Manual for the MOVER – Level 3 Data Schema for Physical and Social Vulnerability Indicators, Indices, and Functions

A report by EPICentre

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Executive Summary

This document provides a guidance manual for accessing and entering data into the MOVER (Multi-Hazard Open Vulnerability Platform for Evaluating Risk) project's Level 3 Vulnerability Data Schema. This project was funded by the Global Facility for Disaster Reduction and Recovery (GFDRR) and the UK Department for International Development (DfID) competitive Challenge Fund, and the MOVER Level 3 data schema is designed mainly for use in the evaluation of vulnerability of developing countries. It provides a platform for the collection of vulnerability data on diverse physical assets (people, crops, residential buildings, industrial warehouses, commercial properties, schools and hospitals, and key components of water, electricity, gas, telecommunications, and transportation networks) subjected to a number of different natural hazard effects (strong winds, earthquakes, riverine floods, storm surge, landslides, tsunami, drought and volcanic ash). The data schema is also designed to capture social vulnerability information, and can accommodate data collected at different geographical scales.

The MOVER Level 3 vulnerability data schema is modular with four main components: the physical vulnerability indicators module, the social vulnerability indicators module, the vulnerability, fragility and damage to loss functions module and the physical, social and hybrid vulnerability indices module. These modules call upon a number of shared supporting tables that list the hazards, assets, intensity measures, loss parameters, damage scales, engineering demand parameters, references and data sources. The presented Level 3 data schema has been coded in PostgreSQL and has been provided with a fully-fledged administration interface. The user is guided in the compilation of the data schema by the advanced customisation of each of the data fields which, with aliases and pre-populated drop down menus, ensures a seamless data entry experience.

This manual provides information for accessing the data schema, a description of the schema structure and explanations of the terms adopted in pre-populated menus coded into the PostgreSQL platform. Examples of how to enter vulnerability data and functions into the MOVER Level 3 platform are also provided.

Finally, recommendations are provided on the use of the data schema.

Contents

Acronyms

BRU	Building Research Unit, Ministry of Lands, Dar es Salaam.
DfID	UK Department for International Development
DOI	Digital Object Identifier
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DS	Damage State
DtL	Damage-to-Loss
EDP	Engineering Demand Parameter
EP	Exceedance Probability
EPICentre	UCL Earthquake and People Interaction Centre
ER	Entity-Relationship
FF	Fragility Function
GDP	Gross Domestic Product
GAM	Generalized Additive Model
GEM	Global Earthquake Model
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographical Information Systems
GLM	Generalised Linear Model
IM	Intensity Measure
IML	Intensity Measure Level
IMPE	Intensity Measure Prediction Equations
ISSN	International Standard Serial Number
LR	Lethality Ratio
MIDR	Maximum Inter-storey Drift Ratio
MOVER	Multi-Hazard Open Vulnerability Platform for Evaluating Risk
ODI	Overseas Development Institute
PDF	Probability Density Function
RR	Repair Rate
UCL	University College London
V_Cat	Vulnerability Category
V_Ch	Vulnerability Characteristic
VF	Vulnerability Function
VI	Vulnerability Indicator
VIx	Vulnerability Index

1 What is the MOVER Level 3 Vulnerability Data Schema?

The “Multi-Hazard Open Vulnerability platform for Evaluating Risk” (MOVER) project was funded by the Global Facility for Disaster Reduction and Recovery (GFDRR) and the UK Department for International Development (DfID) competitive Challenge Fund, to create a robust, open, accessible, and expandable multi-hazard vulnerability database schema that is appropriate for use in developing country contexts. The resulting product, termed the MOVER Level 3 Vulnerability Data Schema (L3DVS), provides a rational, peer-reviewed and tested data schema for the collection of physical and social vulnerability data and models. MOVER L3VDS is designed to accommodate both social and physical vulnerability data evaluated at different geographical scales ((Level 0 National, Level 1 Sub-country, Level 2 Local level, Level 3 single asset). The database schema also supports a gridded system of data entry. In terms of physical vulnerability, it can capture data and models pertaining to a range of different assets (people, crops, residential buildings, industrial warehouses, commercial properties, schools and hospitals, and key components of water, electricity, gas, telecommunications, and transportation networks) subjected to a number of different natural hazard effects (strong winds, earthquakes, riverine floods, storm surge, landslides, tsunami, drought and volcanic ash).

In recognition of the typical paucity of vulnerability data in developing countries, the MOVER L3DVS has been designed to allow for “nullable” entries where possible, and has a modular structure that favours future expansion (as data becomes available). In the case of the physical vulnerability models, a scoring system is also provided that can (1) guide the user in evaluating the usability of any given vulnerability model, and (2) help the user decide on whether vulnerability models developed for assets elsewhere are applicable to the assessment of their geographical area of interest.

MOVER L3DVS has been coded in PostgreSQL and has been provided with a fully-fledged administration interface. The user is guided in the compilation of the data schema by the advanced customisation of each of the data fields which, with aliases and pre-populated drop down menus, ensures a seamless data entry experience.

1.1 Structure of the MOVER L3VDS manual

This manual provides information for accessing and entering data into the MOVER Level 3 Vulnerability Data Schema.

First, common definitions used throughout the manual and the data schema are presented. Information on how to access the data schema are provided in Section 2.

Section 3 presents a description of the MOVER L3VDS architecture, providing an overview of each of the schema modules. Detailed definitions of each of the fields of data in the data schema are provided in Appendices I to IV for the four modules. A number of tables support the modules and data entry, and explanations are provided of the terms adopted in pre-populated menus coded into the PostgreSQL platform.

Finally, Section 4 provides examples of how to enter vulnerability data and functions into the four different modules of the MOVER Level 3 platform.

1.2 Definitions

This section provides key definitions that users should refer to when using the MOVER L3VDS. These generally follow the definitions adopted in the Global Earthquake Model (GEM) series of reports on vulnerability (e.g. Rossetto etal. 2014, D’Ayala and Meslem, 2012, D’Ayala et al. 2016).

Physical vulnerability is used to refer to the susceptibility of assets (people, infrastructure, etc.) exposed to hazardous events to incur losses (e.g. deaths and economic loss).

Social vulnerability refers to the inability of people, organizations, and societies to withstand adverse impacts from multiple stressors to which they are exposed. These impacts are due in part to characteristics inherent in social interactions, institutions, and systems of cultural values.

Intensity Measure (IM) is a parameter used to measure the severity of a natural hazard effect at a particular site.

Intensity Measure Level (IML) is a particular value of the relevant IM.

Vulnerability characteristics (V_Ch) are descriptors of the main factors contributing to the (social or physical) vulnerability of the asset to a hazard. An example of a V_Ch is level of literacy, which contributes to the social vulnerability of populations.

Vulnerability categories (V_Cat) are a grouping of vulnerability characteristics that fall under the same theme. For example, the V_Ch of 'Access to Education' and 'Education Attainment' are grouped within a V_Cat of "Knowledge and Education".

Vulnerability Indicator (VI) is a direct measure or proxy for measuring a vulnerability characteristic (V_Ch). It is a quantitative measure of a single phenomenon. An example VI is the percentage of the population with a primary school level education, when this is used as a proxy for literacy (V_Ch) as part of an evaluation of the V_Cat of "Education". VIs are most commonly used to indicate factors of social vulnerability, but in physical vulnerability are the equivalent of direct quantitative measures or proxies for vulnerability characteristics of the exposure.

Vulnerability Index (VIx) is a quantitative representation of multiple phenomena, i.e., of multiple V_Cat. It is a vulnerability model and is formed through a mathematical combination of several Vulnerability Indicators. An example VIx from the social vulnerability literature is the Human Development Index. In the physical vulnerability sphere VIx usually result from rapid visual surveys of buildings. Examples include the Building Vulnerability Index for tsunami by Papathoma and Dominey-Howes (2003).

It is highlighted that neither VI nor VIx vary with hazard intensity.

Vulnerability Function (VF) is defined as a relationship between a parameter of loss (e.g. fatalities) and an intensity measure (IM). Such functions can be represented in the form of continuous or discrete relationships. VFs can be derived "directly" from regression on historical loss data (empirical), and through the elicitation of expert opinion (heuristic). VFs can also be derived "indirectly" from the combination of a Fragility Function and a Damage-to-Loss model.

Fragility Function (FF) describes the propensity of physical assets (e.g. buildings) to sustain damage under hazardous events. Formally, they express the probability of a damage state (DS) being reached or exceeded given a range of hazard intensity measure levels. FFs can be developed empirically, heuristically, but also analytically (i.e. where a numerical/computational model simulates the response of a structure under increasing hazard intensities).

Damage-to-Loss model (DtL) relates values of loss to the damage states expressed in a Fragility Function. For buildings and most infrastructure DtL models commonly take the form of repair to replacement cost ratios for the examined building class. In the case of pipelines and cables Repair Rates (RR), which describe the average number of repairs per unit length, are more common. In the case of casualties, Damage-to-Loss relationships often take the form of Lethality Ratios (LR), defined by Coburn and Spence (2002) as the ratio of the number of people killed to the number of occupants present in a collapsed building. Revised Level 2 Data Schema

2 Accessing the MOVER Level 3 Data Schema

Data entry to the MOVER L3VDS is managed via an online interface (Adminium, hosted in Heroku). This is done primarily to facilitate the testing of the data schema but also to provide a visual example of the functionalities that the MOVER data schema should retain when integrated with the schemas of the other two Challenge Funds (i.e. drop-down fields, hyperlinks to the supporting tables/ dictionaries of the schema).

The MOVER data schema will be developed further by the EPICentre team but at this stage it is foreseen that only a restricted number of administrators will have direct access to the data hosted on the data schema by using the Adminium interface. This precaution is taken for the following reasons:

- This version of the data schema will benefit form a pilot/ testing period before being developed further;
- For an intrinsic limitation of the hosting platform Heroku which does not allow to differentiate between user groups (e.g., user who can edit, users who can only view), each collaborator in a project is automatically granted administrator privileges. This means that each person listed as a collaborator for the purpose of contributing data could potentially make changes to data contributed by other users;
- Licensing issues may arise with some of the data input by users. Before being released to the general public, the open access of such data needs to be verified.

In view of the above, access to the schema and to the data is managed separately until the next stage of development. Users who would like to contribute to the data will be given, upon request, credentials to access a “schema only” version of the data schema and will be able to follow this manual to populate the data schema. Data input in this way will be initially marked as unverified and will be merged into the master data schema only after being verified by the main administrator. Data contained in the database can be requested separately by email and will be delivered in a .cvs file. The possibility to develop a query tool as part of an online form to request specific portions of the data schema is being investigated.

In order to request access to the data schema, please send an e-mail requestto t.rossetto@ucl.ac.uk or e.verrucci@ucl.ac.uk.

3 Structure of the Level 3 Data Schema

The MOVER L3VDS data schema consists of 4 separate modules; the Vulnerability, Fragility and damage to Loss Functions module, the Physical Indicators module, the Social Indicators module, and the Physical, Social and Hybrid Indices module. These modules work and are presented independently. As shown in Figure 3.1, the four modules link to tables containing descriptive information on the hazards and assets that they relate to, and to tables of references studies and data sets used to populate the indicators, functions and indices. A consistent taxonomy has been used throughout, that is largely based on the GEM taxonomy.

Each module comprises one or more base tables (e.g., the Vulnerability, Fragility and damage to Loss Functions module has in fact three base tables: one for the Fragility functions, one for the Vulnerability functions, and one for the Damage to Loss functions) on which the main information of functions, indicator, and indices are presented. The base tables are linked and point to specific fields of the supporting tables, which work as dictionaries from which supplementary information can be retrieved. The modules and supporting tables are described in the following Section.

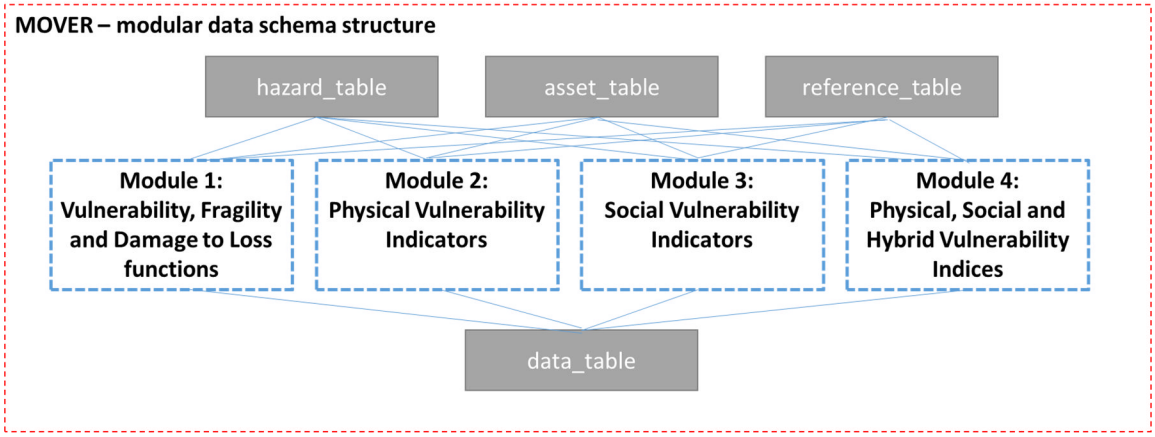


Figure 3.1 – Illustration of the modular structure of the MOVER L3DVS.

4 Components of the Level 3 Data Schema

4.1 MODULE 1: Vulnerability, Fragility and Damage to Loss functions

The Vulnerability, Fragility and Damage to Loss Functions module consists of three base tables (i.e., ff_table, vf_table, and dtl_table) and of six supporting tables which are not shared with the other three modules (i.e., edp, loss_parameter, damage_scale, ff_scoring_table, vf_scoring_table, im_table). The module is also linked to the Hazard, Asset, Reference, and Data tables, which contain supporting data shared across all the four modules. This is illustrated in Figure 4.1.

The Fragility Function base table (ff_table) comprises data fields for recording all necessary fragility function attributes required by a user to reproduce the function. It also comprises fields that contain useful information for the scoring of the fragility functions, (score which is recorded in the scoring_table). Separate entries are made for fragility functions associated with different damage states. The data schema permits recording of the functional form and parameters of fragility functions, but is also flexible enough to also allow the entry of discrete forms of fragility representation, i.e. damage probability matrices (DPM).

The Damage to Loss base table (dtl_table) comprises data fields for recording relationships published for converting damage to assets into loss. Again, these can be entered either in terms of the parameters of a function or as discrete values. Differently from the vulnerability and fragility functions base tables, the DtL table is the only base table of the model that does not have an associated scoring table. The assumption here is that, as DtL function are used as “conversion” functions from the damage assessment of the fragility function to a loss assessment for an indirect vulnerability function. Hence, it is assumed that the scoring given to the Fragility Function to which the DtL function will also apply to the resulting indirect vulnerability function.

The Vulnerability Function base table (vf_table) comprises data fields for recording all necessary vulnerability function attributes required by a user to reproduce the function. It also comprises fields that contain useful information for the scoring of the vulnerability functions, (score which is recorded in the scoring_table). The data schema permits recording of the functional form and parameters of vulnerability functions, but is also flexible enough to also allow the entry of discrete forms of vulnerability representation. Both direct and indirect

vulnerability functions can be accommodated, and in the latter case, details are recorded of the fragility functions and damage to loss models used for deriving the indirect vulnerability function.

Detailed information on each data field included in the module is provided in Appendix I.

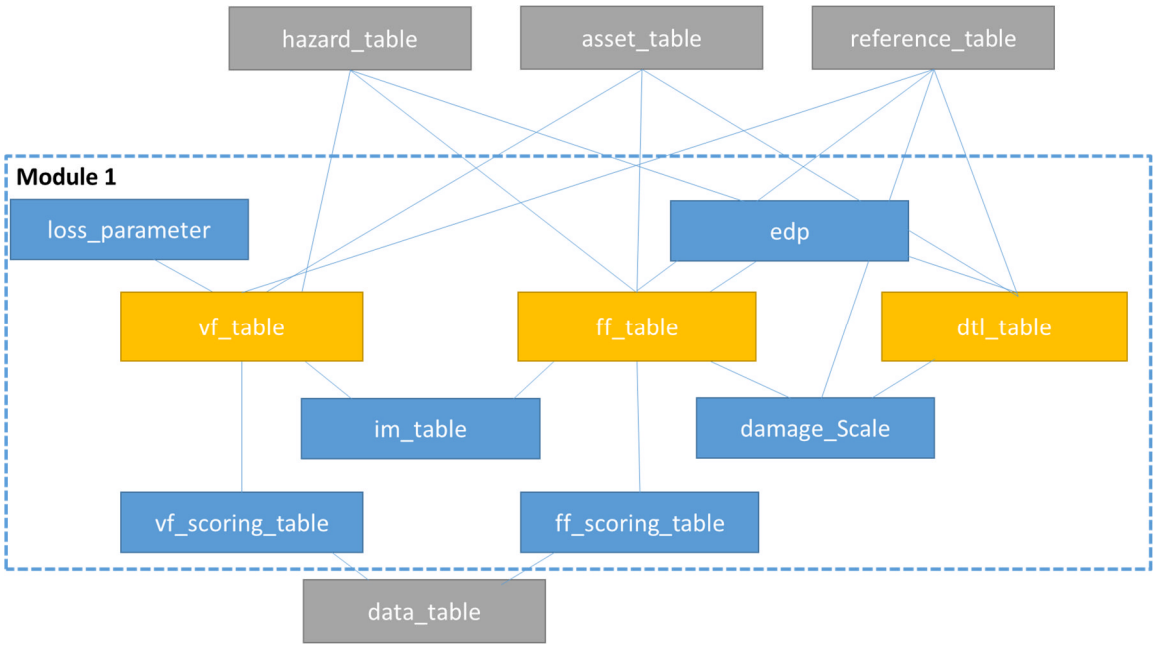


Figure 4.2 – Illustration of the structure of Module 1 of the MOVER L3DVS.

4.2 MODULE 2: Physical Vulnerability Indicators

Figure 4.2 presents the structure of the Physical Vulnerability Indicators module. Appendix II provides a detailed description of each of the data fields in this module. The module also links to the Hazard, Asset, Data and Reference supporting tables.

The physical indicator module comprises a base table, connected to scoring table, and the physical vulnerability categories and characteristics tables. These are used as dictionaries and provide descriptions for the Physical Categories and Characteristics which the indicators are selected to represent. The user is reminded that an indicator is one of many possible measurable proxies of a physical vulnerability characteristic. The physical characteristic instead describes one component of a vulnerability category, (which is described by multiple vulnerability characteristics). A predetermined system of Vulnerability Categories and Characteristics has been developed for the MOVER data schema for the assets considered, which is reproduced in Table 4.1. It is noted that the vulnerability indicator for individual assets will be the actual observable vulnerability characteristic for that asset. Instead, when a vulnerability assessment is made over a geographical area, the indicator becomes the % of the asset population with that characteristic.

Table 4.1 – Physical Vulnerability Categories and Characteristics for Indicator Definition.

Asset type	Physical Vulnerability Category	Physical Vulnerability Characteristic
Buildings	Material of lateral load resisting system	Material type
		Material technology
	Structural regularity	Is regular?
		Irregular direction (plan/vertical)
	LLRS	Type of LLRS
		Seismic code level
	Height	N. of storeys above grade
		N. of storeys below grade
	Roof	Roof shape
		Roof covering material
		Roof system material
		Roof system type
	Floor	Floor system type
		Floor system material
	Date of construction	Building age
		Is design? (engineered/nonengineered)
		Is design retrofit?
	Occupancy	Occupancy type
		Occupancy class
	Foundation type	Foundation system
Lifelines (Bridges)	General bridges	Bridge material
		Bridge type
		Is bridge design? (engineered/nonengineered)
		Bridge usage
	Bridge pier	Pier type
	Bridge spans	N. of spans
		Is span continuous?
	Bridge abutment	Abutment type
	Bridge deck	Deck type
		Deck height
	Bridge bearing	Bearing type
Lifelines (Telecommunications)	General telecommunications	Telecommunication type
		Telecommunication usage
		Is communication component anchored?
Lifelines (Water burried pipelines)	General water burried pipelines	W.B. pipeline age
		W.B. pipeline diameter
		W.B. pipeline joint
		W.B. pipeline material
		W.B. pipeline usage
Lifeline (Water pump)	General water pump	Is W.P. generator independent?
		Is W.P. design?
Lifeline (Water storage)	General water storage	W.S. size
		W.S. body material
		Is W.S. anchored?
		Is W.S. design?

Table 4.1 (Continued) – Physical Vulnerability Categories and Characteristics for Indicator Definition.

Lifeline (Water storage)	General water storage	W.S. usage
Lifelines (Electric substations)	General Electric substations	E.S usage
		E.S. insulation
Lifelines (Waste water lift stations)	General waste water lift stations	Is W.W. design?
Crops	Crop	Crop growcycle
		Crop species
		Crop variety
		Crop season
People	People	

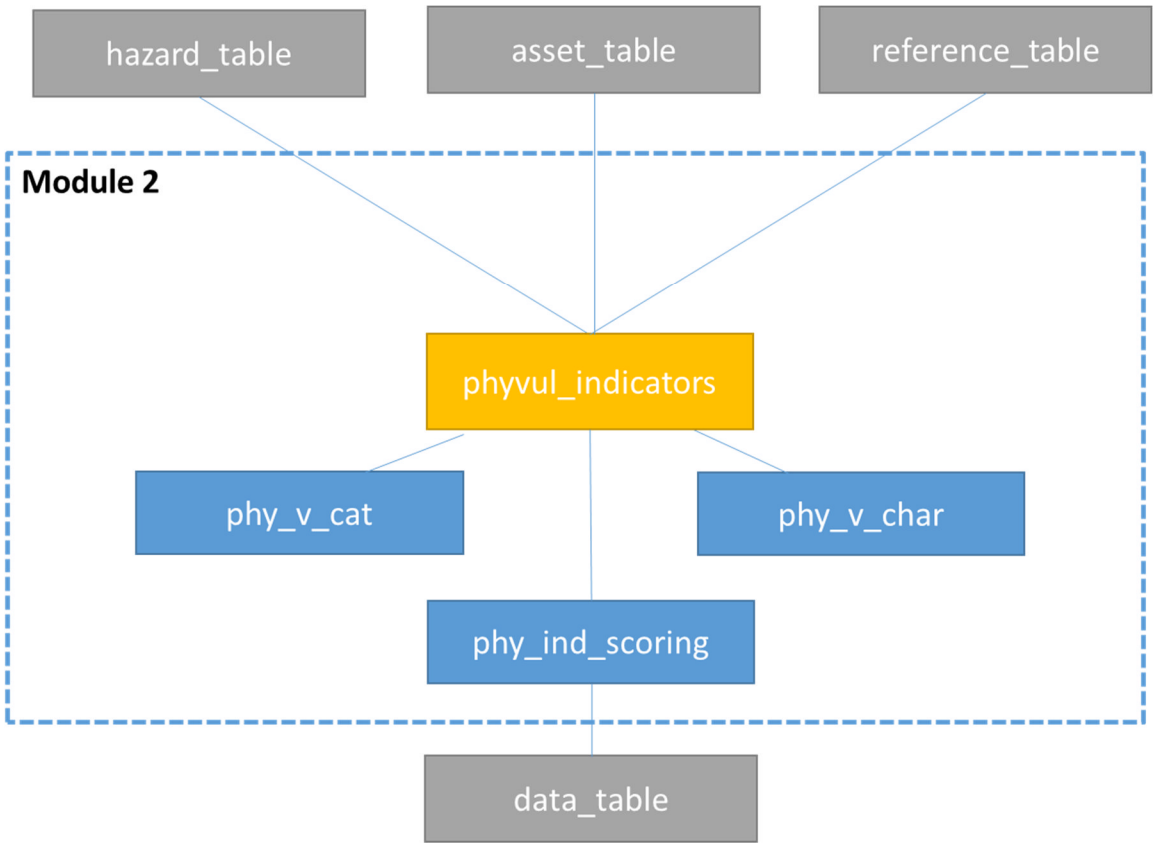


Figure 4.2 – Illustration of the structure of Module 2 of the MOVER L3DVS.

4.3 MODULE 3: Social Vulnerability Indicators

Like the physical indicators module, the social indicators module comprises a base table, supporting scoring table, and also two additional tables: the Social Vulnerability Categories and Characteristics tables. A predetermined system of Vulnerability Categories and Characteristics has been developed for the MOVER data schema, which is reproduced in Table 4.2.

The module also links to the Hazard, Asset, Data and Reference tables. Schema and Description table are therefore the same as the Physical Vulnerability Indicators Module. Figure 4.3 presents the structure of the Social Vulnerability Indicators module. Appendix III provides a detailed description of each of the data fields in this module as well as the set of social vulnerability indicators adopted in MOVER L3DVS.

Table 4.2 – Social Vulnerability categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic
Vulnerable population	Social class (including caste, religious minority, ethnicity)
	Gender – work opportunities
	Gender – right to property
	Gender – Decision power on well-being
	Sexuality
	Age
	Disability
	Migration
	Involuntary displacement
Institutional Governance	Political stability and absence of violence and terrorism
	Government Effectiveness
	Accountability
	Control of corruption
	Rule of Law
	Voice
Governance in Planning and Construction	Risk-informed building coded
	Enforcement of building codes
	Risk-informed planning
Civil Society and Social Capital	Social advocacy and civil society
Financial and Material welfare	Income -remittances
	Income –disposable income
	Income level
	Employment and employment security
	Financial dependency on environmental resources
	Access to credit
	Poverty
	Access to insurance
	Capital assets
	Social Protection

Table 4.2 (Continued) – Social Vulnerability categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic
Food Security	Availability
	Access
	Stability
	Utilization
Preparedness and Local Risk Awareness	Preventive measures
	Knowledge of local hazards
	Civil society and social capital in DRR
	Access to information in DRR
Access and Provision of services	Transports
	Water and waste water services
	Telecommunications
	Energy
	Solid waste management
	Affordability
	Access to Emergency Services
Knowledge and education	Education attainment
	Access to Education
	Technical skills and vocational training
	Existence of DRR curricula in schools
	Affordability
Health	General population health
	Health resources and expenditure

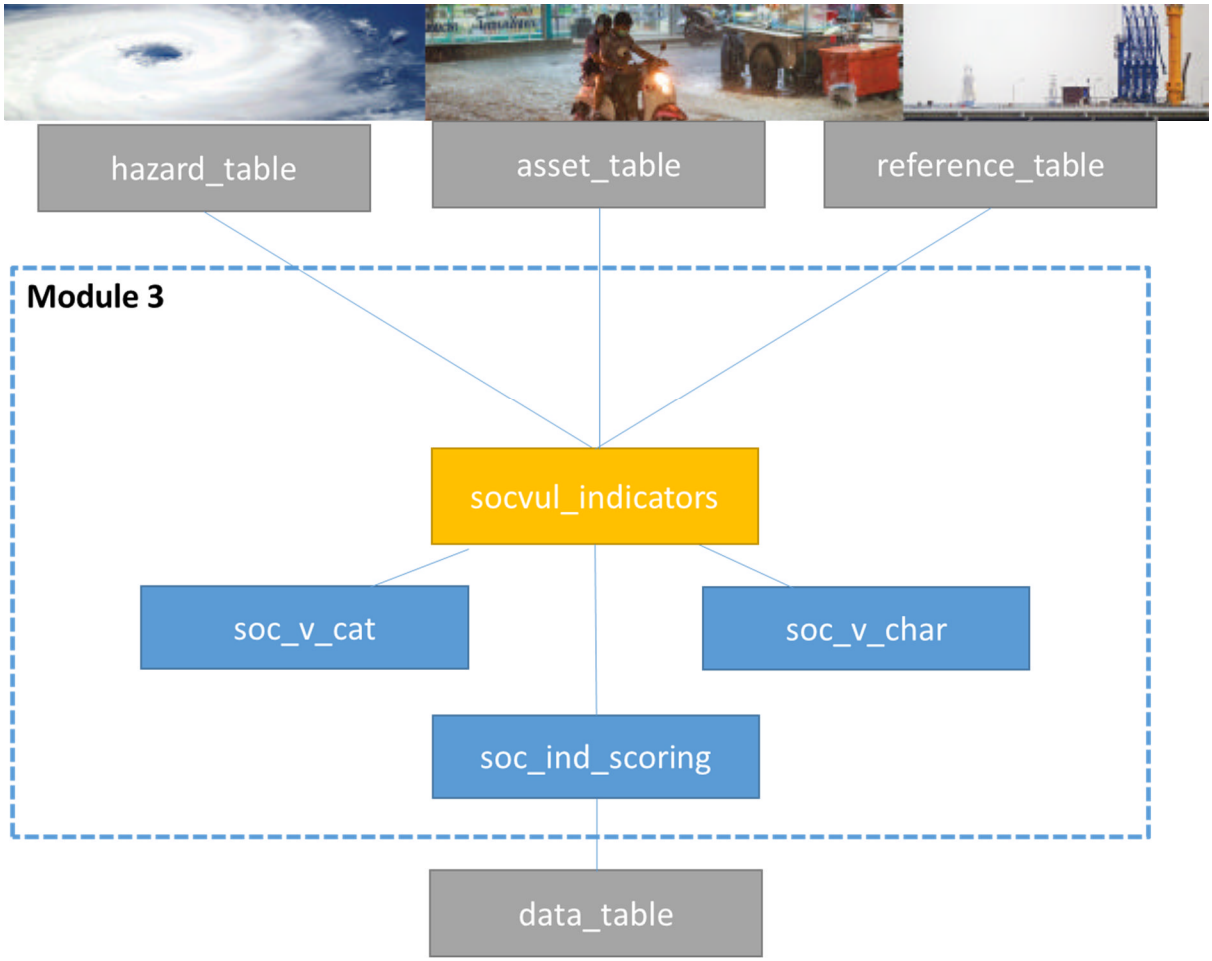


Figure 4.3 – Illustration of the structure of Module 3 of the MOVER L3DVS.

4.4 MODULE 4: Physical, Social and Hybrid Vulnerability Indices

The Physical, Social and Hybrid Indices module comprises a base table and the associated scoring table. It is linked to the Reference table which stores the attributes of the reference study which first introduced the index. The names and values of the indicators that contribute to the index are input manually. Like for the function module, the Indices Module is a collection of indices, and of their attributes, categorised based on their specific applicability to pre-selected hazard and assets. All the attributes listed (e.g., values, weights) refer to the known applications of the index in the literature and cannot be assumed valid for all the case studies. Figure 4.4 presents the structure of the Physical Vulnerability Indicators module. Appendix IV provides a detailed description of each of the data fields in this module.

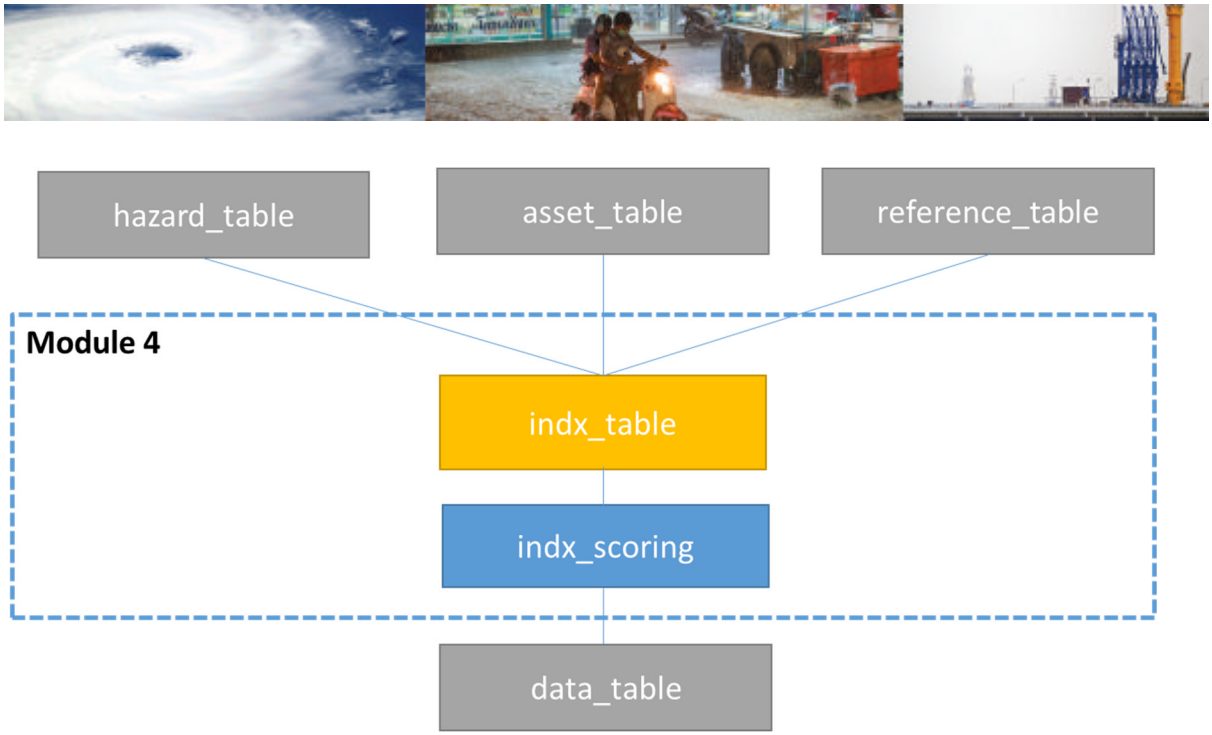


Figure 4.4 – Illustration of the structure of Module 4 of the MOVER L3DVS.

4.5 Supporting Tables to Modules 1-4

This Section describes the supporting tables of Modules 1 to 4 of the MOVER data schema.

As mentioned in Section 3, the supporting tables store supplementary information which the user may wish to access when selecting entries of the main base tables. For example, a user may want to verify the range of the Intensity Measure used in a Fragility Function. As the Fragility Function base table is linked to the IM table, this operation is made possible in the interface by means of associated data discovery, which translates in hyperlinks all the fields in a base table for which a relationship to the any supporting tables exists. The associative discovery links act in all effects as digital dictionaries providing information on attributes that are not fundamental to the characterization of functions, indicators, or indices but that may aid its comprehension and usage.

It is also important to note that the fields for which a relationship between base and supporting table has been implemented are often enumerated fields. The entries of the supporting tables have been established by means of a careful review of the literature, which has helped establish which IMs, damage scales, EDPs and loss parameters are more commonly used. Detailed information on the definitions and formulas of IM, damage scales, EDPs, and loss parameters are provided in the following sections to facilitate data entry, as these are adopted in pre-populated drop-down menus.

Whilst the Hazards, Asset, Intensity measures, Damage Scales, Loss Parameters, EDPs table operate as digital dictionaries, the Reference and Data tables act as repositories of metadata. Lastly, the scoring tables are used to associate scores to the vulnerability and fragility functions

4.5.1 Hazard Table

The Hazard table contains a very limited amount of fields (Table 4.3). It is envisaged that the ‘Hazard type’ entry will be one of the main parameters which will be used by users looking for specific functions, indicators, or indices. Hence, this supporting table is linked to all the base tables of the 4 modules of the MOVER data schema and it also linked to the damage scale table.

Table 4.3 – Schema of the Hazard table, described field by field.

Column name	Alias shown in interface	Description
hazard_id	ID (Hidden field)	Unique identifier of the hazard type and Primary Key
hazard_type	Hazard type	Enumerated type. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, and Drought. The Hazard field is also indexed to link to the FF, VF, DtL functions tables and Intensity Measure and Damage Scale tables.
description	Description	The field describes the hazard type and specifies which hazard subcategories are excluded. Example: Flood excludes flash floods.

4.5.2 Asset Table

This supporting table is linked to all the base tables of the 4 modules of the MOVER data schema and it also linked to the damage scale table. Data types, constraints and description of the fields are provided in Table 4.4Table 4.4 – Schema of the Asset table, described field by field.

Table 4.4 – Schema of the Asset table, described field by field.

Column name	Alias shown in interface	Description
asset_id	ID (Hidden field)	Unique identifier of the hazard type and Primary Key
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crop. In the integration with the data schemas of the Challenge Exposure, this table will be replaced with the Asset table of their schema and it will provide a link to all tables of that schema.
sub-asset	Sub-asset	Description of sub-asset. Example: Unreinforced Masonry
taxonomy	Taxonomy	GEM taxonomy

4.5.3 Intensity Measures (IM) Table

The Intensity Measure (IM) table lists all intensity measures adopted in the description of the most commonly found fragility and vulnerability function literature for the hazards investigated. The schema of the IM table is presented in Table 4.5. The IM Table is called upon by the Fragility Function and Vulnerability Function modules. The definitions of the intensity measures used to prepopulate the table are provided in the text following Table 4.5.

Table 4.5 – Schema of the IM table, described field by field.

Column name	Alias shown in interface	Description
im_id	ID (Hidden field)	Unique identifier of the intensity measure and Primary Key.
hazard_type	Hazard type	Enumerated type. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, and Drought. In the integration with the data schemas of the Challenge Hazard, this table will be replaced with the Hazard table of their schema and it will provide a link to all tables of that schema.
im_symbol	IM Symbol	The symbol of the intensity measure.
definition	Definition	The field describes the intensity measure as a dictionary entry would do. As it is envisaged that, the IM table will operate as a dictionary, this entry cannot be null.
units	Units	Units of reference of the intensity measure. This field can be null if the information is not available.
range	Range (lower bound; upper bound)	Range of the intensity measure, defined by its lower bound and upper bound values. When both values are present, these are separated by a semicolon. If only one value is present, this is set to correspond to the lower bound value. This field can be null if the information is not available.
im_name_f	IM name (indexed field) - For details	The field specifies the name of the intensity measure. The field is enumerated and indexed so that the entries are predefined and allow for the associative discovery of the VF and FF function using a specific intensity measure. The field is also constrained to allow only for unique entries, so as to avoid that multiple user can input the same intensity measure, associating for instance two different definitions to the same intensity measure.

The most commonly adopted intensity measures in vulnerability and risk modelling for each of the eight hazard types considered in MOVER L3VDS are defined here below.

Earthquake IMs

The seismic loading to structural systems (i.e. acceleration time history *a(t)* applied at the foundation of the system) is commonly approximated by a ground motion parameter, which is chosen based on its ability to best represent the actual ground motion record. The selection of the most suitable hazard descriptor may vary depending on the type of structural system and its sensitivity to the main features of a temporal signal, i.e. amplitude; frequency content; duration and number of effective cycles; and its sensitivity to the different components of motion, i.e. displacement, velocity and acceleration, in given directions. The earthquake IM terminology used by the data schema is reported in Table 4.6. and the definitions of these IMs are reported below.

Table 4.6 - Earthquake IMs.

IM Symbol	IM Name
PGA	Peak ground acceleration
PGV	Peak ground velocity
PGD	Peak ground displacement
PGDf	Permanent ground deformation
$Sa(T_1)$	Spectral acceleration
$Sv(T_1)$	Spectral velocity
$Sd(T_1)$	Spectral displacement
CAV	Cumulative absolute velocity
I_α	Arias Intensity
N_{eq}	Effective number of cycles
DB	Bracketed duration
$Da_{5\text{-}95}$	Significant duration a5-95
$Da_{5\text{-}75}$	Significant duration a5-75
MMI	Modified Mercalli Intensity
EMS	European macroseismic scale
I_{Np}	IM by Bojórquez and Iervolino (2011)

AvgSa	Average spectral acceleration

- Peak ground acceleration (*PGA*): The *PGA* is equal to the amplitude of the largest absolute acceleration recorded on an accelerogram at a site during a particular earthquake. Expressed in g or m/s^2.

- Peak ground velocity (*PGV*): The *PGV* is equal to the maximum ground velocity that occurred during earthquake shaking at a location. Expressed in m/s.

- Peak ground displacement (*PGD*): The *PGD* is equal to the maximum ground displacement that occurred during earthquake shaking at a location. Expressed in meters (m).

- Permanent ground deformation (*PGDf*): The permanent ground deformation refers to the unrecoverable soil displacement due to faulting, landslide, settlement or liquefaction induced lateral spreading. In some cases, *PGDfV* is used for vertical ground deformation and *PGDfH* for horizontal ground deformation. Expressed in meters (m).

- Spectral acceleration ($Sa(T_1)$): The $Sa(T_1)$ is the maximum acceleration experienced by a structure, as modelled by a mass on a vertical spring having the same natural period of vibration, T, as the building. Expressed in g or m/s^2.

- Spectral velocity ($Sv(T_1)$): The $Sv(T_1)$ is the maximum velocity experienced by a structure, as modelled by a mass on a vertical spring having the same natural period of vibration, T, as the building. Expressed in m/s.

- Spectral displacement ($Sd(T_1)$): The $Sd(T_1)$ is the maximum displacement experienced by a structure, as modelled by a mass on a vertical spring having the same natural period of vibration, T, as the building. Expressed in meters (m).

- Cumulative Absolute Velocity (*CAV*): The *CAV* is defined as:

$$CAV = \int_0^{t\max} |a(\tau)| \mathrm{d}\tau$$

where $|\alpha(\tau)|$ is the absolute value of acceleration at time t and t_{max} is the total duration of the ground motion record. Expressed in m/s.

- Arias Intensity (I_a): The Arias Intensity is defined as:

$$I_a = \frac{\pi}{2g} \cdot \int_0^{t\max} a(\tau)^2 \mathrm{d}\tau$$

I_a is measured in units of length per time. Expressed in m/s.

- Effective number of cycles (N_{eq}): The N_{eq} is defined as:

$$N_{eq} = \frac{1}{2} \cdot \sum_{i=1}^{2n} \left(\frac{u_i}{u_{max}} \right)^c$$

where n is the total number of cycles, u_i is the amplitude of the *i*th half cycle, u_{max} is the amplitude of the largest half cycle, and c is an application-dependent damage coefficient (c = 2 in Hancock and Bommer, 2005). No units.

- Bracketed duration (D_B): D_B is defined as the time elapsed between the first and last excursions beyond a specified threshold acceleration (typically 0.05 g or 0.1 g). Bracketed duration parameters can be sensitive to the threshold accelerations and to small subevents occurring towards the end of a recording. For these and other reasons, other definitions of duration are often preferred. Expressed in seconds (s)

- Significant duration (D_{a5-95}): D_{a5-95} is defined as the time interval over which the integral of the square of the ground acceleration is within a range between 5 and 95%. Expressed in s.

- Significant duration (D_{a5-75}): D_{a5-75} is defined as the time interval over which the integral of the square of the ground acceleration is within a range between 5 and 75%. Expressed in s.
  *It is noted that significant duration can be also represented as function of the velocity and displacement record, denoted as D_{v5-95} and D_{d5-95} respectively.

- Modified Mercalli Intensity (*MMI*): This scale is an arbitrary ranking based on observed effects, and does not have a mathematical basis. MMI is composed of increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. Expressed in own units.

- IM proposed by Bojórquez and Iervolino, 2011 (I_{Np}): I_{Np}, is a spectral-shape proxy based on Sa(T1) and the parameter N_p, defined as:

  $$I_{N_p} = S_a(T_1) N_p^{\alpha}$$

  where α parameter is assumed to be α = 0.4, and N_p is defined as:

  $$N_p = \frac{S_{a,avg}(T_1,\ldots,T_N)}{S_a(T_1)} = \frac{\left[\prod_i^N S_a(T_i)\right]^{1/N}}{S_a(T_1)}$$

  T_N corresponds to the maximum period of interest and lays within a range of 2 and 2.5 T_1. Expressed in m/s^2.

- Average spectral acceleration (*AvgSa*): *AvgSa* is defined as the mean of the spectral accelerations at a set of periods that are crucial for risk assessment and loss estimation of a structure of interest. These periods, for example, could be equally spaced in the 0.2T1 to 1.5T1 range.

  $$AvgSa = \left[\prod_{i=1}^{n} Sa(T_i)\right]^{1/n}$$

  The quantity n refers here to the number of SA(T)s being averaged. Expressed in m/s^2.

Tsunami IMs

The Tsunami IM terminology used by the data schema is reported in Table 4.7. and the definitions of these IMs are reported below.

Table 4.7 - Tsunami IMs.

IM Symbol	IM Name
h_{ts}	Tsunami inundation depth
v_{ts}	Tsunami velocity
Fr	Froude number
F_{drag}	Drag force
MF	Momentum flux
MMF	Modified momentum flux
F_{QS}	Quasi-steady force

- Tsunami inundation depth (h_{ts}): Peak observed or simulated tsunami inundation depth (h_{peak}) at each building location. Expressed in m.

- Tsunami velocity (v_{ts}): Peak tsunami velocity generally calculated from numerical simulation as the vector sum of the velocity components in the directions of the two orthogonal axes of the 2D flow calculation. Expressed in m/s.

- Froude number(Fr): A measure of flow velocity non-dimensionalized by the gravity-wave velocity:

  $$Fr = \left(\frac{v}{\sqrt{gh}} \right)_{peak}$$

  Unitless IM.·

- Drag force (F): The force exerted on an object (per unit width perpendicular to the direction of flow) due to the movement of a surrounding fluid of density ρ:

  $$F_{drag} = \frac{1}{2} \rho C_d \left(hv^2 \right)_{peak}$$

  where the drag coefficient (C_d) is a function of the object shape and orientation. Expressed in kN.

- Momentum flux (*MF*): A vector in the direction of flow, of magnitude equal to the mass-flow per unit area:

  $$MF = \left(hv^2 \right)_{peak}$$

  Expressed in m^3/s^2.

- Moment of momentum flux (*MMF*): The product of momentum flux and inundation depth, considered a proxy for the overturning moment induced by the flow:

  $$MMF = \left(h.hv^2 \right)_{peak}$$

  Expressed in m^4/s^2.

- Quasi-steady Force(F_{QS}): Alternative steady-state force estimation considering choked and sub-critical flow for a body of width b in a channel of width w:

  $$F_{QS} = \begin{cases} \frac{1}{2}\left[C_{D0}\left(1 + \frac{C_{D0}}{2}\left\{ \frac{b}{w} \right\} \right) \right] \rho v^2 h \;, & Fr < Fr_C \\ \lambda \rho g^{1/3} v^{4/3} h^{4/3} \;, & Fr \geq Fr_C \end{cases}$$

  where:

  - λ is a function of hydrostatic and form drag coefficients, and up-and down-stream Froude Numbers.
  - Fr_c is a function of drag coefficient and blockage ratio (b/w).

  See Foster et al. (2017) for calculation procedure. Expressed in KN.

It is noted that Tsunami flow depth is also one of the most common parameter used when examining tsunami-building interaction and has been extensively used as the hazard variable, or demand parameter, in the construction of existing tsunami fragility curves. This is due to the relative ease with which it can be measured in the field after a tsunami event (e.g. from mud-lines in buildings), and due to the relative reliability of depth outputs from numerical inundation simulations. Furthermore, in recent building design codes the loads associated with tsunami have been considered similar to the loads associated with floods with increased velocities (FEMA, 2008). As the main parameter in flood studies is inundation depth, this has been adopted also in the case of tsunami. However, caution must be applied when comparing flow depth measurements from different studies. During post-tsunami surveys, flow depth is commonly defined as being the height of water measured above ground level (Synolakis & Okal 2005; Rossetto et al. 2007; Reese et al. 2007). Various definitions and names for flow depth can be found in the literature: water level (Reese et al., 2007), inundation depth (Inoue et al., 2007), tsunami depth or water depth (Nandasena et al. 2008). Flow depth should not be confused with tsunami height, or inundation height, which usually represents the maximum water level measured with reference to mean sea level (Inoue et al., 2007; Liu et al. 2005; Nandasena et al., 2008; Tsuji et al. 2006). If parameters are not carefully defined this can

lead to inconsistent results.

Flow velocity influences the hydrodynamic force, surge force, debris impact and damming forces applied by tsunami when they impact buildings. Flow velocities have only rarely been used in the derivation of fragility functions for tsunami (Gokon et al. 2010; Suppasri et al. 2011; Suppasri et al. 2009). This is because they are hard to determine from observations (Reese et al., 2007). Numerical models are able to simulate offshore wave characteristics of tsunami wave forms. However, the physics of the wave form, as it enters the shallow water and encroaches onshore, becomes more complex and requires a much higher bathymetric and topographic resolutions in order for the numerical model to provide a realistic simulation of the flow.

Flood IMs

The flood IM terminology used by the data schema is reported in Table 4.8. and the definitions of these IMs are reported below.

Table 4.8 - Flood IMs

IM Symbol	IM Name
h_{fl}	Flood water depth
v_{fl}	Flood velocity of flow

.

- Flood water depth/Over-floor depth (h_{fl}): Used almost universally because of relative ease to measure in the field, and the relative reliability of depth outputs from numerical inundation simulations. Highly correlated to structural damage of residential buildings. Expressed in m.

- Flood velocity of flow (v_{fl}): Water velocity describes the rate at which flood waters move. Highly correlated to structural damage to infrastructures. Expressed in m/s.

Windstorm IMs

Windstorms are assumed here to include cyclones, typhoons and other forms of strong wind. The windstorm IM terminology used by the data schema is reported in Table 4.9 and the definitions of these IMs are reported below.

Table 4.9 - Windstorm IMs

IM Symbol	IM Name
WV	1-minute sustained wind speed at 10 meters above the ground
PGWS	Peak Gust Wind Speed

- 1-minute sustained winds at 10 meters above the ground (*WV*): Used almost

universally and highly correlated to structural/non-structural damage of residential buildings/infrastructures. Expressed in m/s.

- Peak Gust Wind Speed (*PGWS*): Defined as the peak gust wind speed in the open terrain. Expressed in m/s.

Landslide IMs

The landslide IM terminology used by the data schema is reported in Table 4.10 and the definitions of these IMs are reported below.

Table 4.10 - Landslide IMs

IM Symbol	IM Name
d_{lan}	Landslide flow depth
v_{lan}	Landslide flow velocity
IDF	Debris-flow intensity index
SD_{lan}	Slide displacement
MFD	Maximum foundation displacement

- Landslide flow depth (d_{lan}): Represents the depth of the landslide flow. Expressed in m.
- Landslide flow velocity (v_{lan}): Represents the impact velocity of the landslide. Expressed in m/s.
- Debris-flow intensity index (I_{DF}): I_{DF} is a landslide intensity index proposed by Jakob et al. (2012) , and is computed as:

  $$I_{DF} = d_{lan} v_{lan}^2$$

  Expressed in m^3/s^2.
- Slide displacement (SD_{lan}): Is the displacement associated with the slow moving landslides. Expressed in m.
- Maximum foundation displacement (*MFD*): Is the maximum (absolute) foundation displacement due to landslide. Expressed in m.

Storm Surge

The storm surge IM terminology used by the data schema is reported in Table 4.11 and the definitions of these IMs are reported below.

Table 4.11 – Storm surge IMs

IM Symbol	IM Name
d_{ss}	Storm surge inundation depth
$v_{ss, max}$	Storm surge maximum water velocity

.

- Storm surge inundation depth (d_{ss}): d_{ss} describes the height of water above ground level. Expressed in m.·
- Storm surge maximum water velocity ($v_{ss, max}$): $v_{ss, max}$ describes the maximum water velocity. Expressed in m/s.

Volcanic ash

The volcanic ash IM terminology used by the data schema is reported in Table 4.12 and the definitions of these IMs are reported below.

Table 4.12 – Volcanic Ash IMs

IM Symbol	IM Name
h_{AF}	Ash fall thickness
L_{AF}	Ash loading

- Ash fall thickness (h_{AF}): describes the thickness of the ass, starting from 0.001m and can exceed 0.1m. Expressed in m. ·
- Ash loading (L_{AF}): refers to the loading exerted by an ash fall, and depends on its density ρ (in kg/m3) and the thickness h_{AF} (in m):
  $L_{AF} = \rho g h_{AF}$
  Expressed in kPa.

Drought

The drought IM terminology used by the data schema is reported in Table 4.13 and the definitions of these IMs are reported below.

Table 4.13 - Drought IMs

IM Symbol	IM Name
SPI	Standard Precipitation Index
PDSI	Palmer Drought Severity Index
CMI	Crop Moisture Index

.

- Standard Precipitation Index (*SPI*): It shows the actual precipitation compared to the probability of precipitation for various time frames. The *SPI* is an index based on precipitation only. It can be used on a variety of time scales, which allows it to be useful for both short-term agricultural and long-term hydrological applications. Expressed in own units – *SPI* values, as shown in Table 4.14.

Table 4.14 – SPI Values

SPI values	Description
2.0 or more	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry

- Palmer Drought Severity Index (*PDSI*): The *PSDI* is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil Palmer values may lag emerging droughts by several months; are less well suited for mountainous land or areas of frequent climatic extremes; and are complex—has an unspecified, built-in time scale that can be misleading. Expressed in own units – *PSDI* classification as shown in Table 4.15.

Table 4.15 – PSDI Classification

PSDI Classifications	Description
4.0 or more	extremely wet
3.0 to 3.99	very wet
2.0 to 2.99	moderately wet
1.0 to 1.99	slightly wet
0.5 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

- Crop Moisture Index (*CMI*): The *CMI* is a derivative of the *PDSI*, which looks at moisture supply in the short term for crop producing regions. It monitors week-to-week crop conditions. Whereas the *PDSI* monitors long-term meteorological wet and dry spells, the *CMI* was designed to evaluate short-term moisture conditions across major crop-producing regions.

4.5.4 Damage Scales Table

The Damage Scales table lists the most commonly found damage scales in the fragility function literature for the hazards investigated. The Damage Scales table schema is presented in Table 4.16. The Damage Scale Table is called upon by the Fragility Function module.

Table 4.16 – Schema of the Damage Scale table, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
dm_scale_id	ID (Hidden field)	Unique identifier of the intensity measure and Primary Key
damage_scale_name	Damage scale name (indexed field)	The entry to this fields are enumerated to include all known and frequently used damage scales. A voice is included to point to Bespoke damage scales which refer to a specific reference study. The damage scale name field also creates a relationship between the damage scale table and the FF and DTL tables. Example: Crowley et al_2004.
hazard_type	Hazard type	Enumerated type. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, and Drought.
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crops.
subasset	Sub-asset	The field lists and describes all the sub-assets to which the damage scale can be applied. Example: RC, Masonry, Timber

Table 4.16 (Continued) – Schema of the Damage Scale table, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
dm_scale_reference	Reference (Author_Year_a,b,c)	This field specified the reference study of the damage scale and points to the Title and other attributes of the study in the Reference table. A standard is set for the data entry: Author_Years_a,b,c to make sure that each reference can be used to uniquely identify the associated reference study. For existing damage scales which do not have a well-known acronym the damage scale name and the reference can be the same. Example: Crowley et al_2004.
n_dm_states	N of damage states	This field specifies the total number of damage states that the damage scale studies. This information is important because not all the damage scale have the same numbers of damage states. Example: 4
dm_states_id	Damage states identifiers in the original reference	This field lists all the damage states (separated by a semicolon) as they are identified in the specific damage scale. Example: 1;2;3;4

Table 4.16 (continued) – Schema of the Damage Scale table, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
dm_states_name	Damage states name in the original reference	This field lists all the damage states names (separated by a semicolon) as they are identified in the specific damage scale. It is important to note that, as it happens for the damage states too, different damage scales will have different names associated to a damage state. Example: 1;2;3;4
is_edp_thre	Associated with EDP threshold?	This a boolean TRUE/FALSE field which explains is the damage scale is associated to an EDP threshold.
is_dm_factor	Associated with Damage Factor?	This a boolean TRUE/FALSE field which explains is the damage scale is associated to a damage factor.
is_casualties	Associated with Casualties?	This a boolean TRUE/FALSE field which explains is the damage scale can be associated to a casualties estimation study.
is_downtime	Associated with Downtime?	This a boolean TRUE/FALSE field which explains is the damage scale can be associated to a downtime estimation study. Example: a damage scale which distinguishes damage states between Operational/ Non operational can be used to estimate downtime.

Damage scales represent a set of discrete damage-states, ideally defined by using both text and figures to assess building performance (structural and non-structural) with damage levels classified from no damage to collapse. In this data schema we have included a selection of damage scales that have been widely used seismic risk assessments and post-earthquake damage surveys. The damage scales used in the MOVER L3VDS are summarized in Table 4.17.

Table 4.17 – Damage Scales

Damage scale reference	Hazard	Asset/s of reference	No. of Damage States
EMS-98 (Grünthal, 1998)	Earthquake	RC; Masonry	5
HAZUS-MH MR4 (FEMA, 2003)	Earthquake	US building types	5
Vision 2000 (SEAOC, 1995)	Earthquake	RC; Masonry	5
FEMA 356 (FEMA, 2000)	Earthquake	RC; Masonry	4
Milutinovic and Trendafiloski (2003)	Earthquake	RC; Masonry	6
Blong (2003)	Earthquake	RC; Masonry	6
HRC (Rossetto and Elnashai, 2003)	Earthquake	RC	7
Crowley et al (2004)	Earthquake/ Landslide	RC	4
Lang and Bachmann (2004)	Earthquake	Masonry	6
GNDT (1993)	Earthquake	Italian building types	4
Japan Cabinet Office (2013)	Tsunami	RC, Masonry, Timber	6
EEFIT (2006)	Tsunami	RC	5
Fraser et al. (2013)	Tsunami	RC, Masonry, Timber	5

4.5.5 Loss Parameter Table

The Loss parameter table lists the most commonly found loss parameters in the vulnerability function literature. The Loss parameter table schema is presented in Table 4.18. The Loss parameters that currently are listed in the data schema are briefly presented in Table 4.19. The Loss parameter table is called upon by the Vulnerability Function module.

Table 4.18 – Schema of the Loss Parameter table, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
lp_id	ID (Hidden field)	Unique identifier of the loss parameter and Primary Key
lp_name	Loss Parameter name (indexed field)	Enumerated type. Possible entries include: Relative loss, Fatality Rate, Total fatalities, Economic loss total, Annual average loss, Downtime, Mean damage ratio, Economic loss ratio, Damage Index. This field is indexed and points to the lp_name field in the VF table.
lp_symbol	Loss Parameter symbol	This field specifies the acronym/ symbol usually associated to the loss parameter name.
description	Description	This field describes the loss parameter.
Units	units	Standard units used to measure the loss parameter

Table 4.19 – Loss measures

LP Symbol	LP Name
ELR	Economic loss ratio
MDR	Mean damage ratio
DT	Downtime
AAL	Annual average loss
ELT	Economic loss total
FT	Fatality total
FR	Fatality rate
Rloss	Relative loss
DI	Damage Index

· Economic loss ratio (*ELR*): The economic loss ratio is defined as the economic loss normalized by the economic exposure.

- Mean damage ratio (*MDR*): The *MDR* is the ratio of the repair cost of the structure to its replacement value.

- Downtime (*DT*): Downtime includes the time necessary to plan, finance, and complete repairs on facilities damaged by other various disasters.

- Annual average loss (*AAL*): *AAL* is the value expected to be saved every year in order to cope with all the future losses, and it can be derived from the loss exceedance curve as the of the exceedance rate of loss:

  $$AAL = \int_0^{\infty} v(p)\,\mathrm{d}p$$

  Where v(p) is the exceedance rate of loss, p.

- Economic loss total (*ELT*): *ELT* represent the total level of economic loss expressed in USD.

- Fatality total (*FT*): Total number of fatalities related to a hazard.

- Fatality rate (FR): Fatality rate is defined as the ratio of the total number of disaster-related fatalities (*FT*) to the total population exposed.

- Relative loss (Rloss): The loss is shown as a fraction of the percentage of the estimated total replacement value of property or area and its contents. *Rloss* is

mainly used for flood loss estimation.

- Damage index (*DI*): Damage Index judges the proportion of the replacement cost of the structure.

4.5.6 Engineering Demand Parameter Table

The Engineering Demand Parameter (EDP) table lists the most commonly found EDPs in the analytical fragility function literature for the hazards investigated. The EDP table schema is presented in Table 4.20. The EDPs that currently are listed in the data schema are briefly presented in Table 4.21. The EDP table is called upon by the Fragility Function module.

Table 4.20 – Schema of the Loss Parameter table, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
edp_id	ID (Hidden field)	Unique identifier of the EDP and Primary Key
edp_name	EDP name (indexed field)	Enumerated type. Possible entries include: Park-Ang damage index, Peak floor acceleration, Roof drift ratio, Maximum inter-storey drift ratio, Inter-storey drift ratio for storey i, Demand to capacity ratio. This field is indexed and points to the edp_name field in the FF table.
edp_symbol	EDP symbol	This field specifies the acronym/symbol usually associated to the EDP name.
description	Description	This field describes the loss parameter.
Units	units	Standard units used to measure the loss parameter

In analytical approaches, Engineering Demand Parameters (EDP) are typically used as a proxy of damage level, with EDPs chosen such that they are indicative of the damage state of the entire asset. For instance, in earthquake engineering ranges of values of roof drift or inter-storey drift are commonly adopted to represent specific damage states.

Table 4.21 – EDPs

EDP Symbol	EDP Name
PFA	Peak floor acceleration
RDR	Roof drift ratio
IDRi	Inter-storey drift ratio for storey i
MIDR	Maximum inter-storey drift ratio
D/C	Demand to capacity ratio
DI	Park-Ang damage index

- Peak floor acceleration (*PFA*): The *PFA* represents the peak (over time) acceleration at each floor. Expressed in m/s^2.

- Roof drift ratio (*RDR*): The *RDR* is the ratio of the peak lateral roof displacement to the building height. Unitless IM.

- Inter-storey drift ratio for storey (*IDRi*): The *IDRi* represents the peak (over time) inter-storey drift ratio, and is calculated as the largest difference between the lateral displacements of two adjacent floors, divided by the height of the storey. Unitless IM.

- Maximum inter-storey drift ratio (*MIDR*): The *MIDR* is the maximum (over all stories) *IDRi*. Unitless IM.

- Demand to capacity ratio (*D/C*): The D/C simply refers to the ratio between the external actions applied to the structure (demand) over the ability of the structure to carry the imposed actions (capacity). In its simplest form, a D/C>1 implies failure. However, it is acceptable that the ratio exceeds unity where ductile response is assured. Unitless IM.

- Park-Ang damage index (*DI*): The *DI* (Park et al., 1987) is a damage index that takes into account the effect of maximum deformation and cyclic loads, and is calculated as shown in the formula:

$$DI = \frac{\delta_m}{\delta_u} + \frac{\delta}{Q_y \delta_u} \int dE$$

where δ_m is the maximum experienced deformation of the element (nonlinear dynamic analysis), δ_u is the ultimate deformation (push-over analysis), Q_y is the yielding strength of element, dE is the hysteretic energy absorbed by the element

during the analysis of the time of reply and β is the model's constant parameter. Unitless IM.

4.5.7 Reference Table

The Reference table stores all the information necessary to the identification of reference studies which are associated to the study and validation of functions, damage scales, and intensity measures. It is designed to provide the user with a complete bibliography of the reference studies consulted during the data entry process.

As many of these parameters (e.g., IM, damage scale) may exist in the same record of a single function, the Vulnerability, Fragility and Damage to Loss base tables are linked to the reference table by multiple relationships and by several fields (e.g. im_name, damage_scale_name).

The reference table schema is presented in Table 4.22.

Table 4.22 – Schema of the Reference table, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
id	ID (Hidden field)	Unique identifier of the Reference study and Primary Key
author_name	Reference (Author_Year_a,b,c) (indexed field)	This field identifies the reference studies based on the author/s name/s, year of publication and number of subsequent publications in the same year. This field is indexed and points to the VF, FF, DTL, Damage scale tables.
title	Title	Title of the reference study.
issn	ISSN	When available the International Standard Serial Number is specified. This field can be null.
doi	DOI	When available the Digital Object Identifier is specified. This field can be null.

4.5.8 Data Table

Similar to the Reference table, the Data table also serves as a repository. It has a dual purpose. The first is to identify data sources based on which functions, indicators, and indices have been scored against. The second is to retain the possibility to check on the resources

that are available for population the database, not only to avoid duplication but also to acquire metadata on the user/ institution that has made such data available. It is highlighted that the date of acquisition of the data is an important parameter to take into account in the assessment of indicators and indices, The data table schema is presented in Table 4.23.

Table 4.23 – Schema of the Data table, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
id	ID (Hidden field)	Unique identifier of the Data source table and Primary Key
data_source	Data source	Source or storage location of the data set
description	Description	Description of the data set
data_collector	Data collector	Unique identifier of the data collector
date_collection	Date/Time of collection	Timestamp with time zone field

4.5.9 Vulnerability and Fragility Function Scoring Table

The scoring table for vulnerability and fragility functions have the same schema, which is shown in Table 4.24.

Even though the scoring can be seen as an attribute of the functions, the design of the schema handles these tables as separate entities. This has been done because, for instance, a same function can be applied to more than a country also to the same country by using different set of data. Having the scoring as attributes of the base tables would have implied the need for a data source field in all those tables to score for data quality and also would have forced the user to have as many duplicate entries for all possible combination of countries and data sets available. This design solution resolves the issue of duplication.

Table 4.24 – Schema of the scoring tables, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
id	ID (Hidden field)	Unique identifier of the score given to a function given its geographic applicability and data, and Primary Key
geo_applicability	Geo-applicability	Country ISO code. Example: TZA
function_id/ indicator_id/index_id	ID of the function/indicator/ index	
data_source	Data source	This field specifies the source of the data available.
rationality_score_lev0	Rationality score - Level 0,1,2,3	Enumerative field. Possible entries include: Excellent, Good, Needs Improvement, Unusable. *This field is NULLABLE in the Level 3 data schema, but marked as a compulsory field in the Level 2.*
rationality_score_lev1		
rationality_score_lev2		
rationality_score_lev3		
data_quality_score	Data quality score	Enumerative field, which assesses the quality of the data available to building the function. Possible entries include: Excellent, Good, Needs Improvement, Unusable. *This field is NULLABLE in the Level 3 data schema, but marked as a compulsory field in the Level 2.*

Table 4.24 (Continued) – Schema of the scoring tables, described field by field.

Column name (ordered as in the interface)	Alias shown	Description
combf_score_lev0	Combined function score - Level 0,1,2,3	Enumerative field. Possible entries include: Excellent, Good, Needs Improvement, Unusable. The values of this field are established by taking into consideration both the Rationality score, for each the 4 scales of applicability, and the Data quality score. *This field is NULLABLE in the Level 3 data schema, but marked as a compulsory field in the Level 2.*
combf_score_lev1		
combf_score_lev2		
combf_score_lev3		
combf_score_simple_lev0	Combined function score (Simplified) - Level 0,1,2,3	Enumerative field. Possible entries include: Representative, Unrepresentative. Simplified representation of the combined scoring to the function. *This field is NULLABLE in the Level 3 data schema, but marked as a compulsory field in the Level 2.*
combf_score_simple_lev1		
combf_score_simple_lev2		
combf_score_simple_lev3		

The MOVER scoring system for the Level 3 data schema Vulnerability Functions (VF) and Fragility Functions (FF) is presented in Tables 4.25-4.27. The scoring systems consists in attributing a score to the Rationality and Data Quality of the functions. The scores can either be “Excellent”, “Good”, “Needs Improvement” or “Unuseable”, and criteria are set out for each scoring category according to the type of fragility or vulnerability function being assessed. The scoring must be carried out by the user on the basis of a desired asset and hazard vulnerability evaluation, for a given geographical level. The combined Rationality and Data Quality score provides an assessment as to whether the function is suitable for use and application to the given case study.

Table 4.25. Scoring criteria of the Rationality of a given VF or FF

Rationality Score (RS)	**Description**
Excellent (Ex)	VF or FF is constructed for the same asset class and for the same geographical area to the asset class of the application. **AND** The damage or loss definition in the VF or FF matches the damage or loss definition of interest. **AND** VF or FF uses an Intensity Measure (IM) that is accepted in the international literature as being highly representative of the damage/loss potential of the assessed hazard on the assessed asset class. **AND** First principles are met. **AND** Uncertainty around the VF or FF is presented. **AND** The damage or loss observations used to construct the VF or FF cover the range of IMLs of interest in the assessment.
Good (G)	VF or FF is constructed for a similar (or same) asset class and from the same geographical area as the asset class of the application. **AND** VF or FF uses an Intensity Measure (IM) that is accepted in the international literature as being somewhat representative of the damage/loss potential of the assessed hazard on the assessed asset class. **AND** First principles are met. **AND** Uncertainty around the VF or FF is presented. **AND** The damage or loss observations used to construct the VF or FF cover the range of IMLs of interest in the assessment.

Table 4.25 (Continued). Scoring criteria of the Rationality of a given VF or FF

Rationality Score (RS)	**Description**
Needs Improvement (NI)	VF or FF is constructed for a similar (or same) asset class to the class of interest and for a similar (or same) geographical area to that of the application. **AND** VF or FF uses an Intensity Measure (IM) that is accepted in the international literature as being somewhat representative of the damage/loss potential of the assessed hazard on the assessed asset class. **AND EITHER** First principles are not met. **OR** Uncertainty around the VF or FF is not presented. **OR** The damage or loss observations used to construct the VF or FF do not cover the range of IMLs of interest in the assessment.
Unusable (Un)	VF or FF is not constructed for a similar asset class to the class of interest **OR** for a similar geographical area to that of the application. **OR** VF or FF uses an Intensity Measure (IM) that is accepted in the international literature as not being representative of the damage/loss potential of the assessed hazard on the assessed asset class.

Table 4.26. Scoring criteria of the Function Quality of a given VF or FF.

Function Quality Score (FQS)	**VF or FF Type**	**Description**
Excellent (Ex)	Empirical	VF or FF based on samples representative of the impact of the event to the area that are either unbiased or have been corrected for identified biases. **AND** At least 200 damage or loss observations used to construct the VF or FF. For aggregated damage data, a minimum of 20 observations per bin of IM is used for a minimum of 10 bins.
	Analytical	VF or FF uses high-level asset modelling and engineering assessment carried out according to the accepted state-of-the-art for the hazard. **AND** VF or FF includes variability in asset performance at any given Intensity Measure Level (IML) due to the variability in the hazard loading **AND** in the asset characteristics across an asset class. **AND** At least 200 realisations are used to construct the VF or FF.
	Heuristic	VF or FF obtained from an application of the Cooke's method or similar.

Table 4.26 (Continued): Scoring criteria of the Function Quality of a given VF or FF.

Function Quality Score (FQS)	VF or FF Type	Description
Good (G)	Empirical	VF or FF based on samples representative of the impact of the event to the area that are either unbiased or have been corrected for identified biases. **AND** Between 50 and 199 damage or loss observations used to construct the VF or FF. For aggregated damage data, a minimum of 5 observations per bin of IM is used for a minimum of 10 bins.
	Analytical	VF or FF adopt **EITHER** a simplified asset modelling **OR** simplified engineering assessment carried out according to the accepted state-of-the-art for the hazard (**NOT BOTH**). **AND** At least 50 realisations are used to construct the VF or FF. **OR** VF or FF uses high-level asset modelling and engineering assessment carried out according to the accepted state-of-the-art for the hazard. **AND** VF or FF includes variability in asset performance at any given Intensity Measure Level (IML) due only to the variability in the hazard loading **OR** only due to the variability in the asset characteristics across an asset class. **AND** At least 50 realisations are used to construct the VF or FF.
	Heuristic	VF or FF obtained from an application of the Delphi Method or similar.

Table 4.26 (Continued): Scoring criteria of the Function Quality of a given VF or FF.

Function Quality Score (FQS)	**VF or FF Type**	**Description**
Needs Improvement (NI)	Empirical	VF or FF based on samples representative of the impact of the event to the area that are either unbiased or have been corrected for identified biases. **AND** Between 20 and 50 damage or loss observations used to construct the VF or FF
	Analytical	VF or FF adopt simplified asset modelling **AND** A simplified engineering assessment, carried out according to the accepted state-of-the-art for the hazard. **AND** At least 20 realisations are used to construct the VF or FF. **AND/OR** The damage or loss observations used to construct the VF or FF do not cover the range of IMLs of interest in the assessment **AND/OR** VF or FF includes variability in asset performance at any given Intensity Measure Level (IML) due to the variability in the hazard loading **OR** in the asset characteristics across an asset class.
	Heuristic	Consensus-based assessment reached by eliciting without a formal procedure using at least 5 experts.
Unusable (Un)	All	VF or FF does not meet the criteria of NI

Table 4.27. Combined Rationality and Data Quality Scoring system for VF and FF

Detailed VI Score	Combinations of RS and FQS		Simple VI Score
	RS	FQS	
Excellent	Ex	Ex	Representative
Good	Ex	G	
	G	G	
Needs Improvement	G	NI	
	NI	NI	
Unusable	NI	Un	Unrepresentative
	Un	Un	

4.5.10 Categories and Characteristics Table

These tables are, in essence, dictionaries that aid the user in understanding the meaning of the physical and social vulnerability categories and characteristic and the areas of knowledge that they cover. These tables are essential for the social indicators where definitions of the indicators are not as self-explanatory as physical indicators. The Category and Character tics tables are based on the same schema which is shown in Figure 4.5.

	Column name	Type	Null
	id	integer	NOT NULL
	soc_v_cat_name	soc_vul_cat_enum	NOT NULL
	soc_v_cat_abb	soc_vul_sym_enum	NOT NULL
	description	character varying(250)	

Figure 4.5 - Schema of the Categories and Characteristics tables.

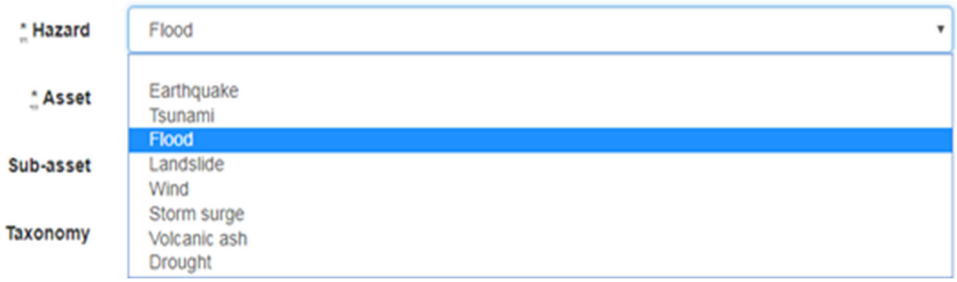
5 Examples of How to Enter Data

This Section provides examples of how a user can enter vulnerability data and models into the MOVER L3VDS. Excamples are provided relating to each of the four modules of the schema.

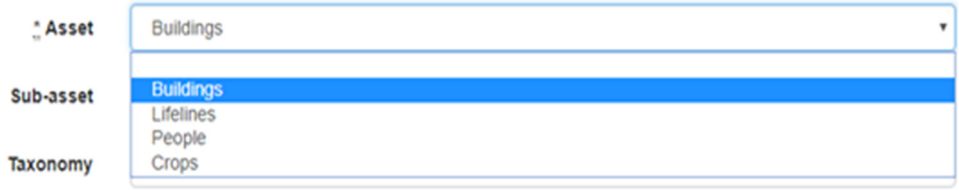
5.1 Example 1: Data entry to Module 1

In this section the procedure for entering a fragility model in the fragility function table of Module 1 is presented. The study by Jalayer et al. (2013), is used as the primary example, however, other studies are also used as a reference to present alternative data entry options. Each entry in the *Fragility function table* or *Vulnerability function table* (Ff_table, Vf_table) corresponds to one fragility or vulnerability curve. For example, if a study presents two sets of fragility functions consisting of five curves each, a total of 10 entries are expected in the *Fragility function table* for the given study.

Hazard: Select the hazard associated with the inputted function from the drop-down menu. The user can choose from seven hazard options, including earthquake, tsunami, flood, landslide, wind, storm surge, volcanic ash and drought.



Asset type: Choose the asset type for which the inputted function is developed. Four asset options are available, namely buildings, lifelines, people and crops.

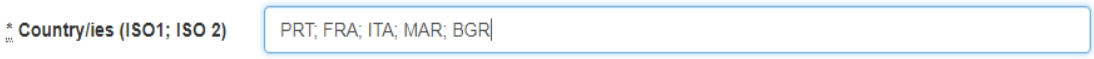


Sub-asset: Type a more detailed description of the specific asset within the asset group. The user is expected to enter the sub-asset description as found in the reference study.

Taxonomy: Type the GEM taxonomy code associated with the sub-asset field. GEM taxonomy codes only apply for building Assets and can be generated using the GEM taxonomy tool found in the following link: https://platform.openquake.org/taxtweb/

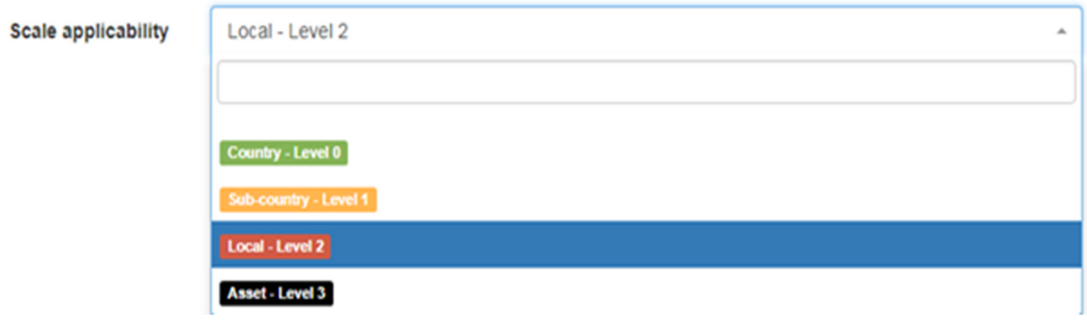
Country/ies (ISO1; ISO 2): Type the 3 letter ISO code associated with the country/ies of interest.

A semicolon is used to separate the ISO codes if more than one country, as in the case of Valencia et al. (2011) shown below:

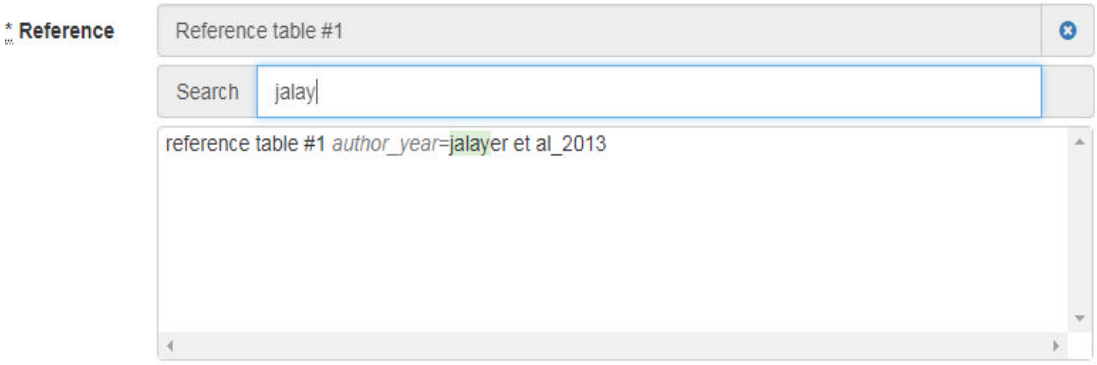


Approach: Scroll down to find the type of approach used or simply type the first few letters to narrow down the available options.

Scale applicability: Choose the scale applicability between Level 0 to Level 3.



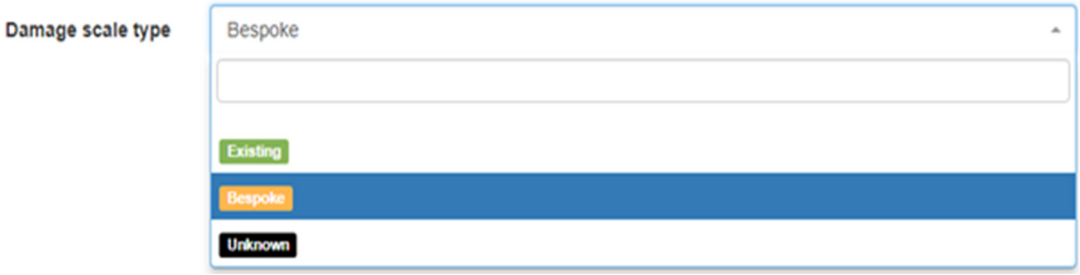
Reference (Author_Year_a,b,c): Start typing the author(s) name(s) in the Search field and select the relevant reference from the list below.



Note that before filling out this field, the reference study must be first entered in the *Reference table* (reference_table). In case two or more reference entries have same name and year of

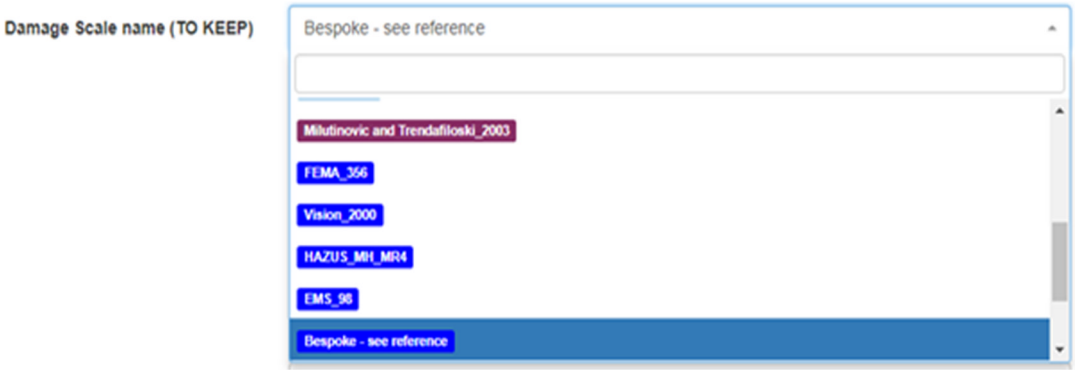
publication, simply add an underscore and a letter a,b,c to distinguish the different entries, e.g. Macabuag et al_2016_a, Macabuag et al_2016_b etc.

Damage scale type: Choose the type of damage scale from the drop-down menu.



This entry is directly linked to *Damage Scale name* and *Damage Scale Reference* entries.

Damage Scale name: Scroll down the list to find the name of the damage scale used in the study, or choose the *Bespoke – see reference* choice, in case the damage scale study in not listed in the menu, or *Unknown* if the damage scale study is not specified in the function of interest.

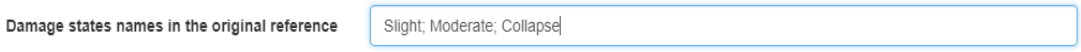


Damage Scale Reference: Start typing the author(s) name(s) in the Search field and select the relevant Damage Scale reference study from the list below. Before filling out this field, the user should first enter the Damage Scale reference study in the *Reference table* (reference_table). Note that the studies associated with the predefined Damage Scale Types (including *Unknown* Damage Scale) are already included in the *Reference table*.

N of damage states: Specify the number of damage states presented in the current study. Note that this is not the total number damage states included in the damage scale. For instance, in the example study shown here only 1 damage state is presented (out of a number of damage states included in the damage scale). In this case, the user should enter 1 in this field.

Damage state names in the original reference: Type the corresponding names of the N number of damage states entered above.

Use semicolon to separate names in cases where more than one states exist. For instance, the fragility function developed by Barud Ali (2017) has 3 damage state entries, as shown below.

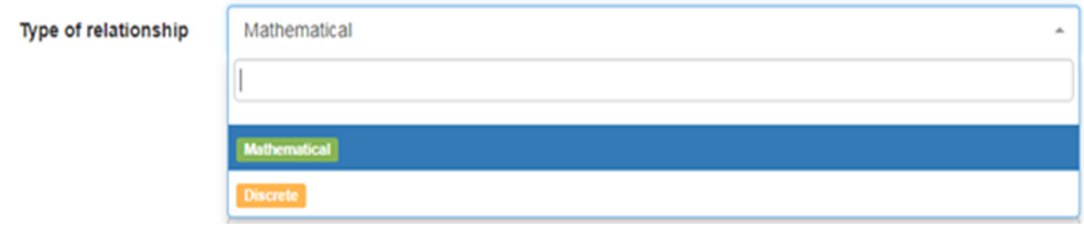


Damage state of the function: Select from the drop-down the name of the damage state of the function or simply type the first few letters to narrow down the available options. Note that unlike the *Corresponding damage states names* option (where all the corresponding names of the N number of damage states are entered), here you only need to specify one damage state.

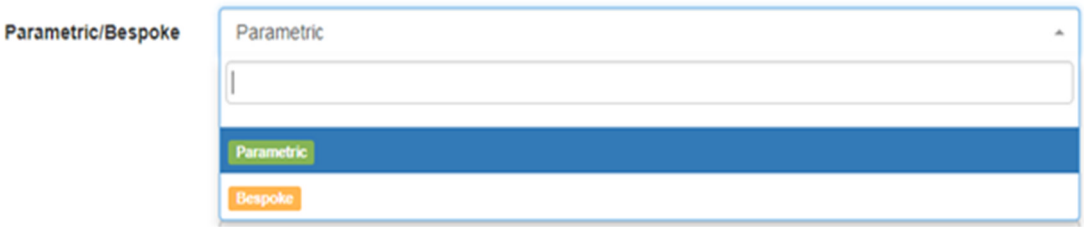
EDP name: Choose from the drop-down the name of the EDP used or simply type the first few letters to narrow down the available options.

EDP damage state threshold: Define the threshold of EDP associated with the damage state. Note that some studies do not provide this information. This entry does not apply for empirical or judgemental functions.

Mathematical/Discrete: Select from the drop-down menu the type of relationship. Possible entries include: Mathematical and Discrete.



Parametric/Bespoke: Select if the study is parametric or bespoke mathematical model.



Mathematical Model: Choose the mathematical model utilized for the derivation of the function. Possible entries include: Cumulative lognormal, Cumulative normal, Exponential, Bespoke - see reference

Bespoke model reference: Provide the reference study of the bespoke model. This entry is only applicable when bespoke mathematical model is used in the study of interest. Before filling out this field, the user should first enter the bespoke model study in the *Reference table* (reference_table).

Parameters names (Par1; Par2): Enter the names of the mathematical parameter(s) separated by a semicolon.

Upper bound parameters values (Value 1; Value 2): Enter the values associated to the upper bound parameters (as defined in *Parameters names* field above) for parametric functions. Such information is not provided for the studies included in the Schema.

Upper bound parameters percentile for parametric functions (Perc1,Perc2): Enter the percentiles associated to the upper bound parameters (as defined in *Parameters names* field above) for parametric functions. Such information is not provided for the studies included in the Schema.

Median parameter: Specify the values of the median parameters corresponding to the parameter names, separated by a semicolon.

Lower bound parameters values (Value 1; Value 2): Enter the values associated to the lower bound parameters (as defined in *Parameters names* field above) for parametric functions. Such information is not provided for the studies included in the Schema.

Lower bound parameters percentile for parametric functions (Perc1,Perc2): Enter the percentiles associated to the lower bound parameters (as defined in *Parameters names* field above) for parametric functions. Such information is not provided for the studies included in the Schema.

EP (only for discrete fragility functions): In this field list the associated exceeded probability values to the IM values of the previous field. Such information is not provided for the studies included in the Schema.

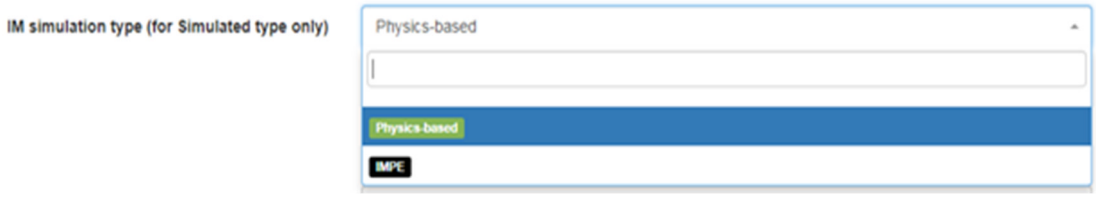
IM values (only for discrete fragility functions): In this field list the IM values for the characterization of discrete functions. Such information is not provided for the studies included in the Schema.

IM name: Select from the drop-down the name of the IM used or simply type the first few letters to narrow down the available options.

IM range: Define the minimum and maximum IM range of the function, separated by a semicolon.

IM method: Choose from the drop-down menu the type of IM method.

IM simulation type (for Simulated type only): When a *Simulated* IM method is chosen, select the type of IM simulation, between *Physics-based* and *IMPE*.



IMPE reference: If *IMPE* is chosen as the *IM simulation type*, provide the IMPE reference. Note that before filling out this field, the reference study must be first entered in the *Reference table* (reference_table).

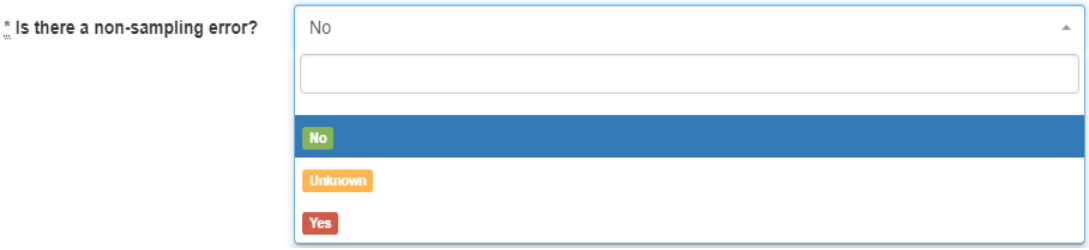
Data countries (ISO1; ISO2;...): Type the 3 letter ISO code associated with the country/ies from where data are obtained. Use semicolon to separate codes in cases where data are obtained from more than one country.

IM data source/s: Start typing the author(s) name(s) in the Search field and select the relevant IM data source reference study from the list below. Before filling out this field, the user should first enter the Damage Scale reference study in the *Reference table* (reference_table).

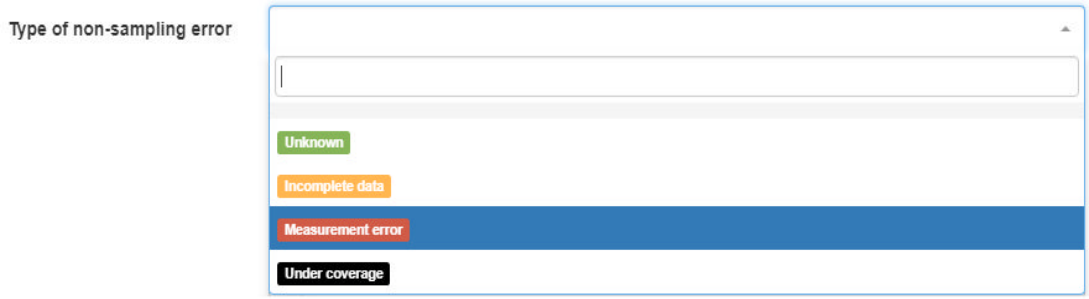
N events: Specify the number of events the function has been built on. Note that some studies do not provide this information.

N assets: Type the number of assets used for the derivation of this function.

Is there a non-sampling error? : Select if non-sampling error was taken into consideration, or choose *Unknown* if such is information was not provided.



Type of non-sampling error: Choose from the drop-down menu the type of non-sampling error. Possible entries include: Under coverage, Incomplete data, Measurement error, Unknown.



Has sampling error been fixed? : Choose from the drop-down menu whether the non-sampling error was fixed or not. This field is applicable only when non-sampling error was considered.

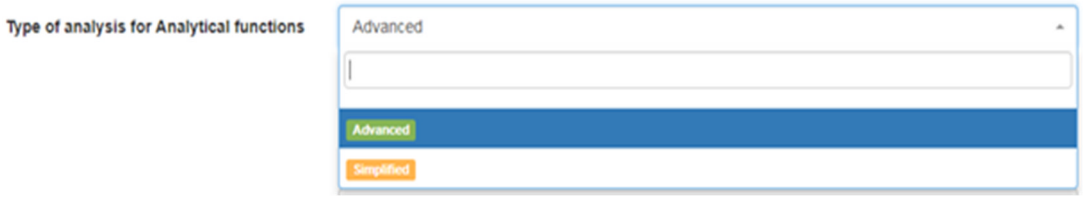
Is data aggregated? : Choose from the drop-down menu whether the data were aggregated or not.

N of data points aggregated: Type the number of aggregated data points used for the evaluation of data quality.

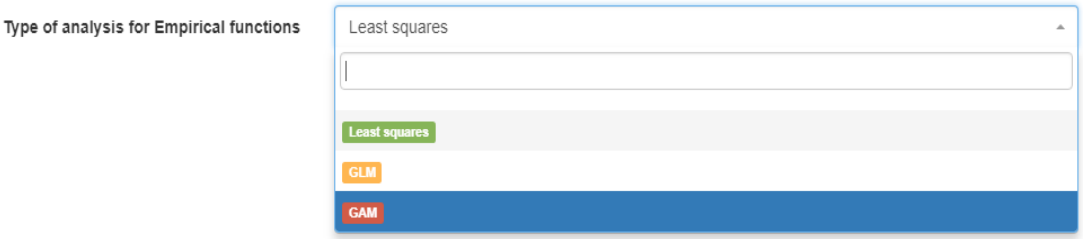
Is data disaggregated? : Choose from the drop-down menu whether the data were disaggregated or not.

N of disaggregated data points: Type the number of disaggregated data points used for the evaluation of data quality.

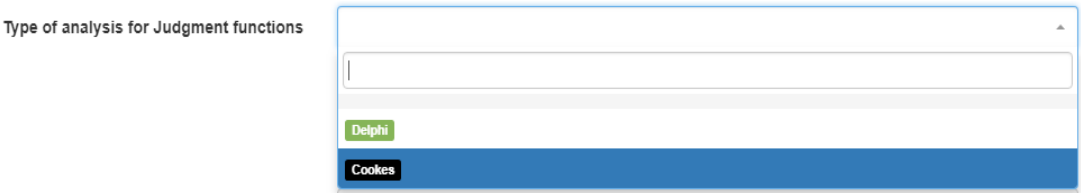
Type of analysis for Analytical functions: Choose analysis type of the analytical function. Possible entries include: Simplified and Advanced.



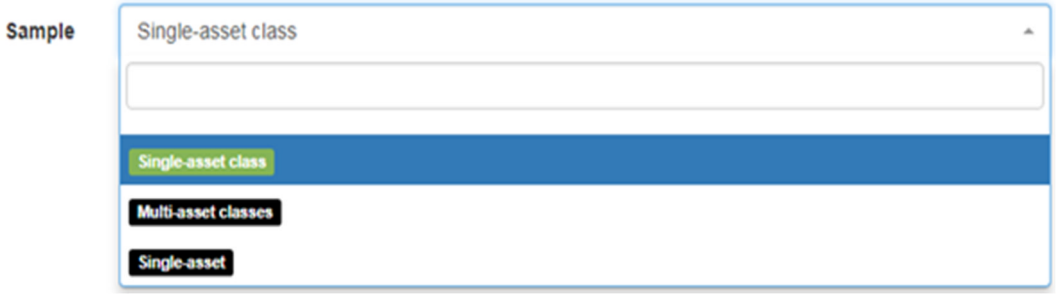
Type of analysis for Empirical functions: Choose analysis type of the empirical function. Possible entries include: Least squares, GLM and GAM.



Type of analysis for Judgement functions: Choose analysis type of the judgement function. Possible entries include: Delphi and Cookes.



Sample: Select from the drop-down menu the type of asset sample. Possible entries include: Single-asset class, Multi-asset classes and Single-asset.



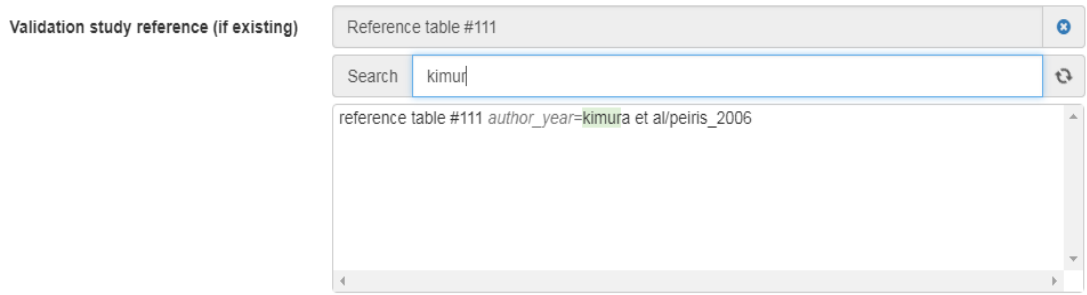
Is the fit good? : Select if goodness of fit test was provided for this study.

Reference study of fitting: If the goodness of fit test was provided, enter the reference model for fitting. Before filling out this field, the user should first enter the Reference study of fitting in the *Reference table* (reference_table).

Has the function been validated? : Specify if the function was validated.

Is the validation study existing? : Select if the validation study is existing.

Validation study reference (if existing): If the validation was conducted, specify the source of independent data used for validation. Start typing the author(s) name(s) in the Search field and select the relevant reference study from the list below. Before filling out this field, the user should first enter the Reference study used for validation in the *Reference table* (reference_table). As an example, the fragility function developed by Murao (2010) was validated against Kimura et al. (2006) and Peiris (2006).



5.2 Example 2: Data entry to Module 2

In this section the procedure for entering data in the physical indicator table of Module 2 is described. The example below illustrates the data entry of building exposure at Admin level 2, as provided by GEM. In this example, the percentage of reinforced masonry buildings (MR according to GEM taxonomy code) located in Mjini city, Zanzibar West region is used as indicator.

Hazard: Fill in this entry with the hazard associated with the physical indicator. The user can choose from eight hazard options, including earthquake, tsunami, flood, landslide, wind, storm surge, volcanic ash, drought and multi-hazard (when the indicator is associated with more than one hazards). In this example, the physical indicator is related to material of lateral load-resisting system of building can be associated with earthquake, tsunami and other hazards, therefore, multi-hazard option is used.

Asset: Choose the asset type of the physical indicator. Four asset options are available, namely buildings, lifelines, people and crops.

Sub asset: Type a detailed description of the specific asset within the asset group, or type the GEM taxonomy code associated with the sub-asset if provided. GEM taxonomy codes only apply for building Assets and can be generated using the GEM taxonomy tool found in the following link: https://platform.openquake.org/taxtweb/

Country iso: Type the 3 letter ISO code associated with the country/ies of interest.

A semicolon is used to separate the ISO codes if more than one country.

Scale applicability: Choose the scale applicability between Level 0 to Level 3. Based on the scale applicability level chosen here, fill in the associated admin level entries below.

Name of Adm_0: Fill in the 3 letter ISO of the country for which data are available.

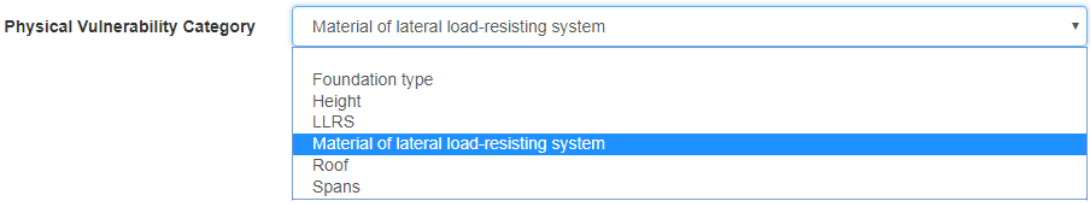
Name of Adm_1: Type the name of Admin level 1, e.g. name of the region. The entry is applicable for scale applicability level 1 or higher, otherwise remains blank.

Name of Adm_2: Type the name of Admin level 2, e.g. name of the city. The entry is applicable for scale applicability level 2 or higher, otherwise remains blank.

Name of Adm_3: Type the name of Admin level 3, e.g. address of the asset. The entry is applicable for scale applicability level 3, otherwise remains blank. In this example, this entry is blank because the data provided are for Admin level 2.

Physical Vulnerability Category: Enter the name of the physical vulnerability category. The categories of the asset features of the physical vulnerability indicators data schema specified in GED4ALL database (Silva et al. 2018)

In this example, the category Material of lateral load-resisting system is used.

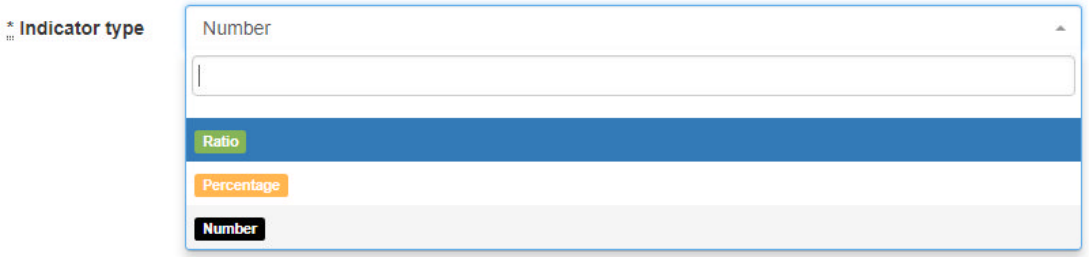


Physical Vulnerability Category (Symbol): Type the predefined symbol (abbreviation) of the physical vulnerability category above.

Physical Vulnerability Characteristic: Enter the name of the physical vulnerability characteristic. The characteristics are the sub-groups of the physical vulnerability categories above. For more details one can refer to GED4ALL database (Silva et al. 2018). In this example, the characteristic Material type (which is a sub group of the category Material of lateral load-resisting system) is used.

Physical Vulnerability Characteristics (Symbol): Type the predefined symbol (abbreviation) of the physical vulnerability characteristic above.

Indicator type: Select from the drop down menu the type of the indicator. Available options include Ratio, Percentage and Number. In this example, the indicator type is *Percentage*.



Indicator name: Specify the physical indicator's name.

Indicator value: Specify the physical indicator's value. A real number entry is expected.

5.3 Example 3: Data entry to Module 3

In this section the procedure for entering data in the social indicator table of Module 3 is described. The example below illustrates the data entry of social indicators at Admin level 1, as provided by GEM. In this example, the percentage of dependent population located in Dodoma region is presented.

Hazard: Fill in this entry with the hazard associated with the social indicator. The user can choose from eight hazard options, including earthquake, tsunami, flood, landslide, wind, storm surge, volcanic ash, drought and multi-hazard (when the indicator is associated with more than one hazards).

Asset type: Choose the asset type of the social indicator. In the case of module 2, the only available asset option is *People.*

Sub-asset: Type a detailed description of the specific asset within the asset group. This entry can be left blank in the case of Module 2.

Country iso: Type the 3 letter ISO code associated with the country/ies of interest.

A semicolon is used to separate the ISO codes if more than one country.

Scale applicability: Choose the scale applicability between Level 0 to Level 3. Based on the scale applicability level chosen here, fill in the associated admin level entries below.

Adm_0 (Country ISO): Fill in the 3 letter ISO of the country for which data are available.

Name of Adm_1: Type the name of Admin level 1, e.g. name of the region. The entry is applicable for scale applicability level 1 or higher, otherwise remains blank.

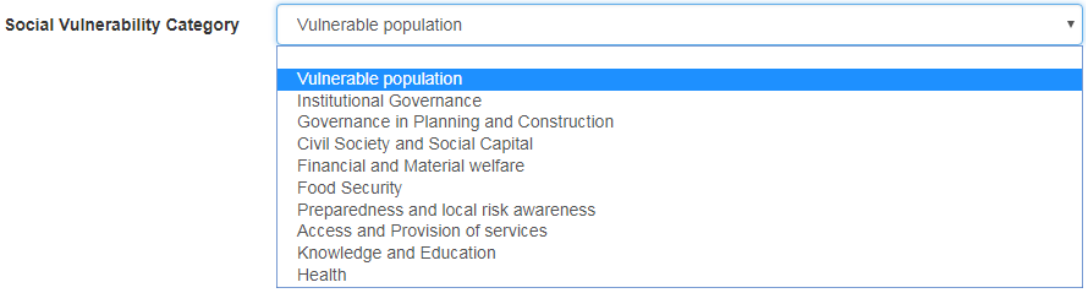
Name of Adm_2: Type the name of Admin level 2, e.g. name of the city. The entry is applicable for scale applicability level 2 or higher, otherwise remains blank. In this example, this entry is blank because the data provided are for Admin level 1.

Name of Adm_3: Type the name of Admin level 3, e.g. address of the asset. The entry is applicable for scale applicability level 3, otherwise remains blank. In this example, this entry is blank because the data provided are for Admin level 1.

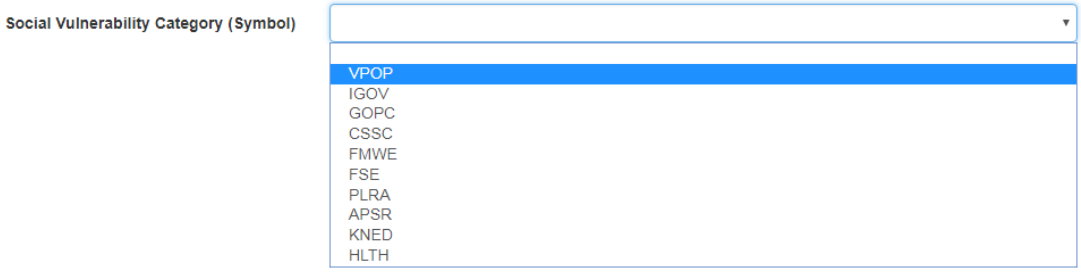
S

ocial Vulnerability Category: Choose the name of the social vulnerability category from the drop-down menu. The categories of the Social vulnerability data schema are specified in the Level 2 MOVER data schema report.

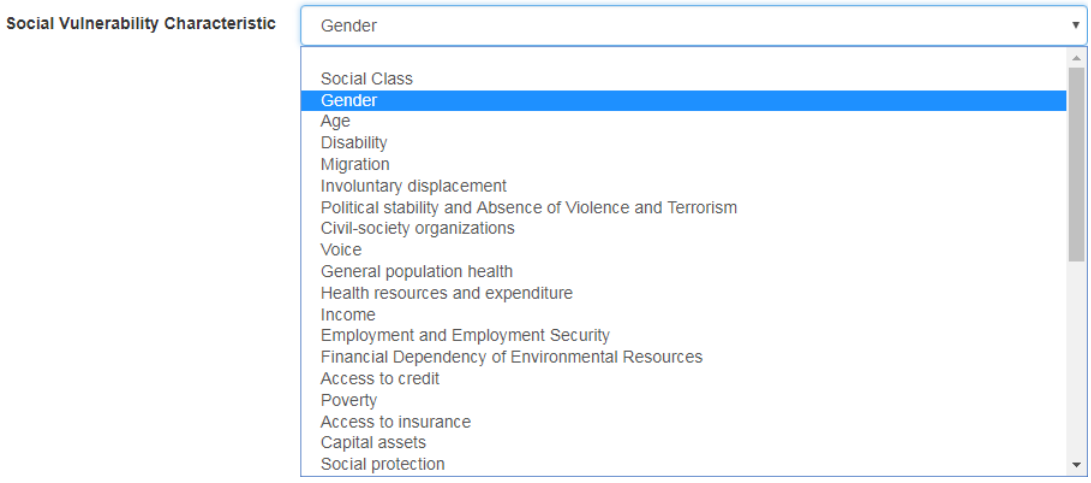
In this example, the category Material of lateral load-resisting system from the group Assets features for Buildings is shown.



Social Vulnerability Category (Symbol): Choose from the drop-down menu the predefined symbol (abbreviation) associated with the social vulnerability category above.

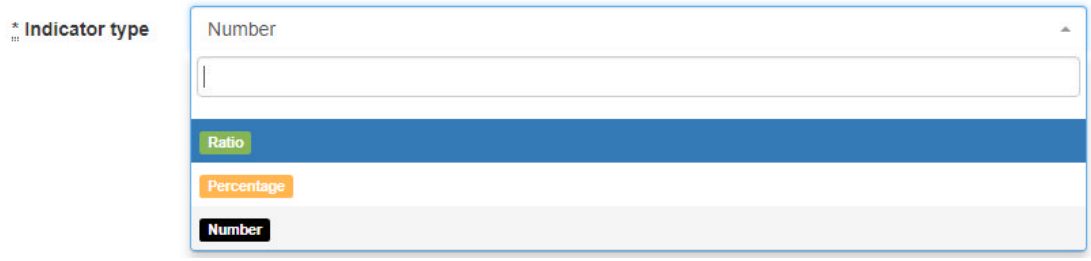


Social Vulnerability Characteristic: Choose the name of the social vulnerability characteristic from the drop-down menu.



Social Vulnerability Characteristic (Symbol): Choose from the drop-down menu the predefined symbol (abbreviation) associated with the social vulnerability characteristic above.

Indicator type: Select from the drop down menu the type of the indicator. Available options include Ratio, Percentage, Number and Average.



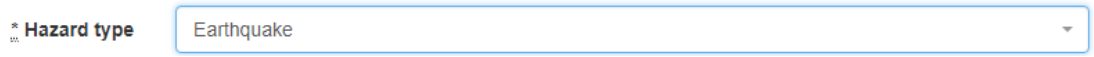
Indicator name: Specify the social indicator's name.

Indicator value: Specify the social indicator's value. A real number entry is expected.

5.4 Example 4: Data entry to Module 4

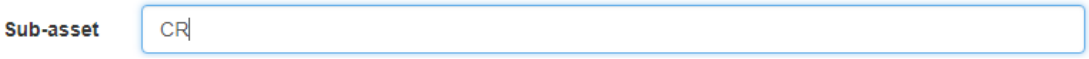
In this section the procedure for entering data in the Physical, Social and Hybrid index tables of Module 4 is described. The example below illustrates the data entry of the Physical Index FEMA P-154, as obtained for reinforced concrete (CR) for areas characterized by very high seismicity levels.

Hazard type: Fill in this entry with the hazard associated with the index of interest. The user can choose from eight hazard options, including earthquake, tsunami, flood, landslide, wind, storm surge, volcanic ash, drought and multi-hazard (when the indicator is associated with more than one hazards). In this example, the index is be associated with earthquake.



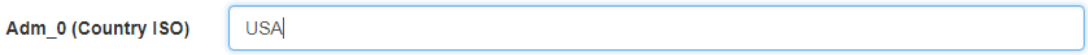
Asset: Choose the asset type of the index. Four asset options are available, namely buildings, lifelines, people and crops.

Sub asset: Type a detailed description of the specific asset within the asset group, or type the GEM taxonomy code associated with the sub-asset if provided. GEM taxonomy codes only apply for building Assets and can be generated using the GEM taxonomy tool found in the following link: https://platform.openquake.org/taxtweb/.



Scale applicability: Choose the scale applicability between Level 0 to Level 3. The example index illustrated here is applied at Asset level (Level 3).

Adm_1 (Country iso): Type the name of the Country (ISO country code) for which data are available for the analysed hybrid index. The FEMA P-154 index is developed for the USA.



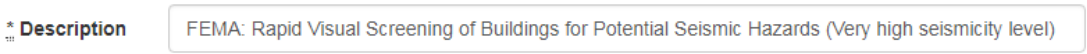
A semicolon is used to separate the ISO codes if more than one country.

Name of Adm_2: Type the name of Admin level 2, e.g. name of the city. This information is not provided for this index, therefore the entry remains blank.

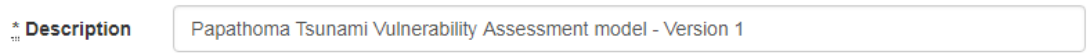
Name of Adm_3: Type the name of Admin level 3, e.g. address of the asset. This information is not provided for this index, therefore the entry remains blank.

Index name: Enter the name of the index.

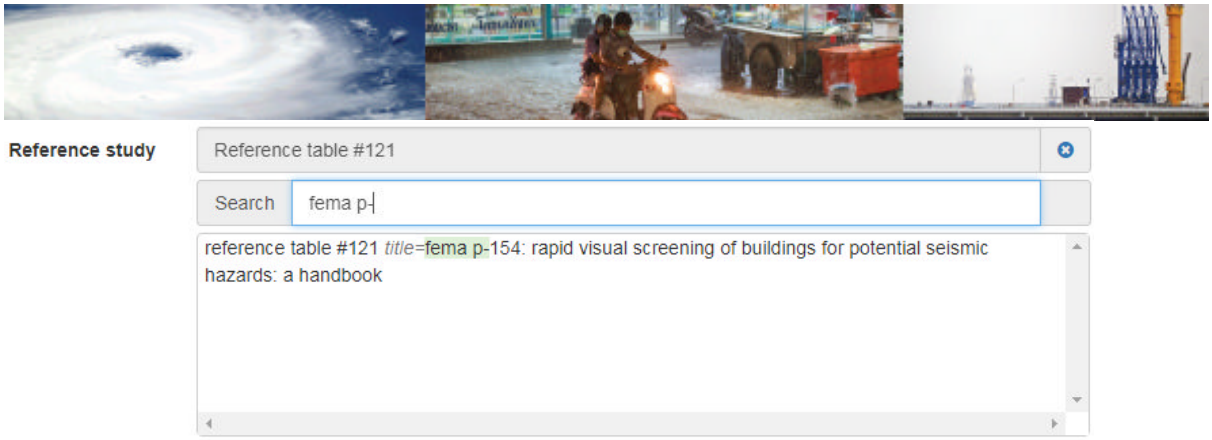
Description: Type the description of the index.



This can be the full form of the abbreviated index names, as for the cave of PTVA index shown below:

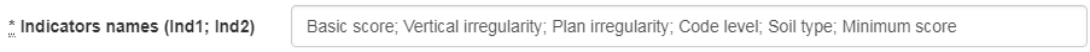


Reference study: Start typing the author(s) name(s) in the Search field and select the relevant reference from the list below.

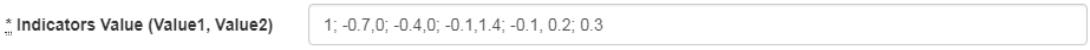


Note that before filling out this field, the reference study must be first entered in the *Reference table* (reference_table). In case two or more reference entries have same name and year of publication, simply add an underscore and a letter a,b,c to distinguish the different entries, e.g. Macabuag et al_2016_a, Macabuag et al_2016_b etc.

Indicators names (Ind1; Ind2): Enter the names of the indicators used in the hybrid index separated by a semicolon. The indicators' names should match the names used in the physical and social indicator entries in the associated tables.



Indicators Value (Value1, Value2): Enter the values of each indicator specified above separated by a comma. The minimum and maximum values are separated by a semicolon as shown in the example below:



Indicators names (Weight1, Weight 2): Enter the weights (if given) of the indicators specified above separated by a comma. In this this example indicators' weight are not provided, therefore this entry is left blank.

Country iso: Type the name of countries which the index can be applied to, unequivocally identified by their ISO codes, separated by a semi-colon.

A semicolon is used to separate the ISO codes if more than one country.

Can be evaluated with current dataschema?: Choose if the present index can be evaluated with the current data schema.

References

Bojorquez, E. and Iervolino, I., (2011). Spectral shape proxies and nonlinear structural response. *Soil Dynamics and Earthquake Engineering*, *31*(7), pp.996-1008.

D'Ayala, D. and Meslem, A., (2012). Guide for selection of existing fragility curves and compilation of the database. *GEM Vulnerability Global Component project*.

D'Ayala, D., Galasso, C., Gehl, P., Macabuag, J., & Rossetto, T. (2015). Guidelines for Global Multi Risk Analysis Database, Epicentre Technical Report, UCL, London.

D'Ayala, D., Meslem, A., Vamvatsikos, D., Porter, K., Rossetto, T., Crowley, H., & Silva, V. (2016). *Guidelines for analytical vulnerability assessment of low- to mid-rise buildings - Methodology* (GEM Technical Report). GEM Foundation

FEMA (2008) Guidelines for design of structures for vertical evacuation from Tsunamis (FEMA P646). Federal Emergency Management Agency, Washington DC

Foster, A. S. J., Rossetto, T., & Allsop, W. (2017). An experimentally validated approach for evaluating tsunami inundation forces on rectangular buildings. Coast. Eng. (in press).

GNDT (1993a). Seismic Risk of public buildings – Part 1 – Methodology Aspects *(in Italian)*. *CNR,* Rome, Italy.

Gokon, H., Koshimura, S., & Matsuoka, M. (2010). Developing tsunami fragility curves for structural destruction in American Samoa. In *8th International Workshop on Remote Sensing for Disaster Response*.

Inoue, S., Wijeyewickrema, A., Matsumoto, H., & Al., E. (2007). Field survey of tsunami effects in Sri Lanka due to the Sumatra-Andaman earthquake of December 26, 2004. In *Tsunami and its hazards in the Indian and Pacifc Ocean* (pp. p395–411). Springer.

Liu, H., Lynett, P., Fernando, H., & Al, E. (2005). Observations by the International Survey team in Sri Lank. *Science*, *308*.

Nandasena, N. a. K., Tanaka, N., & Tanimoto, K. (2008). Tsunami Current Inundation of Ground With Coastal Vegetation Effects: an Initial Step Towards a Natural Solution for Tsunami Amelioration. *Journal of Earthquake and Tsunami*, *02*(02), 157–171. doi:10.1142/S179343110800030X

Papathoma, M. and Dominey-Howes, D. (2003). Tsunami vulnerability assessment and its implications for coastal hazard analysis and disaster management planning, Gulf of Corinth, Greece. *Natural Hazards and Earth System Science* 3 (6), 733-747

Reese, S., Cousins, W. J., Power, W. L., Palmer, N. G., Tejakusuma, I. G., & Nugrahadi, S. (2007). Tsunami vulnerability of buildings and people in South Java – field observations after the July 2006 Java tsunami. *Natural Hazards and Earth System Science*, *7*(5), 573–589. doi:10.5194/nhess-7-573-2007

Rossetto, T., Ioannou, I., & Grant, D. N. (2015). *Existing Empirical Fragility and Vulnerability Functions: Compendium and Guide for Selection* (GEM Technical Report). Pavia, Italy: GEM Foundation. doi:10.13117/GEM.VULNSMOD.TR2015.01

Rossetto, T., Ioannou, I., Grant, D. N., & Maqsood, T. (2014). *Guidelines for empirical vulnerability assessment* (GEM Technical Report). Pavia, Italy: GEM Foundation. doi:10.13117/GEM.VULN-MOD.TR2014.11

Rossetto, T., Peiris, N., Pomonis, A., & Al, E. (2007). The Indian Ocean tsunami of December 26, 2004: observations in Sri Lanka and Thailand. *Natural Hazards*, *122*, p105–124

Suppasri, A., Koshimura, S., & Imamura, F. (2009). Tsunami fragility curves and structural performance of building along the Thailand coast, (2008), 3–8.

Suppasri, A., Koshimura, S., & Imamura, F. (2011). Developing tsunami fragility curves based on the satellite remote sensing and the numerical modeling of the 2004 Indian Ocean tsunami in Thailand. *Natural Hazards and Earth System Science*, *11*(1), 173–189. doi:10.5194/nhess-11-173-2011

Synolakis, C., & Okal, E. (2005). *1992-2002: Perspective on a decade of post-tsunami surveys. In Tsunamis: Case studies and recent developments*. (K. Satake, Ed.). Springer.

Tsuji, Y., Namegaya, Y., Matsumoto, H., & Al., E. (2006). The 2004 Indian Ocean Tsunami in Thailand:Surveyed runup heights and tide gauge data. *Earth, Planets and Space*, p223–232.

APPENDICES

Appendix I – Module 1 Detailed Data Fields

The following tables presents a detailed description of each data field in Module 1 of MOVER L3VDS.

Table I. 1 – Schema of the Vulnerability Functions table, described field by field.

Column name	Alias shown in interface	Description
id	ID (Hidden field)	Unique identifier of the Vulnerability function and Primary Key
hazard	Hazard type	Enumerated field. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, and Drought.
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crop.
sub_asset	Sub-asset	Description of sub-asset. Example: Unreinforced Masonry
taxonomy	Taxonomy	GEM taxonomy
country_iso	Country/ies (ISO1; ISO 2)	List of countries which the function can be applied to, unequivocally identified by their ISO codes, separated by a semi-colon.
approach	Approach	Enumerated type which lists the possible types of vulnerability functions. These include: Empirical, Analytical, Judgement, Hybrid - Analytical/Empirical, Hybrid - Analytical/Judgement, Hybrid - Empirical/Judgement, and Hybrid - Analytical High Fidelity/Low Fidelity.
scale_applicability	Scale applicability	Enumerated field listing as possible entries the four scales of applicability of the damage to loss function Country (Level 0), Sub-country (Level 1), Local(Level 2), Asset (Level 3).
reference	Reference	Reference study of the vulnerability function. Details on each of the reference studies are provided in the Reference table.
loss_parameter	Loss Parameter name	Enumerated field which lists all the identified loss parameters.
vf_relationship	Mathematical/ Discrete	Enumerated field to distinguish between Mathematical and Discrete functions.
vf_math	Parametric/Bespoke	Enumerated field to distinguish between Parametric or Bespoke discrete functions.

Table I. 2 (Continued) – Schema of the Vulnerability Functions table, described field by field.

Column name	Alias shown in interface	Description
vf_math_model	Mathematical Model	Enumerate field. Possible entries include: Cumulative lognormal Cumulative normal Exponential Bespoke - see reference
bespoke_model_reference	Bespoke model reference	Reference study of the bespoke model
par_names	Parameters names (Par1; Par2)	Parameters values names Example: MIDR , Ash depth
ub_par_values	Upper bound parameters value (Value1; Value2)	Example: 0.9; 350
ub_par_perc	Upper bound parameters percentiles (Perc1; Perc2)	Percentiles associated to the upper bound parameters for parametric functions
med_par_value	Median parameter values (Med1; Med2)	Example: 0.2; 0.75
lb_par_values	Lower bound parameters value (Value1; Value2)	Example: 0.01; 3
lb_par_perc	Lower bound parameters percentiles (Perc 1;Perc 2)	Percentiles associated to the lower bound parameters for parametric functions
vf_disc_im	IM values (for discrete functions)	This field lists the IM values for the characterization of discrete functions
vf_disc_ep	EP values (for discrete functions)	This field lists the associated exceeded probability values to the IM values of the previous field.
im_name_f	IM name	Enumerated field which list all the

Table I. 3 (Continued)– Schema of the Vulnerability Functions table, described field by field.

Column name	Alias shown in interface	Description
im_range	IM range	Range of intensity measures. Example: 0;500
im_method	IM method	Enumerated field. Possible entries include: Recorded, Surveyed, Simulated, Unknown
im_sim_type	IM Simulation type (for simulated method only)	Enumerated field: Physics-based; IMPE
impe_reference	IMPE reference (for IMPE simulation only)	Reference study of the IMPE simulation.
data_countries	Data countries (ISO1; ISO2)	Adjustment to Country ISO codes
im_data_source	IM data source/s	Reference studies for the IM data sources
n_events	N events	Numeric entry which specifies the number of events the function has been built on
n_assets	N assets	Numeric entry which specifies the number of assets the function has been built on.
nonsampling_error	Is there a non-sampling error?	Enumerative field. Possible entries are: Yes, No, Unknown
type_nonsampling_error	Type of non-sampling error	Enumerative field. Possible entries include: Under coverage, Incomplete data, Measurement error, Unknown.
is_fix_nonsamp_err	Has non-sampling error being fixed?	Boolean TRUE/FALSE
is_data_aggr	Is data aggregated?	Boolean TRUE/FALSE
n_data_points_aggr	N of data points aggregated	Number of aggregated data points used for the evaluation of data quality.
is_data_disaggr	Is data disaggregated?	Boolean TRUE/FALSE
n_data_points_disaggr	N of data points disaggregated	Number of disaggregated data points used for the evaluation of data quality.

Table I. 4 (Continued)– Schema of the Vulnerability Functions table, described field by field.

Column name	Alias shown in interface	Description
an_analysis_type	Type of analysis for Analytical functions	Enumerated field. Possible entries include: Simplified, Advanced
an_model_type	Analytical model type	Enumerated field. Possible entries include: Simplified, Advanced
em_analysis_type	Type of analysis for Empirical functions	Enumerated field which lists possible types of regression and include: Least squares, GLM, GAM
jd_analysis_type	Type of analysis for Judgement functions	Enumerated field which lists possible elicitation methods and include: Delphi, Cookes.
sample_f	Sample	This enumerated field indicates the type of sampling used and include as possible entries: Single-asset class, Multi-assets classes, Single-asset.
is_fit_good	Is the fit good?	Boolean TRUE/FALSE
fit_ref	Reference model for fitting	Enumerated field. Possible entries include: AIC, BIC, Kolmogorov-Smirnov.
is_validation	Has the function been validated?	Boolean TRUE/FALSE
val_data_source	Data source of independent data	If a validation has been conducted, this field indicates the source of the independent data.
is_existing_val_study	Is the validation study existing?	Boolean TRUE/FALSE
val_study_reference	Validation study reference (if existing)	Reference of the Validation study

Table I. 5 – Schema of the Fragility Functions table, described field by field.

Column name	Alias shown in interface	Description
id	ID (Hidden field)	Unique identifier of the Vulnerability function and Primary Key
hazard	Hazard type	Enumerated field. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, and Drought.
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crop.
sub_asset	Sub-asset	Description of sub-asset. Example: Unreinforced Masonry
taxonomy	Taxonomy	GEM taxonomy
country_iso	Country/ies (ISO1; ISO 2)	List of countries which the function can be applied to, unequivocally identified by their ISO codes, separated by a semi-colon.
approach	Approach	Enumerated type which lists the possible types of vulnerability functions. These include: Empirical, Analytical, Judgement, Hybrid -Analytical/Empirical, Hybrid - Analytical/Judgement, Hybrid - Empirical/Judgement, and Hybrid - Analytical High Fidelity/Low Fidelity.
scale_applicability	Scale applicability	Enumerated field listing as possible entries the four scales of applicability of the damage to loss function Country (Level 0), Sub-country (Level 1), Local(Level 2), Asset (Level 3).
reference	Reference	Reference study of the vulnerability function. Details on each of the reference studies are provided in the Reference table.
dm_scale_type	Damage scale type	Enumerated field which specifies if the damage scale used by the function is ‘Existing’ or ‘Bespoke’.
Damage_scale_name	Damage scale name	Enumerated field that allows the user to choose the name of the damage scale from those listed in the damage scale table. Entries like ‘Bespoke - see reference’, and ‘Unknown’ allow the user to specify if the damage scale is bespoke or if the damage scale is not known.

Table I. 6 (Continued) – Schema of the Fragility Functions table, described field by field.

Column name	Alias shown in interface	Description
n_dm_states	N of damage states	Number of damage states studied in the reference study of the function.
dm_states_name	Damage states names in the original reference	Names of the damage states studied in the reference study of the function, listed using the exact names used in the reference damage scale. The names are separated by a semicolon.
dm_state_f_name	Damage state of the function	Name of the specific damage state studied by the function. The name follow specific nomenclature of the damage scale used.
edp_name	EDP name	It indicates the specific engineering demand parameter (EDP) used to the DS thresholds.
edp_dmstate_thre	EDP threshold	It indicates the specific damage state EDP threshold.
ff_relationship	Mathematical/ Discrete	Enumerated field to distinguish between Mathematical and Discrete functions.
ff_math	Parametric/Bespoke	Enumerated field to distinguish between Parametric or Bespoke discrete functions.
ff_math_model	Mathematical Model	Enumerate field. Possible entries include: Cumulative lognormal Cumulative normal Exponential Bespoke - see reference
bespoke_model_reference	Bespoke model reference	Reference study of the bespoke model
par_names	Parameters names (Par1; Par2)	Parameters values names Example: Mean; logSD
ub_par_values	Upper bound parameters value (Value1; Value2)	Example: 0.9; 350
ub_par_perc	Upper bound parameters percentiles (Perc1; Perc2)	Percentiles associated to the upper bound parameters for parametric functions
med_par_value	Median parameter values (Med1; Med2)	Example:0.2; 0.75

Table I. 7 (Continued) – Schema of the Fragility Functions table, described field by field.

Column name	Alias shown in interface	Description
lb_par_values	Lower bound parameters value (Value1; Value2)	Example: 0.01; 3
lb_par_perc	Lower bound parameters percentiles (Perc1; Perc2)	Percentiles associated to the lower bound parameters for parametric functions
ff_disc_im	IM values (for discrete functions)	This field lists the IM values for the characterization of discrete functions
ff_disc_ep	EP values (for discrete functions)	This field lists the associated exceeded probability values to the IM values of the previous field.
im_name_f	IM name	Enumerated field which list the name of the IM. A drop down list of IM names is provided that links to the IM table.
im_range	IM range	Range of intensity measures. Example: 0; 500
im_method	IM method	Enumerated field. Possible entries include: Recorded, Surveyed, Simulated, Unknown
im_sim_type	IM Simulation type (for simulated method only)	Enumerated field which indicates the type of simulation used to assess the IM. Possible entries are: Physics-based, IMPE
impe_reference	IMPE reference (for IMPE simulation only)	Reference study of the IMPE simulation method.
data_countries	Data countries (ISO1; ISO2)	Adjustment to Country ISO codes
im_data_source	IM data source/s	Reference studies for the IM data sources
n_events	N events	Numeric entry which specifies the number of events the function has been built on
n_assets	N assets	Numeric entry which specifies the number of assets the function has been built on.
nonsampling_error	Is there a non-sampling error?	Enumerative field. Possible entries are: Yes, No, Unknown

Table I. 8 (Continued) – Schema of the Fragility Functions table, described field by field.

Column name	Alias shown in interface	Description
type_nonsampling_error	Type of non-sampling error	Enumerative field. Possible entries include: Under coverage, Incomplete data, Measurement error, Unknown.
is_fix_nonsamp_err	Has non-sampling error being fixed?	Boolean TRUE/FALSE
is_data_aggr	Is data aggregated?	Boolean TRUE/FALSE
n_data_points_aggr	N of data points aggregated	Number of aggregated data points used for the evaluation of data quality.
is_data_disaggr	Is data disaggregated?	Boolean TRUE/FALSE
n_data_points_disaggr	N of data points disaggregated	Number of disaggregated data points used for the evaluation of data quality.
an_analysis_type	Type of analysis for Analytical functions	Enumerated field. Possible entries include: Simplified, Advanced
an_model_type	Analytical model type	Enumerated field. Possible entries include: Simplified, Advanced
em_analysis_type	Type of analysis for Empirical functions	Enumerated field which lists possible types of regression and include: Least squares, GLM, GAM
jd_analysis_type	Type of analysis for Judgement functions	Enumerated field which lists possible elicitation methods and include: Delphi, Cookes.
sample_f	Sample	This enumerated field indicates the type of sampling used and include as possible entries: Single-asset class, Multi-assets classes, Single-asset.
is_fit_good	Is fit good?	Boolean TRUE/FALSE
fit_ref	Reference model for fitting	Enumerated field. Possible entries include: AIC, BIC, Kolmogorov-Smirnov.
is_validation	Has the function been validated?	Boolean TRUE/FALSE
val_data_source	Data source of independent data for validation	If a validation has been conducted, this field indicates the source of the independent data.

Table I. 9 (Continued) – Schema of the Fragility Functions table, described field by field.

Column name	Alias shown in interface	Description
is_existing_val_study	Is the validation study existing?	Boolean TRUE/FALSE
val_study_reference	Validation study reference (if existing)	Reference of the Validation study

Table I. 10 – Schema of the Damage to Loss table, described field by field.

Column name	Alias shown in interface	Description
id	ID (Hidden field)	Unique identifier of the Dtl function and Primary Key
hazard	Hazard type	Enumerated field. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, and Drought.
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crop.
sub_asset	Sub-asset	Description of sub-asset. Example: Unreinforced Masonry
taxonomy	Taxonomy	GEM taxonomy
country_iso	Countries (ISO1; ISO 2)	List of countries which the function can be applied to, unequivocally identified by their ISO codes, separated by a semi-colon.
scale_applicability	Scale applicability	Enumerated field listing as possible entries the four scales of applicability of the damage to loss function Country (Level 0), Sub-country (Level 1), Local(Level 2), Asset (Level 3).
reference	Reference	Reference study of the damage to loss function
dtl_pdf_type	Dtl PDF type	Enumerated field indicating the type of probability distribution used in the function. Possible entries include: Beta, Normal, Lognormal, Uniform, Single-value.

Table I. 11 (Continued) – Schema of the Damage to Loss table, described field by field.

Column name	Alias shown in interface	Description
dtl_parameter	Parameters names (Par1; Par2)	Names of parameters that are used in the probability distribution function, separated by a semi-colon. Example: Mean; SD
dtl_parameters_values	Parameters values (Value1; Value2)	Names of parameters that are used in the probability distribution function, separated by a semi-colon. Example: 1.000; 0.000
dm_scale_type	Damage scale type	Enumerated field which specifies if the damage scale used by the function is 'Existing' or 'Bespoke'.
damage_scale_name	Damage scale name	Enumerated field that allows the user to choose the name of the damage scale from the existing known damage scales listed in the damage scale table. Entries like 'Bespoke - see reference', and 'Unknown' allow the user to specify if the damage scale is bespoke or if the damage scale is not known.
dm_scale_reference	Damage scale reference	Reference study of the damage scale. Each damage scale study is recorded in the Reference table.
n_dm_states	N of damage states	Number of damage states used in the reference study of the function.
dm_states_name	Damage states names in the original reference	Names of the damage states studied in the reference study of the function, listed using the exact names used in the reference damage scale. The names are separated by a semicolon.
dm_state_f_name	Damage state of the function	Name of the specific damage state studied by the function. The name follow specific nomenclature of the damage scale used.

Appendix II – Module 2 Detailed Data Fields

This appendix presents the data fields composing the Physical Vulnerability Indicator module. As the indicators are defined with reference to a Vulnerability Category and Vulnerability Characteristic, Table II.2 presents these categories and characteristics for the different physical assets considered currently by the MOVER L3VDS. It is noted that the vulnerability indicator for individual assets will be the actual observable vulnerability characteristic for that asset. Instead, when a vulnerability assessment is made over a geographical area, the indicator becomes the % of the asset population with that characteristic.

Table II.1 – Schema of the Physical Vulnerability Indicators table, described field by field.

Column name	Alias shown in interface	Description
id	ID (Hidden field)	Unique identifier of the physical vulnerability indicator and Primary Key
hazard_type	Hazard type	Enumerated type. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, Drought, and Multi-hazard
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crop. In the integration with the data schemas of the Challenge Exposure, this table will be replaced with the Asset table of their schema and it will provide a link to all tables of that schema.
subasset	Sub-asset	The field lists and describes all the sub-assets to which the indicator is applied. Example: RC, Masonry, Timber
country_iso	Country/ies (ISO1; ISO 2)	List of countries which the function can be applied to, unequivocally identified by their ISO codes, separated by a semi-colon.
scale_applicability	Scale applicability	Enumerated field listing as possible entries the four scales of applicability:Country (Level 0), Sub-country (Level 1), Local(Level 2), Asset (Level 3).
adm_0	Adm_0 (Country ISO)	Name of the Country (ISO country code) for which data are available for the analysed physical indicator
adm_1	Name of Adm_1	Example: name of region
adm_2	Name of Adm_2	Example: Name of city
adm_3	Name of Adm_3	Example: Address of asset

Table II.1 (Continued)– Schema of the Physical Vulnerability Indicators table, described field by field.

Column name	Alias shown in interface	Description
grid	Grid	Example: Grid#
phy_v_cat_name	Physical Vulnerability Category	Enumerative filed: which lists all the Physical Vulnerability Categories identified in Level 2
phy_v_cat_symbol	Physical Vulnerability Category (Symbol)	Defined abbreviations for the Physical Vulnerability Categories
phy_v_char_name	Physical Vulnerability Characteristic	Enumerative filed: which lists all the Physical Vulnerability Characteristics identified in Level 2
phy_v_char_symbol	Physical Vulnerability Characteristics (Symbol)	Defined abbreviations for the Physical Vulnerability Characteristics
indicator_type	Indicator Type (Ratio, Percentage)	Enumerative field listing the types of available indicators. Example: Percentage
indicator_name	Indicator Name	Example: % of irregular residential buildings
Indicator_value	Indicator value	Real number

Table II.2 – Physical Vulnerability Categories and Characteristics for Indicator Definition.

Asset type	Physical Vulnerability Category	Physical Vulnerability Characteristic
Buildings	Material of lateral load resisting system	Material type
		Material technology
	Structural regularity	Is regular?
		Irregular direction (plan/vertical)
	LLRS	Type of LLRS
		Seismic code level
	Height	N. of storeys above grade
		N. of storeys below grade
	Roof	Roof shape
		Roof covering material
		Roof system material
		Roof system type
	Floor	Floor system type
		Floor system material
	Date of construction	Building age
		Is design? (engineered/nonengineered)
		Is design retrofit?
	Occupancy	Occupancy type
		Occupancy class
	Foundation type	Foundation system
Lifelines (Bridges)	General bridges	Bridge material
		Bridge type
		Is bridge design? (engineered/nonengineered)
		Bridge usage
	Bridge pier	Pier type
	Bridge spans	N. of spans
		Is span continuous?
	Bridge abutment	Abutment type
	Bridge deck	Deck type
		Deck height
	Bridge bearing	Bearing type
Lifelines (Telecommunications)	General telecommunications	Telecommunication type
		Telecommunication usage
		Is communication component anchored?
Lifelines (Water burried pipelines)	General water burried pipelines	W.B. pipeline age
		W.B. pipeline diameter
		W.B. pipeline joint
		W.B. pipeline material
		W.B. pipeline usage
Lifeline (Water pump)	General water pump	Is W.P. generator independent?
		Is W.P. design?
Lifeline (Water storage)	General water storage	W.S. size
		W.S. body material
		Is W.S. anchored?
		Is W.S. design?

Table II.2 (Continued) – Physical Vulnerability Categories and Characteristics for Indicator Definition.

Lifeline (Water storage)	General water storage	W.S. usage
Lifelines (Electric substations)	General Electric substations	E.S usage
		E.S. insulation
Lifelines (Waste water lift stations)	General waste water lift stations	Is W.W. design?
Crops	Crop	Crop growcycle
		Crop species
		Crop variety
		Crop season
People	People	

Appendix III – Module 3 Detailed Data Fields

Table III.1 – Schema of the Social Vulnerability Indicators table, described field by field.

Column name	Alias shown in interface	Description
id	ID (Hidden field)	Unique identifier of the social vulnerability indicator and Primary Key
hazard_type	Hazard type	Enumerated type. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, Drought, and Multi-hazard
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crops. In the integration with the data schemas of the Challenge Exposure, this table will be replaced with the Asset table of their schema and it will provide a link to all tables of that schema.
subasset	Sub-asset	The field lists and describes all the sub-assets to which the indicator is applied. Example: RC, Masonry, Timber
country_iso	Country/ies (ISO1; ISO 2)	List of countries which the function can be applied to, unequivocally identified by their ISO codes, separated by a semi-colon.
scale_applicability	Scale applicability	Enumerated field listing as possible entries the four scales of applicability: Country (Level 0), Sub-country (Level 1), Local (Level 2), Asset (Level 3).
adm_0	Adm_0 (Country ISO)	Name of the Country (ISO country code) for which data are available for the analysed physical indicator
adm_1	Name of Adm_1	Example: name of region
adm_2	Name of Adm_2	Example: Name of city

Table III. 1 (Continued) – Schema of the social Vulnerability Indicators table, described field by field.

Column name	Alias shown in interface	Description
adm_3	Name of Adm_3	Example: Address of asset
grid	Grid	Example: Grid#
soc_v_cat_name	Social Vulnerability Category	Enumerative filed: which lists all the Social Vulnerability Categories identified in Level 2
soc_v_cat_symbol	Social Vulnerability Category (Symbol)	Defined abbreviations for the Social Vulnerability Categories
soc_v_char_name	Social Vulnerability Characteristic	Enumerative filed: which lists all the Social Vulnerability Characteristics identified in Level 2
soc_v_char_symbol	Social Vulnerability Characteristics (Symbol)	Defined abbreviations for the Social Vulnerability Characteristics
indicator_type	Indicator Type (Ratio, Percentage, Number)	Enumerative field listing the types of available indicators. Example: Percentage
indicator_name	Indicator Name	Example: % of irregular residential buildings
Indicator_value	Indicator value	Real number

Table III.2 – Social Vulnerability Indicators sorted in their categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic	Indicator Level 3
Vulnerable population	Social class (including caste, religious minority, ethnicity)	% of population part of a minority
	Gender – work opportunities	% of women in formal employment
		Ratio of average female to male income
	Gender – right to property	% of female population who own a house
		% of female population who own land
		% of female population who own a business
		% of female population owning a motorised vehicle
		% of female population with a mobile phone account
		% of female population owning an account with a financial institution
		% of household with a female head (female headed households)
	Gender – Decision power on well-being	Average age at birth of first child
		Average age at first marriage
		Number of births per 1000 women over-15
		% of female accessing prenatal care
		% of women over 15 using a contraceptive method
		% of women with no control on sexual habits and reproductive health
		Female genital mutilation prevalence (%)
	Sexuality	
	Age	% of population aged less than 4 years and more than 64
	Disability	% of population with a mental disability
		% population with a mobility disability
	Migration	% of legal immigrant over total population
	Involuntary displacement	% of internally displaced population
		% of refugees population

Table III.2 (Continued) – Social Vulnerability Indicators sorted in their categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic	Indicator Level 3
Institutional Governance	Political stability and absence of violence and terrorism	n. of violent crimes per 1000 population in a year
		n. of acts of terror per 1000 population in a year
	Government Effectiveness	
	Accountability	
	Control of corruption	
	Rule of Law	
	Voice	% of adult population with right to vote
Governance in Planning and Construction	Risk-informed building coded	
	Enforcement of building codes	
	Risk-informed planning	
Civil Society and Social Capital	Social advocacy and civil society	n. of civil society organizations/1000 people
Financial and Material welfare	Income -remittances	Personal remittances, received (current US$) per year
		Personal remittances, received (% of GDP) per year
	Income –disposable income	% of population with disposable income
	Income level	GDP per person employed (constant 2011 PPP $)
		% of dependent population
		Median HH income
		GINI coefficient
	Employment and employment security	% of employed working-age population
		Labour force, total
		% of working-age population employed in public jobs
		% of working-age population employed in private jobs
	Financial dependency on environmental resources	% population engaged in agriculture
		% population rearing livestock
		% population in Fish farming
		% of population working in the tourism industry
	Access to credit	Domestic credit provided by financial sector (% of GDP)
	Poverty	Urban poverty gap at national poverty lines (%)
		Rural poverty gap at national poverty lines (%)
		% of population living below national poverty line

Table III.2 (Continued) – Social Vulnerability Indicators sorted in their categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic	Indicator Level 3
Financial and Material welfare	Access to insurance	% of HH covered by hazard insurance police
		% of businesses covered by hazard insurance policy
		% of crops covered by hazard insurance policy
	Capital assets	% of population owning land
		% of population owning a house
		% of owner-occupied houses
		% of population living in vulnerable constructions
		Ratio tenants/homeowners
		% of homelessness
		% of population owning a motorised vehicle
	Social Protection	% of employed population with Sick leave coverage
		% of employed population with maternity leave coverage
		Adequacy of unemployment benefits and ALMP (% of total welfare of beneficiary households)
		Coverage (%) -All Social Protection and Labour
		% of population with social security scheme
		% of population in state welfare
		Share of population above the statutory retirement age (aged 65 or above) benefiting from an old-age pension
		Beneficiaries of cash income support (% of the poor)
		Share of unemployed receiving regular periodic social security unemployment benefits
		Percentage of poor children receiving child benefits
Food Security	Availability	Average supply of protein of animal origin
		Average protein supply
		Share of dietary energy supply derived from cereals, roots and tubers
		Average value of food production
		Average dietary energy supply adequacy

Table III.2 (Continued) – Social Vulnerability Indicators sorted in their categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic	Indicator Level 3
Food Security	Access	Depth of the food deficit
		Rail lines density
		Gross domestic product per capita (in purchasing power equivalent)
		Prevalence of undernourishment
		Prevalence of severe food insecurity in the total population
	Stability	Per capita food production variability
		Cereal import dependency ratio
		Percentage of arable land equipped for irrigation
		Value of food imports over total merchandise exports
		Per capita food supply variability
		Fluctuation in food prices (+/-% over average)
	Utilization	Percentage of children under 5 years of age who are underweight
		Percentage of children under 5 years of age affected by wasting
		Percentage of children under 5 years of age who are stunted
Preparedness and Local Risk Awareness	Preventive measures	% of HH with a preparedness plan
		% of HH that have uptaken hazard specific mitigation to relevant hazards
		% of businesses with a continuity plan
		% of population trained in first aid
		% of population trained in search and rescue
	Knowledge of local hazards	Tourists, migrants and refugees population ratio over local population
		n. of hazardous events (from small emergencies to disasters) experiences in past 10 years
		% of children who are taught DRR in primary school
	Civil society and social capital in DRR	% of population that would know what to do in case of a hazardous event.
		% of people who volunteer for a DRR organization
	Access to information in DRR	% of population speaking the principal national language
		% of population owning a television
		% of population owning a radio
		% of population with internet access
		% of population with mobile phone access

Table III.2 (Continued) – Social Vulnerability Indicators sorted in their categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic	Indicator Level 3
Access and Provision of services	Transports	Railways, passengers carried (million passenger-km)
		km of passable roads per km sq
		Principal Arterial km per km sq
	Water and waste water services	% of total population with access to grid sanitation facilities
		% of urban population with access to grid sanitation facilities
		% of rural population with access to grid sanitation facilities
		% of total population with access to grid sanitation facilities
		% of urban population with access to grid sanitation facilities
		% of rural population with access to grid sanitation facilities
		% of population accessing water through wells/ public tap or standpipe
		% of population with drinking water source
	Telecommunications	Mobile cellular subscriptions per 1000 people
		Mobile cellular subscriptions per 1000 people
		Fixed broadband subscriptions per 1000 people
	Energy	% of urban population with access to energy (oil or gas)
		% of rural population with access to energy (oil or gas)
		% of total population with access to energy (oil or gas)
		Access to electricity, rural (% of rural population)
		Access to electricity, urban (% of urban population)
		Access to electricity (% of total population)
		% of population with cooking energy source, non-grid
		% of population with heating energy source, non-grid
	Solid waste management	% of population covered by a solid waste collection public program

Table III.2 (Continued) – Social Vulnerability Indicators sorted in their categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic	Indicator Level 3
Access and Provision of services	Affordability	% of HH yearly income spent for electricity
		% of HH yearly income spent for water
		% of HH yearly income spent for energy (oil/gas)
		% of HH yearly income spent for waste water services
		% of HH yearly income spent for solid waste collection services
	Access to Emergency Services	% of population that can be reached by a fire brigade
		Number of fire fighters - per 1,000 people
		% of population that can be reached by a police brigade
		Number of police offices - per 1,000 people
		Presence of peace keepers (number of troops, police, and military observers in mandate) - per 1,000 people
Knowledge and education	Education attainment	% of female children in school (over total female population in primary school age)
		Female/male ratio population of 25+ bachelors or equivalent education attainment
		Educational attainment, at least Bachelor's or equivalent, population 25+, total (%) (cumulative)
		Literacy rate, adult total (% of people ages 15 and above)
		Educational attainment, at least completed primary, population 25+ years (%) (cumulative)
		Children in school (% of primary school age)
	Access to Education	n. of schools within a 1 km radius
		Percentage population working as teachers in primary education who are trained, both sexes (%)
	Technical skills and vocational training	Enrolment in secondary vocational training, both sexes (number)
	Existence of DRR curricula in schools	% of children who are taught DRR in primary school
	Affordability	% of yearly HH income spent on education

Table III.2 (Continued) – Social Vulnerability Indicators sorted in their categories and characteristics.

Social Vulnerability Category	Social Vulnerability Characteristic	Indicator Level 3
Health	General population health	Incidence of tuberculosis (per 100,000 people)
		% of population with HIV
		% children (0-14) living with HIV
		Life expectancy at birth
		Infant mortality rate (per 100,000 infants)
		Incidence of malaria (per 1000,000 population at risk)
		Prevalence of undernourishment (% of population)
		Maternal mortality ratio (modelled estimate, per 100,000 live births)
	Health resources and expenditure	n. of physicians per 1000 people
		n. nurses and midwives per 1,000 people
		n. of ambulances per 1,000 people
		% of population cover by health care provision
		% of birth attended by skilled staff
		Health expenditure per capita (current US$)
		Hospital beds (per 1,000 people)
		Community health workers (per 1,000 people)
		Pregnant women receiving prenatal care (%)

Appendix IV – Module 4 Detailed Data Fields

Table IV.1 – Schema of the Indices table, described field by field.

Column name	Alias shown in interface	Description
id	ID (Hidden field)	Unique identifier of the index and Primary Key
hazard_type	Hazard type	Enumerated type. Possible entries include: Earthquake, Tsunami, Flood, Wind, Landslide, Storm surge, Volcanic ash, Drought, and Multi-hazard
asset	Asset type	Enumerated type. Possible entries include: Buildings, Lifelines, People, Crop. In the integration with the data schemas of the Challenge Exposure, this table will be replaced with the Asset table of their schema and it will provide a link to all tables of that schema.
subasset	Sub-asset	The field lists and describes all the sub-assets to which the indicator is applied. Example: RC, Masonry, Timber
Country_iso	Country/ies (ISO1; ISO 2)	List of countries which the index can be applied to, unequivocally identified by their ISO codes, separated by a semi-colon.
scale_applicability	Scale applicability	Enumerated field listing as possible entries the four scales of applicability: Country (Level 0), Sub-country (Level 1), Local (Level 2), Asset (Level 3). When dealing with an index which indicators are measured at more than one scale it is recommended that all the values of the indicators are aggregated (when possible) at the coarser level.
adm_0	Adm_0 (Country ISO)	Name of the Country (ISO country code) for which data are available for the analysed physical indicator
adm_1	Name of Adm_1	Example: name of region
adm_2	Name of Adm_2	Example: Name of city
adm_3	Name of Adm_3	Example: Address of asset
grid	Grid	Example: Grid#

Table IV.1 (Continued) – Schema of the Indices table, described field by field.

Column name	Alias shown in interface	Description
grid	Grid	Example: Grid#
index_name	Index name	Enumerative filed: which lists all the Social Vulnerability Categories identified in Level 2
index_description	Description	Description of the index
index_reference	Reference study	Reference study which first used the Index.
index_ind	Indicators names (Ind1; Ind2)	Separated by a semi-colon
index_ind_values	Indicators Value (Value1, Value2)	Separated by a semi-colon
index_ind_weights	Indicators names (Weight1, Weight 2)	Separated by a semi-colon
is_evaluated	Can be evaluated with current data schema?	Boolean field. It specifies if the index can be measured with the indicators stored in the data schema.