Disaster Risk Assessment in Baja California, Mexico

A Comprehensive State Situation Analysis

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Image on cover page: Meeting of the State Civil Protection Council April 7, 2010

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Acronyms and Abbreviations

API	Integral Port Administration	Administración Integral del Puerto
APRE	Risk Evaluation Action Plan	Plan de Acción para Evaluación de Riesgo
B.C.	Baja California	Baja California
C-4	Command Center	Centro de Control, Comando, Comunicación y Cómputo
CALTECH	California Institute of Technology	California Institute of Technology
CAPUFE	Federal Roads and Bridges and Related Services Revenue	Caminos y Puentes Federales de Ingresos y Servicios Conexos
CENACE	Energy Control National Center	Centro Nacional de Control de Energía
CENAPRED	National Center for Disaster Prevention	Centro Nacional de Prevención de Desastres
CESPT	State Public Service Commission of Tijuana (Tijuana Water Supply System)	Comisión Estatal de Servicios Públicos de Tijuana
CESPE	State Public Service Commission of Ensena da (Ensenada Water Supply System)	Comisión Estatal de Servicios Públicos de Ensenada
CIBNOR	Northwest Biological Research Center of Northwest SC.	Centro de Investigaciones Biológicas del Noroeste S.C.
CIC	Civil Engineers College Association	Asociación de Colegios de Ingenieros Civiles
CICESE	Scientific Research Center and Higher Education of Ensenada	Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California
CFE	Federal Energy Commission	Comisión Federal de Electricidad
COLEF	The North Border Institute	El Colegio de la Frontera Norte
CONAGUA	National Water Commission	Comisión Nacional del Agua
CONAFOR	National Forestry Commission	Comisión Nacional Forestal
CONACyT	National Council for Science and Technology	Consejo Nacional de Ciencia y Tecnología
CONANP	National Commission of Protected Natural Areas	Comisión Nacional de Áreas Naturales Protegidas
DAU	Urban Administration Office	Departamento de Administración Urbana
DDU	Urban Development Office	Oficina de Desarrollo Urbano
DEPC	State Civil Protection Office	Dirección Estatal de Protección Civil
DIF	Integral Family Development	Desarrollo Integral de la Familia
DMPC	Tijuana Civil Protection Office	Dirección Municipal de Protección Civil de Tijuana
DMPCE	Ensenada Civil Protection Office	Dirección Municipal de Protección Civil de Ensenada
DMPCM	Mexicali Civil Protection Office	Dirección Municipal de Protección Civil de Mexicali
DMPCR	Playas de Rosarito Civil Protection Office	Dirección Municipal de Protección Civil de Playas de Rosarito

DSPM	Public Security Municipal Office	Oficina Municipal de Seguridad Pública
DOSP	Works and Public Services Office	Dirección de Obras y Servicios Públicos
DRR	Disaster Risk Reduction	Disaster Risk Reduction
DPC BC	Baja California Civil Protection Office	Dirección de Protección Civil del Estado de Baja California
DPCT	Tijuana Civil Protection Office	Dirección de Protección Civil de Tijuana
DWP	Disaster Watch Project	Disaster Watch Project
ENSO	El Niño Southern Oscillation	El Niño Southern Oscillation
FOPREDEN	National Fund for Natural Disasters Prevention	Fondo para la Prevención de Desastres Naturales
GobB.C.	Baja California State Government	Gobierno del Estado de Baja California
GEOS	Magazine of the Geophysics Union	Revista de la Unión Geofísica Mexicana
GIS	Geographic Information System	Geographic Information System
GRIP	Global Risk Identification Programme	Global Risk Identification Programme
IMIP	Municipal Planning and Research Institute	Instituto Municipal de Investigación y Planeación de Mexicali y de Ensenada
IMPLAN	Municipal Planning Institute	Instituto Municipal de Planeación Tijuana
IDNDR	International Decade for Natural Disaster Reduction	International Decade for Natural Disaster Reduction
INEGI	National Institute of Statistic, Geography and Informatics	Instituto Nacional de Estadística, Geografía e Informática
IPCC	Intergovernmental Panel on Climate Change	Intergovernmental Panel on Climate Change
MT	Tijuana Municipality	Municipio de Tijuana
NASA	National Aeronautic and Space Administration	National Aeronautic and Space Administration
NAVY	2nd Navy Zone	2a. Zona Naval
MODIS	Moderate Resolution Imaging Spectroradiometer	Moderate Resolution Imaging Spectroradiometer
OME	Administration State Office	Oficina de la Administración del Estado
PEACCBC	State Action Programme for Climate Change	Programa Estatal de Acción ante el Cambio Climático
PEMEX	Mexican Petroleum	Petróleos Mexicanos
PFP	Federal Police	Policía Federal Preventiva
RADIUS	Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters	Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters
REDESClim	The Hydro-meteorological Disasters and Climate Network	Red de Desastres Hidro-meteorológicos y Climáticos
RESNOM	Northwest of Mexico Seismic Network	Red Sísmica del Noroeste de México
SAHOPE	Secretary of Human Settlements and Public Works	Secretaria de Asentamientos Humanos Y Obras Publicas del Estado
SEDENA	Ministry of Defense	Secretaría de la Defensa Nacional
SEDESOL	Social Development Secretary	Secretaría de Desarrollo Social
SEE	State School System	Sistema Educativo Estatal

SEMAR	National Navy	Secretaría de Marina
SIERA	Systematic Inventory and Evaluation for Risk Assessment	Systematic Inventory and Evaluation for Risk Assessment
SINAPROC	National Civil Protection System	Sistema Nacional de Protección Civil
SGG	Government General Secretariat	Secretaría General de Gobierno
SOI	Southern Oscillation Index	Southern Oscillation Index
SPA	Environmental Protection Department	Secretaría de Protección Ambiental
SMN	National Weather Service	Servicio Meteorológico Nacional
TELNOR	Northwest telephone company	Teléfonos del Noroeste
UABC	Baja California Autonomous State University	Universidad Autónoma de Baja California
UACH	Chihuahua Autonomous University	Universidad Autónoma de Chihuahua
UANL	Nuevo Leon University	Universidad Autónoma de Nuevo León
UMPC	Mexicali Civil Protection Unit	Unidad Municipal de Protección Civil
UNESCO	United Nations Educational, Scientific and Cultural Organization	Organización de las Naciones Unidas para la Educacíon, la Ciencia y la Cultura

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Executive Summary

This report presents the implementation and results of the evaluation of the current situation of risk assessment in Baja California State, Mexico and the identification of the necessary actions to achieve a comprehensive understanding of the risks associated to natural events.

The project performs a systematic inventory of the currently available risk information in the State and assesses its validity using the SIERA (Systematic Inventory and Evaluation for Risk Assessment) methodology developed by the Global Risk Identification Programme (GRIP) hosted by the United Nations Development Programme (UNDP). Through this process, the project clearly identifies what is missing to complete the risk assessment of the State and prepares an action plan to implement it. The SIERA methodology allows for a comprehensive assessment of the current situation that includes not only the identification of existing information on disaster risk but also the technical and institutional capacities in addition to the legal, political and institutional frameworks within which these activities are performed. The involvement of authorities, institutions and representatives of different sectors of society in the process of identifying the information and capabilities, helps to validate the information obtained and also, creates awareness among these actors on the importance of understanding the risk of disasters in the State, to implement effective measures to reduce it to acceptable levels.

The resulting plan is based on the comparison between the existing information and capabilities that have been identified and the comprehensive list provided by the SIERA methodology of all the information and capabilities needed to achieve a clear understanding of the State's risks.

It is expected that the findings and recommendations reported in this document provide the basis for the implementation of the State's risk assessment that will provide a comprehensive understanding of disaster risk in Baja California, its causes and geographic distribution, its potential impact on the population and its development. This understanding, and the identification of effective mitigation options, will help to prepare an effective, evidence-based Disaster Risk Reduction and Management Strategy for Baja California State.

This report is divided in five chapters:
Chapter 1 describes: introduction to the project, goals, objectives, used methodology, and the expected outcome of its implementation.

Chapter 2 describes the implementation of the methodology with the local necessary adaptations to the conditions in academic and government sectors. The implementation follows 3 steps: 1) identification and inventory collection, 2) detailed review and evaluation and 3) overall state situation.

Chapter 3 presents a detailed review and assessment oaboutf the risk information risk in Baja California: risk analysis studies (risk, hazard and disasters), available data and their quality; methodologies and tools; skills and experts ability, institutional capacity, and risk the State risk management system in the State. Based on this information, the major hazards identified in the State are: earthquakes, floods, landslides, droughts, Santa Ana winds, and wildfires. Each hazard is presented differently in each municipality. The only risk assessment studies important for decision making found in the State, are for earthquakes and floods, which have and there is good information for improvement. The information available ofto the rest of hazards: landslides, droughts, Santa Ana winds;, is still scarce. However, improvement is expected to improve based on the published results of this project.

Chapter 4 presents a Baja California current situation analysis obtained an analysis of the current situation of Baja California from the evaluation in cChapter 3. SuchThe analysis presents is a detailed description of the current situation,: goals and, challenges, strengths and weaknesses in the State, and needsthe needs of external support for risk assessment and management in the State. Among the problems identified for the implementation of activities and studies to understand the State risk of the State, is the lack of support from the government institutions responsible for making proposals, and the lack of adequate funding. Being both the , both seems to be the most important things to solve.

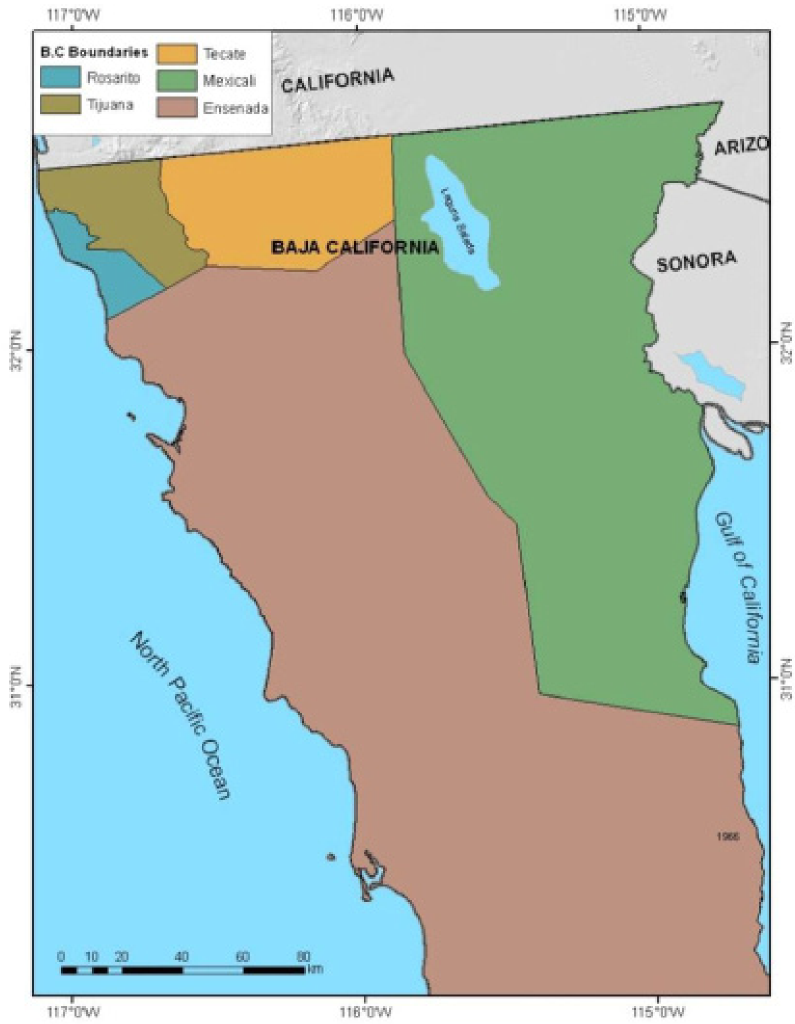
Chapter 5 presents an Action Plan with recommendations to implement the State Risk Assessment in Baja California. Recommendations are provided of the methodological and institutional frameworks needed to develop a Risk Reduction Strategy that properly reflects local realities. It is recommended to implement a Risk Information System in Baja California (e-library) using the informa¬tion collected and validated by this projectThe implementation is recommended of the initial phase of a Risk Information System in Baja California (e-library) using the information collected and validated by this project.

1. Introduction

1.1 Background: SIERA for Baja California

Baja California (B.C.) is located at the Northwest (NW) of Mexico in the Northern part of the Peninsula of B.C., geographically, between the 114° 30'W and 117° 10'W and between the 28° 00'N and 32° 43'N parallels (SGG and DPC BC, 2003). It is a State of the Republic of Mexico, and is divided in five municipalities: Mexicali, Ensenada, Tijuana, Tecate, and Playas de Rosarito (Figure 1). The State has an area of around 72,000 km^2 and a population of 3.1 million in 2009. Tijuana is the largest municipality in population, accounting for 50.6% of the State's total population.

Figure 1: Cities of Baja California, their boundaries and location



Baja California is likely to experience different hazards due to natural phenomena being the most important: earthquakes, floods, landslides, droughts and Santa Ana winds. Chapter 3 describes the disaster profile of these hazards.

In search for solutions to mitigate disasters caused by these hazards, many studies have been conducted by different institutions in each municipality. However, there is not a complete risk assessment in the State. There is a considerable amount of research and information on hazards and the risk associated with these. These studies include information on methodologies and data used to analyze risk for some hazards. Most of the information is scattered in different academic institutions, government and private sector and in some cases, the existence of such information is unknown, therefore, it is not used and that leads to the duplication of studies.

To complete risk assessment in the State, a methodology should be implemented to evaluate the current situation in the context of risk the State's risk assessment, in order to have a good diagnosis of what is done, what is needed and to prepare an action plan to implement the evaluation and create a Disaster Risk Reduction Strategy (DRR).

It is necessary to create a DRR in B.C., to identify effective disaster mitigation options, to develop management guidelines, which guide, coordinate and ensure the achievement of concrete and tangible goals in the disaster risk management process of B.C., with the firm intention to increase public safety and to protect the State development process.

This project implemented the methodology Systematic Inventory and Evaluation for Risk Assessment (SIERA), designed to assess the ability of a region or country. It was developed by the Global Risk Identification Programme of the United Nations (GRIP), which is based on a systematic inventory of the current available risk information in Baja California and its validation for risk assessment throughout the State.

SIERA methodology in addition to a systematic inventory of what exists in natural risks facilitates the evaluation of quality and validity of the existing information. The validated information will eventually be integrated into an electronic library that will be the basis of a Risk Information System of the State, which shall make this information available to all potential users.

1.2 General Objectives

a) Understand the current situation of the State of B.C. in terms of risk assessment.

b) Create recommendations for the imple mentation of a Risk Assessment Action Plan, and

c) Create recommendations for the devel opment of a Disaster Risk Reduction Strategy for the State.

Particular Objectives

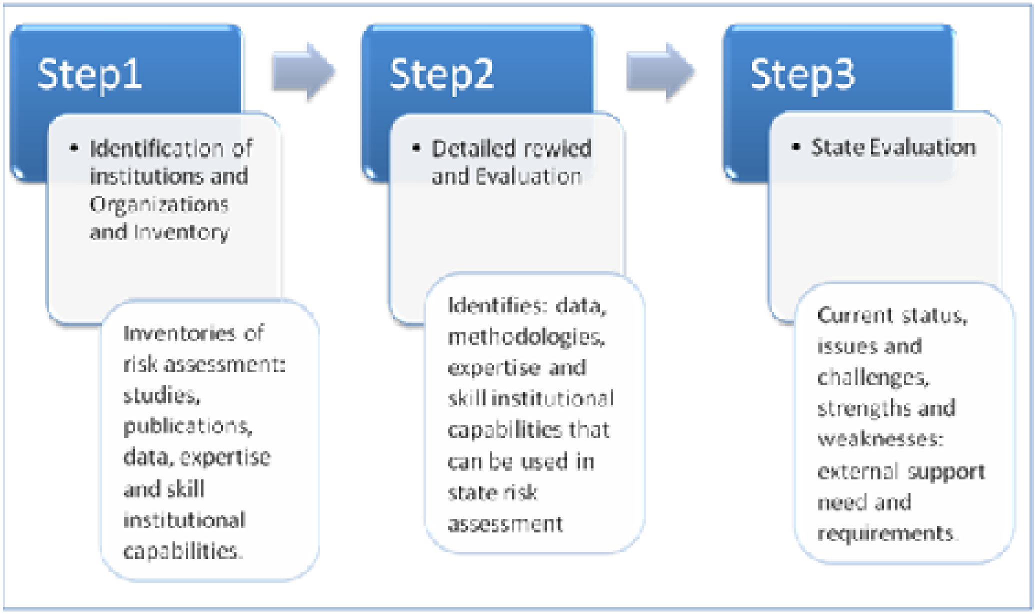
- Understand the current situation analysis and risk management on the State of B.C.
- Identify and evaluate what is already done to avoid duplication of efforts and promote optimization of resources.
- Engage in the process, authorities and several sectors of society.
- Initiate the risk Information System (electronic library)
- Design locally the Risk Analysis Plan for B.C. basing in the understanding of the current situation and needs.
- Identify challenges to improve the State current situation

1.3 Expected Results

- Diagnosis of the current situation of the State in terms of existing natural risks.
- Catalog of information available for risk assessment in the State.
- Institutional arrangements for coordination of activities on risk analysis in B.C.
- A Risk Analysis Action Plan in B.C., based on the evaluation of what exists and the identified needs.
- Recommendations to develop a Disaster Reduction Strategy.
- Electronic Library (e-Library) as part of the Risk Information System in B.C.

2. Activities

Figure 2: Situation evaluation process on risk assessment in Baja California



To achieve the objectives of this project the SIERA methodology was developed in three steps (Figure 2).

Step 1:

Identification of Institutions and Organizations: Through risk and hazard studies were identified in the websites of academic and governmental institutions of Baja California. From these studies, information was obtained on basic and intermediate data, risk assessment studies, and a list of professionals in the fields of disaster risks and natural hazards.

Interviews and Inventory: The identified experts in natural risk assessment studies (hazard, evaluation and risk analysis) of every institution were interviewed to know and collect as much information as possible on their work. This information was the key to enrich the inventories on risk information. Table 1 presents the list of professionals interviewed.

In addition to interviews with experts, an exhaustive search was performed to get information on projects and publications through the Internet, where possible. This information was used to develop lists of inventories of experts, institutions and on studies related to: hazard, risk, vulnerability, exposure evaluation and risk analysis (projects, studies, reports and articles). Table 2 summarizes the list of inventories utilized.

Table 1: Personnel interviewed

Name	Institution	obtained information	City
Antonio Rosquillas	DMPC	Information on natural disaster risk management.	Tijuana
Inocencio Cuellar, Arch.	IMIP	Information on basic and intermediate data.	Mexicali
Luis H. Mendoza MSc.	CICESE	Studies on risk and earthquake hazards	Ensenada
Raul Castro Ph.D	CICESE	Studies on earthquake hazards	Ensenada
Sergio Vázquez MSc.	CICESE	Studies on risk and landslides hazard	Ensenada
Edgar Pavía Ph. D.	CICESE	Studies on hydro-meteorological hazards.	Ensenada
John Fletcher Ph. D.	CICESE	Studies on earthquake hazards and information of basic and intermediate data available in CICESE.	Ensenada
Francisco Suárez Vidal MSc.	CICESE	Studies on geological hazards	Ensenada
Modesto Ortíz Ph.D.	CICESE	Information of available data in CICESE and what is required, for studies on tsunami hazard.	Ensenada
Alejandro Hinojosa MSc.	CICESE	Information of basic and intermediate data available in CICESE.	Ensenada
Juan Manuel Rodríguez Esteves Ph. D	COLEF	Studies on natural disasters risk and information on necessities and requirements to improve studies	Tijuana
Grupo RADIUS	Several	Several studies on risk analysis and information on what is, and what is needed to improve risk assessment in Tijuana.	Tijuana

Table 2: Inventories

Inventory	Information
Worksheet 1	Inventory of organizations and institutions
Worksheet 2	Inventory of risk assessment studies / projects
Worksheet 3	Inventory of publications, reports, and risk-related maps
Worksheet 4	Inventory of intermediate, basic data, and base maps
Worksheet 5	Inventory of methodologies, tools, and guidelines
Worksheet 6	Inventory of data sources (carriers)
Worksheet 7	Inventory of disaster (risk) management practices
Worksheet 8	Inventory of needs and requirements for risk information

Some obstacles were found to develop the step 1, especially to have risk information directly from institutions and professionals identified; this process took more time than the predicted in the work plan of activities, however it was improved as follow.

Obstacles encountered:

- The access of the risk information was limited, only a few studies were shared.
- People, who have conducted these studies, are already in other task and when we talked to them about this project, they directed us with their technician or secre-

tary to obtain the information. They didn't know about the subject, so several questions remained unanswered.
- Interviews with all experts were difficult to carry out, because they live in different cities of the State.
- Discussion meetings with experts, in accordance with the SIERA methodology, were not possible because they live in different cities of the State and had too much work due to the Mexicali earthquake M= 7.2 (April 4, 2010). Therefore, they did not have a chance to travel to this specific meeting.
- It is important to note that in some cases the information found through the internet was limited because subscription to websites was required to access the information.

Issues fixed:
- A list of experts of institutions and agencies, whose staff have remained on their job longer, and have more knowledge about the evolution of risk in their cities.
- To achieve the filling of inventories, much of the information was obtained through the internet.
- There were two meetings with the Tijuana Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters (RADIUS) group (Figure 3 and 4). The first meeting was held in order to present them the objectives of this Project, and to ask their support in getting more information about natural disasters, and risk assessment studies in B.C. This group is formed by research institute experts, government personnel, and independent professionals. The second meeting was to clarify questions concerning the filling of forms as well as questions about the scope of the project. The response was good as was the information obtained from some members of the group.

Figure 3: Expert on earthquake risk studies and in charge of SIERA Project, Luis Mendoza during a RADIUS meeting, presenting the SIERA project in February, 2011

Figure 4: Several academic institutions experts, government and independent professionals in the Tijuana RADIUS meeting February, 2011

Step 2: Detailed Review and Evaluation
Using the SIERA methodology, this project presents diagnosis information of the situation on risk management in B.C. Figure 5 shows the integration and evaluation of information of all inventories. The process consisted in a detailed assessment of the information on: projects, reports, publications, methodologies, expert's knowledge and skills, and institutional capacities, with the aim to find out data, experts and institutions that may be used for the State risk evaluation. The key data was identified based on the interviews and results of Step 1 of this chapter.

Evaluation was done as follows:

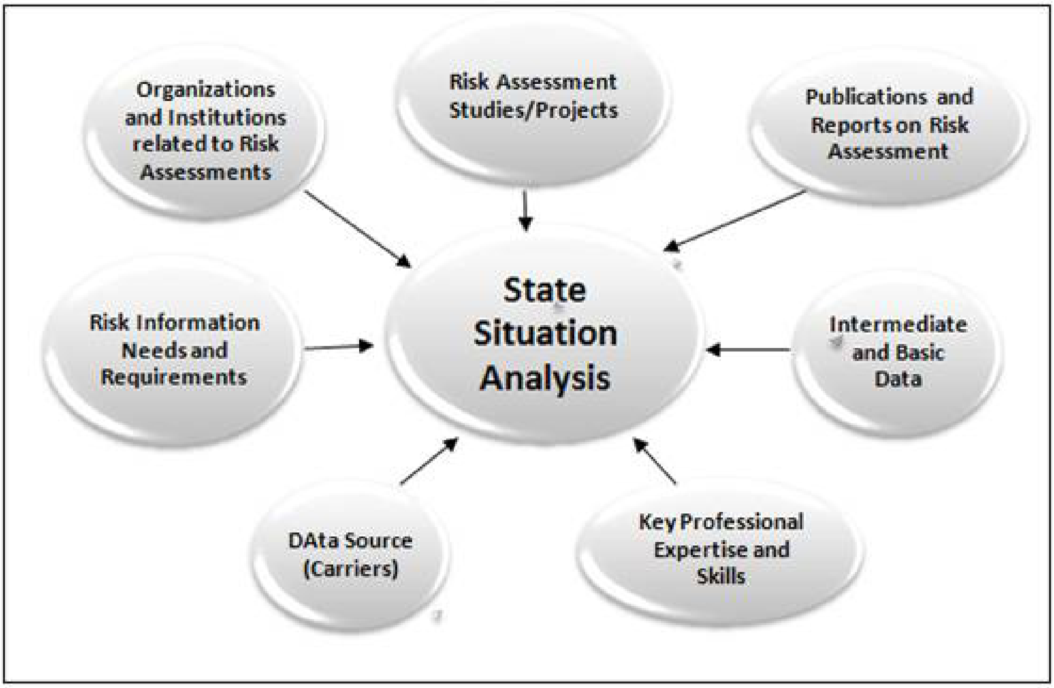
1. Classification of projects, studies, reports and articles.
   a) Risk Studies: those studies that include the three risk elements: hazard, vulnerability and exposition.
   b) Hazard studies: those studies that only have information on how hazard behaves without an analysis of its impact.

2. Data quality:
   a) Intermediate Data: they are processed data and can be used directly to conduct risk analysis.
   b) Basic Data: they can be used to produce intermediate data.
   c) Coverage: if the work was done at local or regional level.
   d) Resolution and Scale: If there are maps, the most important is the scale. A scale of 1:5000 was selected, because precision can be appreciated, and1:25000 because it has more coverage even though the resolution is not precise. If there are aerial photographs the resolution of 20m is acceptable with a maximum of 100m. About data, quantity and quality were evaluated, and also if they were a product or were compiled from another source.

3. Methodologies: The techniques used in each one of the studies and if they were innovative, functional and applicable to other areas.

4. Institutional Capacity: Institutions and experts:
   a) Institutions evaluation: This was done taking into account several aspects: experience, skills and abilities in terms of mandate, expertise and skills of experience, resources, data, information exchange and networking, and relationships with government. This was done taking into account several aspects: experience, skills, abilities, mandate, expertise, resources, data, information exchange and networking, and rela¬tionships with government
   b) Evaluation of Experts: Key experts were identified based on assessing the history of research experience on issues of risk and/or natural disasters, and works conducted in the State.

Figure 5: Categories of inventories to assess the risk in Baja California..



Step 3: Overall State Situation Analysis

The overall State Situation Analysis on risk assessment is based on the following characteristics:

- Current status;
- Issues and challenges;
- Strengths and weaknesses;
- External support needs and requirements.

The evaluation of the characteristic mentioned here is described in chapter 4, and it provides the statements for the implementation of a State risk assessment action plan, which are suggested in chapter 5.

3. Detailed Review and Evaluation

3.1 State hazard and disaster profiles

3.1.1 Hazard profile

3.1.1.1 Earthquake

Baja California is a region with an elevated seismic hazard due to its location at the border of the North American and Pacific tectonic plates, which have a significant relative movement of 56 mm/year, producing great concentration of stress in the earth crust (Legg and Kennedy, 1991). From the seismotectonic point of view, Baja California is in the province called “cizalle zone of South California” (Suárez et al., 1991), characterized by a complex system of faults that transmit the slip main movement between the North American and Pacific plates.

According to the seismic history, shown in table 3, and seismic hazard and risk assessment studies, experts conclude that cities at North B.C. are located where significant seismic activity is manifested by the occurrence of moderate and high seismic magnitudes, particularly in Mexicali. Figure 6, shows the epicentral distribution of seismic magnitudes more or equal to 3, occurred during the period of 1973 to July 2010 registered in the Mexico Northwest Seismic Network catalogs, (RESNOM), and California Institute of Technology (CALTECH).

Table 3: Baja California historic earthquakes

No.	Date	Latitude	Longitude	Magnitude	Location
1	1852-11-29	32.5	-115	6.5	Lago Volcano
2	1875-11-15	32.5	-115.5	6.2	Valle Imperial
3	1892-02-24	32.55	-115.63	7	Laguna Salada
4	1906-04-19	32.9	-115.5	6.2	Valle Imperial
5	1915-06-23	32.8	-115.5	6	Valle Imperial
6	1915-11-21	32	-115	7.1	Lago Volcano
7	1934-12-31	32.2	-115	7.1	Delta Colorado
8	1940-05-19	32.73	-115.5	7	Valle Imperial
9	1956-02-09	31.75	-115.91	6.8	San Miguel
10	1956-02-09	31.75	-115.91	6.1	San Miguel
11	1956-02-14	31.5	-115.5	6.3	San Miguel
12	1956-02-15	31.5	-115.5	6.4	San Miguel
13	1956-12-13	31	-155	6	Gulf of California
14	1966-08-07	31.8	-114.5	6.3	Gulf of California
15	1979-10-15	32.64	-115.3	6.5	Valle Imperial
16	1980-06-09	32.21	-115	6.4	Victoria
17	2010-04-04	32.25	-115.28	7.2	Sierra Cucapah

Figure 6: Seismic epicentral distribution with magnitude ≥3.0, reported by RESNOM (CICESE) for Mexican territory and Caltech for U.S.A. territory from 1978 to October 2010 (Elaborated by Ena Gámez)

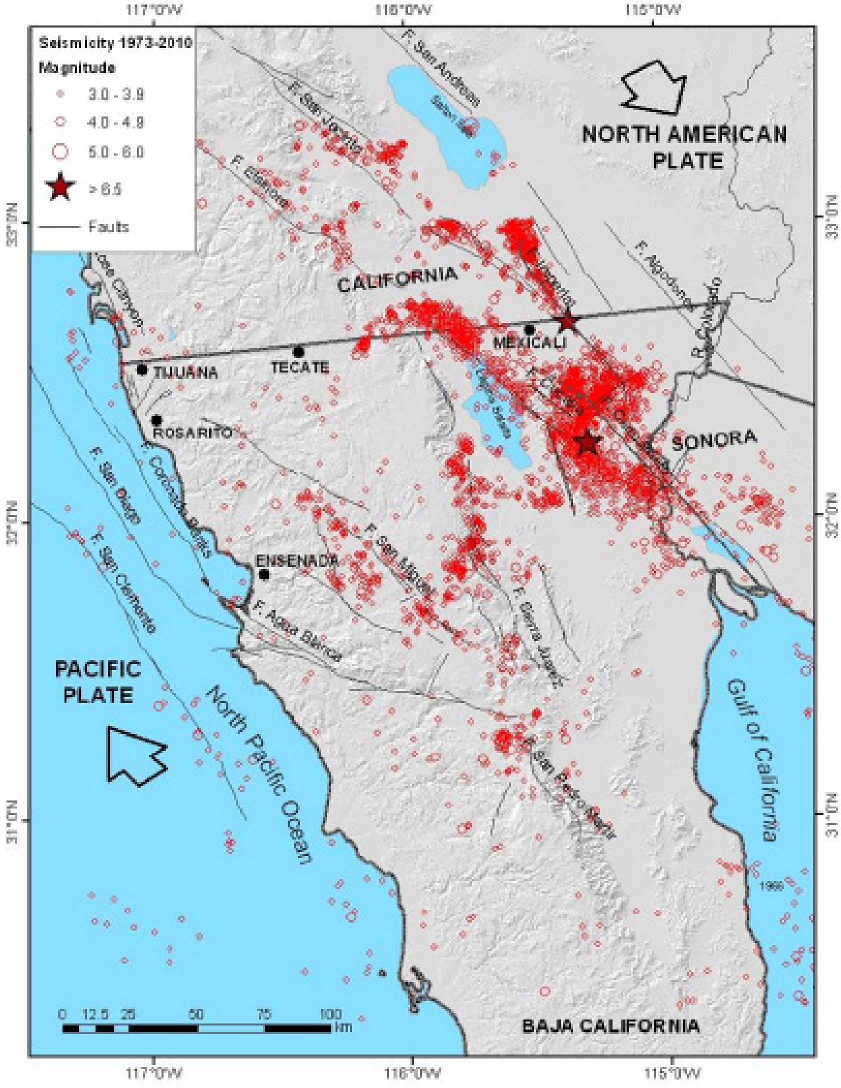


Table 4: Baja California historic floods

No.	Date	City
1	1874	Tijuana
2	1891	Tijuana
3	1906	Mexicali
4	1916	Tijuana
5	1978	Ensenada
6	1980	Tijuana-Ensenada
7	1982-1983	Tijuana
8	1992-1993	Tijuana
9	1997-1998	Tijuana
10	2001	Mexicali
11	2004	Ensenada
12	2008	Playas de Rosarito

Most projects, results and techniques that have been developed about seismic hazard in Baja California are found at the Scientific Research Center and Higher Education of Ensenada (CICESE) library. The hazard profile information is taken from Gámez (2008).

Historic earthquakes shown in table 3 with magnitude bigger or equal than 6.0, have resulted in disaster for the cities close to the epicenters; population, infrastructure and state economy have suffered damaged. To mitigate future events, studies on seismic risk have been developed, which can help cities to reduce their risk and be prepared in case of an earthquake.

3.1.1.2 Flood

Floods have occurred in B.C. because of precipitation, a product of climatological and meteorological processes in combination with low drainage capacity of cities and geological characteristics.

Within the climate processes that affect B.C. is the El Niño Southern Oscillation (ENSO) phenomenon, which is a natural climatic event that takes place in the central equatorial pacific. These conditions generate strong rainfalls and changes in weather and fisheries in the countries near the South Eastern Pacific, as well as in other parts of the world (S. Avaria et al., 2004).

Regarding the meteorological processes that B.C. experiences there are cyclones and hurricanes with some regularity of occurrence (every 3 or 7 years), (Ojeda and Álvarez, 2000). The influence of hurricanes occur primarily between the months of August and September (most recent example is hurricane Nora in September 1997, where in Mexicali produced 45 mm of rainfall in a 24 hrs. period), (Rodríguez, 2002) and thus, several floods in the region, which are described in section 3.1.2: Disaster Profile.

During the period of 1948 to 2000 there are records of heavy rains in Mexicali, which were in October, 1972, August 1977, December 1982 and October 1992. In this regard there is evidence that may explain the occurrence of heavy rain in the city. In the one hand, the passage of hurricanes in the Pacific Ocean makes that heavy rains be registered in large areas. In the case of B.C., in October 1972, hurricane Joanne was present; Doreen in August 1977; Paul in September 1982; and Lester in August 1992. These events probably were related with the phenomenon El Niño, as this occurred in 1972, 1976, 1982 and 1991; indicating that two heavy rains coincided with this, and the other two occurred during its terminal phase. However, these precipitations may be due to a combination of these two climatological phenomena (Rodríguez, 2002).

Due to the characteristics of its physical environment, the city of Tijuana is highly vulnerable to hazards and floods (Ojeda and Álvarez, 2000). In the study realized by Bocco et al., (1993), was found that while in Tijuana the return period of extreme floods is low (75 years); it can be repeated on an average of, every three years, with probability of 0.7 (table 4).

B.C. is relatively arid so the drainage system probably was designed for a relatively low average precipitation, which now is insufficient because precipitation has increased due to climate change. Also, it has suffered from accelerated urbanization and migration processes, which increase the demand of the drainage system and soil surfaces covered with asphalt before collecting water (SGG and DPC BC, 2003).

3.1.1.3 Landslide

Landslides in B.C. are due to land instability, as consequence of pronounced slopes in some areas and low competence of some lithological units that outcrop in the region (Cruz Castillo, 2000), in combination with a non-planning urban growth (Rosquillas et. al., 2007).

Most important landslides in NW of B.C. occur in the Tijuana - Ensenada Toll Highway #1 from km 61 to km 99, and in the urban area of Tijuana (Cruz Manuel, 2000).

The municipality with the largest landslide hazard and vulnerability is Tijuana due to urban growth. As its population increased, the land of high areas slopes and riverbeds were used. Because of land mass movements and cuts without knowledge, and to build houses without planning, the ground debilitated. Another factor that contributed to this effect was the lack of public services, as people dump their sewage and irrigation water directly on the ground, resulting in a landslide (Rosquillas et al., 2007).

In Rosarito landslides are less frequent but there are some areas prone to landslides. In Ensenada, a small area presents landslide risk at the Southern part of the City. Mexicali has areas prone to landslides but are out of the urban area and Tecate has not had landslides.

3.1.1.4 Drought

Droughts are recurrent climate events that have large societal impacts including human suffering and crop losses. The consequences of drought reach a wide range of sectors: agriculture, water resources management, and power supplies.

Usually, droughts (wet spells) mean persistent below (above) normal rainfall over a long time period. During any time, there are some regions over the United States and Mexico under drought or wet spells (Kingtse and Schemm, 2008). Information about this hazard is available only for general studies of the country.

3.1.1.5 Wildfire and Santa Ana Winds

A Santa Ana event occurs when a high pressure system to the east of the North Pacific moves towards the continent over northern or central California (Lynn and Svejkovsky, 1984). The Santa Ana Condition is a mechanism that substantially contributes to the fertilization of the ocean off the Peninsula of B.C. This occurs during the fall and winter, is mainly characterized by dry winds from the Northeast, waking up storms of dust (Figure 7a), and in turn promotes the spread of wildfires (Figure 7b)

Figure 7: a) Dust transported to the ocean during a Santa Ana Condition, February 9 to 11, 2002. Courtesy of a National Aeronautic and Space Administration (NASA) Project: SeaWifFS (Ortiz Figueroa, 2009). b) Southern California wildfires smokeon October 26 2003. City names are in black; fire names in white (Westerling et al., 2004).

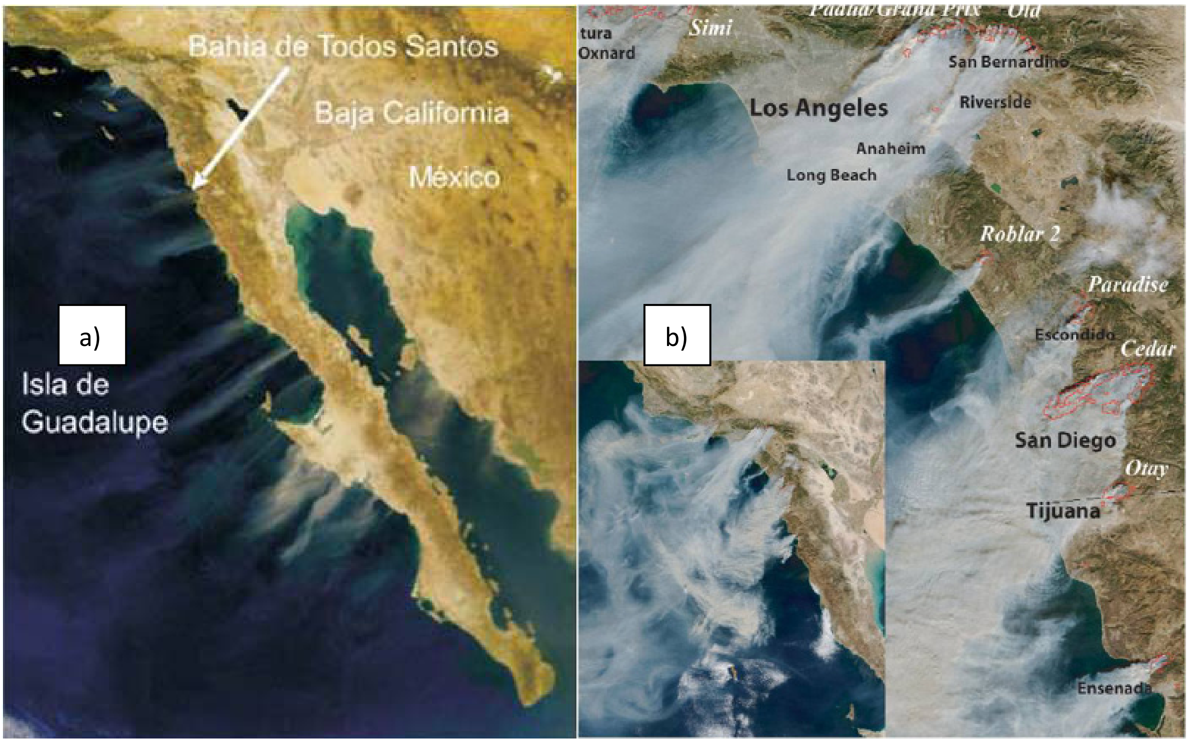


Table 5: Publications on earthquake disaster in Baja California

Disasters	Damages
Earthquakes of 1927	General information about this earthquake is missing. 80% of adobe houses were collapsed in Pueblo Nuevo, most of them were built with this material. (Ley G. J. and Calderon A.G., 2008).
The Imperial Valley Earthquake of 1940	There was no report about the loss estimation in Mexicali; however there is a document made by Americans from 1941 about the damages in USA, (Ulrich, 1941) which indicates that in Mexicali the direct damage was no large, but a short circuit caused by the earthquake set fire to a large hotel, destroying it. Two lives were lost in this region.
The Imperial Valley, California earthquake of 1979	Damages in USA and Mexicali. There was no information about loss estimation in Mexicali (Reagor et al., 1982). The main airport built at East of Mexicali, was extremely damaged; minor damage occurred to some Government buildings. Walls fell in some houses. A store was heavily damaged from bricks falling from the storefront and from shattering of the display windows.
The Mexicali Valley Earthquake of June 9, 1980	Damages in houses, road, railroads, bridges, irrigations canals and landslides, (Prince et al., 1982) Most structural engineering damages in buildings occurred 2 km close to the Southern of Cerro Prieto geothermal field. The more damaged building was a church which had to be demolished few days after the earthquake.
The Cucapah Earthquake of 2010	Damage due to the Cucapah Earthquake of 2010 included broken gas pipes that resulted in 11 fires, 4,389 houses completely destroyed or severely damaged, 351 damaged schools from which 57 were seriously damaged, Also were damaged 5 hospitals, 7 churches, 13 sports clubs and 7 cultural centers. An estimated 25,000 people were affected. Damage to hospitals was mainly infrastructural (loss of power and communications). About 200 km of highways and roads were damaged. The losses in rural and urban areas in Mexicali had a cost of 427, million dollars (Disaster Watch project GRIP, 2010).

by the lack of moisture in the air. With this, settlers in addition to breathing the dust also breathe the smoke, having, as consequence, the exacerbation in respiratory allergies (Ortiz Figueroa, 2009).

Similarly in the Sierra San Pedro Mártir and Sierra Juárez, between the municipalities of Tecate and Ensenada, more fires are triggered due to the density and characteristics of plants biomass accumulation and flammability (CONANP, 2006).

3.1.2 Disaster profile

3.1.2.1 Earthquake

From the five municipalities in the State of B.C., the only city affected by earthquakes has been Mexicali; however, the seismic hazard is present for the entire State of B.C. There have been five earthquakes in Mexicali that have caused extensive damage throughout the history recorded in the years, 1927, 1940, 1979, 1980 and 2010. A summary of damage caused by these earthquakes is presented below (Table 5).

There are no records of the earthquake in 1927, and any technical information or damage assessment. A 2008 publication mentioned building damage, but information is scarce, and it does not provide more information about the disaster.

Although damage assessment were not conducted for the earthquakes of 1940 and 1979 in Mexicali, these events caused significant

Figure 8: Earthquake hazard studies in B. C.

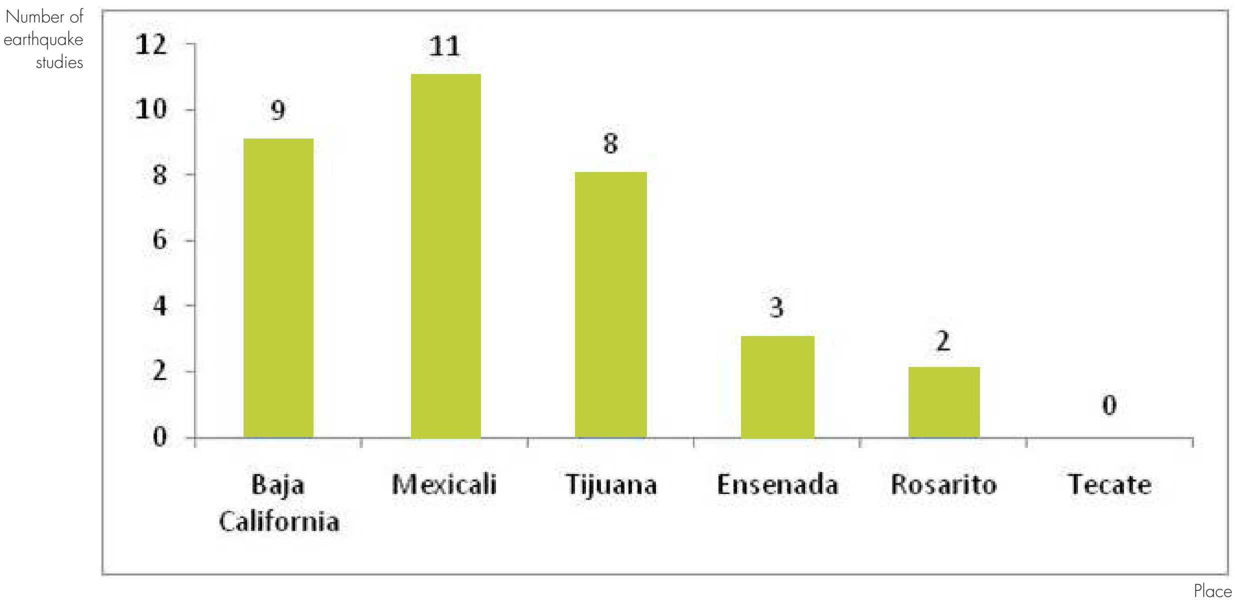


Table 6: Publications on earthquake hazard studies of Baja California

Hazard study name	Coverage	Institution/Publisher
Project		
Characterization and quantification of effects and what sedimentary environment of Mexicali Valley produce in the land masses movement caused by strong earthquakes.	Mexicali	CICESE
Gas Radon evaluation in Mexicali Valley and its relation with geologic and seismic faults.	Mexicali	UAB.C.*, Mexicali – Engineering Institute
Seismic Microzonation for Mexicali.	Mexicali	DEPC*, CICESE
Earthquakes M>6 in Mexicali-Imperial Valley, generation and distribution of structures associated to liquefaction.	Mexicali	CICESE
Seismic Microzonation of Tijuana urban zone.	Tijuana	DEPC, CICESE
Identification and foundation study of Tijuana City vulnerable zones.	Tijuana	Tijuana Municipality, CICESE
Seismic risk evaluation in slopes of Colonia Roma, Tijuana, B.C.	Tijuana	LEYCA Constructores del Noroeste, S.A. de C.V.
Tijuana Municipality Risk Atlas – "A tool for emergency response"	Tijuana	DMPC*
Study for identification of seismic microzonation into the "Ampliación Ejido Plan Libertador" Playas de Rosarito municipality B.C.	Rosarito	CICESE- SEDESOL*
Seismic risk and evaluation of Tectonic Plates Margin at Northwest of Baja California: a multi-disciplinary study.	B.C.	CICESE
Thesis of master degree		
Microzonation of dominant period of the soil for urban cities of Baja California.	Tijuana, Mexicali, Ensenada and Tecate	CICESE
An attenuation study of seismic waves in northwestern Baja California.	Ojos Negros Valley, Ensenada	CICESE
Local effect of the geology for the seismic response in the Ojos Negros Valley, Baja California	Ojos Negros Valley, Ensenada	UANL*
Report		
Baja California State Risk Atlas	Mexicali	B.C. DEPC*
Municipal Risk Atlas of Mexicali Civil Protection Office	Mexicali	DMPCM*
Risk Mapping for Strategic Planning of Shelter Response in Tijuana, Baja California, México.	Tijuana	DPCT*
Study for the identification and foundation of vulnerable seismic zone for Tijuana, B.C	Tijuana	CICESE
General Geological Reconnaissance and Application to Risk Analysis for the Urban Development Partial Program of Corridor Rosarito Century XXI, Playas de Rosarito Municipality, B.C.	Rosarito	CICESE
Evaluation of polygon 515011 current situation in Colonia Lázaro Cárdenas, Ensenada Municipality, because of unsettling phenomena, indicated in risk maps.	Ensenada	CICESE
Publication		
Earthquake M>6 in Mexicali-Imperial Valley, distribution and generation of structures associated to liquefaction	Mexicali	GEOS*
Recent vertical deformation in Mexicali Valley and its relationship with tectonics. Seismicity and the exploitation of the Cerro Prieto Geothermal Field. México.	Mexicali	Pure Applied Geophysics
Distribution of material damages in the Mexicali Valley, B.C. caused by earthquakes from June 1rst to September 10th of 1999. M=4.8	Mexicali	GEOS
An empirical model for estimating horizontal Fourier acceleration spectra for the Imperial-Mexicali valley region,	Mexicali	Geofisica Internacional.
Natural disasters in Mexicali, B.C. Diagnostic about risk and urban vulnerability	Mexicali	Frontera Norte

The RESNOM seismic catalog and its bearing on studies of the seismicity of northwestern México,	B.C.	Geofísica Internacional
Micro tremor observations from the seismic network RESNOM of Baja California, Mexico	B.C.	Di Geof. Teor. ed Appl
P and S wave site response of the seismic network RESNOM determined from earthquakes of northern Baja California	B.C.	Pure and Appl. Geophys.
The RESNOM seismic catalog and its bearing on the seismicity of northwestern Mexico.	B.C.	Geofísica Internacional
Direct body-wave Q estimates in Northern Baja California, México	B.C.	Phys. Earth and Pln. Int.
Distribution of seismic energy in the border region of both Californias	B.C.	GEOS
Catalogue of the active regional faults at Northern of Baja California	B.C.	GEOS
If an earthquake were to occur in the La Nacion fault? Contribution for a seismic scenario in Tijuana	Tijuana	COLEF*
Seismic intensities for Tijuana Region, Baja California, from a possible rupture of the La Nacion fault (MW=6.5).	Tijuana	GEOS

**UAB.C.: Universidad Autónoma de Baja California; DEPC: State Civil Protection Office; DMPC: Tijuana Municipality –Civil Protection Office; SEDESOL: Social Development Secretary; UANL: Nuevo Leon University; DMPCM: Mexicali Municipal Civil Protection Office; DPCT: Tijuana Civil Protection Direction; GEOS: Geophysics Mexican Union ; COLEF : North Border Institute.*

3.1.2.2 Flood

Of the 12 historical flood records for B.C., shown in Table 4, nine of them have report that contains information on economic losses, population impact or structures damage (table 7).

Tables 4 and 7 show that municipalities with greater flood risk are Tijuana and Mexicali, followed by Ensenada and in lower frequency Playas de Rosarito. Below is described in detail how flood disasters have been studied in each municipality.

Flooding in the Municipality of Tijuana
In 1874, rains caused the overflowing of the Tijuana River causing flooding. There were no reports of damage in this flood. Due to floods in 1891 the town of Tia Juana (in that time US territory), had to be moved to its current place (Conklin, 1988). Information about this flood is available on a compilation of Ministry of Education and the State Government of B.C., 1988.

Information about flood damages in 1916 is limited and is available in: Rodríguez (2007). This article also provides information on economic losses and population affected by floods in 1982-1983, these data is from the newspaper El Heraldo of B.C., January, February and March, 1983.

Information of storm damage that hit Tijuana-Ensenada and Tecate in 1980 is available available. This data was published by CENAPRED (Bitran, 2001). Thein a publication elaborated by the National Center for Disaster Prevention (CENAPRED) (Bitran, 2001); this document focuses in making a report of natural disasters around Mexico without much detail at municipal level.

The worst flooding in Tijuana in the last 50 years occurred in January 1993 during a moderate El Niño episode. Assessing the impact of flooding was conducted by COLEF researchers at the Department of Urban Studies and the Environment and of COLEF and was published in the Frontera Norte Magazine., and Aalsolso by researchers of the department of Oceanography (CICESE) whose results were published in thean international magazine: Climate Research.

Information on economical losses and population affected, was published in the following newspapers: El Mexicano: January and February 1993 and the San Diego Union Tribune: January 1993; and these was collected by Rodríguez (2007). Likewise, information can be found in the Atlas Municipal Risk Management Atlas, inat the Municipal Tijuana Civil Protection Office of Tijuana, Version 1.0, developed by Antonio Rosquillas et al., (2000).

Table 7: Publications on flood disasters in Baja California

Disaster	Damages
Mexicali, 1906	The Colorado River stopped flowing into the Sea of Cortez and it ran in the opposite direction following the course of the Alamo to the Salton Trough (Walther, 1985) flooding both valleys. For 18 months people lived to defend against the destruction caused by water (Padilla, 1998). Mexicali and Calexico almost disappeared (Aguirre, 1983) among the wreckage was flooded farms and total loss of crops in the Imperial Valley, while much of the town of Mexicali and the railway were destroyed (Kering, 2001).
Tijuana, 1916	Destruction of part of the racetrack and bridge La Marimba (Rivera, s. f.).
Ensenada, 1978	Ensenada had severe floods originated by storms, which devastated several populated zones that were irregularly settled in river beds; there were 10 casualties and many material damages (IMIP, 2006).
Tijuana-Ensenada, 1980	For this flooding were reported 20 missing people, 6 towns destroyed, 30 000 people affected and economical losses for 2,000 million pesos (Bitran, 2001).
Tijuana, Ensenada and Tecate, 1980	3 deaths, 14,000 affected and 12 evacuated colonies.
Tijuana, 1982-1983	8 deaths, 2400 affected and economical losses for 1613 million pesos (Rodríguez, 2007).
Tijuana, 1992-1993	The worst flooding in Tijuana in the last 50 yearsr occurred in January 1993 during a moderate El Niño episode. The event produced 87 mm of rain in 2 days, more than one-third of the annual rainfall, and 210 mm in half a month. There were 38 casulaties, 8000 people affected, 1960 hectare damaged (10 % was urban area) and $ 560 million pesos in economical losses (infrastructure) (Bocco, et al., 1993).
Tijuana, 1997-1998	The rainfall reached 432 mm resulting in 12 deaths, 1050 affected and $ 1281 million of new pesos in economic losses (Rodriguez, 2007). The flooding forcing 5,000 to 8,000 people from their homes flooding conditions were exacerbated by insufficient storm drains and buildings on hillsides (AP Worldstream, 1998).
Mexicali, 2001	8 colonies were flooded, affecting 26 811 people, 4 colonies were blackouts affecting 3804 people and 5 colonies had 3 affected road accidents (La Crónica, 2001).
Ensenada, 2004	El Arroyo Campillo overflowed causing floods in roads and houses of Chapultepec district lower area; dozens of people were evacuated (IMIP, 2006).
Playas Rosarito, 2008	On December 2008 intensive rain caused severe floods in main roads of Playas de Rosarito, and streams were over-flowed making transit almost impossible. Many houses were damaged in different zones of the city and evacuation was necessary (Rodríguez, 2007).

The Tijuana's Civil Protection Office identified a number of hazard zones after the torrential rains of El Niño 1993. (Institute for Regional Studies of the Californias). (http://wwwrohan.sdsu.edu/index.html).

About the flooding occurred in 1997-1998; the information on losses was published in the newspaper El Mexicano, during January and February 1998 and it was collected by Rodríguez (2007). As in 1993, Tijuana's Civil Protection Office identified a number of hazard zones after the torrential rains of El Niño 1998 (Institute for Regional Studies of the Californias). On the other hand, the CENAPRED in their publication "Characteristics on the socio-economic impact of major disasters occurred in Mexico during the period of 1980-99", presented data of economical losses and population damages (Bitran, 2001). It should be noted that the quoted data are very different from those reported by Rodríguez (2007).

Flooding in the Municipality of Mexicali

One of the first floods occurred in Mexicali was in 1906 (Ley and Calderon, 2008). Disaster information is in the publication of Walter Meade (1985), data on indirect economic losses (meaning when there is damage to crops, farms, areas, however, the economic costs of this losses is unknown) are found in Aguirre (1983) and Padilla (1988), both studies are cited by Ley and Calderon (2008) and in a thesis developed at the UABC. (Kering, 2001). For the 2001 flood loss data were reported in the newspaper La Cronica of B.C., Mexicali, B.C. of March 1, 2001.

Flooding in the Municipality of Ensenada

Only three events were found due to flooding disaster in Ensenada: in 1978, 1980 and 2004. Information on indirect losses from the floods of 1978 and 2004 are in the Atlas of Risks and Natural Hazards. 2nd Stage; conducted by IMIP. For the 1980 flood was only found statistical data of human impact and on economical losses, which are in a publication prepared by CENAPRED (Bitran, 2001).

Flooding in the Municipality of Playas de Rosarito

The flood of 2008 had a strong impact in the residential areas, and part of the population was evacuated. There was only one publication with the information on this disaster (Rodríguez, 2007).

Flooding in the Municipality of Tecate

For Tecate was found only a register of storm disaster occurred in 1980. There was just statistical data of human impact and economical losses without any more details on the event. This data was published be CENAPRED (Bitran, 2001).

Due to disaster history in B.C. 22 studies have been conducted on flood hazard (projects, theses, reports, maps and publications), these are shown in figure 9 and summarized in table 8.

Figure 9: Flood hazard studies at NW of Mexico: Baja California, Baja California Sur, Sonora, Sinaloa y Chihuahua; NW of B.C.: San Quintin, Ensenada and Mexicali; B.C.: Tijuana, Mexicali, Ensenada, Tecate and Rosarito.

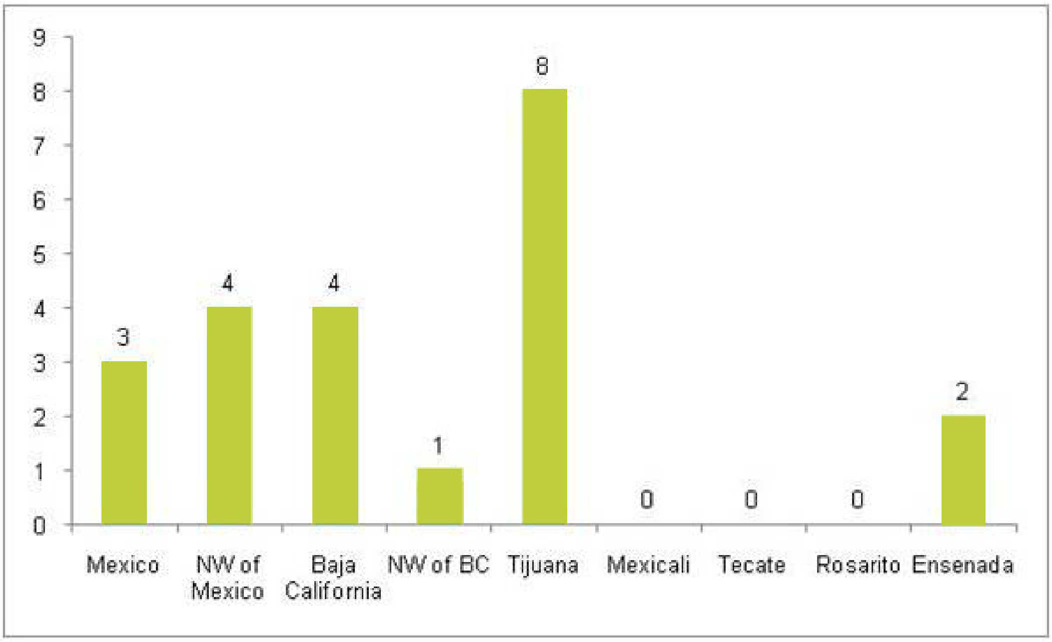


Table 8: Publications on flood hazard studies of Baja California

Hazard study name	Coverage	Institution/**Publisher**
Projects		
Municipality Risk Atlas of Tijuana -"A tool for emergency response".	Tijuana	DMPC-CICESE
Climatologically forecast	Mexico-B.C.	CICESE
"El Niño Phenomenon" Climatology	B.C.	CICESE
Landslides characterization caused by rainfall in Ensenada, Baja California, Mexico, from landslides ravine physical model.	Ensenada	UAB.C.
Master´s degree thesis		
Climatic variability in the Península of Baja California. Theses	B.C.	UAB.C., 1985
The use of empirical orthogonal functions for the physical description of rainfall patterns in the northwestern part of Mexico.	NW of Mexico*	UAB.C., 1993
Characterization of the rainfall in northwestern part of Baja California.	NW of B.C.*	CICESE, 1999

Trends of extreme rainfall in northwestern Mexico and southwestern United States and projection under climate change.	NW of Mexico*	CICESE, 2008
Estimation of variability coastal hydro-meteorological hazards to the strip Tijuana-Ensenada, B.C.	Tijuana-Ensenada	COLEF-CICESE, 2010
Publications		
Interpolation methods applied to the generation of base climate of Baja California State	B.C.	UAB.C., 1990
Variability of extreme precipitation events in Tijuana, Mexico	Tijuana	Climate Research, 2004
Fifty years in rainfall history in Tijuana.	Tijuana	COLEF, 2005
Atlas of the River Tijuana Basin.	Tijuana	COLEF, 2005
The effects of El Niño in Tijuana (1997-1998).	Tijuana	COLEF-IRD, 2006
Trends of extreme rainfall in northwestern Mexico and southwestern United States and projection under climate change.	NW of Mexico*	GEOS, 2008
Droughts, hurricanes, frost, rainfall: Natural disasters? An expert optionoipinion of the System of Public Research Centers System CONACYT.	México	CICESE, 2010
Regional trends of daily precipitation indices in Northwest Mexico and Southwest United States.	NW of Mexico*	Journal Of Geophysical Research, 2010
Characteristic of the socioeconomic impact of the principal disasters in Mexico in the period 1980-1999.	Mexico	CENAPRED
Report		
Critical Flood Zone Maps of Tijuana.	Tijuana	DMPC
Maps		
Justification study for determination of risk zones in Arroyo La Rinconada, Tijuana.	Tijuana	IMPLAN

NW of Mexico= Baja California, Baja California Sur, Sonora, Sinaloa y Chihuahua; NW of B.C.: San Quintin, Ensenada and Mexicali; B.C.: Tijuana, Mexicali, Ensenada, Tecate and Rosarito.*

Table 9: Publications of landslide disasters in Baja California

Disasters	Damages
Landslide Lomas del Rio, Tijuana 2001	Damage to 18 housing in construction and 6 buildings, each one with 6 levels.
Landslide Colonia Maestros, Tijuana 2001	Damage to 10 housing and rupture of a section of aqueduct water, 30% of Tijuana's population had no water for 8 days.
Landslide Colonia Defensores, Tijuana 2002	60 families affected and damage to 47 houses (CENAPRED, 2002).
Landslide colonia Ramírez -Cumbres del Rubí, Tijuana 1998, 2000, 2002	80 families affected.

3.1.2.3 Landslide

Information on landslide disasters was obtained only for Tijuana. In this municipality occurred six events (table 9) and the damage assessment data is found in Rosquillas et al., (2007); and CENAPRED specifically made the assessment evaluation for the valuation of landslide damage occurred in 2002 in Colonia Defensores (CENAPRED, 2002).

Due to these disasters, there have been several hazard studies (table 10) of small colonies in the municipalities of Tijuana and Rosarito where this type of disaster has taken place. However there is no any publication about the magnitude of disaster. Most of the studies have been realized by geologists of CICESE, and the results are in technical reports of the Seismology Department and also in the Tijuana Civil Protection Office.

Table 10: Publications on landslide hazard studies of Baja California

No	Name	Category	Institution	coverage	Year
Project					
1	Geologic risk associated with faulting in areas El Pato and El Pastejé, Tijuana, Baja California.	Hazard	CICESE	Tijuana	1993
2	Geological risk assessment due to landslides in the City of Tijuana B.C., Mexico. Thesis for a Master in Science degree in Earth Science.	Hazard	CICESE	Tijuana	1994
3	Landslides induced by earthquakes in Tijuana	Hazard	CICESE	Tijuana	1996
4	Study of three landslide zones in Tijuana city, Baja California.	Hazard	CESPT* CICESE	Tijuana	1998
5	Seismic risk evaluation in slopes of Colonia Roma, Tijuana, Baja California.	Hazard	LEYCA CICESE	Tijuana	1999
6	Tijuana Municipality Risk Atlas – "A tool for emergency response"	Hazard	DMPCT CICESE	Tijuana	2000
7	Geological – Geophysical study of soils occupied by the installations of Federal Secondary School # 4 and Bachilleres College, in Colonia Jardines de la Mesa, Tijuana, B.C.	Hazard	GobB.C.* SEE CICESE	Tijuana	2000
8	Technique information analysis related to land masses movement that has affected the Tijuana-Ensenada Highway since its construction.	Hazard	CAPUFE CICESE	Tijuana - Ensenada	2002
9	Delimitation of a non apt area for human settlements and urban infrastructure in the land masses movement zone of Colonies: Cumbres del Rubí, Anexa Ramírez, and Tejamen, in San Antonio de los Buenos District, Tijuana, B.C.	Hazard	GobB.C. CESPT CICESE	Tijuana	2003
10	Slopes movement or land masses movement in Tijuana, Baja California.	Hazard and Disaster	CESPT DMPC CICESE	Tijuana	2007
11	Geological Study for the affected zone by land mass displacement in Colonia Camino Verde, District of La Mesa, Tijuana, B.C.	Hazard	GobB.C. CESPT CICESE	Tijuana	2005
12	Geological study in the affected zone by land masses movement in Colonia Anexa Roma, in Playas de Tijuana District, Tijuana, Baja California.	Hazard	CESPT CICESE	Tijuana	2005
13	Geologic and seismic risk assessment study in Colonia del Rio y Anexa in Tijuana, B.C.	Hazard	GobB.C. SAHOPE* CICESE	Tijuana	1993
14	General Geological Reconnaissance and Application to Risk Analysis for the Urban Development Partial Program of Corridor Rosarito Century XXI, Playas de Rosarito Municipality, B.C.	Hazard	Rosarito Municipality, CICESE	Rosarito	2005
15	General Geologic Reconnaissance of Playas de Rosarito Municipality, Baja California.	Hazard	Rosarito Municipality, CICESE	Rosarito	2008
16	Characterization of geological factors controlling landslides in the area of San Miguel-Salsipuedes, Ensenada, B.C. México. Thesis for a Master in Science degree in Earth Science.	Hazard	CICESE	Ensenada	1995
17	Landslides characterization caused by rainfall in Ensenada, Baja California, México, from a landslides ravine physical model.	Hazard	UAB.C.	Ensenada	In process
Thesis of master degree					
18	Geological risk assessment for landslides in the area Salsipuedes-Cíbola del Mar, Ensenada, Baja California. Thesis for Master in Sciences degree in Earth Science.	Hazard	CICESE	Ensenada	1998

19	Assessing the potential of surface runoff at the Guadalupe Valley NE, using the method of curve number and satellite images.	Hazard	CICESE	Ensenada	2005
Publications					
20	Reforestation of Tijuana, Baja California as a mechanism for natural risk reduction.	Hazard	Estudios Fronterizos - UAB.C.	Tijuana	2000
21	Landslides on the slopes of the Defensores colony Baja California, Tijuana B.C.	Disaster	CENAPRED	Tijuana	2002

**GobB.C.: Gobierno de B.C.; SAHOPE: State Secretariat for Human Housing and Public Work; CESPT: State Public Service Commission of Tijuana*

Table 11: Studies on drought hazard in Baja California

No	Name	Category	Institution	Coverage	Year
Project					
1	Thematic network for prevention of hydro-meteorological disasters (REDESClim).	Disaster	CICESE	B.C.	In process
Thesis of master degree					
2	Characterization of synoptic climatic areas in the Peninsula of Baja California.	hazard	CICESE	B.C.	1987
3	Interpolation methods applied for the generation of the Baja California State base climatology.	hazard	UAB.C.	B.C.	1990
Publication					
4	Droughts, hurricanes, frosts, rains: Natural? Disasters. An expert opinion of the Research Public Center System of CONACyT.	Hazard	CICESE - electronic magazine	Mexico	2010
5	Mexican drought: an observational modeling and tree ring study of variability and climate change.	Hazard	Atmósfera 22(1), 1-31 (2009)	Mexico	2009
6	Droughts and Persistent Wet Spells over the United States and Mexico.	Hazard	Journal of Climate	Mexico	2008

3.1.2.4 Drought

Drought is one of the most important hazards in B.C.; while global warming is a fact, climate change will have significant impact on this region. Drought has a broad range of impacts; however, there is no comprehensive database of losses or information on past disasters.

Currently there is an ongoing Project on disaster monitoring: "The Hydro-meteorological Disasters and Climate Network" (REDESClim) for all Mexico, which is about disasters associated to natural phenomena. This project began in September, 2010. The network includes a "Group of Drought Monitor of North of Mexico", which collaborates with the "Drought Monitor of North America". In this group participates researchers from INECOL- Chihuahua, the Northwest Biological Research Center (CIBNOR), National Water Commission (CONAGUA), National Navy (SEMAR), CICESE, Chihuahua Autonomous University (UACH); who develop projects aimed at understanding the processes associated to drought, and to mitigate the effects on the environment and society. This group has developed tools for continuous monitoring of drought and Geographic Information Systems (GIS) for the border states of Northern Mexico. (Muñoz et al., 2006; Núñez et al., 2007). Network Manager: Tereza Cavazos – CICESE (Gaceta CICESE # 146). The studies found on this hazard are shown in table 11.

3.1.2.5 Wildfire and Santa Ana Winds

The majority of wildfires in B.C. are less than 5000 ha, causing the loss of livestock feed and affecting the State economy, since the most productive activity and of major importance in the region is livestock (CONANP, 2006).

Table 12: Hazard Studies of Santa Ana winds and wildfires in Baja California

No	Name	Category	Institution	Coverage	Year
Project					
1	Preliminary Study of wildfires as ecological factor and its relation with chaparral in the common land "Mexicali Valley Natives" [Thesis] (Bachelors Degree).	Hazard	UAB.C.	Mexicali	1986
2	Uncontrolled fire and chaparral resilience in the Sierra Juarez, Baja California, Mexico. Thesis (Master of Science).	Hazard	University of California, Riverside	Ensenada	1984
Publication					
3	"Santa Ana Condition"… Not all is dry wind, allergies and wildfires.	Hazard	GEOS	B.C.	2009
4	Evolution and extension of the Santa Ana winds of February 2002 in the ocean off California and Baja California	Hazard	Marine Sciences	B.C.	2003
5	Climate, Santa Ana winds and Autumn wildfires in Southern California.	Hazard	EOS	B.C.	2004

Although there are no studies of damage assessment and economic losses on wildfires in B.C., there is a Program on Conservation and Management of the Sierra San Pedro Mártir which includes policies and recommendations to mitigate wildfires. The website is: http://www2.ine.gob.mx/publicaciones/download/564.pdf.

Information about this hazard is in Table 12.

3.2 Risk assessment studies

The existing risk assessment studies for B.C. cover earthquake, flood and landslide hazards. For drought and Santa Ana winds found no risk assessment studies conducted in B.C.

3.2.1 Earthquake

In B.C. there are still no comprehensive studies of seismic risk assessment. The closest to that are the seismic scenarios that estimate the damages that may result from the occurrence of a major earthquake affecting the studied region. These damage scenarios have been used to identify the appropriated measures to reduce such damages and respond effectively to post-earthquake contingencies. So far there has been no study evaluating economic losses due to earthquakes in B.C.

Mexicali presents more seismic hazard than the other cities in B.C., and Tijuana is the most vulnerable. Ensenada, Rosarito and Tecate also have seismic hazard and vulnerability to the presence of earthquakes. There are studies in B.C. that have tried to combine hazard, exposure and vulnerability to estimate potential losses, only seven projects have been fully completed (table 13).

Due to its vulnerability Tijuana is the city where more seismic risk studies have been done, however there is a proposal made by the State Government, to make a study of "Seismic Risk Evaluation in five cities of B.C. State, México" (Tijuana, Mexicali, Ensenada, Playas de Rosarito y Tecate). (http://www.iadb.org/en/projects/project,1303.html?id=ME-T1032)

This proposal focuses in the seismic risk assessment of the 5 cities mentioned above, identifying the factors that contribute to risk and that can be controlled through State and local mitigation strategies. Seismic risk reduction strategies will be developed for the five cities.

This Project will provide updated information regarding earthquake risk, and other phenomena associated with it, (site effects and collateral hazards) that can become more destructive than the event itself. The information collected and the resulting data will be integrated into a Geographic Information System (GIS) available for viewing via the Internet, which will be developed in parallel to the capture of information generated at various stages of the project. Yet, there are no funds available to develop this proposal. Of seven published risk studies in B.C., only the four done for Tijuana have been applied for decision making (Ac-

Table 13: Publications on earthquake risk studies of Baja California

Risk study name	Year	Coverage	Institutions
Project			
(RADIUS) Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters –.Case Study: Tijuana.	1998	Tijuana	IDNDR, Tijuana Municipality (TM), through the Civil Protection Office.
Diagnosis of Urban Risk in the Metropolitan area of Tijuana.	2002	Tijuana	Municipal Civil Protection Office – XVI city Council and CICESE
Cross-Cutting Project for risk reduction in Asia, Latin America and the Caribbean. In collaboration with the representation of UNESCO in México.	2003	Tijuana	UNESCO, Tijuana Municipality, CICESE
Risk Mapping for Strategic Planning of Shelter Response in Tijuana, Baja California, México.	2009	Tijuana	Tijuana Municipality, Civil Protection Office, CICESE, International Federation of Red Cross and Red Crescent Societies.
Seismic Risk Evaluation in five cities of Baja California State, México	To be implemented	Baja California	Government Board Office of B.C, Civil Protection State Directorate (DEPC)
Thesis of master degree			
Application of the seismic microzonation to the vulnerability of critical facilities for Ensenada city, B.C.	2003	Ensenada	CICESE
Seismo-tectonic and site effects in the assessment of the seismic response in Mexicali, Baja California.	2008	Mexicali	CICESE
Publication			
Seismic vulnerability and civil protection of schools in Mexicali, Baja California. Mexico	2004	Mexicali	Third International Congress on the Development of Physical Infrastructure Education. Nuevo Vallarta. 18 pp.

tion Plans or Programmes).

Table 14 shows a summary of the Action Plans, which are available in the website of Tijuana Civil Protection Office (DMPC):

http://www.tijuana.gob.mx/dependencias/proteccioncivil/planes.asp.

Thesis studies of Table 13 are very useful to decision makers in B.C., but they have not been used yet.

In the Project: "Diagnosis of Urban Risk in the Metropolitan area of Tijuana", are mentioned laws and regulations for land movement works for Tijuana municipality, and also the legal framework that regulates land use and the typical forms of construction. For the other cities there are no plans, publications, programs, strategies or policies and regulations for risk management.

3.2.2 Flood

Even though in the State of B.C., floods are one of the main hazards, works realized on risk evaluation are few, as it can be appreciated in table 15. Some are just risk scenarios and others evaluate hazard with vulnerability. From the 11 cited studies, only one of them focuses on the evaluation of economic losses, which was performed for the city of Tijuana. Most of the studies have been conducted for Tijuana, which focus primarily in evaluating the impact of hazard to the population such as: economic losses, (example: Bocco et al., 1993 and Bitran, 2001), hazard diagnosis, event occurrence probability through events that already occurred, and identification of flooding critical areas; all this in order to develop management guidelines for decision making regarding this hazard.

The Project "Diagnosis of Urban Risk in the Metropolitan Area of Tijuana" concludes that in order to minimize the impact of disasters in urban areas, requires permanent coordination policies at national, regional, local level, engaging all sectors involved in risk reduction and emergency response.

Table 14: Publications on Earthquake Disaster (Risk) Management Practices

Components	Leading Organization	Effective Date	Observation
Strategy or Framework			
Seismic Risk Management Inter-institutional Program associated to future urban development of the city of Tijuana, B.C. (RADIUS).	CICESE, DMPCT and institutions (PEMEX*, CESPE*, DIF*, CIC*, DDU*, TELNOR*, C-4*, CFE*, DSPM*, API*, PFP*, SEDENA*, CAPUFE).	1998- current date	http://radius-tij.cicese.mx
Implementation strategy of an action plan to reduce risk in Tijuana.	CESPT, CFE, TELNOR, Z Gas, CFE- CENACE*, CAN*, DAU*, SEE*, DOSP*, PEMEX, OME*, SEMPRA Energy.	2002	Several seismic prevention action plans were elaborated.
Action Plans or Programmes			
Municipal Contingency Plan for Earthquakes, Tijuana. B.C	Civil Protection Office of Tijuana, City council of Tijuana. RADIUS Group of Tijuana	2000-2003	It is going to be reviewed and modified by RADIUS-GRT, because the city has changed the last 8 years.
Municipal Contingency Plan for geologic risks, Tijuana, B.C	DPCT, City council of Tijuana. RADIUS	2000	http://www.tijuana.gob.mx/dependencias/proteccioncivil/planes.asp
Municipal Contingency Plan for Hydro-meteorological risk, 2007. Tijuana, B.C	DMPC-Tijuana	2007	http://www.tijuana.gob.mx/dependencias/proteccioncivil/planes.asp
Guideline to elaborate the contingency scholar plan, 2008.	DMPC-Tijuana	2008	hhttp://www.tijuana.gob.mx/dependencias/proteccioncivil/planes.asp
Handbook of building, evaluation and rehabilitation of houses - AIS La Red	DMPC-Tijuana		http://www.tijuana.gob.mx/dependencias/proteccioncivil/planes.asp
Policy & regulations			
Security of schools for Baja California.	Government Board Office of B.C	2007	http://www.bajacalifornia.gob.mx/VI_Informe/resultados_gestion/04%20SEG.pdf

PEMEX: Mexican Oil; CESPE: State Public Service Commission of Tijuana; DIF: Integral Family Development; CIC: Civil Engineers College; DDU: Urban Development Office, TELNOR: Northwestern Mobile; C-4: Command Center; CFE: Energy Federal Commission; DSPM: Public Security Municipal Office; Navy: 2a. Naval Zone, API: Integral Port Administration; PFP: Federal Preventive Police; SEDENA: Ministry of Defence; CENACE: National Center for Energy Control; CAN; DAU: Urban administration; SEE: School System; DOSP: Public works; OME: Administration State Office.*

In the Project "El Niño Effect", after an analysis of diverse policies and programs on natural disasters due to this phenomenon, were proposed strategies for prevention and mitigation in natural disasters with emphasis on:

- Implementation of a water resources management policy.
- Redefinition of the criteria for Civil Protection, in order to improve socio-economic conditions for the population, and thus reduce vulnerability.
- The design of inclusive public policies.
- Creation of a regional and urban development programs that effectively regulates the urban processes throughout the country.
- Reorientation of Federal budget expenditures, giving more resources to institutions responsible of economic, social and urban programs.
- Promotion of multidisciplinary research (scientific and social) that contribute to a better understanding of the relation between Mexican society and natural disasters.

Table 15: Publications on flood risk studies of Baja California

Risk study name	Year	Coverage	Institution
Publisher			
Characteristic of the socioeconomic impact of the major disasters in Mexico during 1980-1999.	2001	Mexico	CENAPRED
Diagnosis of Urban Risk in the Metropolitan area of Tijuana.	2002	Tijuana	DMPC – XVI Ayuntamiento
Impacts of El Niño in México	2004	Mexico	
Study of future climate scenarios and adaptation processes to climate change for the State of Baja California.	2006	B.C.	CICESE, UAB.C. and COLEF
Atlas Risk Assessment and Natural Hazards 2nd Stage: Floods	2006	Ensenada	IMIP
Study of meteorological and climatic disasters (droughts, floods, etc) In the State of Baja California during century XXI.	In Process	B.C.	CICESE
Thematic Network to prevent hidro-meteorological disasters (Disaster)	In Process	B.C.	CICESE
Thesis of master degree			
Social vulnerability and risk to disaster in Tijuana Baja California.	2005	Tijuana	COLEF, 2005
Natural Risk and Social vulnerability in Tijuana.	1996	Tijuana	COLEF, 1996
Publications			
Flooding impact assessment (January 1993). Integral use of remote perception and systems.	1993	Tijuana	Frontera Norte, 1993
Reforestation in Tijuana, Baja California as mechanism of natural risk reduction.	2000	Tijuana	Estudios Fronterizos, 2000
Natural disasters in Mexicali, B. C.: Diagnostic on risk and urban vulnerability.	2002	Mexicali	COLEF, 2002
Confrontation of Natural Disasters: Social construction of risk and climatic variability.	2007	Tijuana	COLEF, 2007

The Ensenada "Atlas of Risks and Natural Hazards" was developed to strengthen actions that help to reduce vulnerability to floods.

The study "Social vulnerability and disasters risk in Tijuana B.C." (Bringas, 2005), has as main goal, as presented in its summary: to identify areas at risk of disaster to hazard such as rains. It should be noted that there was no access to the publication, just to the summary; therefore was not possible an evaluation of its content.

The vulnerability study "Natural Risks and Social Vulnerability in Tijuana" presents social vulnerability maps associated to flood hazard risk. As in the studies made by COLEF, and other academic institutions, suggests strategies in disaster reduction. However, there was no information on whether these proposals have been carried out, unlike the studies conducted by governmental agencies as the Municipal Civil Protection Office - Tijuana, which are implemented.

Vulnerability studies found are useful for risk assessment studies and decision making.

Currently developing is the project "State Action Programme to Climate Change (PEACC) of B.C." which objective is to evaluate the current situation of the climate change effects in B.C., Mexico. In the same way are conducting a preliminary diagnosis and analysis of potential impact that climate change could have in various socio-economic sectors of the State as are: energy, water, agriculture, livestock, health, transport, urban development, tourism, marine ecosystems and terrestrial biodiversity. The goal for the end of 2009 was to propose to the State Government, measures and mitigation strategies and adaptation to

Table 16: Publications on floods disaster (risk) management practices

Components	Leading Organization	Effective Date	Observation
Strategy or Framework			
Municipal Contingency Plan for Hydro-meteorological Risk v 5.0	Tijuana Municipal Council, the Fire Department Office and DPCT	2007	http://www.tijuana.gob.mx/ver_PDF.asp?filename=http://www.tijuana.gob.mx:80/dependencias/proteccioncivil/pdf2/Plan%20Municipal%20de%20Contingencias%20para%20Riesgos%20Hidrometeorologicos%20v%202007.pdf&titulo=
Critical Flood Zone Maps of Tijuana. 2006-2007 v. 1.2	DPCT	2007	
Action Plans or Programmes			
State Programme of Action to Climate Change.	CICESE, UABC and COLEF, likewise this Project is supported by SPA, GobB.C.*.	2008	http://peac-B.C..cicese.mx/

**GobB.C.: Baja California Government State*

Table 17: Studies of landslides risk in Baja California

No	Name	Category	Institution	coverage	Year
Project					
1	Diagnosis of Urban Risk in the Metropolitan area of Tijuana.	Risk	DMPC	Tijuana	2002
2	Geologic study of a selected area to build several roads in La Cuestecita zone, in San Antonio de los Buenos District, Tijuana, B.C	Risk	TM–Urbanization Unit-CICESE	Tijuana	2005

climate change conditions of the century XXI waiting to be translated in public policies that benefit the B.C. society. This project involves more than 60 researchers from CICESE, UABC and COLEF and is financed by the Department of Environmental Protection (SPA) of the State Government of B.C.

Based on the history of disasters and flood risk studies in Tijuana, there have been developed contingency plans for this type of eventualities. We had access to some of them (Table 16), for the other municipalities has not been found any publication.

3.2.3 Landslides

There are two studies on landslide risk analysis in Tijuana (Table 17), but only one covers the whole city. The other study covers a small colony and assesses vulnerability on the stretch of the highway and the damages that would be expected.

3.3 Existing methodologies and tools

This section presents the methodologies used for risk assessment studies for earthquake and flood; some of them have been useful for landslide studies. Since there aren't any studies on risk assessment for droughts and Sana Ana winds, the methodologies that could be used for future risk evaluation studies are unknown. Instead, two studies of climatological hazards are available in which the following methodologies were used, they are shown in Table 22.

3.3.1 Earthquake

To characterize the seismic hazard, studies

Table 18: Methodologies/models used in earthquake hazard assessments studies

Methodologies/Tools Name	Brief Description	Case Studies
Equations for Estimating Horizontal Response Spectra and Peak Acceleration	They provide tables for estimating random horizontal-component peak acceleration and 5 percent damped pseudo-acceleration response spectra in terms of the natural, rather than common, logarithm of the ground motion parameter. The equations give ground motion in terms of moment magnitude, distance, and site conditions for strike-slip, reverse-sip, or unspecified faulting mechanisms.	Tijuana, Mexicali and Ensenada
Nakamura Technique	It is a method for site response estimation using ambient vibration measurements, consists in taking the ratio between the Fourier spectra of the horizontal and vertical components of the ambient vibrations (H/V ratios). These ratios on soft soil sites exhibit a clear peak that is correlated with the fundamental resonant frequency.	B.C.
Seismic Refraction Methods	The seismic refraction method is used to identify the layers of material to ground level, with adequate capacity to specific works of Civil Engineering. For shallow soils 30m of deep.	B.C.
The Multichannel Analysis of Surface Waves (MASW)	The multichannel analysis of surface waves (MASW) method is one of the seismic survey methods evaluating the elastic condition (stiffness) of the ground for geotechnical engineering purposes. MASW first measures seismic surface waves generated from various types of seismic sources—such as sledge hammer—analyzes the propagation velocities of those surface waves, and then finally deduces shear-wave velocity (Vs) variations below the surveyed area that is most responsible for the analyzed propagation velocity pattern of surface waves.	Tijuana, Rosarito and Mexicali
Seismic Instrumentation Northwest Seismic Network in Mexico (RESNOM)	It is a network that has been kept in operation for over two decades by staff of the Department of Seismology of CICESE. The network is designed to record seismic activity in the northern region of B.C. and the western portion of the state of Sonora, Mexico, between 30 and 33 degrees north latitude and 114 and 117 degrees west longitude, approximately.	B.C.
Interferometry SAR	1915-11-21	32
(Synthetic Aperture Radar),	InSAR is a remote sensing technique used for applications such as the generation of numerical models of the terrain (NTMs) and monitoring of surface deformations.	Mexicali
LIDAR (Light Detection And Ranging)	LIDAR (Light Detection And Ranging, also LADAR) is an optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the target with light, often using pulses from a laser.	B.C.
GIS	A geographic information system (GIS), geographical information system, or geospatial information system is a system that captures, stores, analyzes, manages and presents data with reference to geographic location data. In the simplest terms, GIS is the merging of cartography, statistical analysis and database technology. GIS may be used in archaeology, geography, cartography, remote sensing, land surveying, public utility management, natural resource management, precision agriculture, photogrammetry, urban planning, emergency management, GIS in Environmental Contamination, landscape architecture, navigation, aerial video and localized search engines.	B.C.

done in B.C. are based in Microzonation maps that show soil's seismic response, especially in urban areas, catalogs of historic earthquakes and seismic intensity maps. There are microzonation maps of soil´s seismic response (Peak Ground Velocity, Peak Ground Acceleration and Modified Mercalli Intensities) only for Tijuana, Mexicali and Ensenada, which are contained in each hazard studies about microzonation or seismic response, showed in table 6 (in Table 23 of next section shows a list of these products).

The microzonation maps were elaborated considering scenarios of earthquake occurrence, using predictive equations for estimation of the soil parameters. These maps are used for urban planning and to update the specifications of the safety seismic factor for the region, and the expected damage on the buildings. Methodologies used in B.C., to make these maps and hazards studies are listed in table 18. The applied techniques have been well used and they are replicable for next hazard studies.
For seismic risk assessment techniques and methodologies are proposed by GHI and RADIUS, but have been applied only in Tijuana and not for the rest of B.C. Other techniques for seismic risk studies, scenarios and vulnerability indices have been applied in Ensenada, Mexicali and Tijuana. A summary of these techniques is shown in Table 19.

Table 19: Methodologies/models used in earthquake risk assessments studies

Methodology Name	Brief Description	Case Studies
(RADIUS	The application of RADIUS varies from city to city. Those criteria were selected based on individual city. Based on the MMI value of all existing structural and infrastructural types of city, damage curves can be calculated.	Tijuana
GeoHazards International (GHI) method	The GeoHazards International (GHI) method of assessing community earthquake safety estimates the risk of life loss from earthquakes in cities around the world. The algorithm is inspired by loss estimation and produces results that indicate the relative severity of cities´ earthquake risk, the sources of risk within each city, and the relative effectiveness of potential mitigation options.	Tijuana and Mexicali
FEMA 226, 1992. Collocation impacts on the vulnerability of lifelines during earthquakes with applications to the Cajon Pass, California.	This document presents a new analysis method to identify the increase in the seismic vulnerability of individual lifeline systems (communication systems, electric power systems, fuel pipelines, and transportation lifeline) due to their proximity to other lifelines in the Cajon Pass. The primary objective of the study was to determine how the time to restore full service would be affected by the collocation of several types of lifelines in the same congested corridor.	Mexicali
ATC-13, 1985. Earthquake damage evaluation data for California, Applied Technology Council.	The ATC-13 report was developed to provide expert-opinion earthquake damage and loss methodology and data for use in estimating local, regional, and national economic impacts from earthquakes in California. The ATC-13 report includes: (1) expert-opinion motion-damage relationships, presented in the form of damage probability matrices, for 78 classes of structures, including buildings (40 classes) and lifeline structures (electrical, water, sanitary sewer, natural gas and telephone components and systems); (2) methods and data for estimating damage and loss resulting from collateral hazards, including fault rupture, ground failure, inundation, and fire; (3) estimates of the time required to restore damaged buildings and lifeline structures to their pre-earthquake functionality; (4) inventory methodology to estimate the type, distribution, and number of man-made facilities throughout California; and (5) methodology and data for estimating deaths and injuries.	Ensenada and Mexicali
Earthquake Disaster Risk Index (EDRI)	The EDRI is a composite index that directly compares the overall earthquake disaster risk of cities worldwide and describes the relative contributions of various factors to that risk. The EDRI adds the following five indicators together to rate each city´s risk: Hazard, Exposure, Vulnerability External Context, and Emergency Response and Recovery. The EDRI was designed to use data collected in a library, and was demonstrated by evaluating ten cities around the world.	Tijuana and Mexicali
Damages earthquake scenario	A hypothetical earthquake is chosen to estimate the seismic intensities in the city through several techniques. One of techniques is applying empirical methods, which evaluates the seismic response of ground expressed with the spatial distribution of ground peak acceleration, velocity, and response spectra, and isoseismal maps, calculated using empirical predictive equations or using the RADIUS99 tool.	Tijuana, Mexicali, Ensenada
ATC-21, FEMA 154, 2002 Rapid visual screening of buildings for potential seismic hazards: a handbook	It provides a standard rapid visual screening procedure to identify, inventory, and rank buildings that are potentially seismically hazardous. Although RVS is applicable to all buildings, its principal purpose is to identify (1) older buildings designed and constructed before the adoption of adequate seismic design and detailing requirements, (2) buildings on soft or poor soils, or (3) buildings having performance characteristics that negatively influence their seismic response. Once identified as potentially hazardous, such buildings should be further evaluated by a design professional experienced in seismic design to determine if, in fact, they are seismically hazardous.	Ensenada and Mexicali

3.3.2 Flood

Because there are few studies on flood risk analysis, few methodologies are known for this type of studies, which are mostly carried out by COLEF since in this institution are the researchers engaged in this kind of analysis (Rodríguez Ph. D.). These methodologies are based on rates and patterns that combined with Geographic Information Systems; discuss environmental and spatial problems in urban areas. However, these studies are no completed because they focus only in risk scenarios or vulnerability issues (Table 20).

Likewise there are methods / techniques to fully evaluate hazard of flooding elements, which are carried out more frequently by CICESE (Table 21). However, has not been found yet a municipal or State flood hazard map development by CICESE.

Table 20: Methodologies/models used in flood risk assessments studies

Methodologies/Tools Name	Brief Description	Case Studies
Projects		
Computational Models	Without information the project is in process	B.C.
Forecast Models	Design of future scenarios in case of hydrometeorological disasters.	B.C.
Environmental Indicators	Without information the project is in process	
Delphi Method	The Delphi method intends to facilitate consensus between experts on current knowledge gaps and consists of a written questionnaire.	Ensenada
Flood Risk Model (RI= acronym in Spanish)	It is made from the following index:: RI= Flood Risk; IP= Risk Index; IV= Vulnerability Index; IPen= Slope Index; IE= Runoff rate; IG= Geomorphology Index; IUS= Land Use Index (the acronym are in Spanish)	Ensenada
Costs associated with climate variability	To evaluate the economic costs caused by El Niño is required to specify the monetary values that each economic activity yields to the total national wealth. The revised information is obtained from national accounts and variations in existence, relating both to the monetary losses. As there is no accurate accounting of both existing assets and losses occurred, and know that the appreciation of who conducts the assessment is no less subjective, the results should be considered only as an approximation.	México
Climate Scenarios	Regional: Obtain scenarios for different socio-economic sectors such as water, agriculture, livestock, tourism, health, among others.	LEYCA Constructores del Noroeste, S.A. de C.V.
	Local: Statistical model Statistical DownScaling Model (SDSM) is a user-friendly software package designed to implement statistical downscaling methods to produce high-resolution monthly climate information from coarse-resolution climate model (GCM) simulations. The software also uses weather generator methods to produce multiple realizations (ensembles) of synthetic daily weather sequences. Site-specific daily scenarios for maximum and minimum temperatures, precipitation, humidity. SDSM also produces a range of statistical parameters such as variances, frequencies of extremes, spell lengths.	B.C.
Thesis Master Degree		
Risk Estimation	It is done through a combination of two main variables and each turn consists of a number of factors including: Susceptibility to relief: geomorphology, and lithology pending Social vulnerability, population density, land use and housing quality.	B.C.
Publication		
Tool SIG to impact evaluated	Were combined geographic information systems Integrated Land and Water Information System (ILWIS) which GIS integration and tools for processing and analysis of products generated by remote sensing, combined with remote sensing techniques (such as photo interpretation or processing digital satellite images-tate) have been used frequently to analyze environmental and spatial problems in urban areas.	Tijuana
SAVANE GIS, development by Institut Scientifique pour le Développement en Coopération (ORSTOM) and interviews	SAVANE is Geographic Information System (SIG). Its purpose is to gather, generate, process and map geographic data from diverse sources and types, such as survey data, thematic maps, topographic data and from network, satellite image, aerial photographs, numerical models of terrain, etc. SAVANE core is a system of managing a relational database that includes the location of them, and about which are developed; many functions for spatial analysis, cartography, statistics and PR. This is a comprehensive tool for analysis and research in geography, urban planning, and the organization of space, the study and management of the environment.	Tijuana

Table 21: Methodologies/models on flood hazard studies

Methodologies/Tools	Brief Description	Case Studies
Thesis Master Degree		
Correlation analysis	Set of statistical techniques used to measure the strength of the association between two variables. The main objective of correlation analysis is to determine how intense the relationship between two variables. Usually the first step is to display data in a scatter plot.	NW of B.C.
General Circulation Model (GCM).	Are mathematical algorithms that try to simulate the earth's climate system. These models are in the top of the hierarchy of climate models are coupled (atmosphere-ocean and soil) and variables predicting changes in a longer time. Mathematical expressions that make up a GCM can be analyzed separately within the three major parties that comprise these models: (1) the dynamics of the climate system that describes the large-scale movement of air masses and transport of energy and momentum, (2) the physics of the climate system such as transmission of radiation through the atmosphere, thermodynamics, and evaporation, and (3) other factors such as ocean atmosphere interaction, topography, and parameters vegetation. These statements are based on physical laws such as conservation of energy and mass as well as empirical relations based on characteristics and trends, such as formulas that relate temperature and humidity with cloud formation.	NW of B.C.
ENSO Index	ENSO is the most important coupled ocean-atmosphere phenomenon to cause global climate variability on interannual time scales. Here we attempt to monitor ENSO by basing the Multivariate ENSO Index (MEI) on the six main observed variables over the tropical Pacific. These six variables are: sea-level pressure (P), zonal (U) and meridional (V) components of the surface wind, sea surface temperature (S), surface air temperature (A), and total cloudiness fraction of the sky (C).	NW of B.C.
Empirical Orthogonal Functions (EOFs).	This method consists of estimating the spatial variability patterns (principal empirical modes) and their associated temporal variability (coefficients of expansion) that accounts for most of the variance contained in a matrix space / time of a parameter.	NW of B.C.
Social Vulnerability	The first type of vulnerability to hydrometeorological phenomena (Vulnerability 1), involving housing with tin roofs and wooden walls, which would seriously damaged in the event of flooding (hydro-meteorological phenomenon). By overlaying SAVANE GIS, the land use issues rated), population density, and strength of the housing (1), results in the identification of four categories of vulnerability: very low, low, medium and high.	Tijuana
Publication		
Southern Oscillation Index (SOI)	Is calculated from the fluctuations of the pressure difference between the Australian city of Darwin (Western Pacific) and the island of Tahiti (Central Pacific). Negative values of the SOI often indicate episodes of the Child. These negative values are often accompanied with a warm Central and Eastern Pacific, a decrease in the strength of trade winds and drought in the north and east of Australia.	Tijuana
Precipitation Index	A number that indicates positive or negative behavior of a parameter (the rain), based on statistical data, which may be related or compared to another related parameter. During El Niño, to develop an objective forecast of rain, it should correlate the SOI with the corresponding index of precipitation in each locality.	NW of Mexico

Table 22: Methodologies for climatological hazard studies

Methodology Name	Brief Description	Case Studies
QuikScat (Santa Ana Winds and Wildfire)	The method consists of ocean wind observations from the SeaWinds scatterometer aboard the QuikScat satellite. This instrument is microwave radar that measures both the speed and direction of winds near the ocean surface.	B.C.
Aerial photography (Drought, Santa Ana Winds and Wildfire)	It is the taking of photographs of the ground from an elevated position. The term usually refers to images in which the camera is not supported by a ground-based structure. Cameras may be hand held or mounted, and photographs may be taken by a photographer, triggered remotely or triggered automatically.	B.C.

3.3.3 Santa Ana winds

See Table 22 for information on climatological hazard studies.

3.4 Data availability and quality

3.4.1 Intermediate data

Intermediate data were found for earthquake and flood hazard (Tables 23 and 24). Data for earthquakes are useful for landslide studies. For wildfires, the intermediate data available are maps of potential fires zones (graphically are present areas prone to wildfires for the entire country of Mexico and land use maps). These maps are in a document prepared by the National Forestry Commission (CONAFOR) and are for the entire country on a large scale with few details for each state.: http://www.conafor.gob.mx/portal/index.php/temas-forestales/suelos. For drought and Santa Ana winds hazard, there is only basic data.

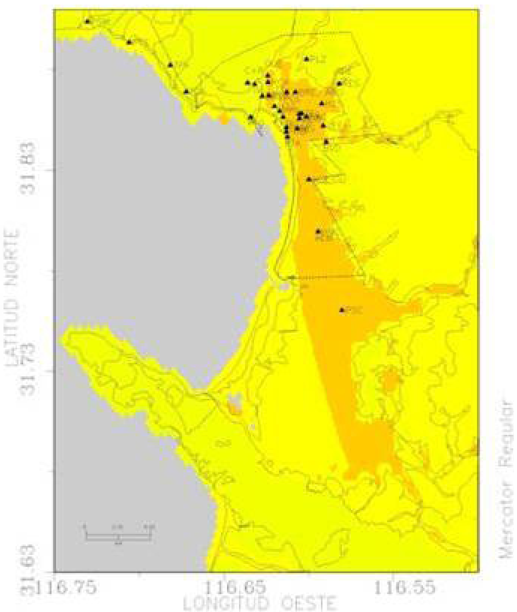
3.4.1.1 Earthquake

In B.C. studies are available on aspects related to the sesimotectonic framework relevant for designing of micro-zonation maps and in estimating the expected structural damage. Predictive maps of seismic intensities are available for the cities of Ensenada, Tijuana and Mexicali in reports and thesis done by CICESE as shown in Figures 10-12. The combination of these two studies would result in a seismic risk study for the State. For the cities of B.C. there are intermediate and basic information to carry out risk assessment projects, the list of these data is shown in Tables 23 and 24.

The only institution that has worked in the intermediate data collection for seismic risk studies is CICESE. These data are the result of CICESE studies and projects with several government institutions and are available in the reports and thesis presented in each project.

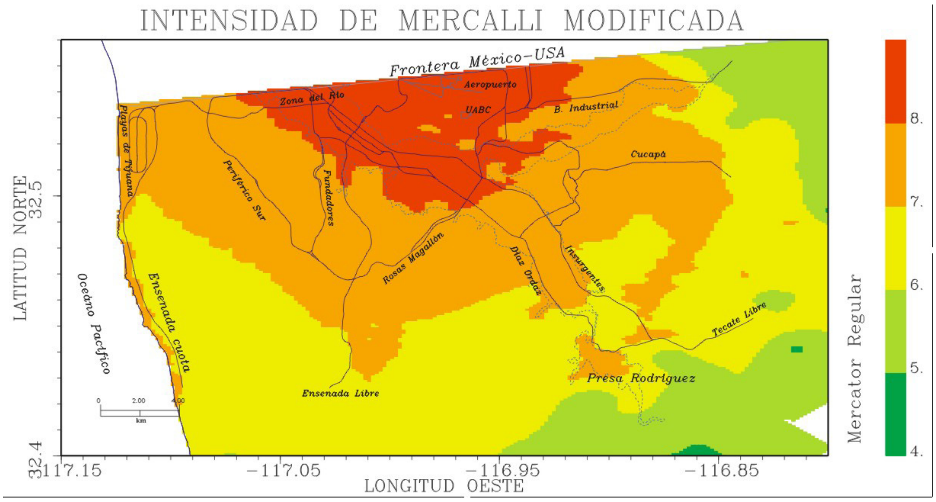
Institutions with exposure data of population, critical structures and infrastructure are the Civil Protection Offices by Municipality and State, IMIP, IMPLAN and INEGI, the latter covering the whole country.

Figure 10: Value distribution of modified Mercalli intensities, for Ensenada



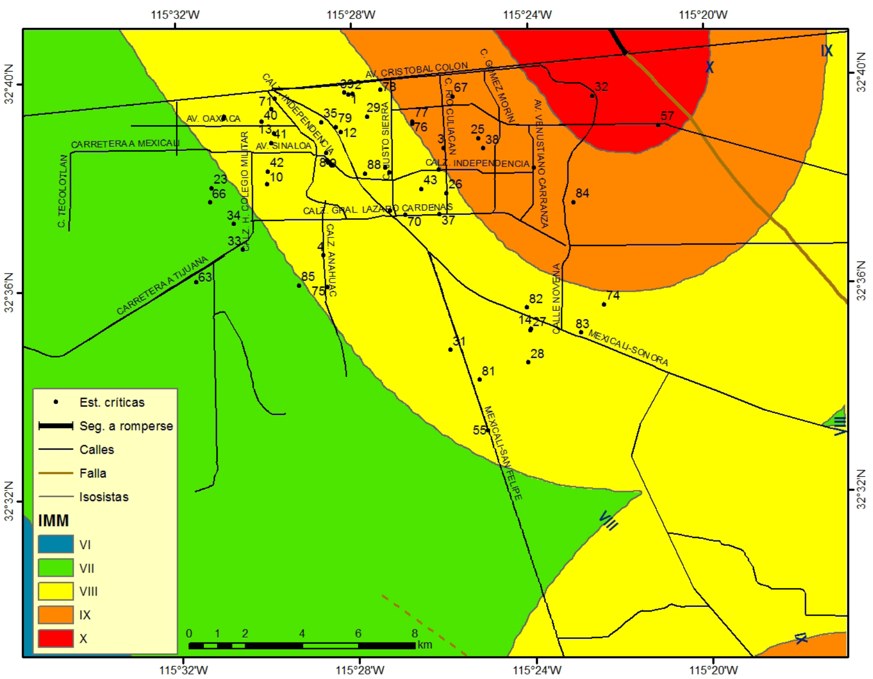
Intensities calculated for a proposed earthquake with Mw=6.8 in the San Miguel fault (Soares, 2003).

Figure 11: Value distribution of modified Mercalli intensities, for Tijuana



Predictive map of modified Mercalli intensity, expected to breakdown of La Nacion fault Mw= 6.5. It includes the site effect shear velocity 30. (Acosta et al., 2009).

Figure 12: Value distribution of modified Mercalli intensities, for Mexicali



Map of intensities on the Modified Mercalli scale, for the joint analysis of the breaking of the Imperial fault segments (Mw=6.46) and Cerro Prieto (Mw=6.54). Includes site effect shear velocity 30. (Gamez, 2008).

Table 23: Intermediate data for earthquake risk studies

Category	Coverage	Data Sets	Remarks	Year
Hazard	Mexicali	- Peak Ground Acceleration Maps - Peak Ground Velocity Maps - Spectral Seismic Response Maps - Energy Maps - Modified Mercalli Intensity Maps (MMI) - Shear wave velocities propagation on the first 30 meter of the ground. β_{30}. - Amplification factors of the soil with respect to the rock - Seismic scenarios	CICESE: - Seismic Microzonation for Mexicali. - Seism-tectonic and site effects in the assessment of the seismic response in Mexicali, B.C. Scale: 1:200,000	2007-2008
	Tijuana	- Peak Ground Acceleration Maps - Peak Ground Velocity Maps - Spectral Seismic Response Maps - Energy Maps - Modified Mercalli Intensity Maps (MMI) - Seismic scenarios - Maps of dominant periods of the soil	CICESE: Seismic Microzonation in urban zone of Tijuana - Scale: 1:200,000	2009
	Rosarito	- Shear wave velocities propagation on the first 30 meter of the ground. β30. - Maps of dominant periods of the soil	CICESE-SEDESOL Study for the identification of seismic micro-zoning in the colony "Ampliación Ejido Plan Libertador" Playas de Rosarito, B.C. Scale: 1:200,000	2009
	Tecate, Ensenada, Tijuana, Mexicali	Maps of dominant periods of the soil 1:150000	Thesis - CICESE Library - Maps of the urban areas of the soil ground motion in terms of the vibration dominant period (DP)	2004
	Ensenada	- Peak Ground Acceleration Maps - Peak Ground Velocity Maps - Modified Mercalli Intensity Maps (MMI)	Thesis - CICESE Library - Application of seismic micro-zoning the vulnerability of critical structures in the city of Ensenada, B.C.	2003
	Valle de Ojos negros - Ensenada	- Shear wave velocities propagation on the first 30 meter of the ground. β30. - Map of maximum values of the relative amplifications of movement of soil - Peak Ground Acceleration Maps - Peak Ground Velocity Maps	Thesis UANL - CICESE Effect of local geology on the seismic response of soils in the Ojos Negros valley, B.C.. Scale: 1:200,000	2003
Exposure	B.C	- Short-term economic indicators (3295 in 23 sub-series) - Population	INEGI	2010
		Catalogue of Schools in B.C.	SEE	
	Ensenada	Catalogue for Critical and Strategic facilities for the city of Ensenada.	Thesis - CICESE Library - Application of seismic micro-zoning the vulnerability of critical structures give the city of Ensenada, B.C.	2003
		- Catalogue of Industries in Ensenada - Catalogue of infrastructures in Ensenada	IMIP - Ensenada	2009
	Mexicali	Catalogue for Critical and Strategic Structures for the city of Mexicali.	Seism-tectonic and site effects in the assessment of the seismic response in Mexicali, B.C.	2008
		Catalogue of schools, critical structures and infrastructure in Mexicali.	DEPC	
		Catalogue of infrastructures in Mexicali	IMIP- Mexicali	
	Tijuana	Catalogue of infrastructures and critical structures	DMPC- Tijuana IMPLAN	

Table 24: Intermediate data for floods risk studies

Category	Coverage	Data Sets	Remarks	Year
Hazard	Ensenada	Flood Map	IMIP	2009-2011
	Tijuana	Flood Risk Map	Study conducted by COLEF. Hydro-meteorological risks. This type of risk is established by the overlap of susceptibility and social vulnerability, to see the response of households and the risks to a hydro-meteorological event.	1996
		Social Vulnerability Map	Study conducted by COLEF. The overlap in SAVANE GIS with topics like land use (classify), population density and resistance housing give as result four categories for vulnerability.	1996
		Critical Flood Zone Maps of Tijuana.		2007
		Danger zone Map Arroyo La Rinconada, Tijuana	IMPLAN	
Exposure	Ensenada	Atlas Risk Assessment and Natural Hazards 2nd Stage: Flood Exposure data about critical structures and infrastructures: Port areas, streets, Highways, Roads and electrical stations.	IMIP, the data has cost	2009-2011
	Tijuana	Development urban Map in Tijuana 1889-1997, hydrology is included.	Publisher by COLEF	2006

3.4.1.2 Flood

Because most common hazards in B.C. are floods, there have been some maps of possible flooding areas associated to social vulnerability mainly for Tijuana and Ensenada, some examples are shown in figures 13-17.

Such data are considered intermediate and are very few (Table 24). Their availability is subject to a cost mainly in institutions as IMIP and Informatics, Statistics and Geography National Institute (INEGI); others are found in publications and thesis, but we don't know if the information has been used for risk assessment studies, for example maps of figures 12 and 13. IMIP shares hazard and vulnerability maps of Ensenada online for free (Figure 16). Likewise the DEPC has developed flooding hazard maps for each municipality of B.C., but the used technique to elaborate them is unknown (Figures 15 and 17).

Figure 13: Hazard map: types and degrees of risk in the urban area of Tijuana, B. C. (Romo, 1996)

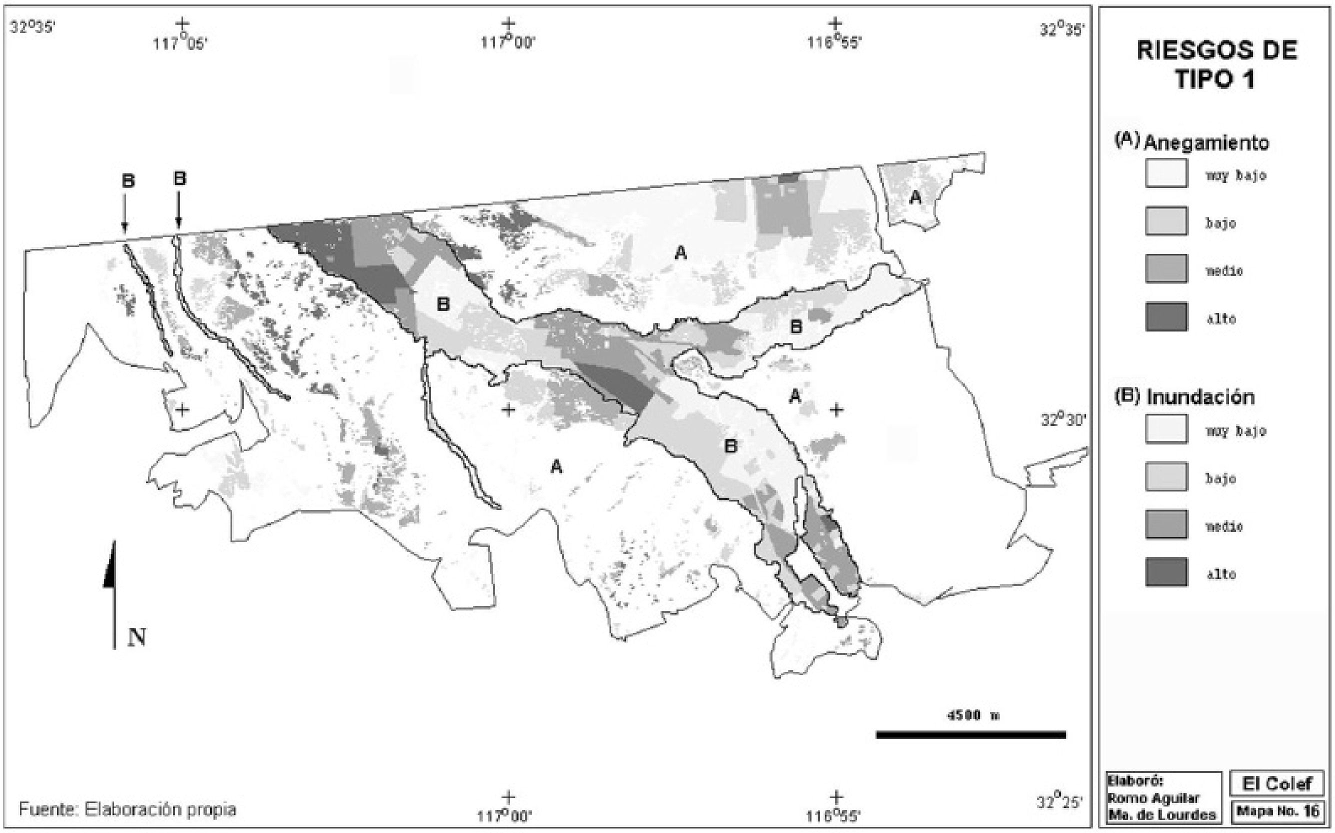


Figure 14: Map of social vulnerability for Tijuana (Romo, 1996)

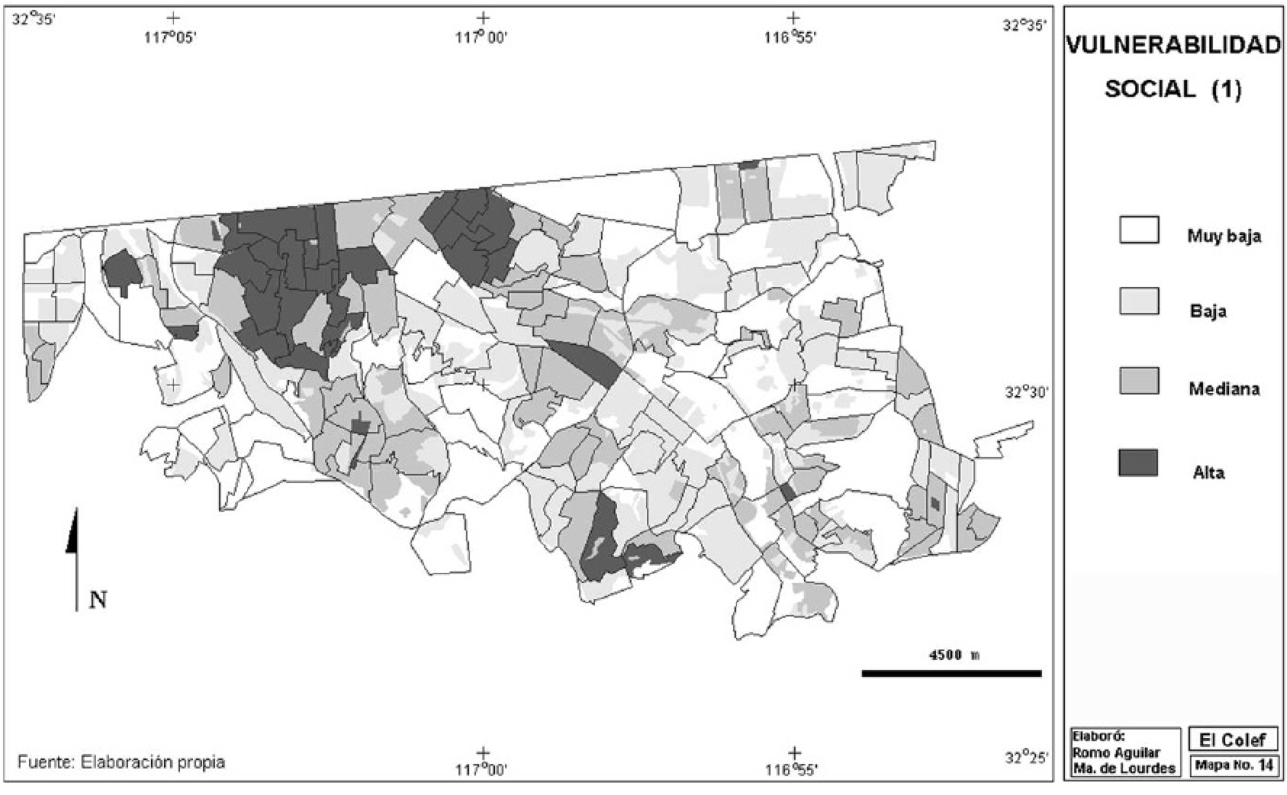


Figure 15: Identification of flood risk zones of Tijuana and Rosarito (SGG and DPC BC, 2003)

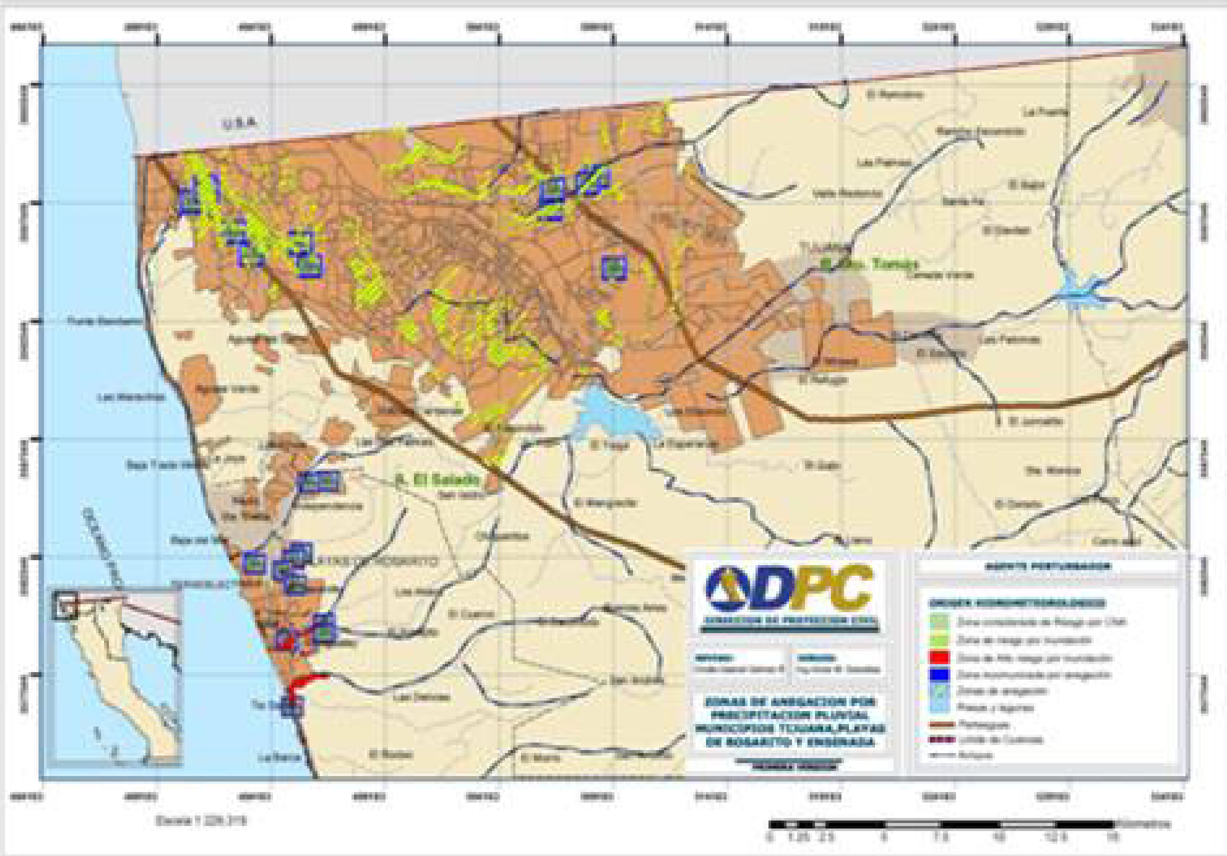


Figure 16: a) Flood hazard map for Ensenada
b) Map of floods vulnerability rate in Ensenada (IMIP 2009-2011)

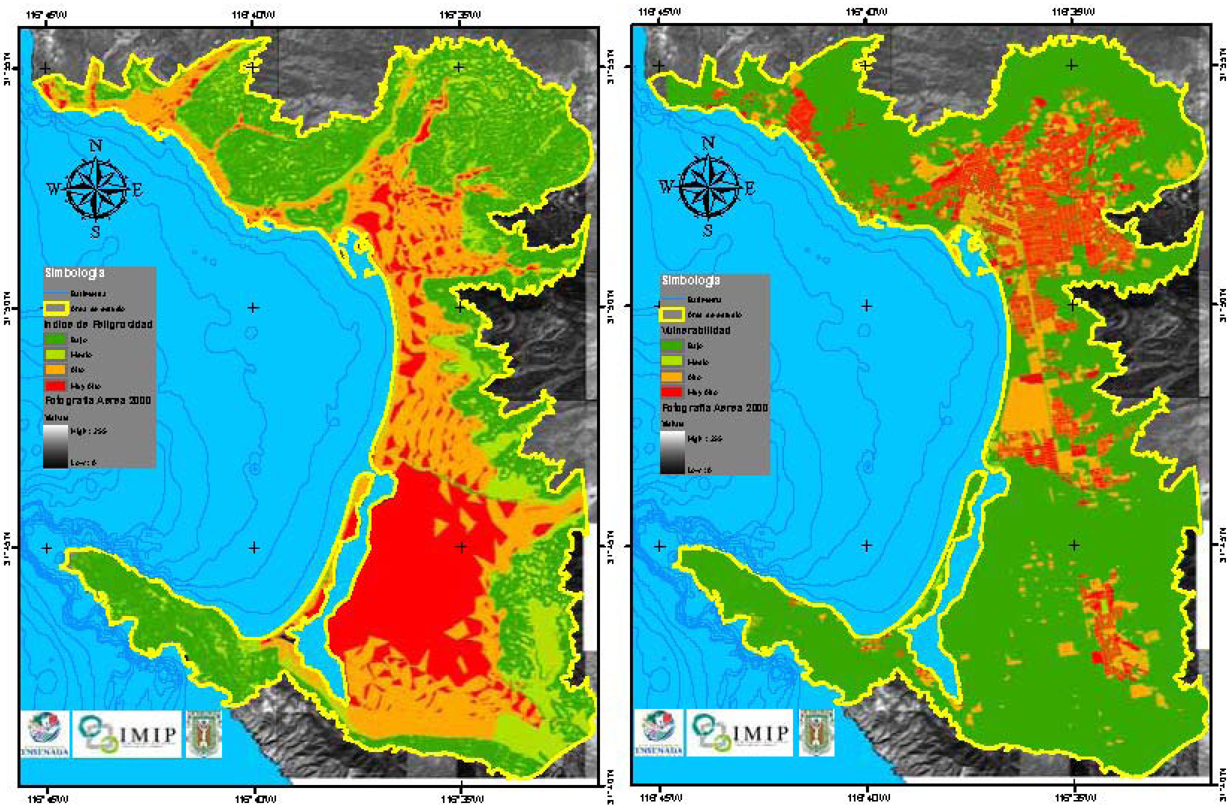
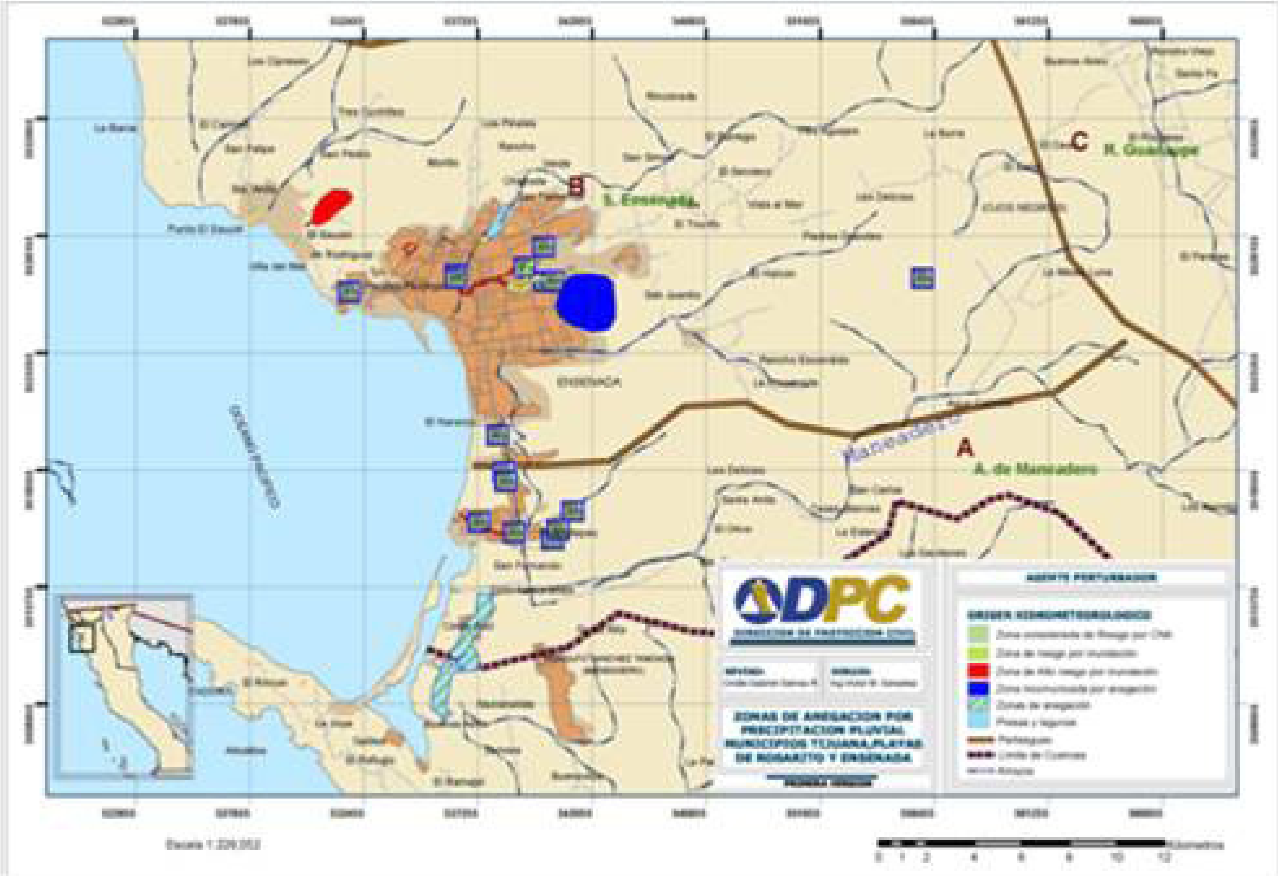


Figure 17: Identification of flood risk zones of Ensenada (SGG and DPC BC, 2003)



3.4.2 Basic data

Basic Data are available in different institutions such as CICESE, CONAFOR, IMIP, INEGI and CONAGUA. Most of them are available for the public with the exception of some data from INEGI, which have some cost. They come in various formats (*.DGW, *.SHP, *.MIF, *.DGN, *.DXF, *.BIL, *.IMG, *.ASCII,) and with different coverage.
Table 25 shows the basic data for all hazards (earthquakes, flood, landslide, drought and Santa Ana winds with wildfire).

Table 25: Basic Data for all hazards in Baja California

Data	Quality	Data format	Institution
Fault lines map Geological map Topographic map Bathymetry of the Mexican Pacific and Gulf of Mexico Seismic catalog and map Soil typology Digital Elevation Model Depth of level phreatic level Flow distribution channel Hydrologic Maps Daily precipitation data Scanned and georeferenced maps	Scale 1:300,000 and 1:500,000 Scale 1:250,000 from 1975 From 1978-2011. Scale 1:300,000	*.shp* Press and Digital *.ascii Press and Digital (*.RST, *.IMG)	CICESE - PEMEX (PEMEX have fault line maps, but they don´t share the information) CICESE
Data Isotherms and Contours Maps water vapor, visible and infrared. Rainfall, possible flooding, vaporization and humidity Satellite Image GOES East	Data from 24hrs.	*.img, *.ascii	CONAGUA
Cartography urban and rural	1:10,000 1:25,000 1:50,000 1:250,000	Press and digital (*.DWG, *.SHP, *.MIF, *.DGN and *.DXF)	INEGI IMIP, IMPLAN
Satellite image: 261 LANDSAT images from July 2007 to February 2010 681 MODIS images from November 2007 to December 2009 ERS-2 Ortophotos Vectorial data: Surface and groundwater hydrology Natural Resources	Resolution LANDSAT: Data can obtain raw, gereferencing, ortorectify or to merge. The resolution is between 15, 30, 60 and 120m MODIS: In real time 250m 2 bands 500m 5 bands 1km 29 bands ERS-2: Data can obtain raw, with ratiometric correction or georeferencing. Resolution: 100 m Scale 1: 10 000, 1: 25 000 y 1: 50 000 Scale 1: 1 000 000 y 1: 250 000	Press and digital (*.dwg, *.shp, *.mif, *.dgn and *.dxf)	INEGI
Topography: Altimetry Altimetry (by state) Pipe lines Pipe lines (by state) Communication route Communication route (by state) Digital Elevation Model Lidar DEM continuous surface Lidar DEM continuous field High resolution LiDAR DEM	Scale: 1:1 000 000 1: 25 000 y 1: 50 000 1: 1000 000 Vectorial data: 1: 1 000 000 to download Scale 1: 50 000 Resolution 5 m Resolution 5 m	Press and digital (*.DWG, *.SHP, *.MIF, *.DGN and *.DXF)	INEGI

3.5 Professional expertise and skills

A state risk assessment team, according with GRIP criteria, would be ideally composed of the following specialists:

- Disaster Risk Management Specialist
- Geological Hazard (risk) specialists
- Hydro-meteorological Hazard (risk) Specialists
- Structural engineers
- Socio- Economic experts
- GIS specialists

There are five specialists who are engaged in risk studies as shown in Table 26. However, there have been experts that have been involved in work or publication about risk studies, but not often engaged with this kind of work.

There is enough information about specialists in earthquake hazard studies. The vast majority of them are engaged in scientific research studies and most of the studies have not been applied to perform risk projects. Most of the researchers are engaged in hazards studies, as is the case of CICESE and UABC.

There has not been found in the State any risk study publication done by structural engineers. There is a College Association of Civil Engineers that prepares professionals in this type of work, but their products are still unknown.
It is not known about socio-economic experts who are dedicated to making disaster loss assessment. The government is responsible for making this assessment; however, there are not publications on how they do the assessment. For example, is unknown how the government made the loss estimation about the earthquake for the April 4, 2010, which was published in a local newspaper.

Specialists in GIS are in all institutions, but the applications for seismic risk studies in GIS are very few. One application with this tool was done for a project about shelters in Tijuana to visualize in Google maps. At least there is one GIS operator in the following institutions: CICESE, COLEF, UABC, IMIP, (Mexicali and Ensenada), Planning Municipal Institute (IMPLAN), DMPC (Tijuana, Rosarito, and Ensenada) UMPC and DEPC.

Figure 18 shows data found in the entire State of B.C. of specialists in each area of risk assessment. The number 0 means that there is no information yet. Details of specialists in this figure are in a worksheet in the annexes.

Figure 18: Professional expertise and skills found in public information until 2010, this list is still updating

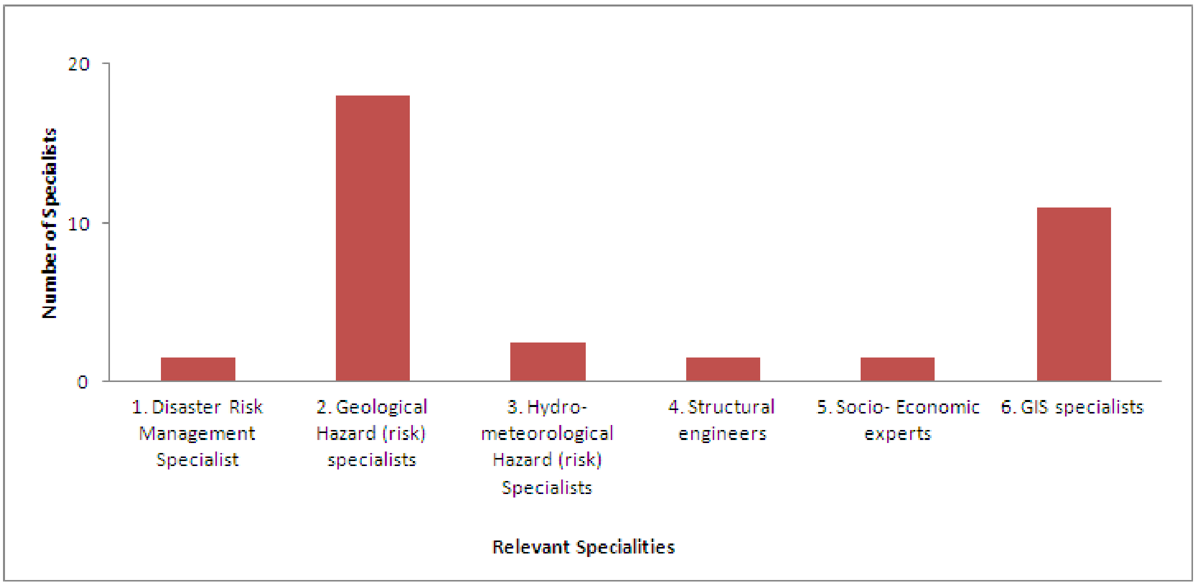


Table 26: Key professionals' expertise and skills among others

Experts	Academic position	Research interests	Experience	Speaking
Disaster Risk Management specialist	Antonio Rosquillas Director of Civil Protection Office in the Municipality Tijuana.	Great ability to develop proposals and cooperation agreements with other institutions. Highly committed to its responsibility to prevent and respond to emergencies.	15 years as Director of the municipal civil protection office (5 municipalities). Tijuana RADIUS group's founder and board member.	Spanish and English
Earthquake hazard (risk) specialist	Luis H. Mendoza Garcilazo MSc. CICESE Researcher	Earthquake engineering and seismic response of structures. Risk seismic attenuation, site response and zoning.	30 years of experience on CICESE and 25 in seismic and geological risk He got resources for national and international prevention.	Spanish and English
Earthquake hazard (risk) specialist	José Guadalupe Acosta Chang MSc. CICESE Researcher	Seismic engineering, seismic site response and seismic microzonation.	31 years. Laboratory data processing applied to seismic engineering.	Spanish and English
Disaster risk specialist on Hydro-meteorological hazard	María Tereza Cavazos Pérez. Ph.D CICESE Researcher Climate Change and Variability	Global climate change and regional impact. Meteorology and climatology and large-scale regional.		Spanish and English
Disaster Risk specialist on geo-hydrological hazard	Juan Manuel Rodríguez Esteves Ph.D Regional Director COLEF at Nogales, Sonora and Mexicali, B.C.	Environmental issues, geography and anthropology of disaster risk. Research interests: environmental and development problems. Geography of risk. Anthropology disaster.	Coordination of research of the faculty of Geography and Regional Planning at the University of Guadalajara. Director of the Department of Urban Studies and the Environment (April 2007 to October 2010).	Spanish English Portuguese
Disaster Risk specialist on geo-hydrological hazard	Judith Ley García Ph. D. UAB.C., Research and Graduate Coordinator at the Institute for Social Research.	Urban Studies, Industry and environment, planning, risk assessment and planning, geomatics applications.		

3.6 Institutional capacity

The inventoried institutions show that 22 of them between academic and government are related to earthquakes and floods studies (hazard, risk analysis, basic and intermediate data) in B.C.

CICESE is very well trained to perform earthquake risk assessments, and in the State, is the institution specialized in this type of work. However it has no staff engaged in risk assessment studies. Also it has experience in flood hazard, because in this institution is the Forecast Meteorological Laboratory at the Department of Physical Oceanography with experts on the subject.

COLEF is an academic institution which has performed more risk studies for several hazard and risk scenario studies, in technical coordination with CICESE and with government institutions.

Governmental institutions have information on basic and intermediate data, useful for developing risk assessment studies and risk scenarios; some data are free but others, as data from IMPLAN, IMIP, PEMEX, TELNOR, CFE and INEGI have a cost.

Governmental institutions as IMIP and IMPLAN, are interested in carrying out hazard and risk studies, and have the mandate in decision making. According to the information contained in the inventories, these institutions have developed projects on vulnerability analysis; however, they do not have the necessary expertise for studies related to risk assessment, unlike the Tijuana Civil Protection Office, which has experience in the subject. This institution, and the ones of its kind in each municipality, takes part in surveys and damage assessment after a disaster, as read in newspapers. It should be noted that currently no database exists to contain this information.

State Civil Protection Office and the Civil Protection Office of each municipality make material damages recognition or assessment after a disaster, as from newspapers, but has not been found any inventory of these damages. This information and costs assessment are needed and, after having it, must be available to the public. CONAGUA and CONAFOR are government institutions responsible for making decisions on climate risk. Table 27 shows the list of institutions that are involved in flood hazard studies, either conducting only studies on risk analysis, hazard, or providing data (basic and intermediate) for analysis.

Table 27: Key institutions related to flood studies in Baja California (hazard, risk assessment, intermediate and basic data)

No.	Institution	Mission	Data information
Academic			
1	Center for Scientific Research and Higher Education at Ensenada (CICESE)	To generate knowledge and develop technologies that may contribute to the solution of national and regional problems through basic and applied research and the development of human resources at the graduate level, in the areas of biology, physics, computer science, ocean and earth sciences, within a framework of responsibility, ethic and leadership for the benefit of the society.	Earthquake hazard, with some studies about risk. Intermediate and basic data required for risk assessment studies.
			Flood hazard, with a project in process about risk. Basic data required for studies hazard.
2	Northern Border College (COLEF)	Scientific and Teaching Research Center specialized in the study of the problematic Mexican – USA border region and works in transforming knowledge to help in planning and decision making in Mexican border cities.	Earthquake hazard and vulnerability studies, intermediate data about exposure of economy and population.
			Intermediate data about vulnerability and hazard.
3	Autonomous University of Baja California (UABC)	To promote viable alternatives for social, economy, politics and cultural development of B.C. and the country, through the integral formation, training and actualization of professionals; generating scientific and humanitarian knowledge, technological development and applications pertinent to the state, country and world sustainable development.	Earthquake hazard.
			Risk and Hazard Project about flood.
Government institutions sharing basic and intermediate data			
4	Federal Electricity Commission (CFE)	Federal Government Organism in charge of planning the National Energy System. It is a decentralized public organism, with juridical presence and own patrimony.	Intermediate data about exposure of: Electrical Power Substations, Transmission Towers & Power Lines. It has this information, however, it is not available for the general public
5	Petroleos Mexicanos (PEMEX)	Decentralized Federal Organism which goal is to explore and exploit oil and other strategic activities that constitute the national oil industry, maximizing to a long term period the hydrocarbon economic value, and satisfying client necessities with quality and in harmony with community and environment.	Earthquake hazards (Fault maps, geologic maps). It has this information; however, it is not available for the general public.
6	State Water Commision (CEA)	Decentralized public organism with juridical personality and own patrimony. It establishes the norms, on planning and coordination of projects and actions related to works of en bloc water transportation and distribution.	Exposure: Reservoirs & -Canals

7	Social Development Board (SEDESOL)	Formulating, conducting and promoting territorial politics that lead to an including, arranged and sustainable development, for cities and regions. In coordination with state and municipal authorities, the implementation of programs and projects that stimulates local social and economic activities with the participation of private and social sectors; and in decisions and actions to confront globalization and social integration challenges.	Earthquake hazard and risk studies
8	National Water Commission (CONAGUA)	The National Water Commission (CONAGUA) is an administrative, normative, technical, consultative and decentralized agency of the Ministry of the Environment and Natural Resources (SEMARNAT). To manage and preserve national waters and their inherent goods in order to achieve sustainable use, with joint responsibility of the three tiers of government (federal, state, and municipal) and society as a whole.	Hydro-meteorological data Meteorological data
9	State Utilities Commission Mexicali, Tijuana, Ensenada(CESPM-CESPT-CESPE)	Provide potable water and sewerage system adequate quality and quantity at the lowest cost, encouraging saving and water culture as indispensable means of life and community development.	Exposure: Dams, Reservoirs & -Canals, Water & Sewer Lines. It has this information, however, it is not available for the general public
10	Planning and Research Municipal Institute of Ensenada (IMIP- Ensenada)	It has authority in decision making and government politics. In is a research, urban planning and social participation decentralized institution with juridical personality.	Flood studies, Aerial photography.
11	Municipal Planning Institute (IMPLAN-Tijuana)	It has authority in decision making and governmental politics in Tijuana.	Vulnerability indicators databases, studies. Exposure of population, buildings, critical facilities and infrastructures.
12	Planning and Research Municipal Institute of Mexicali (IMIP-Mexicali)	To elaborate and instrument urban plans, programs and projects that Mexicali municipality requires for its sustainable development, strengthening its identity with technical and scientific basis and criteria and community participation.	Vulnerability indicators databases, studies Exposure of population, buildings, critical facilities and infrastructures.
13	National Statistics and Geography Institute (INEGI)	Capturing, processing and diffusion information about the whole Mexican territory, population and economy. All in just one institution with the responsibility of generating statistical and geographical information. Coordinator of the Statistic and Geography National Information System.	Basic and Intermediate data: Hydro-geological maps, DEM, Orthophotos, satellites imagine. Exposure of population and vulnerability indicators database.
14	State Educational System (SEE)	To fairly provide and promote education, culture and sport services to the state population.	Earthquake Exposure: schools catalogue
15	Northwest Telephone Company (TELNOR)	A subsidiary of Teléfonos de México that operates in the State of Baja California and the Northwest of the state of Sonora	Exposure: infrastructure; Telecommunications lines. It has this information; however, it is not available for the general public.
Government institutions for use and decision making			
16	Municipal Civil Protection Directorate in Mexicali (UMPC)	To protect life and health of Mexicali inhabitants, public and private property and the environment, before a provoked disaster caused by natural or anthropogenic disasters, through actions that reduce life loss, health, and material destruction.	Earthquake hazard and risk studies Risk Atlas Exposure information of: population, buildings, critical facilities and infrastructures. Vulnerability studies.
17	Municipal Civil Protection Office in Tijuana (DMPCT)	It has authority in decision making and governmental politics.	Earthquake hazard and risk studies. Strategies and action plan for about hazards and vulnerability assessments in Tijuana: Flood. Hazards Projects and Atlas: Flood. Data: meteorological reports, cyclones path. Vulnerability studies Risk Atlas Exposure information of: Population, buildings, critical facilities and infrastructures
18	Municipal Civil Protection Office in Ensenada (DMPCE)	To establish the basis for integration, coordination and functionality of the civil protection system. It has authority in surveillance and certification of installations and items related with the safety of people and economic materials.	Earthquake hazard and risk studies Meteorological reports, cyclone path map. Risk Atlas Vulnerability studies. Exposure information of: Population and buildings.

<table>
<tr><td>19</td><td>Municipal Civil Protection Office in Rosarito (DMPCR)</td><td>It has authority in decision making and governmental politics of Playas de Rosarito.</td><td colspan="2">Earthquake hazards studies. Exposure information of: Population and buildings.</td></tr>
<tr><td>20</td><td>Municipal Civil Protection Office in Mexicali (DMPCM)</td><td>To protect life and health of Mexicali inhabitants, public and private property and the environment, before a provoked disaster caused by natural or anthropogenic disasters, through actions that reduce life loss, health, and material destruction.</td><td colspan="2">Risk Atlas for Mexicali
Hazard projects: Flood
Exposure: Population, buildings, critical facilities and infrastructures
Vulnerability studies</td></tr>
<tr><td rowspan="2">21</td><td rowspan="2">Civil Protection State Office (DEPC)</td><td rowspan="2">It has authority in decision making and governmental politics in the State of B.C..</td><td>Earthquake hazard and risk studies.</td><td rowspan="2">Risk Atlas Exposure information of population, buildings, critical facilities and infrastructures.</td></tr>
<tr><td>Atlas y mapas, reporte hydrometeorologic.</td></tr>
<tr><td>22</td><td>Government Board Office (GobB.C.)</td><td>Mandate for decision making.</td><td colspan="2">Vulnerability of structures and infrastructures.
Exposure: critical facilities and infrastructure</td></tr>
</table>

3.7 National DRM/DRR system

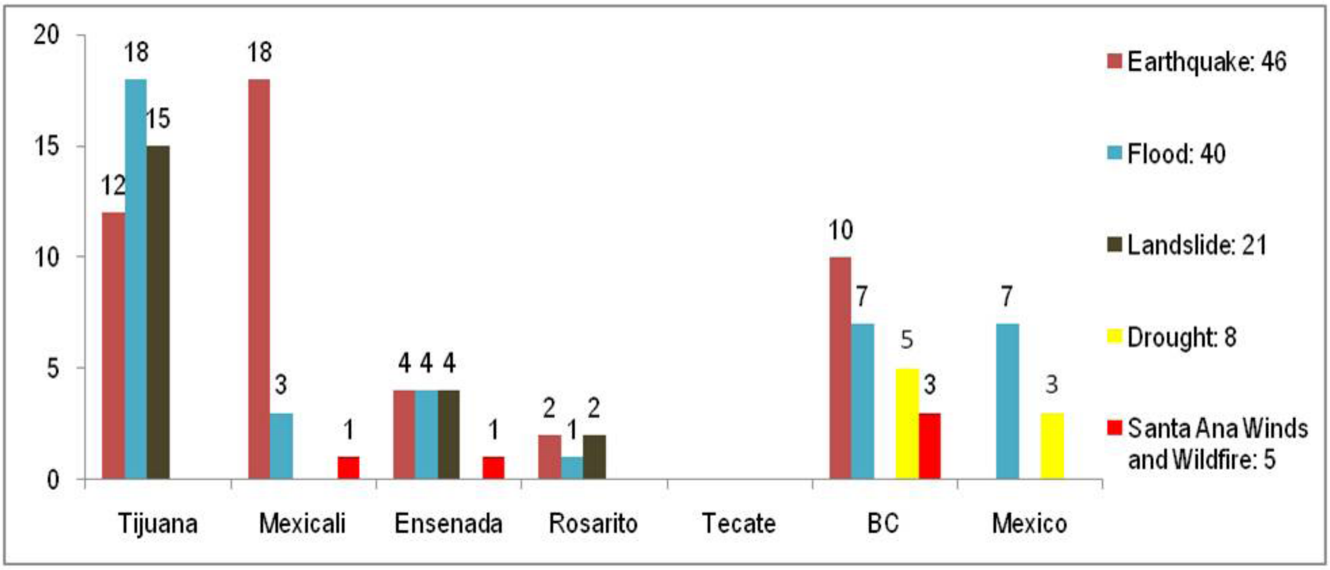
There is not a statewide system that includes all organizations and sectors with risk management functions and disaster risk reduction.

The CENAPRED http://www.cenapred.gob.mx/es/, is the national system that includes all organizations in the country that work in disaster prevention. CENAPRED main responsibility is to support the National Civil Protection System (SINAPROC) in technical requirements that their operation demand. It conducts research, training, implementation and dissemination on natural and human phenomena that may lead to disaster situation and actions to reduce and mitigate the negative effects of such phenomena.

At State level DEPC governs the functions of disaster risk reduction; however, this institution pays attention to emergencies more than to risk management.

4. Overall State Situation Evaluation

Figure 19: Studies realized in B.C., including reports on past disasters, and risk and hazard assessment



4.1 Current status

4.1.1 Risk Evaluation

There are many useful studies on risk evaluation in B.C. which include, hazard assessment, basic data to construct hazard maps, physical and social variables, reports on past disasters and risk analysis studies. Studies have been of local, state and national level, the latter including of course, the State of B.C. (Figure 19). Of the 120 studies including this report, only 4% are on risk evaluation (earthquake and floods), other studies focus more on hazard and a small number on vulnerability analysis.

4.1.2 Institutional Capacity

Academic institutions are often responsible for natural hazard assessment, together with some government institutions. Most experts work on hazard assessment, and not engaged in risk evaluation and vulnerability, of physical and socio-economic conditions.

4.1.3 Strategies, action plans, policies and regulations

Some hazard and risk studies have been used in the municipality of Tijuana to work on disaster prevention measures or emergency response, contingency plans and atlas of hazards: earthquakes, floods and landslides. Likewise, simulations guidelines were formulated on how to face emergencies based on risk studies results. These plans and guidelines are available to the public in the Tijuana Civil Protection Office website.

4.1.4 Financing

Studies and projects related to the issue of risk disasters have been financed by international organizations like GRIP, International Decade for Natural Disaster Reduction (IDNDR), United Nations Education Science and Cultural Organization (UNESCO) and UN-HABITAT; by National Council of Science and Technology (CONACyT) for scientific research projects; by the State and Federal Government and private sector as:

Fund for the Prevention of Natural Disasters

(FOPREDEN): Federal
Social Development Secretary (SEDESOL): Federal

Department of Environmental Protection (SPA): Federal

State Public Service Commission of Tijuana (CESPT): B.C. State

State Civil Protection Office (DEPC): B.C. State

Federal Roads and Bridges and Related Services Revenue (CAPUFE): Federal

Energy Federal Commission (CFE): Federal

Mexican Oil (PEMEX): Federal

LEYCA: Private

4.2 Issues and Challenges

The main problem to carry out risk assessment studies has been the lack of support from government institutions responsible of decision making. There are no long term strategies that integrate and guide the activities and efforts that now are being done in isolation, to ensure and monitor progress in the process of disasters risk reduction. Proposals for risk assessment projects in B.C. have to compete with other priorities and interests of the Municipality or the State. Political will of authorities is needed to create a strategy in the government plan that supports and coordinates risks assessment projects.

Academic institutions dedicated to conduct hazard studies, also, have little support for risk assessment projects. Their priority is purely in scientific and theoretical issues which have better options to be financed by CONACyT. The appropriate mechanisms must be created to continuously update the risk assessment projects, methodologies and data, as well as making proper disclosure of what exist promoting information exchange.

Coordination among government and academic institutions should be improved to make better proposals and get national or international funding, showing the use of results of previews studies and documenting the impact that disasters would have in the State's economy.

Also, it is necessary to involve different society sectors to work hard within this kind of projects. This would help different sectors to understand the risks that affect their industry and find effective solutions to reduce them. Also it would help to promote the exchange and integration of information, and to consider the interests of all sectors in the solutions and recommendations that may be proposed. It would generate a sense of appropriation from all sectors and finally prepare the necessary conditions for the implementation of the mitigation options identified by risk studies.

Finally, it is necessary to demonstrate, in a clear and easy understanding, the positive impact of these studies that will increase public safety and property, the protection of the developed processes and an appropriate and well informed decision making from government.

Only, if these difficulties and shortcomings are overcome, would generate interest and support form authorities and citizens that would make available the resources needed to implement these activities.

4.3 Strengths and weaknesses

Strengths

1. The tools and basic data are very com plete and of good quality, and are a good basis for studies to evaluate hazards and risks of the State. They are:
   - Seismological Network in Northwestern Mexico and database
   - Weather stations and meteorological forecast laboratory
   - The Hydro meteorological and Climate Disaster Network
   - Basic data and maps with good resolution in both hazards (earthquakes, rains)

2. There are good methodologies and technology for earthquake risk assessment, even though there is little experience in the use and application of methodologies for a comprehensive assessment of risk to other hazards. Methodologies for seis-

mic risk assessment in the city of Tijuana, Ensenada and Mexicali, can be applied state wide and to other cities.

3. Academic institutions have worldwide links with other institutions and very good technology. They are capable to develop projects in risk assessment and count with appropriate tools to do it, and a staff with Ph D, and Masters Sciences degrees in issues related to the different natural hazards.

4. In the municipality of Tijuana, efforts have been devoted to the mitigation of disaster risk on an ongoing basis during the lasts municipal governments and have generated interest, involvement and support for projects related to risk. It has increased the awareness of the need for risk management, and community participates (Tijuana RADIUS Group) in workshops to be a safe city to natural hazards. There has been political support for this municipality since it is the most vulnerable to all natural hazards prevalent in Baja California.

5. Since 1998 talks on risk issues began with the Tijuana RADIUS Group (GTR), which since then, has been participating and supporting projects and strategies for disaster risk reduction. The Group comprises representatives from over 40 institutions of Tijuana, and has maintained regular monthly meetings by more than 10 years, even after the project ended with United Nations in1999; to promote the implementation of a Disaster Risk Reduction Action Plan in Tijuana.

Weaknesses

1. In the risk assessment studies conducted for Baja California economic loss assessment was not performed. Most risk studies focus only on hazard analysis, and there is much conceptual confusion between risk and hazard.

2. Weaknesses are found particularly in methodologies and/or data on flood and earthquake hazards. Moreover as it is already known which are the most of ten affected municipalities, these studies were not performed in other geographic areas. These are not repeated in other geographic areas; so there are no studies in municipalities where the hazard is not frequent. (example: Playas de Rosarito and Tecate municipality)

3. Information in intermediate data for risk assessment studies is missing, such as maps of hydro-meteorological hazards, and supporting documents to know their use and application. Some maps are not understood and nobody use them. There are no probabilistic or deterministic maps in flood hazard for recurrence periods or water height. Until now, flood risk studies are a hazards inventory. Other elements to be included in a risk study are physical, social and economic vulnerability.

4. There are few experts specialized in risk assessment and risk management, both needed to cover the entire State. There are missing socio-economic experts, structural engineers, and vulnerability assessment experts, and also are missing experts in risk evaluation for hydro-meteorological hazards.

5. The use that has been made of these studies is minimal, there are good works, but they are not used, perhaps because no one knows about them. Few studies are found in thesis or project reports and although these studies have approaches to risk reduction strategies, is somewhat difficult for the government to use them due to its lack of knowledge.

6. No funding is allocated annually for risk studies. As mention earlier the lack of political support, because in its mandate has been giving priority to other community needs. It is thought that as a hazard is not frequent, no risk studies are needed. Example of that has been Ensenada.

4.4 External support needs and requirements

To improve the situation, challenges and weaknesses mentioned above, the State needs to:

- Continue funding for projects in risk studies;
- Prevention policy vision;
- Specialize staff in risk assessment for all hazards;
- Awareness and participation of the community;
- Development of new techniques in accordance to the physical environment of Baja California for all hazards;
- Continually update the Atlas of risk for all the hazards throughout the State;
- Create programs and risk management strategies that determine the acceptable level of risk.

5. Recommendations and Suggestions

5.1 Scope and Context of State Risk Assessment

Currently, Baja California has not a strategy to guide Disaster Risk Management programs and activities. To facilitate effective Disaster Risk Management, an evidence-based, multi-year strategy is required that has measurable goals and monitoring and evaluation mechanisms. Such a strategy can be prepared only when there is a clear understanding of the disaster risk – its causes, distribution, magnitude and likelihood – as well as of effective, feasible mitigation options. This understanding is achieved through the implementation of a comprehensive disaster risk assessment and evaluation. The results of the Systematic Inventory and Evaluation for Risk Assessment (SIERA) reported here recommend a comprehensive State risk assessment that considers the 5 more important hazard types: earthquakes, floods, landslides, droughts and Santa Ana winds. Given the State's demographic characteristics, the State risk assessment should cover, mainly the urban areas, which accounts for most of the State population.

The assessment of the risk assessment situation in Baja California, which is reported here, produced many recommendations on what needs to be done to achieve a good understanding of the risk associated to natural events. The following are among the most important recommendations:

- Creation of a mechanism for the systematic collection and analysis of information on past disasters in order to learn from the State's history of disasters damages to all natural hazards in each municipality;
- Compilation and update of informationfrom studies dated more older than 10 years old;
- Integration of existent studies in each municipality to consistently continue with the identification of missing studies to assess State risk.
- Implementation by local institutions of studies to complete the identified hazards profile for each municipality with local institutions;
- Implementation by local institutions of studies to assess physical, social and economic vulnerabilities that reflect the realities of Baja California;
- Implementation by local institutions of socio-economic studies to estimate the impact of extreme natural events on the economic activities in each municipality.

By completing the above mentioned activities, risk assessments can be performed for each one of the five municipalities of Baja California. Then, taking advantage of the consistency and compatibility of the local assessments, they can be integrated to have the State risk assessment for Baja California.

5.2 State-specific methodological framework

Developing methodologies for risks assessment in urban areas where highest population is concentrated, which contributes in many ways the increased risk. Methodologies must include:

- Identify and understand the hazards profile in the State
- Define the objectives of risk analysis in the State
- Consistency with national strategies in risk reduction, guidelines and policies.
- Include SIERA methodology for risk assessment
- Define the acceptable level of risk according to the situation of each municipality and produce scenarios for different purposes:
    - To prepare for an emergency: it should take periods of recurrence between 5 and 10 years
    - For urban planning and investment: the return period could take between 50 and 100 years

- For insurance purposes (risk transfer): it is suggested to take the "worst scenarios".

Notes:
Acceptable risk: The level of potential losses that a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions.

Risk transfer : The process of formally or informally shifting the financial consequences of particular risks from one party to another whereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party (UNISDR terminology, 2009).

5.3 Needs and requirements for capacity building

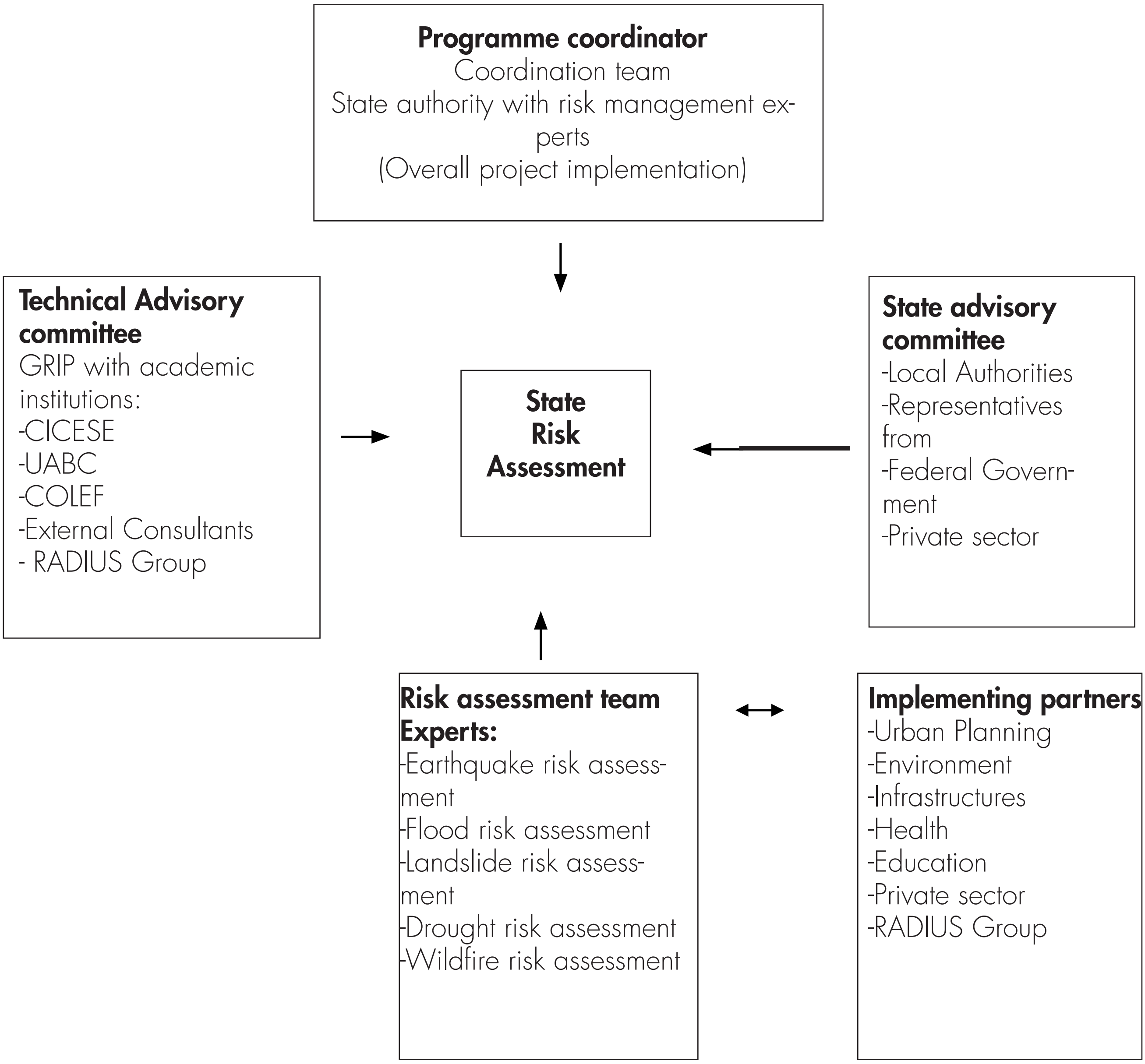
Institutional technical training, in assessment studies of flood hazard, droughts, landslides, Santa Ana winds and wildfires is recommended. This training is recommended because there is a lack of studies on risk assessment. To make sure that these efforts have continuity and sustainability, is recommended training in risk assessment methods, and a good coordination among institutions to share data and results.

It is recommended to establish a DRM / DRR (Disaster Risk Management/Disaster Risk Reduction) State level system. It is recommended to appoint and train a government institution that coordinates an Action Plan, with institutions and organizations related with risk assessment. The recommended institution to establish this system is the State Government through the State Civil Protection Office.

5.4 Coordination and Governance framework

A coordination structure must be implemented to develop the State Risk Assessment Action Plan. It should delegate, who coordinates, the activities by institutions according to needs and requirements for risk assessment (hazard, vulnerability, exposure). Recommendable for Baja California, must involve all institutions identified in this report. The State Government in collaboration with the 5 local governments must coordinate the implementation of risk assessment. The coordination structure (figure 20) would consist of:

Figure 20: Coordination and Government framework for risk assessment



- Coordination team: composed of a programme coordinator from the State government in charge of disaster risk management and a technical coordinator from a prestigious state technical institution, at a minimum. It is in charge of overall project implementation.

- State advisory committee: establishes priorities of the project according with the needs and requirements of the State. It ensures the interests of several society sectors (public, private and community), promotes the visibility of the project and its ownership.

- Technical Advisory committee: provides technical advice on risk assessment, its applications and revises the project for technical accuracy. It ensures the quality of the project products.

- Risk assessment team: Composed of a group of disaster risk management experts, hazard specialists, structural engineers, economists, social scientists, and information analysts, it is responsible for the implementation of all project activities. To ensure the sustainability of the State Risk Assessment, it is highly recommended that the risk assessment team be built with a long-term vision.

- Implementing partners: they are the agencies and institutions that keep and/or provide information needed for the State risk assessment and the establishment of the State Risk Information System. They work together with the risk assessment team to review and validate the results, the calibration of methodologies and the publication of the application results.

5.5 Implementation strategy and action plan:

To create a State Risk Assessment Action Plan, based on the evidences understanding of the magnitude of risk, characteristics, spatial distribution, causes and possible mitigation options of disaster risks, the following activities are recommended:

- To organize a meeting involving the different stakeholders to set up the priorities for risk reduction and define objectives of the action plan.
- To develop the Municipality and State Risk Atlas.
- To create a comprehensive assessment of main hazard profile for the State.
- To have a comprehensive analysis of the current situation in the State and establish the scope and context for the BC Risk Assessment, according with the SIERA results.
- To initiate the State Risk Assessment following the proposed methodology in 5.2
- To initiate the Risk Information System in BC (e-library)
- To establish institutional agreements to coordinate the main activities of the Risk Assessment in BC
- To Create a Disaster Risk Reduction Strategy based on results of the BC Risk Assessment.

These activities require an extensive participation of various parties at stake, in particular decision/policy makers, who are the most immediate users of the risk assessment results. In terms of relevant roles it suggested to follow the coordination framework of 5.4.

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