WP3–Representative models of Built Environment Typologies (BETs) prone to SUOD/SLOD. Case studies selection and data collection

T3.2 - Identification of BETs and their typical risks related to the selected SUOD/SLOD including typical users'exposure

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Abstract

Starting from previous analysis of single disasters, this deliverable aims at the identification of matrixes od representation data of BE for single risks and combination of recurrent risks hazards, and then to provide similar matrix for recurrent BETs involved for the project and identified in D3.2.1. In detail, the process comprehends a multi-step method based and aimed at: i) summing up single risk models (RMs) analysed in the project towards their re-organization with BE parameters - and their sub-qualification by means of descriptors - and single sub-elements of risk (Hazard, Vulnerability and Exposure); ii) assessing relevant parameters involved in Hazard component of single RMs for the identification of recurrent combinations of hazards iii) qualifying parameters and descriptors according to their information data; iv) calibrating the data with the representation tools selected for the project (BIM, GIS, VT-based) ; v) creating a set of reduced matrixes for each single risk concerning specific focuses involved in the project; vi) creating a limited set of reduced matrixes for the data representation in all the chosen (and recurrent) combinations of risk Hazards; vii) applying the reduced matrixes (for single and combined risks) for BETs. In detailed, the process involves the Seismic (SRM), Terroristic (TRM), Heatwave (HRM) and Pollution (PRM) Risk Models and identifies the recurrent combination of their Hazard in a detailed sample of Italian cities.

Keywords

Risk model calibration; representation criteria; recurrent combination of Risk hazards; Italian cities; Matrix of representation criteria for BE and BETs

Approvals

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0.1	30.04.2021	Case study data checking and preliminary integration	Elena Cantatore	POLIBA
1.0	30.07.2021	Coordination with D3.3.3 and additional case study data checking	Silvana Bruno	POLIBA
1.2	03.08.2021	Integration of case study data on morphological and constructive parameters	Elena Cantatore	POLIBA

Summary

1. Introduction

The concepts of "Risk", "Threat" and "Disaster" embodies the necessity to assess the fundamental relations between the events and the assessed objects exposed to the risk, threat and disasters.

Due to the goals of the BE S²ECURe project, this report aims at summarizing the risk models of previous works, relating them to the Built Environment. In detail, this deliverable cannot propose the multi-risk assessment in a probabilistic or statistic point of view, but it aims at the recognition of recurrent combinations of risk and prevalent parameters involved in the BE characterization – as detailed in D1.1.2 and D1.1.3 – related to the selected SUOD and SLOD risks.

As far as the goal concerns, this deliverable tries to answer to "which are the recurrent combination of SLOD/SUOD hazards for italian cities?", "There are some parameters involved in two or more risk models?" "which features of these parameters are involved in single risk and in the multi-risk assessments?" and finally "how the features and parameters can be represented?".

In this deliverable selected SLOD and SUOD risks are analysed as Risk models (combination of Hazard, Vulnerability and Exposure), applied to a selected number of cases of italian cities to determine recurrent combinations of hazards, and decomposed according to the BE characters chosen for this project. As it clear, the process of breaking down for the risk models derived from the assessment of previous deliverable results and thus from the scientific literature review and cannot directly related to the BE characters.

Then, the process of their representation is the result of a specific methods, detailed in next section, that aimed at the reorganization of BE characters, specific features involved into the model risks and the systematization according to the main criteria of BET representation.

2. Method

In order to solve the necessity in guaranteeing the representation of features involved in the risk (and recurrent multi-risk) models, the characters of BE require to be "qualified" and "characterized" according to their prevalent features involved in the risk modelling. Thus, the criteria or their representation could be scaled to the tools/methods for BETs representation and specific trainings, as identified in D3.1.3.

For these reasons and aiming at the goals, the process follows a specific flow of actions organized in 4 specific steps:

- Review of Seismic (D1.2.1, D1.2.2 and D1.2.3) and terrorist risk models (D1.3.1) for the SUOD and Heatwaves and pollution risk models (D2.2.5) for SLOD aiming at the discretization of them according to the BE characters identified in D1.1.2. Here, the assessment of discretized parameters derived from the expertise of scientists as well as the literature review organized in the aforementioned deliverables. In this phase, all the disasters are discretized according to the scientists' expertise and results on previous deliverables, then, all of them are re-proposed to all the URs in order identifying some other level of details or other recurrent features/properties. These results are discussed in §3, and a specific sub-section is dedicated to the single disaster (§3.1 for SRM, §3.2 for TRM, §3.3 for HRM, §3.4 for HRM). Finally, all the parameters were checked according to single RMs in order to highlight recurrences in relevance for each of them (§3.5).
- Identification of recurrent combination of hazard in a coherent sample of Italian cities. Here, the analysis is supported by a wider scale of data derived by specific databases of natural and human

disasters. This phase is supported by the creation of a combination matrix about the natural-human multi-hazard combinations to apply to BETs. The analysis is developed in §4.

- Calibration of BE characters according to specific descriptors of them related to the specific risk model. Here, the calibration aims at the association to specific "properties or details" – called "descriptors" - to the main characters identified for the BE, as the specific set of properties involved in the risk models (§5).
- Assessment for information details of characters and descriptors according to the scale of representation. In this phase all the involved descriptors are associate to their information types, assessed for main informative associated data (quantitative – e.g. Geometric data – Boolean – presence/absence – or qualitative – ranges of value, describing properties). This assessment follows in §6;
- The assessment of representation criteria for descriptors and BE characters, according to their qualification and tools/methods for BETs representation. In detail, this phase aims at the systematization of BETs representation models (GIS-based, BIM-based, VR-based) defining three different systems of representation criteria.
- Finally, the creation of a set of reduced system of representation criteria for BETs. Here, each reduced system of representation is associated to the recurrent combinations of risks identified in the second phase.

3. Review of SLOD/SUOD risk models and parametrization assessment according to BE characters

3.1. Analysis of Seismic Risk Model (SRM)

Starting from the D1.2.1, D1.2.2 and D1.2.3 for Seismic (SRM), Table x summarizes the relevance of the BE characters according to each sub-class of risk assessment (Hazard H, Vulnerability V, Exposure E).

Table 1. Analysis of parameters for BE classification involved in seismic risk model for Hazard, Vulnerability and Exposure

Code	Description	H	V	E
	Section 1: MAIN TYPE			
S1_0	Morpho-typology		X	
S1_1	Dimension of OS		X	
S1_2	Hmax built front		X	
S1_3	hmin built front			
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_1	Type of Aggregates		X	
S2_F_2	Accesses		X	
S2_F_3	Special buildings		X	X
S2_F_4a	Town walls		X	
S2_F_4b	Porches		X	
S2_F_5a	Green area		x	X
S2_F_5b	Water		X	X
S2_F_6	Quote differences / slope		X	
	Content			

S2_C_1	Special buildings		X	
S2_C_2	Quote difference/slope		X	
S2_C_3	Protections measure of slope/quote difference		X	
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)		X	X
S2_C_5a	Green area			X
S2_C_5a	Water			X
S2_C_6	Underground cavities		X	
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_1	Homogeneity of built environment age		X	
S3_F_2	Homogeneity of constructive techniques		X	
S3_F_3	Fixed obstacles			
S3_F_4	Temporary obstacles		X	
	Content			
S3_C_1	Pavement type		X	
S3_C_2	Pavement condition		X	
S3_C_3	Fixed obstacles		X	
S3_C_4	Temporary obstacles		X	
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding			X
S4_2	Special uses of OS			X
S4_3	Strategic building / Special uses of building facing OS			X
S4_4	Accessibility for vehicle			X
S4_5	Accessibility for pedestrian			X
S4_6	Vehicles (parking)		X	
S4_7	Sights			X
S4_8	Sensitive targets			X
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS			
S5_1	Seismic intensity	X		
S5_2	Climate classification [DPR 412/1993]			
S5_3	Climate conditions			X
S5_4	Multi-hazard potential	X		
S5_5	Ground type	X		
S5_6	Lifeline utilities		X	
S5_7	OS interconnection		X	

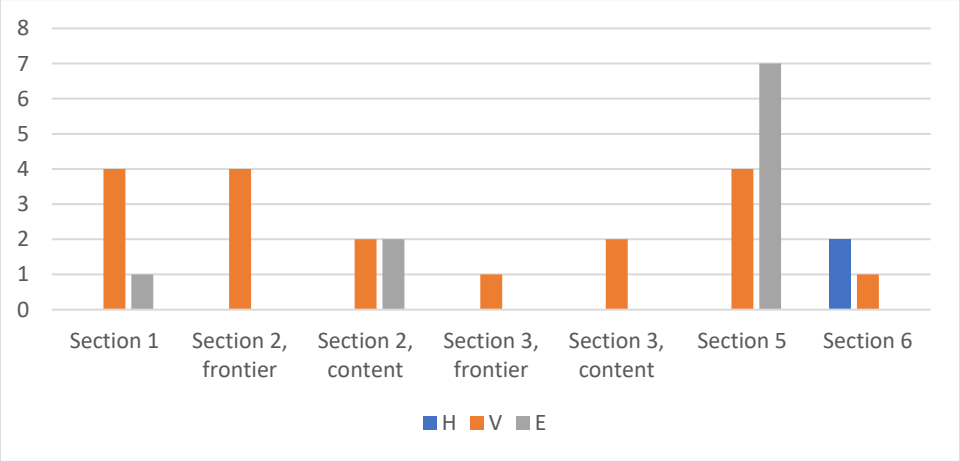

Figure 1. Assessment of incidence for each section of BE classification in Seismic Risk Model

As a first assessment of distributions, Figure 1 highlights the incidence of each section for the BE classification codes related to the seismic Risk model. In detail:

- The main relevance of environmental characters (Section 5) for the Hazard; in this case, it derives from the previous classification of Seismic hazard classification according to national regulations.
- The prevalent incidence of "uses" (Section 4) for the assessment of Exposure;
- The relevance of Typology (Section 1), Geometry of spaces (Section 2) and constructive characteristics (Section 3) for the Vulnerability.

For each of them, the involved characters are specified according to the descriptors derived by literatures. Moreover, due to their "information nature", all the parameters are classified focusing on their qualitative or quantitative nature of the associated information. All the data are divided reflecting the belonging to specific sub-element of risk assessment.

Thus, all the BE classification codes and specific descriptors are summarized according to SRM and detailed for "information character". Following, Table 2,

Table 3 and Table 4 summarize them dividing them for Hazard, Vulnerability and Exposure, respectively. According to the process described in the first part of the method (§2), the presented descriptors are related to the final process of recognition-check between single RMs and single descriptors.

Table 2. Properties' qualification of parameters for BE classification involved in Seismic risk model for Hazard

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m^2; m/m, etc)
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS			
S5_1	Seismic intensity	Ground motion severity	Q	
		Seismic microzonation	Q	

		Max magnitude of historical earthquakes	Q
S5_4	Multi-hazard potential	classes	Q
S5_5	Ground type	classes of types	Q

Table 3. Properties' qualification of parameters for BE classification involved in Seismic risk model for Vulnerability

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m^2; m/m, etc)
	Section 1: MAIN TYPE			
S1_0	Morpho-typology	main class	Q	
S1_1	Dimension of OS	area	q	m^2
		perimeter	q	m
		width	q	m
S1_2	Hmax built front	H max	q	m
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_1	Type of Aggregates	Incidence	q	%
		length for types (or classes) of aggregates	q	m
		number of SU	q	-
		length of SU	q	m
		regularity in plan	Q	
		irregularity in elevation	Q	
		total covered surface	q	m^2
		number of storeys	q	-
		Ratio H max / width (OS)	Q	
		Ratio H med / width (OS)	Q	
S2_F_2	Accesses	number	q	-
		width	q	m
		position	Q	
S2_F_3	Special buildings	presence	Q	
		incidence (linear)	q	%
		number	q	-
		length of special buildings front	q	%
		height	q	m

		height of gable	q	m
S2_F_4a	Town walls	presence	Q	
		linear extension	q1	m
		position	Q	
		width or depth	q1	m
S2_F_4a	Porches	presence	Q	
		linear extension	q1	m
		position	Q	
		width or depth	q1	m
S2_F_5a	green area	Presence of green area	Q	
		crowding potential	q	pp/m^2
S2_F_5a	water	Presence of water	Q	
		crowding potential	q	pp/m^2
S2_F_6	Quote differences / slope	Quote difference	q	m
		Slope		%
	Content			
S2_C_1	Special Buildings	incidence (ratio sup/sup tot)	q	%
		number	q	-
		height	q	m
		area	q	m^2
		length	q	m
		width	q	m
		height of gable	q	m
S2_C_2	Quote difference/slope	Quote difference	q	m
		Slope		%
S2_C_3	Protection measure of slope/quote difference	presence	Q	
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	presence fountain	Q	
		presence of monuments	Q	
		incidence (area)	q	%
		number	q	-
S2_C_6	Underground cavities		Q	
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_1	Homogeneity of built environment age	Homogeneity	Q	
		last intervention period	Q	
		state of conservation	Q	
		wall disconnection in plan	q	m
		wall disconnection in elevation	q	m
S3_F_2	Homogeneity of constructive techniques	Homogeneity	Q	
		masonry quality	Q	
		wall thickness	q	m

		max distance between party walls	q	m
		roof types	Q	
		horizontal structure types	Q	
		staggered floors	q	-
		% openings	q	%
		vertical alignment of openings	q	-
		min edge distance of openings	q	m
		jointed facades	q	-
		superimposed/additional storeys	q	-
		no-structural protruding and decorative elements	q	-
		anti-seismic devices	q	-
S3_F_3	Fixed obstacles	incidence on total linear extension of frontier	q	%
		length	q	m^2
		influence in emergency paths	Q	
S3_F_4	Temporary obstacles	incidence (linear)	q	%
		length	q	m^2
		influence in emergency paths	Q	
	Content			
S3_C_1	Pavement type	classes of pavement	Q	
S3_C_2	Pavement condition	Classes of conditions	Q	
S3_C_3	Fixed obstacles	incidence on total AS area	q	%
		area	q	m^2
		influence in emergency paths	Q	
S3_C_4	Temporary obstacles	incidence	q	%
		area	q	m^2
		influence in emergency paths	Q	
	SECTION 4: CHARACTERISTICS OF USE			
S4_6	Vehicles (parking)	incidence (area for OS)	q	%
		incidence to prevalent dimension (linear for LS)	q	%
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS			
S5_6	Lifeline utilities	Presence of Lifeline Utilities	Q	
S5_7	OS interconnection	Classes OS network	Q	

Table 4. Properties' qualification of parameters for BE classification involved in Seismic risk model for Exposure

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m^2; m/m, etc)
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_3	Special buildings	presence	Q	
S2_F_5a	Green area	presence	Q	
		crowding potential	q	person/ m^2
S2_F_5b	Water	crowding potential	q	person/ m^2
	Content			
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	Presence of Monuments	Q	
S2_C_5a	Green area	presence	Q	
		crowding potential	q	person/ m^2
		Special temporary opening	Q	
S2_C_5b	Water	crowding potential	q	person/ m^2
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_4	Temporary obstacles	incidence	q	%
	Content			
S3_C_4	Temporary obstacles			
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding	crowding potential	q	person/ m^2
		tourism attraction	q	arrivals/inhabitants [pp/pp]
S4_2	Special uses of OS	crowding potential	q	person/ m^2
S4_3	Strategic building / Special uses of building facing OS	presence of special buildings or special uses	Q	
		crowding potential	q	person/ m^2
		presence of school or hospitals	Q	
S4_4	Accessibility for vehicle	incidence of accessibility to vehicles to total accesses	q	
		Temporary accessibility	Q	

S4_5	Accessibility for pedestrian	incidence of accessibility to pedestrian to total accesses	q	% - m/m
S4_7	Sights	presence of sight	Q	
		tourism attraction	q	arrivals/inhabitants [pp/pp]
		crowding potential		person/ m^2
S4_8	Sensitive targets	presence of Sensitive target	Q	
		% presence of Sensitive target	q	

3.2. Analysis of Terrorism Risk Model (TRM)

Similarly to previous section and starting from the D1.3.1 for Terrorism risk model (TRM), Table 5 summarizes the relevance of the BE characters according to each sub-class of risk assessment (Hazard H, Vulnerability V, Exposure E).

Table 5. Analysis of parameters for BE classification involved in terrorism risk model for Hazard, Vulnerability and Exposure

Code	Description	H	V	E
	Section 1: MAIN TYPE			
S1_0	Morpho-typology		X	
S1_1	Dimension of OS		X	
S1_2	Hmax built front			
S1_3	hmin built front			
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_1	Type of Aggregates			
S2_F_2	Accesses	X	X	
S2_F_3	Special buildings			
S2_F_4	Town walls/porches			
S2_F_5	Water/green area			X
S2_F_6	Quote differences / slope			
	Content			
S2_C_1	Special buildings			
S2_C_2	Quote difference/slope		X	
S2_C_3	Protections measure of slope/quote difference			X
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)		X	
S2_C_5	Water/green area		X	X
S2_C_6	Underground cavities			
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_1	Homogeneity of built environment age			
S3_F_2	Homogeneity of constructive techniques			

S3_F_3	Fixed obstacles	X	X	X
S3_F_4	Temporary obstacles	X	X	X
	Content			
S3_C_1	Pavement type			
S3_C_2	Pavement condition			
S3_C_3	Fixed obstacles		X	X
S3_C_4	Temporary obstacles		X	X
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding	X		X
S4_2	Special uses of OS	X		X
S4_3	Strategic building / Special uses of building facing OS	X		X
S4_4	Accessibility for vehicle		X	
S4_5	Accessibility for pedestrian		X	
S4_6	Vehicles (parking)			X
S4_7	Sights	X		X
S4_8	Sensitive targets	X		X
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS			
S5_1	Seismic intensity			
S5_2	Climate classification [DPR 412/1993]			
S5_3	Climate conditions			
S5_4	Multi-hazard potential			
S5_5	Ground type			
S5_6	Lifeline utilities			
S5_7	OS interconnection			

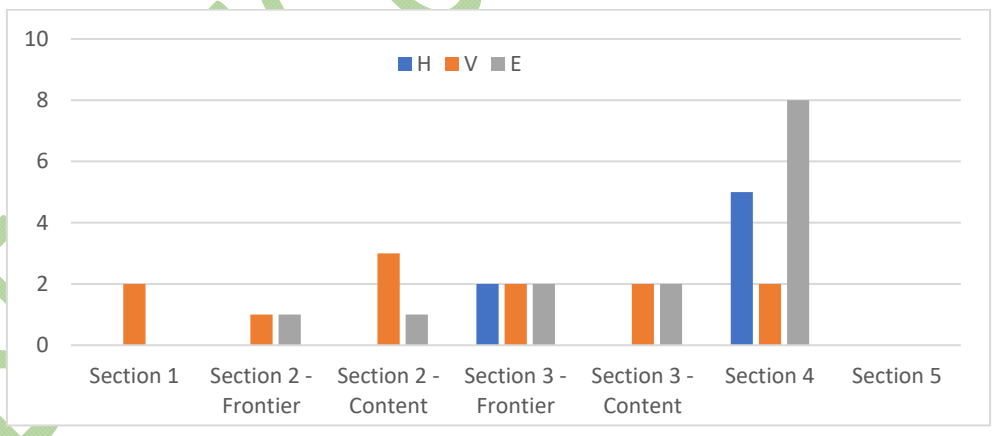

Figure 2. Assessment of incidence for each section of BE classification in Terrorist Risk Model

As discussed in previous sub-section, Figure 2 summarizes the incidence of each section of BE classification for the Terrorism Risk Model. Differently from the SRM, the TRM does not highlight the same relevance for Hazard assessment. In fact, as detailed in D.1.3.1, today Terrorism is not assessed by specific classes of hazard as for the natural hazards, but it is related to political, economic and religious features that are usually related

to national or international relevance. Thus, the inherent hazard related to TRM is mainly associated to the uses of the place (Section 4) and specific constructive features along the Frontier (Section 3 – Frontier).

Thus, all the BE classification codes and specific descriptors are summarized according to TRM and detailed for "information character". Following, Table 6,Table 7and Table 8 summarize them dividing them for Hazard, Vulnerability and Exposure, respectively. As well as for SRM, final descriptors are reported.

Table 6. Properties' qualification of parameters for BE classification involved in Terrorism risk model for Hazard

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m²; m/m, etc)
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE Frontier			
S2_F_2	Accesses	Mitigation systems	Q	
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS Frontier			
S3_F_3	Fixed obstacles	n. of protection system	q	-
		Mitigation systems	Q	
S3_F_4	Temporary obstacles	n. of protection system	q	-
		Mitigation systems	Q	
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding	Crowing level	q	person/ m² arrivals/inhabitants [pp/pp]
		Tourism attraction	q	
S4_2	Special uses of OS	Temporal special uses	Q	
S4_3	Strategic building / Special uses of building facing OS	presence	Q	
		simbolicity	Q	
S4_7	Sights	presence	Q	
		simbolicity	Q	
S4_8	Sensitive targets	presence	Q	
		simbolicity	Q	

Table 7. Properties' qualification of parameters for BE classification involved in Terrorism risk model for Vulnerability

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m²; m/m, etc)
	Section 1: MAIN TYPE			
S1_0	Morpho-typology	classes	Q	

S1_1	Dimension of OS	area	q	m^2
		perimeter	q	m
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_2	Accesses	Width	q	m
		number	q	-
	Content			
S2_C_2	Quote difference/slope	quote difference	q	m
		slope	q	%
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	incidence	q	% - m^2/ m^2
		efficacy of protection	Q	
S2_C_5	Water/green area	density (green)	q	% - m^2/ m^2
		efficacy in protection	Q	
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_3	Fixed obstacles	incidence	q	% - m^2/ m^2
		efficacy of protection	Q	
S3_F_4	Temporary obstacles	incidence	q	% - m^2/ m^2
		efficacy of protection	Q	
	Content			
S3_C_3	Fixed obstacles	incidence	q	% - m^2/ m^2
		efficacy of protection	Q	
S3_C_4	Temporary obstacles	incidence	q	% - m^2/ m^2
		efficacy of protection	Q	
	SECTION 4: CHARACTERISTICS OF USE			
S4_4	Accessibility for vehicle		Q	
S4_5	Accessibility for pedestrian		Q	

Table 8. Properties' qualification of parameters for BE classification involved in Terrorism risk model for Exposure

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m^2; m/m, etc)
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_5	Water/green areas	crowding potential (green area)	q	pp/ m^2
		influence in emergency routes	Q	
	Content			
S2_C_3	Protections measure of slope/quote difference	influence in emergency routes	Q	

S2_F_5	Water/green areas	crowding potential (green area)	q	pp/ m^2
		influence in emergency routes	Q	
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_3	Fixed obstacles	extension	q	m^2
		influence in emergency routes	Q	
S3_F_4	Temporary obstacles	extension	q	m^2
		influence in emergency routes	Q	
	Content			
S3_C_3	Fixed obstacles	extension	q	m^2
		influence in emergency routes	Q	
S3_C_4	Temporary obstacles	extension	q	m^2
		influence in emergency routes	Q	
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding		q	pp/ m^2
S4_2	Special uses of OS	crowding potential	q	pp/ m^2
S4_3	Strategic building / Special uses of building facing OS	crowding potential	q	pp/ m^2
S4_6	Vehicles (parking)	influence in emergency routes	Q	
S4_7	Sights	crowding potential	q	pp/ m^2
S4_8	Sensitive targets		Q	

3.3. Analysis of Heatwave Risk Model (HRM)

Starting from the analysis reported in D2.2.1, D2.2.2, D2.2.3, D2.2.4 and D2.2.5 for Heatwave risk model (HRM), Table 9 summarizes the relevance of the BE characters according to each sub-class of risk assessment (Hazard H, Vulnerability V, Exposure E).

Table 9. Analysis of parameters for BE classification involved in Heatwave risk model for Hazard, Vulnerability and Exposure

Code	Description	H	V	E
	Section 1: MAIN TYPE			
S1_0	Morpho-typology		X	
S1_1	Dimension of OS		X	X
S1_2	Hmax built front		X	
S1_3	hmin built front		X	
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_1	Type of Aggregates			
S2_F_2	Accesses		X	
S2_F_3	Special buildings			
S2_F_4a	Town walls			
S2_F_4b	Porches		X	

S2_F_5a	Green area		X	
S2_F_5b	Water		X	
S2_F_6	Quote differences / slope		X	
	Content			
S2_C_1	Special buildings			
S2_C_2	Quote difference/slope			
S2_C_3	Protections measure of slope/quote difference			
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)			
S2_C_5a	Green area		X	X
S2_C_5a	Water		X	X
S2_C_6	Underground cavities			
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_1	Homogeneity of built environment age			
S3_F_2	Homogeneity of constructive techniques		X	
S3_F_3	Fixed obstacles		X	
S3_F_4	Temporary obstacles			
	Content			
S3_C_1	Pavement type		X	
S3_C_2	Pavement condition		X	
S3_C_3	Fixed obstacles		X	
S3_C_4	Temporary obstacles			
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding			X
S4_2	Special uses of OS			X
S4_3	Strategic building / Special uses of building facing OS		X	X
S4_4	Accessibility for vehicle		X	
S4_5	Accessibility for pedestrian			X
S4_6	Vehicles (parking)		X	X
S4_7	Sights			X
S4_8	Sensitive targets		X	X
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS			
S5_1	Seismic intensity			
S5_2	Climate classification [DPR 412/1993]	X		
S5_3	Climate conditions	X		
S5_4	Multi-hazard potential	X	X	
S5_5	Ground type		X	
S5_6	Lifeline utilities			
S5_7	OS interconnection			

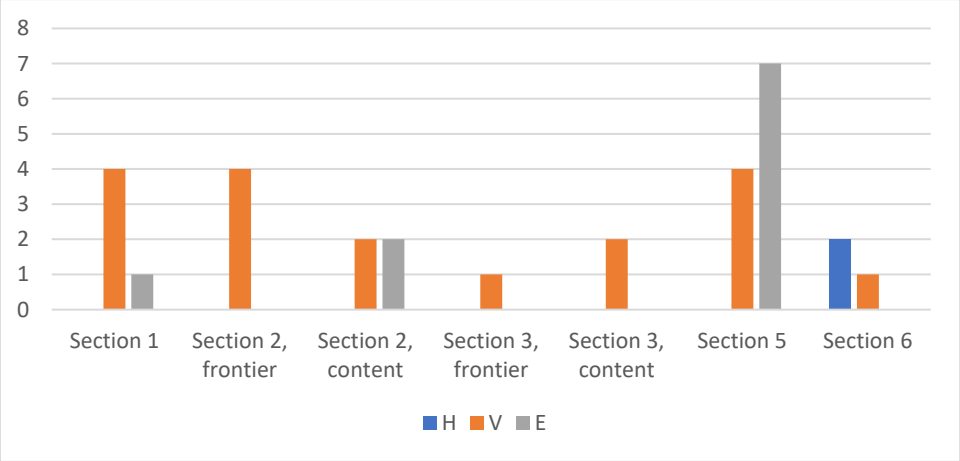

Figure 3. Assessment of incidence for each section of BE classification in Heatwave Risk Model

As well as for the SRM, Figure 3 highlights the main relevance of environmental characters (Section 5) for the Hazard. In fact, the environmental characters are related to the climate classification according to national instruments, as independent factors from BE features. This is in line with the macro-classification of Heatwave and seismic risks as "natural" events. Similarly, Typology (Section 1), Geometry of spaces (Section 2) and constructive characteristics (Section 3) directly influence the Vulnerability of HRM, while the "uses" of places (Section 4) the Exposure.

For each of them, the involved characters are specified according to the descriptors derived by literatures. Moreover, due to their "information nature", all the parameters are classified focusing on their qualitative or quantitative nature of the associated information. All the data are divided reflecting the belonging to specific sub-element of risk assessment.

As in previous cases, all the BE classification codes and specific descriptors are summarized according to HRM and detailed for "information character". Following, Table 10,Table 11and Table 12 summarize them dividing them for Hazard, Vulnerability and Exposure, respectively.

Table 10. Properties' qualification of parameters for BE classification involved in HRM for Hazard

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m^2; m/m, etc)
SECTION 5: ENVIRONMENTAL CHARACTERISTICS				
S5_2	Climate classification [DPR 412/1993]	Climate zone	Q	
		Latitude (North/South)	Q	
S5_3	Climate conditions	Wind/breeze speed	q	m/s

		Wind/breeze direction azimuth	q	°
		Air temperature	q	°C
		Solar Irradiation	q	W/m²
		Relative humidity	q	%
S5_4	Multi-hazard potential	Pollution sources presence Boolean	q	mass/volume (e.g. mg/l)
		Pollution sources on wind/breeze trajectory Boolean	q	°
		Current season (e.g. summer)	Q	

Table 11. Properties' qualification of parameters for BE classification involved in HRM for Vulnerability

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m²; m/m, etc)
	Section 1: MAIN TYPE			
S1_0	Morpho-typology	Main dimension azimuth	q	°
		Canyon aspect ratio	q	m/m
		Proximity of sidewalk to traffic	q	m
		Proximity of sidewalk to greenery	q	m
		Proximity of sidewalk to water	q	m
S1_1	Dimension of OS	width	q	m
		Street width	q	m
		Sidewalk width	q	m
S1_2	Hmax built front	Average building height	q	m
S1_3	hmin built front	Average building height	q	m
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE Frontier			
S2_F_2	Accesses	width	q	m
		location / orientation (azimuth)	q	Coordinates
S2_F_4b	porches	presence	Q	
		location	q	Coordinates
		width or depth	q	m

S2_F_5a	green area	presence	Q	
		linear extension	q	m
		Greenery location or position with respect to LS/AS	q or Q	Coordinates
		Greenery density	q	m^2 / m^2
S2_F_5b	Water	presence	Q	
		Water body location or position with respect to LS/AS	q or Q	Coordinates
		Water body area	q	m^2
		Water body volume	q	m^3
S2_F_6	Quote differences / slope	Slope	q	% or m/m or °
	Content			
S2_C_5a	green area	presence of green area	Q	
		incidence for total area	q	%
		extension area	q	m^2
		Greenery type (seasonal/ever green and species)	Q	
		Greenery adsorption capacity	q	mass/time o mass/area (e.g. mg/s or g/m^2)
		Greenery height	q	m
		Greenery width	q	m
		Tree crown shape	Q	
		Tree crown diameter	q	m
S2_C_5b	Water	presence of water	Q	
		extension (area)	q	m^2
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_2	Homogeneity of constructive techniques	Facade finishing material	Q	
		Facade finishing albedo	q	-
		Facade finishing ageing	q	years
		Facade finishing current roughness	q	-
		Facade finishing aged albedo	q	-
		Facade cleanness	Q	
		Facade heat capacity	q	J/ kg K
S3_F_3	Fixed obstacles	Obstacle location	q	Coordinates
		Obstacle shade boolean	Q	
	Content			

S3_C_1	Pavement type	Pavement finishing material	Q	
		incidence (area) for classes of pavements	q	%
S3_C_2	Pavement condition	Pavement finishing ageing	q	years
		Pavement finishing current roughness	q	-
		Pavement finishing aged albedo	q	-
S3_C_3	Fixed obstacles	Obstacle translucency boolean	Q	
		Obstacle height	q	m
		Obstacle width	q	m
	SECTION 4: CHARACTERISTICS OF USE			
S4_4	Accessibility for vehicle	Traffic intensity	q	vehicles / km
		presence of street	Q	
		Temporary accessibility	Q	
S4_3	Strategic building / Special uses of building facing OS	Sensitive targets attraction to building use Boolean	Q	
		Presence of Schools Boolean	Q	
		Presence of Hospitals Boolean	Q	
		Presence of Care home Boolean	Q	
S4_8	Sensitive targets	presence of Sensitive target (people as hard target)	q	-
		presence of Sensitive target (elders/frail/gender/youngsters)	q	-
		% presence of Sensitive target (elders/frail/gender/youngsters)	q	%
S4_6	Vehicles (parking)	Parking area presence Boolean	Q	
		Parking area location	q	Coordinates
		Parking area	q	m^2
		Parking width	q	m
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS			
S5_5	Ground type	Ground roughness	q	-
		Ground albedo	q	-
		Ground heat capacity	q	J/ kg K

Table 12. Properties' qualification of parameters for BE classification involved in HRM for Exposure

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m^2; m/m, etc)

	Content			
S2_C_5a	green area	crowing potential	q	person/ m^2
		Special temporary opening	Q	
S2_C_5b	Water	crowing potential	q	person/ m^2
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding	people present	q	pp
		Crowing level	q	person/ m^2
		Exposure duration	q	h
S4_2	Special uses of OS	crowing potential	q	person/ m^2
S4_3	Strategic building / Special uses of building facing OS	presence of special buildings or special uses	Q	
		crowding potential	q	person/ m^2
		Presence of Schools Boolean	Q	
		Presence of Hospitals Boolean	Q	
		Presence of Care home Boolean	Q	
		Sensitive targets attraction to building use Boolean	Q	
S4_5	Accessibility for pedestrian	Pedestrian street presence Boolean	Q	
		Walking area	q	m^2
		Walking width	q	m
S4_6	Vehicles (parking)	Parking area presence Boolean	Q	
		Parking area location	q	Coordinates
		Parking area	q	m^2
		Parking width	q	m
S4_7	Sights	crowding potential	q	person/ m^2
S4_8	Sensitive targets	presence of Sensitive target (people as hard target)	q	-

3.4. Analysis of Pollution Risk Model (PRM)

Starting from the analysis reported in D2.2.1, D2.2.2, D2.2.3, D2.2.4 and D2.2.5 for the Pollution risk model (PRM), Table x summarizes the relevance of the BE characters according to each sub-class of risk assessment (Hazard H, Vulnerability V, Exposure E).

Table 13. Analysis of parameters for BE classification involved in Pollution risk model for Hazard, Vulnerability and Exposure

Code	Description	H	V	E
	Section 1: MAIN TYPE			
S1_0	Morpho-typology		X	

S1_1	Dimension of OS	X	X
S1_2	Hmax built front	X	
S1_3	hmin built front	X	
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE		
	Frontier		
S2_F_1	Type of Aggregates		
S2_F_2	Accesses	X	
S2_F_3	Special buildings		
S2_F_4a	Town walls		
S2_F_4b	Porches	X	
S2_F_5a	Green area	X	
S2_F_5b	Water		
S2_F_6	Quote differences / slope	X	
	Content		
S2_C_1	Special buildings		
S2_C_2	Quote difference/slope		
S2_C_3	Protections measure of slope/quote difference		
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)		
S2_C_5a	Green area	X	X
S2_C_5a	Water	X	X
S2_C_6	Underground cavities		
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS		
	Frontier		
S3_F_1	Homogeneity of built environment age		
S3_F_2	Homogeneity of constructive techniques	X	
S3_F_3	Fixed obstacles		
S3_F_4	Temporary obstacles		
	Content		
S3_C_1	Pavement type		
S3_C_2	Pavement condition	X	
S3_C_3	Fixed obstacles	X	
S3_C_4	Temporary obstacles		
	SECTION 4: CHARACTERISTICS OF USE		
S4_1	Crowding		X
S4_2	Special uses of OS		X
S4_3	Strategic building / Special uses of building facing OS	X	X
S4_4	Accessibility for vehicle	X	
S4_5	Accessibility for pedestrian		X
S4_6	Vehicles (parking)	X	X
S4_7	Sights		X
S4_8	Sensitive targets	X	X
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS		
S5_1	Seismic intensity		

S5_2	Climate classification [DPR 412/1993]		
S5_3	Climate conditions	X	
S5_4	Multi-hazard potential	X	
S5_5	Ground type		X
S5_6	Lifeline utilities		
S5_7	OS interconnection		

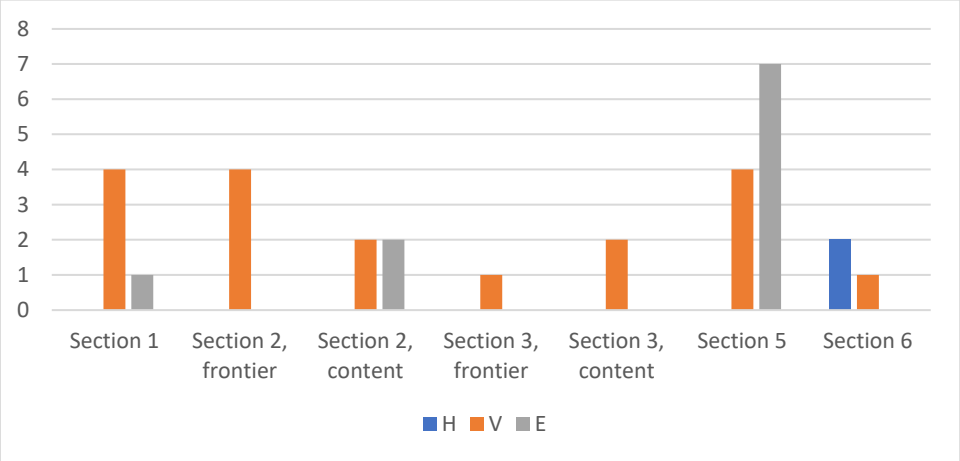

Figure 4. Assessment of incidence for each section of BE classification in Pollution Risk Model

Also for PRM, Figure 4 reports the incidence of each section of BE classification for Hazard, Vulnerability and Exposure, highlighting similar relevance of SRM and HRM. In detail, Vulnerability quote in Risk assessment is influenced by elements (in term of descriptors) which are part of all the sections identified for the BE (type, geometry, use, construction, environmental parameters). On the other hand, Exposure is related to the uses of BE as a clear correlation between human activities and cities exposures to such SLOD events. Concerning the Hazard, the incidence of the Environmental parameters cannot be strictly related to the "natural" features of SLOD but to the relevance of environmental parameters in exacerbate the Hazard.

As in previous cases, all the BE classification codes and specific descriptors are summarized according to PRM and detailed for "information character". Following, Table 14,Table 15 and Table 16 summarize them dividing them for Hazard, Vulnerability and Exposure, respectively.

Table 14. Properties' qualification of parameters for BE classification involved in PRM for Hazard

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m²; m/m, etc)
SECTION 5: ENVIRONMENTAL CHARACTERISTICS				
S5_3	Climate conditions	Wind/breeze speed	q	m/s

		Wind/breeze direction azimuth	q	°
		Air temperature	q	°C
		Solar Irradiation	q	W/m²
S5_4	Multi-hazard potential	Pollution sources presence Boolean	Q	
		Pollution sources on wind/breeze trajectory Boolean	Q	°
		Current season (e.g. summer)	Q	
		Pollution sources load	q	mass/volume (e.g. mg/l)

Table 15. Properties' qualification of parameters for BE classification involved in PRM for Vulnerability

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m²; m/m, etc)
	Section 1: MAIN TYPE			
S1_0	Morpho-typology	Main dimension azimuth	q	°
		Canyon aspect ratio	q	m/m
		Proximity of sidewalk to traffic	q	m
		Proximity of sidewalk to greenery	q	m
S1_1	Dimension of OS	Street width	q	m
S1_2	Hmax built front	Average building height	q	m
S1_3	hmin built front	Average building height	q	m
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE			
	Frontier			
S2_F_2	Accesses	width	q	m
		location / orientation (azimuth)	q	Coordinates
S2_F_4b	porches	presence	Q	
		location	q	Coordinates
		width or depth	q	m
S2_F_5a	green area	presence	Q	
		linear extension	q	m

		Greenery location or position with respect to LS/AS	q or Q	Coordinates
		Greenery density	q	m^2 / m^2
S2_F_6	Quote differences / slope	Slope	q	% or m/m or °
	Content			
S2_C_5a	green area	presence of green area	Q	
		incidence for total area	q	%
		extension area	q	m^2
		Greenery type (seasonal/ever green and species)	Q	
		Greenery adsorption capacity	q	mass/time or mass/area (e.g. mg/s or g/m^2)
		Greenery height	q	m
		Greenery width	q	m
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS			
	Frontier			
S3_F_2	Homogeneity of constructive techniques	Facade finishing current roughness	q	-
		Facade cleanness	Q	
		Facade pollutant deposition capacity	q	mass/time o mass/area (e.g. mg/s or g/m^2)
	Content			
S3_C_2	Pavement condition	Pavement finishing current roughness	q	-
S3_C_3	Fixed obstacles	Obstacle height	q	m
		Obstacle width	q	m
	SECTION 4: CHARACTERISTICS OF USE			
S4_4	Accessibility for vehicle	Traffic intensity	q	vehicles / km
		presence of street	Q	
		Temporary accessibility	Q	
S4_3	Strategic building / Special uses of building facing OS	Sensitive targets attraction to building use Boolean	Q	
		Presence of Schools Boolean	Q	
		Presence of Hospitals Boolean	Q	
		Presence of Care home Boolean	Q	
S4_8	Sensitive targets	presence of Sensitive target (people as hard target)	q	-
		presence of Sensitive target (elders/frail/gender/youngsters)	q	-
		% presence of Sensitive target (elders/frail/gender/youngsters)	q	%

S4_6	Vehicles (parking)	Parking area presence Boolean	Q	
		Parking area location	q	Coordinates
		Parking area	q	m^2
		Parking width	q	m
		SECTION 5: ENVIRONMENTAL CHARACTERISTICS		
S5_5	Ground type	Ground roughness	q	-

Table 16. Properties' qualification of parameters for BE classification involved in PRM for Exposure

Code	Description	Specific descriptor	Information details for the descriptor (Qualitative Q or Quantitative q)	Unit of measurements required for the quantitative descriptor (m^2; m/m, etc)
	Content			
S2_C_5a	green area	crowing potential	q	person/ m^2
		Special temporary opening	Q	
S2_C_5b	Water	crowing potential	q	person/ m^2
	SECTION 4: CHARACTERISTICS OF USE			
S4_1	Crowding	people present	q	pp
		Crowing level	q	person/ m^2
		Exposure duration	q	h
S4_2	Special uses of OS	crowing potential	q	person/ m^2
S4_3	Strategic building / Special uses of building facing OS	presence of special buildings or special uses	Q	
		crowding potential	q	person/ m^2
		Presence of Schools Boolean	Q	
		Presence of Hospitals Boolean	Q	
		Presence of Care home Boolean	Q	
		Sensitive targets attraction to building use Boolean	Q	
S4_5	Accessibility for pedestrian	Pedestrian street presence Boolean	Q	
		Walking area	q	m^2
		Walking width	q	m
S4_6	Vehicles (parking)	Parking area presence Boolean	Q	
		Parking area location	q	Coordinates
		Parking area	q	m^2
		Parking width	q	m

S4_7	Sights	crowding potential	q	person/ m^2
S4_8	Sensitive targets	presence of Sensitive target (people as hard target)	q	-

3.5. Final assessment of BE characters in multi-risk models

Checking the classification codes of BE for all the Risk models, Table 17 summarizes all the characters involved. In detail, the overlapping process of categorization of BE prone to all the risks supports the process of "enrichment" of BETs. In fact, for all the properties involved in BETs, all the properties will be defined and qualified according to the main properties involved.

Table 17. assessment BE code involved in single risk model (SRM, TRM, HRM and PRM) – represented with X – and total involvement of them for each risk (final score column)

Code	Description	SRM	TRM	HRM	PRM	final score
	Section 1: MAIN TYPE					
S1_0	Morpho-typology	X	X	X	X	4
S1_1	Dimension of OS	X	X	X	X	4
S1_2	Hmax built front	X		X	X	3
S1_3	hmin built front			X	X	2
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE					
	Frontier					
S2_F_1	Type of Aggregates	X				1
S2_F_2	Accesses	X	X	X	X	4
S2_F_3	Special buildings	X	X			2
S2_F_4a	Town walls	X	X			2
S2_F_4b	Porches	X	X	X	X	4
S2_F_5a	Green area	X	X	X	X	4
S2_F_5b	Water	X	X	X		3
S2_F_6	Quote differences / slope	X		X	X	3
	Content					
S2_C_1	Special buildings	X	X			2
S2_C_2	Quote difference/slope	X	X			2
S2_C_3	Protections measure of slope/quote difference	X	X			2
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	X	X	X		3
S2_C_5a	Green area	X	X	X	X	4
S2_C_5b	Water	X	X	X	X	4
S2_C_6	Underground cavities	X				1
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS					
	Frontier					
S3_F_1	Homogeneity of built environment age	X				1
S3_F_2	Homogeneity of constructive techniques	X		X	X	3
S3_F_3	Fixed obstacles	X	X	X		3
S3_F_4	Temporary obstacles	X	X			2
	Content					
S3_C_1	Pavement type	X		X		2
S3_C_2	Pavement condition	X		X	X	3
S3_C_3	Fixed obstacles	X	X	X	X	4
S3_C_4	Temporary obstacles	X	X			2

SECTION 4: CHARACTERISTICS OF USE						
S4_1	Crowding	X	X	X	X	4
S4_2	Special uses of OS	X	X	X	X	4
S4_3	Strategic building / Special uses of building facing OS	X	X	X	X	4
S4_4	Accessibility for vehicle	X	X	X	X	4
S4_5	Accessibility for pedestrian	X	x	X	X	4
S4_6	Vehicles (parking)	X	X	X	X	4
S4_7	Sights	X	X	X	X	4
S4_8	Sensitive targets	X	X	X	X	4
SECTION 5: ENVIRONMENTAL CHARACTERISTICS						
S5_1	Seismic intensity	X				1
S5_2	Climate classification [DPR 412/1993]			X		1
S5_3	Climate conditions	X		X	X	3
S5_4	Multi-hazard potential	X		X	X	3
S5_5	Ground type	X		X	X	3
S5_6	Lifeline utilities	X				1
S5_7	OS interconnection	X				1

4. Hazard combinations for a national sample

As discussed in section 3, the selected "environmental" parameters influence S-H-PRMs due to their high coherence with "natural-based" phenomena. In these cases, environmental parameters chosen for the qualification of BEs (or BETs) are associated to a wider scale than OS or LS. Concerning the TRM, terrorism phenomenon cannot be directly related to these due to the man-made" responsibility in moving such risk.

In order to determine the most recurrent combination of Hazards in BETs and thus their assessment in the recurrent combinations (BETs-Risk Models), this section provides a first level of analysis of hazard combinations in a specific national sample. The analysis includes some main findings and points some constrains to solve some incompatibility between homogeneity of data and nature of risk models. In details:

- Due to the wide scale of relevance for "environmental" parameters, SRM and HRM are analysed according to the main (national and international) datasets provided for occurred natural hazards.
- Specifically for SRM, all the Italian land is featured by classes of seismic Hazard (http://esse1-gis.mi.ingv.it/) thus, just the higher classes are included in the analysis.
- TRM is considered on an over-ordered scale, providing the hazard severity on the lower possible scale available for specific international databases of events.
- PRM cannot modelled for wide scale and requires to be properly referred to local urban stations. In order to adjust the scale, mean values of urban pollutants can be analysed, as representative descriptor of PRM for Hazard.
- the chosen sample is homogeneous with the system of squares analysed for the identification of parameters involved in recurrent BETs (see D.3.1.1).

Due to that, the sample of 133 cities - as major cities in each Italian province – are analysed for SRM, TRM, HRM and PRM taking into account:

- Italian seismic zonation for SRM identified by INGV and collected in the available database (Protezione Civile 2020). As discussed before, just cities with higher classes of hazard (1÷3) are checked.

- The Global Terrorism Database® (GTD) for the TRM; here the period of analysis is 1999-2018 and the lower scale of detail is referred to the city (START).
- The EM-DAT database for the HRM. In this case, the analysed period concerns 1900-2020. Due to the scale of such natural event, the recoded events the referred to region or province ((CRED)).
- The Air Quality Statistics provided by the European Environmental Agency is considered to quantify Pollutants quantities for cities (detailly, PM10 ones) for PRM (European Environmental Agency). In this case, only urban and sub-urban stations are considered (as classified according the national guidelines (de'Munari et al. 2004)) and the 90.41 percentile of yearly values in each city are considered for the reference period 2010-2019.

All the cities in the sample are characterized with data collected. In detail, for every case, region, province, city and detailed name of square is identified. For the qualification of previous events, "seismic zonation" (for SRM) identifies the class of seismic hazard associated to each city; "n. of attack in the city" and "n. of attack in the province" (for TRM) report the number of occurred Terrorist events in the specific city and in other ones in the same province, respectively. "n. heatwave" (for HRM) counts the number of occurred heatwaves in the province or city. Finally, "mean value recorded for PM10 [40μg/m^3]" expresses the value of the defined pollutant source in all the extended land of city as limit value for human health, assessed in the calendar year (UNION 2008). The values are summarized in Annex I.

As a second step, a matrix of hazard combinations is created in Table 18, considering for all the cities the presence of the single hazard when:

- "Seismic zonation" = [1,2,3];
- N. terrorist events > 1
- N. Heatwaves > 1
- 90.41 percentile measure of Pollution source > 40μg/m^3

Table 18. Matrix of Hazard combinations in the selected sample

	Region	Province	Town	Square	SRM Seismic zonation INGV	TRM n. of attack in the city GTD	HRM n. heatwaves EM-DAT	PRM PM10 > 50µg/m³ EEA	Comb.
1	VALLE D'AOSTA	AO	Aosta	Piazza Emile Chanoux					S P
2	PIEMONTE	AL	Alessandria	Piazza Papa Giovanni XXIII					S P
3	PIEMONTE	AT	Asti	Piazza San Secondo					P
4	PIEMONTE	BI	Biella	Piazza Duomo					S P
5	PIEMONTE	CN	Cuneo	Piazza Tancredi Galimberti					S P
6	PIEMONTE	NO	Novara	Piazza della Repubblica					P
7	PIEMONTE	TO	Torino	Piazza San Carlo					S T H P
8	PIEMONTE	TO-1	Moncalieri	Piazza Umberto I				n.a.	S H
9	PIEMONTE	VB	Verbania	Piazza Ranzoni					P
10	PIEMONTE	VC	Vercelli	Piazza Cavour					P
11	LOMBARDIA	BG	Bergamo	Piazza Vecchia					S P
12	LOMBARDIA	BS	Brescia	Piazza della Loggia					S T P
13	LOMBARDIA	CO	Como	Piazza del Duomo					P
14	LOMBARDIA	CR	Cremona	Piazza del Comune					S P
15	LOMBARDIA	LC	Lecco	Piazza XX Settembre					S P
16	LOMBARDIA	LO	Lodi	Piazza della Vittoria					S P
17	LOMBARDIA	MI	Milano	Piazza del Duomo					S T H P
18	LOMBARDIA	MN	Mantova	Piazza Sordello					S P
19	LOMBARDIA	MB	Monza	Piazza Trento e Trieste					S P
20	LOMBARDIA	PV	Pavia	Piazza Duomo					S P
21	LOMBARDIA	PV-1	Vigevano	Piazza Ducale					S P
22	LOMBARDIA	SO	Sondrio	Piazza Garibaldi					S P
23	LOMBARDIA	VA	Varese	Piazza San Vittore					T H P
24	TRENTINO ALTO ADIGE	BZ	Bolzano	Piazza del Grano					H
25	TRENTINO ALTO ADIGE	TN	Trento	Piazza Duomo					S T H P
26	VENETO	BL	Belluno	Piazza Duomo					S H P
27	VENETO	PD	Padova	Piazza delle Erbe					T H P
28	VENETO	RO	Rovigo	Piazza Vittorio Emanuele					H P

29	VENETO	TV	Treviso	Piazza Duomo									S H P
30	VENETO	VE	Venezia	Piazza San Marco									T H P
31	VENETO	VR	Verona	Piazza dei Signori									S T H P
32	VENETO	VI-1	Bassano del Grappa	Piazza del Castello								n.a.	S H
33	VENETO	VI	Vicenza	Piazza dei Signori									S H P
34	FRIULI VENEZIA GIULIA	GO	Gorizia	Piazza della Vittoria									S T P
35	FRIULI VENEZIA GIULIA	PN	Pordenone	Piazza San Marco									S T P
36	FRIULI VENEZIA GIULIA	TS	Trieste	Piazza Unità d'Italia									S H P
37	FRIULI VENEZIA GIULIA	UD	Udine	Piazza Matteotti									S P
38	LIGURIA	GE	Genova	Piazza delle Vigne									S T H P
39	LIGURIA	SP	La Spezia	Piazza Cavour									S
40	LIGURIA	IM	Imperia	Piazza S.Giovanni								n.a.	S
41	LIGURIA	IM-1	Sanremo	Piazza Santa Brigida									S T
42	LIGURIA	SV	Savona	Piazza Sisto IV									S P
43	TOSCANA	AR	Arezzo	Piazza Grande									S P
44	TOSCANA	FI	Firenze	Piazza del Duomo									S T H P
45	TOSCANA	FI-1	Empoli	Piazza Farinata degli Uberti									S P
46	TOSCANA	GR	Grosseto	Piazza Dante									P
47	TOSCANA	LI	Livorno	Piazza Grande									S T P
48	TOSCANA	LU	Lucca	Piazza dell'Anfiteatro									S P
49	TOSCANA	MS	Massa	Piazza Mercurio									S
50	TOSCANA	MS-1	Carrara	Piazza Alberica									S P
51	TOSCANA	PI	Pisa	Piazza dei Cavalieri									S P
52	TOSCANA	PT	Pistoia	Piazza del Duomo									S T P
53	TOSCANA	PO	Prato	Piazza del Comune									S P
54	TOSCANA	SI	Siena	Piazza del Campo									S P
55	EMILA ROMAGNA	BO	Bologna	Piazza Maggiore									S T P
56	EMILA ROMAGNA	FE	Ferrara	Piazza Trento e Trieste									S P
57	EMILA ROMAGNA	FC	Forli	Piazza Aurelio Saffi									S P
58	EMILA ROMAGNA	FC-1	Cesena	Piazza del Popolo									S P
59	EMILA ROMAGNA	MO	Modena	Piazza Grande									S T P
60	EMILA ROMAGNA	MO-1	Carpi	Piazza Martiri									S P
61	EMILA ROMAGNA	PR	Parma	Piazza Duomo									S T P

62	EMILA ROMAGNA	PC	Piacenza	Piazza dei Cavalli				S P
63	EMILA ROMAGNA	RA	Ravenna	Piazza del Popolo				S P
64	EMILA ROMAGNA	RN	Rimini	Piazza Cavour				S P
65	EMILA ROMAGNA	RA-1	Faenza	Piazza del Popolo				S P
66	EMILA ROMAGNA	RE	Reggio Emilia	Piazza Camillo Prampolini				S P
67	UMBRIA	PG	Perugia	Piazza IV Novembre				S T P
68	UMBRIA	PG-1	Spoleto	Piazza del Mercato				S
69	UMBRIA	TR	Terni	Piazza della Repubblica				S P
70	MARCHE	AN	Ancona	Piazza del Plebiscito				S H P
71	MARCHE	AP	Ascoli Piceno	Piazza del Popolo				S H P
72	MARCHE	FM	Fermo	Piazza del Popolo			n.a.	S T H
73	MARCHE	MC	Macerata	Piazza della Libertà				S T H
74	MARCHE	PU	Pesaro	Piazza del Popolo				S H P
75	MARCHE	PU-1	Urbino	Piazza Rinascimento				S H P
76	ABRUZZO	CH	Chieti	Piazza San Giustino			n.a.	S
77	ABRUZZO	AQ	L'Aquila	Piazza del Duomo				S
78	ABRUZZO	AQ-1	Sulmona	Piazza XX Settembre			n.a.	S
79	ABRUZZO	PE	Pescara	Piazza della Rinascita				S P
80	ABRUZZO	TE	Teramo	Piazza Sant'Anna				S P
81	LAZIO	FR	Frosinone	Piazza Cairoli				S P
82	LAZIO	LT	Latina	Piazza del Popolo				S T P
83	LAZIO	RI	Rieti	Piazza Cesare Battisti				S P
84	LAZIO	RM	Roma	Piazza Navona				S T H P
85	LAZIO	RM-1	Velletri	Piazza Giuseppe Mazzini			n.a.	S H
86	LAZIO	RM-2	Tivoli	Piazza del Seminario			n.a.	S
87	LAZIO	VT	Viterbo	Piazza del Plebiscito				S T
88	MOLISE	CB	Campobasso	Largo San Leonardo				S P
89	MOLISE	CB-1	Termoli	Piazza Duomo				S P
90	MOLISE	IS	Isernia	Piazza Andrea d'Isernia				S
91	CAMPANIA	NA	Napoli	Piazza Plebiscito				S T H P
92	CAMPANIA	NA-1	Pompei	Piazza Bartolo Longo			n.a.	S H
93	CAMPANIA	SA	Salerno	Piazza Alfano				S P
94	CAMPANIA	AV	Avellino	Piazza Libertà				S P

95	CAMPANIA	BN	Benevento	Piazza Orsini				S P
96	CAMPANIA	CE	Caserta	Piazza Duomo				S T P
97	PUGLIA	BA	Bari	Piazza dell'Odegitria				S P
98	PUGLIA	BA-1	Altamura	Piazza del Duomo				S
99	PUGLIA	BA-2	Bitonto	Piazza Cavour			n.a.	S
100	PUGLIA	BA-3	Gravina in Puglia	Piazza Benedetto XIII			n.a.	S
101	PUGLIA	BAT	Andria	Piazza Duomo				S P
102	PUGLIA	BAT-1	Barletta	Piazzetta del Duomo				S
103	PUGLIA	BAT-2	Bisceglie	Piazza Duomo			n.a.	S
104	PUGLIA	BAT-3	Trani	Piazza Duomo			n.a.	S
105	PUGLIA	BR	Brindisi	Piazza Duomo				P
106	PUGLIA	FG	Foggia	Piazza Francesco De Santis				S P
107	PUGLIA	FG-1	Manfredonia	Piazza del Popolo				S P
108	PUGLIA	FG-5	San Severo	Piazza della Repubblica			n.a.	S
109	PUGLIA	LE	Lecce	Piazza Duomo				H P
110	PUGLIA	TA	Taranto	Piazza Duomo				S
111	BASILICATA	MT	Matera	Piazza Vittorio Emanuele			n.a.	S H
112	BASILICATA	PT	Potenza	Largo Duomo				S
113	CALABRIA	CT	Catanzaro	Piazza Duomo				S
114	CALABRIA	CS	Cosenza	Piazza Duomo				S P
115	CALABRIA	KR	Crotone	Piazza Duomo				S P
116	CALABRIA	RC	Reggio Calabria	Piazza Duomo				S T
117	CALABRIA	VV	Vibo Valentia	Piazza Armando Diaz				S
118	SICILIA	AG	Agrigento	Piazza Don Giovanni Minzoni				S T H P
119	SICILIA	CL	Caltanisetta	Piazza Garibaldi			n.a.	H
120	SICILIA	CT	Catania	Piazza Università				S H P
121	SICILIA	EN	Enna	Piazza Duomo				S H
122	SICILIA	EN-1	Piazza Armerina	Piazza Cattedrale			n.a.	S H
123	SICILIA	ME	Messina	Piazza Duomo				S H
124	SICILIA	PA	Palermo	Piazza Pretoria				S T H P
125	SICILIA	RG	Ragusa	Piazza Duomo				S H
126	SICILIA	SR	Siracusa	Piazza Minerva				S H P
127	SICILIA	TR	Trapani	Piazza Lucatelli				S H

128	SARDEGNA	CA	Cagliari	Piazza Palazzo	[redacted]	[redacted]	T P
129	SARDEGNA	NU	Nuoro	Piazza Sebastiano Satta			T
130	SARDEGNA	OR	Oristano	Piazza Eleonara d'Arboria			P
131	SARDEGNA	SS	Sassari	Piazza d'Italia			
132	SARDEGNA	SS-1	Alghero	Piazza del Teatro			
133	SARDEGNA	SU	Iglesias	Piazza Municipio			

Figure 5. Distribution of combination of S-T-H-P hazard in the sample (right) and distribution of percentages (left)

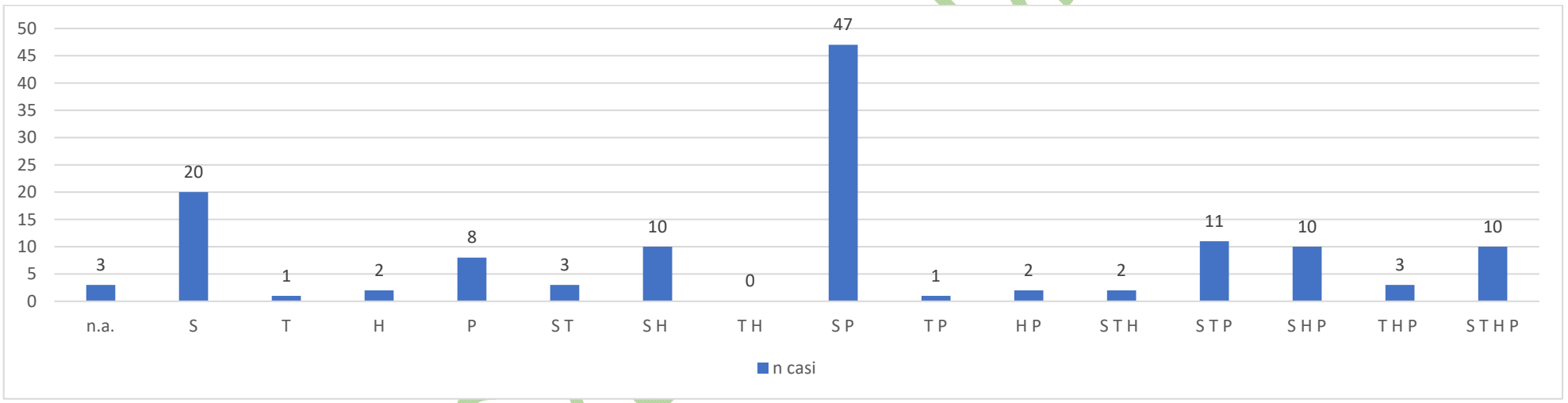

Figure 5 shows the distribution of combinations of hazards for the analysed Risk models in the analysed sample. It shows the higher relevance in combination with SRM (as discussed before, all the Italian territory is considered prone to seismic risk), highlighting major cases in SH, ST and SP couples of hazard types, and STH and THP as relevant combination between three hazards. The last combination is represented by the combination between all the risk analysed in the project, highlighting in the statistical analysis a 3% of cases (take note that the chosen ST combination has 4% of representativeness).

Thus, the chosen combinations of potential risks for environmental factors follows in the list, indicating the % on the sample:

- Seismic + Heatwave (S H) (10 cases)
- Seismic + Pollution (S P) (47 cases)
- Seismic + Terrorism (S T) (3 cases)
- Seismic + Terrorism + Pollution (S T P) (11 cases)
- Seismic + Heatwave + Pollution (S H P) (10 cases)
- Terrorism + Heatwave + Pollution (T H P) (3 cases)
- Seismic + Terrorism + Heatwave + Pollution (that comprehends all the analysed risks in previous deliverables) (10 cases)

4.1. Critical analysis of time-related hazard recurrency

Previous analysis of recurrency of hazards in the Italian sample aimed at the identification of multi-hazard combinations based on Italian classification of seismic hazard and previous hazardous events already occurred for Terrorism, heatwaves and pollution levels.

One of the most critical issue in concerning combinations is the time-related hazard recurrency of disasters events, also considering the odds of their contemporary presence. In fact, if the analysis of previous combinations can help in identifying mitigation strategies that can support the multi-risk reduction in combined hazard expositions, the contemporary of events cannot be directly related. However, some notes can be highlighted, in the light of the nature of the hazards:

i. Considering the SLOD events, Heatwaves and Pollutions can be considered as long-time exposure events, taking into account:
    a. Due to the nature of Heatwaves as “A period of abnormally hot and/or unusually humid weather […] Typically a heat wave lasts two or more days”[1], the time-related events affect cities in medium term [> 2-10 days].
    b. Considering the Pollution events and databases useful in assessing the critical level of pollutants, levels of pollutant concentration are stored taking into account mean values and their statistical representability (in term of percentile) related to the year of measures. Thus, PR hazard odds cover long term hazards [> 30 days].

ii. Considering the SUOD events analysed in the project, their classification cannot be related to their time-related notion (Sudden) but to the nature of action which move the events:
    a. Seismic events are natural phenomena mainly related to geo-mechanics properties of land/territories, land motion characters. Due to that, the seismic events cannot be considered as “planned” one or affected by time variation in starting [unplanned events].

[1] https://www.emdat.be/Glossary#letter_h

b. Terrorism attacks are conceived as human-based events, based on the "will" of perpetrators. Due to that and differently from the previous SUOD events, TR hazard can be affected by environmental conditions that influence perpetrators actions. In that sense, environmental border characters can affect the choice in planning the events [planned events]

Due to such considerations, a double system of time-related hypothesis can be structured considering the combination between SLOD and SUOD events:

- due to the long-time dependency of SLOD events, Pollution and Heatwaves can be considered as background events during the sudden occurrence, where pollution represents the most time-extended SLOD event.
- Considering the capacity to influence SUOD events, Seismic activities can influence a terroristic attack, while any interreference exists in combining contemporaneity of terrorism (first) and seismic (then) events.

Thus, considering the combinations of hazards derived in previous section, a set of time-ordered events is identified, using → or ← to indicate the possible time-consequence of events:

- Seismic ← Heatwave (H → S)
- Seismic ← Pollution (P → S)
- Seismic ← Terrorism (T → S)
- Seismic ← Terrorism ← Pollution (P → T → S)
- Seismic ← Heatwave ← Pollution (P → H → S)
- Terrorism ← Heatwave ← Pollution (P → H → T)
- Seismic + Terrorism + Heatwave + Pollution (P → H → T → S)

These recurrent combinations of multi-hazards required to be assessed according to the real contemporary occurrences between sudden events. In fact, despite the odds of occurrence of these events and due to the real combination to consider for the project, we will consider combinations that involve just 1 sudden event combined with SLOD one/ones. All the other recurrent combinations can be analysed in order to verify the influence of mitigation strategies when the other sudden event occurs. Thus, the final combination of events to simulate (T.4) in BETs can be focused on three main combinations (Comb):

Comb1. (H → S)
Comb2. (P → S)
Comb3. (P → H → T)

Combination (P → H → S) can be overlooked as direct combination between Combinations 1 and 2

5. Calibration of BE characters according to specific descriptors related to the SUOD/SLOD risk models and to BETs

According to the main goal of the phase, all the BE characters are discussed, involving all the descriptors introduced in the specific section. In detail, all the characters are categorized according to main relevant descriptors, highlighting specific details and codified (Descriptor code). Thus, the descriptors identify and introduce a second level of details for similarities between models. However, according to the process of BET identification in D3.1.1, some codes or specific descriptors are already codified for their representation, incidence or classes of properties. It is the case of following parameters for which the BET code is associated:

- S1_0 (morphological configuration) → **P1** (a,b,c)
- S1_1 (dimension of OS) → **P2** (d,e)
- S2_F_1 (structural type of buildings in the frontier) → **P3** (f,g)
- S2_F_2 (permeability of OS referring to position and geometry of accesses) → **P4** (h,i)

- S2_F_3 (the presence of Special buildings along the frontier) → **P5** (l,m)
- S3_F_2 (Homogeneity in construction techniques) → **P6** (n,o)
- S2_F_5 (the presence and the extension of porches along the frontier) → **P7** (p,q)
- S2_F_7 - S2_C_6 (the presence of Slope along the frontier and/or content) → **P8** (r,s)
- S2_F_7 - S2_C_8 (the presence of green area along the frontier and/or content) → **P9** (t,u)

In fact, as described in D.3.1.1, BETs are recurrent typologies of BE for recurrent combinations of morphological and constructive features which are influenced or influence the selected SLOD or SUOD events. In this section, not all the BET code parameters were directly associated to a specific and single descriptor as the consequence of the major detail of description reached in single Risk modelling. For some derived P code for BETs, two or more descriptors can be related. However, if the BET parameter is not directly included in the risk, it can be related to a specific set of descriptors. Thus, every descriptor involved in the identification and qualification of each BET parameter (P1-P9) will be directly noted or associated to specific set of them using different colours (Table 19).

Table 19. Summary of Paramenters involved in BET and legend of associated colours

	P1	Morphological configuration		**P2**	Dimensions		**P3**	Structural type
	P4	Permeability (accesses)		**P5**	Special buildings		**P6**	Homogeneity of constructive technique
	P7	Porches		**P8**	Slope		**P9**	Green

Then, for all the descriptor the equivalent interrelation with the risks is assessed with the discussion of the last score. Here, the efficacy of descriptor for each risk model is assessed using "x" (Table 20).

Table 20. Summary of descriptors and assessment of relevance of each risk

Code	Description	descriptor code	descriptor	SRM	TRM	HRM	PRM	final score
	Section 1: MAIN TYPE							
S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	x	x	x	x	4
		S1_0.1	Main dimension azimuth			x	x	2
		S1_0.2	Canyon aspect ratio			x	x	2
		S1_0.3	Proximity of sidewalk to traffic			x	x	2
		S1_0.4	Proximity of sidewalk to greenery			x	x	2
		S1_0.5	Proximity of sidewalk to water			x		1
S1_1	Dimension of OS	S1_1.1	area	x	x	x	x	4
		S1_1.2	perimeter	x	x			2
		S1_1.3	width	x		x		2
		S1_1.4	Sidewalk width			x		1
		S1_1.5	street width			x	x	2
S1_2	Hmax built front	S1_2.1	H max	x				1

		S1_2.2	Average building height	x		x	x	3
S1_3	hmin built front	S1_3.1	Average building height			x	x	2
		SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE						
	Frontier							
S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	x				1
		S2_F_1.2	Length of the built front	x				1
		S2_F_1.3	number of SU	x				1
		S2_F_1.4	length of SU	x				1
		S2_F_1.5	height of SU front	x				1
		S2_F_1.6	regularity in plan	x				1
		S2_F_1.7	irregularity in elevation	x				1
		S2_F_1.8	total covered surface	x				1
		S2_F_1.9	number of storeys	x				1
		S2_F_1.10	Ratio H max / width (OS)	x				1
		S2_F_1.11	Ratio H med / width (OS)	x				1
S2_F_2	Accesses	S2_F_2.1	number	x	x			2
		S2_F_2.2	width	x	x	x	x	4
		S2_F_2.3	position / orientation (azimuth)			x	x	2
		S2_F_2.4	presence of mitigation/control systems		x			1
S2_F_3	Special buildings	P5	presence	x	x			2
		S2_F_3.2	incidence (linear)	x				1
		S2_F_3.3	number	x	x			2
		S2_F_3.4	length of special buildings front	x	x			2
		S2_F_3.5	height	x				1
S2_F_4a	Town walls	S2_F_4a.1	presence	x	x			
		S2_F_4a.2	linear extension	x	x			
		S2_F_4a.3	position	x				
		S2_F_4a.4	width or depth	x				
S2_F_4b	porches	P7	presence	x	x	x	x	4
		S2_F_4b.2	linear extension	x	x			2
		S2_F_4b.3	position	x	x	x	x	4
		S2_F_4b.4	width or depth	x	x	x	x	4
S2_F_5a	green area	P9f	Presence of green area	x	x	x	x	4
		S2_F_5.a.2	crowding potential	x	x	x	x	4
		S2_F_5.a.5	incidence for total perimeter		x			1
		S2_F_5.a.6	extension (linear)		x	x	x	3
		S2_F_5.a.7	Green Area Position (related to LS or AS)			x	x	2
		S2_F_5.a.8	green area density		x	x	x	3
S2_F_5b	Water	S2_F_5.b.1	Presence of Water	x	x	x	x	4
		S2_F_5.b.2	crowding potential	x	x			2
		S2_F_5.b.3	incidence for total perimeter		x			1
		S2_F_5.b.4	extension of water content		x			1
		S2_F_5.b.5	Water Position (related to LS or AS)			x		1
		S2_F_5.b.6	Water body area			x		1
		S2_F_5.b.7	Water body volume			x		1

S2_F_6	Quote differences / slope	S2_F_6.1	quote difference	x	x			2
		P8f	slope	x	x	x	x	4
	Content							
S2_C_1	Special buildings	S2_C_1.1	incidence (ratio sup/sup tot)	x	x			2
		S2_C_1.2	number	x	x			2
		S2_C_1.3	height	x				1
		S2_C_1.4	area	x	x			2
		S2_C_1.5	length	x				1
		S2_C_1.6	width	x				1
		S2_C_1.7	height of gable	x				1
S2_C_2	Quote difference/slope	S2_C_2.1	quote difference	x	x			2
		P8c	slope	x	x			2
S2_C_3	Protections measure of slope/quote difference	S2_C_3.1	presence	x	x			2
		S2_C_3.2	influence in emergency routes		x			1
S2_C_4	Monuments (i.e. obelisk, statues, fountain, archeol. site)	S2_C_4.1	presence fountain	x	x	x		3
		S2_C_4.2	presence of monuments	x	x			2
		S2_C_4.3	incidence (area)	x	x			2
		S2_C_4.4	number of monuments	x	x			2
		S2_C_4.5	efficacy of protection		x			1
S2_C_5a	Green area	P9c	Presence of Green area	x	x	x	x	
		S2_C_5a.1	crowding potential	x	x	x	x	4
		S2_C_5a.2	incidence for total area		x	x	x	3
		S2_C_5a.3	Special temporary opening	x		x	x	3
		S2_C_5a.5	extension (area)		x	x	x	3
		S2_C_5a.6	Greenery type (seasonal/ever green and species)			x	x	2
		S2_C_5a.7	Greenery adsorption capacity			x	x	2
		S2_C_5a.8	Greenery height			x	x	2
		S2_C_5a.9	Greenery width		x	x	x	3
		S2_C_5a.10	Tree crown shape			x		1
		S2_C_5a.11	Tree crown diameter			x	x	2
S2_C_5a	Water	S2_C_5b.1	crowding potential	x	x	x	x	4
		S2_C_5b.2	incidence for total area		x			1
		S2_C_5b.3	extension (area)		x	x		2
		S2_C_5b.4	Presence of Water	x	x			2
S2_C_6	Underground cavities	S2_C_6.1	presence	x				1
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS							
	Frontier							
S3_F_1	Built environment age	S3_F_1.1	homogeneous/not homogeneous	x				1
		S3_F_1.2	last intervention period	x				1
		S3_F_1.3	state of conservation	x				1

		S3_F_1.4	wall disconnection in plan	x			1
		S3_F_1.5	wall disconnection in elevation	x			1
S3_F_2	Constructive techniques	P6	homogeneous/not homogeneous	x			1
		S3_F_2.2	masonry quality	x			1
		S3_F_2.3	roof types	x			1
		S3_F_2.4	horizontal structure types	x			1
		S3_F_2.5	staggered floors	x			1
		S3_F_2.6	% openings	x			1
		S3_F_2.7	vertical alignment of openings	x			1
		S3_F_2.8	min edge distance of openings	x			1
		S3_F_2.9	jointed facades	x			1
		S3_F_2.10	superimposed/additional storeys	x			1
		S3_F_2.11	no-structural protruding and decorative elements	x			1
		S3_F_2.12	anti-seismic devices	x			1
		S3_F_2.13	Facade finishing material			x	1
		S3_F_2.14	Facade finishing albedo			x	1
		S3_F_2.15	Facade finishing ageing			x	1
		S3_F_2.16	Facade finishing current roughness			x	x 2
		S3_F_2.17	Facade finishing aged albedo			x	1
		S3_F_2.18	Facade cleanness			x	x 2
		S3_F_2.19	Facade heat capacity			x	1
		S3_F_2.20	Facade pollutant deposition capacity				x 1
S3_F_3	Fixed obstacles	S3_F_3.1	Obstacle location		x	x	2
		S3_F_3.2	Obstacle shade boolean			x	1
		S3_F_3.3	incidence on total linear extension of frontier	x	x		2
		S3_F_3.4	length	x	x		2
		S3_F_3.5	n. of mitigation system		x		1
		S3_F_3.6	Mitigation systems		x		1
		S3_F_3.7	Efficacy in protection		x		1
		S3_F_3.8	influence in emergency paths	x	x		2
S3_F_4	Temporary obstacles	S3_F_4.1	incidence on total linear extension of frontier	x	x		2
		S3_F_4.2	length	x	x		2
		S3_F_4.3	n. of mitigation system		x		1
		S3_F_4.4	Mitigation systems		x		1
		S3_F_4.5	Efficacy in protection		x		1
		S3_F_4.6	influence in emergency paths	x	x		2
	Content						
S3_C_1	Pavement type	S3_C_1.1	classes of pavement	x			1
		S3_C_1.2	Pavement finishing material			x	1
		S3_C_1.3	incidence (area) for classes of pavements			x	1
		S3_C_1.5	Pavement finishing albedo			x	1
S3_C_2	Pavement condition	S3_C_2.1	Classes of conditions	x			1

		S3_C_2.2	Pavement finishing ageing			x		1
		S3_C_2.3	Pavement finishing current roughness			x	x	2
		S3_C_2.4	Pavement finishing aged albedo			x		1
S3_C_3	Fixed obstacles	S3_C_3.1	Obstacle translucency boolean			x		1
		S3_C_3.2	Obstacle height			x	x	2
		S3_C_3.3	Obstacle width		x	x	x	3
		S3_C_3.4	incidence on total AS area	x	x			2
		S3_C_3.5	Efficacy in protection		x			1
		S3_C_3.6	area	x	x			2
		S3_C_3.7	influence in emergency paths	x	x			2
S3_C_4	Temporary obstacles	S3_C_4.1	incidence on total AS area	x	x			2
		S3_C_4.2	Efficacy in protection		x			1
		S3_C_4.3	area	x	x			2
		S3_C_4.4	influence in emergency paths	x	x			2
SECTION 4: CHARACTERISTICS OF USE								
S4_1	Crowding	S4_1.1	people present			x	x	2
		S4_1.2	crowding potential	x	x	x	x	4
		S4_1.3	tourism attraction	x	x			2
		S4_1.4	Exposure duration			x	x	2
		S4_1.5	Presence of emergency plan		x			1
S4_2	Special uses of OS	S4_2.1	Sensitive targets attraction to OS		x			1
		S4_2.2	crowding potential	x	x	x	x	4
		S4_2.3	Temporal special uses		x			1
S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	x	x	x	x	4
		S4_3.2	crowding potential	x	x	x	x	4
		S4_3.3	Symbolism level		x			1
		S4_3.4	Presence of Schools	x		x	x	3
		S4_3.5	Presence of Hospitals	x		x	x	3
		S4_3.6	Presence of Care home			x	x	2
		S4_3.7	Sensitive targets attraction to building use		x	x	x	3
S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	x	x			2
		S4_4.2	Traffic intensity			x	x	2
		S4_4.3	presence of street		x		x	2
		S4_4.4	level of accessibility		x			1
		S4_4.5	Temporary accessibility	x	x	x	x	4
S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	x	x			2
		S4_5.2	Pedestrian street presence Boolean			x	x	2
		S4_5.3	walking area			x	x	2
		S4_5.4	Walking width			x	x	2
S4_6	Vehicles (parking)	S4_6.1	incidence (area for AS)	x	x			2
		S4_6.2	incidence to prevalent dimension (linear for LS)	x				1

		S4_6.3	influence in emergency routes		x			1
		S4_6.4	Parking area presence Boolean		x	x	x	3
		S4_6.5	Parking area location		x	x	x	3
		S4_6.6	Parking area		x	x	x	3
		S4_6.7	Parking width		x	x	x	3
S4_7	Sights	S4_7.1	presence of sight	x	x			2
		S4_7.2	tourism attraction	x	x			2
		S4_7.3	crowding potential	x	x	x	x	4
S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)		x	x	x	3
		S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	x		x	x	3
		S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	x		x	x	3
		S4_8.4	Symbolism level		x			1
SECTION 5: ENVIRONMENTAL CHARACTERISTICS								
S5_1	Seismic intensity	S5_1.1	Ground motion severity	x				1
		S5_1.2	Seismic micro-zonation	x				1
S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone			x		1
		S5_2.2	Latitude (North/South)			x		1
S5_3	Climate conditions	S5_3.1	Wind/breeze speed			x	x	2
		S5_3.2	Wind/breeze direction azimuth			x	x	2
		S5_3.3	Air temperature	x		x	x	3
		S5_3.4	Solar Irradiation			x	x	2
		S5_3.5	Relative humidity			x		1
S5_4	Multi-hazard potential	S5_4.1	classes?	x				1
		S5_4.2	Pollution sources presence Boolean			x	x	2
		S5_4.3	Pollution sources on wind/breeze trajectory Boolean			x	x	2
		S5_4.4	Current season (e.g. summer)			x	x	2
		S5_4.5	Pollution sources load				x	1
S5_5	Ground type	S5_5.1	classes of types	x				1
		S5_5.2	Ground roughness			x	x	2
		S5_5.3	Ground albedo			x		1
		S5_5.4	Ground heat capacity			x		1
S5_6	Lifeline utilities	S5_6.1	Presence of Lifeline Utilities	x				1
S5_7	OS interconnection	S5_7.1	Classes OS network	x				1

6. Analysis of information details about characters and descriptors

The collection of information details required for each risk model has been assessed independently from the BET identification. Due to that a first analysis of information details could be done in order to qualified them aiming at their representation.

Mostly, data collected are previously classified according to their Qualitative (Q) or Quantitative (q) character. However, a second level of classification could be assessed for them. Quantitative (q) collected data could be classified in term of:

q1. Geometric features of characters that could be directly measured or derived – as combination of two or more geometric data - in geometric-base BET models (e.g. BIM, GIS);
q2. Boolean data as derived quantitative information details; in this case, the presence/absence of urban elements or specific features of single element could be express as Boolean;
q3. Enumerated data type, derived by the counting the presence of BE elements involved in risk models;
q4. Quantitative properties/attributes of elements characterized by specific units of measurement;

As far as the qualitative characters concern, in this case Q data could be classified mostly as properties of BE characters that usually are expressed according to:

Q1. Ranges of values – so by conditions;
Q2. Descriptive – so textual.

Similarly, all the features/properties can be referred to specific elements or to the wide territory as well as they can characterize parts or single elements of the OS/LS. Thus, characters require to be referred according the most coherent "scale of reference", supporting the level of knowledge implementation at the correct scale. In fact, according to the inherent classification of BE characters, each properties/characterization can describe the:

L1. Site level referring to the features that are independent of OS/LS. The scale is overarched than the OS level, thus features characterize the city or territorial areas.
L2. OS/LS level includes all the properties widely referred to the OS/LS without spatial exception. Dimension, perimeter of Open Areas and properties of single element compared with the Open area (e.g., incidence, position of each element) are part of this scale of spatial reference.
L3. Frontier or content level comprises all the features referred to single elements or their group specifically located in the frontier or in content. Here, all the properties that characterize the frontier or content are included such as the extension of elements along the frontier.
L4. Single elements or component; here, all the properties are independent of the frontier/content or OS/LS but they are referred to the single elements being part into the OS/LS.

Due to this double level of classification, Table 21. Categorization of descriptors in Section 1 and Section 5 according to data type information and scale of detail reports all the descriptors – for section 1 and 5 - categorized according to le scale of reference detail and classification of information detail. Moreover, specifically for q1 and q4 quantitative data type, units are introduced in the last column.

Table 21. Categorization of descriptors in Section 1 and Section 5 according to data type information and scale of detail

Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]
	Section 1: MAIN TYPE					
S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2	
		S1_0.1	Main dimension azimuth	q1	L2	degree

		S1_0.2	Canyon aspect ratio	q1	L2	m/m
		S1_0.3	Proximity of sidewalk to traffic	q1	L4	m
		S1_0.4	Proximity of sidewalk to greenery	q1	L3	m
		S1_0.5	Proximity of sidewalk to water	q1	L3	m
S1_1	Dimension of OS	S1_1.1	area	q1	L2	mq
		S1_1.2	perimeter	q1	L2	m
		S1_1.3	width	q1	L2	m
		S1_1.4	Sidewalk width	q1	L3	m
		S1_1.5	street width	q2	L4	m
S1_2	Hmax built front	S1_2.1	H max	q1	L3	m
		S1_2.2	Average building height	q1	L3	m
S1_3	hmin built front	S1_3.1	Average building height	q1	L3	m
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE					
	Frontier					
S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100
		S2_F_1.2	Length of the built front	q1	L3	m
		S2_F_1.3	number of SU	q3	L3	
		S2_F_1.4	length of SU	q1	L3	m
		S2_F_1.5	height of SU front	q1	L3	m
		S2_F_1.6	regularity in plan	Q1	L3	
		S2_F_1.7	irregularity in elevation	Q1	L3	
		S2_F_1.8	total covered surface	q1	L3	m^2
		S2_F_1.9	number of storeys	q3	L3	
		S2_F_1.10	Ratio H max / width (OS)	Q1	L2	
		S2_F_1.11	Ratio H med / width (OS)	Q1	L2	
S2_F_2	Accesses	S2_F_2.1	number	q3	L4	
		S2_F_2.2	width	q1	L4	m
		S2_F_2.3	position / **orientation (azimuth)**	q1	L3	
		S2_F_2.4	presence of mitigation/control systems	q2	L3	
S2_F_3	Special buildings	P5	presence	q2	L2	
		S2_F_3.2	incidence (linear)	q1	L2	m/m *100
		S2_F_3.3	number	q3	L2	
		S2_F_3.4	length of special buildings front	q1	L4	m
		S2_F_3.5	height	q1	L4	m
S2_F_4a	Town walls	S2_F_4a.1	presence	q2	L2	
		S2_F_4a.2	linear extension	q1	L3	m
		S2_F_4a.3	position	q1	L3	
		S2_F_4a.4	width or depth	q1	L4	m
S2_F_4b	Porches	P7	presence	q2	L2	
		S2_F_4b.2	linear extension	q1	L3	m
		S2_F_4b.3	position	q1	L3	
		S2_F_4b.4	width or depth	q1	L4	m
S2_F_5a	green area	P9f	presence of green area	q2	L2	
		S2_F_5.a.1	crowding potential	Q2	L4	

		S2_F_5.a.2	Special temporary opening	Q2	L4	
		S2_F_5.a.4	incidence for total perimeter	q1	L3	% (m/m *100)
		S2_F_5.a.5	extension (linear)	q1	L4	m
		S2_F_5.a.6	Green Area Position (related to LS or AS)	q1	L3	
		S2_F_5.a.7	green area density	q1	L4	m^2 (veg)/ m^2 (green area)
S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2	
		S2_F_5.b.2	crowding potential	Q2	L4	
		S2_F_5.b.3	incidence for total perimeter	q1	L3	% (m/m *100)
		S2_F_5.b.4	extension of water content	q1	L4	m
		S2_F_5.b.5	Water Position (related to LS or AS)	q1	L2	
		S2_F_5.b.6	Water body area	q1	L4	m^2
		S2_F_5.b.7	Water body volume	q1	L4	m^3
S2_F_6	Quote differences / slope	S2_F_6.1	quote difference	q1	L3	m
		P8f	slope	q1	L3	m/m*100
	Content					
S2_C_1	Special buildings	S2_C_1.1	incidence (ratio sup/sup tot)	q1	L3	m^2/m^2 *100
		S2_C_1.2	number	q3	L4	
		S2_C_1.3	height	q1	L4	m
		S2_C_1.4	area	q1	L3	m^2
		S2_C_1.5	length	q1	L3	m
		S2_C_1.6	width	q1	L3	m
		S2_C_1.7	height of gable	q1	L3	m
S2_C_2	Quote difference/slope	S2_C_2.1	quote difference	q1	L3	m
		P8c	slope	q1	L3	m/m*100
S2_C_3	Protections measure of slope/quote difference	S2_C_3.1	presence	q2	L4	
		S2_C_3.2	influence in emergency routes	Q2	L3	
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	S2_C_4.1	presence fountain	q2	L4	
		S2_C_4.2	presence of monuments	q2	L4	
		S2_C_4.3	incidence (area)	q1	L2	m^2/ m^2 *100
		S2_C_4.4	number	q3	L4	
		S2_C_4.5	efficacy of protection	Q2	L4	
S2_C_5a	Green area	P9c	Presence of Green area	q2	L2	
		S2_C_5a.1	crowding potential	Q2	L4	
		S2_C_5a.2	incidence (area)	q1	L2	m^2/ m^2*100
		S2_C_5a.3	Special temporary opening	Q2	L4	
		S2_C_5a.4	extension (area)	q1	L4	m^2
		S2_C_5a.5	Greenery type (seasonal/ever green and species)	Q2	L4	
		S2_C_5a.6	Greenery adsorption capacity	q4	L4	mass/time or mass/area (e.g. mg/s or g/ m^2)
		S2_C_5a.7	Greenery height	q1	L4	m

		S2_C_5a.8	Greenery width	q1	L4	m
		S2_C_5a.9	Tree crown shape	Q2	L4	
		S2_C_5a.10	Tree crown diameter	q1	L4	m
S2_C_5b	Water	S2_C_5b.1	crowding potential	Q2	L4	
		S2_C_5b.2	incidence for total area	q1	L2	
		S2_C_5b.3	extension (area)	q1	L4	
		S2_C_5b.4	Presence of Water	q2	L4	
S2_C_6	Underground cavities	S2_C_6.1	presence	q2	L4	
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS					
	Frontier					
S3_F_1	Homogeneity of built environment age	S3_F_1.1	homogeneous/not homogeneous	Q2	L3	
		S3_F_1.2	last intervention period	Q1	L3	
		S3_F_1.3	state of conservation	Q2	L3	
		S3_F_1.4	wall disconnection in plan	q2	L3	
		S3_F_1.5	wall disconnection in elevation	q2	L3	
S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3	
		S3_F_2.2	masonry quality	Q1	L3	
		S3_F_2.3	Roof types	Q2	L3	
		S3_F_2.4	horizontal structure types	Q2	L3	
		S3_F_2.5	staggered floors	q2	L3	
		S3_F_2.6	% openings	q1	L3	m^2/ m^2*100
		S3_F_2.7	vertical alignment of openings	q2	L3	
		S3_F_2.8	min edge distance of openings	q1	L3	m
		S3_F_2.9	jointed facades	q3	L3	
		S3_F_2.10	superimposed/additional storeys	q2	L3	
		S3_F_2.11	no-structural protruding and decorative elements	q2	L3	
		S3_F_2.12	anti-seismic devices	q2	L3	
		S3_F_2.13	Facade finishing material	Q2	L4	
		S3_F_2.14	Facade finishing albedo	q4	L4	-
		S3_F_2.15	Facade finishing ageing	q4	L4	years
		S3_F_2.16	Facade finishing current roughness	q4	L4	-
		S3_F_2.17	Facade finishing aged albedo	q4	L4	-
		S3_F_2.18	Facade cleanness	Q2	L4	
		S3_F_2.19	Facade heat capacity	q4	L4	J/ kg K
		S3_F_2.20	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m^2)
S3_F_3	Fixed obstacles	S3_F_3.1	Obstacle location	q1	L2	
		S3_F_3.2	Obstacle shade boolean	q2	L4	
		S3_F_3.3	incidence on total linear extension of frontier	q1	L2	m/m*100
		S3_F_3.4	length	q1	L4	m
		S3_F_3.5	n. of mitigation system	q3	L4	
		S3_F_3.6	Mitigation systems	Q2	L4	

		S3_F_3.7	Efficacy in protection	Q2	L4	
		S3_F_3.8	influence in emergency paths	Q2	L2	
S3_F_4	Temporary obstacles	S3_F_4.1	incidence on total linear extension of frontier	q1	L2	m/m*100
		S3_F_4.2	length	q1	L4	m
		S3_F_4.3	n. of mitigation system	q3	L4	
		S3_F_4.4	Mitigation systems	Q2	L4	
		S3_F_4.5	Efficacy in protection	Q2	L4	
		S3_F_4.6	influence in emergency paths	Q2	L2	
	Content					
S3_C_1	Pavement type	S3_C_1.1	classes of pavement	Q1	L3	
		S3_C_1.2	Pavement finishing material	Q2	L3	
		S3_C_1.3	incidence (area) for classes of pavements	q1	L4	m^2/ m^2 *100
		S3_C_1.4	Pavement finishing material	Q2	L3	
		S3_C_1.5	Pavement finishing albedo	q4	L3	-
S3_C_2	Pavement condition	S3_C_2.1	Classes of conditions	Q2	L3	
		S3_C_2.2	Pavement finishing ageing	q4	L3	years
		S3_C_2.3	Pavement finishing current roughness	q4	L3	-
		S3_C_2.4	Pavement finishing aged albedo	q4	L3	-
S3_C_3	Fixed obstacles	S3_C_3.1	Obstacle translucency boolean	q2	L4	
		S3_C_3.2	Obstacle height	q1	L4	m
		S3_C_3.3	Obstacle width	q1	L4	m
		S3_C_3.4	incidence on total AS area	q1	L2	m^2/ m^2 *100
		S3_C_3.5	Efficacy in protection	Q2	L4	
		S3_C_3.6	area	q1	L4	m^2
		S3_C_3.7	influence in emergency paths	Q2	L2	
S3_C_4	Temporary obstacles	S3_C_4.1	incidence on total AS area	q1	L2	m^2/ m^2 *100
		S3_C_4.2	Efficacy in protection	Q2	L4	
		S3_C_4.3	area	q1	L4	m^2
		S3_C_4.4	influence in emergency paths	Q2	L2	
	SECTION 4: CHARACTERISTICS OF USE					
S4_1	Crowding	S4_1.1	people present	q4	L2	person (pp)
		S4_1.2	crowding potential	Q2/q4	L2	pp/ m^2
		S4_1.3	tourism attraction	q4	L2	arrivals/inhabitants [pp/pp]
		S4_1.4	Exposure duration	q4	L2	hrs
		S4_1.5	presence of emergency plan	q2	L2	
S4_2	Special uses of OS	S4_2.1	Sensitive targets attraction to OS	Q2	L2	
		S4_2.2	crowding potential	Q2	L2	
		S4_2.3	Temporal special uses	Q2	L2	
S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2	
		S4_3.2	crowding potential	Q2	L4	
		S4_3.3	Symbolism level	Q2	L4	
		S4_3.4	Presence of Schools	q2	L2	

		S4_3.5	Presence of Hospitals	q2	L2	
		S4_3.6	Presence of Care home	q2	L2	
		S4_3.7	Sensitive targets attraction to building use	Q1	L4	
S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	q1	L2	m/m *100
		S4_4.2	Traffic intensity	q4/Q1	L2	Vehicle/km
		S4_4.3	presence of street	q2	L2	
		S4_4.4	level of accessibility	Q2	L2	
		S4_4.5	Temporary accessibility	Q2	L4	
S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	q1	L2	m/m *100
		S4_5.2	Pedestrian street presence Boolean	q2	L2	
		S4_5.3	walking area	q1	L4	mq
		S4_5.4	Walking width	q1	L4	m
S4_6	Vehicles (parking)	S4_6.1	incidence (area for AS)	q1	L3	m^2/ m^2 *100
		S4_6.2	incidence to prevalent dimension (linear for LS)	q1	L3	m/m *100
		S4_6.3	influence in emergency routes	Q2	L2	
		S4_6.4	Parking area presence Boolean	q2	L2	
		S4_6.5	Parking area location	q1	L2	
		S4_6.6	Parking area	q1	L4	m^2
		S4_6.7	Parking width	q1	L4	m
S4_7	Sights	S4_7.1	presence of sight	q2	L2	
		S4_7.2	tourism attraction	Q1	L4	
		S4_7.3	crowding potential	Q2	L4	
S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)	q2	L2	
		S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2	
		S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%
		S4_8.4	Symbolism level	Q2	L2	
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS					
S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1	
		S5_1.2	Seismic micro-zonation	Q2	L1	
S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1	
		S5_2.2	Latitude (North/South)	Q2	L1	
S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s
		S5_3.2	Wind/breeze direction azimuth	q4	L1	degree
		S5_3.3	Air temperature	q4	L1	°C
		S5_3.4	Solar Irradiation	q4	L1	W/ m^2
		S5_3.5	Relative humidity	q4	L1	%
S5_4	Multi-hazard potential	S5_4.1	classes	Q2	L1	

		S5_4.2	Pollution sources presence Boolean	q2	L2	
		S5_4.3	Pollution sources on wind/breeze trajectory Boolean	q2	L2	
		S5_4.4	Current season (e.g., summer)	Q2	L1	
		S5_4.5	Pollution sources load	q4	L2	mass/volume (e.g. mg/l)
S5_5	Ground type	S5_5.1	classes of types	Q2	L1	
		S5_5.2	Ground roughness	q4	L2	-
		S5_5.3	Ground albedo	q4	L2	-
		S5_5.4	Ground heat capacity	q4	L2	J/ kg K
S5_6	Lifeline utilities	S5_6.1	Presence of Lifeline Utilities	Q2	**L1**	
S5_7	OS interconnection	S5_7.1	Classes OS network	Q2	**L1**	

7. Assessment of representation criteria for BE descriptors and characters, according to their qualification and tools/methods for BETs representation

As discussed in D.3.1.3 and, specifically, in the operative workflow in §10.1, BETs and all the features have to be represented in digital environments by means of BIM and VR derived from the BIM-centric approach, as well as in GIS (Figure 6). In detail, GIS should include the 2D models – useful for human-based simulation tools as Netlogo -, while BIM the 3D ones; both will be useful for the creation of virtual environments of BETs to be analysed in specific simulations (single risks and combination with users' behaviour), aiming at the specific training. Moreover, the VR environments – as a structured Virtual Tour created by spherical images - can support the representation of BE as a specific database, viewable and easily modifiable. In this case, the VT supports the collection and organization of data with any specific aims in supporting simulations. On the other hand, the BIM-to-VR environments are functional for the assessment of users' behaviour in the modelled environment (BETs) towards the specific training and finally, to support the results to introduce in the pervasive training.

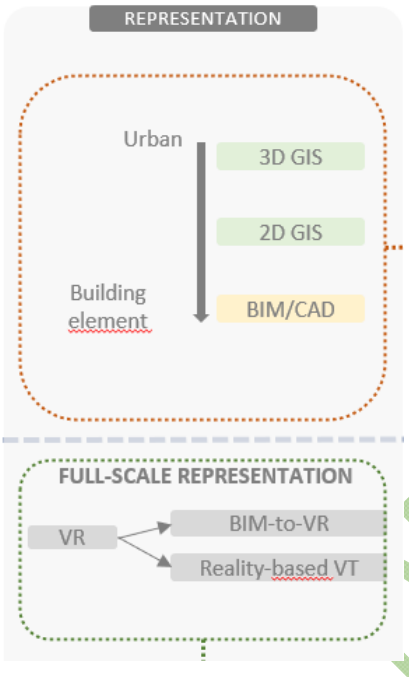

Figure 6. Detail of the operative workflows focused on the representation

Thus, the parameters involved in describing the risks, as well as the descriptor, requires to be translated in term of their "representability" in the specific tools. Due to that, the following sections aim at the definition of specific criteria representation of parameters and descriptors in GIS, BIM, and VT tools, respectively. Firstly, 4 classes of **Representation Criteria** are introduced to solve the level of representability for each descriptor for BIM, GIS and VT models. In detail:

- R1 The descriptor is measurable in the model
- R2 The descriptor is a property in the model (- es. area, volume)
- R3 The descriptor is obtained with a conditional/analytical formula from other descriptors
- R4 The descriptor is represented as digital content (image, pdf)

Due to the nature of VT, main differences exist in R codes between GIS/BIM and VT environments that require to be discussed in separately.

Then, among the parameters, the BE elements are isolated as homogeneous types and discussed for their 2D or 3D representation in GIS, BIM and VT models. The Table 22 summarizes the BE elements to represent in the digital environments. In detail, the parameters are associated to specific classes of BE elements and for each of them details for representation are reported according with the specific rules: for GIS as introduced in the Annex II, while for VT and BIM digital models the rules are derived according to previous discussions in §6 of D.3.1.3 and §4.2 of D3.1.2, respectively, but re-introduced following.

Table 22. Summary of Graphical information for BE elements in BIM, GIS and VT

ELEMENT	CODE OF ELEMENT	BIM - GRAPHICAL INFORMATION	GIS - GRAPHICAL INFORMATION		VT - GRAPHICAL INFORMATION
			N1	N5	

OS	OS	Pavement (OS)	Add PolOAS (derived from PolBF)	Add PolOS (derived from PolBF)	LoR A + LoR B
AS	AS	Pavement (AS)	Add PolAS (Derivable from PolBF)	Add PolAS (Derivable from PolBF)	LoR A + LoR B
BUILDING FRONTS/ SPECIAL BUILDINGS	BF	Wall (BF)	PolBF	PolBF	LoR A + LoR B
SIDEWALK	SW	Pavement (SW)	PolSW	PolSW	LoR A + LoR B
STREET	ST	Pavement (ST)	PolST (Derivable PolBF - PolSW)	PolST (Derivable PolBF - PolSW)	LoR A + LoR B
WATER	WT	Add object (WT)	PolWT	PolWT	LoR A + LoR B
MITIGATION/CONTROL SYSTEM	MC	Add object (MC)	Add Line (LineMC)	Add Line (LineMC)	LoR A + LoR B
ACCESSES	AC	Add object (MC)	LinAC (Derivable from PolBF)	LinAC (Derivable from PolBF)	LoR A + LoR B
TOWN WALLS	TW	Wall (TW)	PolTW	PolTW	LoR A + LoR B
PORCHES	PR	Add object (PR)	PolPR	PolPR	LoR A + LoR B
GREEN AREA	GR	Add object (GR)	PolGR	PolGR	LoR A + LoR B
TERRAIN/STAIRS	SL	Terrain/pavement/stair (SR)	PolSL	PolSL	LoR A + LoR B
PROTECTION MISURES OF SLOPE/QUOTE DIFFERENCE	PM	Add object (PR)	Add LinePM	Add LinePM	LoR A + LoR B
MONUMENTS	MN	Add object (MN)	PolMN	PolMN	LoR A + LoR B
UNDERGROND CAVITIES	UC	Add object (UC)	Add PolUC	Add PolUC	LoR A + LoR B
FIXED OBSTACLES (including fontaine, manuments)	FO	Add object (FO)	PolFO	Add PolFO	LoR A + LoR B
TEMPORARY OBSTACLES	TO	Add object (TO)	Add PolTO	Add PolTO	LoR A + LoR B
VEHICLES (parking)	PK	Pavement (PK)	PolPK	PolPK	LoR A + LoR B
CROWDING		Human-agent	n.a.	n.a.	LoR A + LoR B
SIGHTS	SG	Wall/Add object (SG)	PolSG	PolSG	LoR A + LoR B

Table 23. Code for Representation information in VT models (see D.3.1.3 in §6.VR tools for BETs representation)

Code VT	
LoR A	Graphical information in spherical photos (scenes)
LoR B	Graphical information in hotspot plans
LoR C	Graphical information in detailed hotspots

Table 24. BIM graphical information discussed for the representation of BETs (See D.3.1.2 in §4.2 BET representation in BIM)

GRAPHICAL INFORMATION (as BIM objects)	
Mass	generic mass from Cad – GIS – SCAN data
Wall-by-face	AS/LS wall modelled by mass face, so to be updated if mass change for any reason, and specify only the core material (no plaster, finishes, etc);
Space separator line	line for space delimitation, from 2 ends of wall, in correspondence of access
Space	automatic space delimited by wall and space separation line

Topography	Toposurface of the AS/LS, without considering the nearby OS (other LS or AS):
Subregion	Area inside an existing toposurface, with different material (i.e. grass).

Finally, all the parameters and descriptors were collected and organized in a systematic couple of representation rules (Representation Rule for Element; Representation criteria of Descriptor). In Table 27 specific columns with datatype details are inserted in order to relate the criteria to the specific tool (BIM, GIS and VT). Table 27 reports the data types of information in order to complete the representation codes with their nature. Specifically, for BIM two data types classes are introduced due to the main possibility to use Revit® or Archicad® for the representation (Table to implement). For GIS, data type classification is introduced in Table 39 in Annex II.

Table 25. Data type information for Autodesk REVIT Tool (source: https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2014/ENU/Revit/files/GUID-57C2F6A1-9947-47FA-A980-C8DF6B25E218-htm.html)

REVIT Data Type	Description
Text	A value that is entered as text. This value is completely customizable.
Integer	A value that is expressed as an integer.
Number	A value that is numeric. Can have real numbers.
Length	A value that is the length of an element or sub-component.
Area	A value that is the area of an element or sub-component.
Volume	A value that is the volume of an element or sub-component.
Angle	A value that is the angle of an element or sub-component.
Slope	Can be used to create parameters that define slope.
Currency	Can be used to create currency parameters in Addition to the default Cost parameter.
Mass Density	A value that represents the mass per unit volume of a material.
URL	Provides a web link to a userAddefined URL.
Material	A value that is the material for the element.
Yes/No	Used most often for instance properties when the parameter is defined with either a Yes or No.

Table 26. Data type information for Graphisoft ARCHICAD Tool (source: https://helpcenter.graphisoft.com/useradguide/76720/)

ARCHICAD Data Type	Description
String	Any text or number
Number	Any number expressed in decimals
Integer	A whole number
True/False	A logical true or false value
Tags List	A tag or series of tags.
Option Set	Provides a fixed set of options. The user can choose a value from this set.
Area	A value that is the area of an element or sub-component.
Length	A value that is the length of an element or sub-component.
Angle	A value that is the angle of an element or sub-component
Volume	A value that is the volume of an element or sub-component.

Table 27. Matrix of couple data for Representation Rule for Element; Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments for all the risk involved (S,T,H,PRM)

Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
	Section 1: MAIN TYPE													
S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
		S1_0.1	Main dimension azimuth	q1	L2	degree	R2	OS+BF	PolOS + PolBF	Real	Angle	Angle	R4	LoR C
		S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
		S1_0.3	Proximity of sidewalk to traffic	q1	L4	m	R1	SW+ST	PolSW + PolST	Real	Length	Length	R4	LoR C
		S1_0.4	Proximity of sidewalk to greenery	q1	L3	m	R1	SW+GR	PolSW + PolGR	Real	Length	Length	R4	LoR C
		S1_0.5	Proximity of sidewalk to water	q1	L3	m	R1	SW+WT	PolSW + PolWT	String	Length	Length	R4	LoR C
S1_1	Dimension of OS	S1_1.1	area	q1	L2	m^2	R2	OS	PolOS	Real	Area	Area	R4	LoR C
		S1_1.2	perimeter	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
		S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
		S1_1.4	Sidewalk width	q1	L3	m	R2	SW	PolSW	Real	Length	Length	R4	LoR C
		S1_1.5	street width	q2	L4	m	R2	ST	PolST	Real	Length	Length	R4	LoR C
S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
		S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
S1_3	hmin built front	S1_3.1	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
	SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE Frontier													
S2_F_1	Structural types	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
		S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
		S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
		S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
		S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
		S2_F_1.6	regularity in plan	Q1	L3		R2	BF	PolBf	String	Text	String	R4	LoR A + LoR C
		S2_F_1.7	irregularity in elevation	Q1	L3		R2	BF	PolBf	String	Text	String	R4	LoR A + LoR C
		S2_F_1.8	total covered surface	q1	L3	m^2	R1	BF	PolBf	Real	Number	Number	R4	LoR C
		S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
		S2_F_1.10	Ratio H max / width (OS)	Q1	L2		R3	BF	PolBf	Real	Number	Number	R4	LoR C
		S2_F_1.11	Ratio H med / width (OS)	Q1	L2		R3	BF	PolBf	Real	Number	Number	R4	LoR C
S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
		S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
		S2_F_2.3	Position / orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
		S2_F_2.4	presence of mitigation/control systems	q2	L3		R2	MC/AC	LinAC/LinMC	String	Text/Multi-line text	String/Option set/Tags List	R1	LoR A + LoR B
S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
		S2_F_3.2	incidence (linear)	q1	L2	m/m *100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
		S2_F_3.3	number	q3	L2		R3	BF	PolBF	Integer	Number	Number	R1	LoR A + LoR B
		S2_F_3.4	length of special buildings front	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
		S2_F_3.5	height	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
		S2_F_3.6	area	q1	L3	m^2	R2	BF	PolBF	Real	Area	Area	R4	LoR C

		S2_F_3.7	height of gable	q1	L3		R1	BF	PolBF	Real/Real	Length/Length	Length/Length	R4	LoR C
S2_F_4a	Town walls	S2_F_4a.1	presence	q2	L2		R2	TW	PolTW	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S2_F_4a.2	linear extension	q1	L3	m	R1/R2	TW	PolTW	Real	Length	Length	R4	LoR C
		S2_F_4a.3	position	q1	L3		R1	TW	PolTW	Real/Real	Length/Length	Length/Length	R4	LoR C
		S2_F_4a.4	width or depth	q1	L4	m	R2	TW	PolTW	Real	Length	Length	R4	LoR C
		S2_F_4a.5	area	q1	L3	m^2	R2	TW	PolTW	Real	Area	Area	R4	LoR C
S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
		S2_F_4b.2	linear extension	q1	L3	m	R1	PR	PolPR	Real	Length	Length	R4	LoR C
		S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
		S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
		S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
		S2_F_5.a.1	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
		S2_F_5.a.2	Special temporary opening	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
		S2_F_5.a.4	incidence for total perimeter	q1	L3	% (m/m *100)	R3	GR	PolGR	Real	Number	Number	R4	LoR C
		S2_F_5.a.5	extension (linear)	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C
		S2_F_5.a.6	Green Area Position (related to LS or AS)	q1	L3		R1	GR	PolGR	Real/Real	Length/Length	Length/Length	R4	LoR C
		S2_F_5.a.7	green area density	q1	L4	m^2 (veg)/ m^2 (green area)	R3	GR	PolGR	Real	Number	Number	R4	LoR C
		S2_F_5.a.8	influence in emergency paths	Q2	L2		R2	GR	PolGR	Real	Number	Number	R4	LoR C
		S2_F_5.a.9	area	q1	L3	m^2	R2	GR	PolGR	Real	Area	Area	R4	LoR C
S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S2_F_5.b.2	crowding potential	Q2	L4		R2	WT	PolWT	String	Text	String	R4	LoR C
		S2_F_5.b.3	incidence for total perimeter	q1	L3	% (m/m *100)	R3	WT	PolWT	Real	Number	Number	R4	LoR C
		S2_F_5.b.4	extension of water content	q1	L4	m								
		S2_F_5.b.5	Water Position (related to LS or AS)	q1	L2		R1	WT	PolWT	Real	Length	Length	R4	LoR C
		S2_F_5.b.6	Water body area	q1	L4	m^2	R2	WT	PolWT	Real	Length/Area	Length/Area	R4	LoR C
		S2_F_5.b.7	Water body volume	q1	L4	m^3	R2	WT	PolWT	Real	Volume	Volume	R4	LoR C
S2_F_6	Quote differences / slope	S2_F_6.1	quote difference	q1	L3	m	R1	TR + SR	PolTR + PolSR	Real	Length	Length	R4	LoR C
		P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope		R4	LoR A + LoR B + LoR C
	Content													
S2_C_1	Special buildings	S2_C_1.1	incidence (ratio sup/sup tot)	q1	L3	m^2/m^2 *100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
		S2_C_1.2	number	q3	L4		R3	BF	PolBF	Integer	Number	Number	R1	LoR A + LoR B
		S2_C_1.3	height	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
		S2_C_1.4	area	q1	L3	m^2	R2	BF	PolBF	Real	Area	Area	R4	LoRC
		S2_C_1.5	length	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
		S2_C_1.6	width	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
		S2_C_1.7	height of gable	q1	L3	m	R1	BF	PolBF	Real/Real	Length/Length	Length/Length	R4	LoR C
S2_C_2	Quote difference/slope	S2_C_2.1	quote difference	q1	L3	m	R2	TR + SR	PolTR + PolSR	Real	Length	Length	R4	LoR A + LoR B + LoR C
		P8c	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope		R4	LoR C

S2_C_3	Protections measure of slope/quote difference	S2_C_3.1	presence	q2	L4		R2	PM	LinePM	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S2_C_3.2	influence in emergency routes	Q2	L3		R3	PM	LinePM	String	Text/Multi-line text	String	R4	LoR C
S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	S2_C_4.1	presence Fontaine	q2	L4		R2	MN	PolMN	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S2_C_4.2	presence of monuments	q2	L4		R2	MN	PolMN	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S2_C_4.3	incidence (area)	q1	L2	m^2/ m^2 *100	R2	MN	PolMN	Real	Number	Number	R4	LoR C
		S2_C_4.4	number	q3	L4		R3	MN	PolMN	Integer	Number	Number	R1	LoR A + LoR B
		S2_C_4.5	efficacy of protection	Q2	L4		R2	MN	PolMN	String	Text/Multi-line text	String	R4	LoR C
		S2_C_4.6	area	q1	L3	m^2	R2	MN	PolMN	Real	Area	Area	R4	LoR C
S2_C_5a	Green area	P9c	Presence of Green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S2_C_5a.1	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
		S2_C_5a.2	incidence (area)	q1	L2	m^2/ m^2*100	R3	GR	PolGR	Real	Number	Number	R4	LoR C
		S2_C_5a.3	Special temporary opening	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
		S2_C_5a.4	extension (area)	q1	L4	m^2	R2	GR	PolGR	Real	Length	Length	R4	LoR C
		S2_C_5a.5	Greenery type (seasonal/ever green and species)	Q2	L4		R2	GR	PolGR	String	Text/Multi-line text	String/Option set	R1/R4	LoR A + LoR B + LoR C
		S2_C_5a.6	Greenery adsorption capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/ m^2)	R2	GR	PolGR	String	Text/Multi-line text	String	R4	LoR C
		S2_C_5a.7	Greenery height	q1	L4	m	R2	GR	PolGR	Real	Length	Length	R4	LoR C
		S2_C_5a.8	Greenery width	q1	L4	m	R2	GR	PolGR	Real	Length	Length	R4	LoR C
		S2_C_5a.9	Tree crown shape	Q2	L4		R2	GR	PolGR				R4	LoR C
		S2_C_5a.10	Tree crown diameter	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C
		S2_C_5a.11	efficacy for protection	Q2	L4		R2	GR	PolGR	String	Text/Multi-line text	String	R2	LoR C
		S2_C_5a.12	influence in emergency paths	Q2	L2		R2	GR	PolGR	String	Text/Multi-line text	String	R2	LoR C
S2_C_5b	Water	S2_C_5b.1	crowding potential	Q2	L4		R2	WT	PolWT	String	Text	String	R4	LoR C
		S2_C_5b.2	incidence for total area	q1	L2		R3	WT	PolWT	Real	Number	Number	R4	LoR C
		S2_C_5b.3	extension (area)	q1	L4		R2	WT	PolWT	Real	Area	Area	R4	LoR C
		S2_C_5b.4	Presence of Water	q2	L4		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S2_C_5b.5	efficacy for protection	Q2	L4		R2	WT	PolWT	String	Text/Multi-line text	String	R2	LoR C
S2_C_6	Underground cavities	S2_C_6.1	presence	q2	L4		R2	UC	PolUC	Boolean	Yes/No	True/False	R1	LoR A + LoR B
	SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
	Frontier													
S3_F_1	Homogeneity of built environment age	S3_F_1.1	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
		S3_F_1.2	last intervention period	Q1	L3		R2	BF	PolBF	String	Text	String	R4	LoR C
		S3_F_1.3	state of conservation	Q2	L3		R2	BF	PolBF	String	Text	String	R4	LoR A + LoR C
		S3_F_1.4	wall disconnection in plan	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C
		S3_F_1.5	wall disconnection in elevation	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C

S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
		S3_F_2.2	masonry quality	Q1	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
		S3_F_2.3	**wall thickness**	**q1**	**L3**	**m**	**R2**	**BF**	**PolBF**	**Real**	**Number**	**Number**	**R4**	**LoR C**
		S3_F_2.4	**max distance between party walls**	**q1**	**L3**	**m**	**R2**	**BF**	**PolBF**	**Real**	**Number**	**Number**	**R4**	**LoR C**
		S3_F_2.5	roof types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
		S3_F_2.6	horizontal structures types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
		S3_F_2.7	staggered floors	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
		S3_F_2.8	% openings	q1	L3	m^2/ m^2*100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
		S3_F_2.9	vertical alignment of openings	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
		S3_F_2.10	min edge distance of openings	q1	L3	m	R3	BF	PolBF	Real	Number	Number	R1/R4	LoR A + LoR C
		S3_F_2.11	jointed facades	q3	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
		S3_F_2.12	superimposed/additional storeys	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
		S3_F_2.13	no-structural protruding and decorative elements	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
		S3_F_2.14	anti-seismic devices	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
		S3_F_2.15	Facade finishing material	Q2	L4		R2	BF	PolBF	String	Text/Material	String/Material	R1/R4	LoR A + LoR C
		S3_F_2.16	Facade finishing albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
		S3_F_2.17	Facade finishing ageing	q4	L4	years	R2	BF	PolBF	Integer	Integer	Integer	R2	LoR C
		S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
		S3_F_2.19	Facade finishing aged albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
		S3_F_2.20	Facade cleanness	Q2	L4		R2	BF	PolBF	String	Text	String	R2	LoR A + LoR B + LoR C
		S3_F_2.21	Facade heat capacity	q4	L4	J/ kg K	R2	BF	PolBF	Real	Heat capacity (Energy)	Heat capacity	R2	LoR C
		S3_F_2.22	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m^2)	R2	BF	PolBF	Real	Number	Number	R2	LoR C
S3_F_3	Fixed obstacles	S3_F_3.1	Obstacle location	q1	L2		R1	FO	PolFO	Real/Real	Length/Length	Length/Length	R1	LoR A + LoR B
		S3_F_3.2	Obstacle shade boolean	q2	L4		R2	FO	PolFO	Boolean	Yes/No	True/False	R2	LoR C
		S3_F_3.3	incidence on total linear extension of frontier	q1	L2	m/m*100	R3	FO	PolFO	Real	Number	Number	R3	LoR C
		S3_F_3.4	length	q1	L4	m	R2	FO	PolFO	Real	Area	Area	R2	LoR C
		S3_F_3.5	n. of mitigation system	q3	L4		R3	FO	PolFO	Integer	Number	Number	R3	LoR A + LoR B
		S3_F_3.6	Mitigation systems	Q2	L4		R2	FO	PolFO	String	Text/Multi-line text	String/Option set	R2	LoR A + LoR B
		S3_F_3.7	Efficacy in protection	Q2	L4		R2	FO	PolFO	String	Text/Multi-line text	String	R2	LoR C
		S3_F_3.8	influence in emergency paths	Q2	L2		R2	FO	PolFO	String	Text/Multi-line text	String	R2	LoR C
		S3_F_3.9	**area**	**q1**	**L4**	**m^2**	**R2**	FO	PolFO	**Real**	**Length**	**Length**	**R4**	**LoR C**
S3_F_4	Temporary obstacles	S3_F_4.1	incidence on total linear extension of frontier	q1	L2	m/m*100	R3	TO	PolTO	Real	Number	Number	R3	LoR C
		S3_F_4.2	length	q1	L4	m	R2	TO	PolTO	Real	Area	Area	R2	LoR C
		S3_F_4.3	n. of mitigation system	q3	L4		R3	TO	PolTO	Integer	Number	Number	R3	LoR A + LoR B
		S3_F_4.4	Mitigation systems	Q2	L4		R2	TO	PolTO	String	Text/Multi-line text	String/Option set	R2	LoR A + LoR B

		S3_F_4.5	Efficacy in protection	Q2	L4		R2	TO	PolTO	String	Text/Multi-line text	String	R2	LoR C
		S3_F_4.6	influence in emergency paths	Q2	L2		R2	TO	PolTO	String	Text/Multi-line text	String	R2	LoR C
		S3_F_4.7	area	q1	L3	m^2	R2	TO	PolTO	Real	Area	Area	R4	LoRC
	Content													
S3_C_1	Pavement type	S3_C_1.1	classes of pavement	Q1	L3		R3	OS+SW+ST	PolOS + PolSW + PolST	String	Text	String/Option set	R4	LoR C
		S3_C_1.2	Pavement finishing material	Q2	L3		R2	OS+SW+ST	PolOS + PolSW + PolST	String	Material	String/Material	R1/R4	LoR A + LoR B + LoR C
		S3_C_1.3	incidence (area) for classes of pavements	q1	L4	m^2/ m^2 *100	R2	OS+SW+ST	PolOS + PolSW + PolST	String	Number	Number	R2	LoR C
		S3_C_1.4	Pavement finishing albedo	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
S3_C_2	Pavement condition	S3_C_2.1	Classes of conditions	Q2	L3		R2	OS+SW+ST	PolOS + PolSW + PolST	String	Text	String/Option set	R1/R4	LoR A + LoR B + LoR C
		S3_C_2.2	Pavement finishing ageing	q4	L3	years	R2	OS+SW+ST	PolOS + PolSW + PolST	Integer	Number	Number	R4	LoR C
		S3_C_2.3	Pavement finishing current roughness	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
		S3_C_2.4	Pavement finishing aged albedo	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
S3_C_3	Fixed obstacles	S3_C_3.1	Obstacle translucency boolean	q2	L4		R2	FO	PolFO	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C
		S3_C_3.2	Obstacle height	q1	L4	m	R2	FO	PolFO	Real	Length	Length	R4	LoR C
		S3_C_3.3	Obstacle width	q1	L4	m	R2	FO	PolFO	Real	Length	Length	R4	LoR C
		S3_C_3.4	incidence on total AS area	q1	L2	m^2/ m^2 *100	R3	FO+AS	PolFO + PolOS	Real	Number	Number	R4	LoR C
		S3_C_3.5	Efficacy in protection	Q2	L4		R2	FO	PolFO	String	Text/Multi-line text	String	R4	LoR C
		S3_C_3.6	area	q1	L4	m^2	R2	FO	PolFO	Real	Area	Area	R4	LoR C
		S3_C_3.7	influence in emergency paths	Q2	L2		R2	FO	PolFO	String	Text/Multi-line text	String	R4	LoR C
S3_C_4	Temporary obstacles	S3_C_4.1	incidence on total AS area	q1	L2	m^2/ m^2 *100	R3	TO+AS	PolTO + PolOS	Real	Number	Number	R4	LoR C
		S3_C_4.2	Efficacy in protection	Q2	L4		R2	TO	PolTO	String	Text/Multi-line text	String	R4	LoR C
		S3_C_4.3	area	q1	L4	m^2	R2	TO	PolTO	Real	Area	Area	R4	LoR C
		S3_C_4.4	influence in emergency paths	Q2	L2		R2	TO	PolTO	String	Text/Multi-line text	String	R4	LoR C
	SECTION 4: CHARACTERISTICS OF USE													
S4_1	Crowding	S4_1.1	people presents	q4	L2	person (pp)	R2			Integer	Number	Number	R1	LoR A + LoR B
		S4_1.2	crowding potential	Q2/q4	L2	pp/ m^2	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
		S4_1.3	tourism attraction	q4	L2	arrivals/inhabitants [pp/pp]	R2			String	Text/Multi-line text	String	R4	LoR C
		S4_1.4	Exposure duration	q4	L2	hrs	R2			Real	Number	Number	R4	LoR C
		S4_1.5	presence of emergency plan	q2	L2		R2	OS	PolOS	Boolean	Yes/No	True/False	R4	LoR C
S4_2	Special uses of OS	S4_2.1	Sensitive targets attraction to OS	Q2	L2		R2	OS	PolOS	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
		S4_2.2	crowding potential	Q2	L2		R2	OS	PolOS	String	Text	String	R1/R4	LoR A + LoR B + LoR C
		S4_2.3	Temporal special uses	Q2	L2		R2	OS	PolOS	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
		S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
		S4_3.3	Symbolism level	Q2	L4		R2	BF	PolBF	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
		S4_3.4	Presence of Schools	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B

		S4_3.5	Presence of Hospitals	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
		S4_3.6	Presence of Care home	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
		S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	q1	L2	m/m *100	R2	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
		S4_4.2	Traffic intensity	q4/Q1	L2	Vehicle/km	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
		S4_4.3	presence of street	q2	L2		R2	ST	PolST	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S4_4.4	level of accessibility	Q2	L2		R2	ST	PolST	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
		S4_4.5	Temporary accessibility	Q2	L4		R2	ST	PolST	String	Text	String	R4	LoR C
S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	q1	L2	m/m *100	R3	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
		S4_5.2	Pedestrian street presence Boolean	q2	L2		R2	ST	PolST	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S4_5.3	walking area	q1	L4	m^2	R2	ST+OS	PolST + PolOS	Real	Area	Area	R4	LoR C
		S4_5.4	Walking width	q1	L4	m	R2	ST+OS	PolST + PolOS	Real	Length	Length	R4	LoR C
S4_6	Vehicles (parking)	S4_6.1	incidence (area for AS)	q1	L3	m^2/ m^2 *100	R3	PK	PolPK	Real	Number	Number	R4	LoR C
		S4_6.2	incidence to prevalent dimension (linear for LS)	q1	L3	m/m *100	R3	PK	PolPK	Real	Number	Number	R4	LoR C
		S4_6.3	influence in emergency routes	Q2	L2		R2	PK	PolPK	String	Text/Multi-line text	String	R4	LoR C
		S4_6.4	Parking area presence Boolean	q2	L2		R2	PK	PolPK	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
		S4_6.6	Parking area	q1	L4	m^2	R2	PK	PolPK	Real	Area	Area	R4	LoR C
		S4_6.7	Parking width	q1	L4	m	R2	PK	PolPK	Real	Length	Length	R4	LoR C
		S4_6.8	Parking lenght (LS)	q1	L4	m	R2	PK	PolPK	Real	Length	Length	R4	LoR C
S4_7	Sights	S4_7.1	presence of sight	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S4_7.2	tourism attraction	Q1	L4		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String/Enum	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
		S4_7.3	crowding potential	Q2	L4		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text	String	R1/R4	LoR A + LoR B + LoR C
		S4_7.4	Symbolism level	Q2	L4		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text	String	R4	LoRC
S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
		S4_8.4	Symbolism level	Q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
	SECTION 5: ENVIRONMENTAL CHARACTERISTICS													
S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
		S5_1.2	Seismic microzonation	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
		S5_1.3	Max magnitude of historical earthquakes	Q2	L1		R2					String	Text	String
S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1		R2			String	Text	String/Option set	R4	LoR C

		S5_2.2	Latitude (North/South)	Q2	L1		R2		String	Text	String/Option set	R4	LoR C	
S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2		Real	Speed (Structural)	Number	R4	LoR C	
		S5_3.2	Wind/breeze direction azimuth	q4	L1	degree	R2		Real	Angle	Angle	R4	LoR C	
		S5_3.3	Air temperature	q4	L1	°C	R2		Real	Temperature (HVAC)	Number	R4	LoR C	
		S5_3.4	Solar Irradiation	q4	L1	W/ m^2	R2		Real	Number	Number	R4	LoR C	
		S5_3.5	Relative humidity	q4	L1	%	R2		Real	Number	Number	R4	LoR C	
		S5_3.6	Pollutant concentration	Q2		AQI								
S5_4	Multi-hazard potential	S5_4.1	classes	Q2	L1		?		String	Text	String/Option set	R4	LoR C	
		S5_4.2	Pollution sources presence Boolean	q2	L2		R2		Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C	
		S5_4.3	Pollution sources on wind/breeze trajectory Boolean	q2	L2		R2		Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C	
		S5_4.4	Current season (e.g. summer)	Q2	L1		R2		String	Text	String/Option set	R4	LoR C	
		S5_4.5	Pollution sources load	q4	L2	mass/volume (e.g. mg/l)	R2		String	Text/Multi-line text	String/Option set	R4	LoR C	
S5_5	Ground type	S5_5.1	classes of types	Q2	L1		R2	TR	String	Text	String/Option set	R4	LoR C	
		S5_5.2	Ground roughness	q4	L2	-	R2	TR	String	Text	String/Option set	R4	LoR C	
		S5_5.3	Ground albedo	q4	L2	-	R2	TR	Real	Number	Number	R4	LoR C	
		S5_5.4	Ground heat capacity	q4	L2	J/ kg K	R2	TR	Real	Heat capacity (Energy)	Heat capacity	R4	LoR C	
S5_6	Lifeline utilities	S5_6.1	Presence of Lifeline Utilities	Q2	**L1**		R2		String	Text	String/Option set	R4	LoR C	
S5_7	OS interconnection	S5_7.1	Classes OS network	Q2	**L1**		R2		String	Text	String/Option set	R4	LoR C	

8. Identification of reduced representation criteria for BEs exposed to single and recurrent combinations of risks

As introduced in the section 2, the fourth step of methodology support the process of the project defining a limited set of reduced matrixes of representation criteria for BE, starting from the resulting one in §7 (Table 27). In that sense, the creation of reduced matrixes is supported by critical analysis of risks and risks models aiming at:

- Solve redundant descriptors derived by the observation of SoA on single risks according to a double level of detail (§8.1):
  - The reduction of descriptors related to BETs significance (D3.2.1) if any parameters or descriptors indirectly involved in the analysis result to be poorly influent or not representative of the Italian sample;
  - By reducing the number of descriptors influencing Exposure as the results of most relevant factors taken into account in D.3.2.3.
- Identify for each risk the most representative parameters and descriptors involved in single risks, considering specific issues. In detail, according to the flowchart of activities in D3.1.3, reduced matrixes will support the representation both of BEs and BETs delineating specific conditions of BE in which human interact during the disaster (§8.2).
- Similarly, identify the equivalent set of reduced matrixes for recurrent and significant combinations of hazards identified in §4.1 (§8.2).

8.1. Matrix reduction for recurrent factors on Physical parameters and Exposure relevance.

As discussed in previous section, the complex matrix of representation criteria (Table 27) derives from the analysis of single risks and specific descriptors influencing the risks according to the wide literature review collected in previous Deliverables (see §3). At the actual state, the matrix counts 252 descriptors involving all the chosen parameters for the BE description.

Considering the aims of T3.2 of the project, D3.2.1 and D3.2.3 are referred to physical parameters involved in BETs and exposures features involved in social exposure, respectively. Due to that, this section has the aim to re-border the total matrix in order to define a reduced one referred to significant parameters really present in Italian cases and efficiently involved in assessing the human involvement in the BE.

In detail, Figure 7 shows the process of reduction derived by this first level of expert judgment.

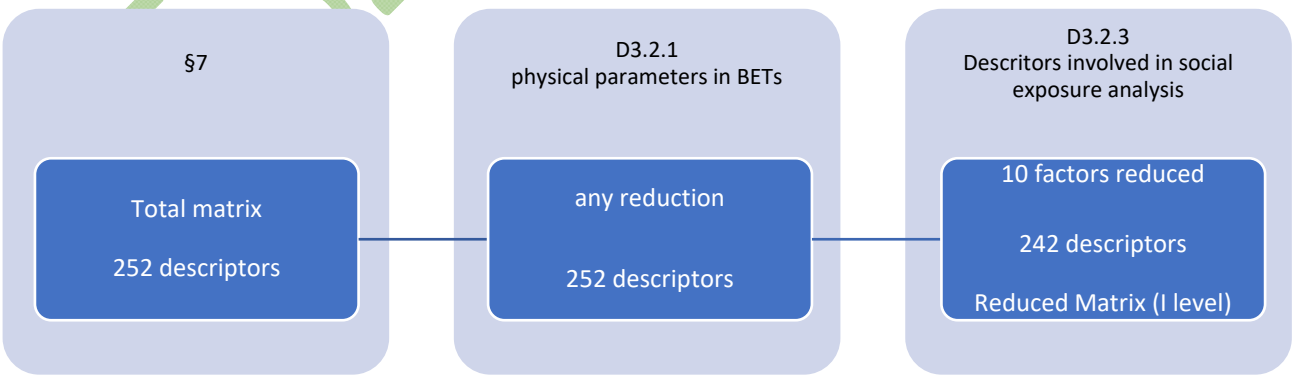

Figure 7. Process of matrix reduction derived by the expert judgment for physical parameters describing BETs (D3.2.1) and factors involving social exposure (D3.2.3)

In detail, D3.2.1 cannot provide the reduction of the matrix due to the highlighted combinations of parameters involved. In fact:

- Concerning the P1 (classes of shapes) and P2 (dimensions of OS/LS), the relative descriptors are just reduced for variability of detail (not discussed here);
- P3 (Structural types), P6 (homogeneity in construction techniques) and P7 (porches) have not analysis for the absence of specific data (not discussed here)
- Analysis of P4 (permeability of BE) highlighted reduced results for the goals of this section (any details on n. of access and dimension);
- P5, identified for the recognition of "presence of special building" and "number of Special buildings" cannot provide a reduction of relative parameters, but superior values for the latter (max n. of Special building =4);
- Statistical analysis on P8 (slope) and P9 (green area) reflected several combinations for their primary characters (presence and % for slope, and presence and % of green area on the total extension of AS) that cannot help in reducing the matrix.

As far as the expert judgment discussed in D3.2.3, some descriptors are delated, as follows:

- S2_F_5.a.3 and S2_C_5a.3 "**Special temporary opening"** related to green areas located both in content and frontier.
- S4_2.2 "crowding potential" in the OS assessed during special uses of the BE
- S4_5.2 "Pedestrian street presence Boolean" and S4_5.4 "Walking width" referred to the "accessibility for pedestrian"
- S4_6.3 "influence in emergency routes", S4_6.4 "Parking area presence Boolean", S4_6.6 "Parking area" and S4_6.7 "Parking width" in assessing the parking areas
- S4_7.3 "crowding potential" associated to the presence of sights in the BE.

Detailed reduction is applied to other singles parameters when they affect Exposures for single risks. In fact, according to the association between descriptor and Exposure relevance, the reduction can affect parameters for single risks; it is the case for:

- S4_1.3 "tourism attraction" as descriptor of Crowing in the BE when it is considered as an Exposure descriptor for SRM;
- S4_4.2 "Traffic intensity" and S4_4.5 "Temporary accessibility" in the accessibility for vehicle in the SRM
- S4_5.1 "incidence of accessibility to pedestrian to total accesses" in the Accessibility for pedestrian in SRM
- S4_6.5 "Parking area location" in parking parameter both for TRM and H-PRMs; for the latter it represents also a descriptor for Vulnerability
- S4_7.1 "presence of sight" and S4_7.2 "tourism attraction" for the parameter sights in the SRM

8.2. Identification of reduced matrix for single risk models

According to the process of reduction described in §8, the matrix, reduced according to the first step (§8.1) has been reduced according to specific filters applied for single risk model. For each of them, one issue has been identified in order to highlight specific issue in the whole RM when previous analysis on the SoA cannot

directly provided. As a note, all the reduced matrixes preserve the descriptors related to the BETs identification according to the goals of the project. In detail:

- Concerning the SRM, the applied filter consists in relating the process of debris generation to the alteration of paths, as well as in increasing the human exposure during the emergency (output: Matrix SRMred).
- The TRM discussed in D1.3.1 already provided specific scenarios of attack types that has prevalent effect in human losses (see T2 for armed attacks and T3). Moreover, according to the AHP process, specific weights of parameters involved in TRM for T2 and T3 were provided. In detail, all the descriptors involved in the "target index", "Prevention index" for Hazard, "accessibility index" for Vulnerability and "crowding index" for Exposure are chosen as most relevant for the analysis. Linking the indexes to the descriptors, all the descriptors related to the presence of symbolic (sights, special buildings) or natural attractors (green areas, fountains) and their areas are considered as influent for the reduced matrix for Hazard; concerning the Vulnerability, all the parameters that characterized the accesses and their permeability to vehicles and pedestrians are considered; finally, all the descriptors influencing the crowding levels of the BE (total) and attractors (as local variation) are considered for the Exposure (output: Matrix TRMred).
- For HRM and PRM parameters are selected according their relevance in modifying microclimate (for HRM) and pollutant concentrations (for PRM) at BE scale. Due to the nature of such events, for both the selection of parameters follows the necessity to determine how such events can influence human position and movement in and inside the BE. It is in line with the issues identified for combination of hazards identified and discussed in § 4.1 (outputs: Matrix HRMred and PRMred).

Following, Table 28,

Table 29, Table 29 and Table 31 report the reduced matrix as discussed, showing the representation criteria and the equivalent relation in the Model Risk (indicating Hazard, Vulnerability or Exposure relation).

Final single-risk reduced matrixes reflect a good constrain of number of descriptors as reported in Figure 8.

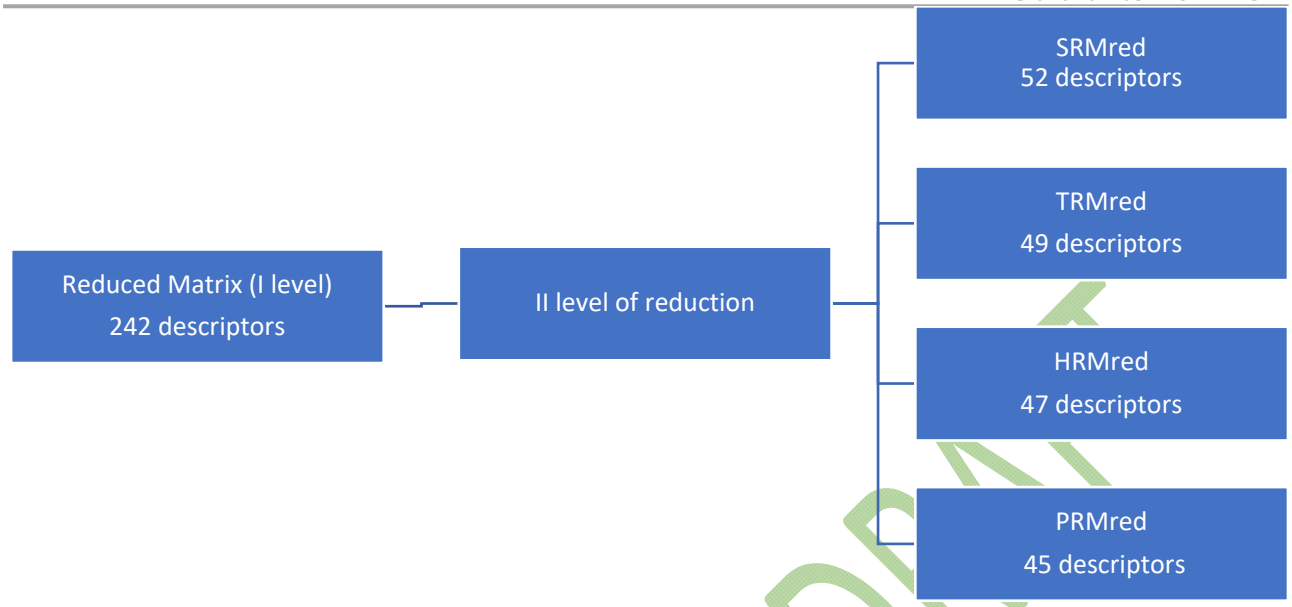

Figure 8. Application of II level of reduction applied to the Reduced Matrix I for single risks and number of descriptors involved for each reduced matrix.

Table 28 Matrix of couple data for Representation Rule for Element for the Reduced matrix of SRMred; Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments; H, V, E identify the relevance of each descriptor in the reduced Risk Model

Risk model	Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
SRM		Section 1: MAIN TYPE													
V	S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
V	S1_1	Dimension of OS	S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
V	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
		SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE													
		Frontier													
V	S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
V			S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
V			S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V			S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
V			S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
V			S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V	S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
V			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
V/E	S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V			S2_F_3.4	length of special buildings front	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
V			S2_F_3.5	height	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
V			S2_F_3.7	height of gable	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
V	S2_F_4a	Town walls	S2_F_4a.1	presence	q2	L2		R2	TW	PolTW	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V			S2_F_4a.2	linear extension	q1	L3	m	R1/R2	TW	PolTW	Real	Length	Length	R4	LoR C
V			S2_F_4a.3	position	q1	L3		R1	TW	PolTW	Real/Real	Length/Length	Length/Length	R4	LoR C
V			S2_F_4a.4	width or depth	q1	L4	m	R2	TW	PolTW	Real	Length	Length	R4	LoR C
V	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V			S2_F_4b.2	linear extension	q1	L3	m	R1	PR	PolPR	Real	Length	Length	R4	LoR C
V			S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
E	S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
E			S2_F_5.a2	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
E	S2_F_5b	Water	S2_F_5.b.2	crowding potential	Q2	L4		R2	WT	PolWT	String	Text	String	R4	LoR C
V	S2_F_6	Quote differences / slope	P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR A + LoR B + LoR C
		Content													
V	S2_C_1	Special buildings	S2_C_1.3	height	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
V			S2_C_1.5	length	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
V			S2_C_1.6	width	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
V			S2_C_1.7	height of gable	q1	L3		R1	BF	PolBF	Real/Real	Length/Length	Length/Length	R4	LoR C
V	S2_C_2	Quote difference/slope	P8c	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C

V/E	S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	S2_C_4.2	presence of monuments	q2	L4		R2	MN	PolMN	Boolean	Yes/No	True/False	R1	LoR A + LoR B
E	S2_C_5a	Green area	S2_C_5a.1	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
E	S2_C_5b	Water	S2_C_5b.1	crowding potential	Q2	L4		R2	WT	PolWT	String	Text	String	R4	LoR C
		SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
		Frontier													
V	S3_F_1	Homogeneity of built environment age	S3_F_1.2	last intervention period	Q1	L3		R2	BF	PolBF	String	Text	String	R4	LoR C
V			S3_F_1.3	state of conservation	Q2	L3		R2	BF	PolBF	String	Text	String	R4	LoR A + LoR C
V			S3_F_1.4	wall disconnection in plan	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C
V			S3_F_1.5	wall disconnection in elevation	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C
V	S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
V			S3_F_2.2	masonry quality	Q1	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
V			S3_F_2.3	wall thickness	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
V			S3_F_2.5	roof types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
V			S3_F_2.8	% openings	q1	L3	mq/mq*100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
V			S3_F_2.13	no-structural protruding and decorative elements	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
V			S3_F_2.14	anti-seismic devices	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
		Content													
		SECTION 4: CHARACTERISTICS OF USE													
E	S4_1	Crowding	S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
E	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
E			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
E			S4_3.4	Presence of Schools	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
E			S4_3.5	Presence of Hospitals	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
E	S4_8	Sensitive targets	S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
E			S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
		SECTION 5: ENVIRONMENTAL CHARACTERISTICS													
H	S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
H			S5_1.2	Seismic microzonation	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
H	S5_5	Ground type	S5_5.1	classes of types	Q2	L1		R2	TR		String	Text	String/Option set	R4	LoR C

Table 29 Matrix of couple data for Representation Rule for Element for the Reduced matrix of TRMred; Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments; H, V, E identify the relevance of each descriptor in the reduced Risk Model

Risk model	Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
TRM		Section 1: MAIN TYPE													
V	S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
H	S1_1	Dimension of OS	S1_1.1	area	q1	L2	mq	R2	OS	PolOS	Real	Area	Area	R4	LoR C
			S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
		SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE													
		Frontier													
	S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
			S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
			S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
			S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
			S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
			S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V	S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
V			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
H			S2_F_2.4	presence of mitigation/control systems	q2	L3		R2	MC/AC	LinAC/LinMC	String	Text/Multi-line text	String/Option set/Tags List	R1	LoR A + LoR B
H	S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
H			S2_F_3.3	number	q3	L2		R3	BF	PolBF	Integer	Number	Number	R1	LoR A + LoR B
H	S2_F_4a	Town walls	S2_F_4a.1	presence	q2	L2		R2	TW	PolTW	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H			S2_F_4a.5	area	q1	L3	m^2	R2	TW	PolTW	Real	Area	Area	R4	LoR C
H	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
H			S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
H/E	S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
E			S2_F_5.a2	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
H/E			S2_F_5.a.9	area	q1	L3	m^2	R2	GR	PolGR	Real	Area	Area	R4	LoR C
H	S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
E			S2_F_5.b.2	crowding potential	Q2	L4		R2	WT	PolWT	String	Text	String	R4	LoR C
H			S2_F_5.b.4	extension of water content	q1	L4	m	R2	WT	PolWT	Real	Length	Length	R4	LoR C
E	S2_F_6	Quote differences / slope	P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR A + LoR B + LoR C
		Content													
H	S2_C_1	Special buildings	S2_C_1.2	number	q3	L4		R3	BF	PolBF	Integer	Number	Number	R1	LoR A + LoR B
H			S2_C_1.4	area	q1	L3	m^2	R2	BF	PolBF	Real	Area	Area	R4	LoRC
H	S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	S2_C_4.1	presence fontaine	q2	L4		R2	MN	PolMN	Boolean	Yes/No	True/False	R1	LoR A + LoR B

H			S2_C_4.2	presence of monuments	q2	L4		R2	MN	PolMN	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H			S2_C_4.4	number of monuments	q3	L4		R3	MN	PolMN	Integer	Number	Number	R1	LoR A + LoR B
H			S2_C_4.6	area	q1	L3	m^2	R2	MN	PolMN	Real	Area	Area	R4	LoR C
H	S2_C_5a	Green area	P9c	Presence of Green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B
E			S2_C_5a.1	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
H			S2_C_5a.4	extension (area)	q1	L4	mq	R2	GR	PolGR	Real	Length	Length	R4	LoR C
		SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
		Frontier													
H	S3_F_3	Fixed obstacles	S3_F_3.5	n. of mitigation system	q3	L4		R3	FO	PolFO	Integer	Number	Number	R3	LoR A + LoR B
H			S3_F_3.6	Mitigation systems	Q2	L4		R2	FO	PolFO	String	Text/Multi-line text	String/Option set	R2	LoR A + LoR B
H	S3_F_4	Temporary obstacles	S3_F_4.3	n. of mitigation system	q3	L4		R3	TO	PolTO	Integer	Number	Number	R3	LoR A + LoR B
H			S3_F_4.4	Mitigation systems	Q2	L4		R2	TO	PolTO	String	Text/Multi-line text	String/Option set	R2	LoR A + LoR B
		Content													
		SECTION 4: CHARACTERISTICS OF USE													
H/E	S4_1	Crowding	S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
H			S4_1.3	tourism attraction	q4	L2	arrivals/ inhabitants [pp/pp]	R2			String	Text/Multi-line text	String	R4	LoR C
H	S4_2	Special uses of OS	S4_2.1	Sensitive targets attraction to OS	Q2	L2		R2	OS	PolOS	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
H	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
E			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
H			S4_3.3	Symbolism level	Q2	L4		R2	BF	PolBF	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
V	S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	q1	L2	m/m *100	R2	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
V			S4_4.4	level of accessibility	Q2	L2		R2	ST	PolST	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
V	S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	q1	L2	m/m *100	R3	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
	S4_7	Sights	S4_7.1	presence of sight	q2	L2				PolOs + PolMN + PolBF + PolGR + PolWT			True/False		
H								R2	OS+MN+BF+GR+WT		Boolean	Yes/No		R1	LoR A + LoR B
			S4_7.4	Symbolism level	Q2	L4				PolOs + PolMN + PolBF + PolGR + PolWT		Text	String		
H								R2	OS+MN+BF+GR+WT		String			R4	LoRC
	S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)	q2	L2				PolOs + PolMN + PolBF + PolGR + PolWT			True/False		
H/E								R2	OS+MN+BF+GR+WT		Boolean	Yes/No		R1	LoR A + LoR B
			S4_8.4	Symbolism level	Q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
H															

Table 29 Matrix of couple data for Representation Rule for Element for the Reduced matrix of HRMred; Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments; H, V, E identify the relevance of each descriptor in the reduced Risk Model

Risk model	Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
HRM		Section 1: MAIN TYPE													
	S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
V			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
V	S1_1	Dimension of OS	S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
V	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
V			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
		SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE													
		Frontier													
	S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
			S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
			S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
			S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
			S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
			S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
	S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
V			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
V			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
	S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V			S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
V			S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
V	S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V			S2_F_5.a7	green area density	q1	L4	mq(veg)/mq(green area)	R3	GR	PolGR	Real	Number	Number	R4	LoR C
V	S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V			S2_F_5.b.6	Water body area	q1	L4	mq	R2	WT	PolWT	Real	Length/Area	Length/Area	R4	LoR C
V			S2_F_5.b.7	Water body volume	q1	L4	mc	R2	WT	PolWT	Real	Volume	Volume	R4	LoR C
V	S2_F_6	Quote differences / slope	P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR A + LoR B + LoR C
		Content													
	S2_C_2	Quote difference/slope	P8c	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C
V	S2_C_5a	Green area	P9c	Presence of Green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V			S2_C_5a.4	extension (area)	q1	L4	mq	R2	GR	PolGR	Real	Length	Length	R4	LoR C
V			S2_C_5a.10	Tree crown diameter	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C
		SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
		Frontier													
	S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
V			S3_F_2.16	Facade finishing albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C

V		+2.16	S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
V			S3_F_2.21	Facade heat capacity	q4	L4	J/ kg K	R2	BF	PolBF	Real	Heat capacity (Energy)	Heat capacity	R2	LoR C
		Content													
V	S3_C_1	Pavement type	S3_C_1.4	Pavement finishing albedo	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
V	S3_C_2	Pavement condition	S3_C_2.3	Pavement finishing current roughness	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
		SECTION 4: CHARACTERISTICS OF USE													
E	S4_1	Crowding	S4_1.1	people presents	q4	L2	person (pp)	R2			Integer	Number	Number	R1	LoR A + LoR B
E			S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
E			S4_1.4	Exposure duration	q4	L2	sec/min/hrs	R2			Real	Number	Number	R4	LoR C
E	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
E			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
V & E			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V	S4_4	Accessibility for vehicle	S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
V & E	S4_6	Vehicles (parking)	S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
E	S4_8	Sensitive targets	S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V			S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
		SECTION 5: ENVIRONMENTAL CHARACTERISTICS													
H	S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
H	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2			Real	Speed (Structural)	Number	R4	LoR C
H			S5_3.3	Air temperature	q4	L1	°C	R2			Real	Temperature (HVAC)	Number	R4	LoR C
H			S5_3.4	Solar Irradiation	q4	L1	W/mq	R2			Real	Number	Number	R4	LoR C
V	S5_5	Ground type	S5_5.2	Ground roughness	q4	L2	-	R2	TR		String	Text	String/Option set	R4	LoR C
V			S5_5.3	Ground albedo	q4	L2	-	R2	TR		Real	Number	Number	R4	LoR C
V			S5_5.4	Ground heat capacity	q4	L2	J/ kg K	R2	TR		Real	Heat capacity (Energy)	Heat capacity	R4	LoR C

Table 30 Matrix of couple data for Representation Rule for Element for the Reduced matrix of PRMred; Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments; H, V, E identify the relevance of each descriptor in the reduced Risk Model

Risk model	Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
PRM		Section 1: MAIN TYPE													
	S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
V			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
V			S1_0.3	Proximity of sidewalk to traffic	q1	L4	m	R1	SW+ST	PolSW + PolST	Real	Length	Length	R4	LoR C
	S1_1	Dimension of OS	S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
V	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
V			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
		SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE													
		Frontier													
	S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
			S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
			S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
			S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
			S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
			S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
	S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
V			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
V			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
	S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V			S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
V			S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
V	S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V			S2_F_5.a.6	Green Area Position (related to LS or AS)	q1	L3		R1	GR	PolGR	Real/Real	Length/Length	Length/Length	R4	LoR C
V			S2_F_5.a7	green area density	q1	L4	m^2(veg)/ m^2 (green area)	R3	GR	PolGR	Real	Number	Number	R4	LoR C
V	S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V	S2_F_6	Quote differences / slope	P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR A + LoR B + LoR C
		Content													
	S2_C_2	Quote difference/slope	P8c	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C
V	S2_C_5a	Green area	P9c	Presence of Green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V			S2_C_5a.4	extension (area)	q1	L4	m^2	R2	GR	PolGR	Real	Length	Length	R4	LoR C
V			S2_C_5a.6	Greenery adsoprtion capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/ m^2)	R2	GR	PolGR	String	Text/Multi-line text	String	R4	LoR C
V			S2_C_5a.10	Tree crown diameter	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C
		SECTION 3: CONSTRUCTIVE CHARACTERISTICS													

		Frontier													
	S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
V			S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
V			S3_F_2.22	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m^2)	R2	BF	PolBF	Real	Number	Number	R2	LoR C
		Content													
V	S3_C_2	Pavement condition	S3_C_2.3	Pavement finishing current roughness	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
		SECTION 4: CHARACTERISTICS OF USE													
E	S4_1	Crowding	S4_1.1	people presents	q4	L2	person (pp)	R2			Integer	Number	Number	R1	LoR A + LoR B
E			S4_1.2	crowding potential	Q2/q4	L2	pp/ m^2	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
E			S4_1.4	Exposure duration	q4	L2	sec/min/hrs	R2			Real	Number	Number	R4	LoR C
E	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
E			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
V & E			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V	S4_4	Accessibility for vehicle	S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
V & E	S4_6	Vehicles (parking)	S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
E	S4_8	Sensitive targets	S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V			S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
		SECTION 5: ENVIRONMENTAL CHARACTERISTICS													
H	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2			Real	Speed (Structural)	Number	R4	LoR C
H			S5_3.3	Air temperature	q4	L1	°C	R2			Real	Temperature (HVAC)	Number	R4	LoR C
H			S5_3.4	Solar Irradiation	q4	L1	W/ m^2	R2			Real	Number	Number	R4	LoR C
H			S5_3.6	Pollutant concentration	Q2		AQI	R2			Real	Number	Number	R4	LoR C
H	S5_4	Multi-hazard potential	S5_4.2	Pollution sources presence Boolean	q2	L2		R2			Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C
V	S5_5	Ground type	S5_5.2	Ground roughness	q4	L2	-	R2	TR		String	Text	String/Option set	R4	LoR C

8.3 Identification of reduced matrixes for selected Combinations of Hazards

According to the main goals of this section, reduced matrixes are created also for the selected combination of hazards identified in §4.1 and exactly for H → S, P → S and P → H → T.

Following

Table 31, Table 32 and Table 33 show the matrixed namely introduced as Comb(H-SRMred), Comb(P-SRMred) Comb(P-H-TRMred). Figure 9 summarizes reduced matrixes involved for the creation of combination matrixes and reports the total amount of descriptors involved.

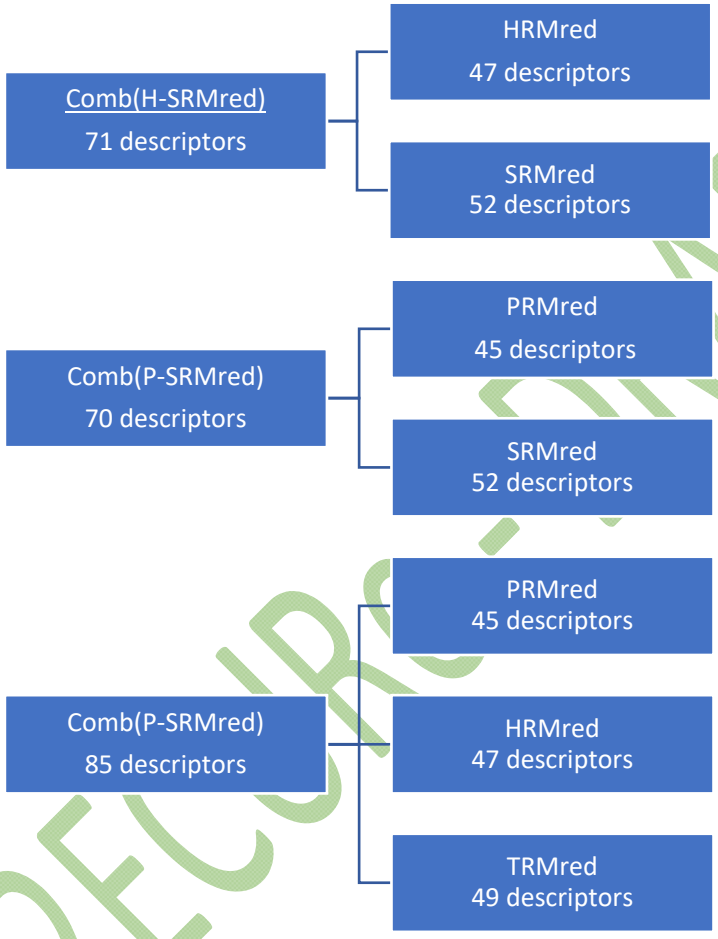

Figure 9 Relations between reduced matrixes for single risks and reduced matrixes for combination of hazards.

Table 31 Matrix of couple data for Representation Rule for Element for the Comb(H-SRMred); Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments; H, V, E identify the relevance of each descriptor in the reduced combination of Risk Models

Risk model		Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
SRM	HRM		Section 1: MAIN TYPE													
V		S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
	V			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
V	V	S1_1	Dimension of OS	S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
V	V	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
V	V			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
			SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE Frontier													
V		S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
V				S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
V				S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V				S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
V				S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
V				S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V		S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
V	V			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
	V			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
V/E		S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V				S2_F_3.4	length of special buildings front	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
V				S2_F_3.5	height	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
V				S2_F_3.7	height of gable	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
V		S2_F_4a	Town walls	S2_F_4a.1	presence	q2	L2		R2	TW	PolTW	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V				S2_F_4a.2	linear extension	q1	L3	m	R1/R2	TW	PolTW	Real	Length	Length	R4	LoR C
V				S2_F_4a.3	position	q1	L3		R1	TW	PolTW	Real/Real	Length/Length	Length/Length	R4	LoR C
V				S2_F_4a.4	width or depth	q1	L4	m	R2	TW	PolTW	Real	Length	Length	R4	LoR C
V	V	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V				S2_F_4b.2	linear extension	q1	L3	m	R1	PR	PolPR	Real	Length	Length	R4	LoR C
V	V			S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
V	V			S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
V				S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
E	V	S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
	V			S2_F_5.a6	green area density	q1	L4	mq(veg)/ mq(green area)	R3	GR	PolGR	Real	Number	Number	R4	LoR C
V	V	S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
	V			S2_F_5.b.5	Water body area	q1	L4	mq	R2	WT	PolWT	Real	Length/Area	Length/Area	R4	LoR C
	V			S2_F_5.b.6	Water body volume	q1	L4	mc	R2	WT	PolWT	Real	Volume	Volume	R4	LoR C
V	V	S2_F_6	Quote differences / slope	P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR A + LoR B + LoR C
			Content													
V		S2_C_1	Special buildings	S2_C_1.3	height	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
V				S2_C_1.5	length	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
V				S2_C_1.6	width	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
V				S2_C_1.7	height of gable	q1	L3		R1	BF	PolBF	Real/Real	Length/Length	Length/Length	R4	LoR C
V		S2_C_2	Quote difference/slope	P8c	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C

	V	S2_C_5a	Green area	S2_C_5a.4	extension (area)	q1	L4	mq	R2	GR	PolGR	Real	Length	Length	R4	LoR C
	V			S2_C_5a.10	Tree crown diameter	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C
			SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
			Frontier													
	V	S3_F_1	Homogeneity of built environment age	S3_F_1.2	last intervention period	Q1	L3		R2	BF	PolBF	String	Text	String	R4	LoR C
	V			S3_F_1.3	state of conservation	Q2	L3		R2	BF	PolBF	String	Text	String	R4	LoR A + LoR C
	V			S3_F_1.4	wall disconnection in plan	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C
	V			S3_F_1.5	wall disconnection in elevation	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C
	V	S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
	V			S3_F_2.2	masonry quality	Q1	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
	V			S3_F_2.3	wall thickness	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
	V			S3_F_2.5	roof types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
	V			S3_F_2.8	% openings	q1	L3	mq/mq*100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
	V			S3_F_2.13	no-structural protruding and decorative elements	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
	V			S3_F_2.14	anti-seismic devices	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
	V			S3_F_2.16	Facade finishing albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
	V			S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
	V			S3_F_2.21	Facade heat capacity	q4	L4	J/ kg K	R2	BF	PolBF	Real	Heat capacity (Energy)	Heat capacity	R2	LoR C
			Content													
	V	S3_C_1	Pavement type	S3_C_1.4	Pavement finishing albedo	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
	V	S3_C_2	Pavement condition	S3_C_2.3	Pavement finishing current roughness	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
			SECTION 4: CHARACTERISTICS OF USE													
	E	S4_1	Crowding	S4_1.1	people presents	q4	L2	person (pp)	R2			Integer	Number	Number	R1	LoR A + LoR B
E	E			S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
	E			S4_1.4	Exposure duration	q4	L2	sec/min/hrs	R2			Real	Number	Number	R4	LoR C
E	E	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
E	E			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
E				S4_3.4	Presence of Schools	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
E				S4_3.5	Presence of Hospitals	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
	V & E			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
	V	S4_4	Accessibility for vehicle	S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
	V & E	S4_6	Vehicles (parking)	S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
E	E	S4_8	Sensitive targets	S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
E	V			S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
			SECTION 5: ENVIRONMENTAL CHARACTERISTICS													

H		S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1		R2		String	Text	String/Option set	R4	LoR C
H				S5_1.2	Seismic microzonation	Q2	L1		R2		String	Text	String/Option set	R4	LoR C
	H	S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1		R2		String	Text	String/Option set	R4	LoR C
	H	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2		Real	Speed (Structural)	Number	R4	LoR C
E	**H**			S5_3.3	Air temperature	q4	L1	°C	R2		Real	Temperature (HVAC)	Number	R4	LoR C
	H			S5_3.4	Solar Irradiation	q4	L1	W/mq	R2		Real	Number	Number	R4	LoR C
H		S5_5	Ground type	S5_5.1	classes of types	Q2	L1		R2	TR	String	Text	String/Option set	R4	LoR C
	V			S5_5.2	Ground roughness	q4	L2	-	R2	TR	String	Text	String/Option set	R4	LoR C
	V			S5_5.3	Ground albedo	q4	L2	-	R2	TR	Real	Number	Number	R4	LoR C
	V			S5_5.4	Ground heat capacity	q4	L2	J/ kg K	R2	TR	Real	Heat capacity (Energy)	Heat capacity	R4	LoR C

Table 32 Matrix of couple data for Representation Rule for Element for the Comb(P-SRMred); Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments; H, V, E identify the relevance of each descriptor in the reduced combination of Risk Models

Risk model		Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
SRM	PRM		Section 1: MAIN TYPE													
V		S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
	V			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
	V			S1_0.3	Proximity of sidewalk to traffic	q1	L4	m	R1	SW+ST	PolSW + PolST	Real	Length	Length	R4	LoR C
V		S1_1	Dimension of OS	S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
V	V	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
V	**V**			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
			SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE Frontier													
V		S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
V				S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
V				S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V				S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
V				S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
V				S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V		S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
V	**V**			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
	V			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
V/E		S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V				S2_F_3.4	length of special buildings front	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
V				S2_F_3.5	height	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
V				S2_F_3.7	height of gable	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
V		S2_F_4a	Town walls	S2_F_4a.1	presence	q2	L2		R2	TW	PolTW	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V				S2_F_4a.2	linear extension	q1	L3	m	R1/R2	TW	PolTW	Real	Length	Length	R4	LoR C
V				S2_F_4a.3	position	q1	L3		R1	TW	PolTW	Real/Real	Length/Length	Length/Length	R4	LoR C
V				S2_F_4a.4	width or depth	q1	L4	m	R2	TW	PolTW	Real	Length	Length	R4	LoR C
V	**V**	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
V				S2_F_4b.2	linear extension	q1	L3	m	R1	PR	PolPR	Real	Length	Length	R4	LoR C
V	**V**			S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
V	**V**			S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
V				S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
E	V	S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C

	V			S2_F_5.a.5	Green Area Position (related to LS or AS)	q1	L3		R1	GR	PolGR	Real/Real	Length/Length	Length/Length	R4	LoR C
	V			S2_F_5.a6	green area density	q1	L4	mq(veg)/mq(green area)	R3	GR	PolGR	Real	Number	Number	R4	LoR C
V	V	S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V	V	S2_F_6	Quote differences / slope	P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR A + LoR B + LoR C
			Content													
V		S2_C_1	Special buildings	S2_C_1.3	height	q1	L4	m	R2	BF	PolBF	Real	Length	Length	R4	LoR A + LoR B + LoR C
V				S2_C_1.5	length	q1	L4	m	m	R2	BF	PolBF	Real	Length	Length	R4
V				S2_C_1.6	width	q1	L4	m	m	R2	BF	PolBF	Real	Length	Length	R4
V				S2_C_1.7	height of gable	q1	L3	m	R1	BF	PolBF	Real/Real	Length/Length	Length/Length	R4	LoR C
V		S2_C_2	Quote difference/slope	P8c	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C
E	V	S2_C_5a	Green area	P9c	Presence of Green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B
	V			S2_C_5a.4	extension (area)	q1	L4	mq	R2	GR	PolGR	Real	Length	Length	R4	LoR C
	V			S2_C_5a.6	Greenery adsoprtion capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/mq)	R2	GR	PolGR	String	Text/Multi-line text	String	R4	LoR C
	V			S2_C_5a.10	Tree crown diameter	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C
			SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
			Frontier													
V		S3_F_1	Homogeneity of built environment age	S3_F_1.2	last intervention period	Q1	L3		R2	BF	PolBF	String	Text	String	R4	LoR C
V				S3_F_1.3	state of conservation	Q2	L3		R2	BF	PolBF	String	Text	String	R4	LoR A + LoR C
V				S3_F_1.4	wall disconnection in plan	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C
V				S3_F_1.5	wall disconnection in elevation	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R4	LoR A + LoR C
V		S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
V				S3_F_2.2	masonry quality	Q1	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
V				S3_F_2.3	wall thickness	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
V				S3_F_2.5	roof types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
V				S3_F_2.8	% openings	q1	L3	mq/mq*100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
V				S3_F_2.13	no-structural protruding and decorative elements	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
V				S3_F_2.14	anti-seismic devices	q2	L3		R2	BF	PolBF	Boolean	Yes/No	True/False	R1/R4	LoR A + LoR C
	V			S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
	V			S3_F_2.22	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m²)	R2	BF	PolBF	Real	Number	Number	R2	LoR C
			Content													
	V	S3_C_2	Pavement condition	S3_C_2.3	Pavement finishing current roughness	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
			SECTION 4: CHARACTERISTICS OF USE													
	E	S4_1	Crowding	S4_1.1	people presents	q4	L2	person (pp)	R2			Integer	Number	Number	R1	LoR A + LoR B
E	E			S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C

	E			S4_1.4	Exposure duration	q4	L2	sec/min/hrs	R2			Real	Number	Number	R4	LoR C
E		S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2									
	E								R2	BF	PolBF				R1	LoR A + LoR B
E	**E**			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
E				S4_3.4	Presence of Schools	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
E				S4_3.5	Presence of Hospitals	q2	L2		R2	BF	PolBF	String	Multi-line text	String	R1	LoR A + LoR B
	V E			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
	V	S4_4	Accessibility for vehicle	S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
	V E	S4_6	Vehicles (parking)	S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
E		S4_8	Sensitive targets	S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2							True/False		
	E								R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No		R1	LoR A + LoR B
E				S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%					Number	Number		
	V								R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real			R1/R4	LoR A + LoR B + LoR C
			SECTION 5: ENVIRONMENTAL CHARACTERISTICS													
H		S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
H				S5_1.2	Seismic microzonation	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
~~H~~				~~S5_1.3~~	~~Max magnitude of historical earthquakes~~	~~Q2~~	~~L1~~		~~R2~~			~~String~~	~~Text~~	~~String~~	~~R4~~	~~LoR C~~
	H	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2			Real	Speed (Structural)	Number	R4	LoR C
E	**H**			S5_3.3	Air temperature	q4	L1	°C	R2			Real	Temperature (HVAC)	Number	R4	LoR C
	H			S5_3.4	Solar Irradiation	q4	L1	W/mq	R2			Real	Number	Number	R4	LoR C
	H			S5_3.6	Pollutant concentration	Q2		AQI	R2			Real	Number	Number	R4	LoR C
	H	S5_4	Multi-hazard potential	S5_4.2	Pollution sources presence Boolean	q2	L2		R2			Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C
H		S5_5	Ground type	S5_5.1	classes of types	Q2	L1		R2		TR	String	Text	String/Option set	R4	LoR C
	V			S5_5.2	Ground roughness	q4	L2	-	R2		TR	String	Text	String/Option set	R4	LoR C

Table 33 Matrix of couple data for Representation Rule for Element for the Comb(P-H-TRMred); Representation criteria of Descriptor (E_{Tool};R_{code}) in BIM, GIS and VT digital environments; H, V, E identify the relevance of each descriptor in the reduced combination of Risk Models

Risk model			Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
TRM	**HRM**	**PRM**		Section 1: MAIN TYPE													
V			S1_0	Morpho-typology	P1	main class (compact/elongated/very elongated)	Q1	L2		R3	OS	PolOS	Enum	Text	String/Option set	R1	LoR B + LoR C
	V	**V**			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
	V	**V**			S1_0.3	Proximity of sidewalk to traffic	q1	L4	m	R1	SW+ST	PolSW + PolST	Real	Length	Length	R4	LoR C
H	E	E	S1_1	Dimension of OS	S1_1.1	area	q1	L2	mq	R2	OS	PolOS	Real	Area	Area	R4	LoR C
	V				S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
	V	V	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
	V	**V**			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
				SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE Frontier													
			S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C

					S2_F_1.2	length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
					S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
					S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
					S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
					S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
V			S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
V	**V**	**V**			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
	V	**V**			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
H					S2_F_2.4	presence of mitigation/control systems	q2	L3		R2	MC/AC	LinAC/LinMC	String	Text/Multi-line text	String/Option set/Tags List	R1	LoR A + LoR B
H			S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
H					S2_F_3.3	number	q3	L2		R3	BF	PolBF	Integer	Number	Number	R1	LoR A + LoR B
H			S2_F_4a	Town walls	S2_F_4a.1	presence	q2	L2		R2	TW	PolTW	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H					S2_F_4a.5	area	q1	L3	m^2	R2	TW	PolTW	Real	Area	Area	R4	LoR C
H	**V**	**V**	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
	V	**V**			S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
	V	**V**			S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
H					S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
H/E	V	V	S2_F_5a	green area	P9f	presence of green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
E	E	E			S2_F_5.a2	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
	V	**V**			S2_F_5.a.5	Green Area Position (related to LS or AS)	q1	L3		R1	GR	PolGR	Real/Real	Length/Length	Length/Length	R4	LoR C
V	**V**	**V**			S2_F_5.a6	green area density	q1	L4	mq(veg)/mq(green area)	R3	GR	PolGR	Real	Number	Number	R4	LoR C
H	**V**	**V**	S2_F_5b	Water	S2_F_5.b.1	Presence of Water	q2	L2		R2	WT	PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
E	E				S2_F_5.b.2	crowding potential	Q2	L4		R2	WT	PolWT	String	Text	String	R4	LoR C
H					S2_F_5.b.3	extension of water content	q1	L4	m	R2	WT	PolWT	Real	Length	Length	R4	LoR C
E	**V**				S2_F_5.b.5	Water body area	q1	L4	mq	R2	WT	PolWT	Real	Length/Area	Length/Area	R4	LoR C
	V				S2_F_5.b.6	Water body volume	q1	L4	mc	R2	WT	PolWT	Real	Volume	Volume	R4	LoR C
E	V	V	S2_F_6	Quote differences / slope	P8f	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR A + LoR B + LoR C
				Content													
H			S2_C_1	Special buildings	S2_C_1.2	number	q3	L4		R3	BF	PolBF	Integer	Number	Number	R1	LoR A + LoR B
H	E	E			S2_C_1.4	area	q1	L3	m^2	R2	BF	PolBF	Real	Area	Area	R4	LoRC
V			S2_C_2	Quote difference/slope	P8c	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C
H			S2_C_4	Monuments (i.e. obelisk, statues, fontaine, archeol. site)	S2_C_4.1	presence fontaine	q2	L4		R2	MN	PolMN	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H					S2_C_4.2	presence of monuments	q2	L4		R2	MN	PolMN	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H					S2_C_4.4	number of monuments	q3	L4		R3	MN	PolMN	Integer	Number	Number	R1	LoR A + LoR B
H	V				S2_C_4.6	area	q1	L3	m^2	R2	MN	PolMN	Real	Area	Area	R4	LoR C
H	V	V	S2_C_5a	Green area	P9c	Presence of Green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B
E	E	E			S2_C_5a.1	crowding potential	Q2	L4		R2	GR	PolGR	String	Text	String	R4	LoR C
H	**V**	**V**			S2_C_5a.4	extension (area)	q1	L4	mq	R2	GR	PolGR	Real	Length	Length	R4	LoR C
	V	**V**			S2_C_5a.6	Greenery adsoprtion capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/mq)	R2	GR	PolGR	String	Text/Multi-line text	String	R4	LoR C
	V	**V**			S2_C_5a.10	Tree crown diameter	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C

			SECTION 3: CONSTRUCTIVE CHARACTERISTICS														
			Frontier														
		S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
	V			S3_F_2.16	Facade finishing albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
	V	V		S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
	V			S3_F_2.21	Facade heat capacity	q4	L4	J/ kg K	R2	BF	PolBF	Real	Heat capacity (Energy)	Heat capacity	R2	LoR C
		V		S3_F_2.22	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m²)	R2	BF	PolBF	Real	Number	Number	R2	LoR C
H			S3_F_3	Fixed obstacles	S3_F_3.5	n. of mitigation system	q3	L4		R3	FO	PolFO	Integer	Number	Number	R3	LoR A + LoR B
H					S3_F_3.6	Mitigation systems	Q2	L4		R2	FO	PolFO	String	Text/Multi-line text	String/Option set	R2	LoR A + LoR B
H			S3_F_4	Temporary obstacles	S3_F_4.3	n. of mitigation system	q3	L4		R3	TO	PolTO	Integer	Number	Number	R3	LoR A + LoR B
H					S3_F_4.4	Mitigation systems	Q2	L4		R2	TO	PolTO	String	Text/Multi-line text	String/Option set	R2	LoR A + LoR B
			Content														
	V		S3_C_1	Pavement type	S3_C_1.4	Pavement finishing albedo	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
			S3_C_2	Pavement condition	S3_C_2.1	Classes of conditions	Q2	L3		R2	OS+SW+ST	PolOS + PolSW + PolST	String	Text	String/Option set	R1/R4	LoR A + LoR B + LoR C
	V	V			S3_C_2.3	Pavement finishing current roughness	q4	L3	-	R2	OS+SW+ST	PolOS + PolSW + PolST	Real	Number	Number	R4	LoR C
			SECTION 4: CHARACTERISTICS OF USE														
	E	E	S4_1	Crowding	S4_1.1	people presents	q4	L2	person (pp)	R2			Integer	Number	Number	R1	LoR A + LoR B
H/E	E	E			S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
H					S4_1.3	tourism attraction	q4	L2	arrivals/inhabitants [pp/pp]	R2			String	Text/Multi-line text	String	R4	LoR C
	E	E			S4_1.4	Exposure duration	q4	L2	sec/min/hrs	R2			Real	Number	Number	R4	LoR C
H			S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
E	E	E			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
H					S4_3.3	Symbolism level	Q2	L4		R2	BF	PolBF	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
H	V & E	V & E			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
V			S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	q1	L2	m/m *100	R2	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
	V	V			S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
V					S4_4.4	level of accessibility	Q2	L2		R2	ST	PolST	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
V			S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	q1	L2	m/m *100	R3	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
			S4_6	Vehicles (parking)	S4_6.1	incidence (area for AS)	q1	L3	mq/mq *100	R3	PK	PolPK	Real	Number	Number	R4	LoR C
E	V & E	V & E			S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
H			S4_7	Sights	S4_7.1	presence of sight	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H					S4_7.4	Symbolism level	Q2	L4		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text	String	R4	LoRC

H/E			S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)	q2	L2		R2	OS+MN+BF+GR +WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
	E	E			S4_8.2	presence of Sensitive target (elders/frail/gender/youngsters)	q2	L2		R2	OS+MN+BF+GR +WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
	V	V			S4_8.3	% presence of Sensitive target (elders/frail/gender/youngsters)	q1	L2	%	R3	OS+MN+BF+GR +WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
H					S4_8.4	Symbolism level	Q2	L2		R2	OS+MN+BF+GR +WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
				SECTION 5: ENVIRONMENTAL CHARACTERISTICS													
	H		S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
	H	H	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2			Real	Speed (Structural)	Number	R4	LoR C
	H	H			S5_3.3	Air temperature	q4	L1	°C	R2			Real	Temperature (HVAC)	Number	R4	LoR C
	H	H			S5_3.4	Solar Irradiation	q4	L1	W/mq	R2			Real	Number	Number	R4	LoR C
		H			S5_3.6	Pollutant concentration	Q2		AQI	R2			Real	Number	Number	R4	LoR C
	H	H	S5_4	Multi-hazard potential	S5_4.2	Pollution sources presence Boolean	q2	L2		R2			Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C
	V	V	S5_5	Ground type	S5_5.2	Ground roughness	q4	L2	-	R2	TR		String	Text	String/Option set	R4	LoR C
	V				S5_5.3	Ground albedo	q4	L2	-	R2	TR		Real	Number	Number	R4	LoR C
	V				S5_5.4	Ground heat capacity	q4	L2	J/ kg K	R2	TR		Real	Heat capacity (Energy)	Heat capacity	R4	LoR C

9. Identification of reduced matrixes to BETs

According to the main aim of the BE S2ECURe project, the use of BETs allows the identification and the analysis of reduced and representative BE prone to SR, TR, PR and HR, referring to the Main type, characteristic of geometry and space and Constructive characters (Section 1 to 3). The assessment for the identification of representative BETs is the result of parallel D3.2.1, where 9 recurrent types are identified as combination of 6 main parameters involved in the statistical analysis. Specifically, parameters involved are:

- P1 - Morphology: Prevalent shape of the OS, catalogued by typology, in terms of compactness and regularity of the shape.
- P2 - Dimensions: Comparison between maximum height (Hmax) and median height (Hmed) of the frontiers and OS minimum width (Wmin).
- P4 - Accesses: In terms of numbers, position and width (permeability of BET, see Table 19, §5).
- P5 - Special building: Related to the presence of building with a special function (Y/N).
- P8 – Slope: Presence of slope ground (ranges: <5%; >5%).
- P9 - Green - Presence of green in terms of % of green area on the overall OS area (Y/N).

On the other hand, P3 (structural types), P6 (homogeneity in construction) and P7 (porticoes) are not included in the statistical analysis. Due to that, the identification of reduced matrixes of BET is the result of the system made of the reduced matrixes for each Combination (H-SRMred, P-SRMred, P-H-TRMred) and parameters involved in BETs. Specifically, all the parameters involved in section 1 to 3 for the BE representation are considered while, all the parameters not directly involved in BET, such as those referred to Characteristic of use and environmental characteristics are not excluded for the identification of the reduced matrixes of BETs, according to the main aim of such tool: the whole representation. However, as main differences in BETs identified in D3.2.1 and this deliverable, matrixes do not include specific value, but re-comprehend the parameters involved in representing BETs. In detail, for each BET (1a to 5) is analysed the concordance with the necessity to represent 9 parameters involved in the starting BETs. As it is clear, some repetitions exist in determining recurrences: for each combination of risks, three reduced matrixes of descriptors are identified as matrix types (see Table 34).

Table 34. Recurrency in representing BETs and relative parameters (represented (Y), not represented (N), noy available (-).

	1a	1b	2a	2b	3	4a	4b	4c	5
P1	Y	Y	Y	Y	Y	Y	Y	Y	Y
P2	Y	Y	Y	Y	Y	Y	Y	Y	Y
P3	-	-	-	-	-	-	-	-	-
P4	Y	Y	Y	Y	Y	Y	Y	Y	Y
P5	Y	N	Y	N	N	Y	Y	N	N
P6	-	-	-	-	-	-	-	-	-
P7	-	-	-	-	-	-	-	-	-
P8	Y	Y	Y	Y	Y	Y	Y	Y	Y
P9	N	N	N	N	N	N	N	N	Y

Matrix type 1 | Matrix type 2 | Matrix Type 3

Moreover, aiming at a homogeneous system of information between morphological data used for the identification of BET in D3.2.1 and matrixes for BETs representation, few parameters have been modified or simplified. In detail:

- parameter P1 “main class (compact/elongated/very elongated)” is substituted with two descriptors in order to describe:
  - P1a “area regularity”
  - P1b “Radius ratio”
- Green area is always associated to the content. Here, the parameters involved are referred to:
  - The percentage of green area to the total BET area,
  - position in the content. In this case, two descriptors are included to describe (see Figure 10)
    - The central angle (α) measured for the smaller side of green area and refers to the geometric barycentre (G) of the OS;
    - The smaller measure of green area (w_g)
- The parameter “slope” (P8c and P8f) is unified and referred both to content and frontier (P8).
- Considering the presence of Special buildings in the contents, this case is always denied according to the method of assessment of BETs (D3.2.1)
- Other reductions are referred to the people “elements”. In detail:
  - the Crowding descriptor “people present” (S4_1.1) is eliminated due to its redundancy with the potential crowding where BET area is identified;
  - S4_8.3 “presence of Sensitive target (elders/frail/gender/youngsters)” as Boolean data appears to be redundant with “% presence of Sensitive target (elders/frail/gender/youngsters)”.
- Some considerations are referred to the qualification of constructive characteristics of buildings of BETs derived for local or temporal features, as well as the presence of very detailed data or information related to suffered transformations. It’s the case of S3_F_1.2 “last intervention period”, S3_F_1.3 “state of conservation”, S3_F_2.13 “no-structural protruding and decorative elements” and S3_F_2.14 “anti-seismic devices”.
- Finally, the S5_1.2 “Seismic microzonation” as well as S5_5.1 “classes of types” (for ground type) is reduced for the analysis due to the idealization of BETs which are independent from any location.

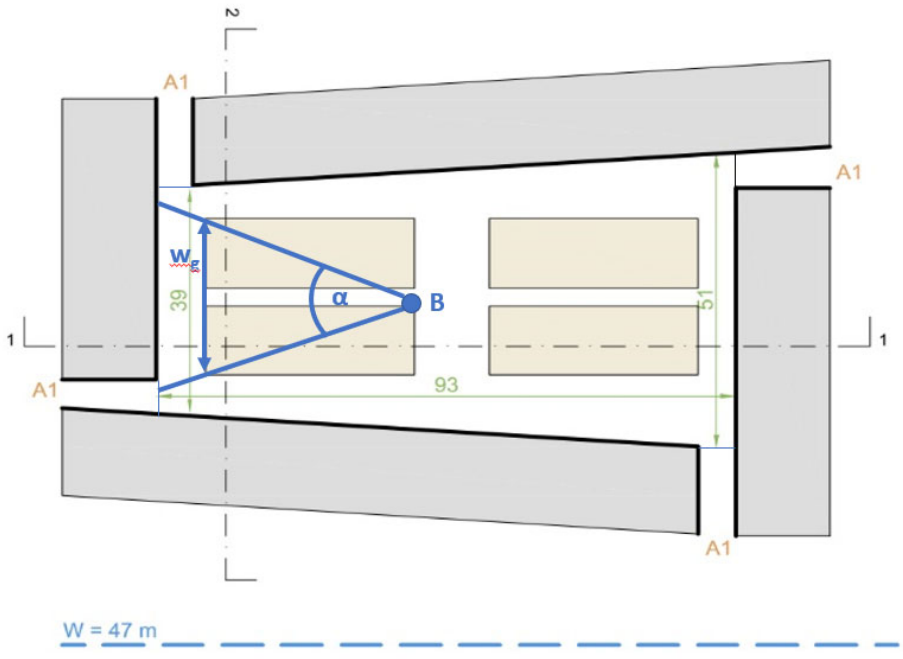

Figure 10. Parameters for the identification of green area location

Thus, for each BET type and combination of risk identified in §8 a reduced matrix is created according to the flow in Figure 11.

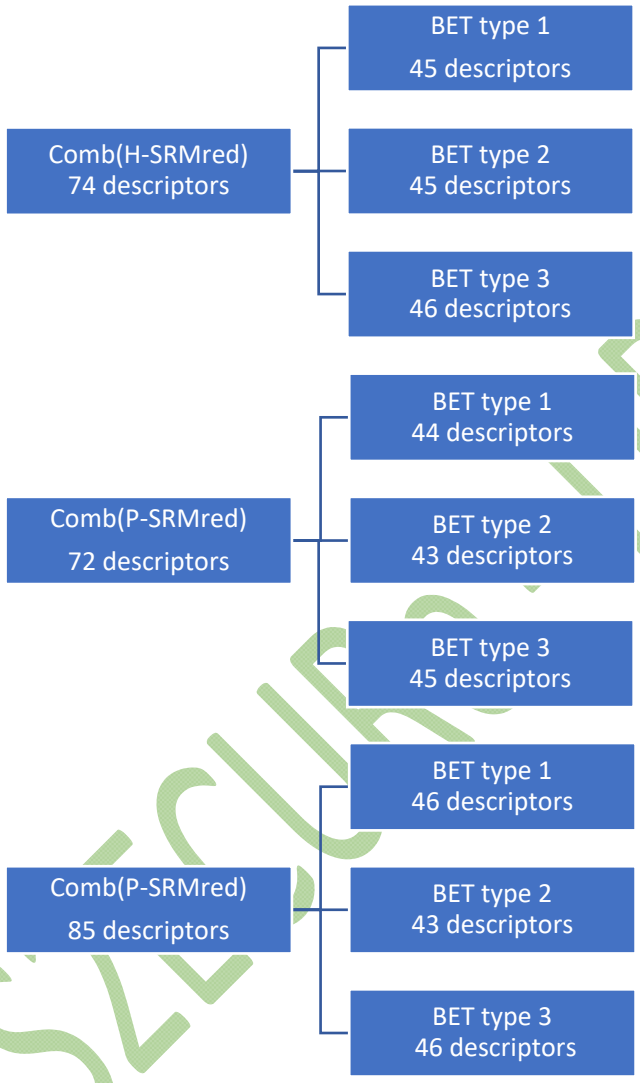

Figure 11. Systems of reduced matrixes and n. of descriptors involved, identified for BET types 1, 2 and 3 for each combination of risks

Following Tables Table 35Table 36 and

Table 37 report the reduced matrixes for the combination H-S, P-S and P-H-T for the BET types 1, 2 and 3, respectively.

*Table 35. Reduced Matrix type 1 (BETs 1b, 2b, 3, 4c). Couple data for Representation Rule for Element for the Comb(**H-SRMred**), Comb(**P-SRMed**) and (**P-H-TRMed**); Representation criteria of Descriptor (ETool;Rcode) in BIM, GIS and VT digital environments*

Comb. Involved			Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
				Section 1: MAIN TYPE													
H-S	P-S	P-H-T	S1_0	Morpho-typology	P1a	area regularity	q1	L2		R3	OS	PolOS	String	Text	String	R4	LoR C
H-S	P-S	P-H-T			P1b	Radius ratio	q1	L2	%	R3	OS	PolOS	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
	P-S	P-H-T			S1_0.3	Proximity of sidewalk to traffic	q1	L4	m	R1	SW+ST	PolSW + PolST	Real	Length	Length	R4	LoR C
		P-H-T	S1_1	Dimension of OS	S1_1.1	area	q1	L2	mq	R2	OS	PolOS	Real	Area	Area	R4	LoR C
H-S	P-S	P-H-T			S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
				SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE													
				Frontier													
H-S	P-S	P-H-T	S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.2	Length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
H-S	P-S	P-H-T			S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
H-S	P-S	P-H-T	S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
H-S	P-S	P-H-T			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
		P-H-T			S2_F_2.4	presence of mitigation/control systems	q2	L3		R2	MC/AC	LinAC/LinMC	String	Text/Multi-line text	String/Option set/Tags List	R1	LoR A + LoR B
H-S	P-S	P-H-T	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
H-S	P-S				S2_F_4b.2	linear extension	q1	L3	m	R1	PR	PolPR	Real	Length	Length	R4	LoR C
H-S	P-S				S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
H-S	P-S				S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
				Content / Frontier													
H-S	P-S	P-H-T	S2_C_2	Quote difference/slope	P8	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C
				SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
				Frontier													
H-S	P-S	P-H-T	S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
H-S	P-S				S3_F_2.2	masonry quality	Q1	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
H-S	P-S				S3_F_2.3	wall thickness	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C

H-S	P-S				S3_F_2.5	roof types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
H-S	P-S				S3_F_2.8	% openings	q1	L3	mq/mq*100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
~~H-S~~	~~P-S~~				~~S3_F_2.13~~	~~no-structural protruding and decorative elements~~	~~q2~~	~~L3~~		~~R2~~	~~BF~~	~~PolBF~~	~~Boolean~~	~~Yes/No~~	~~True/False~~	~~R1/R4~~	~~LoR A + LoR C~~
~~H-S~~	~~P-S~~				~~S3_F_2.14~~	~~anti-seismic devices~~	~~q2~~	~~L3~~		~~R2~~	~~BF~~	~~PolBF~~	~~Boolean~~	~~Yes/No~~	~~True/False~~	~~R1/R4~~	~~LoR A + LoR C~~
H-S		P-H-T			S3_F_2.16	Facade finishing albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
H-S	P-S	P-H-T			S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
H-S		P-H-T			S3_F_2.21	Facade heat capacity	q4	L4	J/ kg K	R2	BF	PolBF	Real	Heat capacity (Energy)	Heat capacity	R2	LoR C
	P-S	P-H-T			S3_F_2.22	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m²)	R2	BF	PolBF	Real	Number	Number	R2	LoR C
			SECTION 4: CHARACTERISTICS OF USE														
H-S	P-S	P-H-T	S4_1	Crowding	S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T			S4_1.3	tourism attraction	q4	L2	arrivals/inhabitants [pp/pp]	R2			String	Text/Multi-line text	String	R4	LoR C
		P-H-T	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
H-S	P-S	P-H-T			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T			S4_3.3	Symbolism level	Q2	L4		R2	BF	PolBF	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
H-S	P-S	P-H-T			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		P-H-T	S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	q1	L2	m/m *100	R2	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
		P-H-T			S4_4.4	level of accessibility	Q2	L2		R2	ST	PolST	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T	S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	q1	L2	m/m *100	R3	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T	S4_6	Vehicles (parking)	S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
		P-H-T	S4_7	Sights	S4_7.1	presence of sight	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		P-H-T			S4_7.4	Symbolism level	Q2	L4		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text	String	R4	LoRC
		P-H-T	S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H-S	P-S	P-H-T			S4_8.3	% per user profile depending on age, gender, prevalent presence space (i.e. indoor, outdoor	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
			SECTION 5: ENVIRONMENTAL CHARACTERISTICS														
H-S	P-S		S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
~~H-S~~	~~P-S~~				~~S5_1.3~~	~~Max magnitude of historical earthquakes~~	~~Q2~~	~~L1~~		~~R2~~			~~String~~	~~Text~~	~~String~~	~~R4~~	~~LoR C~~
H-S		P-H-T	S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1		R2			String	Text	String/Option set	R4	LoR C

H-S	P-S	P-H-T	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2			Real	Speed (Structural)	Number	R4	LoR C
H-S	P-S	P-H-T			S5_3.3	Air temperature	q4	L1	°C	R2			Real	Temperature (HVAC)	Number	R4	LoR C
H-S	P-S	P-H-T			S5_3.4	Solar Irradiation	q4	L1	W/mq	R2			Real	Number	Number	R4	LoR C
	P-S	P-H-T			S5_3.6	Pollutant concentration	Q2		AQI	R2			Real	Number	Number	R4	LoR C
	P-S	P-H-T	S5_4	Multi-hazard potential	S5_4.2	Pollution sources presence Boolean	q2	L2		R2			Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C
~~H-S~~	~~P-S~~		~~S5_5~~	~~Ground type~~	~~S5_5.1~~	~~classes of types~~	~~Q2~~	~~L1~~		~~R2~~	~~TR~~		~~String~~	~~Text~~	~~String/Option set~~	~~R4~~	~~LoR C~~
H-S	P-S	P-H-T	S5_5	Ground type	S5_5.2	Ground roughness	q4	L2	-	R2	TR		String	Text	String/Option set	R4	LoR C
H-S		P-H-T			S5_5.3	Ground albedo	q4	L2	-	R2	TR		Real	Number	Number	R4	LoR C
H-S		P-H-T			S5_5.4	Ground heat capacity	q4	L2	J/ kg K	R2	TR		Real	Heat capacity (Energy)	Heat capacity	R4	LoR C

*Table 36. Reduced Matrix type 2 (BETs 1a, 2a, 4a, 4b). Couple data for Representation Rule for Element for the Comb(**H-SRMred**), Comb(**P-SRMed**) and (**P-H-TRMed**); Representation criteria of Descriptor (ETool;Rcode) in BIM, GIS and VT digital environments*

Comb. Involved			Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
				Section 1: MAIN TYPE													
H-S	P-S	P-H-T	S1_0	Morpho-typology	P1a	area regularity	q1	L2		R3	OS	PolOS	String	Text	String	R4	LoR C
H-S	P-S	P-H-T			P1b	Radius ratio	q1	L2	%	R3	OS	PolOS	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
	P-S	P-H-T			S1_0.3	Proximity of sidewalk to traffic	q1	L4	m	R1	SW+ST	PolSW + PolST	Real	Length	Length	R4	LoR C
		P-H-T	S1_1	Dimension of OS	S1_1.1	area	q1	L2	mq	R2	OS	PolOS	Real	Area	Area	R4	LoR C
H-S	P-S	P-H-T			S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
				SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE													
				Frontier													
H-S	P-S	P-H-T	S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.2	Length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
H-S	P-S	P-H-T			S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
H-S	P-S	P-H-T	S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
H-S	P-S	P-H-T			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
		P-H-T			S2_F_2.4	presence of mitigation/control systems	q2	L3		R2	MC/AC	LinAC/LinMC	String	Text/Multi-line text	String/Option set/Tags List	R1	LoR A + LoR B
H-S	P-S	P-H-T	S2_F_3	Special buildings	P5	presence	q2	L2		R2	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
		P-H-T			S2_F_3.3	number	q3	L2		R3	BF	PolBF	Integer	Number	Number	R1	LoR A + LoR B
H-S	P-S				S2_F_3.4	length of special buildings front	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
H-S	P-S				S2_F_3.5	height	q1	L4	m	R1	BF	PolBF	Real	Length	Length	R4	LoR C
		P-H-T			S2_F_3.6	area	q1	L3	m^2	R2	BF	PolBF	Real	Area	Area	R4	LoR C
H-S	P-S				S2_F_3.7	height of gable	q1	L3	m								
H-S	P-S	P-H-T	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
H-S	P-S				S2_F_4b.2	linear extension	q1	L3	m	R1	PR	PolPR	Real	Length	Length	R4	LoR C
H-S	P-S				S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
H-S	P-S				S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
				Content / Frontier													
H-S	P-S	P-H-T	S2_C_2	Quote difference/slope	P8	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C
				SECTION 3: CONSTRUCTIVE CHARACTERISTICS													
				Frontier													
H-S	P-S	P-H-T	S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
H-S	P-S				S3_F_2.2	masonry quality	Q1	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C

H-S	P-S				S3_F_2.3	wall thickness	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
H-S	P-S				S3_F_2.5	roof types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
H-S	P-S				S3_F_2.8	% openings	q1	L3	mq/mq*100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
~~H-S~~	~~P-S~~				~~S3_F_2.13~~	~~no-structural protruding and decorative elements~~	~~q2~~	~~L3~~		~~R2~~	~~BF~~	~~PolBF~~	~~Boolean~~	~~Yes/No~~	~~True/False~~	~~R1/R4~~	~~LoR A + LoR C~~
~~H-S~~	~~P-S~~				~~S3_F_2.14~~	~~anti-seismic devices~~	~~q2~~	~~L3~~		~~R2~~	~~BF~~	~~PolBF~~	~~Boolean~~	~~Yes/No~~	~~True/False~~	~~R1/R4~~	~~LoR A + LoR C~~
H-S		P-H-T			S3_F_2.16	Facade finishing albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
H-S	P-S	P-H-T			S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
H-S		P-H-T			S3_F_2.21	Facade heat capacity	q4	L4	J/ kg K	R2	BF	PolBF	Real	Heat capacity (Energy)	Heat capacity	R2	LoR C
	P-S	P-H-T			S3_F_2.22	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m^2)	R2	BF	PolBF	Real	Number	Number	R2	LoR C
			SECTION 4: CHARACTERISTICS OF USE														
H-S	P-S	P-H-T	S4_1	Crowding	S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T			S4_1.3	tourism attraction	q4	L2	arrivals/inhabitants [pp/pp]	R2			String	Text/Multi-line text	String	R4	LoR C
		P-H-T	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
H-S	P-S	P-H-T			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T			S4_3.3	Symbolism level	Q2	L4		R2	BF	PolBF	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
H-S	P-S	P-H-T			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		P-H-T	S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	q1	L2	m/m *100	R2	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
		P-H-T			S4_4.4	level of accessibility	Q2	L2		R2	ST	PolST	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T	S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	q1	L2	m/m *100	R3	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T	S4_6	Vehicles (parking)	S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
		P-H-T	S4_7	Sights	S4_7.1	presence of sight	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		P-H-T			S4_7.4	Symbolism level	Q2	L4		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text	String	R4	LoRC
		P-H-T	S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H-S	P-S	P-H-T			S4_8.3	% per user profile depending on age, gender, prevalent presence space (i.e. indoor, outdoor	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
			SECTION 5: ENVIRONMENTAL CHARACTERISTICS														
H-S	P-S		S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
~~H-S~~	~~P-S~~				~~S5_1.3~~	~~Max magnitude of historical earthquakes~~	~~Q2~~	~~L1~~		~~R2~~			~~String~~	~~Text~~	~~String~~	~~R4~~	~~LoR C~~

H-S		P-H-T	S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1		R2		String	Text	String/Option set	R4	LoR C
H-S	P-S	P-H-T	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2		Real	Speed (Structural)	Number	R4	LoR C
H-S	P-S	P-H-T			S5_3.3	Air temperature	q4	L1	°C	R2		Real	Temperature (HVAC)	Number	R4	LoR C
H-S	P-S	P-H-T			S5_3.4	Solar Irradiation	q4	L1	W/mq	R2		Real	Number	Number	R4	LoR C
	P-S	P-H-T			S5_3.6	Pollutant concentration	Q2		AQI	R2		Real	Number	Number	R4	LoR C
	P-S	P-H-T	S5_4	Multi-hazard potential	S5_4.2	Pollution sources presence Boolean	q2	L2		R2		Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C
~~H-S~~	~~P-S~~		~~S5_5~~	~~Ground type~~	~~S5_5.1~~	~~classes of types~~	~~Q2~~	~~L1~~		~~R2~~	~~TR~~	~~String~~	~~Text~~	~~String/Option set~~	~~R4~~	~~LoR C~~
H-S	P-S	P-H-T	S5_5	Ground type	S5_5.2	Ground roughness	q4	L2	-	R2	TR	String	Text	String/Option set	R4	LoR C
H-S		P-H-T			S5_5.3	Ground albedo	q4	L2	-	R2	TR	Real	Number	Number	R4	LoR C
H-S		P-H-T			S5_5.4	Ground heat capacity	q4	L2	J/ kg K	R2	TR	Real	Heat capacity (Energy)	Heat capacity	R4	LoR C

*Table 37. Reduced Matrix type 3 (BET 5). Couple data for Representation Rule for Element for the Comb(**H-SRMred**), Comb(**P-SRMed**) and (**P-H-TRMed**); Representation criteria of Descriptor (ETool;Rcode) in BIM, GIS and VT digital environments*

Comb. Involved			Code	Description	descriptor code	descriptor	Q/q code	Scale code	[u.m.]	R code (GIS/BIM)	EBIM code	EGIS code	GIS Data Type	BIM (REVIT) Data Type	BIM (ARCHICAD) Data Type	R code (VT)	EVT code
			Section 1: MAIN TYPE														
H-S	P-S	P-H-T	S1_0	Morpho-typology	P1a	area regularity	q1	L2		R3	OS	PolOS	String	Text	String	R4	LoR C
H-S	P-S	P-H-T			P1b	Radius ratio	q1	L2	%	R3	OS	PolOS	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S1_0.2	Canyon aspect ratio	q1	L2	m/m	R3	OS+BF+ST	PolOS + PolBF + PolST	Real	Number	Number	R4	LoR C
	P-S	P-H-T			S1_0.3	Proximity of sidewalk to traffic	q1	L4	m	R1	SW+ST	PolSW + PolST	Real	Length	Length	R4	LoR C
		P-H-T	S1_1	Dimension of OS	S1_1.1	area	q1	L2	mq	R2	OS	PolOS	Real	Area	Area	R4	LoR C
H-S	P-S	P-H-T			S1_1.3	width	q1	L2	m	R2	OS	PolOS	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T	S1_2	Hmax built front	S1_2.1	H max	q1	L3	m	R2	BF	PolBF	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S1_2.2	Average building height	q1	L3	m	R3	BF	PolBF	Real	Length	Length	R4	LoR C
			SECTION 2: CHARACTERISTICS OF GEOMETRY AND SPACE														
			Frontier														
H-S	P-S	P-H-T	S2_F_1	Type of Aggregates	S2_F_1.1	% of SA	q1	L3	m/m*100	R3	BF	PolBf	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.2	Length of the built front	q1	L3	m	R1	BF	PolBf	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.3	number of SU	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
H-S	P-S	P-H-T			S2_F_1.4	length of SU	q1	L3	m	R1	BF	PolBf	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.5	height of SU front	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_F_1.9	number of storeys	q3	L3		R2	BF	PolBf	Real	Number	Number	R1	LoR A + LoR C
H-S	P-S	P-H-T	S2_F_2	Accesses	S2_F_2.1	number	q3	L4		R3	AC	LinAC	Integer	Number	Number	R1	LoR A + LoR B
H-S	P-S	P-H-T			S2_F_2.2	width	q1	L4	m	R2	AC	LinAC	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_2.3	position/orientation (azimuth)	q1	L3		R1	AC	LinAC	Real	Length/Length	Length/Length	R4	LoR C
		P-H-T			S2_F_2.4	presence of mitigation/control systems	q2	L3		R2	MC/AC	LinAC/LinMC	String	Text/Multi-line text	String/Option set/Tags List	R1	LoR A + LoR B
H-S	P-S	P-H-T	S2_F_4b	Porches	P7	presence	q2	L2		R2	PR	PolPR	Boolean	Yes/No	True/False	R1	LoR A + LoR B + LoR C
H-S	P-S				S2_F_4b.2	linear extension	q1	L3	m	R1	PR	PolPR	Real	Length	Length	R4	LoR C
H-S	P-S				S2_F_4b.3	position	q1	L3		R2	PR	PolPR	Real/Real	Length/Length	Length/Length	R4	LoR C
H-S	P-S				S2_F_4b.4	width or depth	q1	L4	m	R2	PR	PolPR	Real	Length	Length	R4	LoR C
H-S	P-S	P-H-T			S2_F_4b.5	area	q1	L3	m^2	R2	PR	PolPR	Real	Area	Area	R4	LoR C
			Content / Frontier														
H-S	P-S	P-H-T	S2_C_2	Quote difference/slope	P8	slope	q1	L3	m/m*100	R2	TR + SR	PolTR + PolSR	Real	Slope	Number	R4	LoR C
			Content														
H-S	P-S	P-H-T	S2_C_5a	Green area	P9a	Presence of Green area	q2	L2		R2	GR	PolGR	Boolean	Yes/No	True/False	R1	LoR A + LoR B
					P9b	central angle measured to the OS barycentre	q1	L2	°	R1	GR	PolGR	Real	Number	Number	R4	LoR C
					P9c	minimum width of green area	q1	L4	m	R3	GR	PolGR	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_C_5a.2	incidence for total area	q1	L2	mq/mq*100	R3	GR	PolGR	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S2_C_5a.4	extension (area)	q1	L4	mq	R2	GR	PolGR	Real	Length	Length	R4	LoR C
	P-S	P-H-T			S2_C_5a.6	Greenery adsoprtion capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/mq)	R2	GR	PolGR	String	Text/Multi-line text	String	R4	LoR C

H-S	P-S	P-H-T			S2_C_5a.10	Tree crown diameter	q1	L4	m	R1	GR	PolGR	Real	Length	Length	R4	LoR C
			SECTION 3: CONSTRUCTIVE CHARACTERISTICS														
				Frontier													
H-S	P-S	P-H-T	S3_F_2	Homogeneity of constructive techniques	P6	homogeneous/not homogeneous	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
H-S	P-S				S3_F_2.2	masonry quality	Q1	L3		R2	BF	PolBF	String	Text	String/Option set	R1/R4	LoR A + LoR C
H-S	P-S				S3_F_2.3	wall thickness	q1	L3	m	R2	BF	PolBF	Real	Number	Number	R4	LoR C
H-S	P-S				S3_F_2.5	roof types	Q2	L3		R2	BF	PolBF	String	Text	String/Option set	R4	LoR C
H-S	P-S				S3_F_2.8	% openings	q1	L3	mq/mq*100	R3	BF	PolBF	Real	Number	Number	R4	LoR C
~~H-S~~	~~P-S~~				~~S3_F_2.13~~	~~no structural protruding and decorative elements~~	~~q2~~	~~L3~~		~~R2~~	~~BF~~	~~PolBF~~	~~Boolean~~	~~Yes/No~~	~~True/False~~	~~R1/R4~~	~~LoR A + LoR C~~
~~H-S~~	~~P-S~~				~~S3_F_2.14~~	~~anti-seismic devices~~	~~q2~~	~~L3~~		~~R2~~	~~BF~~	~~PolBF~~	~~Boolean~~	~~Yes/No~~	~~True/False~~	~~R1/R4~~	~~LoR A + LoR C~~
H-S		P-H-T			S3_F_2.16	Facade finishing albedo	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
H-S	P-S	P-H-T			S3_F_2.18	Facade finishing current roughness	q4	L4	-	R2	BF	PolBF	Real	Number	Number	R2	LoR C
H-S		P-H-T			S3_F_2.21	Facade heat capacity	q4	L4	J/ kg K	R2	BF	PolBF	Real	Heat capacity (Energy)	Heat capacity	R2	LoR C
	P-S	P-H-T			S3_F_2.22	Facade pollutant deposition capacity	q4	L4	mass/time o mass/area (e.g. mg/s or g/m^2)	R2	BF	PolBF	Real	Number	Number	R2	LoR C
			SECTION 4: CHARACTERISTICS OF USE														
H-S	P-S	P-H-T	S4_1	Crowding	S4_1.2	crowding potential	Q2/q4	L2	pp/mq	R2			String	Text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T			S4_1.3	tourism attraction	q4	L2	arrivals/inhabitants [pp/pp]	R2			String	Text/Multi-line text	String	R4	LoR C
		P-H-T	S4_3	Strategic building / Special uses of building facing OS	S4_3.1	presence of special buildings or special uses	q2	L2		R2	BF	PolBF				R1	LoR A + LoR B
H-S	P-S	P-H-T			S4_3.2	crowding potential	Q2	L4		R2	BF	PolBF	String	Text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T			S4_3.3	Symbolism level	Q2	L4		R2	BF	PolBF	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
H-S	P-S	P-H-T			S4_3.7	Sensitive targets attraction to building use	Q1	L4		R3	BF	PolBF	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		P-H-T	S4_4	Accessibility for vehicle	S4_4.1	incidence of accessibility to vehicles to total accesses	q1	L2	m/m *100	R2	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T			S4_4.2	Traffic intensity	q4/Q1	L2	**Vehicle/km**	R2	ST	PolST	Real/Number/Enum	Number/Text	String	R4	LoR C
		P-H-T			S4_4.4	level of accessibility	Q2	L2		R2	ST	PolST	String	Text/Multi-line text	String	R1/R4	LoR A + LoR B + LoR C
		P-H-T	S4_5	Accessibility for pedestrian	S4_5.1	incidence of accessibility to pedestrian to total accesses	q1	L2	m/m *100	R3	ST+AC	PolST + PolAC	Real	Number	Number	R4	LoR C
H-S	P-S	P-H-T	S4_6	Vehicles (parking)	S4_6.5	Parking area location	q1	L2		R1	PK	PolPK	Real/Real	Length/Length	Length/Length	R1/R4	LoR A + LoR B + LoR C
		P-H-T	S4_7	Sights	S4_7.1	presence of sight	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
		P-H-T			S4_7.4	Symbolism level	Q2	L4		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	String	Text	String	R4	LoRC

		P-H-T	S4_8	Sensitive targets	S4_8.1	presence of Sensitive target (people as hard target)	q2	L2		R2	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Boolean	Yes/No	True/False	R1	LoR A + LoR B
H-S	P-S	P-H-T			S4_8.3	% per user profile depending on age, gender, prevalent presence space (i.e. indoor, outdoor	q1	L2	%	R3	OS+MN+BF+GR+WT	PolOs + PolMN + PolBF + PolGR + PolWT	Real	Number	Number	R1/R4	LoR A + LoR B + LoR C
			SECTION 5: ENVIRONMENTAL CHARACTERISTICS														
H-S	P-S		S5_1	Seismic intensity	S5_1.1	Ground motion severity	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
~~H-S~~	~~P-S~~				~~S5_1.3~~	~~Max magnitude of historical earthquakes~~	~~Q2~~	~~L1~~		~~R2~~			~~String~~	~~Text~~	~~String~~	~~R4~~	~~LoR C~~
H-S		P-H-T	S5_2	Climate classification [DPR 412/1993]	S5_2.1	Climate zone	Q2	L1		R2			String	Text	String/Option set	R4	LoR C
H-S	P-S	P-H-T	S5_3	Climate conditions	S5_3.1	Wind/breeze speed	q4	L1	m/s	R2			Real	Speed (Structural)	Number	R4	LoR C
H-S	P-S	P-H-T			S5_3.3	Air temperature	q4	L1	°C	R2			Real	Temperature (HVAC)	Number	R4	LoR C
H-S	P-S	P-H-T			S5_3.4	Solar Irradiation	q4	L1	W/mq	R2			Real	Number	Number	R4	LoR C
	P-S	P-H-T			S5_3.6	Pollutant concentration	Q2		AQI	R2			Real	Number	Number	R4	LoR C
	P-S	P-H-T	S5_4	Multi-hazard potential	S5_4.2	Pollution sources presence Boolean	q2	L2		R2			Boolean	Yes/No	True/False	R1/R4	LoR A + LoR B + LoR C
~~H-S~~	~~P-S~~		~~S5_5~~	~~Ground type~~	~~S5_5.1~~	~~classes of types~~	~~Q2~~	~~L1~~		~~R2~~	~~TR~~		~~String~~	~~Text~~	~~String/Option set~~	~~R4~~	~~LoR C~~
H-S	P-S	P-H-T	S5_5	Ground type	S5_5.2	Ground roughness	q4	L2	-	R2	TR		String	Text	String/Option set	R4	LoR C
H-S		P-H-T			S5_5.3	Ground albedo	q4	L2	-	R2	TR		Real	Number	Number	R4	LoR C
H-S		P-H-T			S5_5.4	Ground heat capacity	q4	L2	J/ kg K	R2	TR		Real	Heat capacity (Energy)	Heat capacity	R4	LoR C

Conclusions

The application of the method illustrated in Section 2 provides the retrieval of 212 descriptors involved in risk assessment of seismic, terroristic, heat wave and pollution hazards, classified for representation, their repetitions in each risk and influence in hazard, vulnerability and exposure measurement. These repetitions have been compared with the most relevant multi-hazard combinations, as result of the statistical analysis of seismic, terroristic, heat wave and pollution hazards for the selected sample of 133 case studies (from D3. 1.3), in order to define a specific set of descriptors that describe the BE components and elements involved in the combinations of risks. This set of descriptors will be deployed for risk simulations in the selected scenarios where more than single hazard can occur simultaneously (HS, HP and THP), to have a measure of their impact on the Built Environment (human behaviours and Open Spaces). In the specific, these extracted descriptors will be considered in GIS and BIM models of the BE, as just available or added parameters, for risk assessment, as calculation of Hazard, vulnerability and exposure and colour mapping of BE elements according to their index and relevance in the assessment and resolutions of risks scenarios.

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Annex I. Summary of results for the identification of multi-risk combinations tested on the sample (133 BEs)

Table 38. Qualification of hazard for S,T,H,PRMs, counting the events or qualifying each hazard for all the cases in the chosen sample

					SRM	TRM		HRM	PRM	
	Region	Province	Town	Square	Seismic zonation	n. of attack in the city	n. other attack in the province	n. heatwaves	mean urban value of PM10 (90.41 Percentile) (2010-2019)	Maximum mean value recorded in the urban station (for cities with mean values <40 µg/m³)
					INGV	GTD		EM-DAT	EEA (40 µg/m³)	
1	VALLE D'AOSTA	AO	Aosta	Piazza Emile Chanoux	3	0	0	0	40.86	
2	PIEMONTE	AL	Alessandria	Piazza Papa Giovanni XXIII	3	0	0	0	71.06	
3	PIEMONTE	AT	Asti	Piazza San Secondo	4	0	0	0	67.06	
4	PIEMONTE	BI	Biella	Piazza Duomo	3	0	0	0	45.31	
5	PIEMONTE	CN	Cuneo	Piazza Tancredi Galimberti	3S	0	0	0	44.50	
6	PIEMONTE	NO	Novara	Piazza della Repubblica	4	0	0	0	57.88	
7	PIEMONTE	TO	Torino	Piazza San Carlo	3	12	1	2	83.94	
8	PIEMONTE	TO-1	Moncalieri	Piazza Umberto I	3	0	0	2	n.a.	
9	PIEMONTE	VB	Verbania	Piazza Ranzoni	4	0	0	0	34.50	48
10	PIEMONTE	VC	Vercelli	Piazza Cavour	4	0	0	0	64.69	
11	LOMBARDIA	BG	Bergamo	Piazza Vecchia	3	0	0	0	66.31	
12	LOMBARDIA	BS	Brescia	Piazza della Loggia	2	4	0	0	71.40	
13	LOMBARDIA	CO	Como	Piazza del Duomo	4	0	0	0	62.25	
14	LOMBARDIA	CR	Cremona	Piazza del Comune	3	0	0	0	69.59	
15	LOMBARDIA	LC	Lecco	Piazza XX Settembre	3	0	0	0	53.86	
16	LOMBARDIA	LO	Lodi	Piazza della Vittoria	3	0	0	0	69.10	
17	LOMBARDIA	MI	Milano	Piazza del Duomo	3	21	1	3	78.02	
18	LOMBARDIA	MN	Mantova	Piazza Sordello	3	0	0	0	68.89	
19	LOMBARDIA	MB	Monza	Piazza Trento e Trieste	3	0	0	0	78.19	
20	LOMBARDIA	PV	Pavia	Piazza Duomo	3	0	0	0	64.00	
21	LOMBARDIA	PV-1	Vigevano	Piazza Ducale	3	0	0	0	65.86	
22	LOMBARDIA	SO	Sondrio	Piazza Garibaldi	3	0	0	0	49.66	
23	LOMBARDIA	VA	Varese	Piazza San Vittore	4	1	1	1	54.25	

24	TRENTINO ALTO ADIGE	BZ	Bolzano	Piazza del Grano	4	0	0	1	30.65	40
25	TRENTINO ALTO ADIGE	TN	Trento	Piazza Duomo	3	2	2	1	41.88	
26	VENETO	BL	Belluno	Piazza Duomo	2	0	0	1	35.86	43
27	VENETO	PD	Padova	Piazza delle Erbe	4	3	3	1	74.56	
28	VENETO	RO	Rovigo	Piazza Vittorio Emanuele	4	0	0	1	66.38	
29	VENETO	TV	Treviso	Piazza Duomo	3	0	3	1	76.06	
30	VENETO	VE	Venezia	Piazza San Marco	4	2	0	1	64.54	
31	VENETO	VR	Verona	Piazza dei Signori	3	2	0	2	66.75	
32	VENETO	VI-1	Bassano del Grappa	Piazza del Castello	3	0	0	1		
33	VENETO	VI	Vicenza	Piazza dei Signori	3	0	0	1	73.29	
34	FRIULI VENEZIA GIULIA	GO	Gorizia	Piazza della Vittoria	2	1	0	0	41.67	
35	FRIULI VENEZIA GIULIA	PN	Pordenone	Piazza San Marco	2	1	0	0	54.30	
36	FRIULI VENEZIA GIULIA	TS	Trieste	Piazza Unità d'Italia	3	0	0	1	41.37	
37	FRIULI VENEZIA GIULIA	UD	Udine	Piazza Matteotti	2	0	1	0	45.18	
38	LIGURIA	GE	Genova	Piazza delle Vigne	3	4	1	1	34.22	52.2
39	LIGURIA	SP	La Spezia	Piazza Cavour	3	0	0	0	33.55	38.4
40	LIGURIA	IM	Imperia	Piazza S.Giovanni	2	0	0	0	n.a.	
41	LIGURIA	IM-1	Sanremo	Piazza Santa Brigida	2	1	0	0	32.00	34
42	LIGURIA	SV	Savona	Piazza Sisto IV	3	0	0	0	32.08	45
43	TOSCANA	AR	Arezzo	Piazza Grande	2	0	0	0	45.25	
44	TOSCANA	FI	Firenze	Piazza del Duomo	3	8	1	1	44.34	
45	TOSCANA	FI-1	Empoli	Piazza Farinata degli Uberti	3	0	0	0	53.00	
46	TOSCANA	GR	Grosseto	Piazza Dante	4	0	0	0	29.44	41
47	TOSCANA	LI	Livorno	Piazza Grande	3	2	0	0	31.02	41
48	TOSCANA	LU	Lucca	Piazza dell'Anfiteatro	3	0	0	0	59.23	
49	TOSCANA	MS	Massa	Piazza Mercurio	3	0	0	0	36.00	39
50	TOSCANA	MS-1	Carrara	Piazza Alberica	3	0	0	0	42.50	
51	TOSCANA	PI	Pisa	Piazza dei Cavalieri	3	0	0	0	45.25	
52	TOSCANA	PT	Pistoia	Piazza del Duomo	2	1	0	0	40.71	
53	TOSCANA	PO	Prato	Piazza del Comune	3	0	0	0	53.29	

54	TOSCANA	SI	Siena	Piazza del Campo	3	0	0	0	42.00	
55	EMILA ROMAGNA	BO	Bologna	Piazza Maggiore	3	9	0	0	48.90	
56	EMILA ROMAGNA	FE	Ferrara	Piazza Trento e Trieste	3	0	0	0	57.00	
57	EMILA ROMAGNA	FC	Forli	Piazza Aurelio Saffi	2	0	0	0	48.44	
58	EMILA ROMAGNA	FC-1	Cesena	Piazza del Popolo	2	0	0	0	44.57	
59	EMILA ROMAGNA	MO	Modena	Piazza Grande	3	1	0	0	59.35	
60	EMILA ROMAGNA	MO-1	Carpi	Piazza Martiri	3	0	0	0	54.75	
61	EMILA ROMAGNA	PR	Parma	Piazza Duomo	3	1	0	0	60.38	
62	EMILA ROMAGNA	PC	Piacenza	Piazza dei Cavalli	3	0	0	0	57.51	
63	EMILA ROMAGNA	RA	Ravenna	Piazza del Popolo	3	0	0	0	53.46	
64	EMILA ROMAGNA	RN	Rimini	Piazza Cavour	2	0	0	0	58.40	
65	EMILA ROMAGNA	RA-1	Faenza	Piazza del Popolo	2	0	0	0	42.43	
66	EMILA ROMAGNA	RE	Reggio Emilia	Piazza Camillo Prampolini	3	0	0	0	56.31	
67	UMBRIA	PG	Perugia	Piazza IV Novembre	2	1	0	0	43.25	
68	UMBRIA	PG-1	Spoleto	Piazza del Mercato	1	0	0	0	32.13	38
69	UMBRIA	TR	Terni	Piazza della Repubblica	2	0	0	0	58.58	
70	MARCHE	AN	Ancona	Piazza del Plebiscito	2	0	1	1	52.89	
71	MARCHE	AP	Ascoli Piceno	Piazza del Popolo	2	0	1	1	37.50	47.1
72	MARCHE	FM	Fermo	Piazza del Popolo	2	5	0	1	n.a.	
73	MARCHE	MC	Macerata	Piazza della Libertà	2	1	0	1	29.23	37
74	MARCHE	PU	Pesaro	Piazza del Popolo	2	0	0	1	50.27	
75	MARCHE	PU-1	Urbino	Piazza Rinascimento	2	0	0	1	38.13	43
76	ABRUZZO	CH	Chieti	Piazza San Giustino	2	0	1	0	n.a.	
77	ABRUZZO	AQ	L'Aquila	Piazza del Duomo	2	0	0	0	35.33	38
78	ABRUZZO	AQ-1	Sulmona	Piazza XX Settembre	1	0	0	0	n.a.	
79	ABRUZZO	PE	Pescara	Piazza della Rinascita	3	0	0	0	54.57	
80	ABRUZZO	TE	Teramo	Piazza Sant'Anna	2	0	0	0	42.26	
81	LAZIO	FR	Frosinone	Piazza Cairoli	2B	0	0	0	95.13	
82	LAZIO	LT	Latina	Piazza del Popolo	3A	1	0	0	45.56	
83	LAZIO	RI	Rieti	Piazza Cesare Battisti	2A-2B	0	0	0	40.38	
84	LAZIO	RM	Roma	Piazza Navona	2A-3A-3B	31	2	1	49.80	
85	LAZIO	RM-1	Velletri	Piazza Giuseppe Mazzini	2B	0	0	1	n.a.	
86	LAZIO	RM-2	Tivoli	Piazza del Seminario	2B	0	0	0	n.a.	

87	LAZIO	VT	Viterbo	Piazza del Plebiscito	2B	1	0	0	30.86	36
88	MOLISE	CB	Campobasso	Largo San Leonardo	2	0	0	0	32.38	41
89	MOLISE	CB-1	Termoli	Piazza Duomo	3	0	0	0	34.36	52
90	MOLISE	IS	Isernia	Piazza Andrea d'Isernia	1	0	0	0	35.00	38
91	CAMPANIA	NA	Napoli	Piazza Plebiscito	2	3	0	1	55.87	
92	CAMPANIA	NA-1	Pompei	Piazza Bartolo Longo	2	0	0	1	n.a.	
93	CAMPANIA	SA	Salerno	Piazza Alfano	2	0	0	0	55.58	
94	CAMPANIA	AV	Avellino	Piazza Libertà	2	0	0	0	69.04	
95	CAMPANIA	BN	Benevento	Piazza Orsini	1	0	0	0	65.41	
96	CAMPANIA	CE	Caserta	Piazza Duomo	2	1	0	0	62.08	
97	PUGLIA	BA	Bari	Piazza dell'Odegitria	3	0	0	0	39.73	49
98	PUGLIA	BA-1	Altamura	Piazza del Duomo	3	0	0	0	30.00	33
99	PUGLIA	BA-2	Bitonto	Piazza Cavour	3	0	0	0	n.a.	
100	PUGLIA	BA-3	Gravina in Puglia	Piazza Benedetto XIII	3	0	0	0	n.a.	
101	PUGLIA	BAT	Andria	Piazza Duomo	3	0	0	0	40.33	
102	PUGLIA	BAT-1	Barletta	Piazzetta del Duomo	2	0	0	0	38.43	39.8
103	PUGLIA	BAT-2	Bisceglie	Piazza Duomo	3	0	0	0	n.a.	
104	PUGLIA	BAT-3	Trani	Piazza Duomo	3	0	0	0	n.a.	
105	PUGLIA	BR	Brindisi	Piazza Duomo	4	0	0	0	37.76	42
106	PUGLIA	FG	Foggia	Piazza Francesco De Santis	2	0	0	0	39.65	41.2
107	PUGLIA	FG-1	Manfredonia	Piazza del Popolo	2	0	0	0	36.82	42
108	PUGLIA	FG-5	San Severo	Piazza della Repubblica	2	0	0	0	n.a.	
109	PUGLIA	LE	Lecce	Piazza Duomo	4	0	0	1	36.86	44.6
110	PUGLIA	TA	Taranto	Piazza Duomo	3	0	0	0	33.71	39
111	BASILICATA	MT	Matera	Piazza Vittorio Emanuele	3	0	0	2	n.a.	
112	BASILICATA	PT	Potenza	Largo Duomo	1	0	0	0	32.41	37.3
113	CALABRIA	CT	Catanzaro	Piazza Duomo	2	0	1	0	29.77	35.4
114	CALABRIA	CS	Cosenza	Piazza Duomo	1	0	0	0	38.27	44.92
115	CALABRIA	KR	Crotone	Piazza Duomo	2	0	0	0	45.42	
116	CALABRIA	RC	Reggio Calabria	Piazza Duomo	1	2	0	0	30.69	32.5
117	CALABRIA	VV	Vibo Valentia	Piazza Armando Diaz	1	0	0	0	30.93	34.2
118	SICILIA	AG	Agrigento	Piazza Don Giovanni Minzoni	2	1	0	1	40.00	
119	SICILIA	CL	Caltanisetta	Piazza Garibaldi	4	0	0	1	n.a.	

120	SICILIA	CT	Catania	Piazza Università	2	0	0	1	35.28	41
121	SICILIA	EN	Enna	Piazza Duomo	2	0	0	1	26.33	30
122	SICILIA	EN-1	Piazza Armerina	Piazza Cattedrale	2	0	0	1	n.a.	
123	SICILIA	ME	Messina	Piazza Duomo	1	0	0	2	32.43	32.86
124	SICILIA	PA	Palermo	Piazza Pretoria	2	1	0	1	46.46	
125	SICILIA	RG	Ragusa	Piazza Duomo	2	0	1	1	35.75	39
126	SICILIA	SR	Siracusa	Piazza Minerva	2	0	0	1	50.82	
127	SICILIA	TR	Trapani	Piazza Lucatelli	2	0	0	1	26.40	26.4
128	SARDEGNA	CA	Cagliari	Piazza Palazzo	4	2	0	0	47.09	
129	SARDEGNA	NU	Nuoro	Piazza Sebastiano Satta	4	1	1	0	23.92	27
130	SARDEGNA	OR	Oristano	Piazza Eleonara d'Arboria	4	0	0	0	30.63	49
131	SARDEGNA	SS	Sassari	Piazza d'Italia	4	0	0	0	28.09	35.3
132	SARDEGNA	SS-1	Alghero	Piazza del Teatro	4	0	0	0	27.70	27.7
133	SARDEGNA	SU	Iglesias	Piazza Municipio	4	0	0	0	33.50	34

Annex II. Representation criteria for BE descriptors and characters in GIS

As it is well known, GIS is a Vector based tool mainly used for the representation of large-scale area thus, it is used to store spatial data. In detail, in GIS models the data can be represented as:

- Geospatial data in form of coordinates that generally represent locations on the earth's surface;
- Vector data by means of
    - Points to represent objects with the only locations. Here, the use of points for the representation of objects depends on the scale of representation and the real dimension of the object.
    - Line or arch, usually used for the shape of geographic features that cannot be represented in the general scale of the model;
    - Polygons used for the representation of areas.

The creation process of GIS models for cities or their parts is the results of urban details codification according to the "Allegato 1 - Catalogo dei dati territoriali – Specifiche di contenuto per i DataBase Geotopografici" in Decreto del Presidente dei Ministri 10 Novembre 2011. In a general point of view, Italian surface and uses are represented by the use of homogeneous Geo-topographic Databases (GeoT DBs). The "Allegato I" identifies the specific and minimum system of data, as properties, to associate and represent in each GeoT DBs identified as National Core (NC). Two type of NCs are currently used for the representation of Italian surface that mainly differ in term of scale of representation: NC1 – 1:1000/2000 - and NC5 - 1:5000/10000.

The implementation of databases according to each NC follows a specific system of categorization of data and properties by means of codes. In detail, to each represented element (point, line or polygon) is associated a system of codes (couple of numbers) related to the hierarchic sequence of:

- Layer
- Theme
- Class

Specifically, for each class, the database is implemented associating an attribute to the represented element - as a property – by the use of datatype information, as in Table 39.

Table 39. Datatype of attribute in Italian GeoT DB

CODE	NAME	DESCRIPTION
Boolean	Boolean data	True/False
Date	Date	dd/mm/yy
Enum	Enumerated	List of values
Integer	Integer numeric value	Integer number
Real	numeric value	Number with decimals
String	Alphanumeric data	Line with ASCII data
Numeric String	Numeric line	Line with only numbers

This classification allows to technicians and public administrations to have some preliminary information directly associated to the elementary vector data. Thus, discussing the representation criteria of BE in GIS, the summary of data, information and geometry already organized in Italian Territorial Information Systems allows to understand the basic level of information in a GIS model to be implemented. In detail, the Layer 2

- Buildings and anthropic and Layer 6 – Vegetation constructions constitute the main layers to discuss the first level of BE data in GIS.

In detail, some Elements of BE are summarized in Table 40 according to the GeoT DB, both in NC1 and NC5.

Table 40. Reference of BE elements in GeoT DB classification (NC1 and NC5) and their representation/qualification rules

BE ELEMENT	LAYER	THEME	CLASS	ATTRIBUTE	RAPPRESENTATION IN GIS	NC1	NC5
Building	2 – Buildings and anthropic constructions				Polygon	x	x
Special Building	2 – Buildings and anthropic constructions	Edificato	Tipologia Edilizia	Chiesa/Castello/ anfiteatroCampanile/ St-io/Cattedrale	Polygon	x	x
Sidewalk	2 – Buildings and anthropic constructions	Manufatti	Manufatto d'infrastruttura di trasporto	Marciapiede	Polygon	x	x
Fountain (water)	2 – Buildings and anthropic constructions	Manufatti	Manufatto monumentale e di arredo urbano	Fontana/monumento	Polygon	x	x
Green Area	6-Vegetazione	Verde urbano	Area verde	Giardino non qualif./prato/ alberi/	Polygon	x	x
Town walls	2 – Buildings and anthropic constructions	Manufatti	Muro o divisione in spessore	mura di cinta di città	Polygon	x	x
Porches	2 – Buildings and anthropic constructions	Edificato	Unita' volumetrica	soffitto di portico/soffitto di sottopassaggio/soffitto di loggia/ archivolto, corridoio coperto	Polygon	x	
Stairs	2 – Buildings and anthropic constructions	Edificato	Particolare architettonico	scalinata o scala esterna di edificio	Polygon	x	
Monuments and sights	2 – Buildings and anthropic constructions	Manufatti	Manufatto monumentale e di arredo urbano	Fontana/monumento	Polygon	x	x

As it is clear, the GIS models can be implemented according to the proper scale of detail required for BE or BET representation. This process is the results of the Addition of elements in basic GIS model (in NC1 or NC5). However, the implementation process requires to use the vector data (polygons, lines or points) that will

constitute the new elements to enrich with information (in database). Main rule in modelling new objects with vector data is the use of Polygons or lines as planar projection of real BE elements, featured by the same x-y dimension. Heights (z-dimension) should be always implemented as a detailed information.

The Addiction of 3D elements in GIS environments is possible but usually, the use of 3D models, as BIM ones, is preferred.