GED4ALL

Global Exposure Database for Multi-Hazard Risk Analysis

D2 - Multi-hazard Exposure Taxonomy

SUBMITTED BY:

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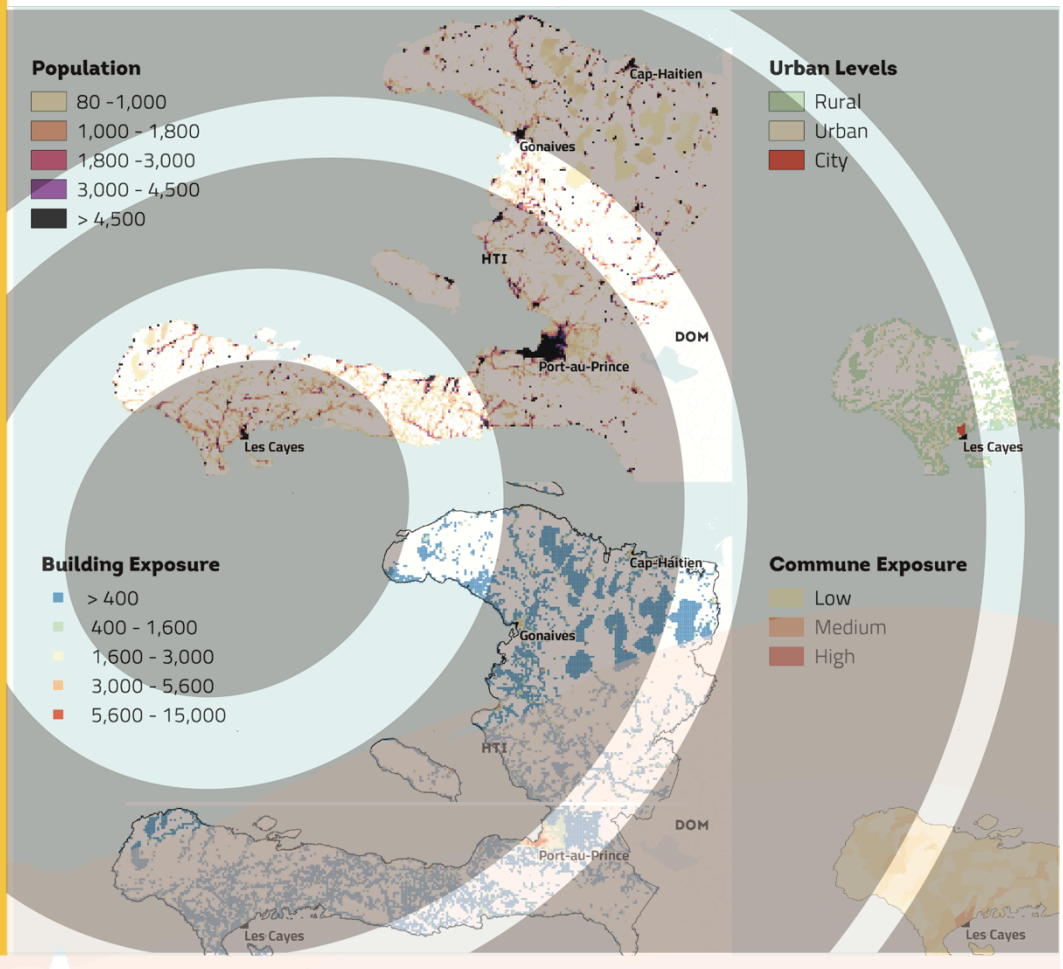

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D2 - Multi-hazard Exposure Taxonomy

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Abstract

A consortium comprised by the Global Earthquake Model Foundation, ImageCat Inc. and the Humanitarian OpenStreetMap Team has been chosen by the Global Facility for Disaster Risk Reduction and Recovery to develop an open exposure database for multi-hazard risk assessment, as part of the Challenge Funds supported by the Department for International Development of the United Kingdom. This database is capable of storing different assets, while considering relevant attributes for six natural hazards: earthquakes, floods, volcanoes, strong winds, tsunamis and drought. The development of an open database to characterize the built-up environment at a global scale requires a uniform methodology to classify the elements exposed to the natural hazards. This deliverable describes a comprehensive multi-hazard GED4ALL taxonomy capable of classifying the building stock, lifelines, crops, livestock, forestry and socio-economic data. This taxonomy will be applied to the country of Tanzania to develop an exposure model at the national scale, and to the city level of Dar Es Salaam to demonstrate how an exposure dataset at a building-by-building resolution can be created. Moreover, this process will be demonstrated for five countries around Tanzania (Ethiopia, Uganda, Kenya, Malawi and Mozambique).

Keywords

Taxonomy, classification system, multi-hazard, buildings, lifelines, crops, livestock, forestry, socio-economic indicators.

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Introduction

A uniform classification system (taxonomy) for categorizing the built environment exposed to the hazard is fundamental for the development of a global exposure database. Such taxonomy must be able to capture attributes relevant for various perils (e.g. the ones featured by the ThinkHazard![1] platform), cover a wide range of assets, and be sufficiently flexible and comprehensive to be applicable worldwide. The taxonomy also assumes special importance for the integration of the different products of the challenge fund, since it creates the link between the exposure datasets and the vulnerability functions, or to any existing damage or loss databases. Four main categories of assets were considered for the development of the multi-hazard taxonomy:

- Buildings
- Lifelines
- Crops, livestock and forestry
- Socio-economic data

For the development of the uniform taxonomy for buildings (i.e. residential, commercial, industrial, agricultural, educational and healthcare), the GEM Building Taxonomy v2.0 was considered as a starting point (Brzev *et al*.[2] 2013). This classification system was created considering a wide spectrum of existing taxonomies (e.g. PAGER-STR Jaiswal *et al*[3]. 2010, WHE[4]), and despite the fact that it was originally developed with a focus on earthquakes, it features several parameters relevant for other perils such as floods and hurricanes (e.g. existence of floors below ground, type of roof). Moreover, the taxonomy is flexible and can be modified and expanded to capture additional attributes for other hazards. Currently the GEM Building Taxonomy comprises 13 main attributes: azimuth of the building axis, material of the lateral load-resisting system, lateral load-resisting system, height, date of construction or retrofit, occupancy, building position within a block, shape of the building plan, structural irregularity, exterior walls, roof, floor and foundation system.

The European FP7 Syner-G project[5] and the HAZUS technical manual[6] were used as the basis for developing a taxonomy of lifelines/infrastructure (e.g. roads, railways, bridges, storage tanks, electric grid, water supply and gas networks). The taxonomy is defined though several attributes, similar to the building taxonomy. Each attribute has a number of levels that can be combined to generate a taxonomy string or category.

[1] ThinkHazard! - http://thinkhazard.org/

[2] GEM Building Taxonomy version 2.0: https://www.globalquakemodel.org/resources/publications/technical-reports/gem-building-taxonomy-report/

[3] https://earthquake.usgs.gov/static/lfs/data/pager/Jaiswal_Wald_Porter_(2010)_PAGER_Building_Inventory_Spectra.pdf

[4] World Housing Encyclopedia: http://www.world-housing.net/

[5] Syner-G project: http://www.vce.at/SYNER-G

[6] HAZUS technical manual: https://www.fema.gov/media-library-data/20130726-1820-25045-6286/hzmh2_1_eq_tm.pdf

The development of the taxonomy for crops, livestock and forestry was performed considering the classification system proposed by the Food and Agriculture Organization (FAO) for crops and livestock, and the UNESCO-defined categories of forestry. The classification of livestock and forestry was included in this project based on requests from stakeholders.

For what concerns the taxonomy for the socio-economic data, this consortium leveraged on the work performed by the Karlsruhe Institute of Technology and GEM, who have created sub-national databases of socio-economic data for South East Asia, East Sub-Saharan Africa and Central/South America for multi-hazard disaster risk assessment.

The proposed GED4ALL multi-hazard taxonomy will be used in the development of the exposure model for Tanzania at the national level, and for Dar Es Salaam at the city level. This taxonomy could be easily incorporated into supporting tools for field data collection or development of exposure datasets using modelling approaches, as further explained in this report.

Multi-Hazard Building Taxonomy

The GEM Building Taxonomy

The GEM Building Taxonomy v2.0 describes and classifies buildings in a uniform manner and it was originally developed for earthquake risk assessment purposes (Brzev et al. 2013). The taxonomy proposes a unique description (string) that provides information regarding the attributes that are relevant for the seismic performance of a specific building or a building class.

Four main criteria were considered for the development of the GEM Building Taxonomy: *i)* to be relevant to seismic performance of different construction types; *ii)* be comprehensive yet simple; *iii)* be collapsible; and *iv)* adhere to principles that are familiar to the range of users. Finally, the taxonomy was developed to be flexible and extensible for application to non-buildings and other natural hazards.

The GEM Building Taxonomy v2.0 uses the following 13 attributes to describe individual buildings and building classes:

1. **Direction** - describes the orientation of building(s) in two principal horizontal directions of the building plan which are perpendicular to one another.
2. **Material of the lateral load-resisting system** - e.g. "masonry" or "wood".
3. **Lateral load-resisting system** - the structural system that provides resistance against lateral earthquake forces through vertical and horizontal structural components, e.g. "wall", "moment frame", etc.
4. **Height** - building height above ground in terms of the number of storeys (e.g. a building is 3-storey high); this attribute also includes information on the number of basements (if present) and the ground slope.
5. **Date of construction or retrofit** - identifies the year when the building construction was completed.
6. **Occupancy** - the type of activity (function) or use of the building; it is possible to describe a diverse range of occupancies - for example, residential occupancies include informal housing (slums) as well as high-rise apartment buildings.
7. **Building position within a block** - the position of a building within a block of buildings (e.g. "detached building" is not attached to any other building).
8. **Shape of the building plan** - e.g. L-shape, rectangular shape, etc.
9. **Structural irregularity** - a feature of a building's structural arrangement, such as one storey significantly higher than other storeys, an irregular building shape, or change of structural system or material that produces a known vulnerability during an earthquake. Examples: re-entrant corner, soft storey, etc. In recognition of the fact that a building may have more than one irregularity, the user is able to identify primary and secondary irregularity.
10. **Exterior walls** - material of exterior walls (building enclosure).
11. **Roof** - this attribute describes the roof shape, material of the roof covering, structural system supporting the roof covering, and roof-wall connection.

12. **Floor** - describes floor material, floor system type, and floor-wall connection.
13. **Foundation system** - that part of construction where the base of the building meets the ground. The foundation transmits loads from the building to the underlying soil. For example, a shallow foundation supports walls and columns in a building for hard soil conditions, and a deep foundation needs to be provided for buildings located in soft soil areas.

Depending on the available information and desired level of detail, each attribute can be described by one or multiple levels. The taxonomy scheme is flexible and provides an opportunity for adding new attributes and/or modifying the existing ones. Figure 1 shows 13 taxonomy attributes of the GEM Building Taxonomy (shown in grey colour). The first level of detail is shown in blue colour, the second level of detail is shown in purple colour, and the third level of detail is shown in yellow colour.

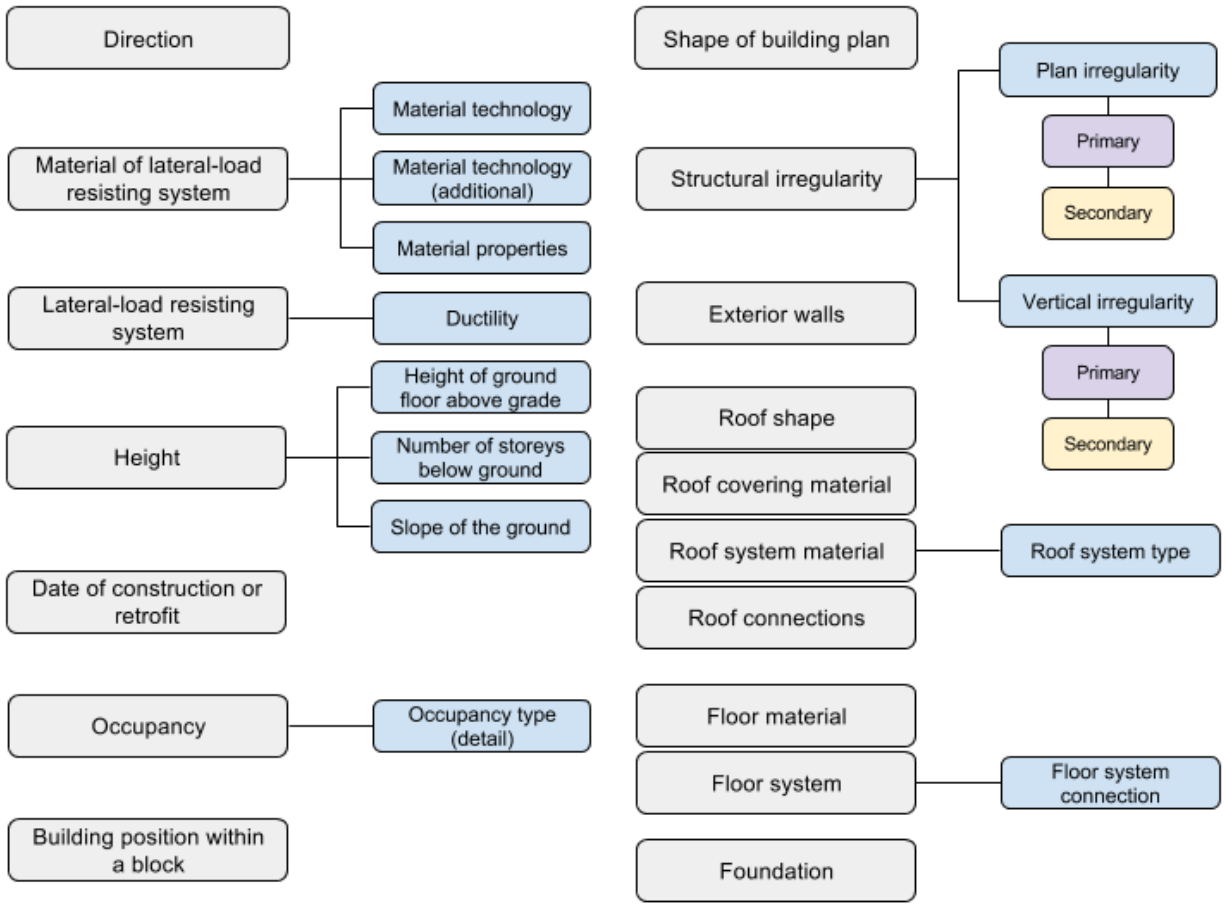


Figure 1 - GEM Building Taxonomy v2.0 structure.

General rules for classifying buildings using the GEM Taxonomy v2.0

In this section, we briefly describe how to classify a building following the GEM Building Taxonomy. The following rules need to be followed:

- Attributes need to be entered in the same sequence as listed in the taxonomy schema.
- When information about an attribute or a specific level of detail is not available, a “99” entry can be assigned.
- Each attribute is described using a unique identifier (ID).
- The slash sign "/" is used to separate attributes.
- Numerical input is specified by a text ID, the colon sign “:”, and a number (e.g. height or date of construction).
- A plus sign "+" is used to include additional level of detail for a given attribute (e.g. level 1 or level 2).

Table 1 illustrates an application of the taxonomy though three examples of widely different building typologies.

Table 1 – Illustrative Examples for Application of GEM Taxonomy v2.0.

Example	Illustration of the building	Description and taxonomy string
1		Reinforced concrete structure (cast-in-place) with infilled frames in one direction (LFINF), and *other lateral load-resisting system* (LO) in the perpendicular direction. The building has a rectangular shape and it is detached from other structures. The structure is used for (heavy) industrial purposes. DX+PF/CR+CIP/LFINF/DY+OF/LO/LH/HEX:1//IND+IND1/BPD/PLFR/IRRE//RME+RME1//
2		A single-storey post-and-beam bamboo house (LPB). Exterior walls are composed of vegetative materials. The plinth level of the building is at approximately 0.8 m height above the grade level. DX/W+WBB/LPB+DNO/DY/W+WBB/LPB+DNO/HEX:1+HFAPP:0.8//RES+RES1////EWV/RSH2//

3		A 14-storey residential reinforced concrete apartment building with ductile walls. It has reinforced concrete floors and a flat concrete roof. DX/CR+CIP/LWAL+DUC/DY/CR+CIP/LWAL+DUC/HEX:14//RES+RES2////EWC/RSH1+RC/FC+FC2+FWCP/

Review of GEM Taxonomy v2.0

Since its release in November 2013 the GEM Building Taxonomy v2.0 has been used to describe hundreds of buildings around the world. The taxonomy has been tested through several projects, workshops, and training activities in Europe, Africa, Middle East, South and Central America. Feedback has been collected regarding the level of detail, accuracy and flexibility in the building description. The improvements proposed for inclusion in the multi-hazard GED4ALL taxonomy are discussed below.

Attribute "Direction"

Buildings may have different lateral load-resisting systems (LLRS) in the two principal directions of the building plan. This has been considered in the current taxonomy through the attribute "Direction". However, it is redundant to specify this attribute if the LLRS is the same in both directions. Therefore, it is proposed to only include this information if the direction is relevant for the description of the structure.

Table 2 – Proposed Attribute "Direction"

Current		Proposed	
DX	Direction X	--	Direction X, unspecified direction
		DXP	**Direction X, parallel to street**
DY	Direction Y	--	Direction Y, unspecified direction
		DYO	**Direction Y, orthogonal (perpendicular) to street**

Table 3 – Proposed removal of Attribute "Description of the direction"

Current in DX		Proposed
D99	Unspecified direction	Delete this level
PF	Parallel to street	
Current in DY		**Proposal**
D99	Unspecified direction	Delete this level
OF	Perpendicular to street	

Attribute "Material of lateral load-resisting system"

It is common to find buildings that have more than one predominant material in the lateral load-resisting system, especially in vernacular and informal construction. Therefore, it is proposed to include an option for informal materials, and mixed materials in this attribute, as shown in Table 4 (changes are shown in bold).

Table 4 - Attribute "Material of lateral load-resisting system"

Current		Proposed	
MAT99	Unknown material	--	**Unknown material**
C99	Concrete, unknown reinforcement	**C**	**Concrete, unknown reinforcement**
CR	Concrete, reinforced	CR	Concrete, reinforced
CU	Concrete, unreinforced	CU	Concrete, unreinforced
SRC	Concrete, composite with steel section	SRC	Concrete, composite with steel section
S	Steel	S	Steel
ME	Metal (except steel)	ME	Metal (except steel)
M99	Masonry, unknown reinforcement	**M**	**Masonry, unknown reinforcement**
MUR	Masonry, unreinforced	MUR	Masonry, unreinforced
MCF	Masonry, confined	MCF	Masonry, confined
MR	Masonry, reinforced	MR	Masonry, reinforced
E99	Earth, unknown reinforcement	**E**	**Earth, unknown reinforcement**
ER	Earth, reinforced	ER	Earth, reinforced
EU	Earth, unreinforced	EU	Earth, unreinforced
W	Wood	W	Wood
		MIX*	**MIX(material_a-material_b)*, mixed materials (hybrid or composite)**
		INF	**Informal materials**
MATO	Other material	MATO	Other material
* Option to chose two possible materials of LLRS from the following material list:			

CR	Concrete, reinforced
CU	Concrete, unreinforced
S	Steel
M	Masonry, unknown reinforcement
MUR	Masonry, unreinforced
MCF	Masonry, confined
MR	Masonry, reinforced
MUR-ST	Stone masonry, unreinforced
ER	Earth, reinforced
EU	Earth, unreinforced (or mud)
W	Wood

Example: MIX(CR-MUR-ST)

Attribute "Lateral Load-Resisting System" (LLRS)

The following modifications are proposed for the attribute Lateral load-resisting system (LLRS): *i)* to update the detail for infilled frames (LFINF) and hybrid systems (LH), *ii)* to revise the ductility detail, and *iii)* to include a new level of detail for column/wall density.

Changes in LLRS for "Infilled frames"

An additional level of detail is proposed for the attribute "Lateral load-resisting system" when indicated as "Infilled frame" (LFINF).

Table 5 - Attribute LLRS - Infilled frame (LFINF).

Current	Proposed	
Not available	--	Infill material unknown
	MUR	Unreinforced masonry
	MUR-CL	Unreinforced masonry, fired clay bricks
	MUR-CLB	Unreinforced masonry, fired clay hollow blocks or tiles
	MUR-AAC	Unreinforced masonry, AAC blocks (aerated autoclaved blocks)
	MUR-FAB	Unreinforced masonry, fly ash bricks
	MUR-CBH	Unreinforced masonry, hollow concrete blocks
	MUR-CBS	Unreinforced masonry, solid concrete blocks
	MR	Reinforced masonry
	MR-CL	Reinforced masonry, clay brick
	MR-CBH	Reinforced masonry, hollow concrete block
	MR-CBS	Reinforced masonry, solid concrete block
	MUR-ST	Unreinforced stone masonry
	MIS	Infill isolated (separated) from the frame

Changes in LLRS for "Hybrid system"

Field surveys have indicated that there are buildings with different lateral load-resisting systems in the same direction. This is particularly common in vernacular and informal construction. Therefore it is proposed to extend the description of hybrid systems to be able to identify the type of hybrid system (in vertical or horizontal plane). It is also important to be able to indicate the two main LLRSs for the same direction (X or Y) within a building. This is illustrated in Table 6. Note that primary and secondary systems (sys_a and sys_b) need to be chosen from a list of available LLRSs (see Table 2 in Appendix A).

Table 6 - Attribute LLRS - Hybrid LLRS (LH).

Current		Proposed	
LH	Hybrid lateral load-resisting system	--	Hybrid lateral load-resisting system
		Level 1	
		LHV **	LHV(sys_a-sys_b), hybrid LLRS in vertical (V) plane
		LHP **	LHV(sys_a-sys_b), hybrid LLRS in plan (horizontal plane)
** (sys_a= primary system and sys_b=secondary system) Option to chose two possible LLRS from the list. Example: LHV(LFM-LWAL)			

Changes in LLRS for "Ductility" level 1 detail and new level 2 detail "Code Provisions"

Buildings are designed to perform at different levels of ductility based on the expected seismic hazard demand and the code requirements applicable during the design and construction. For example, seismic performance may be significantly different for otherwise similar adjacent reinforced concrete buildings with different seismic detailing, thus leading to different ductility potential. The current taxonomy has level 1 "System ductility" detail for the attribute "Lateral load-resisting system". The buildings can be classified as ductile (DUC) or non-ductile (DNO). Therefore, it is proposed to expand "System ductility" detail (Table 7) and to include a new level 2 detail related to the "Code provisions" (Table 8).

Table 7 - Attribute LLRS - Ductility level.

Current		Proposed	
DU99	Ductility unknown	--	**Ductility unknown**
DUC	Ductile	**DNO**	**Non-ductile**
DNO	Non-ductile	**DUL**	**Low ductility**
DBD	Equipped with base isolation and/or energy dissipation devices	**DUM**	**Moderate ductility**
		DUH	**High ductility**
		DBD	Equipped with base isolation and/or energy dissipation devices

Table 8 - Attribute LLRS – Code provisions.

Current	Proposal	
Not available	--	Code provisions unknown
	CDN	No-code or not designed for lateral loads
	CDL	Low code
	CDM	Moderate code
	CDH	High code

Add level of detail in LLRS for "Column/Wall Density"

The structural response of buildings under lateral loads has a direct link with the density/ratio of the columns and walls area with respect to the building plan area. Moreover, some building codes require a minimum ratio in order to guarantee an appropriate design. Therefore, it is proposed to include level 3 to the "Lateral load-resisting system" attribute to describe the "Column/Wall density" (Table 9).

Table 9 - Attribute LLRS – Column/Wall density.

Current	Proposal	
	--	Density unknown
Not available	DMW*	Masonry wall density
	DCW*	Reinforced concrete wall density
	DCL*	Column density
* Float specifying the density or ratio between the total area of columns per floor and the area of the building plan. Must be less than 1.0. Level 3 it is not valid for the following LLRS: (LN) No lateral load-resisting system, (LH) Hybrid lateral load-resisting system, (LO) Other lateral load-resisting system		

Attribute "Height"

To increase the flexibility in the description of building height characteristics, it has been proposed to expand the attribute and add a level of detail (Tables 10 and 11).

It is also suggested to move the level of detail "Height of ground floor level above grade" to the new attribute "Ground floor hydrodynamics" (Table 9 in Appendix A).

Changes in "Height" ("Number of storeys above ground")

In the current taxonomy it is not possible to specify that a building has a minimum number of storeys (e.g., 8 or more). It is proposed to enable open ranges for specifying the number of storeys (HBET) (Table 10).

Table 10 - Attribute "Height" - Number of storeys above ground.

Current		Proposal	
H99	Number of storeys unknown	--	Number of storeys unknown
HEX	Exact number of storeys above ground	**H**	**Exact number of storeys above ground**
HBET	Range of number of storeys above ground	**HBET***	**Range of number of storeys above ground**
HAPP	Approximate number of storeys above ground	HAPP	Approximate number of storeys above ground
*HBET will be specified as: HBET(3-7). It is possible to leave blank intervals, which will indicate that the upper or lower bound are unknown.			

Add level of detail in "Height" for the total or inter-storey height

It has been proposed to enable description of a building or a building class by its total height or the inter-storey height. Therefore, an additional level of detail is proposed to include this information (Table 11).

Table 11 - Attribute "Height" - Height of the structure.

Current	Proposal	
Not available	--	Height unknown
	HHT	HHT:n, total height of the structure above level. Float specifying height of the structure in meters. Must be at least 2.0.
	HHI	HHI:n, inter-storey height (average). Float specifying the average floor height in meters. Must be at least 1.0.

Attribute: "Date"

An additional level of detail is proposed for the attribute "Date" to capture information regarding the physical condition or maintenance of the building.

Table 12 - Attribute "Date" - Physical condition/maintenance level.

Current	Proposal	
Not available	--	Physical condition unknown
	YMP	Poor physical condition/maintenance
	YMM	Moderate physical condition/maintenance
	YMG	Good physical condition/maintenance

Attributes: “Building position within a block” and “Shape of building plan”

In the current taxonomy there are two independent attributes to indicate the “building position within a block” and the “Shape of building plan”. Considering that both attributes refer to exterior geometrical characteristics of a building or a building class, it is proposed to merge them into a single attribute. As a result “building position within a block” will become the main attribute, and “Shape of building plan” will be the level 1 detail, as presented in Table 7 of Appendix A.

Attribute: “Structural irregularity”

It is proposed to simplify this attribute by removing the Level 3 detail “Secondary level of irregularity”. This is the only attribute in the taxonomy with a Level 3 detail.

Table 13 - Attribute “Structural irregularity”.

Current		Proposal	
IR99	Unknown structural irregularity	--	Unknown structural irregularity
IRRE	Regular structure	IRE	Regular structure
IRIR	Irregular structure	--	Irregular structure
Level 1: “Plan irregularity”			
Current		Proposal	
IRPP	Plan irregularity-primary	IRP	Plan irregularity-primary
Level 1.1: “Irregularity details”		**Level 1.1: “Irregularity details”**	
IRN	No irregularity	--	No irregularity
TOR	Torsion eccentricity	TOR	Torsion eccentricity
REC	Re-entrant corner	REC	Re-entrant corner
IRHO	Other horizontal irregularity	IRHO	Other horizontal irregularity
IRPS	Plan irregularity-secondary	--	Plan irregularity-secondary
Level 1.1.1: “Secondary Irregularity details”		**Level 1.1.1: “Secondary Irregularity details”**	
IRN	No irregularity	--	No irregularity
TOR	Torsion eccentricity	TOR	Torsion eccentricity
REC	Re-entrant corner	REC	Re-entrant corner
IRHO	Other horizontal irregularity	IRHO	Other horizontal irregularity

<table>
<tr><th>Current</th><th>Proposal</th></tr>
<tr><td colspan="2">Level 2: “Vertical irregularity”</td></tr>
<tr><td>IRVP — Vertical structural irregularity - primary</td><td>IRV — Vertical structural irregularity - primary</td></tr>
<tr><td>Level 2.1: “Irregularity details”
IRN — No irregularity
SOS — Soft storey
CRW — Cripple wall
SHC — Short column
POP — Pounding potential
SET — Setback
CHV — Change in vertical structure (includes large overhangs)
IRVO — Other vertical irregularity</td><td>Level 2.1: “Irregularity details”
-- — No irregularity
SOS — Soft storey
CRW — Cripple wall
SHC — Short column
POP — Pounding potential
SET — Setback
CHV — Change in vertical structure (includes large overhangs)
IRVO — Other vertical irregularity</td></tr>
<tr><td>IRVS — Vertical structural irregularity - secondary</td><td>-- — Vertical structural irregularity - secondary</td></tr>
<tr><td>Level 2.1.1: “Secondary Irregularity details”
IRN — No irregularity
SOS — Soft storey
CRW — Cripple wall
SHC — Short column
POP — Pounding potential
SET — Setback
CHV — Change in vertical structure (includes large overhangs)
IRVO — Other vertical irregularity</td><td>Level 2.1.1: “Secondary Irregularity details”
-- — No irregularity
SOS — Soft storey
CRW — Cripple wall
SHC — Short column
POP — Pounding potential
SET — Setback
CHV — Change in vertical structure (includes large overhangs)
IRVO — Other vertical irregularity</td></tr>
</table>

Attribute: “Roof” and “Floor”

In the description of the “Roof system material” and “Floor system material”, update the description of “Metal roof” and “Metal floor” to “Metal/Steel roof” and “Metal/Steel floor” respectively.

Additional Multi-Hazard Features

The GEM Building Taxonomy v2.0 covers a wide range of attributes that are relevant to the structural performance of buildings, not only under earthquake hazard, but also other natural hazards, like wind and floods. However, a comprehensive multi-hazard building taxonomy needs to include a few additional characteristics, as discussed in the following text.

Attribute: "Exterior walls" - openings

An additional level of detail is proposed for the attribute "Exterior walls", to describe the openings (windows and doors) in the exterior walls. This additional level of detail provides relevant information regarding building performance under wind action.

Table 14 - Attribute "Exterior walls" – Openings.

Current	Proposal	
Not available	--	Openings unknown
	WOL	Large openings (i.e. more than 50% of the wall surface area is occupied by windows and/or doors)
	WOM	Moderate openings (i.e. from 20% to 50% of the wall surface area is occupied by windows and/or doors)
	WOS	Small openings (i.e. less than 20% of the wall surface area is occupied by windows and/or doors)
	WON	No openings

Table 15 - Attribute "Exterior walls" – Window protection.

Current	Proposal	
Not available	--	Protection unknown
	PNO	Windows not protected
	PRW	Weak window protection
	PRS	Strong window protection

Attribute: "Ground floor hydrodynamics"

Ground floor hydrodynamics is relevant for the building performance when subjected to floods and tsunamis. Ground floor hydrodynamics refer to the opening ratio of a ground floor plan exposed to a potential water flow. For example, a building with an open ground floor (with no walls) is less susceptible to damage under tsunami flows; on the other hand, the building is more susceptible to damage due to floods.

Table 16 - Attribute "Ground floor hydrodynamics".

Current	Proposal	
Not available	--	Ground floor hydrodynamics unknown
	GFO	Ground floor plan fully open (no walls)
	GFH	Ground floor plan partially open (i.e. with at least 50% of walls).
	GFM*	Not open, many doors and/or windows (i.e. more than 20% of wall surface area).
	GFN*	Not open, few doors and/or windows (i.e. less than 20% of wall surface area).
* The openings are related to the building façades that are potentially exposed to flows		

Attribute: "Fire protection"

An additional attribute is proposed to describe the level of fire protection for all structural elements.

Table 17 - Attribute "Fire insulation".

Current	Proposal	
Not available	--	Fire protection unknown
	FIN	Fire protection absent (non-existent)
	FII	Fire insulation present
	FIS	Sprinkler system present

Improving Usability of the Taxonomy

An important feedback collected during past projects and workshops has been related to the usability (ease of use) of the taxonomy. The following proposal aims to create a more application-friendly and efficient taxonomy string:

- Remove the "99" entry when information about an attribute or a specific level of detail is not available. Omit all unknown details from the final string.
- For the attribute "Occupancy", it is suggested to remove the duplicated string from the attribute description and leave only the string corresponding to the level of detail (e.g RES + RES1 should be just RES1).
- For the attribute "Roof system material", it is suggested to remove the duplicated string from the attribute description and leave only the string corresponding to the level of detail (e.g RC + RC1 should be just RC1). Moreover, the roof shape should be indicated as the main attribute characteristic.

Proposed Multi-Hazard Building Taxonomy (GED4ALL)

A multi-hazard building taxonomy called GED4ALL has been proposed by taking into consideration the potential improvements of the GEM Building Taxonomy v2.0 described in the previous section. The main modifications in the current taxonomy which are incorporated in the GED4ALL taxonomy are:

- Improvements in user friendliness through simpler strings.
- Improved level of detail for informal construction built using mixed materials and hybrid lateral load-resisting systems.
- Additional details in the Lateral load-resisting system (LLRS) attribute related to ductility characteristics and seismic code provisions.
- Addition of new attributes that capture ground floor hydrodynamics, openings in exterior walls, and fire protection.

In total, 14 attributes have been included in GED4ALL taxonomy with multiple levels of detail. These 14 attributes enable the user to describe a building or a building class by assigning characteristics relevant to its structural response under multi-hazard actions. GED4ALL taxonomy is depicted in the general schema shown in Figure 2. Main attributes are shown in grey colour, level 1 detail are shown in blue colour, level 2 details are shown in purple colour, and level 3 details are shown in yellow colour.

This multi-hazard building taxonomy (hereafter termed as GED4ALL Building Taxonomy) can also be represented in a tabular form (Table 18). All attributes and their corresponding levels of detail are presented in tabular form in Appendix A.

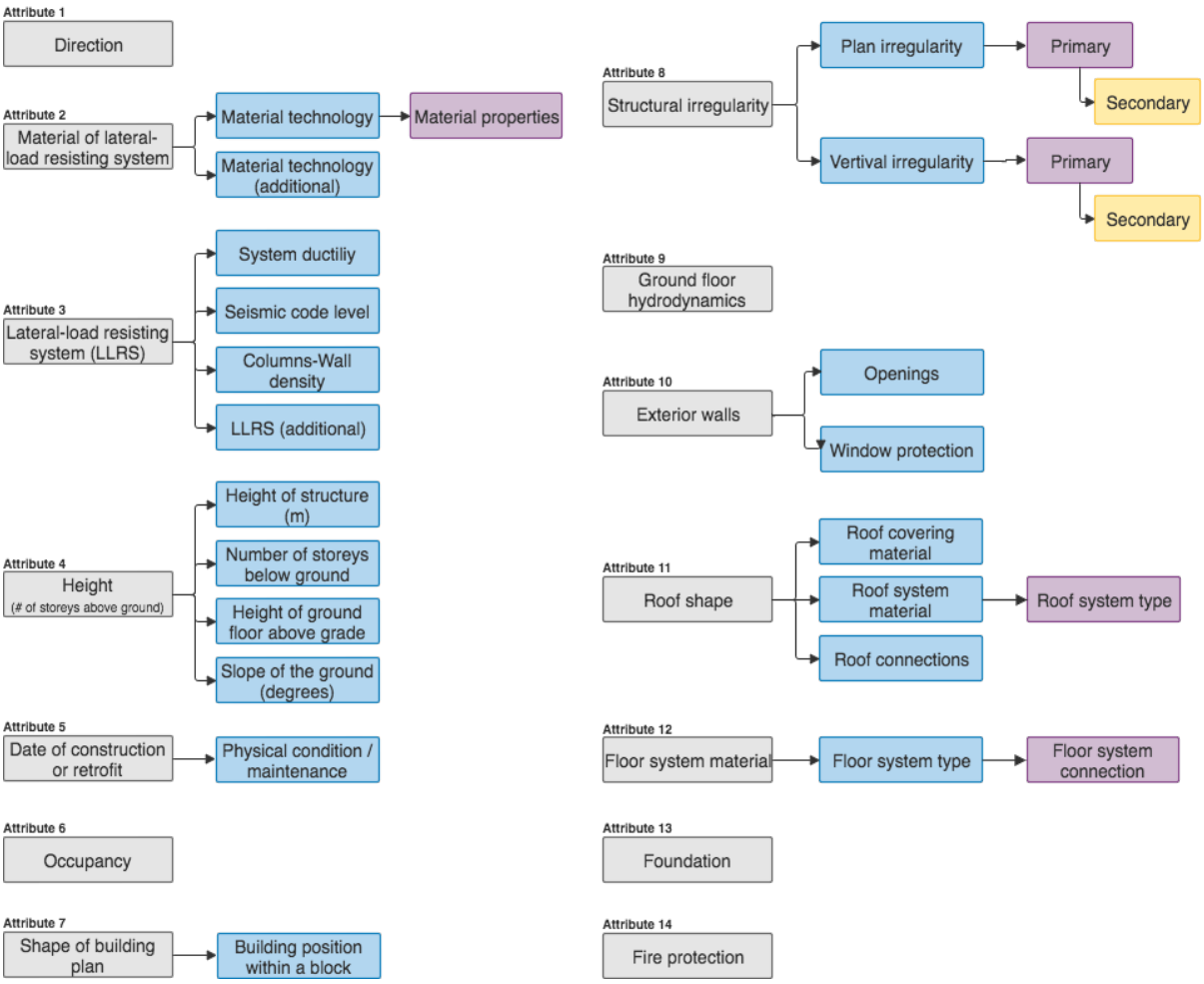


Figure 2 - Proposed schema for GED4ALL multi-hazard building taxonomy.

The following rules must be followed while describing buildings using GED4ALL taxonomy:

- Each attribute is described using the unique identifier (ID), indicated in Appendix A.
- When specifying ranges of values (e.g. HBEX), the two integers should be separated by a "-", as opposed to a "," used in the GEM Building Taxonomy v2.0.
- If the LLRS is the same in both directions, the "Direction" attribute can be omitted.
- The separator "/" only needs to be included between existing IDs, and not imposed even if an ID will not be specified. For example, a reinforced concrete building with masonry walls instead of "DX/CR//DY/CR///////EWMA///", can simply be CR/EWMA.

Table 18 - Attributes for GED4ALL Building Taxonomy.

Attribute		Appendix A	Attribute levels
1	Direction	Table 1	* Direction of the building
2	Material of the Lateral Load-Resisting System	Table 2	* Material type
			Material technology (Level 1)
			Material properties (Level 1.1)
			Material technology (additional) (Level 2)
3	Lateral Load-Resisting System	Table 3	* Type of lateral load-resisting system
			System ductility (Level 1)
			Seismic code level (Level 2)
			Columns-Wall density (Level 3)
			Lateral load-resisting system (additional) (Level 4)
4	Height	Table 4	* Number of storeys
			Height of structure (m) (Level 1)
			Number of storeys below ground (Level 2)
			Height of ground floor above grade (Level 3)
			Slope of the ground (degrees) (Level 4)
5	Date of Construction or Retrofit	Table 5	* Construction completed (year)
			Physical condition / maintenance (Level 1)
6	Occupancy	Table 6	* Building occupancy class - general
			Building occupancy class - detailed (Level 1)
7	Shape of the Building Plan	Table 7	* Plan shape (footprint)
			Building Position within a Block (Level 1)
8	Structural Irregularity	Table 8	* Regular or irregular
			Plan irregularity (Level 1)
			Plan irregularity details: Primary (Level 1.1) Secondary (Level 1.1.1)
			Vertical irregularity (Level 2)
			Vertical irregularity details: Primary (Level 2.1) Secondary (Level 2.1.1)
9	Ground floor hydrodynamics	Table 9	* Ground floor hydrodynamics
10	Exterior Walls	Table 10	* Material of exterior walls
			Openings (Level 1)
			Windows protection (Level 2)
11	Roof	Table 11	* Roof shape
			Roof covering material (Level 1)
			Roof system material (Level 2)
			Roof system type (Level 2.1)
			Roof connections (Level 3)
12	Floor	Table 12	* Floor system material
			Floor system type (Level 1)
			Floor connections (Level 1.1)
13	Foundation System	Table 13	* Foundation System
14	Fire protection	Table 14	* Fire protection

* Main attribute description

Taxonomy strings for the examples presented in Table 1, which illustrated the application of the GEM Building Taxonomy 2.0, are shown in Table 19. The table gives a comparison between the current taxonomy and proposed GED4ALL taxonomy.

Table 19 - A comparison of taxonomy strings for the GEM v2.0 and GED4ALL Building Taxonomies.

Example	GEM Building Taxonomy v2.0	GED4ALL Building Taxonomy
1	DX/W+WBB/LPB+DNO/DY/W+WBB/LPB+DNO/HEX:1+HFAPP:0.8//RES+RES1////EWV/RSH2//	W+WBB/LPB+DNO/H:1+HFAPP:0.8/RES1/EWV/RSH2
2	DX/CR+CIP/LWAL+DUC/DY/CR+CIP/LWAL+DUC/HEX:14//RES+RES2////EWC/RSH1+RC/FC+FC2+FWCP/	CR+CIP/LWAL+DUH/H:14/RES2/EWC/RSH1+RC/FC+FC2+FWCP
3	DX+PF/CR+CIP/LFINF/DY+OF/CR+CIP/LH/HEX:1//IND+IND1/BPD/PLFR/IRRE//RME+RME1//	DXP/CR+CIP/LFINF+MCR/DYO/CR+CIP/LHP(LFINF-LPB)/H:1/IND1/PLFR+BPD/IRE/RSH2+RME1

Simplified Multi-Hazard Building Taxonomy

The proposed GED4ALL taxonomy is a comprehensive collection of relevant attributes for characterizing the performance of buildings for multi-hazard risk assessment. However, its use can be overwhelming for less experienced users or mappers. For this reason, we have identified a subset of attributes that considerably influence the performance of buildings, as discussed in the following text. These attributes constitute the "Simplified Multi-Hazard Building Taxonomy", which is fully compatible with the GED4ALL Building Taxonomy.

Identification of the key attributes

The key attributes have been selected based on the feedback collected during the Inception Workshop in Pavia and Stakeholder Meeting in London, and through a literature review that analised the most common, relevant and easy to define features used in building inventory development. The following list describes each attribute:

- **Material of the Lateral-load resisting system (LLRS)***:* The structural performance of a building depends heavily on the predominant construction material, as well as the structural system. In most cases, this attribute can be identified through a visual inspection. Additional information about the structural system will require engineering knowledge or interaction with local experts (e.g. whether a building was built using reinforced or unreinforced masonry).
- **Ductility***:* Observed damage in past earthquakes has demonstrated the significant relevance of ductility in the building's response. This attribute is optional since it may require detailed information of the building. However, in some cases this attribute can also be inferred through the main construction material (e.g. wooden structures are usually ductile) or age of construction (modern structures are usually ductile).

- **Height***:* The height of the structure is relevant for the majority of hazards and has the advantage of being easy to define. A building has three main characteristics related to the height that are relevant for its performance under different hazards:
    - *Height or number of storeys above grade:* when information regarding building height is available, it is possible to infer a few other relevant parameters such as weight, and general geometric properties of the structure, like built-up area and natural period of vibration.
    - *Number of storeys below ground (basements)*: the damage of building during flood events is directly linked to the number of basements.
    - *Height of ground floor above grade:* this height (or height of the access to the building compared to the ground level), can avoid damage or losses due to floods if this height is not reached.
- **Date of construction or retrofit***:* Provides information relevant to the construction practice, materials and possible physical condition of the building. The date of construction can also be linked with the expected ductility level if a seismic code was enforced during the construction period.
- **Occupancy***:* Construction characteristics are directly related to the occupancy type (e.g. residential, commercial, industrial, healthcare, educational). Moreover this attribute can be related with the expected number of occupants in a given time period (e.g. day, night).
- **Ground floor hydrodynamics**: refers to the amount of openings in the ground floor, which are relevant for accessing flood and tsunami risk associated with a building.
- **Openings**: this attribute is mainly relevant for flows (wind, floods, tsunami and volcanoes), and it has a primary influence on the failure mechanism and performance of a building exposed to natural hazards. For example, damage assessment surveys showed that the second most common failure is penetration of windows by debris, causing both non-structural and structural damage.
- **Roof shape and material**: This attribute is of particular importance when characterizing the building performance under wind forces (or hurricanes), volcanic ash fall and snow.

The structure of the Simplified Building Taxonomy is depicted in Figure 3. Such taxonomy could be easily employed in the collection of building data on the field. We note again that each attribute is described in the GEM Glossary, along with several photos illustrating building examples from different parts of the world.

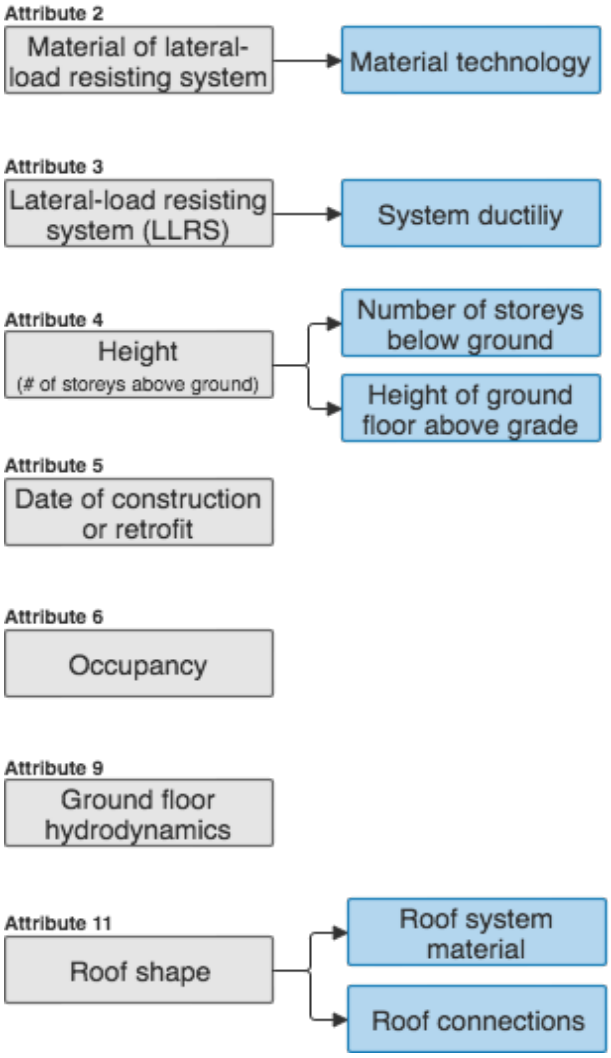


Figure 3 - Simplified multi-hazard GED4ALL building taxonomy.

Tools for Building Classification

GEM has supported the development of tools and guidelines for building classification. Three main tools can be mentioned in this regard: TaxTweb, the IDCT (Inventory Data Capture Tools), and the Building Classification Tool. Similar tools can be developed or adapted to support the application of GED4ALL taxonomy.

The GEM Building Taxonomy v2.0 is accompanied by TaxTWeb[7], an online graphical interface (see Figure 4) for editing GEM Taxonomy strings.

[7] TaxTWeb Tool - http://taxtweb.openquake.org

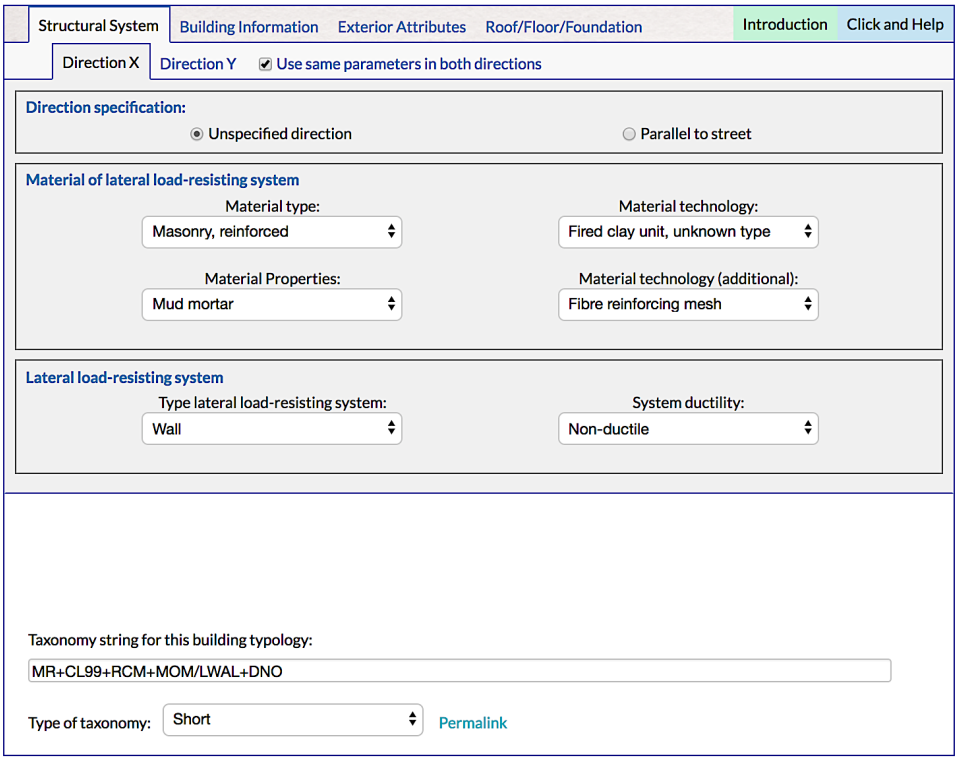


Figure 4 – Graphical User Interface of TaxTWeb.

The companion online GEM glossary[8] explains around 400 terms contained in the taxonomy classification with nearly 700 images. The terms have been listed in alphabetical and numerical order, and Figure 5 presents an example of the tool.

[8] GEM Online Glossary - https://taxonomy.openquake.org

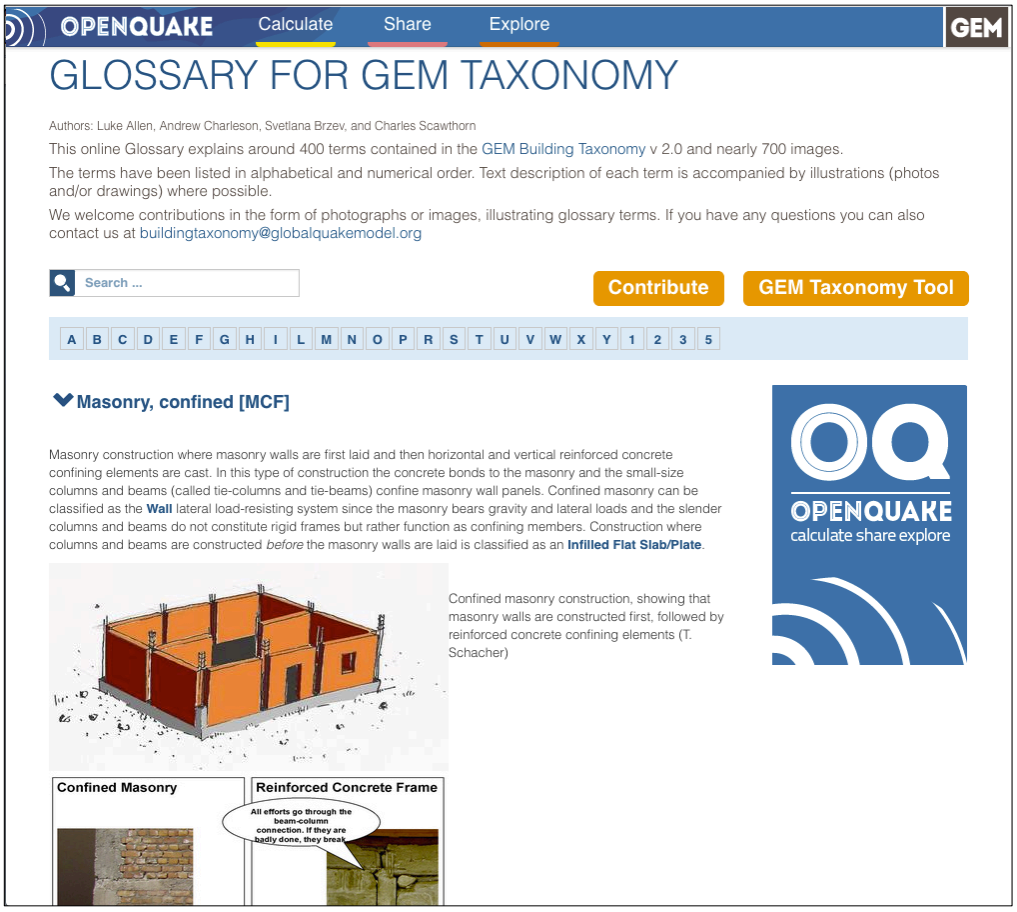


Figure 5 – Example of the interface for the GEM Taxonomy Glossary.

The *IDCT*[9] is a field survey collection tool for Android and Windows operating systems, which allows individual and teams to collect field information through the GEM Building Taxonomy v2.0. The *IDCT* uses a map interface, and allows users to mark survey points, capture building attributes, export survey data and import offline map data. It was conceived for collecting pre-event inventory and post-event damage data. Figure 6 illustrates some of the interfaces of the IDC tool.

[9] IDCT - https://play.google.com/store/apps/details?id=org.globalquakemodel.org.idctdo&hl=en

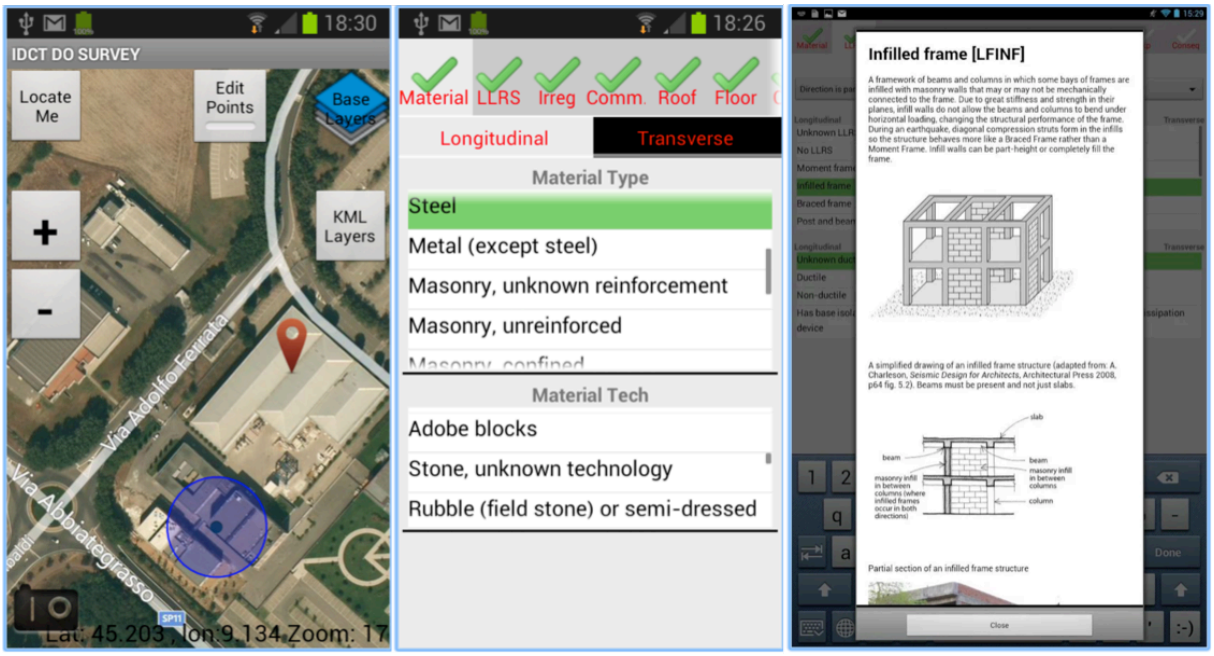


Figure 6 – Graphical User Interface of the Inventory Data Capture Tool.

The *Building Classification Tool*[10] is a web-based application hosted and accessible through the OpenQuake platform. The tool was designed to create a global database of building characteristics through online building survey data from experts around the world in the field of structural and earthquake engineering. The web-based application consists of a query regarding the most significant attributes which define a country's building stock (e.g. building material, lateral load resisting system, height, level of ductility, irregularities). It closely follows the GEM Building Taxonomy schema. The application allows the choice of occupancy. Currently the following six occupancies have been considered: (i) residential, (ii) commercial, (iii) industrial, (iv) healthcare, (v) governmental and (vi) educational. Users are able to quantify relative frequency of occurrence of a given building class in both rural or urban areas of a specific country.

[10] Building Classification Tool - https://platform.openquake.org/building-class

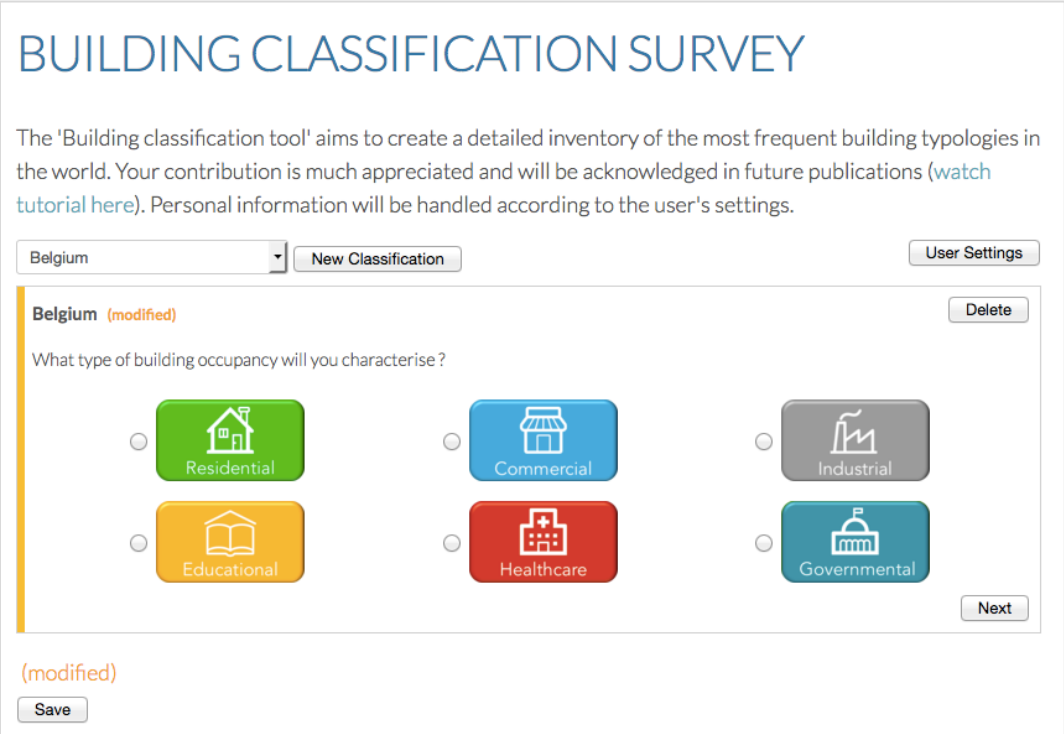


Figure 7 – Graphical User Interface of the Building Classification Tool.

Multi-hazard Infrastructure Taxonomy

This category of elements that may suffer damage or loss from natural hazards comprises structures which are often more complex than regular residential or industrial buildings, and may have a large geographical expansion. These elements are organized in this section in three main sub-groups: lifelines, bridges and energy generation facilities. Other important elements were either disregarded at this stage (e.g. oil refineries, chemical plants) or can already be covered by the building taxonomy described in the previous section (e.g. hospitals, schools, fire departments, police stations, government buildings, communication offices). It is also relevant to note that the taxonomy proposed in this section aims at classifying elements at a high level, and that a much more comprehensive and detailed approach would be necessary to properly accommodate all of the structural, non-structural and functional characteristics of these elements. Although such detailed classification system for infrastructure was out of the scope of this project, we refer a few studies that have covered these topics.

Lifelines

Lifelines include spatially distributed systems capable of managing or providing energy, resources or transportation. These include road and railway networks, power grid, pipelines (used by the potable water supply and water-waste (sewerage) systems, oil and gas networks), storage tanks, potable water and wastewater systems and communication networks. Three main sources of information have been used for the definition of the taxonomy for lifelines: the outcomes from the FP7 European Project Syner-G (Systemic Seismic Vulnerability and Risk Analysis for Buildings, Lifeline Networks and Infrastructures Safety Gain - http://www.vce.at/SYNER-G), the recommendations from HAZUS[11], and the classification system adopted by the OpenStreetMap (OSM) initiative.

Amongst all of the different types of lifelines, the transportation network is certainly the one for which a highest effort has been made to map its elements at the global scale. OSM is undoubtedly the largest and most complete source of open information concerning the location of roads and railways. For this reason, a decision was made to follow closely the classification usually used to catalogue roads within OSM.

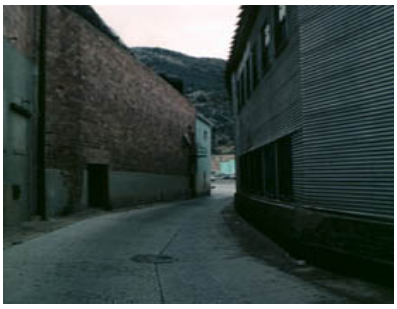
Road network

OSM uses six main categories to classify the **road network** in each country, as described in Table 12. This taxonomy is strongly based on the classification system adopted by OSM, as described in the associated Wikipedia page[12].

[11] Federal Emergency Management Agency (FEMA) [2012] Hazus - MH 2.1 – Earthquake Model Technical Manual, Department of Homeland Security, Washington, D.C., United States of America.
[12] OpenStreetMap Wikipedia page - roads: https://wiki.openstreetmap.org/wiki/Map_Features#Highway

Table 20 - Description of the road categories following the OSM classification system.

Category	Description	Photo
Motorway RDN+MO	A restricted access major divided highway, normally with 2 or more running lanes plus emergency hard shoulder. Equivalent to the Freeway, Autobahn, etc.	
Trunk RDN+TR	The most important roads in a country's system that aren't motorways. (Need not necessarily be a divided highway.)	
Primary RDN+PR	The next most important roads in a country's system. (Often link larger towns.)	
Secondary RDN+SE	The next most important roads in a country's system. (Often link towns.)	
Tertiary RDN+TE	The next most important roads in a country's system. (Often link smaller towns and villages)	

Unclassified RDN+UN	The least most important through roads in a country's system – i.e. minor roads of a lower classification than tertiary, but which serve a purpose other than access to properties. Often link villages and hamlets.	
Residential RDN+RE	Roads which serve as an access to housing, without function of connecting settlements. Often lined with housing.	
Service RDN+SR	For access roads to, or within an industrial estate, camp site, business park, car park etc.	
Unknown RDN	This category can be used when a road has been mapped but there is no additional information concerning its typology.	

The road network in Tanzania currently present in OSM is illustrated in Figure 8. It should be noted that frequently other categories of roads might be used, and it is not mandatory to follow the classification presented herein (and described on the OSM page). This is due to the fact that the data in OSM is provided by volunteers whose mapping expertise differs considerably.

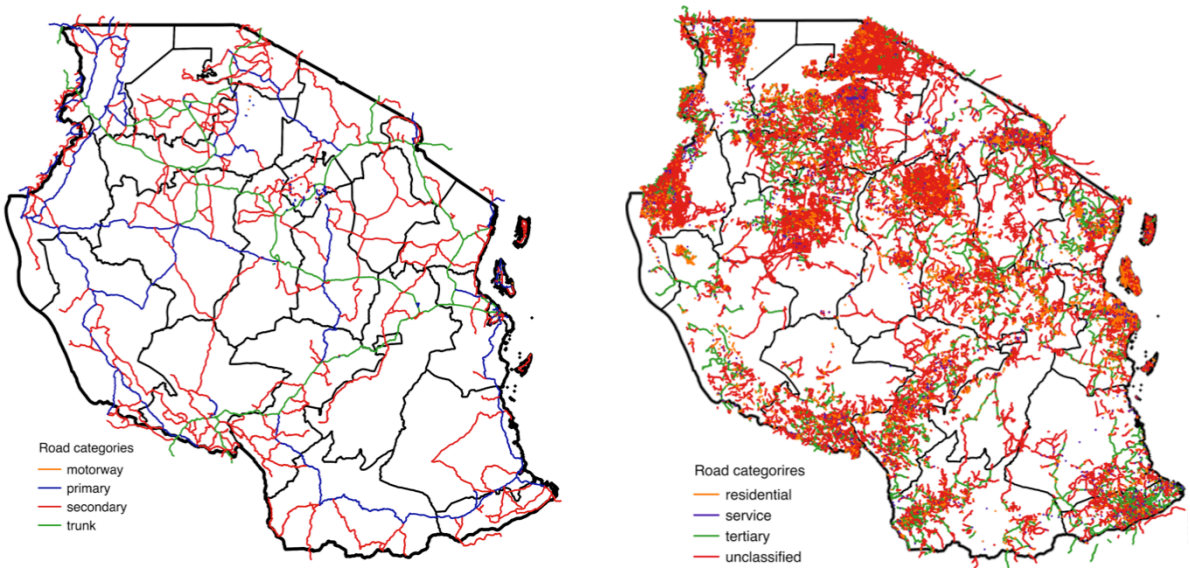


Figure 8 - Illustration of the road system in Tanzania: motorway, primary, secondary and trunk (left); residential, service, tertiary and unclassified roads (right).

Railway network

The classification system for the **railway network** follows the same approach adopted for the road network. Table 21 describes the railway categories, which are strongly based on the OSM classification system[13].

Table 21 - Description of the railway categories following the OSM classification system.

Category	Description	Photo
Light rail RLW+LR	A higher-standard tram system, normally in its own right-of-way. Often it connects towns and thus reaches a considerable length (tens of kilometer).	

[13] OpenStreetMap Wikipedia page - Railays: https://wiki.openstreetmap.org/wiki/Map_Features#Railway

Monorail RLW+MR	A railway with only a single rail. A monorail can run above the rail like in Las Vegas and Disneyland or can suspend below the rail like the Wuppertal Schwebebahn (Germany).	
Rail RLW+RL	Full sized passenger or freight trains in the standard gauge for the country or state.	
Subway RLW+SW	A city passenger underground rail service running mostly grade separated.	
Tram RLW+TR	One or two carriage rail vehicles, usually sharing motor road.	
Unknown RLW	This category can be used when a railway has been mapped but there is no additional information concerning its typology.	

The railway network in Tanzania currently present in OSM is illustrated in Figure 9.

Figure 9 - Railway network in Tanzania.

Pipelines (potable water/wastewater system, oil/gas network) and storage tanks

The taxonomy presented herein has been developed using the classification experience developed in Syner-G and STREST (D4.4, Crowley et al[14]., 2016). The most important attributes for the structural performance of pipelines (as identified by a number of studies including those documented in ALA[15] and FEMA[16]) are:

- Material: with more ductile materials showing lower damage.
- Joints: with continuous joints such as welded or mechanically restrained showing better performance than rigid segmented joints, such as cement.
- Extent of corrosion: that can be identified from age, wall thickness, corrosion protection and surrounding soil type.
- Diameter: with larger pipes demonstrating lower damage rates than smaller pipes.
- Position: as wall thickness increases and soils improve with depth).

Although all of these attributes could be used to describe the performance of **pipelines**, many of them are correlated and the majority of available fragility functions only use, at a maximum, the following attributes: content, position, material, joint type, soil type and diameter. The taxonomy string should be defined using the appropriate element codes for each attribute, presented in the following manner:

[14] Crowley H, Casotto C, Pitilakis K, Kalliopi K, Argyroudis S, Fotopoulou S, Lanzano G, Salzano E, Iervolino I, Basco A, Matos J, Schleiss A, Uckan E, Miraglia S, Courage W. (2016) Report on the taxonomy of CIs based on their vulnerability characteristics and exposure to natural hazard initiating events. STREST Deliverable 4.4.

[15] ALA (2001) Seismic fragility formulations for water systems. American Lifeline Alliance, ASCE, Washington, DC.

[16] FEMA (2004). HAZUS-MH Technical Manual. Federal Emergency Management Agency, Washington DC, United States.

PPL/CONTENT/POSITION/MATERIAL/JOINT_TYPE/SOIL_TYPE/DIAMETER

Where PL indicates that it is a pipeline that is being classified. The options for each one of these attributes are described in Table 22.

Table 22 - Attributes, codes and values for the pipelines taxonomy.

Attribute	Code	Value
Content	CGS	Gas
	COL	Oil
	CPW	Potable water
	CWW	Wastewater
	COT	Other content
	--	Unknown
Position	PBU	Buried
	PEL	Elevated
Material	MPC	Polyvinyl chloride
	MPE	Polyethylene
	MCI	Cast iron
	MDI	Ductile iron
	MWS	Welded steel
	MRM	Reinforced plastic mortar
	MRM	Resin transfer moulding
	MAC	Asbestos-cement
	MC	Concrete
	MCL	Clay
	MO	Other material
	MUB	Unknown, brittle
	MUD	Unknown, ductile
	--	Unknown material
Joint type	JAW	Arc welded
	JGW	Gas welded
	JCE	Cemented
	JFW	Fillet weld
	JBS	Bell and spigot (caulked)
	JRI	Riveted
	JMR	Mechanical restrained
	JSC	Screwed

	JRU	Rubber gasket
	JSG	Unknown, segmented
	JCO	Unknown, continuous
	JO	Other joint
	--	Unknown joint
Soil type	SCO	Corrosive
	SNC	Non corrosive
	--	Unknown soil type
Diameter	DSM	Small (< 40 cm)
	DLG	Large (≥ 40 cm)
	--	Unknown diameter

For example, a 30 cm diameter, buried, welded steel pipeline with arc-welded connections carrying potable water in corrosive soil would be described as follows: PPL/CPW/PBU/MWS/JAW/SCO/DSM. The minimum attributes that should be collected when mapping pipelines are position, material and joint type.

For storage tanks, several past studies[17] have identified the main attributes that influence the structural performance, as described below:

- Material: with steel and reinforced concrete being the main materials used.
- Anchorage: with unanchored tanks being highly vulnerable.
- Height-to-diameter ratio: with tanks with larger ratios, i.e. slender tanks, showing a higher vulnerability.
- Amount of liquid stored: as full tanks are subject to larger lateral forces and overturning moments due to liquid sloshing.

Considering these findings, the taxonomy string for **storage tanks** should be defined using the appropriate element codes for each attribute, presented in the following manner:

STT/POSITION/MATERIAL/ANCHORAGE/SHAPE_FACTOR/CONTENT

Where STT indicates that it is a storage tank that is being classified. The options for each one of these attributes are described in Table 23.

[17] Gehl P., Desramaut N., Réveillère A and Modaressi H. (2014) Fragility functions of gas and oil networks. In Pitilakis et al. (2014).

Table 23 - Attributes, codes and values for the storage tanks taxonomy.

Attribute	Code	Value
Position	PAG	At grade
	PEL	Elevated
Material	MST	Steel
	MCR	Reinforced Concrete
	MOT	Material, other
	--	Material, unknown
Anchorage	ANC	Anchored
	AUN	Unanchored
	--	Unknown anchorage
Shape	SSQ	Squat (Height/Diameter < 0.7)
	SSL	Slender (Height/Diameter ≥ 0.7)
	--	Unknown shape factor
Content flammable	CFI	Inflammable content
	CFF	Flammable content
	--	Unknown content
Content level	CLF	Near full (50-100%)
	CLH	Up to half-full (<50%)
	CLE	Empty (0%)
	--	Unknown content level

For example, a 90% full steel anchored tank located at grade with a height over diameter ratio of 0.3 would be described as follows: STT/PAG/MST/ANC/SSQ//CLF. The minimum attributes that should be gathered when mapping storage tanks are position, material and anchorage.

Power grid

An electric power grid is composed by four main components: substations, distribution circuits, transmission towers and energy generation facilities (the latter component is discussed in the following section). The classification of these components for the purposes of disaster risk management has been performed somewhat independently around the world. Two main classification systems have been proposed for the United States and Europe. The former is defined on the HAZUS Manual, while the latter is described in Deliverable 2.3[18] of the FP7 European project Syner-G. For this project we propose to follow the taxonomy adopted by HAZUS, which is less comprehensive than the European counterpart, but allows capturing the capacity (e.g. voltage) of the elements. For the purposes of assessing damage due to natural disasters, it is also relevant to identify the presence of anchorage and

[18] Syner-G Deliverable 2.3: http://www.vce.at/SYNER-G/pdf/deliverables/D2.03_SYNER-G_Final.pdf

whether the elements have been designed according to a particular code. The taxonomy for component of the **power grid** can thus be presented in the following manner:

PWG/COMPONENT/ANCHORAGE/CODE

Where PWG indicates that this element belongs to a power grid. The options for each one of these attributes are described in Table 24.

Table 24 – Attributes, codes and values for the power grid taxonomy.

Attribute	Code	Value
Component	SSL	Low Voltage (<115 KV) Substation
	SSM	Medium Voltage (115-500 KV) Substation
	SSH	High Voltage (>500 KV) Substation
	DTC	Distribution circuit
	TMT	Transmission tower
Anchorage	ANC	Anchored
	AUN	Unanchored
	--	Unknown anchorage
Code provisions	CDN	No code (non-engineered)
	CDL	Low code
	CDM	Moderate code
	CDH	High code
	C99	Code provisions unknown

For example, a substation with a voltage capacity of 350 KV, which has been anchoraged and designed following a modern design regulation would be described as follows: PWG/SSM/ANC/CDH.

Potable water and wastewater systems

Potable water systems are comprised by water treatment plants, storage tanks, pipelines and pumping stations, while wastewater systems are composed by wasterwater treatment plants, lifting stations and pipelines. Systems to classify storage tanks and pipelines have been already proposed in the previous sections. For the remaining components, once again two main classification systems can be mentioned: the one proposed for the United States and the one for Europe. The former can be found on the HAZUS

Manual, while the latter is described in Deliverable 2.5[19] of the FP7 European project Syner-G. We propose to follow the taxonomy proposed by HAZUS, with a few additions based on the European counterpart. For the purposes of assessing damage due to natural disasters, it is also relevant to identify the presence of anchorage and whether the elements have been designed according to a particular code. The taxonomy for components of the **potable water system** can thus be presented in the following manner:

PWR/COMPONENT/ANCHORAGE/CODE

Where PWR indicates that this element belongs to a potable water system. The options for each one of these attributes are described in Table 28.

Table 25 – Attributes, codes and values for the power grid taxonomy.

Attribute	Code	Value
Component	PWS	Small potable water treatment plant (<50 MGD)
	PWM	Medium potable water treatment plant (50-200 MGD)
	PWL	Large potable water treatment plant (>200 MGD)
	PPS	Small pumping plant (<10 MGD)
	PPM	Medium pumping plant (10-50 MGD)
	PPL	Large pumping plant (>50 MGD)
Anchorage	ANC	Anchored
	AUN	Unanchored
	--	Unknown anchorage
Code provisions	CDN	No code (non-engineered)
	CDL	Low code
	CDM	Moderate code
	CDH	High code
	--	Code provisions unknown

For example, a potable water treatment plant with a capacity of 220 MGD, which has been anchoraged and designed following a modern design regulation would be described as follows: PWR/PWL/ANC/CDH.

[19]http://www.vce.at/SYNER-G/pdf/deliverables/D2.05_Definition%20of%20system%20components.pdf

On the other hand, the taxonomy for components of the **wastewater system** can be presented in the following manner:

WWR/COMPONENT/ANCHORAGE/CODE

Where WWR indicates that this element belongs to a wastewater system. The options for each one of these attributes are described in Table 26.

Table 26 – Attributes, codes and values for the power grid taxonomy.

Attribute	Code	Value
Component	WWS	Small wastewater treatment plant (<50 MGD)
	WWM	Medium wastewater treatment plant (50-200 MGD)
	WWL	Large wastewater treatment plant (>200 MGD)
	LSS	Small lift station (<10 MGD)
	LSM	Medium lift station (10-50 MGD)
	LSL	Large lift station (>50 MGD)
Anchorage	ANC	Anchored
	AUN	Unanchored
	--	Unknown anchorage
Code provisions	CDN	No code (non-engineered)
	CDL	Low code
	CDM	Moderate code
	CDH	High code
	--	Code provisions unknown

For example, a wastewater lift station with a capacity of 40 MGD, which has been anchoraged and designed following a modern design regulation would be described as follows: WWR/LSM/ANC/CDH.

Communication system

A communication system is comprised by offices dedicated to the reception and dissimination of information (e.g. telephones offices, call centers, TV stations, radio station, telecomunication stations),

supporting transmitter towers and distribution circuits. The classification of such offices is already fairly covered by the general GED4ALL building taxonomy described in the previous sections. The remaining components have been classified strongly based on the classification system proposed by HAZUS. For the purposes of assessing damage due to natural disasters, it is also relevant to identify the presence of anchorage and whether the elements have been designed according to a particular code. The taxonomy for components of a **communication system** can thus be presented in the following manner:

COM/COMPONENT/ANCHORAGE/CODE

Where PWR indicates that this element belongs to a potable water system. The options for each one of these attributes are described in Table 27.

Table 27 – Attributes, codes and values for the power grid taxonomy.

Attribute	Code	Value
Component	TRD	AM or FM radio transmitters
	TTV	TV stations or transmitters
	TWE	Weather stations or transmitters
	TTT	Telecommunication transmitters
	TOT	Other stations or transmitters
	DTC	Distribution circuit
Anchorage	ANC	Anchored
	AUN	Unanchored
	--	Unknown anchorage
Code provisions	CDN	No code (non-engineered)
	CDL	Low code
	CDM	Moderate code
	CDH	High code
	--	Code provisions unknown

For example, a telecommunication tower, which has been not been anchoraged or designed according to any regulation, would be described as follows: COM/TTT/AUN.

Bridges

Bridges are one of the most vulnerable structures within the road or railway systems, and are essential for the socio-economic development of a particular region, and for operations regarding rescue and recovery in case of disasters. There are already some existing classification systems around the world: ATC-13[20], NIBS[21], Basoz and Kiremidjian[22], HAZUS, Nielson[23] and Syner-G[24]. However, most of these classifications simply provide a list (usually limited) of possible categories. Moreover, often these lists are tailored to the structures that exist in a given region (e.g. North America), and thus not applicable on a global scale.

For this project, we propose adopting the taxonomy developed within the Syner-G project. This classification system considered the aforementioned taxonomies, and follows the same approach presented for buildings: a comprehensive collapsable system, which can be easily simplified with no additional information is available. The Syner-G taxonomy identified the following features as critical to classify the structural performance of bridges: construction material, type of superstructure, type of deck, pier to deck connection, number and type of piers, number and length of spans, irregularities and code provisions. Based on these findings, the following attributes were chosen to define the taxonomy for bridges:

- Main material of construction: general material (MM1), detailed material (MM2)
- Superstructure: type of superstructure (TS1), type of deck (TS2)
- Deck characteristics (DC)
- Deck structural system (DS)
- Pier to deck connection (PDC)
- Pier to superstructure connection (PSC)
- Number of piers (NP)
- Section of the pier: shape of the section (TS1), type of section (TS2)
- Height of the pier (HP)
- Spans (SP)
- Spans characteristics (SC)
- Type of connection to the abutments (TCA)
- Bridge configuration (BC)
- Level of seismicity (LS)

The taxonomy for bridges can thus be presented in the following manner:

[20] ATC. 1985. Earthquake Damage Evaluation Data for California. Report No. ATC-13, Applied Technology Council.
[21] NIBS - Risk Management Solutions (RMS) 1996. Development of a standardized loss earthquake estimation methodology, prepared for the National Institute of Building Sciences by Risk Management Solutions, Inc., Menlo Park, CA.
[22] Basoz N.I, Kiremidjian A.S., King S.A. & Law K.H. 1999. Statistical analysis of bridge damage data from 1994 Northridge, CA earthquake, Earthquake Spectra 15(1): 25-54.
[23] Nielson B. 2005. Analytical fragility curves for highway bridges in moderate seismic zones, Phd Thesis, School of Civil and Environmental Engineering Georgia Institute of Technology.
[24] Syner-G Deliverable D3.6 - Fragility functions for roadway bridges.
www.vce.at/SYNER-G/pdf/deliverables/D3.06_Fragility%20functions%20for%20roadway%20bridgesFinal.pdf

BRG/MM1-MM2/TD1-TD2-DC/DSS/PDC/TC1-NP/TS1-TS2-HP/Sp-SC/TCA/BC/LS

Where BRG indicates that this string identifies a bridge. The options for each one of these attributes are described in Table 28. Although the taxonomy string might look excessively complex, it should be noted that in the vast majority of the cases only a few attributes will be available, which reduces significantly the length of the taxonomy string.

Table 28 - Attributes, codes and values for the bridge taxonomy.

Attribute	Code	Level 1 value	Attribute	Code	Level 2 value
General material	C	Concrete	Detailed material	CR	Reinforced concrete
	M	Masonry		PC	Pre-stressed concrete
	S	Steel		HSC	High strength concrete
	I	Iron		ASC	Average strength concrete
	W	Wood		LSC	Low strength concrete
	MIX	Mixed		ASC	Autoclaved aerated concrete
				MUR	Unreinforced masonry
				RM	Reinforced masonry
				ADO	Adobe
				CL	Fired clay brick
				CLBLH	Fired hollow clay tile
				ST	Stone
				STDRE	Dressed stone
				STRUB	Rubble (field stone) or semi-dressed stone
				MOL	Lime mortar
				MOC	Cement mortar
				MOM	Mud mortar
				CB	Concrete masonry block
				H%	High % of voids
				L%	Low % of voids
Super structure	GB	Girder bridge	Type of deck	SS	Solid slab
	AB	Arch bridge		SV	Slab with voids

	SPB	Suspension bridge		B	Box girder
	SB	Slab bridge		MA	Modern arch bridge
				AA	Ancient arch bridge
Deck characteristics	DC	[include the width of the deck in meters]			
Deck structural system	SSU	Simply supported			
	CO	Continuous			
Pier to deck connection	NIS	Not isolated			
	IS	Isolated			
Pier to superstructure connection	SCP	Single-column pier			
	MCP	Multi-column pier			
Number of piers	NP	[include the number of piers]			
Shape of section of the pier	CY	Cylindrical	Type of section of the pier	SO	Solid
	R	Rectangular		HO	Hollow
	OB	Oblong			
	W	Wall-type			
Height of the pier	HP	[include the height of the pier in meters]			
Spans	SSP	Single span	Spans characteristics	NS	[include number of spans]
	MS	Multi spans		SL	[include the width of the deck in meters]
Connection to the abutments	F	Free			
	M	Monolithic			
	IS	Isolated			
Bridge configuration	R	Regular			
	SR	Semi-regular			
	IR	Irregular			
Level of seismicity	NSD	No seismic design			
	SD	Seismically designed			

As previously mentioned, not all categories need to be defined. In fact, in the vast majority of the cases most likely only the main construction material will be known. For example, Reinforced concrete bridge with box girder and a deck monolithically connected to wall-type piers would translate into the following taxonomy string: C-RC/Gb-B//NIS//W.

Energy generation facilities

Facilities to generate energy can be extremely complex, and a uniform taxonomy capable of characterizing every facility at a global scale is probably impractical, and certainly out of the scope of this project. Instead, we propose herein a simple classification system, which only characterizes the facility according to the source of energy and the production capacity. The taxonomy for these elements is represented in the following manner:

EN/SOURCE/CAPACITY

Where EN indicates that this element represents an energy generation facility. The options for each the source of energy and power capacity are described in Table 29.

Table 29 - Attributes, codes and values for energy generation facilities.

Attribute	Code	Value
Energy Source	OIL	Oil
	GEO	Geothermal
	NUC	Nuclear
	HYD	Hydroelectric
	WND	Wind
	SOL	Solar
	TDL	Tidal wave
	GAS	Gas
	BIO	Biomass
	O	Other
	--	Unknown
Power Capacity	PC:	Value (integer)
	--	Unknown power capacity

For example, a nuclear power plant with a power capacity of 400 MW would be described as follows: EN/NUC/PC:400.

Socio-economic Indicators Taxonomy

Natural hazards are a complex phenomenon featuring large number of interactions that result into loss of lives, livelihoods and interruption of systems. The potential impacts result from the collective behaviour of: the built environment, earth's biophysical systems and communities socio-economic characteristics. The socio-economic indicators are related to the capacity of populations to prepare, respond and recover from potential damage. For example, education theme is related to awareness, which is essential for a population to avoid and cope with a disaster.

The Socio-economic Indicators Taxonomy aims at identifying and describing a set of variables which provide a basis for understanding and measuring resilience, social vulnerability and economic vulnerability. The taxonomy system is divided into eight main themes (economy, education, environment, government and institutional capacity, index, health, infrastructure and population), each theme is later subdivided to different levels of detail. The indicators taxonomy is designed to account for the following criteria:

1. Applicability at various geographical levels (national, regional and local).
2. Qualitative and quantitative indicators (numbers, ratios and indices).
3. Relevance for multi-hazard risk assessment.

The eight main themes in the Socio-economic Indicator Taxonomy are the following:

1. **Economy** - measures the welfare and social security levels of communities
2. **Education** - provides information about invested resources and expected outcome of education, access and participation to education
3. **Environment** - defines the underlying conditions that make an environment susceptible to damage, disaster experience and prevalence
4. **Governance and institutional capacity** - institutional performance and regulatory efficiency, corruption control and stability of political system
5. **Health** - population health conditions and health sector capabilities
6. **Index** - range of indexes that cover different sectors, for example, the Disaster Risk Index used by the United Nation Development programme to monitor the global evolution of risk.
7. **Infrastructure** - Transportation and communication infrastructure, status and access to utility lifelines
8. **Population** - defines community demographics: structure, distribution and size.

Each theme is then divided into a number of sub-themes, as represented in Figure 10.

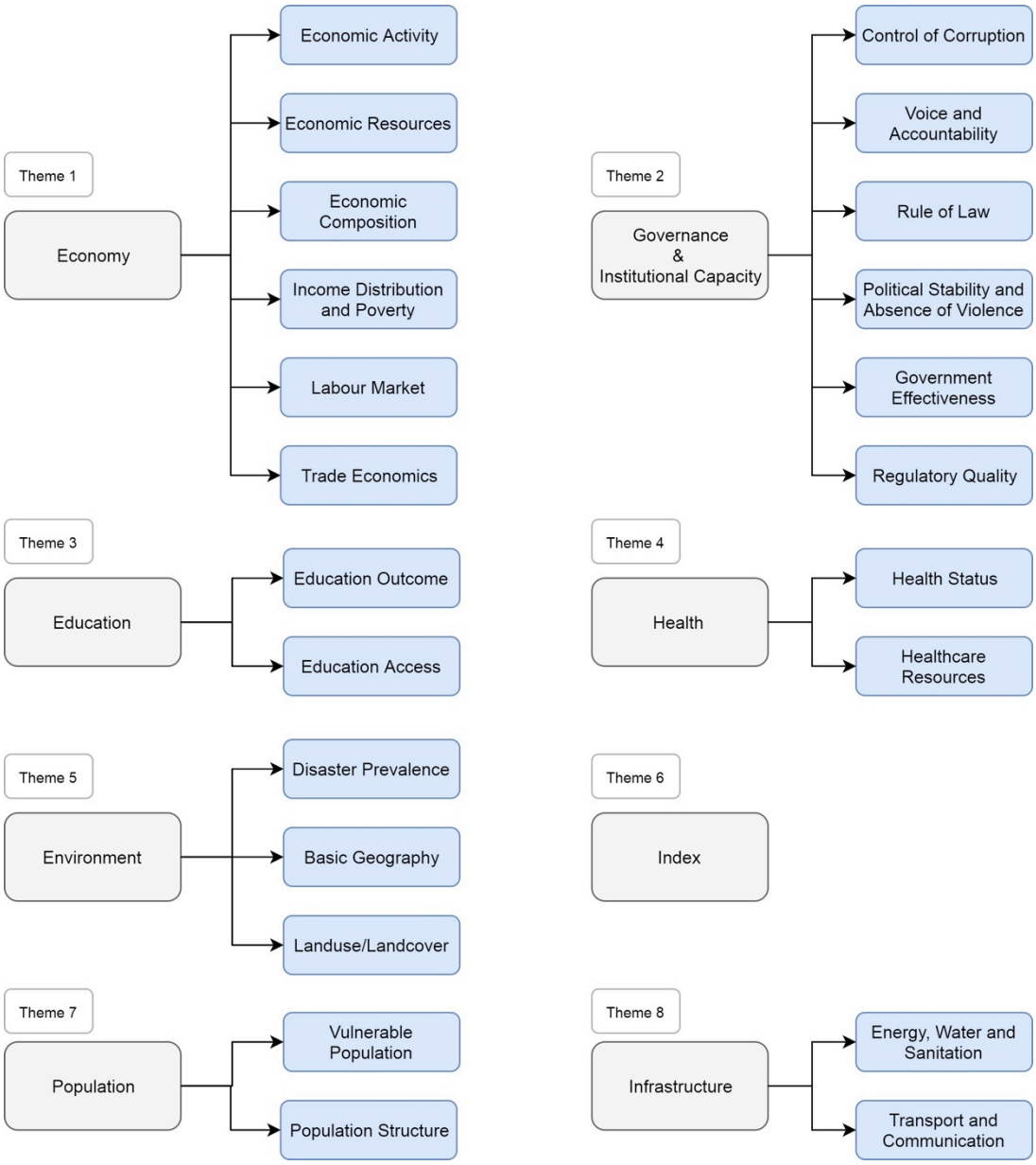


Figure 10 - Schema for socio-economic indicators taxonomy system.

The sub-themes composed by 215 variables. For example, Figure 11 illustrates the full structure of the taxonomy for the population theme.

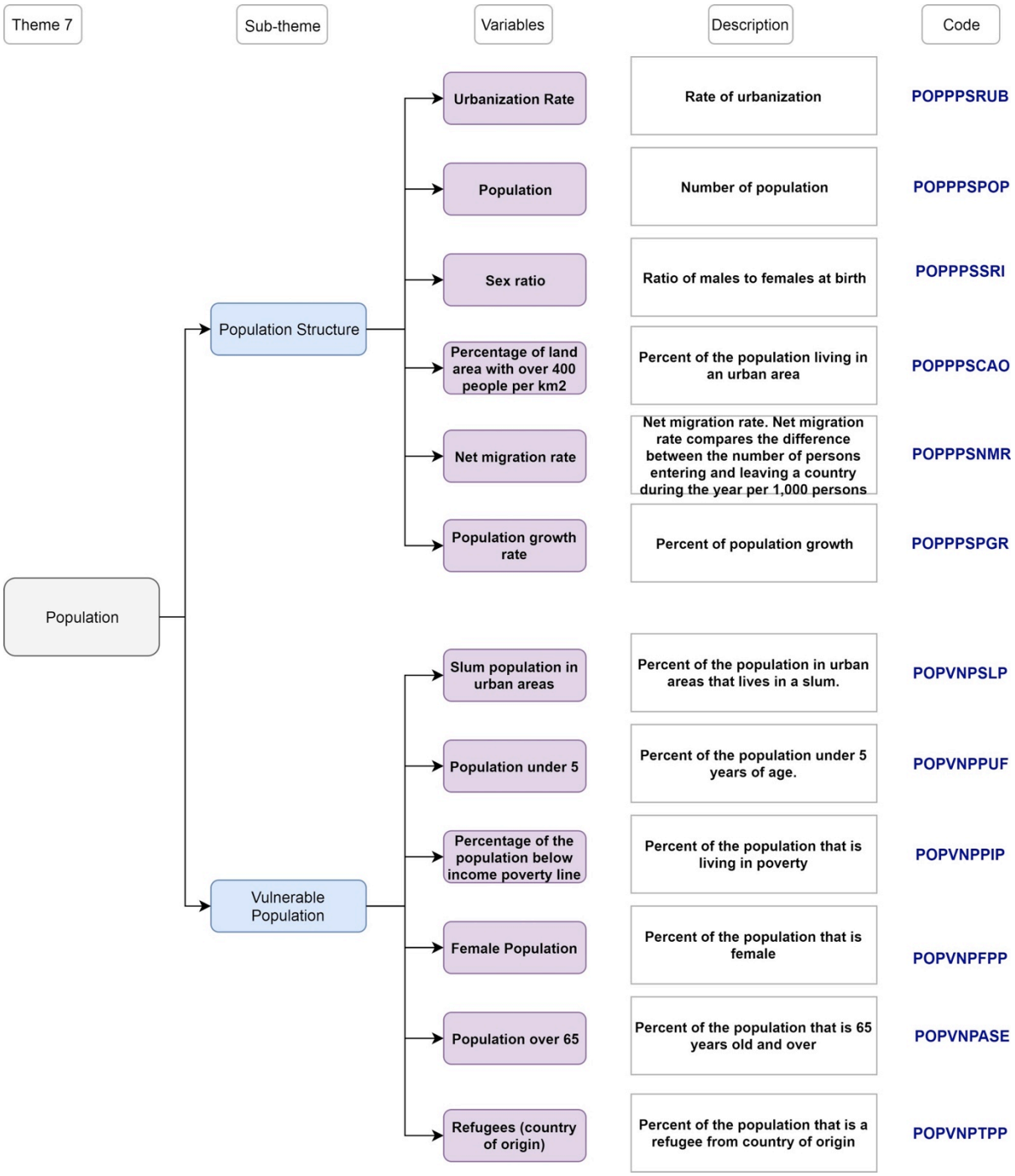


Figure 11 - Schema for Population theme.

The taxonomy string (code) is comprised by three parts: theme, sub-theme and variable name, leading to a unique code comprised by the first letters of each level name. Figure 12 illustrates how the taxonomy string is constructed by the variable urbanization rate. All of the themes, subthemes and variables are presented in Appendix B.

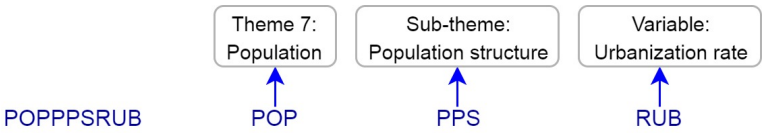


Figure 12 - Code system for the variable urbanization rate.

In addition, a description is provided for each variable specifying the unit of measurement (e.g. number, ratio, index, rate).

The Socio-economic Indicators Taxonomy has been used in GEM's national socio-economic database for several countries in South America, the Caribbean, Central America, East Africa and South-East Asia. This information is collected mostly of the respective national statistical offices. As an example, Figure 13 shows the socio-economic variables for Tanzania for the themes economy, population, education and infrastructure. This taxonomy is also compatible with GEM's OpenQuake open source tools.

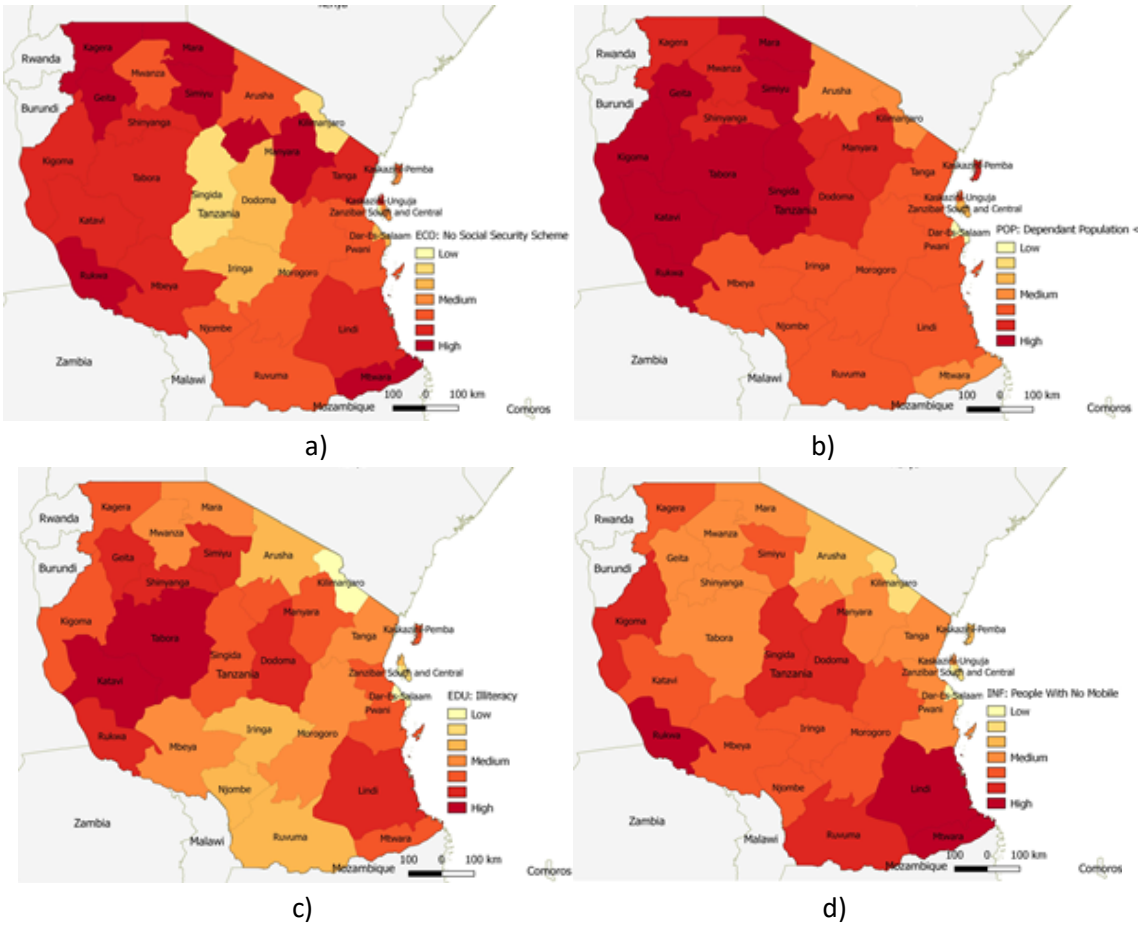


Figure 13 - Socio-economic data for Tanzania considering variables from four different themes: a) economy, b) population, c) education and d) infrastructure.

Crops, Livestock and Forestry Taxonomy

The taxonomy for crops (or agriculture), forestry and livestock was defined based on existing classification systems supported by the Food and Agriculture Organization (FAO).

For crops, the classification system[25] in the 2000 agricultural census programme was adopted. This system comprises a wide range of attributes such as growing cycle (temporary/permanent), crop species, crop variety, season, land type, amongst others. The taxonomy proposed herein uses the first and second categorization levels proposed by FAO, as well as the growing cycle (e.g. permanent or temporary). The taxonomy for crops is represented in the following manner:

LEVEL1+LEVEL2

Where CRP indicates that this element is representing a particular crop. The available options for level 1 and 2 are described in Table 30. A simple numerical code was attributed to each class or sub-class of crop in order to maintain consistency with the original FAO classification.

Table 30 - Codes and values for the crops taxonomy.

Level 1		Level 2	
Code	**Value**	**Code**	**Value**
CRP1	Cereals	1	Wheat
		2	Maize
		3	Rice
		4	Sorghum
		5	Barley
		6	Rye
		7	Oats
		8	Millets
		9	Other
CRP2	Vegetables and melons	1	Leafy or stem vegetables
		2	Fruit-bearing vegetables
		3	Root, bulb, or tuberous vegetables
		4	Mushrooms and truffles

[25] FAO Classification system for crops:
http://www.fao.org/fileadmin/templates/ess/documents/world_census_of_agriculture/appendix3_r7.pdf

		5	Other
CRP 3	Fruits and nuts	1	Tropical and subtropical fruits
		2	Citrus fruits
		3	Grapes
		5	Berries
		6	Pome fruits and stone fruits
		7	Nuts
		8	Other
CRP4	Oilseed crops	1	Soya beans
		2	Groundnuts
		3	Other
CRP5	Root/tuber crops with high starch or inulin content	1	Potatoes
		2	Sweet potatoes
		3	Cassava Yams
		4	Other
CRP6	Beverage and spice crops	1	Beverage crops
		2	Spice crops
		3	Other
CRP7	Leguminous crops	1	Beans
		2	Broad beans
		3	Chick peas
		4	Cow peas
		5	Lentils
		6	Lupins
		7	Peas
		8	Pigeon peas
		9	Leguminous crops
		10	Other
CRP 8	Sugar crops	1	Sugar beet
		2	Sugar cane

		3	Sweet sorghum
		4	Other
CRP9	Other crops	1	Grasses and other fodder crops
		2	Fibre crops
		3	Medicinal, aromatic, pesticidal, or similar crops
		4	Rubber
		5	Flower crops
		6	Tobacco
		7	Other
CRP	Unknown crop		

For example, a rice field would be described as: CRP1+3.

The taxonomy for livestock also follows closely the approach adopted for crops, which is strongly based on the classification system supported by FAO. The taxonomy for livestock is represented in the following manner:

LEVEL1+LEVEL2

Where LVS indicates that this element is representing a particular livestock. The available options for level 1 and 2 are described in Table 31. A simple numerical code was attributed to each class or sub-class of livestock in order to maintain consistency with the original FAO classification.

Table 31 - Codes and values for the livestock taxonomy.

Level 1		Level 2	
Code	**Description**	**Code**	**Description**
LVS1	Large ruminants	1	Cattle
		2	Buffaloes
		3	Yaks
LVS2	Small ruminants	1	Sheep
		2	Goats
LVS3	Pigs or swines		
LVS4	Equines	1	Horses
		2	Mules and hinnies

		3	Asses
		4	Other (e.g. zebras)
LVS5	Camels and camelids	1	Camels
		2	Llamas and alpacas
LVS6	Poultry	1	Chickens
		2	Ducks
		3	Geese
		4	Turkeys
		5	Guinea fowls
		6	Pigeons
		7	Other
LVS7	Other animals	1	Deer, elk, reindeer
		2	Fur-bearing animals such as foxes
		3	Dogs and cats
		4	Rabbits and hares
		5	Other (e.g. emus, ostriches,
LVS8	Insects	1	Bees
		2	Silkworms
		3	Other worms or insects
LVS	Unknown livestock		

For example, a herd of sheep would be described as follows: LVS2+1.

For what concerns forestry, the existing classification systems vary considerably according to the purpose, products, land use, height of the forest and economic value. Moreover, FAO does not seem to support a particular classification, as observed for crops and livestock. For this project, we propose to use the taxonomy developed by UNESCO. This system[26] classified forestry according to a number of classes and subclasses based on the type of trees or vegetation, and provides clear examples around the world. We propose considering the first and second categorization levels. Additional subclasses are available, but at this stage it would unnecessarily increase the complexity of the classification system. The taxonomy for forestry is represented in the following manner:

LEVEL1+LEVEL2

[26] UNESCO (1973) International classification and mapping of vegetation, United Nations Educational, Scientific and Cultural Organization, ISBN 92-3-001046-4, 93 p., Paris, France

Where FRT indicates that this element is representing a particular forestry. The available options for level 1 and 2 are described in Table 32, with a few examples around the world.

Table 32 - Codes and values for the forestry taxonomy.

Level 1		Level 2	
Code	**Description**	**Code**	**Description**
FRT1	**Closed forest** - formed by threes at least 5 m tall with their crowns interlocking.	1	**Mainly evergreen forest** - the canopy is never without green foliage, but individual trees may shed their leaves (e.g. Sumatra, Atrato Valley (Colombia), Atlantic slopes of Costa Rica, Amazon Basin).
		2	**Mainly deciduous forest** - majority of trees shed their foliage simultaneously in connection to unfavourable season (e.g. North and South America, Southern slopes of the Himalayas and Europe)
		3	**Extremely xeromorphic forest** - dense stands of trees, composed by species such as bottle or tuft rees with succulent leaves (e.g. thorn forest in Southwestern North America and Southwestern Africa)
FRT2	**Woodland** - composed of trees at least 5 m tall with crowns not usually touching but with a coverage of at last 40%.	1	**Mainly evergreen woodland** - the canopy is never without green foliage, but individual trees may shed their leaves (e.g. Mediterranean Basin).
		2	**Mainly deciduous woodland** - majority of trees shed their foliage simultaneously in connection to unfavourable season (e.g. Southern California and American Southeast, Mediterranean Basin)
		3	**Extremely xeromorphic woodland** - dense stands of trees, composed by species such as bottle or tuft rees with succulent leaves (e.g. Southwestern North America and Southwestern Africa)
FRT3	**Scrub** - Shrubland or thicket, composed by vegetation or trees between 0.5 and 5 m.	1	**Mainly evergreen scrub** - the canopy is never without green foliage, but individual species may shed their leaves (e.g. Mediterranean dwarf palm shrubland, Chaparral shrubland in California or Hawaiian tree fern thicket).
		2	**Mainly deciduous scrub** - majority of scrub shed their foliage simultaneously in connection to unfavourable season (e.g. peat mosses in Scotland)
		3	**Extremely xeromorphic (subdesert) shrubland** - very open stands of shrubs, often composed by vegetation with green branches without leaves, some of them with thorns (e.g. mulga scrub in Australia).
FRT4	**Dwarf-scrub and related communities** - vegetation rarely exceeding 0.5 m in height.	1	**Mainly evergreen dwarf-scrub** - mostly dense dwarf-scrub evergreen dominating the landscape (e.g. East Mediterranean mountains).

		2	**Mainly deciduous scrub** - majority of vegetation shed their foliage simultaneously in connection to unfavourable season (e.g. Sierra Nevada in California)
		3	**Extremely xeromorphic dwarf-shrubland** - more or less open formations consisting of dwarf-shrubs or succulent species (e.g. Australia).
		4	**Tundra** - slowly growing, low formations, consisting mainly of dwarf-shrubs beyond the subpolar tree line (e.g. Alaska, Northern Canada, Greenland, Norway, Finland and Siberia).
		5	**Mossy bog formations with dwarf-shrub** - peat accumulations formed mainly by mosses which generally cover the surface as well (e.g. Western Siberian Lowlands in Russia).
FRT5	**Herbaceous vegetation** - mostly comprised by grasslands, which cover surfaces continuously.	1	**Tall graminoid vegetation** - Mostly composed by tall grasslands with heights of over 2 m. Forbs can be presented but their coverage is less than 50% (e.g. Northeast Bolivia, African savannah and upper Nile Valley).
		2	**Medium tall grassland** - Mostly composed by grasslands with heights between 0.5 and 2 m. Forbs can be presented but their coverage is less than 50% (e.g. Sahel region in Africa, Eastern Kansas, glasslands in New Zealand)
		3	**Short grassland** - Mostly composed by grasslands with heights below 0.5 m. Forbs can be presented but their coverage is less than 50% (e.g. alpine regions of Kenya, Colombia and Venezuela).
		4	**Forb vegetation** - the plant community if mostly composed by forbs (more than 50%). (e.g. Sonoran Desert)
		5	**Hydromorphic fresh-water vegetation** - mostly composed by aquatic plants that are structurally supported by water, in wet or flooded regions most of the year (e.g. Amazon Basin)

For example, the Colombian rainforest would be classified as a FRT1+1, while the vegetation in the Sonoran Desert would be represented by FRT5+4.

Final remarks

The collection of exposure data at a global scale requires a uniform system to define the main attributes that may influence the likelihood of the elements exposed to the hazard to suffer damage or loss. Without such system, it becomes impossible to directly compare exposure datasets for different parts of the world, evaluate the amount of property value and population exposed to different level of hazards, or to select sets of vulnerability functions to perform disaster risk assessment.

This deliverables reviewed dozens of classification systems for distinct elements, and proposed a uniform, comprehensive and flexible taxonomy capable of characterizing buildings, lifelines, crops, livestock, forestry and socio-economic data. These classifications systems are currently being employed in the development of exposure datasets for Tanzania, and will be explored in the demonstration of this Challenge Fund in the five neighbouring African countries (Ethiopia, Uganda, Kenya, Malawi and Mozambique).

Despite the recognized need for a uniform taxonomy to classify exposure data for the purposes of disaster risk assessment, it is also fundamental to understand that such systems can be overwhelming (and even intimidating) for less experienced users. To overcome such issue, we have already proposed within this deliverable a simplified version of the most complex classification system (i.e. GED4ALL building taxonomy). Moreover, we have also described a number of supporting tools that have been used by hundreds of risk modellers and mappers around the world in risk assessment exercises. We propose that similar tools should be developed or adapted for this taxonomy, in order to facilitate its use and purpose.

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Appendix A – GED4ALL Building Taxonomy

Table 1: Direction

ID	Attribute 1	Attribute 1
	Direction of building under consideration	**Definition**
--	Direction X	First principal horizontal direction of the building plan. The direction is not known. Example: street survey of buildings which don't have a distinguishable street façade or main entrance, including circular or curved buildings
DXP	Parallel to street	The direction parallel to the façade associated with the street address or the main entrance. This direction is orthogonal to Direction Y.
--	Direction Y	Second principal horizontal direction of the building plan. The direction is not known. Example: street survey of buildings which don't have a distinguishable street façade or main entrance, including circular or curved buildings
DYO	Perpendicular to street	The direction perpendicular (orthogonal) to the façade associated with the street address or the main entrance. This direction is orthogonal to Direction X.

Comment: This attribute is provided to enable the users to enter information about the lateral load-resisting system of a building and its material. Every building has two principal horizontal directions orthogonal (perpendicular) to one another, and it is possible that a building is characterized by different lateral load-resisting systems in these two directions. The terms Direction X and Direction Y are used to overcome difficulties associated with attempts to identify longitudinal and transverse direction of a building. Instead, the directions are related to the orientation of the main façade, usually facing street (also known as street façade).

Table 2: Material of the Lateral Load-Resisting System

ID	Attribute 2	ID	Level 1 (L1)	ID	Level 1.1 (L1.1)
	Material type		**Material technology**		**Material properties**
--	Unknown material				
C	Concrete, unknown reinforcement	--	Unknown concrete technology		
CU	Concrete, unreinforced *	CIP	Cast-in-place concrete		
CR	Concrete, reinforced	PC	Precast concrete		
SRC	Concrete, composite with steel section	CIPPS	Cast-in-place prestressed concrete		
		PCPS	Precast prestressed concrete		
S	Steel	--	Steel, unknown	--	Steel connections, unknown
		SL	Cold-formed steel members	WEL	Welded connections
		SR	Hot-rolled steel members	RIV	Riveted connections
		SO	Steel, other	BOL	Bolted connections
ME	Metal (except steel)	--	Metal, unknown		
		MEIR	Iron		
		MEO	Metal, other		
M	Masonry, unknown reinforcement	--	Masonry unit, unknown	--	Mortar type unknown
MUR	Masonry, unreinforced	ADO	Adobe blocks	MON	No mortar
MCF	Masonry, confined	ST	Stone, unknown technology	MOM	Mud mortar
MR	Masonry, reinforced	STRUB	Rubble (field stone) or semi-dressed stone	MOL	Lime mortar
		STDRE	Dressed stone	MOC	Cement mortar
		CL	Fired clay unit, unknown type	MOCL	Cement:lime mortar
		CLBRS	Fired clay solid bricks	--	Stone, unknown type
		CLBRH	Fired clay hollow bricks	SPLI	Limestone
		CLBLH	Fired clay hollow blocks or tiles	SPSA	Sandstone
		FABRS	Flyash solid bricks (FALG bricks)		
		CB	Concrete blocks, unknown type	SPTU	Tuff
		CBS	Concrete blocks, solid	SPSL	Slate
		CBH	Concrete blocks, hollow	SPGR	Granite
		CBAA	Concrete blocks, aerated autoclaved (AAC)		
		MO	Masonry unit, other	SPBA	Basalt
				SPO	Stone, other type
Only for Masonry, reinforced (MR)		**ID**	**Level 2 (L2)**		
			Material technology (additional)		
		MR99	*Masonry reinforcement, unknown*		

		RS	*Steel-reinforced*	
		RW	*Wood-reinforced*	
		RB	*Bamboo-, cane- or rope-reinforced*	
		RCM	*Fibre reinforcing mesh*	
		RCB	*Reinforced concrete bands*	
E	Earth, unknown reinforcement	--	Unknown earth technology	
EU	Earth, unreinforced	ETR	Rammed earth	
ER	Earth, reinforced	ETC	Cob or wet construction	
		ETO	Earth technology, other	
W	Wood	--	Wood, unknown	
		WHE	Heavy wood	
		WLI	Light wood members	
		WS	Solid wood	
		WWD	Wattle and daub	
		WBB	Bamboo	
		WO	Wood, other	
MIX	Mixed materials (hybrid or composite)	MIX(material_a-material_b), two main materials of the LLRS from the following material list:		
		CR	Concrete, reinforced	
		CU	Concrete, unreinforced	
		S	Steel	
		M	Masonry, unknown reinforcement	
		MUR	Masonry, unreinforced	
		MCF	Masonry, confined	
		MR	Masonry, reinforced	
		MUR-ST	Stone masonry, unreinforced	
		ER	Earth, reinforced	
		EU	Earth, unreinforced (or mud)	
		W	Wood	
INF	Informal materials			
MATO	Other material			

Comment:
* For level 1, only CIP or PC options available

Table 3: Lateral Load-Resisting System

ID	Attribute 3	ID	Level 1 (L1)
	Type of lateral load-resisting system		**System ductility**
--	Unknown lateral load-resisting system	--	Ductility unknown
LN	No lateral load-resisting system	DNO	Non-ductile
LFM	Moment frame	DLO	Low ductility
LFINF	Infilled frame	DMO	Moderate ductility
LFBR	Braced frame	DHI	High Ductility
LPB	Post and beam	DBD	Equipped with base isolation and/or energy dissipation devices
LWAL	Wall		
LDUAL	Dual frame-wall system	**ID**	**Level 2 (L2)**
LFLS	Flat slab/plate or waffle slab		**Seismic code level**
LFLSINF	Infilled flat slab/plate or infilled waffle slab	--	Ductility unknown
--	Hybrid lateral load-resisting system	CDN	No-code
LO	Other lateral load-resisting system	CDL	Low code
		CDM	Moderate code
		CDH	High code
		ID	**Level 3 (L3)**
			Columns-Wall density
		DCW*	Float specifying the density or ratio between the area of columns and/or walls and the area of the building plan. (DCW <= 1)
		* Level 3 it is not valid for the following LLRS: (LN) No lateral load-resisting system, (LH) Hybrid lateral load-resisting system, (LO) Other lateral load-resisting system	
Only for Infilled frame (LFINF)		***ID***	***Level 4 (L4)***
			LLRS (additional) - Infill material
		--	Infill material unknown
		MUR	Unreinforced masonry
		MUR-CL	Unreinforced masonry, fired clay bricks
		MUR-CLB	Unreinforced masonry, fired clay hollow blocks or tiles
		MUR-AAC	Unreinforced masonry, AAC blocks (aerated autoclaved blocks)
		MUR-FAB	Unreinforced masonry, flyash bricks
		MUR-CBH	Unreinforced masonry, hollow concrete blocks
		MUR-CBS	Unreinforced masonry, solid concrete blocks
		MR	Reinforced masonry
		MR-CL	Reinforced masonry, clay brick
		MR-CB	Reinforced masonry, concrete block

	MUR-ST	Unreinforced stone masonry

Only for Hybrid lateral load-resisting system	*ID*	*Attribute*
		LLRS (additional) - Hybrid systems
	LHV **	LHV(sys_a-sys_b), hybrid LLRS in height (a= primary system and secondary system)
	LHP **	LHV(sys_a-sys_b), hybrid LLRS in plan (a= primary system and secondary system)
	**** Options for hybrid systems**	
	LN	No LLRS
	LFM	Moment frame
	LFINF	Infilled frame
	LFBR	Braced frame
	LPB	Post and beam
	LWAL	Wall
	LDUAL	Dual frame-wall system
	LFLS	Flat slab/plate or waffle slab
	LFLSINF	Infilled flat slab/plate or infilled waffle slab
	LO	Other LLRS

Table 4: Height

ID	Attribute 4	ID	Level 1 (L1)
	Number of storeys		**Height of structure (m)**
--	Number of storeys unknown	--	Height unknown
H	H:n, exact number of storeys above ground	HHT	HHT:n, total height of the structure, measured from the ground floor. Float specifying the height of the structures in meters. (HHT>= 1)
HBET	HBET:a-b, range of number of storeys above ground (a=upper bound, and b= lower bound).		
HAPP	HAPP:n, approximate number of storeys above ground.	HHI	HHI:n, inter-storey height (average). Float specifying the average floor height in meters. (HHI>= 1)
		ID	**Level 2 (L2)**
			Number of storeys below ground
		--	Number of storeys below ground unknown
		HBEX	HB:n, exact number of storeys below ground (same as number of basements)
		HBBET	HBBET:a-b, range of number of storeys below ground (a=upper bound, and b= lower bound).
		HBAPP	HBAPP:n, approximate number of storeys below ground
		ID	**Level 3 (L3)**
			Height of ground floor level above grade (m)
		--	Height of ground floor level above grade unknown
		HF	HF:n, exact height of ground floor level above grade
		HFBET	HFBET:a-b, range of height of ground floor level above grade (a= upper bound and b=lower bound).
		HFAPP	HFAPP:n, approximate height of ground floor level above grade
		ID	**Level 4 (L4)**
			Slope of the ground (degrees)
		--	Slope of the ground unknown
		HD	HD:n, slope of the ground (n=float in degrees).

Table 5: Date of Construction or Retrofit

ID	Attribute 5	ID	Level 1 (L1)
	Date of construction		**Physical condition / maintenance**
--	Year unknown	--	Physical condition unknown
Y	Y:n, Exact date of construction or retrofit	YMP	Poor physical condition/maintenance
YBET	YBET:a-b, Upper and lower bound for the date of construction or retrofit	YMM	Moderate physical condition/maintenance
YPRE	YPRE:n, Latest possible date of construction or retrofit	YMG	Good physical condition/maintenance
YAPP	YAPP:n, Approximate date of construction or retrofit		

Comment: There is a possibility of entering information related either to the date of original construction or the retrofit - whichever occurs later. For example, if a building was constructed in 1936 and it was retrofitted in 1991, the user should enter 1991.

Table 6: Occupancy

ID	Attribute 6	ID	Level 1 (L1)
	Building occupancy class		**Building occupancy class - detail**
--	Unknown occupancy type		
--	Residential	RES	Residential, unknown type
		RES1	Single dwelling
		RES2	Multi-unit, unknown type
		RES2A	2 Units (duplex)
		RES2B	3-4 Units
		RES2C	5-9 Units
		RES2D	10-19 Units
		RES2E	20-49 Units
		RES2F	50+ Units
		RES3	Temporary lodging
		RES4	Institutional housing
		RES5	Mobile home
--	Commercial and public	COM	Commercial and public, unknown type
		COM1	Retail trade
		COM2	Wholesale trade and storage (warehouse)
		COM3	Offices, professional/technical services
		COM4	Hospital/medical clinic
		COM5	Entertainment
		COM6	Public building
		COM7	Covered parking garage
		COM8	Bus station
		COM9	Railway station
		COM10	Airport
		COM11	Recreation and leisure
--	Mixed use	MIX	Mixed, unknown type
		MIX1	Mostly residential and commercial
		MIX2	Mostly commercial and residential
		MIX3	Mostly commercial and industrial
		MIX4	Mostly residential and industrial
		MIX5	Mostly industrial and commercial
		MIX6	Mostly industrial and residential
--	Industrial	IND	Industrial, unknown type
		IND1	Heavy industrial
		IND2	Light industrial

--	Agriculture	AGR	Agriculture, unknown type
		AGR1	Produce storage
		AGR2	Animal shelter
		AGR3	Agricultural processing
--	Assembly	ASS	Assembly, unknown type
		ASS1	Religious gathering
		ASS2	Arena
		ASS3	Cinema or concert hall
		ASS4	Other gatherings
--	Government	GOV	Government, unknown type
		GOV1	Government, general services
		GOV2	Government, emergency response
--	Education	EDU	Education, unknown type
		EDU1	Pre-school facility
			School
		EDU3	College/university, offices and/or classrooms
		EDU4	College/university, research facilities and/or labs
--	Other occupancy type	OCO	Other occupancy type

Comment: Adapted from Multi-hazard Loss Estimation Methodology, Earthquake Model, HAZUS®MH Technical Manual, National Institute of Building Sciences and Federal Emergency Management Agency, Washington, DC, 2003, 690 pp.

Table 7: Shape of the Building Plan

ID	Attribute 7	Definition	ID	Level 1 (L1)
BP	**Building Position within the Block**		**PLF**	**Shape of the Building Plan**
--	Building Position within the block unknown		--	Unknown plan shape
BPD	Detached building	Not attached to any other building (free); this applies to buildings that are spaced apart a distance equal to or more than 4% of the height of the lower building	PLFSQ	Square, solid
BP1	Adjoining building(s) on one side	One adjacent building (semi-detached building in North America), e.g. end of a row	PLFSQO	Square, with an interior opening (e.g. a "donut")
BP2	Adjoining buildings on two sides	Corner building with two adjacent buildings (on adjacent sides)	PLFR	Rectangular, solid
BP3	Adjoining buildings on three sides		PLFRO	Rectangular, with an opening
			PLFL	L-shape
			PLFA	A-shape
			PLFB	B-shape
			PLFC	Curved, solid (e.g. circular, elliptical, ovoid)
			PLFCO	Circular, with an opening
			PLFD	Triangular shape, solid
			PLFDO	Triangular shape, with an opening
			PLFE	E-shape
			PLFF	F-shape
			PLFH	H-shape
			PLFS	S-shape
			PLFT	T-shape
			PLFU	U-shape
			PLFX	X-shape
			PLFY	Y-shape
			PLFI	Irregular plan shape

Footprint: Projection of the exterior edge of the building at grade onto the horizontal plane.

Table 8: Structural Irregularity

ID	Attribute 8	ID	Level 1 (L1)*	ID	Level 2 (L2)*
	Regular or irregular		**Plan irregularity**		**Vertical irregularity**
--	Unknown structural irregularity	--	Plan irregular structure	--	Vertical irregular structure
IRRE	Regular structure				
--	Irregular structure				
		ID	**Level 1.1 (L1)***	**ID**	**Level 2.1 (L2.1)***
			Plan irregularity details		**Vertical irregularity details**
		--	No irregularity	--	No irregularity
		TOR	Torsion eccentricity	SOS	Soft story
		REC	Re-entrant corner	CRW	Cripple wall
		IRHO	Other horizontal irregularity	SHC	Short column
				POP	Pounding potential
				SET	Setback
				CHV	Change in vertical structure (includes large overhangs)
				IRVO	Other vertical irregularity
		ID	**Level 1.1.1 (L1.1.1)***	**ID**	**Level 2.1.1 (L2.1.1)***
			Plan irregularity details - secondary		**Vertical irregularity details - secondary**
		IRN	No irregularity	IRN	No irregularity
		TOR	Torsion eccentricity	SOS	Soft story
		REC	Re-entrant corner	CRW	Cripple wall
		IRHO	Other horizontal irregularity	SHC	Short column
				POP	Pounding potential
				SET	Setback
				CHV	Change in vertical structure (includes large overhangs)
				IRVO	Other vertical irregularity

Comment: This table has been updated to reflect the data model used by GEM Risk groups**.** A building can be characterized by primary and secondary plan and vertical irregularity. It is also possible for a building to have plan irregularities and vertical irregularities.

* Only applicable for irregular structures

Table 9: Ground floor hydrodynamics

ID	Attribute 9	
	Ground floor hydrodynamics	**Definition**
--	Ground floor hydrodynamics unknown	The openings are related to the building façades that are potentially exposed to flows
GFO	Ground floor plan fully open (no walls)	
GFH	Ground floor plan partially open (i.e. with at least 50% of walls).	
GFM	Not open, many doors and/or windows (i.e. more than 20% of wall surface area).	
GFN	Not open, few doors and/or windows (i.e. less than 20% of wall surface area).	

Table 10: Exterior Walls

ID	Attribute 10	Description	ID	Level 1 (L1)
	Exterior walls	**Material that covers most of the wall area**		**Openings**
--	Unknown material		--	Openings unknown
EWC	Concrete	Cast in-place or precast concrete panels	WOL	Large openings (i.e. more than 50% of the wall surface area is occupied by windows and/or doors)
EWG	Glass	Glass curtain walls, storefront glass systems	WOM	Moderate openings (i.e. from 20% to 50% of the wall surface area is occupied by windows and/or doors)
EWE	Earth	Adobe, cob, rammed earth, bajareque, quincha, sod, banco, etc.	WOS	Small openings (i.e. less than 20% of the wall surface area is occupied by windows and/or doors)
EWMA	Masonry	Various masonry units (clay bricks/blocks/stone/ceramic tile) in the form of veneers, cavity walls, infill walls	WON	No openings
EWME	Metal	Aluminum planks, corrugated iron or steel sheets (CGI)		
EWV	Vegetative	Matting, palm, thatch, straw, etc.	**ID**	**Level 2 (L2)**
EWW	Wood	Wood planks, wood shingles		**Window protection**
EWSL	Stucco finish on light framing	Metal or wood studs with wood or insulated underlay	--	Protection unknown
EWPL	Plastic/vinyl, various	Plastic siding; plastic sheet	PRO	Protected windows
EWCB	Cement-based boards	Fibre cement or asbestos boards, e.g. GRC, FRC	PNO	Non protected windows
EWO	Material of exterior wall, other			

Table 11: Roof

ID	Attribute 11	ID	Level 1 (L1)	ID	Level 2 (L2)	ID	Level 2.1 (L2.1)	ID	Level 3 (L3)
	Roof shape		Roof covering		Roof system material		Roof system type		Roof connections[1]
--	Unknown roof shape	--	Unknown roof covering	--	Roof material, unknown			--	Roof connection unknown
RSH1	Flat	RMN	Concrete roof without additional covering	--	Masonry	RM	Masonry, unknown	RWCN	Roof-wall diaphragm connection not provided
RSH2	Pitched with gable ends	RMT1	Clay or concrete tile			RM1	Vaulted masonry	RWCP	Roof-wall diaphragm connection present
RSH3	Pitched and hipped	RMT2	Fibre cement or metal tile			RM2	Shallow-arched masonry	RTDN	Roof tie-down not provided
RSH4	Pitched with dormers	RMT3	Membrane roofing			RM3	Composite masonry and concrete roof system	RTDP	Roof tie-down present
RSH5	Monopitch	RMT4	Slate	--	Earthen	RE	Earthen, unknown		
RSH6	Sawtooth	RMT5	Stone slab			RE1	Vaulted earthen roof		
RSH7	Curved	RMT6	Metal or asbestos sheets	--	Concrete	RC	Concrete, unknown		
RSH8	Complex regular	RMT7	Wooden and asphalt shingles			RC1	Cast-in-place beamless reinforced concrete roof		
RSH9	Complex irregular	RMT8	Vegetative			RC2	Cast-in-place beam-supported reinforced concrete roof		
RSHO	Roof shape, other	RMT9	Earthen			RC3	Precast concrete roof with reinforced concrete topping		
		RMT10	Solar panelled roofs			RC4	Precast concrete roof without reinforced concrete topping		
		RMT11	Tensile membrane or fabric roof	--	Metal or steel	RME	Metal or steel, unknown		
		RMTO	Roof covering, other			RME1	Metal or steel beams or trusses supporting light roofing		
						RME2	Metal or steel beams supporting precast concrete slabs		
						RME3	Composite steel deck and concrete slab		
				--	Wood	RWO	Wood, unknown		
						RWO1	Wooden structurewith light roof covering		
						RWO2	Wooden beams or trusses with heavy roof covering		
						RWO3	Wood-based sheets on rafters or purlins		
						RWO4	Plywood panels or other light-weight panels for roof		
						RWO5	Bamboo, straw or thatch roof		
					Fabric	RFA	Fabric, unknown		
						RFA1	Inflatable or tensile membrane roof		
						RFAO	Fabric, other		
				--	Roof material, other	RO	Roof material, other		

Comments: 1 - Roof connections

There are two aspects: (a) does the roof have horizontal shear transfer to the walls, and (b) is the roof internally adequately connected? The latter includes Simpson ties preventing wind lift-off. The former is probably sometimes discernible from the street. The latter can be determined only by interior inspection.

Table 12: Floor

ID	Attribute 12	ID	Level 1 (L1)	ID	Level 2 (L2)
	Floor system material		**Floor system type**		**Floor connections**
--	Floor material, unknown			--	Floor-wall diaphragm connection unknown
FN	No elevated or suspended floor material (single-storey building)			FWCN	Floor-wall diaphragm connection not provided
FM	Masonry	--	Masonry, unknown	FWCP	Floor-wall diaphragm connection present (the role of the connection is to restrain wall out-of-plane forces and to transfer in-plane forces to wall)
		FM1	Vaulted masonry		
		FM2	Shallow-arched masonry		
		FM3	Composite cast-in-place reinforced concrete and masonry floor system		
FE	Earthen	--	Earthen, unknown		
FC	Concrete	--	Concrete, unknown		
		FC1	Cast-in-place beamless reinforced concrete floor		
		FC2	Cast-in-place beam-supported reinforced concrete floor		
		FC3	Precast concrete floor with reinforced concrete topping		
		FC4	Precast concrete floor without reinforced concrete topping		
FME	Metal	--	Metal, unknown		
		FME1	Metal beams, trusses, or joists supporting light flooring		
		FME2	Metal beams supporting precast concrete slabs		
		FME3	Composite steel deck and concrete slab		
FW	Wood	--	Wood, unknown		
		FW1	Wooden beams or trusses and joists supporting light flooring		
		FW2	Wooden beams or trusses and joists supporting heavy flooring		
		FW3	Wood-based sheets on joists or beams		
		FW4	Plywood panels or other light-weight panels for floor		
FO	Floor material, other				

Table 13: Foundation System

ID	Attribute 13
	Foundation System
--	Unknown foundation system
FOSSL	Shallow foundation, with lateral capacity
FOSN	Shallow foundation, no lateral capacity
FOSDL	Deep foundation, with lateral capacity
FOSDN	Deep foundation, no lateral capacity
FOSO	Foundation, other

Comment: Lateral capacity denotes some form of specific lateral support e.g. tie-beams, foundation walls, inclined piles, piles or piers on wide spread footings, etc.

Table 14: Fire protection

ID	Attribute 14
	Fire protection
--	Fire protection unknown
FIP	Fire insulation, presence
FIN	Fire protection, non presence

Appendix B - Socio-economic Indicators Taxonomy

code	theme	subtheme	name
ECOEACVLE	Economy	Economic Activity	Value lost due to electrical outages
ECOEACBEX	Economy	Economic Activity	Budget expenditures
ECOEACCDC	Economy	Economic Activity	Carbon Dioxide Emissions
ECOEACCPI	Economy	Economic Activity	Consumer price index
ECOEACEXS	Economy	Economic Activity	Exports
ECOEACFCE	Economy	Economic Activity	Final consumption expenditure
ECOEACFDP	Economy	Economic Activity	Foreign direct investment, net inflows
ECOEACGCE	Economy	Economic Activity	General government final consumption expenditure
ECOEACGFC	Economy	Economic Activity	Gross fixed capital formation
ECOEACGGE	Economy	Economic Activity	Greenhouse gas emissions
ECOEACGNC	Economy	Economic Activity	GDP Nominal per population
ECOEACGRB	Economy	Economic Activity	General government revenue
ECOEACGRN	Economy	Economic Activity	GDP Nominal
ECOEACGS1	Economy	Economic Activity	Gross savings
ECOEACGUS	Economy	Economic Activity	GNI per capita
ECOEACHEE	Economy	Economic Activity	Net Household final consumption expenditure
ECOEACICR	Economy	Economic Activity	Implied PPP conversion rate
ECOEACIDA	Economy	Economic Activity	Inflation, GDP deflator
ECOEACIMP	Economy	Economic Activity	Imports
ECOEACIPD	Economy	Economic Activity	Income payments (BoP)
ECOEACMEP	Economy	Economic Activity	Military expenditures
ECOEAC039	Economy	Economic Activity	Adjusted savings: consumption of fixed capital
ECOEACPCM	Economy	Economic Activity	PPP conversion factor (GDP) to market exchange rate ratio
ECOEACPEE	Economy	Economic Activity	Remittance Inflows
ECOEACPEP	Economy	Economic Activity	Public expenditure on education
ECOEACTIN	Economy	Economic Activity	Total investment
ECOEACTR1	Economy	Economic Activity	International tourism receipts as a percent of total exports
ECOEACTRA	Economy	Economic Activity	Trade
ECOEACTRE	Economy	Economic Activity	International tourism receipts as a percent of GDP
ECOERETRG	Economy	Economic Resources	Total reserves (includes gold)
ECOERE040	Economy	Economic Resources	Adjusted savings: mineral depletion
ECOERE042	Economy	Economic Resources	Adjusted savings: energy depletion
ECOERE226	Economy	Economic Resources	Net ODA received per capita
ECOEREBRE	Economy	Economic Resources	Budget revenues
ECOERECNT	Economy	Economic Resources	Net taxes on products
ECOEREDEX	Economy	Economic Resources	Debt - external
ECOEREGGD	Economy	Economic Resources	General government gross debt
ECOEREGNS	Economy	Economic Resources	Gross national savings

ECOEREGPC	Economy	Economic Resources	GDP at purchasing power parity per capita
ECOEREIRP	Economy	Economic Resources	Inflation rate (consumer prices)
ECOERELAP	Economy	Economic Resources	Land use - arable land
ECOERELCP	Economy	Economic Resources	Land use - permanent crops
ECOEREMQP	Economy	Economic Resources	Money and quasi money (M2)
ECOERENLB	Economy	Economic Resources	General government net lending/borrowing
ECOEREPDP	Economy	Economic Resources	Public debt
ECOERERDE	Economy	Economic Resources	Research and development expenditure
ECOERETRV	Economy	Economic Resources	Tax revenue
ECOERETTR	Economy	Economic Resources	Total tax rate
ECOECPAGR	Economy	Economic Composition	GDP composition by sector - agriculture
ECOECPWRT	Economy	Economic Composition	Wholesale, retail trade, restaurants and hotels (ISIC G-H)
ECOECPTSC	Economy	Economic Composition	Transport, storage and communication (ISIC I)
ECOECPSER	Economy	Economic Composition	GDP - composition by sector - services
ECOECPOTA	Economy	Economic Composition	Other Activities (ISIC J-P)
ECOECPMMU	Economy	Economic Composition	Mining, Manufacturing, Utilities (ISIC C-E)
ECOECPIND	Economy	Economic Composition	GDP composition by sector - industry
ECOECPCON	Economy	Economic Composition	Construction (ISIC F)
ECOECPAHF	Economy	Economic Composition	Agriculture, hunting, forestry, fishing (ISIC A-B)
ECOIDPLIS	Economy	Income Distribution and Poverty	Income share held by lowest 20%
ECOIDPPPL	Economy	Income Distribution and Poverty	Population below national poverty line
ECOIDPPOG	Economy	Income Distribution and Poverty	Poverty gap at $2 a day (PPP)
ECOIDPGIN	Economy	Income Distribution and Poverty	GINI index
ECOIDPISF	Economy	Income Distribution and Poverty	Income share held by fourth 20 %
ECOIDPISH	Economy	Income Distribution and Poverty	Income share held by highest 20%
ECOIDPISS	Economy	Income Distribution and Poverty	Income share held by second 20 %
ECOIDPIST	Economy	Income Distribution and Poverty	Income share held by third 20 %
ECOIDPPGP	Economy	Income Distribution and Poverty	Poverty gap at $1.25 a day (PPP)
ECOLAMLPT	Economy	Labour Market	Labor force participation rate
ECOLAMRRD	Economy	Labour Market	Researchers in R&D
ECOLAMTEC	Economy	Labour Market	Technicians in R&D
ECOLAMUEP	Economy	Labour Market	Unemployment Rate
ECOLAMEAT	Economy	Labour Market	Employment in agriculture
ECOLAMEIT	Economy	Labour Market	Employment in industry
ECOLAMEPT	Economy	Labour Market	Ratio of youth employment to population ages 15-24
ECOLAMEST	Economy	Labour Market	Employment in services
ECOLAMFLM	Economy	Labour Market	Female legislators, senior officials and managers
ECOLAMLAF	Economy	Labour Market	Labor force

ECOLAMLP1	Economy	Labour Market	Female labor participation rate
ECOLAMPET	Economy	Labour Market	Employment to population ratio ages 15+
ECOTRECID	Economy	Trade Economics	Cost to import
ECOTREMIC	Economy	Trade Economics	Merchandise imports CIF
ECOTREISS	Economy	Trade Economics	Imports of goods and services
ECOTRECED	Economy	Trade Economics	Cost to export
ECOTRE072	Economy	Trade Economics	Tariff rate, most favored nation, weighted mean, all products percentage
ECOTREMTR	Economy	Trade Economics	Merchandise trade
ECOTREIGD	Economy	Trade Economics	Imports of goods and services (BoP)
ECOTREMEX	Economy	Trade Economics	Merchandise exports to developing economies within region
ECOTREEVI	Economy	Trade Economics	Export volume index
ECOTREEVE	Economy	Trade Economics	Export value index
ECOTREEEE	Economy	Trade Economics	Merchandise exports FOB
ECOTRECPT	Economy	Trade Economics	Container port traffic (TEU: 20 foot equivalent units)
EDUEOCSAF	Education	Education Outcome	Female population without secondary education or higher
EDUEEOCCT	Education	Education Outcome	Primary School Completion Rate
EDUEOCEYS	Education	Education Outcome	Expected Years of Schooling
EDUEOCLFM	Education	Education Outcome	Ratio of young literate males to females ages 15-24
EDUEOCLFP	Education	Education Outcome	Illiteracy - female
EDUEOCLMP	Education	Education Outcome	Illiteracy - male
EDUEOCLTP	Education	Education Outcome	Illiteracy
EDUEOCMYS	Education	Education Outcome	Mean Years of Schooling
EDUEOCSAM	Education	Education Outcome	Male population without secondary education or higher
EDUEOCSTJ	Education	Education Outcome	Scientific and technical journal articles
EDUEACEEG	Education	Education Access	Education expenditures
EDUEACPTS	Education	Education Access	Pupil-teacher ratio, secondary
EDUEACPTP	Education	Education Access	Pupil-teacher ratio, primary
EDUEACETG	Education	Education Access	Gross enrollment ratio, tertiary
EDUEACSTG	Education	Education Access	Gross enrollment ratio, secondary
EDUEACBGP	Education	Education Access	Ratio of girls to boys in primary and secondary education
EDUEACEPG	Education	Education Access	Gross enrollment ratio, primary
EDUEACCPT	Education	Education Access	Children out of school, primary
ENVDIPDFT	Environment	Disaster Prevalence	Droughts, floods, extreme temperatures
ENVDIPPLM	Environment	Disaster Prevalence	Population living in areas where elevation is below 5 meters
ENVDIPINP	Environment	Disaster Prevalence	Natural disasters - Population affected
ENVDIPIND	Environment	Disaster Prevalence	Natural disasters - Number of deaths
ENVDIPDRR	Environment	Disaster Prevalence	Disaster risk reduction progress score
ENVGEOLAK	Environment	Basic Geography	Land Area
ENVGEOCLK	Environment	Basic Geography	Geographic Classification
ENVGEOFAP	Environment	Basic Geography	Forest area
ENVGEOWAK	Environment	Basic Geography	Water Area

ENVLULALP	Environment	Landuse/Landcover	Arable land
ENVLULFEC	Environment	Landuse/Landcover	Fertilizer consumption
ENVLULURP	Environment	Landuse/Landcover	Urban pollution
ENVLULPCP	Environment	Landuse/Landcover	Permanent cropland
ENVLULALA	Environment	Landuse/Landcover	Agricultural land
GICPSCCOC	Governance	Control of Corruption	Control of Corruption
GICPSCCRI	Governance	Control of Corruption	Corruption Index
GICLRVSWP	Governance	Voice and Accountability	Percentage of seats held by women in national parliaments
GICLRVVOA	Governance	Voice and Accountability	Voice and Accountability
GICLRVVTE	Governance	Voice and Accountability	Voter Turnout at last parliamentary Election
GICLRVOIR	Governance	Voice and Accountability	Official information is available on request
GICLRVETD	Governance	Rule of Law	Equal treatment and absence of discrimination
GICLRVSLR	Governance	Rule of Law	Strength of legal rights index
GICPSCROL	Governance	Rule of Law	Rule of Law
GICAVTCCL	Governance	Political Stability	Civil conflict is effectively limited
GICPSCPSA	Governance	Political Stability	Political Stability and Absence of Violence
GICAVTVRG	Governance	Political Stability	People do not resort to violence to redress personal grievances
GICAVTLCP	Governance	Political Stability	Losses due to theft, robbery, vandalism, and arson
GICAVTIHO	Governance	Political Stability	Intentional homicides
GICGEFGEF	Governance	Government Effectiveness	Government Effectiveness
GICGEFREQ	Governance	Regulatory Quality	Regulatory Quality
HEAHSTFRT	Health	Health Status	Total fertility rate
HEAHSTLRM	Health	Health Status	Lifetime risk of maternal death
HEAHSTMAL	Health	Health Status	Infectious and parasitic diseases: Malaria (DALYs)
HEAHSTMEI	Health	Health Status	One-year-olds lacking immunization against - Measles
HEAHSTTUC	Health	Health Status	Infectious and parasitic diseases: Tuberculosis (DALYs)
HEAHSTMRI	Health	Health Status	Infant mortality rate
HEAHSTMUF	Health	Health Status	Under 5 years mortality rate
HEAHSTPUP	Health	Health Status	Prevalence of undernourishment
HEAHSTUNC	Health	Health Status	Unmet need for contraception
HEAHSTAAP	Health	Health Status	HIV/AIDS - adult prevalence rate
HEAHSTBAS	Health	Health Status	Births attended by skilled health staff
HEAHSTBRC	Health	Health Status	Crude birth rate
HEAHSTDII	Health	Health Status	Infectious and parasitic diseases: Diarrheal diseases (DALYs)
HEAHSTDPC	Health	Health Status	Dietary Protein Consumption
HEAHSTDRC	Health	Health Status	Crude death rate
HEAHSTLEX	Health	Health Status	Life expectancy at birth
HEAHCRHBE	Health	Healthcare Resources	Hospital beds
HEAHCREHP	Health	Healthcare Resources	Health expenditure, private
HEAHCREPP	Health	Healthcare Resources	Health expenditure, public
HEAHCRERH	Health	Healthcare Resources	External resources for health

HEAHCRHAT	Health	Healthcare Resources	Health expenditure, total
HEAHCRHEC	Health	Healthcare Resources	Health expenditure per capita
HEAHCRNMW	Health	Healthcare Resources	Nurses and midwives
HEAHCRPHY	Health	Healthcare Resources	Physicians
INXHDIGIV	Index	None	Inequality adjusted Human Development Index (Gender Inequality Index)
INXHDI012	Index	None	Human Development Index - 2012
INXXXXSFI	Index	None	State Fragility Index
INXXXXPOL	Index	None	Polity Index IV
INXXXXLSC	Index	None	Liner shipping connectivity index
INXXXXGEI	Index	None	Gender Equity Index
INXXXXGBB	Index	None	GEF benefits index for biodiversity
INXXXXEVI	Index	None	Environmental Vulnerability Index
INXXXXESI	Index	None	Environmental Sustainability Index
INXXXXDRI	Index	None	Disaster Risk Index
INXLPICQL	Index	None	Logistics performance index: Competence and quality of logistics services
INFEWSNGC	Infrastructure	Energy, Water and Sanitation	Natural gas - consumption
INFEWSOCB	Infrastructure	Energy, Water and Sanitation	Oil - consumption
INFEWSOPB	Infrastructure	Energy, Water and Sanitation	Oil - production
INFEWSRFC	Infrastructure	Energy, Water and Sanitation	Renewable internal freshwater resources per capita
INFEWSIWR	Infrastructure	Energy, Water and Sanitation	Rural population access to improved water source
INFEWSACE	Infrastructure	Energy, Water and Sanitation	Population with access to electricity
INFEWSECO	Infrastructure	Energy, Water and Sanitation	Electricity - consumption
INFEWSEIP	Infrastructure	Energy, Water and Sanitation	Net energy imports
INFEWSEPR	Infrastructure	Energy, Water and Sanitation	Electricity - production
INFEWSEUP	Infrastructure	Energy, Water and Sanitation	Energy use (kg of oil equivalent)
INFEWSISP	Infrastructure	Energy, Water and Sanitation	Population access to improved sanitation facilities
INFEWSISR	Infrastructure	Energy, Water and Sanitation	Rural population access to improved sanitation facilities
INFEWSISU	Infrastructure	Energy, Water and Sanitation	Urban population access to improved sanitation facilities
INFEWSIWP	Infrastructure	Energy, Water and Sanitation	Population access to improved water source
INFEWSIWU	Infrastructure	Energy, Water and Sanitation	Urban population access to improved water source
INFTCOBRC	Infrastructure	Transport and Communication	Fixed broadband Internet subscribers
INFTCOATF	Infrastructure	Transport and Communication	Air transport, freight
INFTCOTLC	Infrastructure	Transport and Communication	Telephone lines
INFTCORDE	Infrastructure	Transport and Communication	Road density
INFTCOQPI	Infrastructure	Transport and Communication	Quality of port infrastructure, WEF
INFTCOMVC	Infrastructure	Transport and Communication	Motor vehicles
INFTCOMCC	Infrastructure	Transport and Communication	Mobile cellular subscriptions
INFTCORWG	Infrastructure	Transport and Communication	Railways, goods transported

POPPPSPOP	Population	Population Structure	Population
POPPPSRPP	Population	Population Structure	Rural population
POPPPSRUB	Population	Population Structure	Urbanization Rate
POPPPSSRI	Population	Population Structure	Sex ratio
POPPPSUPR	Population	Population Structure	Urban population
POPPPSADP	Population	Population Structure	Age dependency ratio
POPPPSAPD	Population	Population Structure	Average Population Density (areas over 400 ppl/km2)
POPPPSCAO	Population	Population Structure	Percentage of land area with over 400 people per km2
POPPPSIMP	Population	Population Structure	Foreign Born Migrants
POPPPSLPF	Population	Population Structure	Labour force participation rate - Female
POPPPSNMR	Population	Population Structure	Net migration rate
POPPPSPGR	Population	Population Structure	Population growth rate
POPVNPSLP	Population	Vulnerable Population	Slum population in urban areas
POPVNPPUF	Population	Vulnerable Population	Population under 5
POPVNPPIP	Population	Vulnerable Population	Percentage of the population below income poverty line
POPVNPITA	Population	Vulnerable Population	International tourism arrivals
POPVNPFPP	Population	Vulnerable Population	Female Population
POPVNPASE	Population	Vulnerable Population	Population over 65
POPVNPTPP	Population	Vulnerable Population	Refugees (country of origin)