Words into Action Guidelines:
National Disaster Risk Assessment
Special Topics

G. Use of Geospatial Data in Implementing NDRA

Key words:
geospatial data, spatial data, geographic information systems, GIS

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Geospatial information, also known as spatial or location information, is crucial for understanding disaster risk. We cannot consider the physical processes causing disasters, or how they impact on people and their assets, infrastructure and the environment, if we ignore their location on earth. For example, variations in topography and surface cover play a key role in determining the local flood hazard. Proximity to a tectonic fault influences the earthquake hazard. Spatial distribution of exposure (elements at risk), in proximity to a hazard, is a significant factor of disaster risk; a large magnitude earthquake in an unpopulated area may not cause any damage, whereas a smaller event under a population centre may have disastrous impacts.

Risk mitigation options also vary spatially, as evacuation zones or construction standards reflect the spatially variable nature of hazard. A national risk assessment needs to take into account the geospatial characteristics of the hazard, exposure, vulnerability and coping-capacity components for any particular event. Such information therefore underpins the national risk assessment process.

Geospatial information describes a location or is information/data that can be referenced to a location. There are two types of geospatial data: vector and raster data. Vector data include data stored as point, line and polygon features. For example, point location of a township, or an earthquake felt report; geographic contours and topographic road or rail features characterized as lines; or polygon shaped features of land parcels or a flooding extent. Raster data include aerial photographs, imagery from satellites or digital pictures or scanned maps. Both vector and raster data can be used to support national risk assessments.

Geospatial information underpins most, if not all, national risk assessments, as illustrated in Figure 1. Consequently, geospatial analysis is used in many risk assessment approaches. Using and analysing geospatial data requires specific enabling technologies such as information management systems and analysis and processing tools such as geographic information system (GIS).

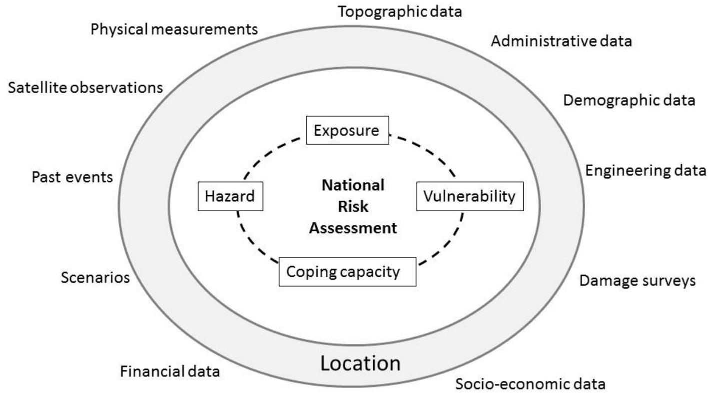

Figure 1 – Examples of the key role of spatial information in a risk assessment

Enabling technology

Technology stack solutions for working with geospatial data can be deployed on desktop, enterprise, cloud and mobile platforms. Software solutions include both commercial off-the-shelf and Free Open Source (FOSS) applications. A valuable comprehensive list of open source geospatial technology stack solutions is maintained by the Open Source Geospatial Foundation (OSGeo)[1].

GIS is a computer system that enables the capture, management, analysis and visualization of geographic information[2]. The value of a GIS is that it "understands"the spatial nature of information, enabling the ability to explore relationships, patterns and trends in relation to other spatial and non-spatial information. Over the past decades, GISs have improved in sophistication and are now a very powerful decision-making tool used for a wide range of applications.

At the same time, there is no one type of system or tool that is uniquely suitable for a national risk assessment. Computational solutions other than strict GIS packages are available or can be developed to better suit particular geospatial data sets or applications. Choices of tool and system should be determined by the context and purpose of the data analysis required.

In addition to contacting individual data custodians, the internet facilitates the sharing of geospatial data through Spatial Data Infrastructures (SDI)[3]. These build on web-based technologies such as content management systems (e.g. GeoNode[4]), web services (e.g. GeoServer[5]) and Linked Data. This infrastructure enables applications to directly consume geospatial data and maps products, without the need to download the data.

Quality management systems

Comprehensive standards systems such as defined by the Open Geospatial Consortium (OGC)[6] and the International Organization for Standardization (ISO) ensure interoperability and consistent quality of geospatial data and their metadata (information about the data)[7][8]. Consistency and interoperability of spatial data is important, especially because natural disasters cross both jurisdictional and sectoral boundaries.

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1 www.osgeo.org

2 www.nationalgeographic.org/encyclopedia/geographic-information-system-gis/

3 https://en.wikipedia.org/wiki/Spatial_data_infrastructure

4 http://geonode.org/

5 https://live.osgeo.org/en/overview/geoserver_overview.html

6 www.opengeospatial.org/

7 www.iso.org/iso/home/store/catalogue_ics/catalogue_detail_ics.htm?csnumber=53798

8 https://www.fgdc.gov/metadata/csdgm-standard

Geospatial reference systems

A fundamental characteristic of geospatial data is that they contain a spatial reference system or have the ability to be tied to a reference system (e.g. coordinate system, projections and datum; able to be identified by an address, place or region name). A GIS maintains the variety of coordinate systems, projection and geodetic datums within the data set itself. As a result, a GIS allows data sets that have different coordinate systems to be overlaid and viewed seamlessly if required data sets are re-projected in order to combine them for analyses. The geospatial reference system is a key metadata element to be captured for all geospatial data sets.

Scale and resolution

Geospatial data or map scale is simply the ratio of map to ground measurement. Zooming in or increasing the scale does not increase the level of accuracy or detail but it will make it clearer to visualize. Data resolution, however, refers to the smallest feature that can be distinguished in the data. For example, a satellite image may capture surface reflectance in 30m pixels. Surface features smaller than 30m will not be individually distinguishable. If data are used beyond their resolution, any results will have a greater level of uncertainty. Therefore, understanding the purpose and resolution at which the data were captured helps understand the level of detail and the accuracy of the information available.

At the same time, processes underpinning disasters, impacts and risk have characteristic scales. Thunderstorms typically impact on smaller spatial scales than hurricanes. Demographic characteristics tend to vary across a country, but may be homogeneous within a suburb. The resolution of the geospatial data used for a risk assessment should be adequate to reflect the detail and level of accuracy required to assess both the processes considered and the scale of analysis. Otherwise, there is a significant risk that a risk assessment is meaningless; or worse, misleading. For example, tsunami inundation is influenced by local variability in elevation. As a result, a national tsunami risk assessment based on low-resolution elevation data may identify local areas as safe, whereas they are actually at risk of inundation[9].

Geospatial data and national risk assessment

A robust national risk assessment requires good quality and consistent geospatial data and tools to support the hazard, exposure, vulnerability and coping capacity components of the risk. If hazard assessments are not already

[9] Griffin J. and others (2015). An evaluation of onshore digital elevation models for modeling tsunami inundation zones. Frontiers in Earth Science 3:32. doi: 10.3389/feart.2015.00032

available, a national risk assessment may require fundamental geospatial data such as topography, rainfall observations or soil data that underpin hazard assessments. Not only for hazard, but also for exposure, vulnerability and coping capacity dimension, the data resolution should reflect the relevant spatial variability at the scale of the assessment.

Typically, collating the data for a national risk assessment will involve multiple agencies and stakeholders that collect different data sets. Data may not be stored as spatial information, but data records can still contain some kind of spatial reference, including street address, suburb or administrative boundary. Integrating different spatial data sets and administrative non-spatial information in a GIS can inform the exposure, vulnerability and coping capacity dimensions of a national risk assessment. Metadata complying with a standard (e.g. ISO 19115[10]) support interoperability of data, and will support the application of different data sets for a national risk assessment.

CASE STUDY

Box 1
A case of a country good practice

Indonesia
Ambon Tsunami Table Top exercise

In 2016, the National Disaster Management Authority (BNPB) used credible hazard science, open spatial data and spatial decision support tools to prepare contingency plans in support of a disaster management exercise. The exercise was based on a worst-case scenario for tsunami hazard in Ambon. Working together with the Humanitarian OpenStreetMap Team (HOT) and the community, it mapped OpenStreetMap exposure data for buildings and roads. The hazard scenario was analysed in the FOSS GIS-based disaster scenario package InaSAFE, (e.g. figure 1) to estimate the impact on communities and infrastructure and to support the participatory development of three subnational contingency plans: for Ambon City, Maluku City and Central Maluku.

Figure 1 - Tsunami impact map of Ambon province

The national Tsunami Table Top exercise tested the tsunami emergency management governance, coordination and communication at the national, provincial and district level. With this activity, BNPB has demonstrated how spatial data and spatial analysis can provide a credible evidence base for disaster risk management activities.

[10] www.iso.org/standard/53798.html

CASE STUDY

Box 2

A case of a country good practice

Australia

Sharing spatial data through the Foundation Spatial Data Framework

The Australian and New Zealand Foundation Spatial Data Framework (FSDF) provides a wide variety of users with a common reference for the assembly, maintenance and a way to discover key government spatial data sets. It contains 10 themes that broadly categorize information, with each theme containing one or more FSDF data sets. Key input data sets for risk assessments are included in many different themes, including geocoded addressing, administrative boundaries, elevation and depth, land cover and land use, imagery, land parcel and property, positioning, water, transport and place names.

FSDF delivers a national coverage of the best available, most current, authoritative source of foundation spatial data that are standardized and quality controlled for over 1,000 input data sets derived from multiple tiers of government.

To organize information within the program, a system called the Location Information Knowledge Platform (LINK) has been developed. LINK is the first attempt in Australia to document and publish in a user-friendly way location information governance, business information and provenance for all of Australia's foundation spatial data. LINK is a cloud-based online content management system that provides users with a range of different ways to interrogate information and discover data they are interested in. LINK provides a common platform to help understand roles and responsibilities of suppliers, aggregators and consumers of the data. It also provides a framework to manage working groups tasked with improving FSDF data into the future.

Resources for further information

There are many relevant communities of practice that focus on the use of spatial data, with a wealth of useful guidelines, tools and case studies that can support geospatial data use for national risk assessments.

The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) develops guiding principles, policies, frameworks, standards and institutional arrangements around geospatial information. UN-GGIM also holds governance of a global ”gazetteer” and global boundaries data, a global geodetic reference frame.

As part of the global community of practice of spatial data, UN-GGIM provides access to extensive knowledge resources through its website[11]. Under UN-GGIM is the Working Group on Geospatial Information and Services for

[11] http://ggim.un.org/

Disasters (WG-DISASTERS)[12].

The Committee on Earth Observation Satellites (CEOS) also has a working group that focuses on disasters, which aims at increasing the contribution of earth observation data to risk management applications[13].

Data Management Association International (DAMA) is a global community of practice for data management. It provides learning and networking opportunities and education materials for data management professionals, and includes a focus on geospatial information[14].

The Open Geospatial Consortium (OGC) is committed to making quality open standards for the geospatial community, enabling better data sharing and interoperability for spatial data[15].

The Open Source Geospatial Foundation (OSGeo) was created to support the collaborative development of open geospatial software. Its webpages include links to a wide range of open source tools and technologies for geospatial data, as well as serving as a hub for technical communities of practice. These pages provide links to open source tools for geospatial data that can be used for national risk assessments.2 These include "generic" GIS tools such as QGIS and GRASS GIS, content management systems such as GeoNode, geospatial libraries such as GDAL and PostGIS, metadata catalogues, and web-mapping tools such as GeoServer and OpenLayers. Additionally, there are more specific disaster mapping tools such as InaSAFE11, a QGIS plugin. Again, the choice of application or tool should be determined by the questions needing to be answered, the type of analysis required and the resolution of the data that are available.

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[12] www.nationalgeographic.org/encyclopedia/geographic-information-system-gis/

[13] http://ceos.org/ourwork/workinggroups/disasters/

[14] www.dama.org

[15] www.opengeospatial.org/