Breed	10	8	10
	Spread	39	32	38
Rural_0_1	Breed	36	30	36
	Spread	33	27	32
Rural_1_0	Breed	11	9	11
	Spread	80	66	79
Rural_1_1	Breed	90	75	90
	Spread	30	25	30



Supplementary Figure 3: Projected urban expansion (2016-2050) under the SSP1 scenario. For visualization purposes, only a selected portion of the study area is displayed. Base map: OpenStreetMap & OpenStreetMap-Foundation (CC-BY-SA).



Supplementary Figure 4: Projected urban expansion (2016-2050) under the SSP5 scenario. For visualization purposes, only a selected portion of the study area is displayed. Base map: OpenStreetMap & OpenStreetMap-Foundation (CC-BY-SA).

Supplementary Table 4. Projected newly developed urban areas (2016-2050) exposed to coastal flooding.

City	Percentile	SSP1/ RCP2.6 (km ²)	SSP2/ RCP4.5 (km ²)	SSP5/ RCP8.5 (km ²)	City	Percentile	SSP1/ RCP2.6 (km ²)	SSP2/ RCP4.5 (km ²)	SSP5/ RCP8.5 (km ²)
ABI	50 th	0.02	0.02	0.02	KHL	50 th	0.00	0.00	0.00
	83 rd	0.03	0.03	0.02		83 rd	0.00	0.00	0.00
BAQ	50 th	0.05	0.15	0.06	LAG	50 th	2.51	2.93	3.10
	83 rd	0.07	0.17	0.07		83 rd	3.76	4.44	4.33
DAR	50 th	4.00	3.74	4.18	SBY	50 th	15.65	8.56	16.52
	83 rd	4.10	4.19	4.63		83 rd	17.57	9.58	19.20
GYE	50 th	0.02	0.03	0.02	STV	50 th	4.34	3.71	5.09
	83 rd	0.03	0.04	0.02		83 rd	6.17	5.25	6.96
HCM	50 th	0.16	0.07	0.19					
	83 rd	0.30	0.13	0.37					

Supplementary Table 5. Projected newly developed urban areas (2016-2050) exposed to riverine flooding.

City	Percentile	SSP1/ RCP2.6 (km ²)	SSP2/ RCP4.5 (km ²)	SSP5/ RCP8.5 (km ²)	City	Percentile	SSP1/ RCP2.6 (km ²)	SSP2/ RCP4.5 (km ²)	SSP5/ RCP8.5 (km ²)
ABI	50 th	0.40	0.46	0.28	KHL	50 th	13.43	10.48	14.54
	83 rd	0.41	0.48	0.30		83 rd	15.59	12.16	17.50
BAQ	50 th	0.75	1.72	0.82	LAG	50 th	3.03	3.43	2.88
	83 rd	1.10	2.23	1.35		83 rd	3.91	4.68	3.84
DAR	50 th	5.28	4.80	4.95	SBY	50 th	62.74	27.61	65.10
	83 rd	6.26	5.90	6.28		83 rd	71.02	31.91	78.46
GYE	50 th	37.80	47.16	34.75	STV	50 th	28.65	24.42	34.68
	83 rd	65.50	73.19	68.47		83 rd	34.35	31.33	46.87
HCM	50 th	50.73	30.41	56.31					
	83 rd	73.05	46.72	89.81					

Supplementary Table 6. Urban areas projected to be exposed to pluvial flooding by 2050 (83rd Percentile).

City	Scenarios	Urban Area Year 2015 km ²	Urban Area Year 2050 km ²	Total Coastal Inundation km ²	Total Fluvial Inundation km ²	Total Pluvial Inundation km ²
ABI	SSP1/RCP2.6	338.64	411.75	0.22	0.84	28.91
	SSP2/RCP4.5	338.64	413.02	0.23	0.92	29.67
	SSP5/RCP8.5	338.64	398.21	0.25	0.81	28.41
BAQ	SSP1/RCP2.6	163.54	218.96	0.37	10.38	23.00
	SSP2/RCP4.5	163.54	232.91	0.49	11.06	26.67
	SSP5/RCP8.5	163.54	216.69	0.41	11.52	25.79
DAR	SSP1/RCP2.6	536.79	923.66	4.93	9.79	90.14
	SSP2/RCP4.5	536.79	908.05	5.19	9.51	89.49
	SSP5/RCP8.5	536.79	918.40	5.72	10.03	92.62
HCM	SSP1/RCP2.6	291.70	407.20	0.35	93.48	71.66
	SSP2/RCP4.5	291.70	426.78	0.37	106.55	80.26
	SSP5/RCP8.5	291.70	391.76	0.38	99.40	73.70
GYE	SSP1/RCP2.6	631.42	964.35	2.89	174.66	126.81
	SSP2/RCP4.5	631.42	840.10	3.07	157.71	118.31
	SSP5/RCP8.5	631.42	963.05	3.71	213.03	143.21
KHL	SSP1/RCP2.6	137.78	348.61	0.00	24.79	25.58
	SSP2/RCP4.5	137.78	298.46	0.00	21.85	22.69
	SSP5/RCP8.5	137.78	334.70	0.00	28.07	27.49
LAG	SSP1/RCP2.6	1416.24	1565.55	50.26	52.64	164.02
	SSP2/RCP4.5	1416.24	1574.33	54.13	55.23	168.67
	SSP5/RCP8.5	1416.24	1550.55	58.27	54.39	168.42
SBY	SSP1/RCP2.6	714.69	1016.15	74.64	249.66	143.47
	SSP2/RCP4.5	714.69	848.36	68.38	222.18	131.52
	SSP5/RCP8.5	714.69	1009.58	83.52	293.28	159.82
STV	SSP1/RCP2.6	352.35	667.79	8.56	76.22	132.66
	SSP2/RCP4.5	352.35	620.93	7.86	80.02	127.96
	SSP5/RCP8.5	352.35	664.57	9.77	112.96	141.00

Supplementary Table 7. Projected newly developed urban areas (2016-2050) exposed to pluvial flooding.

City	Percentile	SSP1/ RCP2.6 (km ²)	SSP2/ RCP4.5 (km ²)	SSP5/ RCP8.5 (km ²)	City	Percentile	SSP1/ RCP2.6 (km ²)	SSP2/ RCP4.5 (km ²)	SSP5/ RCP8.5 (km ²)
ABI	50 th	7.61	7.92	6.40	KHL	50 th	13.72	10.09	13.46
	83 rd	7.74	8.13	7.94		83 rd	15.80	12.04	16.32
BAQ	50 th	6.48	8.82	6.58	LAG	50 th	20.44	22.20	18.90
	83 rd	7.12	9.88	7.51		83 rd	20.64	22.52	19.27
DAR	50 th	50.28	48.75	50.73	SBY	50 th	38.98	20.82	40.31
	83 rd	51.87	50.39	52.61		83 rd	40.64	22.11	44.00
GYE	50 th	21.54	26.94	19.97	STV	50 th	55.16	47.65	57.84
	83 rd	23.19	28.97	21.17		83 rd	56.76	49.31	59.99
HCM	50 th	40.98	26.29	44.69					
	83 rd	43.14	28.29	48.31					

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