Chapter 3

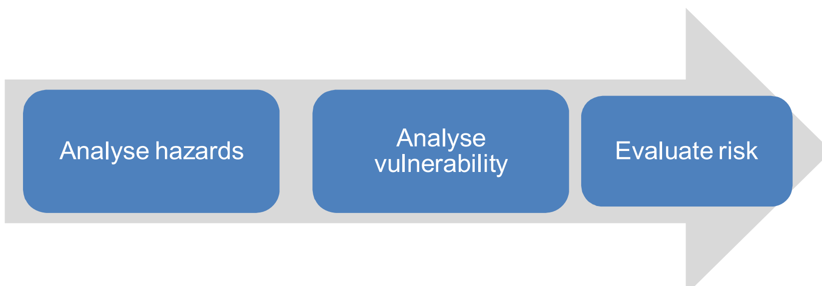
Risk assessment in the National Civil Protection System

This chapter analyses the progress that has been made since 1986 to produce reliable and scalable risk assessments for the most serious risks facing Mexico – including efforts to produce a geographic information system-based mapping of earthquake, hurricane and flood hazards with overlays of the population and infrastructure assets that are exposed to these hazards. Responsibility for risk assessment in civil protection policy planning and implementation is often spread across different bodies and levels of government. This chapter, therefore, also examines how the National Civil Protection System supports the development and use of consistent risk assessment methods to ensure comparable results across different levels of government.

Introduction

Civil protection stakeholders at central and decentralised levels of government should conduct risk assessments to guide the optimal allocation of the limited resources destined for the various phases of disaster risk management. Risk assessment is a methodical determination of the nature and extent of risk to assets of value. It analyses the potential magnitude and likelihood of hazards, and evaluates the vulnerability of assets that could be exposed to such hazards. Without a systematic approach grounded in the best available scientific understanding of hazards, planning and investment in the disaster risk management cycle is arbitrary, more susceptible to uninformed demands and often leads to wasteful, overprotective measures or dangerous neglect of the assets that civil protection is meant to protect: people, property, livelihoods and the environmental resources on which they depend.

Figure 3.1. **Risk assessment**



Risk assessment is the starting point of integrated risk management; its results are used across all phases of the risk management cycle: prevention and mitigation, planning and response, recovery and reconstruction.

This chapter examines how Mexico's National Civil Protection System (*Sistema Nacional de Protección Civil*, SINAPROC) supports efforts to produce a systematic and consistent approach to hazard and vulnerability analysis. It also considers whether SINAPROC has made progress in using the knowledge generated by risk assessments toward such key purposes as:

1. guiding disaster risk reduction measures such as land-use and urban development plans in the designation of high, medium and low risk construction zones (see Chapter 4);
2. raising the population's awareness and informing them of the potential risks confronting them at the national and local levels (see Chapter 4);
3. developing appropriate emergency response plans (see Chapter 5); and
4. estimating disasters damages to ensure financial strategies are implemented that are suitable in light of national risk-bearing capacity and tolerance levels (see Chapter 6).

From risk atlases to multi-sectoral and multi-level risk assessment

Risk identification and analysis are considered to be the key elements underpinning the transition to integrated risk management. After the devastating Mexico City earthquakes of 1985, the momentum to strengthen civil protection capacities led to the development of the first "National Risk Atlas". This collective effort was co-ordinated by the Ministry of the Interior and involved various sectoral ministries (Water, Industry, Infrastructures, Urban Development, Health, Agriculture) and academic expertise from the National Autonomous University of Mexico (*Universidad Nacional Autónoma de México*, UNAM). This risk atlas, however, was mostly a hazard inventory for the national territory. The National Centre for Prevention of Disasters (*Centro Nacional para la Prevención de Desastres*, CENAPRED) published an updated version in 2001, which focused not only on hazard analysis and identification, but also on providing information about disaster risks and past disaster impacts and losses (CENAPRED, 2001).

Toward a multi-sectoral, multi-level risk assessment process

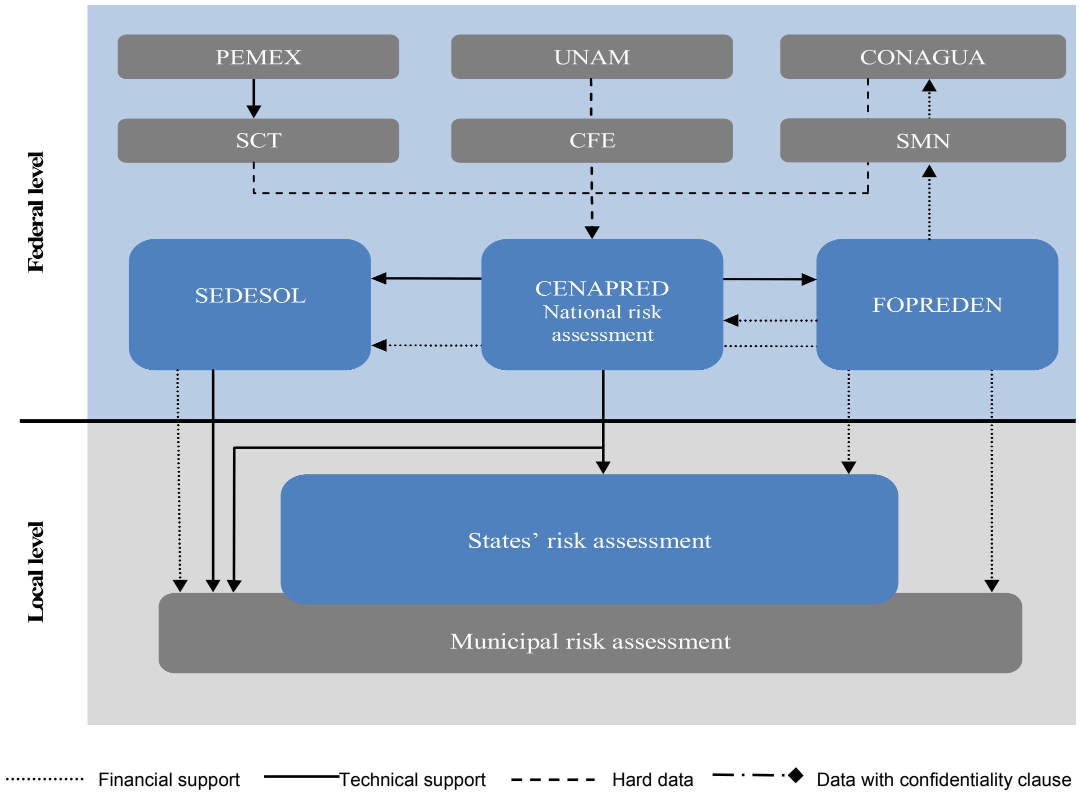
The updated version of the National Risk Atlas was followed by concerted efforts to promote the development and use of risk assessment. For example, the General Law for Civil Protection (*Ley General de Protección Civil*, GLCP) of 2000 and its follow-up policies and plans emphasised the need to expand the use of risk assessment across federal, state and municipal levels of government, as well as horizontally with the various economic and social sectors. An objective of the National Development Plan for 2001-06 was to shift the focus of civil protection from emergency response capabilities toward a more prevention-oriented approach. In particular, it provided for the need to identify and increase knowledge about threats and risks at the community level. Accordingly, the National Programme for Civil Protection 2001-06 acknowledged the risk assessment work that had been conducted previously, and in particular the National Risk Atlas. It also called for its continuous improvement as a geographic information system (GIS) based tool, to be further developed in co-operation between the three levels of governments, and with the social and private sectors.

In 2004, CENAPRED began the development of a third-generation National Risk Atlas. It evaluated hazards, risks and damages linked to disasters, integrated this data into a GIS-based tool, and thereby increased risk knowledge in co-ordination with many contributing organisations. In parallel, the Ministry of Social Development (*Secretaría de Desarrollo Social*, SEDESOL) started to support the development of risk atlases in urban areas in 2004 and published a methodological guide for developing them through its "Habitat" programme. It also launched a GIS tool for risk identification.

In 2006, the SINAPROC Manual clearly laid out the roles of all federal entities in the various areas of risk management (see Annexes E and F). Regarding hazard data collection, mapping and the development of risk information, CENAPRED has the overarching role of supporting the technical development of such information and ensuring it is integrated appropriately into the National Risk Atlas. The various sectoral ministries and organisations, as well as the state and municipal governments, each have a key role to play in their specific areas (Figure 3.2).

Following this clarification of roles and responsibilities for risk assessment, CENAPRED published a full list of guidelines and manuals for the development of risk atlases with the appropriate concepts corresponding to the three levels of government. The benefit of these publications was to highlight how few states and municipalities had developed a risk atlas that met the minimum standards of quality. One of the key priorities of the National Programme of Civil Protection for the period 2008-2012 was to increase the number of states with a state level risk atlas conform to the established guidelines. With significant technical and financial support over this period, the number of completed state risk atlases increased from 6 to 28. Progress at all levels can be expected to continue as promoting risk assessment is one of the seven stated priorities of the 2012 GLCP.

Figure 3.2. **Roles and responsibilities for risk assessment in Mexico**



Notes: * In addition to the UNAM, other national or local universities could be involved in this process.

CONAGUA: National Water Commission; SMN: National Meteorological Service; UNAM: National Autonomous University of Mexico; CFE: Federal Electricity Commission; SCT: Ministry of Communication and Transport.

Source: OECD based on information from SINAPROC.

An evolving process consecrated by the adoption of the 2012 General Law for Civil Protection

From the early stages of the first National Risk Atlas, which was basically a document about hazards, to the development of an online digital tool, Mexico has made clear progress. One of its main achievements is the design and launch of the National Risk Atlas: the result of a holistic, multi-stakeholder and multi-level process, set up to foster analyses of hazards and vulnerabilities from the local to the national level. The various sectoral ministries integrate hazard and vulnerability databases with GIS, risk scenario simulations, disaster loss estimates and updates underlying variables to inform civil protection policies and programmes.

Line ministries and local governments now have the duty to gather data for all hazards databases and information contributing to risks for the development of risk atlases at federal, state and municipal levels. An important development under the 2012 General Law for Civil Protection is that local risk atlases will form part of the legal basis for decisions to issue or deny building permits, and also provide the basis for tools to raise the public's awareness of exposure to risks.

The multi-layered risk atlas process is designed to support the major uses of modern risk assessment: it uses a GIS-based common platform, integrates data from local to national levels, receives multi-stakeholder input and can be regularly updated. CENAPRED has demonstrated leadership in the field of risk assessment both in terms of promoting modern concepts and providing tools and methodologies to SINAPROC stakeholders with direct responsibility for applying them. It provides an effective bridge between the policy, operational and academic research capacities though its resources are quite limited for its wide range of responsibilities, which also include training, the provision of operational and policy advice and scientific research, and monitoring hazards.

Box 3.1. Scientific advisory committees

The importance of creating linkages between the scientific community, academia and policy makers is an internationally recognised good practice in the field of disaster risk management. Civil protection decision making based on the best available scientific knowledge supports government's capacity to establish the most adequate measures for risk management. These connections are particularly important at the risk identification and risk assessment stages, which require technical knowledge.

SINAPROC recognised the importance of including specialised knowledge in civil protection decisions and planning early on, and in 1995 a federal decree created the scientific advisory committees. These committees comprise technical and scientific experts in various fields of natural and social sciences and engineering who provide advice to civil protection authorities. Committees chaired by CENAPRED have been established for geological, hydrometeorological and chemical hazards along with a Technical Advisory Committee for the Popocatépetl volcano with researchers from UNAM's Institute of Geophysics.

At the local level, linkages between local governments and the scientific community are now also well developed, although this was not always the case. The National Development Plan 2001-06 identified the lack of linkages between specialised knowledge and decision making as an opportunity area within SINAPROC. Since then, civil protection authorities in Chiapas, Colima and Jalisco have integrated scientific advisory bodies to advise on risk management matters. The state of Nuevo León also created a specific committee devoted to hydrometeorological phenomena with the participation of the National Water Commission, CONAGUA (Comisión Nacional del Agua). The state of Tamaulipas created a Board for Hurricane Risk Prevention to improve its monitoring capacities.

Source: Agreement creating Scientific Advisory Committees of the National Civil Protection System as Technical Advisory Bodies for the Prevention of Disasters caused by Geological, Hydrometeorologial, Chemical and Socio-organizational phenomena, *Diario Oficial de la Federación*, 6 June 1995; and Mexico's National Development Plan 2001-06.

Gathering the empirical evidence for risk assessment

Setting forth institutional mandates and defining roles and responsibilities are important governance features of the risk assessment process. Actually developing risk assessments, however, combines the difficult task of collecting hazard and exposure data and integrating it with the results of vulnerability analysis. Data collection requires adequate hazard monitoring networks to produce and process it in an appropriate format, and the development of databases for hazard events (e.g. hydrometeorological and seismological data) and socio-economic features (e.g. demographics, assets at risk, social vulnerability).

Hazard data availability and analysis

Meteorological monitoring,

The National Meteorological Service of Mexico (*Servicio* Meteorológico Nacional, SMN) is responsible for weather monitoring and forecasts. In addition to weather and meteorological hazard prediction and warnings (see Chapter 5), it collects meteorological data and has kept a national database of climatic data (temperatures and precipitations) since 1941. The monitoring of meteorological phenomena is assured by a network of 212 meteorological stations, 133 of which are automated, 15 upper-air radiosonde stations and 13 radars. The capacity of this network to produce and gather data could be further improved, as only 6 of the 13 radars were functioning in 2009.

The SMN is part of CONAGUA and has partial access to hydrometeorological data generated by the network of its Directorate of Surface Waters and River Engineering (see next section). In addition, several institutions have their own meteorological networks, both at the federal and state levels. The Navy (*Secretaría de Marina*, SEMAR) has its own atmospheric monitoring system composed of 35 automatic weather stations (AWS) and there is a forecasting centre at PEMEX and the Federal Electricity Commission (*Comisión Federal de Electricidad,* CFE) as well. At the state level, the Ministry of Public Security of Chiapas maintains 13 AWS, the river basin authority of the Mexico valley has 25, the North Gulf basin 26 and the state of Guerrero 36. These multiple networks are not fully operational and/or maintained and they only partially transfer their data to the national level (10% in some cases). Some states and universities, such as the University of Guadalajara, have also invested in weather radars. This scattered landscape for meteorological observation and services in Mexico was evaluated in 2010 by the World Meteorological Organisation (WMO). The results were used for a project financed (61%) by the World Bank in 2012 for the "Modernization of the National Meteorological Service for Improved Climate Adaptation".

The SMN has a historical database specifically for tropical cyclones that make landfall in Mexico, and has mapped out their entry points. However, this database contains little information about the dates, wind strength or states impacted by specific events. In this respect, it is not as complete as the WMO Regional Specialised Meteorological Center (RSMC) in Miami – US-NOAA National Hurricane Center. The RSMC monitors tropical cyclones that generate in the North Atlantic and the North East Pacific. It also maintains a freely accessible database of tropical cyclones dating back to 1958, including all of the meteorological and oceanographic parameters. In 2002, CENAPRED and the Mexican Institute for Water Technology used this database to develop the Climatic Atlas of Tropical Cyclones in Mexico. This atlas contains detailed maps and geospatial analysis of tropical cyclone tracks, their pressure and wind speed. It is publicly available and can be utilised to support the development of risk assessments.

Integrating forward-looking hazard analysis is fundamental in the arena of meteorology. Due to climate change, hazards from the past may not be representative of what will occur in the future. In this respect, research and investments in better understanding the potential impact of climate change on hazard patterns, their intensity and/or their frequency is a key domain for risk assessment. It is also in this context that Mexico developed a project for modernising the SMN, which includes a strong component on climate modelling. The strengthening of the meteorological and climatological capacities of the country was part of the National Special Climate Change Programme 2009-2012, as was the development of a National Atlas on climate change impacts and vulnerability. The development of this atlas, on the model of other atlases in Mexico, should be made a priority so that these data and information are available for forward-looking risk assessment.

Hydrological monitoring

CONAGUA is the federal agency responsible for the entire water cycle, from resource management to water supply and sanitation, irrigation and other water uses. It plays a key role in SINAPROC, from flood risk management to providing drinking water during and after different kinds of disasters. CONAGUA, through its 37 hydrological regions that regroup 728 hydrological basins, monitors water levels and discharge with its dense hydrological network of 499 hydrometric stations, covering most of the 50 major rivers, though not every basin. The network was developed primarily for water resource management: irrigation, urban water supply and energy production – i.e. for water uses, not to counter flood risk. For instance, although rainfall from hurricanes Gilbert and Alex led to devastating floods of the Río Santa Catarina riverbed, there is no regular hydrological monitoring of it, because it is otherwise entirely dried out.

CONAGUA also manages a network of 1 000 reference climatologic stations, which produce precipitation data for the development of hydrological modelling. CFE has its own hydrological monitoring network for managing many of Mexico's major hydroelectric dams. In addition, cross-border exchanges about hydrometeorological conditions and data are established to monitor cross-boundary watershed: the Río Bravo and Colorado rivers cross the Mexico-United States border, while rivers also flow from Guatemala into the hydrological regions of Costa de Chiapas, Grijalva-Usumacinta and Yucatán Este (see Chapter 7).

While national maps of rainfall distribution, with different return periods, are easily available from CENAPRED's website and its publications, hydrological information does not appear to be as accessible. CONAGUA has a geo-database containing information on water tables in the country; however, series of river discharge are not part of this database, which concentrates more on describing water resources and their uses. Nevertheless, a national map ranking the various river basins has been developed by CENAPRED, and CONAGUA's analysis of flooding events provides some information on the hydrological characteristics of the floods occurring in Mexico as well as their extension. These two institutions are currently collaborating to develop the National Flood Atlas, together with the Mexican Institute of Water Technology (*Instituto Mexicano de Tecnología del Agua*, IMTA) and UNAM. This work will gather all hydrometeorological information together and make it available for the development of flood risk assessment at the local level. It is hoped that this ambitious work will result in gathering hydrological information and making a sufficient amount of it available so that flood risk assessment can be developed at a large scale.

Seismological monitoring

The National Seismological Service (*Sistema Sismológico Nacional*, SSN), founded in 1910 and part of UNAM, operates Mexico's national seismological network, which comprises 36 broadband stations covering the country and 19 stations in the Valley of Mexico. Several institutions at the state level also have their own networks, such as universities (Colima), research centres (Sinaloa, Veracruz), civil protection (Chiapas) or even NGOs or private institutions (CIRES in Guerrero, Oaxaca – see Chapter 5). Considering the lack of coverage, co-ordination and data exchange between these networks, along with the ageing of the infrastructure (20% of the stations have exceeded their life cycle), the seismic network in Mexico does not seem to be aligned with the level of seismic risk in the country.

The situation is quite similar regarding the network of accelerometric stations. These stations measure soil acceleration, which is the main cause of damage, whereas the seismographic network registers the seismic waves. The Institute of Engineering of UNAM in charge of this accelerometric network is also working with an ageing and fragmented network, which does not fully cover the country and its high risk areas.

A proposal for modernising the network has been developed by UNAM and includes: *i)* the establishment of 1 seismic station in each of the 8 states that do not yet have one; *ii)* 1 seismic and at least 1 accelerometric station in each of the 22 cities with more than 300 000 inhabitants that are not yet equipped with such stations; *iii)* the creation of 3 sub-networks in the earthquake-prone states of Jalisco, Michoacán and Colima; and *iv)* the strengthening of the accelerometric network around Mexico City. It is important to bear in mind that the seismic network, as the hydrometeorological network, is not only crucial for risk assessment, which is mostly a medium to long-term planning tool – even though it is becoming more and more dynamic. This network is also fundamental for real time monitoring, early warning and emergency preparedness and response, and is essential for saving lives (see Chapter 4).

The SSN has recorded more than 100 years of seismic data and a very high-quality database with seismic data since 1958, the *Base Mexicana de Datos de Sismos Fuertes*, which contains more than 14 000 entries generated by 1 500 earthquakes. This key historical data set could be copied and stored on servers in a seismically safe location. The SSN has analysed the data and mapped out epicentres of every earthquake that has taken place over the past 100+ years. It has also produced analysis and maps of earthquake intensities based on the Mercalli scale as well as the return period. All of these hazard data, information and analysis are available on CENAPRED's website and in its publications.

CFE developed a map of seismic hazards in Mexico in the second edition of the volume for Seismic Design included in its Manual on Civil Works Designing published in 1993. This map, based on the database of major earthquakes, divides the country into four seismic zones (Figure 1.6 on Chapter 1), depending on both the seismicity and the expected ground accelerations, the main cause of damages to buildings and infrastructures. The Manual was updated in 2008 with more precise acceleration maps for various return periods, which is still the reference today. It is available in the public domain and widely utilised in the country. The joint UNAM-CFE-CENAPRED programme on seismic risk in Mexico also developed precise acceleration maps with various return periods in 1996, available in CENAPRED publications.

Exposure and vulnerability analysis

Once natural hazards have been characterised, analysed and mapped, the information can be cross-referenced with information on population and asset exposure, and their vulnerability. Providing this information for risk assessment in a standard format across regions is a common challenge for civil protection services in OECD countries, as it requires combining multiple geographic and socio-economic datasets.

The National Institute of Statistics and Geography (*Instituto Nacional de Estadística y Geografía*, INEGI) is the official provider of geo-referenced information from the national to local levels. INEGI regularly conducts census and population surveys, and provides data and information about land use, population, demographic trends, household incomes, etc. Its system for state and municipal databases (*Sistema Estatal y Municipal de Bases de Datos*, SIMBAD) provides detailed statistical information through an online portal. Furthermore, the National Population Council (*Consejo Nacional de Población*, CONAPO) has compiled many of these socio-economic data at the neighbourhood level of all municipalities to develop the “Marginalisation Index”,[1] which may serve as a proxy for social vulnerability. Maps of the Marginalisation Index are available for all of the municipalities on the CONAPO website.

CENAPRED has also developed and mapped a specific “Index of Social Vulnerability” combining INEGI socio-economic information with results from household surveys related to risk knowledge. The survey gathers information from households across the country at the municipal level with questions about their perceptions of risks and their knowledge of prevention and institutional capacities.

Sectoral agencies and ministries at the federal level map the vulnerabilities of infrastructure under their authority and provide this information for the development of risk assessment. Following earthquakes of a magnitude of 5.0 or higher on the Richter scale, CONAGUA and CFE conduct inspections of dams located close to the epicentre to look for structural damages. Maps of the location of the major dams in the country are made available by CONAGUA, as well as their date of construction – which is a good indicator as ageing infrastructures are more vulnerable. Data on the actual condition of these infrastructures, however, appears to be missing, whereas some countries have begun to make it available for free online.

The Ministry of Communication and Transport (*Secretaría de Comunicaciones y Transportes*, SCT) provides statistics about transport infrastructures, including roads, bridges and harbours, and has developed an atlas for the sector. The SCT has a specific strategy for mapping development at the national level with the objective of making maps of infrastructures in the country available on a public GIS, but this has not yet been implemented. Again, bridges and roads are frequently inspected by the SCT, but information on their vulnerability status is not available. In addition, many of these infrastructures are in the hands of the states, which have their own statistics and databases regarding their infrastructures.

PEMEX has developed a sophisticated database called @ditpemex as well as an Atlas of Strategic Infrastructures (AIE-PEMEX), which includes detailed information on the location of oil sector infrastructure, exposure to natural hazards and vulnerability. The PEMEX Control and Data Acquisition System allows it to monitor pipeline operations throughout the country. This information is not available to the general public, however, as it is classified for reasons of national security. PEMEX can share some of the information with state governments through specific confidentiality agreements as well as with state institutions, although there is not currently such a confidentiality agreement with CENAPRED that would enable it to be used for the National Risk Atlas.

The Ministry of Public Education has developed a publicly available online platform called GEO-SEP, which categorises educational facilities according to level of instruction and physical location – both for public and private educational facilities. A strength of this system is that it provides information about schools located in hazardous zone for the System for the Analysis and Visualization of Risk Scenarios (*Sistema de Análisis y*

Visualización de Escenarios de Riesgo, SAVER) (Box 3.3). The information was gathered through an Educational Infrastructure Survey issued to school principals at national and local institutions of education in 2007.

Finally, a recent initiative from FONDEN could facilitate the development and availability of data on infrastructure exposure and vulnerability. One of FONDEN's strategic objectives is to develop the insurance coverage for state and federal infrastructure (see Chapter 6). To this end, it started to finance the development of infrastructure inventories at the state level in 2010, as these are useful for obtaining insurance coverage. For instance, in 2011 it financed an analysis of the inventory of infrastructures in the state of Sonora and their vulnerability, covering the sectors of transport, water, health and urban areas.

Gathering data on disaster losses is also necessary to develop risk assessment, and especially for conducting probabilistic modelling of potential future losses based on hazard frequency. While the number of deaths due to an event is often available, other measures such as the number of affected people, the number of injured or the number of displaced people are not. For economic losses, this is even more challenging, as there are direct and indirect losses. Direct losses refer to damages to buildings, infrastructure, natural resources and services and other assets. Indirect losses are linked to foregone business activity or supply chain interruption, for example. In Mexico, efforts have been made to gather losses data through the yearly publication of the socio-economic impacts of disasters performed by CENAPRED since 2001. While this publication presents a consistent methodology for calculating direct and indirect losses, it does not receive sufficient data about the latter to publish verifiable statistics.

Risk assessment tools and methodologies

CENAPRED is the lead governmental agency for the development of disaster risk assessment. It has published clear methodological guidelines for developing risk assessments at state and municipal level, and more specifically on how to produce risk atlases. These guidelines provide concrete instructions about the information needed to conduct risk assessment, such as the type of data to use, where to find it and what tools are appropriate to use for mapping (Table 3.1). Furthermore, CENAPRED makes all of its data for the development of risk assessment available and also provides technical support to institutions that are required to conduct one.

Table 3.1. **List of CENAPRED guides for the design of state and municipal risk atlases (2006)**

Basic Guide for the Creation of State and Municipal Hazard and Risk Atlases (Basic Concepts on Dangers, Risks and Their Geographic Representation)
Basic Guide for the Creation of State and Municipal Hazard and Risk Atlases (Geological Phenomena)
Basic Guide for the Creation of State and Municipal Hazard and Risk Atlases (Hydrometeorological Phenomena)
Basic Guide for the Creation of State and Municipal Hazard and Risk Atlases (Chemical Phenomena)
Practical Guide on Chemical Risks (Food)
Practical Guide on Chemical Risks (Pollution)
Practical Guide on Chemical Risks (Epidemics)
Practical Guide on Chemical Risks (Plague)
Basic Guide for the Creation of State and Municipal Hazard and Risk Atlases (Assessment of Physical and Social Vulnerability)

Source: CENAPRED website, *www.cenapred.unam.mx/es*, last consulted in September 2012.

Development of a national risk atlas

Since the publication of the first National Risk Atlas in 1991, and the updated version in 2001, major progress has been made in the development of risk assessment in Mexico. The National Risk Atlas of Mexico, available online at *www.atlasnacionalderiesgos.gob.mx*, is in fact a portal that includes all available risk information on the country: from hazard analysis to vulnerability mapping, all the various national maps are available for a series of hazards on an evolving GIS-based platform. It includes information on economic and human losses and metadata describing the assets at risk. The development of this innovative tool has stimulated the risk assessment process countrywide, as its objective is to gather all of the risk atlases that are developed at state and municipal levels. The integration of atlases from different levels has not yet reached the point, however, where the local level automatically informs the next level above. The key to attaining this objective is to ensure that all entities providing input, from federal to state and municipal levels, use the same methodology and data standards. This requires multi-disciplinary collaborations among many scientific communities and organisations. CENAPRED, as well as the scientific advisory committees (Box. 3.1), could be inspired by international examples where multi-disciplinary data and expertise is combined together in a flexible partnership to support risk assessment (Box.3.2).

Box. 3.2. **Leveraging scientific collaborations: The Natural Hazards Partnership in the United Kingdom**

In the United Kingdom, the Natural Hazards Partnership (NHP) provides information, research and analysis on natural hazards for the development of more effective policies, communications and services for response to civil contingencies, government planners and the first responder community across the United Kingdom. It focuses on natural hazards that disrupt the normal activities of the country's communities or damage its environmental services. The NHP also provides the international community with a model for cross-government hazard management based on a platform of world-class environmental sciences.

The NHP brings together expertise from across leading public sector agencies including: the Environment Agency, Flood Forecasting Centre, Health Protection Agency, Health & Safety Laboratory, Met Office, Natural Environment Research Council, British Geological Survey, Centre for Ecology and Hydrology, National Centre for Atmospheric Science, National Oceanography Centre, Ordnance Survey, Scottish Environment Protection Agency, and the UK Space Agency.

The NHP also contributes towards the Hazard Impact Model (HIM), which combines data and expertise from partners to identify areas and assets which are most vulnerable to a particular hazard. This is intended to help prioritise where to deploy "responder" services, as well as to identify when and where to issue hazard alert warnings.

The NHP also contributes to the National Risk Assessment (NRA) process by providing recommendations on: scientific overview for natural hazards and advising on any new risks that may need inclusion, supplementing current advice on scenarios for existing risks identifying NRA risks that could be linked and could occur concurrently.

Source: OECD (2012), "Disaster Risk Assessment and Risk Financing, A G20/OECD Methodological Framework", OECD, Paris, *www.oecd.org/finance/insurance/G20disasterriskmanagement.pdf.*

SAVER is another tool developed by CENAPRED which is password protected and available to civil protection stakeholders (Box 3.3). It combines information from several sources into one single map with different layers, including all of the critical infrastructures of the country – with the exception of PEMEX. It can provide decision makers with a clear view of the people and resources that could suffer damage when a hazardous event occurs.

Box 3.3. **The SAVER system**

The System for the Analysis and Visualisation of Risk Scenarios (SAVER) is a tool that civil protection authorities in Mexico use to include information from risk scenarios in policy making. CENAPRED created the system to comprise strategic risk information and data from several sources. SAVER integrates risk maps and geo-referenced information on the vulnerability of hospitals, schools, public infrastructure and population into one single database. Currently, its capacity to create risk scenarios is one of its most important characteristics.

SAVER is the result of a horizontal and vertical effort across organisations throughout the country. Ministries such as Social Development, Communications and Transport, and Public Education provided valuable data and information on their infrastructure in order to feed the system's database. Currently, the system comprises 700 hazard layers and socio-economic and vulnerability data. In 2011, the development of SAVER 2.0 increased its capacities allowing the database to be fed online.

The system provides public entities in charge of social, territorial and human development with information about potential damages and affected populations based on historical occurrence records. SAVER 3.0 will integrate data from all 32 state risk atlases. Currently, states such as Jalisco and Chiapas have already provided their databases in support of the system.

Source: Information provided by CENAPRED and the CGPC.

The National Risk Atlas, however, is not conceived as the national risk assessments developed by many OECD countries in which major hazard and threat scenarios are assessed according to common criteria (in terms of their likelihood and impact) to rank them for the purpose of informing decisions about investments in capabilities planning (Box 3.4).

Box. 3.4. **The National Risk Assessment of the Netherlands**

Since 2007, the Netherlands National Safety and Security Strategy has put in put in place an holistic approach to risk management based on preserving five vital interests for the country: territorial, physical, economic and ecological safety, and social and political stability. The main objective of the Netherlands National Risk Assessment (NRA) is to prioritise risks that the Netherlands should prepare for, and develop capabilities to handle civil contingencies accordingly.

The NRA consists of two parts: risk analysis and capabilities analysis. Risk analysis is managed by a network of independent experts who operate under the leadership of the steering committee of the National Security Committee (drawn from ministries, businesses and intelligence services). The experts develop risk scenarios and assign scores for their likelihood and impact according to ten criteria related to vital safety and security interests. Initial ranking results are given according to low and high estimates. The impact assessment is used to analyse the capabilities needed to prevent and/or mitigate each type of risk. The time horizon for NRA scenarios is five years; however, analyses and the corresponding capabilities needed can be reassessed frequently by the expert groups according to new information or changing conditions. A report summarising the results of the NRA is sent each year to Parliament; it is also published on official websites and sent to relevant stakeholders.

Source: Dutch Ministry of Interior and Kingdom Relations (2009), "Working with Scenarios, Risk Assessment and Capabilities in the National Safety and Security Strategy of the Netherlands", Directorate-General for Public Safety and Security.

Risk atlas initiatives at local levels

Risk assessment at the state level

The federal government has placed a high priority on the need for states and municipalities to develop risk atlases so that they can be incorporated into the National Risk Atlas. Considering the important disparities in terms of human and economic resources at the local level, federal entities play a major role homogenising and encouraging the development of states' risk atlases. The federal entities' main challenge is to help states move from atlases that were merely an inventory of hazards to including a dimension of vulnerabilities and hazard exposure. For this purpose, the federal government has put two major mechanisms in place: *i)* strong technical support from CENAPRED; and *ii)* solid economic support from FOPREDEN.

CENAPRED, in addition to its guidelines, provides various forms of technical assistance for the development of risk assessment: from training inspectors to verification of GIS. FOPREDEN constitutes the most important financing mechanism for the elaboration of risk atlases at the state level. Since 2004, FOPREDEN has financed 23 projects related to the elaboration, extension or updating of risk atlases for a total of USD 11 million (FOPREDEN data, 2011). Since 2011, with the introduction new operational rules at FOPREDEN, states must first possess a risk atlas (or be in the process of developing one) to be eligible for funding for disaster risk prevention projects. If a state does not have a risk atlas, FOPREDEN can finance up to 90% of its development cost as its first project. FOPREDEN and CENAPRED reflect a well-articulated system of inter-institutional co-operation through which 21 of the 32 states have received federal technical assistance for the development of risk atlases.

Between 1993 and 2004, only 9 out of 32 states (including the Federal District) had developed a risk atlas, but from 2004 (the effective year of creation of FOPREDEN) to 2009, 17 states developed risk atlases, which shows the high level of efficiency of the federal incentives to support the development of risk atlases. Civil protection stakeholders have a heightened awareness of the importance and utility of risk assessment, and a better understanding of the difference between hazard analysis and risk assessment. Notwithstanding this awareness, civil protection stakeholders at the state and municipal levels require federal resources to support the costs of producing high-quality risk atlases.

In addition to the tools developed at the federal level, some states have developed their own risk information systems. The state of Tabasco developed a System of Geographic Information (SIGET) which allows the population to access the local risk map, among other data. The state of Jalisco has developed a similar tool, the Online System of State Territorial Information (SITEL), which enables users to access risk information at the state or municipality level. The risk maps available show layers of information, such as flood zones layered over infrastructure. Both the SIGET and the SITEL are open information sources available to the public. In the state of Chiapas, the Integrated System of Civil Protection provides statistics and information to the units of civil protection of the state, but this platform is not open to the public. The state of Tamaulipas is in the process of developing these same capacities.

Table 3.2. **Risk atlases by state**

State	Risk Atlas	Year of creation	% of municipalities included	Type of risks			Federal financing	Federal technical support	Public access	Updated
				Earthquake	Hurricane	Flood				
Aguascalientes	Yes	1993	91-100%	●	X	●●	10%	No	No	Yes
Baja California	Yes	2005	91-100%	●●●	●	●●●	70%	No	No	Yes
Baja California Sur	No									
Campeche	Yes	2004	91-100%	●	●	●	10%	Yes	No	No
Chiapas	Yes	2007	10%	●●●	●●●	●●●	61-70%	Yes	Yes	Yes
Chihuahua	Yes	2006	10%	●	●	●	10%	Yes	No	Yes
Coahuila	Yes	N/A	91-100%	●	●	●	21-30%	Yes	No	Yes
Colima	Yes	2008	91-100%	X	●●	●	10%	No	No	N/A
Federal District	Yes	2007	91-100%	●●●	X	●●●	81-90%	No	No	Yes (2008)
Durango	In progress									
Guanajuato	Yes	1994	91-100%	●	●	●	71-80%	Yes	Yes	Yes (2006)
Guerrero	Yes	2006	91-100%	●	●●	●	11-20%	Yes	No	No
Hidalgo	Yes	2008	91-100%	●●●	X	●●●	51-60%	Yes	No	No
Jalisco	Yes	2007	91-100%	●●●	●●●	●●●	90-100%	Yes	Yes	Yes
Mexico[1]	Yes	1994	81-90%	●●	●	●●●	No	Yes	Yes	Yes (2012)
Michoacán	Yes	2004	91-100%	●	●	●●	51-60%	Yes	Yes	Yes
Morelos	Yes	2008	91-100%	●●	X	●●	61-70%	Yes	Yes	No
Nayarit	Yes	2009	91-100%	●	●	●	90%	Yes	No	Yes
Nuevo León	Yes	1999	10%	●	●●	X	10%	No	Yes	Yes (2001)
Oaxaca	Yes	2002	91-100%	●	●	●	31-40%	Yes	Yes	No
Puebla	Yes	1999	91-100%	●	●	●	21-30%	No	No	Yes (2005)
Querétaro	Yes	2008	91-100%	●●●	X	●●●	81-90%	Yes	No	Yes
Quintana Roo	In progress	N/A	10%	X	X	X	10%	No	No	No
San Luis Potosí	Yes	2005	91-100%	●●	●●●	●●●	81-90%	Yes	Yes	Yes
Sinaloa	In progress									
Sonora	Yes	2007	91-100%	●●	●	●	91-100%	Yes	Yes	Yes
Tabasco	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	In progress
Tamaulipas	Yes	2001	81-90%	●●	●●●	●●●	71-80%	Yes	Yes	Yes
Tlaxcala	Yes	2005	91-100%	●	X	X	41-50%	Yes	Yes	Yes (2008)
Veracruz	Yes	2000	91-100%	●●	●●●	●●●	81-90%	Yes	Yes	Yes
Yucatán	Yes	2003	91-100%	●	●●	●	21-30%	Yes	No	No
Zacatecas	Yes	2008	91-100%	X	X	●	10%	Yes	No	Yes

●●● Advanced

●● Medium

● Basic

X Not included

Note: 1. Information updated by the state of Mexico.

Source: Based on CENAPRED's National Risk Atlas, *www.atlasnacionalderiesgos.gob.mx*, accessed in May 2012.

Rapid changes to populations and industrial development imply the need for periodic updates to risk atlases, otherwise inaccuracies could mislead policy decisions. To Mexico's credit, the frequency of updates to risk atlases has accelerated and has been facilitated by the elaboration of CENAPRED's guidelines, which have become an accepted standard for quality assurance. Despite this, disparities in quality persist between different state risk atlases, mainly due to the capability of states to finance updates. Several states such as Mexico, Aguascalientes and Guanajuato created their risk atlases in 1993-94, and only updated them more than 12 years later, illustrating the difficulty to regularly update such a sophisticated technical tool. In general, risk atlases have been updated once every eight years, and usually with the support of a federal subsidy to defray costs. Finally, public access to the risk atlases remains a challenge for many states. Nearly half the federal states' risk atlases are not accessible via the Internet, which undermines one of their main uses – to inform the public and businesses about risks to which they are exposed.

Risk atlases at the municipal level

While the uptake of risk atlases amongst states has grown rapidly with support from FOPREDEN, the geographic scale is too broad to accurately incorporate risks at the municipal level. Municipalities are among the main potential end users of risk atlases. First, risk atlases can aid local civil protection services to design emergency plans. Moreover, since municipalities in Mexico have competence for establishing building codes and land-use zoning plans, risk atlases could be leveraged to ensure these essential tools are based on a scientific understanding of risks in specific locations. The development of risk atlases at the municipal level, however, has been slow across Mexico. Many of the 2 440 municipalities do not give priority to the development of a risk atlas, due to the time and cost of producing a high-quality product. A view often expressed by municipal civil protection stakeholders is that mayors (who are limited to one, non-renewable term in Mexico), prefer to focus on projects that can be accomplished within their three-year term in office. Projects such as building infrastructure, for example, leave a more visible impact in the eyes of the electorate than a risk atlas.

To address these obstacles, the federal government has put in place specific programmes designed to subsidise the cost of developing risk atlases in the most vulnerable municipalities. SEDESOL plays a significant role in encouraging municipalities to develop prevention strategies, especially through the elaboration of risk atlases. In 2011, it launched the Risk Prevention for Human Settlements programme (PRAH, see Chapter 5), which focuses on risk reduction through discouraging the use of land in high risk areas. Eligibility is conditioned on the existence of a risk atlas, which is why the first PRAH projects at the municipal level support the development of risk atlases. The cost sharing between federal and municipal levels is 65-35%, which still represents an important investment for the budget of some municipalities. Federal government support is limited to MXN 3.5 million per atlas, covering such expenses as research, elaboration and updates.

The PRAH programme classifies municipalities into high or very high risk zones. To date, 322 municipalities have been classified as high risk and 295 as very high risk (SEDESOL, 2012b). Based on this classification, priorities are established to finance prevention measures. Only 85 municipal risk atlases have been developed under this programme in high and very high risk municipalities, however, of which just 30 are publicly available (including Mexicali, Cancun, Cozumel, etc.).

While the quantity of municipal risk atlases elaborated is quite low, the risk atlases publicly available financed by SEDESOL in the last years are high-quality products, with a risk dimension (hazard, exposure and vulnerability) and well-developed methodology based on CENAPRED's guidelines. Nevertheless, making them publicly accessible via the Internet is highly problematic, since the file size is not suitable for an ordinary Internet connection, and the full version is only available in PDF format.

Even though SEDESOL aimed to accelerate the programme with the intention to finance 125 municipal risk atlases per year, the budget of its PRAH programme was reduced by 75% in 2012 compared to 2011, thus calling for other federal policies to support the development of risk assessment at the municipal level.

Conclusion

SINAPROC demonstrates a strong commitment to evidence-based risk management policies and has undertaken multiple efforts at every level to gain a better scientific understanding of natural hazards, to map the exposure of populations and valuable assets to those hazards, and to model their vulnerability.

Continued efforts are needed to integrate risk assessment across levels of government. The SAVER tool is an appropriate approach to strengthening these capacities, and justifies a continual effort from the ministries and institutions of the three levels of government to keep the underlying databases up-to-date. Together with different tools being developed by the federal government, SAVER has been able to support the integrated risk management approach in Mexico. Its continual development needs to be perceived as a joint effort with common benefits, focusing on ensuring the safety and resilience of the population and infrastructure.

Linkages need to be reinforced between the innovative tools developed throughout SINAPROC (risk atlases, SAVER, etc.) and disaster risk reduction measures such as land use, urban development plans and risk mitigation infrastructures. This should take top priority as states begin to implement the 2012 General Law for Civil Protection, which requires the development of risk atlases to inform land-use plans.

Recommendations

- Facilitate linkages across risk atlases at all levels, and develop synergies between SAVER and R-FONDEN.
- Harmonise federal support for the development of risk atlases at sub-national levels.
- Strengthen financial and technical support of municipal risk atlases.
- Take stronger account of potential tsunamis in risk atlases.
- Develop the National Atlas on Climate Change Impacts and Vulnerability.
- Reinforce engagement of the private sector in risk assessment processes at all levels.

Note

1. The Marginalisation Index is a composite index integrating the illiteracy rate, education, access to sanitation, water and electricity, number of people per household, quality of housing and access to a refrigerator.

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