Extensible Data Schemas for Multiple Hazards, Exposure and Vulnerability Data

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Abstract

The data required for assessing disaster risk can generally be divided into three categories: hazard, exposure and vulnerability. To date there is no widely accepted approach for storing and sharing such risk-related data using a common data structure. As a result, using risk-related data often requires a significant amount of upfront work to collect, extract and transform data before it can be used for purposes such as a risk assessment. In addition, the lack of a consistent data structure hinders the development of tools that can be used for more than one set of data. In practice, this situation introduces a significant amount of friction in efforts to quantify and manage disaster risk. Here we report on an effort by three consortia to develop extensible, internally consistent schemas for hazard, exposure and vulnerability data. The consortia coordinated their efforts so the three schemas are compatible. For example, the intensity measure types used to define the hazard datasets are compatible with the intensity measures used by the vulnerability models. Similarly, the asset attributes used in the exposure data taxonomy are compatible with the asset attributes used for the vulnerability data. Hazard data can be provided as either event footprints or stochastic catalogs. Exposure classes include buildings, infrastructure, agriculture, livestock, forestry and socio-economic data. The vulnerability component includes fragility and vulnerability functions and indicators for physical and social vulnerability. The schemas also provide the ability to define uncertainties associated with the hazard data and allows the scoring of vulnerability data for relevance and quality. As a proof of concept, the schemas were populated with data covering the three components for Tanzania and with additional exposure data for several other countries.

Introduction

At the 2016 Understanding Risk conference in Venice, the Global Facility for Disaster Reduction and Recovery (GFDRR) and the United Kingdom's Department for International Development (DFID) released a report titled "Solving the Puzzle: Innovating to Reduce Risk" (GFDRR, 2016), which presented a community-based review of actions that could promote disaster risk management (DRM) practices in developing countries. The report was based on input from multiple individuals representing over 100 institutions from five continents, six consultations, 25 written contributions and two online surveys. The report suggested "next steps" in eight categories that would promote DRM in developing countries (Table 1).

Table 1. Potential next steps* for promoting disaster risk management.

Category	Potential next steps
Hazard	Develop a suite of reference hazard events that provide examples of historical and hypothetical events for impact analyses in developing countries
Exposure	Support the enhancement of an open exposure dataset with structural data and building valuation
Vulnerability	Develop open databases of vulnerability functions for a variety of exposures (e.g. structural damage and social vulnerability), spatial resolutions, and hazards
Communication	Formalize a community of practice for the communication of risk assessment information
Capacity	Create development modules to provide training for the interpretation and use of risk assessment results
Platforms	Support an effort to develop standards to support risk model interoperability
Disaster Loss	Develop an open database of site-specific loss data that includes standards for data collection
Reference Data	Support development of open, high-resolution DEMs for developing countries

*Based on the report, Solving the Puzzle (GFDRR, 2016)

As a follow-up to the "Solving the Puzzle" report, three consortia (Table 2) were funded by the 2^{nd} Round of the GFDRR-DFID Challenge Fund[1] to develop hazard, exposure and vulnerability data schemas that would be open and compatible with existing hazard and exposure datasets. There are two major motivations for this effort. The first is to help resolve the common problem, described in the "Solving the Puzzle" report, that in developing countries there is often a paucity of risk-related data. This project was intended as a step towards increasing the amount and availability of data. The second motivation is to remedy the difficulty of dealing with data in a variety of formats. Risk-related data are often created using one of a variety of formats and structures, which can be incompatible and difficult to use in tools other than those they were generated for. There currently are no widely accepted data formats that apply across multiple hazards and, as such, newly created data tend to follow in-house

Table 2. Institutions involved with each component.

Data Category	Institutions
Hazard	British Geological Survey (lead) Global Earthquake Model Earth Observatory of Singapore Norwegian Geotechnical Institute National Oceanographic Centre Centro Internazionale in Monitoraggio Ambientale Institute for Environmental Studies at the University of Amsterdam
Exposure	Global Earthquake Model (lead) ImageCat Inc. Humanitarian OpenStreetMap Team
Vulnerability	University College London (lead) Global Earthquake Model Overseas Development Institute Aardhi University

[1] https://www.gfdrr.org/en/cfsecondround

standards that are often based on a company's or organization's legacy of practice. This situation imposes a significant barrier to developing tools that can be applied to a broad array of data and hinders efforts to scale disaster risk management (DRM) practices. Thus, the goal of creating the data schemas is to provide a more uniform format for storing hazard, exposure and vulnerability data that will promote and facilitate the development of tools that can access and use the data. As the availability of data that follows the schemas increases, we anticipate there will be an increasing motivation for developing DRM tools that use the data and help scale DRM activities.

The effort was focused on developing data schemas that would address a wide range of scenarios (deterministic and probabilistic), uncertainty in the data, multiple hazards, of different scale and format (gridded, site-specific and aggregated data), and multiple asset classes (e.g., socio-economic, agriculture, infrastructure, buildings). Due to the broad nature of the current schemas and their extensibility, the schemas contribute to the work of the Global Risk Assessment Framework[2] (GRAF, 2018) as their extensibility gives them the potential to include data for other hazards and sectors in the scope of the GRAF. In turn, the schemas help to support the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015) goals of reducing disaster risk and the social and economic impacts of disasters, by providing a common data format that promotes the more efficient sharing and use of risk data and the development of new risk assessment tools.

The initial project focus was to develop the schema for use in the development sector. But, to make the schemas more widely applicable, the vulnerability consortium (see Table 2) organized a multi-sector workshop on July 27, 2017 in London. The purpose of the workshop was to provide individuals from the insurance, academic, disaster risk reduction and catastrophe risk modeling communities with an opportunity to provide input on schema requirements.

As a proof of concept, the consortia populated the schemas with a variety of hazard, exposure and vulnerability data which was primarily for Tanzania but also for several other East African countries. The consortia

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[2] https://www.preventionweb.net/disaster-risk/graf

partnered with government agencies and universities and institutions in Tanzania and other countries to identify suitable data. In addition, a prototype data exploration tool[3] was developed to provide access to the data that conformed to the schemas. A final project workshop was held in Dar es Salaam in March 2018 where the consortia and their partners presented their work and discussed next steps.

The schema is already being extended to accommodate loss data and hazard return period data, to improve the data discovery and access tool, and to enable the DRM community to contribute data. These efforts have led to growing interest in contributing and connecting to the schemas. For example, the Insurance Development Forum (IDF) is looking to link the exposure data schema to a new interoperable and open-source exposure data format developed for insurance-specific data, which would enable data to be transformed into formats for use in industry models from providers including OASIS, AIR Worldwide, Impact Forecasting and CoreLogic. This can facilitate greater transfer of national level exposure data between the insurance industry and development sector for risk assessment. The UK Space Agency-funded METEOR project is creating national exposure data sets for 48 developing countries, using the GED4ALL exposure schema developed here, with data uploaded to the schema on completion of METEOR.

Below, we provide introductions to the hazard, exposure and vulnerability data schemas developed through this project. This is followed by an overview of the existing functionality of the data exploration tool and then a discussion of the intended next steps needed to promote the acceptance and use of the data schemas.

Schema Overviews

We use simplified "entity relationship" diagrams to illustrate the different objects that are used for the prototypes of the hazard, exposure and vulnerability schemas (see below). For more details on the schemas, please

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[3] https://assess-risk.info

see the final reports produced by each consortium which are available on the Challenge Fund website[4]. The schemas will also be publicly available via GFDRR's Innovation Lab GitHub[5] site.

Hazard Schema

The extensible schema is designed to handle multiple primary hazards as well as secondary hazards triggered by the primary hazard. The hazard schema was designed for information ranging from a single event to a stochastic event catalog with millions of events. In addition, the schema handles multiple spatial resolutions, uncertainty in hazard intensity, and temporal variability in a hazard. Work is underway to extend the hazard schema to include return period layers for hazard events.

The hazard schema consists of four entities (Figure 1). The first entity, *EventSet*, provides information for a dataset of one or more events and includes information such as the hazard type and the time span represented by the events and when the data was contributed. The *Event* entity provides information for each event in an *EventSet*. The fields for each event describe its probability or frequency of occurrence, what event might have triggered it, and provide additional information.

For each event in the *Event* entity, the *FootprintSet* entity provides information on the hazard and hazard intensity measure. In addition, if a parametric approach is used to define the uncertainty in intensity, the type of relationship is specified along with the parameter values used to define the relationship. This entity also allows for multiple views of a hazard. For example, ground motion from an earthquake event can be characterized by PGA as well as by spectral acceleration at different frequencies.

The *Footprint* entity provides information on the spatial distribution of the hazard intensity for each realization of an entry in the *FootprintSet* entity. Fields include information on the triggering event and uncertainty associated with hazard intensity. Uncertainty can be provided in a parametric form or in the form of multiple

[4] https://www.gfdrr.org/challenge-fund/round-2
[5] https://github.com/search?q=gfdrr

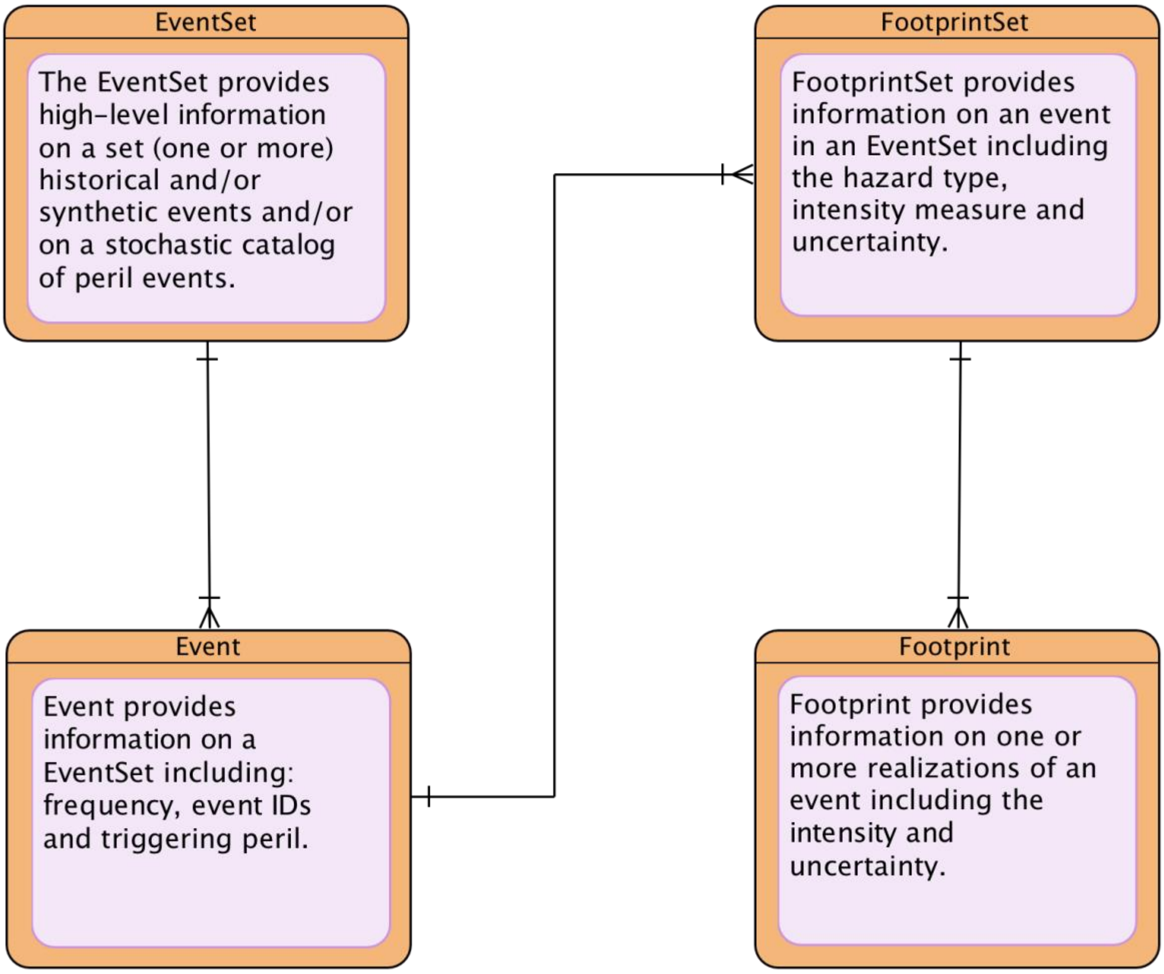

Figure 1. Entity relationship diagram for hazard data.

realizations of an event. If the uncertainty is defined parametrically, then there will usually only be a single entry in the *Footprint* entity for a row in the *FootprintSet*. If the uncertainty is defined nonparametrically, then there will be multiple rows in the *Footprint* entity representing different realizations of an event in the *FootprintSet*.

As an example, consider ground motion data for earthquake(s). The *EventSet* object would provide high-level information on the hazard data such as the creation date for the data, the hazard type, and the geographic location of the earthquakes and ground motion. For each earthquake in the event set, the *Event* object provides information for each event including the event ID, the event frequency (e.g., the annual probability of occurrence), the calculation method (e.g., simulation or observed), and the trigger for the event (e.g., if the hazard is a tsunami, the trigger could be an earthquake.) For each event, the *FootprintSet* object would provide information on how the event is described (e.g., in terms of PGA or spectral acceleration or another metric) and how the uncertainty might be described (e.g., as a parametric distribution such as a lognormal uncertainty.) One event may have one footprint, for example if only one realization of an event had been generated. However, there may be more than one footprint to represent uncertainty in an event (e.g., tsunami inundation based on the mean inundation depth, and depth at the 84% confidence interval would give two footprints for the same event). For each footprint in the *FootprintSet* , the data in the *Footprint* entity provides location information (e.g., geom information) and the intensity of the hazard (e.g., the peak ground acceleration) for each realization of a footprint associated with an event. There may be one or more, even thousands, of realizations depending on how uncertainty is specified. See, for example, Poggi et al. (2017) as an example of how uncertainty is estimated.

As part of the proof-of-concept for the Challenge Fund data schema project, the hazard entities were populated with selected data for events from six different hazards affecting Tanzania (Table 3). The events were selected on an ad-hoc basis and should not be used for decision purposes. The hazard data were collected with input from the Tanzanian partners listed in Table 3.

Table 3. Hazards used for the proof-of-concept.

Event	Example Hazards	Hazard Intensity for Prototype	Tanzanian partners*
Earthquake	Ground shaking	Peak ground acceleration and spectral acceleration	GST UD
Volcano	Ash fall	Tephra loading	GST
Flood	Fluvial flood Pluvial flood	Flood depth	TMA UD
Tsunami	Coastal flooding	Runup depth	TMA
Landslide	Landslide	Landslide susceptibility	GST UD
Drought	Hydrological Meteorological Agricultural Socio-economic	Standardized precipitation index (SPI), standardized precipitation-evaporation index (SPEI), standardized runoff index (SRI), standardized stream flow index (SSFI), standardized soil moisture index (SSMI)	

*GST: Geological Survey of Tanzania; TMA: Tanzanian Meteorological Agency; UD: University of Dodoma.

Exposure Schema

An extended version of the Global Exposure Database for the Global Earthquake Model (GED4GEM) was used to develop the exposure schema, which is named GED4ALL (Silva et al., 2018). The schema accounts for a variety of spatial resolutions, asset classes, temporal variability and exposure models. Exposure data can be either site-specific information that can include geometries for building footprints, gridded data at variable resolutions, or aggregated at the level of administrative regions, postal codes or CRESTA[6] zones. A key feature of GED4ALL is its inclusion of exposure attributes required for quantifying risk from multiple hazards, whereas GED4GEM contained attributes for earthquake assessment only.

Several tools have been developed around the exposure data. There is python code that will import and export data in the Natural Risks Markup Language (NRML) format. Also, to facilitate data export, a python tool was developed to export data in the NRML format used by the OpenQuake-engine (Silva et al., 2014). NRML is an open xml format, which can be used freely either via the Python libraries provided with the OpenQuake engine or other standards compliant with a xml parser toolset. The ability to export in the NRML format means the exposure data can be used directly with the OpenQuake loss estimation tool. There are also utilities[7,8] on the OpenQuake platform that can convert csv data into the NRML format and one that allows a user to develop a taxonomy string in NRML format through the use of drop-down menus, or to decode an existing taxonomy string.

The Humanitarian OpenStreetMap Team developed a tool[9] that uses YAML to export and convert OpenStreetMap (OSM) data into a user-specified format. When the tags for export are properly selected, the python scripts can be used to import the OSM data into the GED4ALL NRML format.

A wide range of asset classes are included in the schema including:

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[6] Catastrophe Risk Evaluation and Standardising Target Accumulations zones, commonly used within the (re)insurance and Catastrophe modeling industry.
[7] https://platform.openquake.org/ipt
[8] https://platform.openquake.org/taxtweb/
[9] https://export.hotosm.org/

- Buildings of different construction and occupancies (e.g., residential, industrial, commercial, healthcare, educational)
- Infrastructure (e.g., roads, railways, bridges, and “lifelines” including power lines and energy generation facilities)
- Agriculture (e.g., crops, livestock and forestry)
- Socio-economic data (e.g., population, gross domestic product and education indices)

Different exposure models are used for the different asset classes and taxonomies. An exposure model will specify the taxonomy used. An asset which is included in the schema will make reference to an exposure model and a taxonomy string that describes its attributes in a form consistent with the exposure model. For the proof-of-concept, buildings are described using a taxonomy derived from GED4GEM that is specific to GED4ALL while crops and forestry assets closely follow the Food and Agriculture Organization (FAO) taxonomy (FAO, 2010).

The use of different exposure models allows for multiple versions of exposure data. An example of when multiple versions of exposure may be desirable include situations where data may describe the same ‘portfolio’ of assets for a given area, but include different attributes at different resolutions, may be owned by different institutions and follow different licenses, or may be generated using different methodologies (e.g., modeled versus observed). Including a temporal component for the exposure data is important to capture important features for many asset classes. For example, crop inventories will vary by season, populations can migrate voluntarily or be involuntarily displaced, and occupancy can vary by time of day (e.g., schools, office buildings, factories). This feature also enables exposure data to be updated over time and referenced to that time point while retaining previous versions in the database.

An entity relationship diagram with the entities in the exposure schema is provided in Figure 2. In addition to the actual schema, a view is provided that can be used for exporting the exposure data in the form of a csv file.

Vulnerability Schema

The vulnerability schema, Multi-hazard Open Vulnerability platform for Evaluating Risk (MOVER), comprehensively accounts for physical as well as social vulnerability (EPICentre, 2018). Physical vulnerability

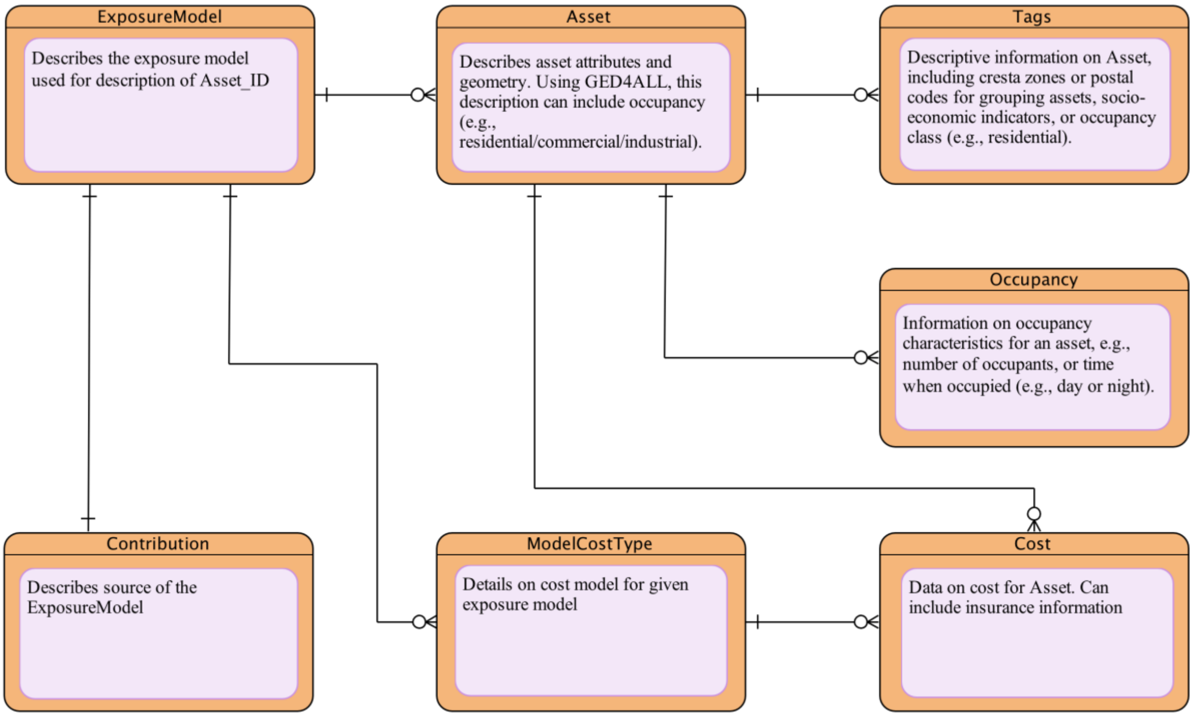

Figure 2. Entity relationship diagram for exposure data.

accounts for the likelihood of exposed assets (e.g., buildings or people) to incur damage and losses (e.g., economic loss or death) in response to a hazard event. A fragility function describes the probability that damage to an asset will equal or exceed a damage threshold (e.g., minor, moderate, severe damage, or collapse); this probability varies with hazard intensity and with asset characteristics (e.g., construction material, height, or roof type). Fragility functions can be derived empirically, through expert elicitation or analytically using theory and numerical models. A damage to loss model describes the relationship between the probable damage state and corresponding monetary loss for an asset (e.g., Yepes et al., 2016). *Vulnerability functions* estimate loss directly – they describe the amount of damage expected due to a given level of hazard intensity (e.g. wind speed) – and can be based on empirical data, expert elicitation or a combination of a fragility function and a damage to loss model.

One unique feature of the MOVER schema is that capable of storing a variety of social vulnerability indicators and indices, in addition to physical fragility and vulnerability functions. Social vulnerability indicators and indexes describe the ability of people and society to withstand the effects of (multiple) stresses to which they are exposed. In contrast to physical vulnerability, social vulnerability is independent of hazard intensity (Thomas et al., 2013). Examples of vulnerability categories include education and food security. The education category includes a variety of vulnerability characteristics such as education level and access to education, while the food security category includes characteristics such as food availability, accessibility, and stability.

A second unique feature is that MOVER includes a scoring mechanism that considers the appropriateness (rationality) and quality of vulnerability and fragility functions, and social vulnerability indices and indicators. This helps users of the data to understand whether the available curves or indices are appropriate for a particular location and for the hazard and/or exposure data it is proposed to use them with, and to determine the overall quality of the curves available as assessed by experts in developing such data.

An entity relationship diagram for the vulnerability schema is shown in Figure 3. Note that identifying an appropriate vulnerability function requires information on both hazard and exposure, and the objects where this information is required are highlighted with green.

A web-based application to visually explore the vulnerability schema was developed and as a proof-of-concept populated with vulnerability data for Tanzania and the five other countries targeted by the Challenge Fund. For the proof-of-concept a significant effort was made to identify vulnerability and fragility functions. However, no

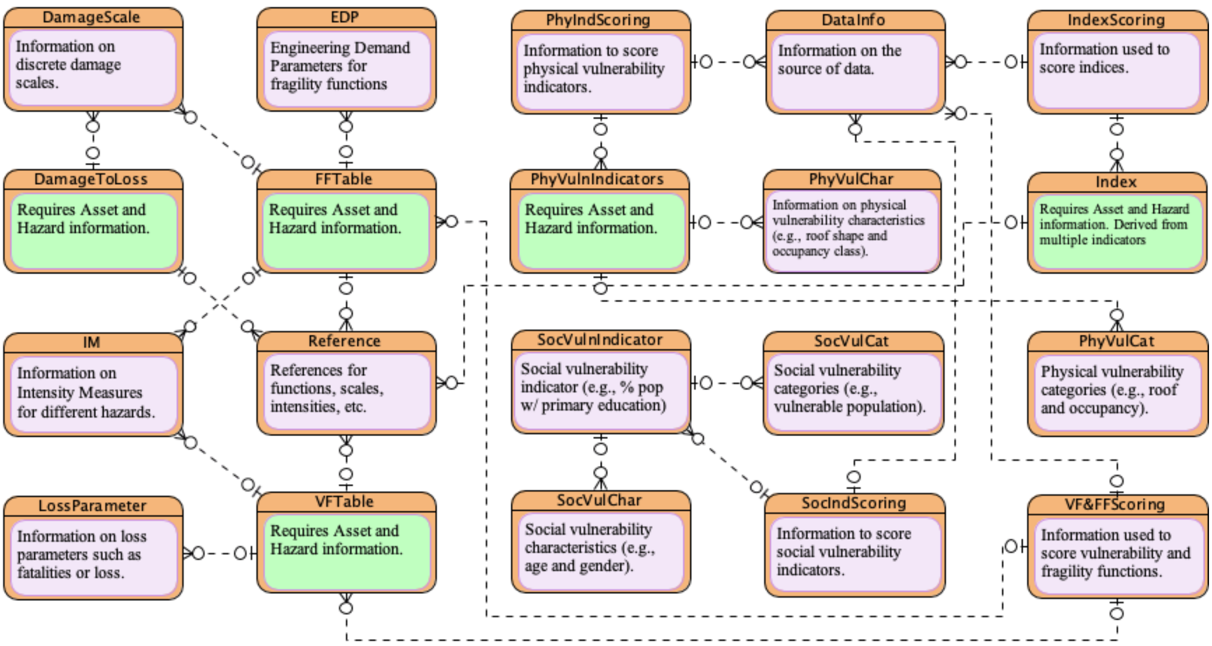

Figure 3. Entity relationship diagram for vulnerability data. The green text box identifies objects that require data on the hazard and asset.

data were found for wind, storm surge and drought, and limited numbers of functions for hazards other than ground shaking from earthquakes.

Data Exploration Tool

For data to be used for disaster risk management it has to be discoverable, available, accessible and usable (GFDRR, 2014). In addition, the data should be well-documented by metadata that provide information critical for determining the data's use and provenance. The development of the data schemas is aimed at making disaster-risk related data more usable by devising a means to make the data available in a consistent format. In order to encourage adoption of the data schemas, and to make the data discoverable, accessible and useable, the GFDRR-DFID Challenge Fund is supporting the development of a data exploration tool[10]. Currently, the tool is a prototype, but it provides a glimpse of what will eventually be a user-friendly platform for exploring, accessing, and contributing data that conforms to the schemas. The following discussion will focus on exposure data as the functionality for exposure data is the most complete. The software is available via the GFDRR Innovation Lab's GitHub account[11].

The landing page for the data explorer is designed to provide a user with two convenient ways to access data: either through a text-based search, or by clicking on a country of interest (Figure 4). Once a country is selected, the map zooms to the country, which is shaded, and a list of exposure data sets whose data are within the extent of the map are displayed on the left-side panel (Figure 5). Note that the panel includes tabs for hazard, exposure and vulnerability data. The default view is for the exposure data, by clicking on the hazard or vulnerability tabs a user can access the hazard or vulnerability data that are relevant to the selected geographic area.

Once a user clicks on an exposure data set listed on the left, it is displayed on the map (Figure 6). A dataset can be added to a "shopping cart" by clicking on the plus button in the left panel. In addition, filters can be applied to view subsets of the data. Finally, a user can select a subset of the data by using a spatial filter on the map such as

[10] http://assess-risk.info
[11] https://github.com/GFDRR/hev-e

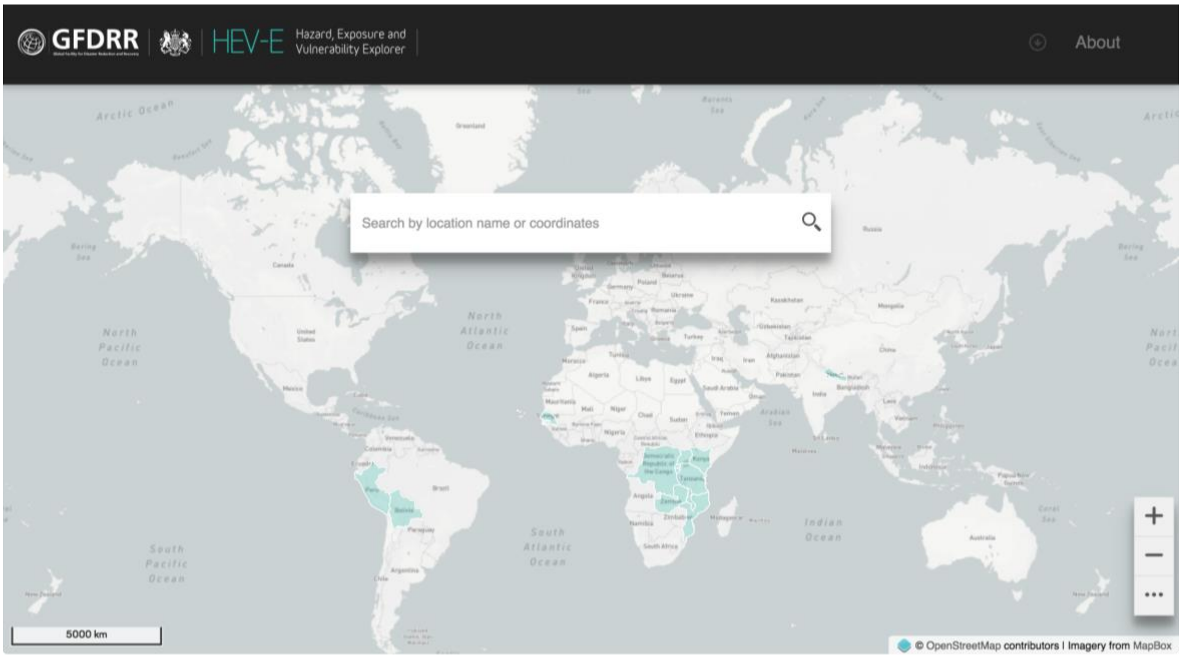

Figure 4. The landing page for the data exploration tool. Countries with data accessible by the site are colored green. Available at http://assess-risk.info

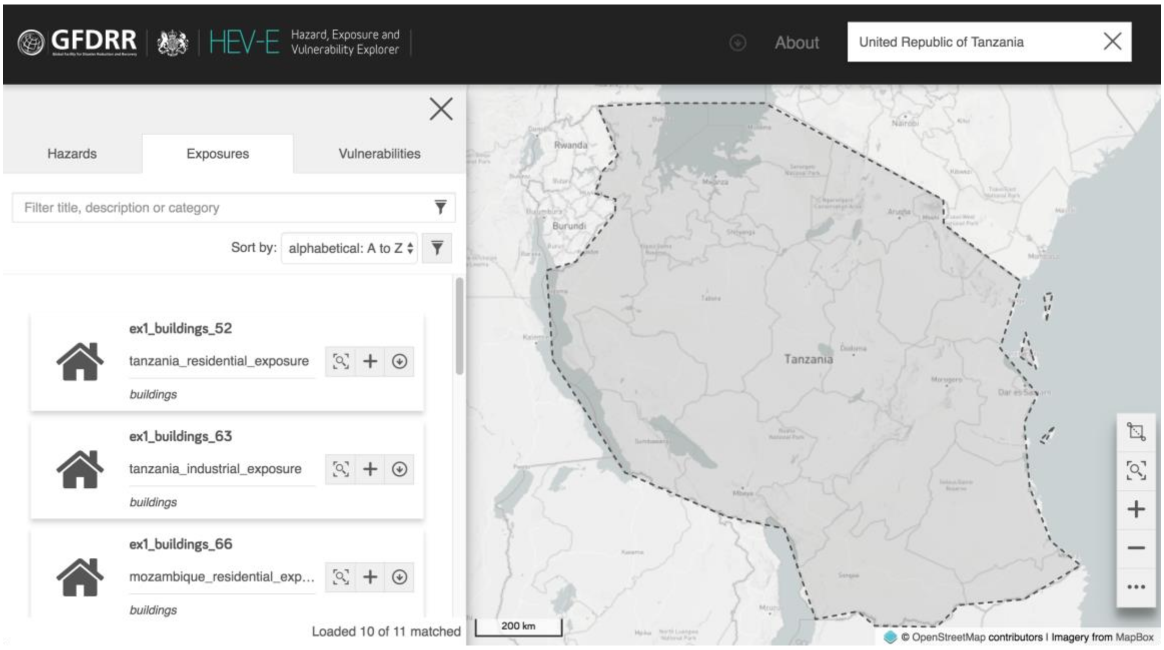

Figure 5. Screenshot showing the selected country, Tanzania, and the exposure datasets available within the extent of the map.

the square on the coastline. Summary statistics for the whole data set, or a subset of the data, are displayed in a panel to the left of the map (Figure 6).

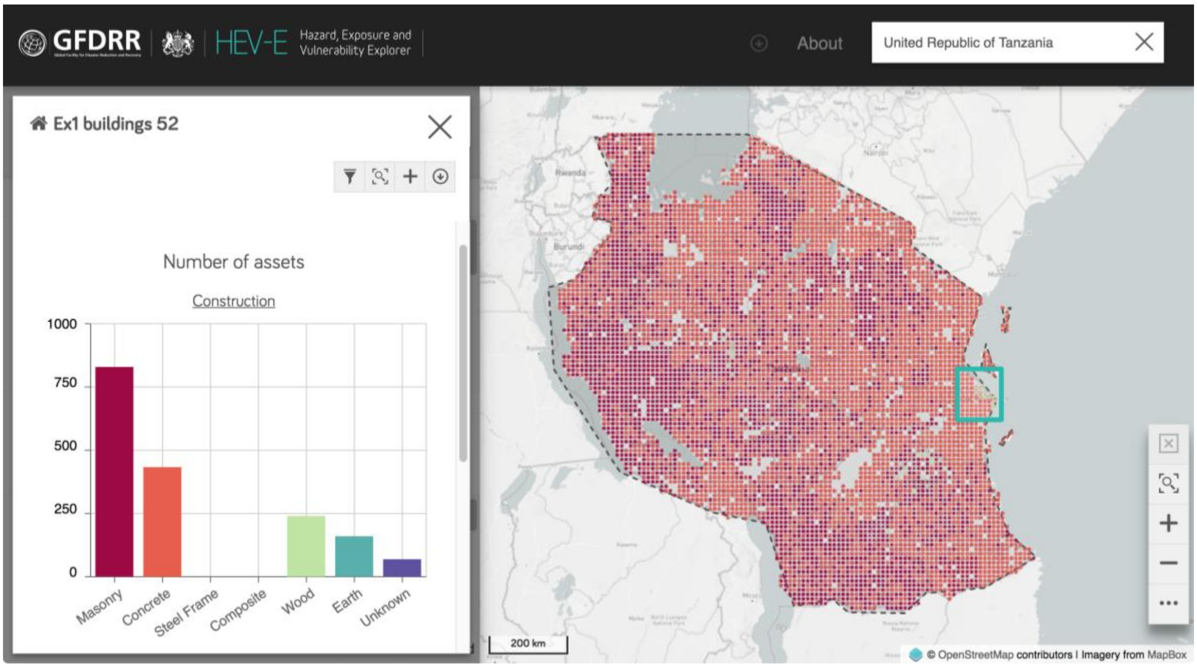

Figure 6. Screenshot of gridded building data for a selected subset of gridded building data for Tanzania. Note the summary graphics in the left panel display the statistics for the subset of the data.

Desired hazard, exposure and/or vulnerability data can also be selected for bulk download by clicking the arrow icons. Data will be available for download in either the format of the full data schema, or as a "flattened" version that provides only a subset of information.

Next Steps and Conclusions

While a significant amount of work has already been accomplished in defining the data schemas, more effort is required to make the schemas and data exploration tool ready for broader use by the risk community. Thus, GFDRR is supporting additional work to:

- Revise the data schemas to make the hazard, exposure and vulnerability schemas more efficient.
- Extend the schemas to account for a variety of risk-related results such as:
    - hazard levels at various return periods (commonly known as hazard maps).
    - loss metrics such as annualized losses, probable maximum losses, exceedance probability curves and occurrence year loss tables.

- Develop utilities to facilitate the conversion of other common data formats into a form consistent with the data schemas to encourage the creation of conforming datasets.
- Continue development of the data exploration tool to improve discovery, access and use of risk-related data.

The totality of these efforts, their coordination with other related interoperability initiatives, and adoption of the schema into data generation and risk assessment projects and workflows, will help address the main issues that motivated this work: the limited data in developing countries and the wide range of formats for existing data. Ultimately, they will help to facilitate the creation, broader use, and incremental improvement of risk data and tools, and improve user access to risk data, to support disaster risk management efforts in developing countries.

References

EPICentre (2018), MOVER – Level 3 Data schema for Physical and Social Vulnerability Indicators, Indices, and Functions, https://www.gfdrr.org/sites/default/files/publication/MOVER Level 3_4 - Physical and Social vulnerability data schemas_UPDATED.pdf

FAO (2010), World Census of Agriculture, Appendix 3, http://www.fao.org/fileadmin/templates/ess/documents/world_census_of_agriculture/appendix3_r7.pdf

GFDRR (2014), *Understanding Risk: Emerging Best Practices in Natural Disaster Risk Assessment*, The World Bank, Washington, DC.

GFDRR (2016), *Solving the Puzzle: Innovating to Reduce Risk*, GFDRR/World Bank, https://www.gfdrr.org/sites/default/files/solving-the-puzzle-report.pdf

GRAF (2018), The Global Risk Assessment Framework:Better decisions for a better future, Concept Note. https://www.preventionweb.net/files/61909_grafconceptnote.pdf

Poggi, V., R. Durrheim, T. Mavonga, G. Weatherill, R. Gee, M. Pagani, A. Nyblade, and D. Delvaux (2017), Assessing seismic hazard of the East African Rift: a pilot study from GEM and AfricaArray, *Bulletin of Earthquake Engineering, 15*(11), 4499-4529, doi:10.1007/s10518-017-0152-4

Silva, V., H. Crowley, M. Pagani, D. Monelli, and R. Pinho (2014), Development of the OpenQuake engine, the Global Earthquake Model's open-source software for seismic risk assessment, *Natural Hazards, 72*, doi:10.1007/s11069-013-0618-x.

Silva V., C. Yepes-Estrada, J. Dabbeek, L. Martins, S. Brzev (2018), GED4ALL - Global Exposure Database for Multi-Hazard Risk Analysis – Multi-Hazard Exposure Taxonomy. GEM Technical Report 2018-01, GEM Foundation, Pavia, Italy. https://www.gfdrr.org/sites/default/files/publication/Exposure data schema_final report.pdf

Thomas, D. S. K., B.D. Phillips, W. E. Lovekamp and A. Fothergill, eds. (2013), Social Vulnerability to Disasters. Boca Raton: CRC Press, 2nd edition, 514pp.

UNISDR (2015), Sendai Framework for Disaster Risk Reduction 2015 – 2030, https://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf

Yepes C, V. Silva, D. D'Ayala, T. Rossetto, I. Ioannou, A. Meslen and H. Crowley (2016), The Global Earthquake Model Physical Vulnerability Database, *Earthquake Spectra*, 32(4):2567-2585.