Supplemental material of

A High-Resolution Framework for Urban Pluvial Flood Risk Mapping

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Introduction

Supplementary information includes information on input data and tool user interfaces. Additionally, we provide figures of the output attribute tables of the applied ArcGIS tools.

	OBJECTID * ▲	Shape *	ID	WR	C	ES	EDQ	Floors	Building type	StatisticalUnit
1	1	Polygon	1	1	1	0	0	1	1	1
2	2	Polygon	2	1	1	0	0	1	1	1
3	3	Polygon	3	2	2	1	1	2	1	1
4	4	Polygon	4	0	1	1	0	2	2	1
5	5	Polygon	5	1	1	1	0	1	1	1
6	6	Polygon	6	1	1	1	0	1	1	1
7	7	Polygon	7	4	3	2	1	2	1	1
8	8	Polygon	8	1	0	0	0	1	1	1
9	9	Polygon	9	2	0	1	0	1	1	1
10	10	Polygon	10	0	0	1	0	2	1	1

Figure S1: Excerpt of input data attribute-table. The screenshot contains the first ten (of 37) rows of the example ArcGIS-layer used for the analysis. WR reflects the welfare recipients, C the Children younger 10 years old, ES the elderly singles above 65 years old, EDQ represents the educational level. A value of one represents one resident leaving school within the past three years without a high school diploma. Floors reflect the number of floors per building and Building type the usage of solely living use (1) or mixed use (2).

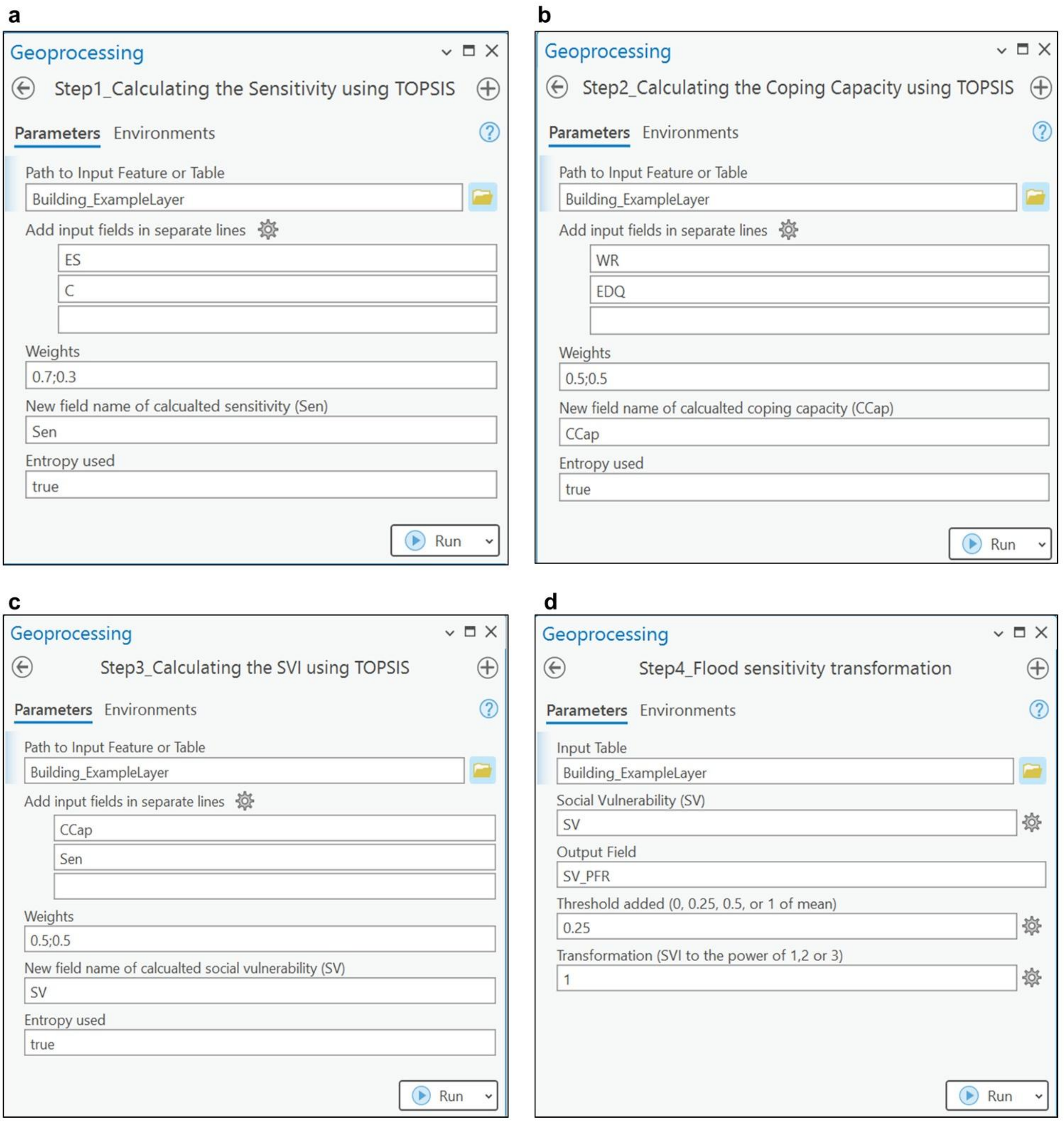

Figure S2: Social Vulnerability Tools. (a) shows the tool used for the calculation of sensitivity using the example layer as input. (b) shows the second tool used for the estimation of coping capacity, whereas (c) depict the calculator of the social vulnerability variable (SV) and its transformation to the final SV index to pluvial flood risk (SV_{PFR})

	OBJECTID *	Shape *	ID	WR	C	ES	EDQ	Floors	Building type	StatisticalUnit	Residents	LivingArea	Area_house	Sen	CCap	SV	SV_PF
1	1	Polygon	1	1	1	0	0	1	1	1	250	9000	221,78	0,25	0,33	0,29	0,18
2	2	Polygon	2	1	1	0	0	1	1	1	250	9000	214,24	0,25	0,33	0,29	0,18
3	3	Polygon	3	2	2	1	1	2	1	1	250	9000	359,24	0,55	0,75	0,63	0,59
4	4	Polygon	4	0	1	1	0	2	2	1	250	9000	372,77	0,58	0	0,64	0,6
5	5	Polygon	5	1	1	1	0	1	1	1	250	9000	209,23	0,58	0,33	0,44	0,33
6	6	Polygon	6	1	1	1	0	1	1	1	250	9000	250,03	0,58	0,33	0,44	0,33
7	7	Polygon	7	4	3	2	1	2	1	1	250	9000	667,58	1,11	1	0,99	1,27
8	8	Polygon	8	1	0	0	0	1	1	1	250	9000	209,23	0	0,33	0,43	0,32
9	9	Polygon	9	2	0	1	0	1	1	1	250	9000	300,29	0,86	0,61	0,69	0,68
10	10	Polygon	10	0	0	1	0	2	1	1	250	9000	285,75	0,86	0	0,85	0,98

Figure S3: Attribute table of the example data table after implementing the Social Vulnerability Toolset. Sensitivity (Sen) and Coping Capacity (CCap) are derived from the input fields welfare recipients (WR), children younger 10 years old(C), elderly singles older 65 years old (ES) and people within a house leaving school within the past three years without high school diploma (EDQ). Columns "Statistical Unit"," Residents" and "Living Area" are obtained from the statistical unit (city sub-level) information and attributed to the building dataset.

Figure S4: Complete workflow of the Exposure tool. Parameters (P) allow the user to set the input and output settings. Yellow boxes depict calculation steps whereas green boxes depict intermediate results. The expression box is used to set the input formula for the calculation of the buildings area, as shown in Eq. 4).

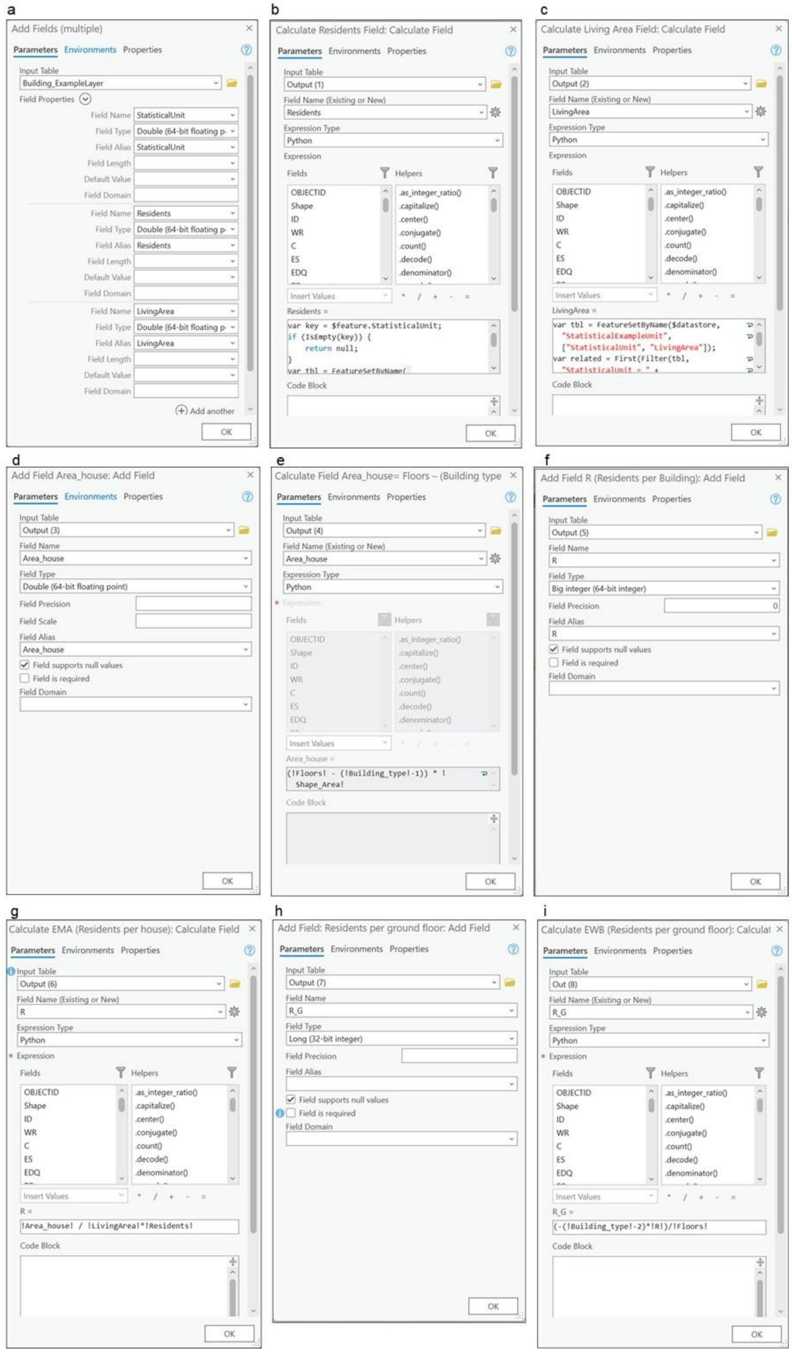

Figure S5: Exposure tool. This graphic depicts the underlying tools of the exposure tool including the combination of statistical unit information with building data (a to c), the estimation of the building area and residents per building (d to f) and the corresponding estimation of exposure index relative to well-being (g) and mobility and accessibility (h,i).

	OBJECTID *	Shape *	ID	WR	C	ES	EDQ	Floors	Building type	StatisticalUnit	Residents	LivingArea	Area_house	EMA	EWB
1	1	Polygon	1	1	1	0	0	1	1	1	250	9000	221,78	5	5
2	2	Polygon	2	1	1	0	0	1	1	1	250	9000	214,24	5	5
3	3	Polygon	3	2	2	1	1	2	1	1	250	9000	359,24	10	5
4	4	Polygon	4	0	1	1	0	2	2	1	250	9000	372,77	8	0
5	5	Polygon	5	1	1	1	0	1	1	1	250	9000	209,23	5	5
6	6	Polygon	6	1	1	1	0	1	1	1	250	9000	250,03	6	6
7	7	Polygon	7	4	3	2	1	2	1	1	250	9000	667,58	20	10
8	8	Polygon	8	1	0	0	0	1	1	1	250	9000	209,23	5	5
9	9	Polygon	9	2	0	1	0	1	1	1	250	9000	300,29	7	7
10	10	Polygon	10	0	0	1	0	2	1	1	250	9000	285,75	6	3

Figure S6: Attribute table of the example data table after implementing the Exposure Toolset. Welfare recipients (WR), children younger 10 years old(C), elderly singles older 65 years old (ES) and people within a house leaving school within the past three years without a high school diploma (EDQ). Columns "Statistical Unit"," Residents" and "Living Area" are obtained from the statistical unit (city sub-level) information and attributed to the building dataset. Residents per building (R) correspond to E_{MA} and Residents per ground floor (R_G) correspond to E_{WB} within the presented framework.

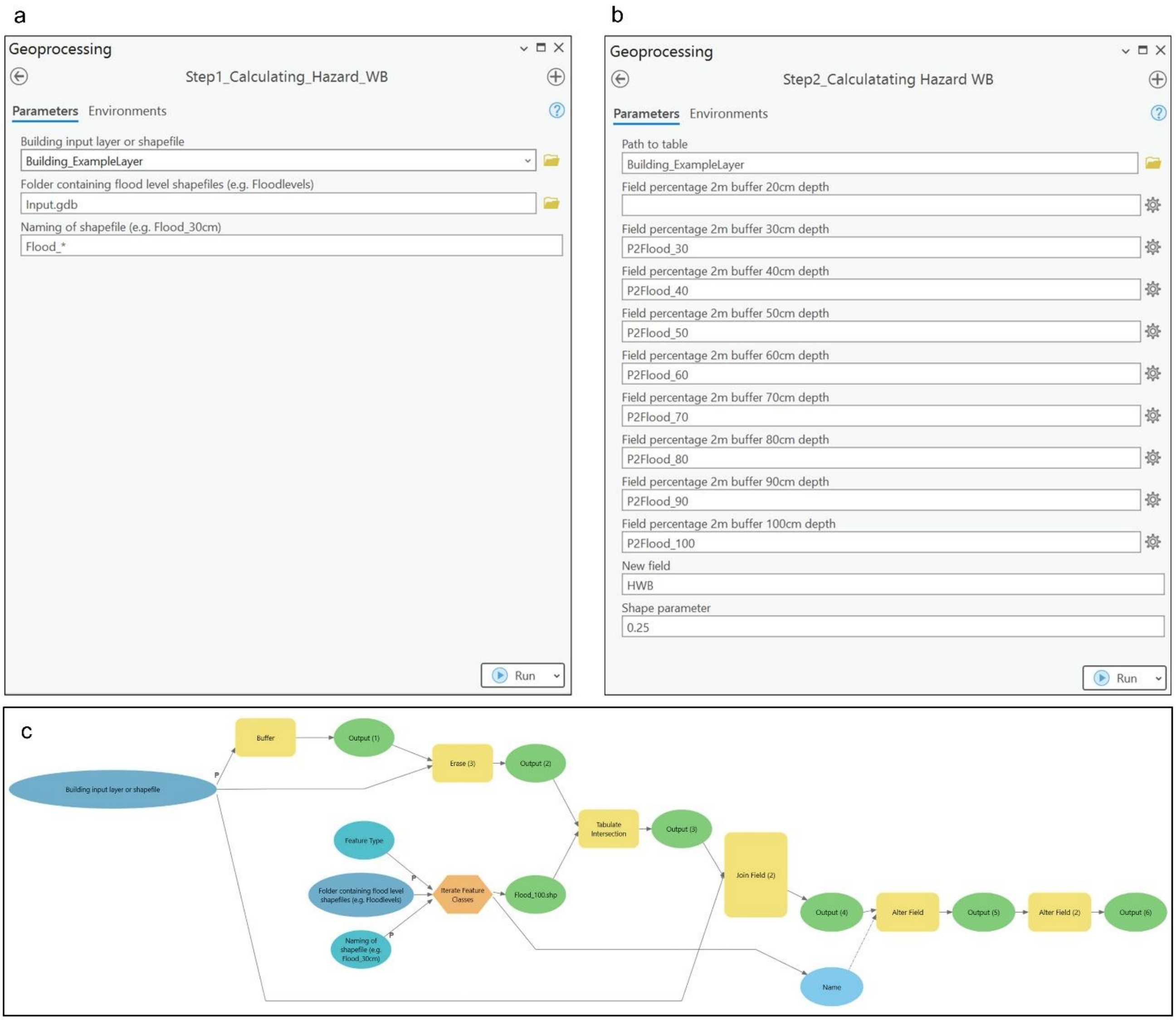

Figure S7: Toolset to calculate the hazard index related to well-being. (a) shows the first tool, used to calculate the intersected areas between flood layers and affected buildings. b) shows the second tool used to calculate the resulting hazard value (HWB). (c) depicts the corresponding workflow behind the first tool (Step 1).

	A2Flood_100	P2Flood_100	A2Flood_90	P2Flood_90	A2Flood_80	P2Flood_80	A2Flood_70	P2Flood_70	A2Flood_60	P2Flood_60	A2Flood_50	P2Flood_50	A2Flood_40	P2Flood_40	A2Flood_30	P2Flood_30	HWB
1	3,27	7,91	21,91	52,95	36,02	87,06	37,65	91	37,96	91,76	37,96	91,76	37,96	91,76	37,96	91,76	7
2	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0,39	1,14	5,95	17,36	10,68	31,17	15	43,78	26,93	78,61	2,87
3	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0,63	2	0
4	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	5,74	8,06	12,22	17,15	0,07
5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0
6	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0
7	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0
8	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0
9	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0
10	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	1,68	4,22	12,64	31,67	0,83

Figure S8: Attribute table of the example data table after implementing the hazard to well-being toolset. Each column depicts the calculated intersections as area in m^2 (A) and percentage (P) for the corresponding flood depth named in the column-header using a 2 m buffer around the building. The resulting hazard index related to well-being (H_{WB}) ranges for the first ten rows between 0 and 7. “Null” values represent zero overlapping areas.

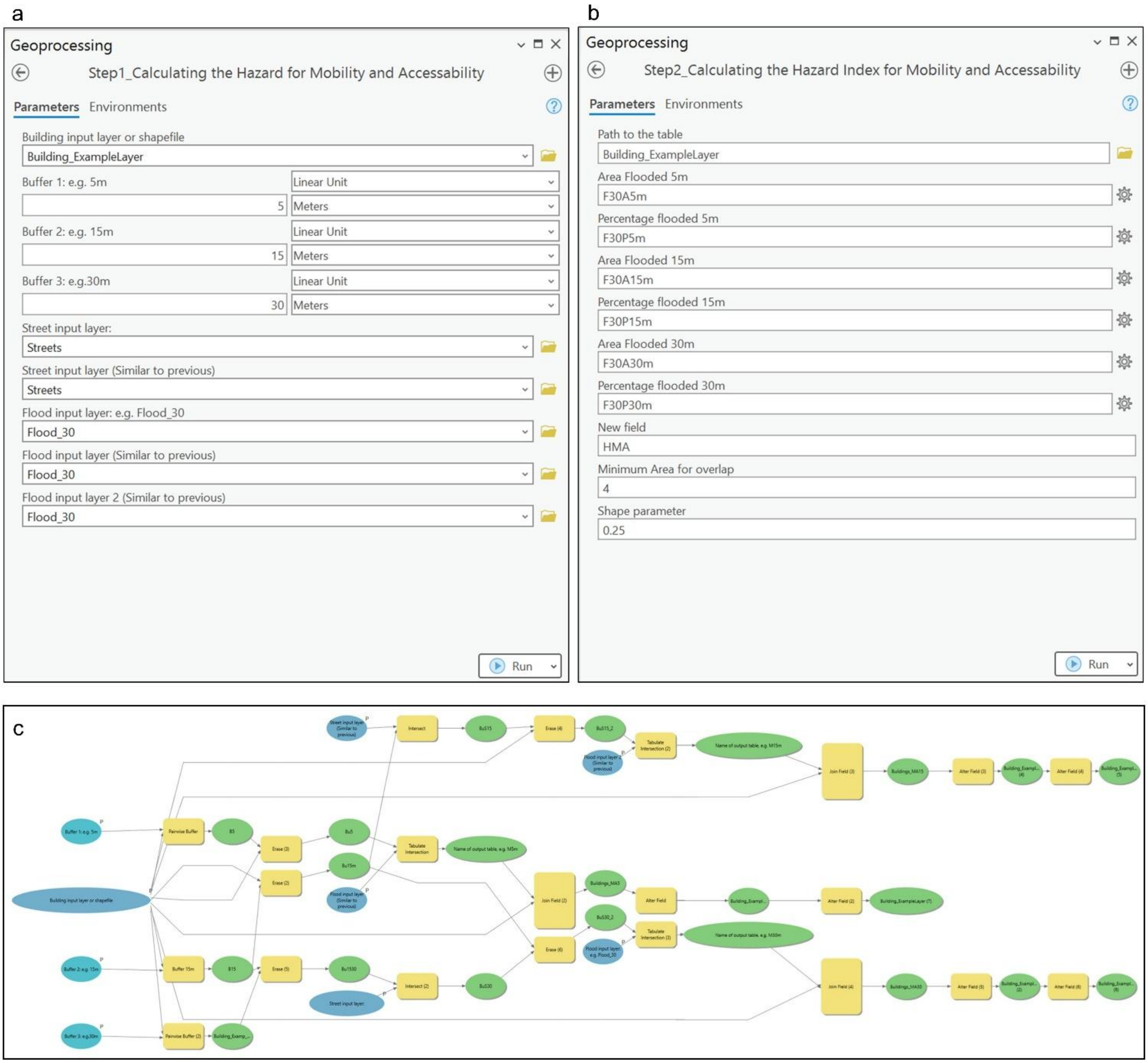

Figure S9: Toolset to calculate the hazard to mobility and accessibility with a 30 cm flood layer. (a) shows the first tool, used to calculate the intersected areas between flood layer and affected building (streets, respectively). (b) shows the corresponding workflow behind the tool and (c) shows the second tool used to calculate the resulting hazard value (HMA).

	OBJECTID * ▲	F30A5m	F30P5m	F30A15m	F30P15m	F30A30m	F30P30m	HMA
1	1	113	94,86	43,69	100	0	0	1
2	2	88,39	86,81	0	0	42,77	100	1
3	3	0,68	0,72	0	0	15,15	4,25	0
4	4	43,85	22,42	0	0	0	0	0,33
5	5	0	0	0	0	3,4	6,74	0
6	6	0	0	0	0	43,68	56,95	1
7	7	0	0	0	0	73,35	45,28	0,99
8	8	0	0	0	0	23,47	48,1	1
9	9	0	0	0	0	0	0	0
10	10	25,37	22,79	0	0	0	0	0,36

Figure S10: Attribute table of the example data table after implementing the Hazard to Mobility and Accessibility Toolset. F305m depicts the calculated intersections as area in m^2 (A) and percentage (P) for the flood depth of 30cm and a 5m buffer around the building, as well as interesting streets with 15m, and 15-30m buffer around the building. The resulting hazard for mobility and accessibility (H_{MA}) ranges for the first ten rows between 0 and 1.

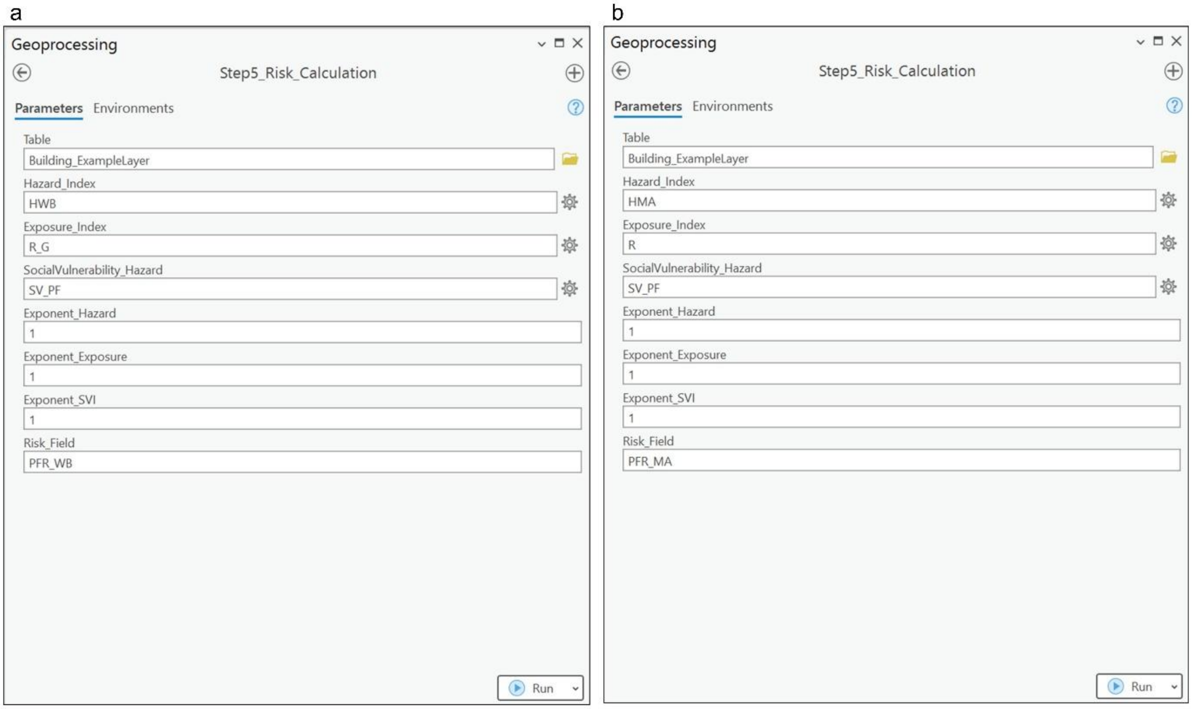

Figure S11: Risk tool within the Pluvial flood risk framework. To calculate the pluvial flood risk to well-being (a) and to mobility and accessibility (b).

	OBJECTID *	ID	WR	C	ES	EDQ	Floors	Building type	StatisticalUnit	Residents	LivingArea	Area_house	HMA	HWB	PFR_WB	PFR_MA
1	1	1	1	1	0	0	1	1	1	250	9000	221,78	1	7	6,16	0,88
2	2	2	1	1	0	0	1	1	1	250	9000	214,24	1	2,87	2,53	0,88
3	3	3	2	2	1	1	2	1	1	250	9000	359,24	0	0	0	0
4	4	4	0	1	1	0	2	2	1	250	9000	372,77	0,33	0,07	0	1,58
5	5	5	1	1	1	0	1	1	1	250	9000	209,23	0	0	0	0
6	6	6	1	1	1	0	1	1	1	250	9000	250,03	1	0	0	2
7	7	7	4	3	2	1	2	1	1	250	9000	667,58	0,99	0	0	25,2
8	8	8	1	0	0	0	1	1	1	250	9000	209,23	1	0	0	1,58
9	9	9	2	0	1	0	1	1	1	250	9000	300,29	0	0	0	0
10	10	10	0	0	1	0	2	1	1	250	9000	285,75	0,36	0,83	2,43	2,09

Figure S12: Attribute table of the example data table after implementing the risk calculation. The columns $PFR_{WB\ and}\ PFR_{MA}$ represent the calculated values for the first 10 rows of the example dataset. The complete dataset and table can be viewed in ArcGIS and the attached excel table file provided in the supplement data.

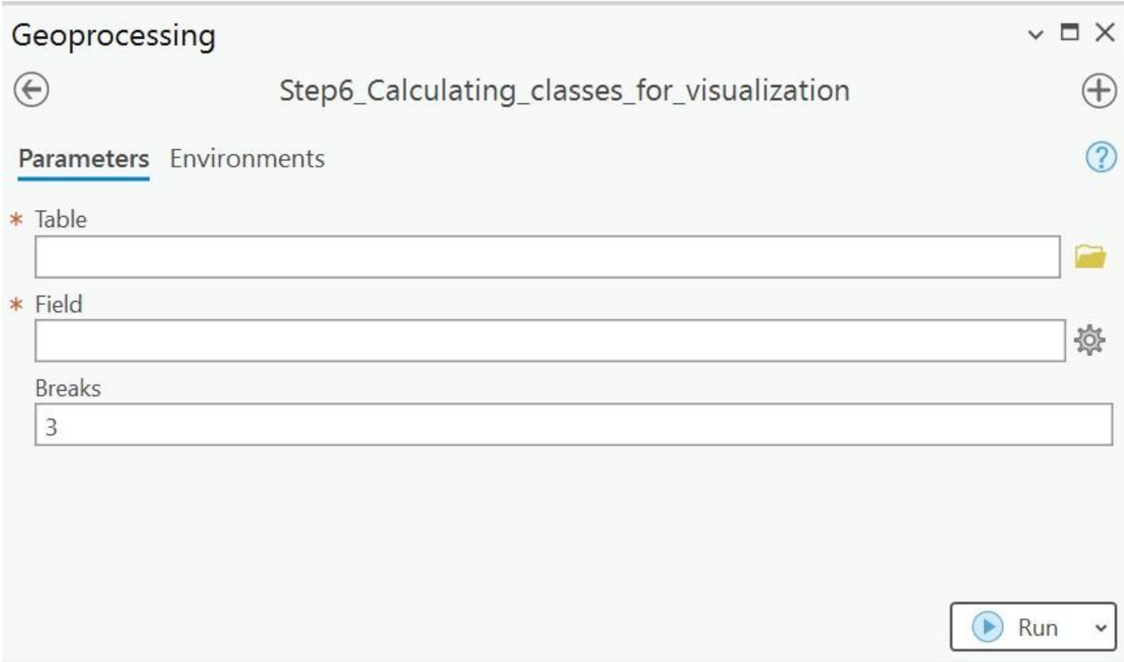

Figure S13: Visualization tool provided within the pluvial flood risk framework. *Breaks* refers to the classes used for the maps using an iterative mean-based filtering process.

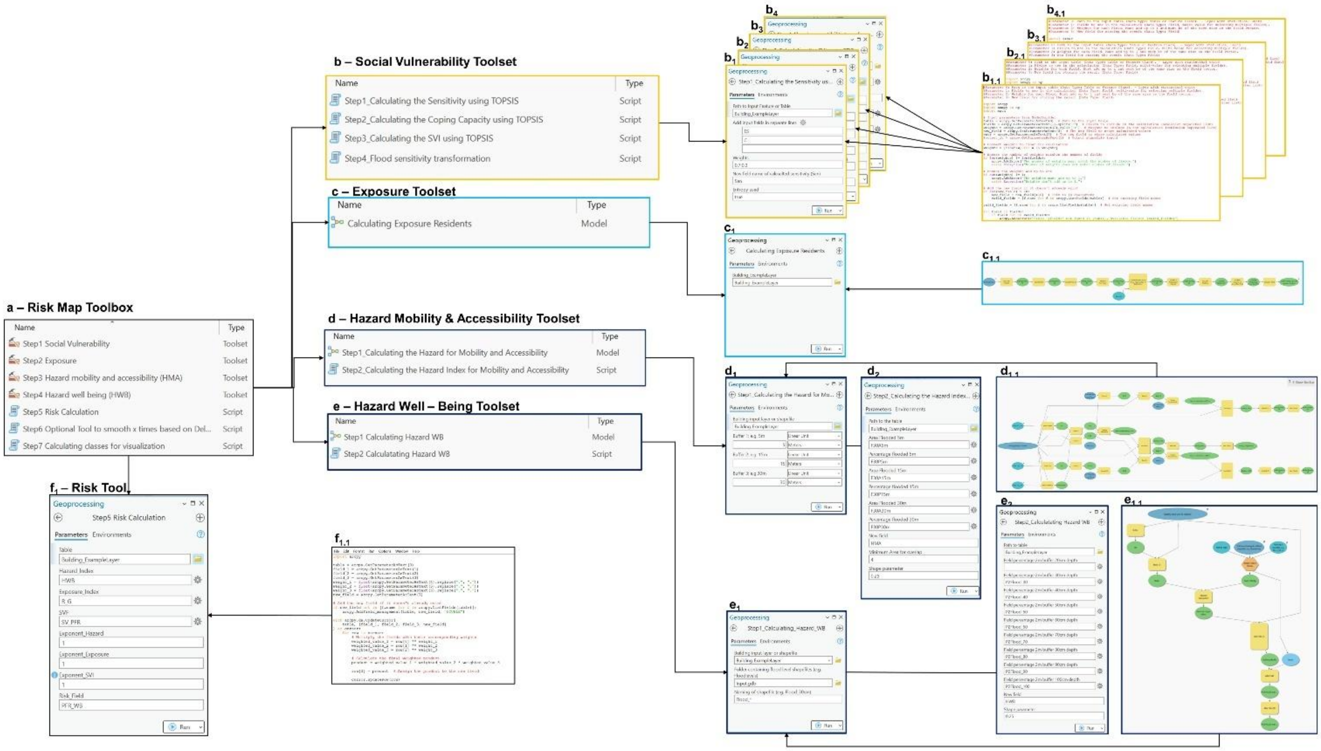

Figure S14: Outline of the Risk Map Toolbox. The coloured borders represent the corresponding risk parameters (Social Vulnerability, Exposure, Hazard). (a) shows the first level of the toolbox whereas (b) to (f) corresponds to toolsets within the toolbox. (b1) to (b4) (c1 to e1 respectively) represent the user interface of the individual toolsets. b1.1 to f.1.1 correspond to the underlying python scripts and model builder toolsets, running in the background of each tool.