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DEVELOPING A METHODOLOGICAL APPROACH FOR A NATIONAL RISK INDEX FOR MEXICO

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To my parents and siblings who are always there, no matter the distance

To all my friends that this adventure has given me

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ABSTRACT

Mexico is particularly susceptible to geological and hydro- meteorological hazards, which are responsible for most of the disasters in the country. Disasters can have many negative effects; besides those produced during the event, there are also indirect and macroeconomic effects whose consequences can cause irreversible changes in the social and economic structures of a country. Despite Mexico has made great progress in risk management; there is still a lack of instruments, such as indicators and indices to assess disaster risk (measuring hazard, exposure and vulnerability) in an integrated and multidisciplinary way and on a sub-national level. Therefore this study tries to develop a risk index that helps to assess risk in Mexico in an integral way. The methodological approach of the World Risk Index and its four components to measure risk: Exposure, Susceptibility, Coping capacities and Adaptive capacities were used as base to this study. In total, twenty-one indicators were developed to assess individually the four components previously mentioned, as well as vulnerability and risk. The results are presented in maps that reflect the current situation of the states in each component. The study shows that, despite some of the states have lower exposure to natural hazards, their current social and economic aspects as well as their lack of coping and adaptive capacities increase their risk of suffering disasters. It was also found that there are big disparities among states and components. These findings can be useful in the future to implement, diversified pre-disaster strategies, according to the weaknesses and strengths of each state preventing human and economic losses and environmental damages.

Keywords:
Disaster risk, vulnerability, exposure, risk reduction.

RESUMEN

México es particularmente susceptible a fenómenos geológicos e hidro-meteorológicos, que son aquellos que causan la mayoría de los desastres en el país. Los desastres pueden tener muchos efectos negativos; además de aquellos que se registran durante el evento, también existen efectos indirectos y macroeconómicos cuyas consecuencias pueden causar daños irreversibles en las estructuras sociales y económicas de un país. A pesar de que México ha tenido un gran progreso en lo referente a la gestión del riesgo, todavía hay una falta de instrumentos, como indicadores e índices que ayuden a evaluar el riesgo a desastres (evaluado las amenazas, exposición y vulnerabilidad) de una forma integral y multidisciplinaria y a un nivel estatal o municipal. Por lo anterior, este estudio trata de elaborar un índice de riesgo que ayude a medir el riesgo en México en una forma multidisciplinaria. Como base, se utilizó la metodología del World Risk Index y sus cuatro componentes para medir el riesgo: Exposición, Susceptibilidad, Capacidades para hacerle frente a los desastres y las Capacidades de Adaptación. En total se desarrollaron 21 indicadores para evaluar individualmente los cuatro componentes anteriormente mencionados, así como vulnerabilidad y riesgo. Los resultados son presentados en mapas que reflejan la situación actual de los estados por componente. El estudio muestra que, a pesar de que algunos estados tienen baja exposición a desastres, sus actuales contextos socio-económicos así como su falta de capacidades de para hacerle frente a los desastres y de adaptación aumentan su riesgo a desastres. Además, se encontró que existen grandes disparidades entre estados y los componentes. Estos resultados pueden ser útiles para la implementación de estrategias pre-desastres diversificadas en el futuro, donde se tengan en cuenta las debilidades y fortalezas de cada estado para prevenir pérdidas humanas y económicas así como daños medio ambientales.

Palabras clave:
Riesgo de desastres, vulnerabilidad, exposición, reducción de desastres.

CONTENT

CHAPTER 1. INTRODUCTION

1.1. Disasters in Mexico

According to the United Nation Office for Disaster Risk Reduction (UNISDR, 2012) disasters caused by natural hazards such as hurricanes, earthquakes, landslides and floods have increased on a global scale. Between 2002 and 2011, were documented 4,130 disasters where 1,117 thousand people lost their lives, with an economic loss of approximately 1,195 billion dollars. Of these documented disasters, 302 occurred in 2011, where, 29,782 people died; 206 million people were affected (almost two times the current total population in Mexico); and where the estimate economic damages where of around 366 billion dollars (approximately the 2011 Gross Domestic Product (GDP) of the seven countries of Central America plus Bolivia and Peru).

Due to its geography and location, Mexico is particularly susceptible to geological and hydro- meteorological hazards, which cause most of the disasters in the country. According to the International Disaster Database (EM-DAT Database 2009), 169 of 207 major disasters registered from 1970 to 2013 in Mexico, were provoked by earthquakes, floods, storms and droughts; causing 15,337 deaths, 17 million affected people (more than the total inhabitants of the most populated state of Mexico in 2010) and economic losses of around 40 billion US dollars (more than the GDP of the two states with the highest marginalization in 2010).

Disasters can have many negative effects; besides those produced during the event, there are also indirect and macroeconomic effects, for example infrastructure damages, environmental changes, changes in development priorities, fiscal imbalances, rise in prices, job losses, GDP declining and changes in population pyramids among others (ECLAC, 2003); furthermore their consequences can extend in the long term and cause irreversible changes in the economic and social structures of a country (Jovel, 1989 in ECLAC, 2003).

This was the case, of Hurricane Paul that hit the Mexican territory in 1982 causing severe damages in the agricultural sector of Sinaloa; where thousands of hectares of croplands got lost, provoking a decrease in the production of some crops at a national level. Another example is the earthquake that struck Mexico City in 1984 which caused significant losses in public infrastructure. (Hospitals and schools were destroyed or damaged). There were a lot of indirect losses due to the disaster as well; the unemployment rate rose, people's personal income decreased, public finances experimented fiscal imbalances and the 1985 national GDP decreased, among others (Bitrán 2001).

1.2. Risk management in Mexico

After the 1984 Mexico City earthquake, the federal government strategy to address the impacts and negative effects of disasters was focused on a civil protection strategy; manly oriented toward the assistance of the population when a disaster occurs (risk identification and monitoring; early warning support; and aid and reconstruction) (Constantino & Dávila 2011). However these have been reactive and conservative practices which leave aside the preventing risk management, therefore the probability of occurrence of disasters is not reduced (Constantino & Dávila 2011).

Ernesto Cordero, the Mexican Minister of Finance from 2009 to 2011, mentioned that the Mexican government has begun to change its disaster management approach to institutional forms aimed to prevent the impacts of disasters. Nonetheless, it has been largely focused on risk transfer; hiring insurances and catastrophe bonds (Ministry of Finance 2006) and on using monetary instruments for financing post-disasters negative effects (Constantino & Dávila 2011) like the Fund of Natural Disasters, which aim is to support the states when the disaster exceeds their coping capacities. But still "these strategies treat only the symptoms and consequences and not the causes" of disasters (Aragón-Durand 2008, p.20).

There is a slight presence of the social dimension in the carried studies and reports; Schroeder &Cabrera (2007) point out that compared to natural hazards studies, there are few studies about risk and vulnerability in Mexico. Besides, theses information related to hazards does not quantify the consequences of the events, and the availability of information depends on the type of hazard and the scale of observation, where the majority of the existing data lies in a national scale (Schroeder & Cabrera 2007).

In their review Schroeder &Cabrera (2007) also found out that there is not a common methodology or consensus about vulnerability and risk and the elements which integrated them. This is the case of the misnamed “risk maps” (which each entity and municipality have to elaborated according to a guideline given by the National Center for Disaster Prevention (CENAPRED)) that in many cases are hazards maps (Schroeder & Cabrera 2007).

Although Mexico has made great progress in risk management and CENAPRED has improve their National Atlas of Risk and has been working in the analysis of it, there is still a need to develop a series of instruments, such as indicators and indices to assess disaster risk (measuring hazard, exposure and vulnerability) in an integrated and multidisciplinary (measuring social, economic and environmental aspects) way and on a sub-national level.

Thus, is it possible to develop a risk index that helps assess risk in Mexico in a multidisciplinary way, based largely on the World Risk Index methodology?

1.3. International Panorama and Benefits of Developing a Natural Risk Index

At international level there has been a paradigm shift about the concept of disasters. The Inter-American Development Bank (BID), defines them as "socio-environmental events whose materialization is the result of the social constructions of risk" (2010, p.1). Thus, governments, civil associations and international organizations have focused on risk management and in a greater or lesser extent; risk reduction has taken part in the decision-making process, in the public policy formulation and the development planning of the countries. (BID 2010).

In the World Conference on Disaster Reduction of 2005, organized by the United Nations, the international community stressed the need to promote strategic and systematic approaches to reduce the risk and the vulnerabilities that most of societies faced (UN 2005 in Birkmann 2006). In this regard, the conference defined the development of vulnerability and risk indicator systems as a key activity, because these systems would allow to the decision makers to measure the impact of disasters in a multidisciplinary way (social, economic and environmental) (UN 2005 in Birkmann 2006).

In this sense, some systems of indicators and indices have been developed at an international scale. Such is the case of the World Risk Index (WRI) developed by the Alliance Development in cooperation with the United Nations University Institute for Environment and Human Security and the Nature Conservancy.

This index is based on the assumption that not just the natural events per se, but also the social, economic and environmental factors, that characterize a country or a society, determine if a hazard can become a disaster (Alliance Development Works et al. 2012). Thus, the index provides a general perspective of disaster risk through a global risk map; where the levels of exposure to natural hazards, the susceptibility of a society, and their lack of coping and adaptive capacities to face a disaster are shown (United Nations Brussels 2013).

The development of a methodological approach for a national risk index for Mexico may provide relevant information for policy maker, allowing them to have a general perspective about risk and vulnerability in Mexico. With the creation of a risk map recognizing spatial risk distribution and identifying priority activities in aspects of susceptibility, coping capacities and adaptive capacities will be possible.

Having a risk index at a state level will help the states in the designing and implementation of proactive pre-disaster actions, taking into consideration their structural characteristics and current abilities. In addition, a risk index might generate social and economic benefits, because the better understanding of risks and their components will help us prepare and assign in a better way, the national and state budgets for risk reduction; as well as the implementation of diversified pre-disaster strategies, according to the weaknesses and strengths of each state preventing human and economic losses and environmental damages.

1.4. Research objectives

General objective

- Develop a national risk index for Mexico, largely based on the world risk index methodology developed by UNU-EHS

- Specific objectives

1. Analyze the gaps regarding information availability.
2. Adapt the WRI methodology for its implementation on an smaller scale (Mexico).
3. Assess the exposure, susceptibility, coping capacities and adaptive capacities.
4. Determine a risk typology for the Mexican states.

CHAPTER 2. THEORETICAL FRAMEWORK

2.1. Disasters, disaster risk, hazard and vulnerability

Over time there have been many theoretical approaches to disaster and the elements which take part in it. Wilches-Chaux (1993) points out that many definitions of disaster have just focused on the consequences of the event (all damages that the event can provoke) but that these do not consider the causes which provoked it.

In this context, there have been new definitions that see disasters in a more integrated way; making emphasis not just in the physical aspect or natural event but also in the social, economic and environmental factors that can trigger it. For example Cardona (2005a, p.1) defines disasters as “socio-environmental events whose materialization is the result of the social construction of risk”; and UNISDR (2004, p.2) states that a “disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk”.

Analyzing in a deeper way the above definitions, risk can be seen as a key element to understand disaster. UNISDR (2009, p.25) defines risk as “the combination of the probability of an event and its negative consequences” meanwhile disaster risk is “the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period” (UNISDR 2009, p.9). It is integrated by the natural hazard and vulnerability that a society faces; and it can be expressed in the next equation (Wisner et al. 2004).

$$Risk = Hazard \times Vulnerability$$

Regarding natural hazards, UNISDR (2009, p.20) defines it as a "natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage". In the other hand vulnerability can be understood as "the conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards" (UNISDR 2004, p.8). Susceptibility, could be described as "characteristics which describes the weakness of a system or element exposed" and coping capacities as "positive resources to deal with the negative impacts of a hazardous event and its impacts"(Birkmann 2007, p.21)

Then, disasters will depend on the interaction of "two opposing forces: those processes generating vulnerability on one side, and the natural hazard events (or sometimes a slowly unfolding natural process) on the other" (Wisner et al. 2004, p.60).

According to Cardona (1993, p.45), disaster risk can be reduced if "it is understood as the result of linking the hazards […] and the vulnerability of the exposed elements" (1993, p.45) and Romero and Maskrey (1993) agree that the only way to reduce the occurrence of disasters is, reducing the causes of vulnerability and not only the external physical aspects of it. Ginkel (2006) goes beyond and affirms that it is necessary to take into account all the forms or types of vulnerabilities that affect a society, its economy and environment (natural and built environment) to reduce disaster risk. Therefore it is necessary to go "from a hazard analysis to an assessment of vulnerability" (Birkmann 2006a, p.9).

In order to develop measuring methods of vulnerability, Birkmann (2006a), in a literature review, identified different conceptual frameworks of vulnerability:

- The double structure of vulnerability by Bohle.
- The sustainable livelihood framework by Chambers and Conway.

- The disaster risk community school.
    - Conceptual framework to identify disaster risk by Davidson and adopted by Bollin.
    - The triangle of risk by Villagrán de León.
- The ISDR framework for disaster risk reduction.
- Turner et al.'s Vulnerability Framework.
- The onion framework by UNU-EHS
- The pressure and release model (PAR model)
- Theoretical framework and model for holistic approach to disaster risk assessment and management by Cardona and Barbat.
- The BBC conceptual framework by UNU-EHS based on Bogardi/Birkmann and Cardona.

These conceptual frameworks show the different spheres of the concept of vulnerability and how it has been systematized (Birkmann 2006b). However this research only has focused on the BBC conceptual framework because is the framework in which the World Risk Index is based.

2.1.1. The BBC conceptual framework

As it was mentioned before, the BBC conceptual framework was developed by the UNU-EHS and it combines elements of the onion framework and the theoretical framework. It is based on the understanding that vulnerability is not static; therefore, its analysis and estimation should include, not just the assessment of disaster impacts of the past; but also the assessment of coping capacities and possible intervention tools to reduce it (Birkmann 2006b).

Furthermore; the BBC framework (figure 1) focuses on the three sustainability spheres (social, economic and environmental) and argues that "the vulnerability assessment has also to take into account the specific hazard type(s) and potential event(s) that the vulnerable society, its economy and environment are exposed to, and the interactions of both that lead to risk" (Birkmann 2006b, p.35). Physical vulnerabilities, such as organizational and institutional aspects are very important and must be analyzed under the three sustainability spheres (Birkmann 2006b).

Another important aspect is that the BBC conceptual Framework "views the environment on one hand as the event sphere from which a hazard of natural origin starts, an on the other the environment itself is vulnerable to hazards of natural origin and to creeping processes"(Birkmann 2006b, p.37).

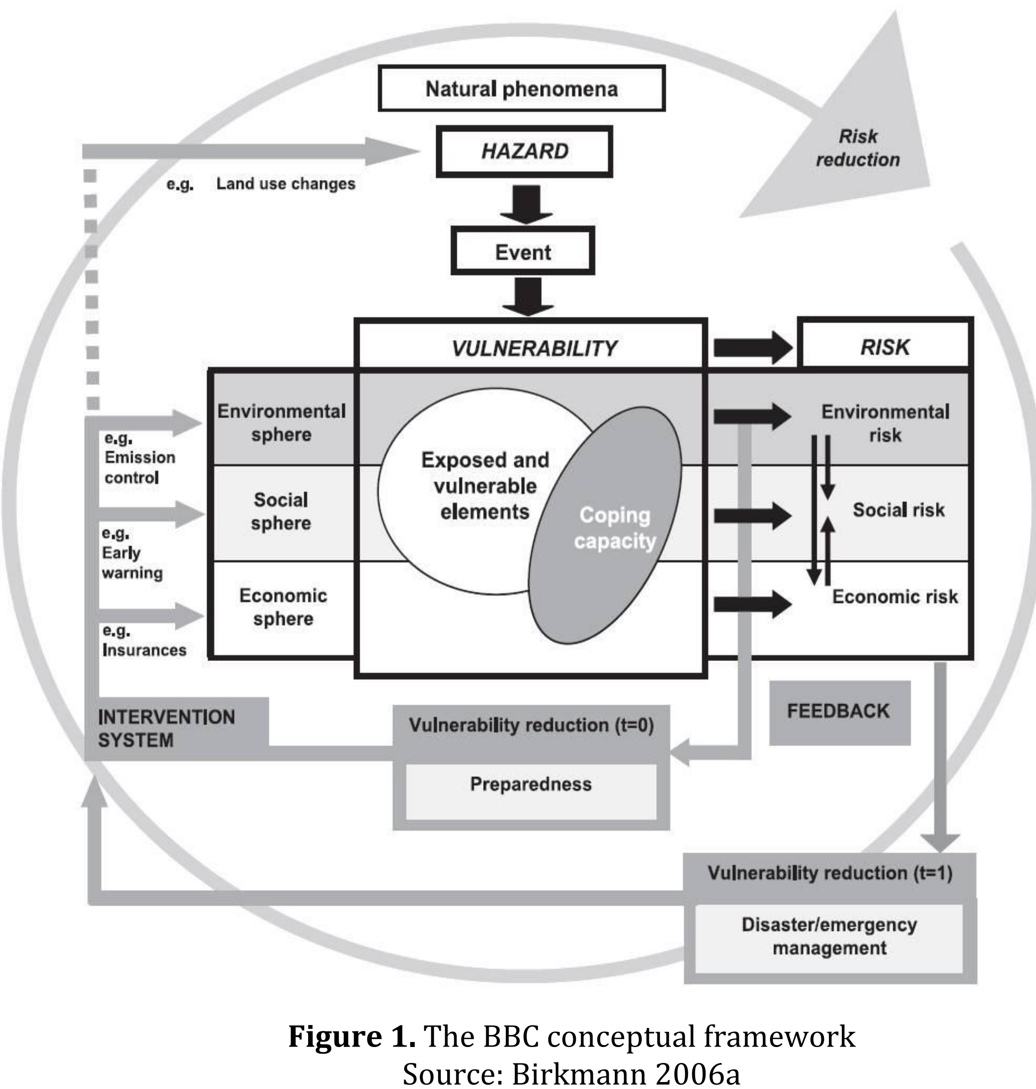


Figure 1. The BBC conceptual framework
Source: Birkmann 2006a

Finally, it promotes a problem solving perspective and proposes two ways of reducing disaster risk and vulnerability regarding the response: the first one related to preventive measures before a risk or disaster strikes a society (anticipates risk and take actions to reduce vulnerability, t=0) and the second one related to the response when a disaster occurs (disaster response and emergency management, t=1) (Birkmann 2006a; 2008).

2.2. Disaster risk management and Disaster Risk Reduction

The change of paradigm in the way disasters are seen and in the elements which influence it; have also changed the approach of institutions, NGO's and Governments for the effective treatment or reduction of risk. It has moved from the concept of Disaster Management towards the concept of Disaster Risk Management (Aquino et al. 2010).

According to the United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR) (2004, 17) Disaster risk management is defined as

> "The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures."

This mean, to focus on a pro-active approach, developing long term and better planned preparedness and prevention strategies before the hazard become a disaster (Baas et al. 2009).

According to Baas et al. (2009) the Disaster Risk Management encompasses three phases: pre-disaster, response and post-disaster; and these phases are also composed of several elements.

The pre-disaster phase is all the preventive actions held to limit the effects of hazards and to strengthen the capacities and resilience of a society. It also includes all the activities that help to determine risk. Its elements are risk assessment, prevention, mitigation, risk transfer, preparedness and early warning systems (Baas et al. 2009; Freeman et al. 2003).

In the response phase, the actions are related to the emergency response; all the activities are focused on saving lives and properties and providing relief to the society during the disaster (Evacuation, immediate relief, assessment of the damages and losses) (Baas et al. 2009; Freeman et al. 2003).

Finally the post-disaster phase is focused in infrastructure rehabilitation, reconstruction and economic and social recovery after a disaster(Baas et al. 2009; Freeman et al. 2003).

Another term widely used when talking about the pro-active approach is disaster risk reduction, that according to UNISDR (2009, 10) is defined as:

> The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Baas et al. (2009) considers that the difference between disaster risk management and disaster risk reduction is that disaster risk reduction focuses on prevention, mitigation and preparation against the impact of hazards in the context of sustainable development; whereas that disaster risk management includes disaster risk reduction (prevention, mitigation and preparation) but goes beyond and considers the response and post disaster actions.

Meanwhile Niekerk (2011) emphasizes that disaster risk reduction focuses on activities on a strategic level of management, while disaster risk management refers to the tactical and operational implementation of disaster risk reduction.

This research will take the distinction made by Baas et al; therefore disaster risk reduction will be understood as part of the disaster risk management. And in this logic, Bass et al. (2009) consider that the main goal of disaster risk management is the reduction of the risk factors and propose a disaster risk management framework with a holistic approach (figure 2) that incorporates risk reduction in the pre-disaster phase of disaster risk management.

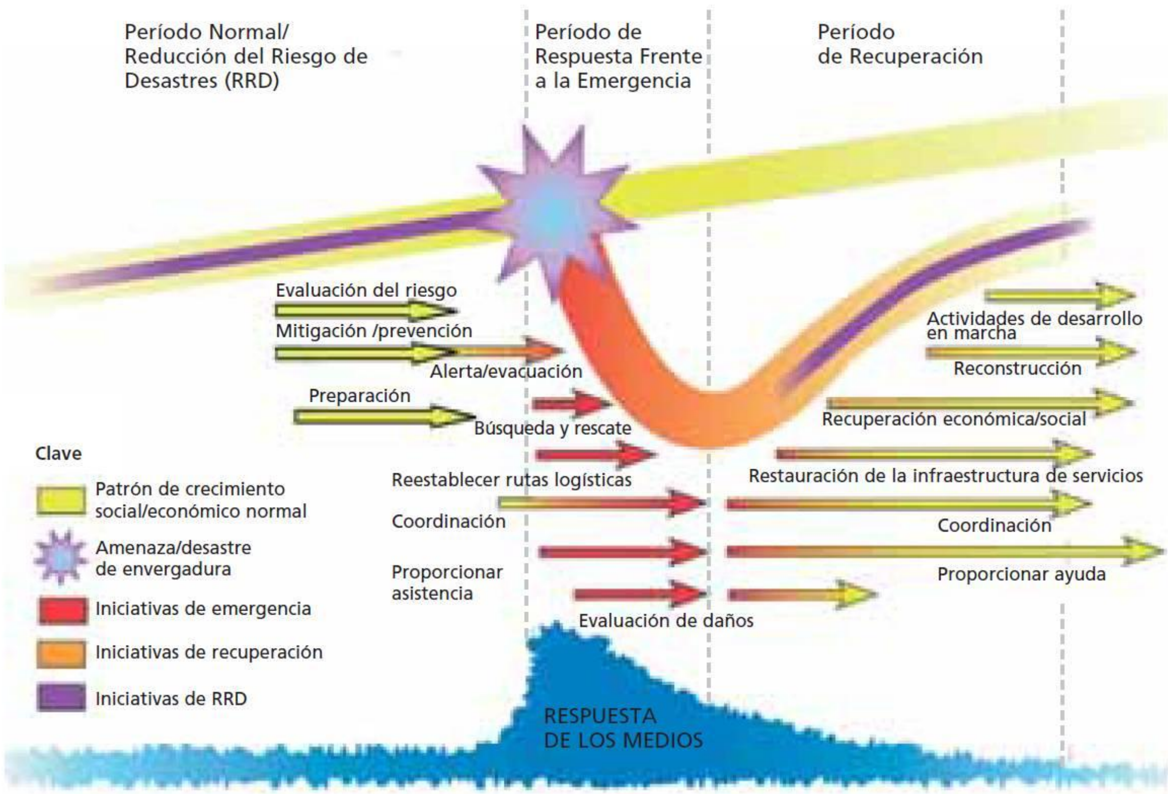


Figure 2. Disaster Risk Management Framework
Source: (Baas et al. 2009)

The understanding of all the elements or actions of the presented framework is very important however due to the aim of this research, the risk assessment element of the pre-disaster phase will only be explained below in a deeper way.

2.2.1. Disaster risk assessment

Identifying and measuring risk and vulnerability before and after a disaster are essential tasks for an effective long term risk reduction (Birkmann 2007). The United Nations Office for Disaster Risk Reduction - Regional Office for Africa (UNISDR AF) (2004) mentions that policy makers and managers in development need appropriate information in order to make effective decisions regarding how to address risk. Therefore risk assessment is a very important part of policy making and decision process because it not only analyses the hazards, their magnitude and probable losses, but also provide a complete understanding of the causes and impacts of the fatalities (United Nations Development Programme (UNPD) 2010).

UNISDR (2009, p.26) defines disaster risk assessment as:

> A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.

It includes the review of the technical characteristics of hazards, the analysis of exposure and vulnerability, the assessment of the effectiveness of coping capacities as well as risk mapping (UNISDR 2009); and it "emphasizes proactive management of disaster risk through reduction of both prospective and accumulated risk. Hence, it covers assessment of risk from future hazards as well as those that have already occurred"(UNISDR AF 2004, p.10).

UNISDR AF (2004) considers that as a management activity, disaster risk assessment has three phases:

1. Problem identification: In this phase what will be assessed has to be determined, and the disaster risk problem has to be identified and located in context. During this phase, it will be also necessary to determine the risk assessment goals.
2. Research and risk analysis: All the actions related to the identification of the parameters of risk, as well as the characterization of the hazard and the determination of the vulnerabilities of the elements at risk will be assessed during this phase.
3. Decision-making: This phase will be related to the process of ranking risk or the outcomes regarding the specific risk criteria, as well as assessing the options available to address the risk.

There are several techniques and tools used for assessing risk; and the use of a particular tool or technique will depend of the scope and aims of the disaster risk assessment (Disaster Assessment Portal 2014). Some of the techniques and tools most used are computer assisted tecniques, cost-benefit analysis, disaster risk indexing, Environmental impact assessment, Geographic information system mapping, Geospatial analysis, Hazard mapping, Participatory analysis, Qualitative analysis, among others (Disaster Assessment Portal 2014).

In the next section the development of indicators and indices as tools (Disaster risk indexing) to measure disaster risk will be explained in a deeper way.

2.3. The use of indicators and indices to measure risk and vulnerability

According to Birkmann (2006b), in order to understand the use, development and different approaches to measure risk and vulnerability with indicators and indices, it is first necessary to have a general understanding of their theoretical foundation (definition and differences, quality criteria basis for its development as well as their development phases).

Thus; in an epistemological sense, there are several approaches to understand and define the role of indicators. One of them related to their purpose; this approach classifies indicators under three perspectives (Gutiérrez 2009):

1. The use and construction of indicators, as information systems for planning, evaluation and decision making. Mainly oriented to governmental and institutional uses for the quantification of socio-economic information (Gutiérrez 2009).
2. Their purpose is systematizing information for statistical analysis about problems and social phenomena. The methodological process is very important and it is established by the investigator who generates the criteria of the research, thus the findings can be seen in the way the investigator wants (Gutiérrez 2009).
3. The third perspective is related to the construction or development of indicators. The researcher identifies the object of study and thinks about the way he can rebuild it theoretically and empirically (Gutiérrez 2009).

Regardless of the purpose of indicators, Gutiérrez states that “the importance of indicators is that they enable the application of qualitative and quantitative methodologies that lead to a theorization of the new object, as a renewed theory and as new knowledge (Gutiérrez 2009, p.20).

Knowing the epistemological sense of indicators, Gallopín (1997, p.15) defines indicators as "individual variables or as variable that are a functions of other variables" and argues that a variable is "an operational representation of an attribute (quality, characteristic, property) of a system" (Gallopín 1997, p.14). Therefore desirable indicators are those that "are variables that summarize or otherwise simplify relevant information, make visible or perceptible phenomena of interest, and quantify, measure, and communicate relevant information"(Gallopín 1997, p.15).

Likewise a vulnerability indicator can be defined as:

> "A variable which is an operational representation of a characteristic or quality of a system able to provide information regarding the susceptibility, coping capacity and resilience of a system to an impact of an albeit ill-defined event linked with a hazard of natural origin" (Birkmann 2006a, p.57).

And a holistic risk indicator is one which takes into account the physical aspects as well as the social, economic and cultural aspects; in other words must be formulated in terms of loads and resistances which represent the pressure and the capacity of support (Cardona et al. 2003).

Indicators (whether or not they be vulnerability / risk indicators) can be qualitative variables, rank variables or quantitative variables (Gallopín 1997) or according to their purpose they can be classified as context indicators (descriptive or predictive) or management indicators (Cardona et al. 2003).

The decision of which type of indicator should be used will depend of the existing data, and the economic costs to get the information. Gallopín (1997) considers that it would be better to use qualitative indicators when there is no quantitative information, when the attribute that wants to be assessed is not quantifiable and when the cost of getting the information is very high.

Independently of the type of indicators, these have to be relevant and their quality will be conditioned by "its ability to indicate the characteristics of a system that is relevant to the underlying interest determined by the goal or guiding vision" (Birkmann 2006a, p.59), this means that their development must be related to goals that can help in the identification of aspects that want to be assessed (Birkmann 2006a).

There are two types of indicator-goals relations (Weiland 1999 in Birkmann 2006b):

1. Focused on the direction or tendency. Hence the indicator assess if the development is increasing or decreasing.
2. Focused on a specific target. Here the indicator shows that a value has been reached and that the value means for example, if it is vulnerable or not.

Thus, their usefulness will depend of the goals as well as their function. Birkmann (2006a, p.62) made a review of different authors[1] where he found that the major functions of vulnerability indicators are:

- The identification and understanding of vulnerability
- Decision-making processes
- Reducing vulnerability
- Designing appropriate disaster reduction strategies
- Setting priorities
- Trend analysis
- Awareness raising
- Background for actions
- Empowerment

In general the development of indicators encompasses nine phases (Maclaren 1996 in Birkmann 2006b) (Figure 3). First the goals must be defined; then the target group, the purpose, the timeframe and the spatial bound of the indicators must be identified (scoping process). In the third phase the conceptual framework is delimited (here, the potential indicators are structured). Then, the selection criteria for potential indicators are defined; subsequently, these potential indicators are identified and in

[1] Benson 2004, Queste and Lauwe 2006, Green 2004, Billing and Madengruber 2006, The Expert Working group of UNU-EHS)

[2] It was taken the following regional classification. 1. Northeast integrated by: Chihuahua, Coahuila,

the sixth phase, the final selection of indicators is defined. The last three phases are focused on the implementation of the set of indicators. In the seventh phase the results are analyzed; then, in the eighth phase a report of the performance of the indicators are presented and finally an assessment of the performance is carried out (Maclaren 1996 in Birkmann 2006b).

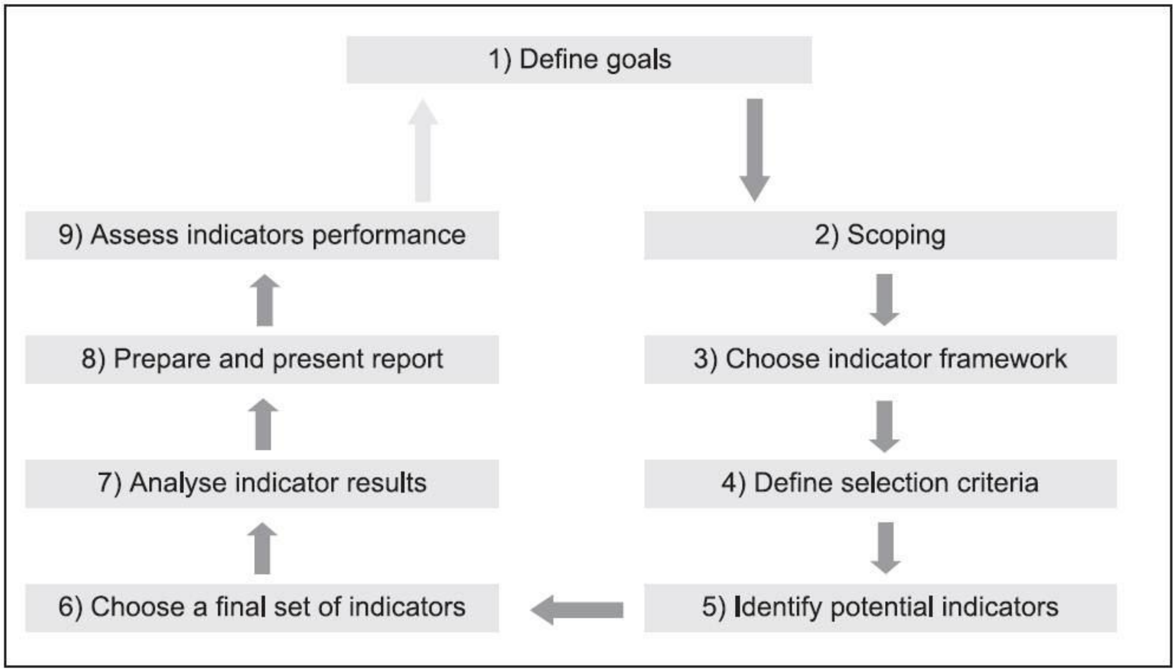


Figure 3: Development process of vulnerability indicators
Source: (Maclaren 1996 in Birkmann 2006b)

At the same time, the development of indicators has to meet certain requirements or quality criteria that support the selection of those indicators. Birkmann (2006a, p.65) enlists the following universal criteria:

- Measurable
- Relevant
- Represent an issue that is important to the relevant topic
- Policy-relevant
- Only measure important key-elements instead of trying to indicate all aspects
- Analytically and statistically sound
- Understandable

- Easy to interpret
- Sensitivity; be sensitive and specific to the underlying phenomenon
- Validity/accuracy
- Reproducible
- Based on available data
- Data comparability
- Appropriate scope

It is important to point out that, irrespective of the type of indicators and functions "it is a major challenge to measure risk […] through a system of transparent, representative and easy to understand indicators" therefore "any framework would have limitations due to the complexity of what is expected to reflect and measure" (Cardona 2005b, p.2).

2.4. The World Risk Index (WRI)

As it was mentioned in Chapter 1, the WRI was developed by the Alliance Development in cooperation with UNU-EHS and the Nature Conservancy as a response to develop new frameworks to measure risk and vulnerability in a holistic and multidisciplinary way.

In this index, the risk is seen as a complex connection of hazards with social, economic and environmental factors; therefore it tries to assesses the exposure of a natural hazard as well as the vulnerability of the society; differentiating between the factors which make a society susceptible, their coping capacities and their adaptive capacities after a disaster strikes (Alliance Development Works et al. 2011).

The index comprises a set of indicators grouped in 4 components:

1. <u>Exposure</u>: “The number of people exposed to a possible natural hazard”(Alliance Development Works et al. 2011, p.14).

2. <u>Susceptibility</u>: “Selected structural characteristics of a society and the framework conditions in which the social actors face potential natural hazards and climate phenomena” (Alliance Development Works, United Nations University, and The Nature Conservancy 2011, 16).

3. <u>Coping</u>: “The capacities of societies and exposed elements (such as systems and institutions) to minimize the negative impact of natural hazards and climate change through direct action and resources [...] includes available abilities and capacities that may be highly relevant for minimizing damages in the occurrence of a hazardous event” (Alliance Development Works, United Nations University, and The Nature Conservancy 2011, 16).

4. <u>Adaptation</u>: “Capacities, measures and strategies that enable communities to change in order to address expected negative consequences of natural hazards and climate change [...] adaptive capacities and measures are strongly aimed at the transformation of current structures (education, status of the environment, etc.)” (Alliance Development Works, United Nations University, and The Nature Conservancy 2011, 17)

In the next chapter more information regarding the indicators and the methodological framework will be presented.

CHAPTER 3. METHODOLOGY

3.1. Scope and study subjects

The present research has an analytical approach because it aims to measure and understand risk in Mexico assessing, separately, exposure and vulnerability as elements that integrate risk. Also, in order to develop the risk index, only available statistical information was used. Moreover, as the methodological framework (explained later in this chapter) was largely based on the WRI, an analysis of the limitations and difficulties to apply it on a subnational level was held.

It is also an applied research because it tries to comprehend and compare disaster risk among the states. And, by assessing individually each element of risk the research tries to find the behavior of these elements or the weakest capacities in each state so the results can help, in a future, to establish differentiated risk reduction strategies.

And finally it is a quantitative research because it involves the collection of quantitative data and its analysis using statistical methods.

The study was held in Mexico and the study subjects were its 31 states and Federal District. The reasons to elaborate an analysis by states, is because states are the second level of government with own autonomy and sovereignty in the country, therefore the entities have capability and authority of decision. Besides, the states are responsible of carrying out actions related to risk reduction and civil protection within their territory.

3.2. World Risk Index (WRI) methodology

In the previous chapter it was mentioned that the WRI is divided into four main components to assess risk. Each of those components is simultaneously divided into subcategories which are integrated by indicators. At total, the WRI is composed by 28 indicators.

Each indicator has a certain weight inside each subcategory. At the same time each subcategory has a certain weight inside each category, and each category has a maximum weight to determine the disaster risk index (Alliance Development Works et al. 2012). Below the indicators by component, their weights and the procedure to obtain the WRI are presented.

<u>Exposure</u>

It focuses on the natural hazards that stroke in any part of the world from 1970 to 2005 and takes into consideration the following five natural hazards (Alliance Development Works, United Nations University, and The Nature Conservancy 2011, p.16):

- Earthquakes
- Storms
- Floods
- Droughts
- See level rise

Exposure is assessed through five indicators (Figure 4). The population exposed to earthquakes, cyclones and floods has a maximum weight of 100% and the population exposed to droughts and see level rise has maximum weight equivalent to 50%. The sum of these two values is divided by the total population to get the total population of a country (expressed in percentage) exposed to those natural hazards. (Alliance Development Works et al. 2012)

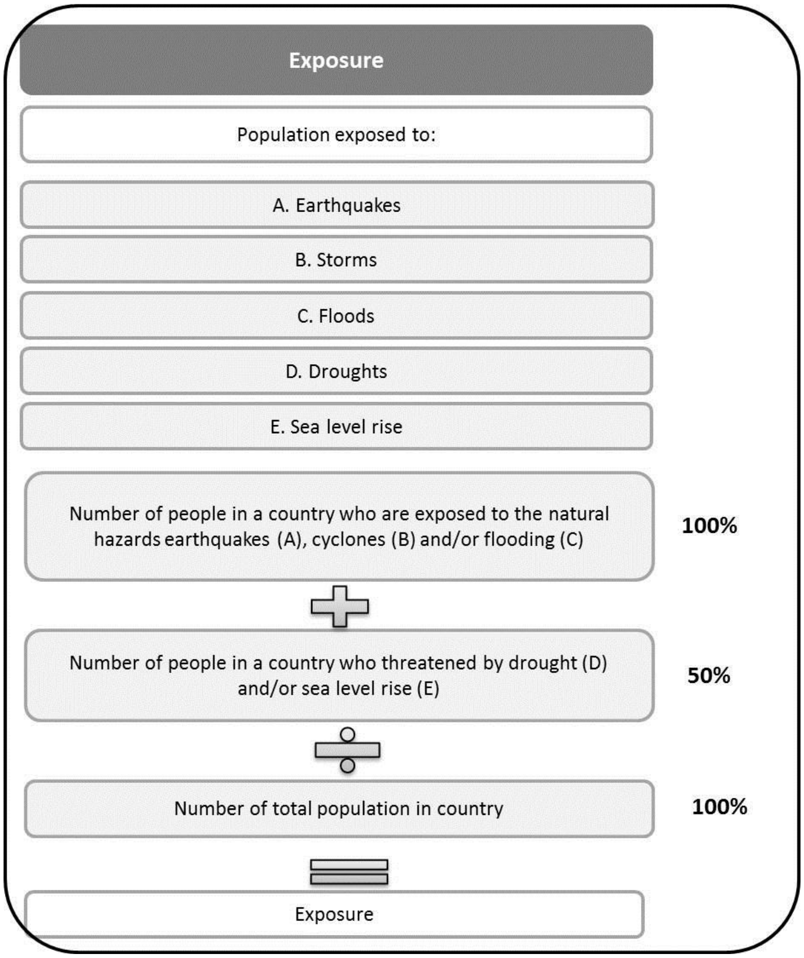


Figure 4. Indicators and weights to assess exposure
Source: (Alliance Development Works et al. 2012)

<u>Susceptibility</u>

It is divided into five subcategories that describe the living situation and condition of the society (Alliance Development Works, United Nations University, and The Nature Conservancy 2011, 16):

- Public infrastructure
- Housing conditions
- Nutrition
- Poverty and dependencies
- Economic capacity and income distribution

It is integrated by seven indicators (Figure 5). One subcategory is not included in the assessment of susceptibility (housing conditions) due to the insufficient data available (Alliance Development Works et al. 2012)

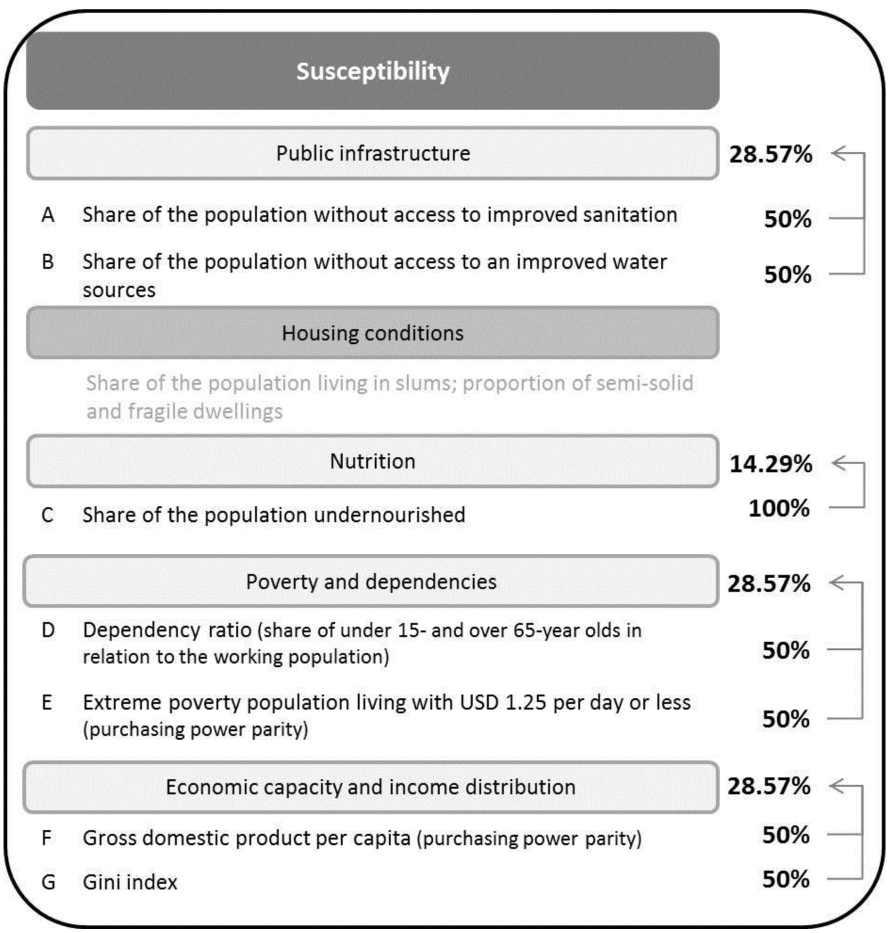


Figure 5. Indicators and weights to assess susceptibility
Source: Alliance Development Works, United Nations University, and The Nature Conservancy 2012)

Coping capacities

It is also composed of five subcategories that reflect the current abilities or capacities of the society and its institutions (Alliance Development Works, United Nations University, and The Nature Conservancy 2011,p.16):

- Government and authorities
- Disaster preparedness and early warning
- Medical services
- Social networks
- Material coverage

It is assessed through five indicators (Figure 6). There are two subcategories which are not taken into account in the assessment because of the lack of data for all of the countries. (Alliance Development Works et al. 2012)

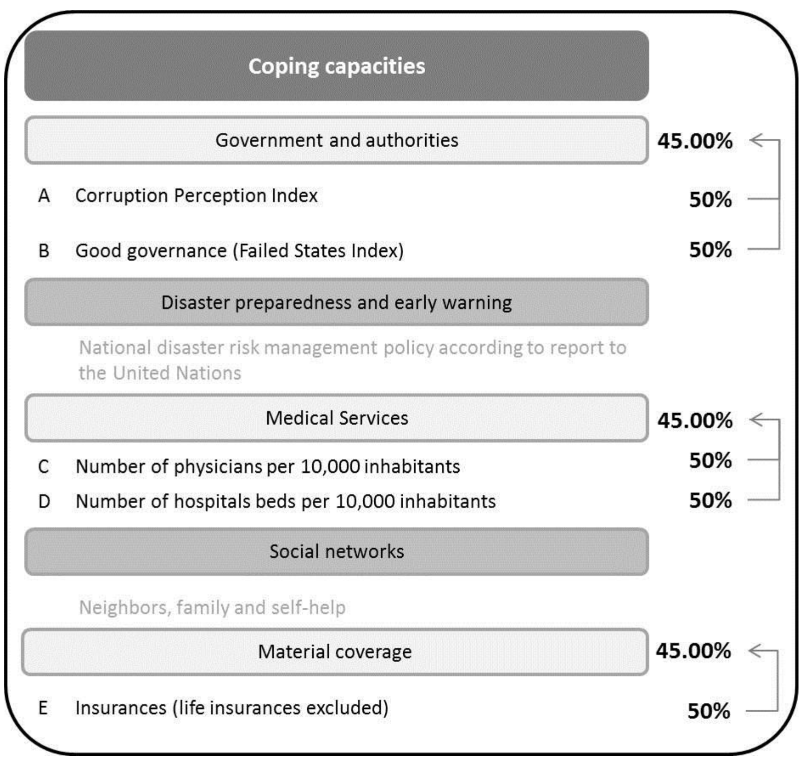


Figure 6. Indicators and weights to assess coping capacities
Source: Alliance Development Works, United Nations University, and The Nature Conservancy 2012

Adaptive capacities

As all of the above mentioned categories, adaptation has five subcategories that may be responsible of making a society more resilient (Alliance Development Works, United Nations University, and The Nature Conservancy 2011, p.17):

- Education and research
- Gender equity
- Environmental status/ecosystem protection
- Adaptation strategies
- Investment

This component is integrated by eleven indicators (Figure. 7). The subcategory of adaptation strategies is excluded of the assessment because of the lack of available information.(Alliance Development Works et al. 2012)

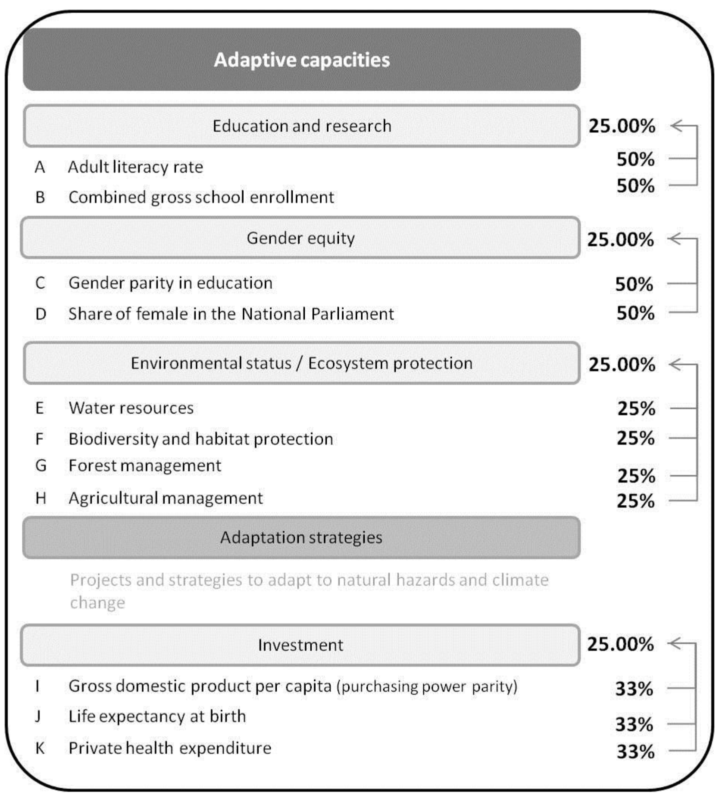


Figure 7: Indicators and weights to assess adaptive capacities
Source: (Alliance Development Works et al. 2012)

After assessing all the categories individually, the disaster risk index can be obtained. Each category takes a specific maximum weight in the formula (Figure 8). The sum of the categories of susceptibility, coping capacities and adaptive capacities is equal to 100 percent and their result is the vulnerability index. By multiplying the exposure category with the vulnerability index the risk index is obtained.

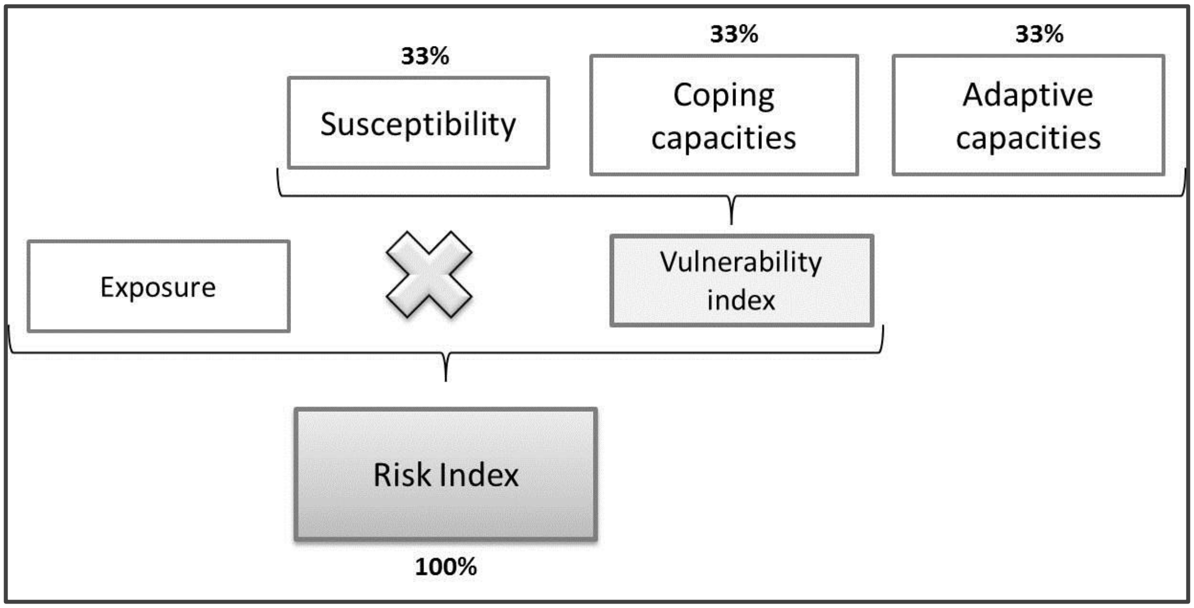


Figure 8. Structure and calculation of the World Risk Index
Source: Own creation based on Alliance Development Works, United Nations University, and The Nature Conservancy 2012

3.3. Structure of the Risk Index for Mexico

3.3.1. Adaptation of the World Risk Index to the national scale

As it was mentioned before, the methodological approach proposed in this study is based largely on the WRI. Hence, the study assumes the components of risk described in the WRI and many of their indicators were applied in the study; however there are others which were adapted according to the specific circumstances of Mexico and some others were not used due to the lack of information to elaborate them (It will be explained in a deeper way in the results chapter).

A similar case occurs with the weights of indicators and subcategories. For some of them the same weight was assumed but some modifications were made for others This is the case of the component of coping capacities, that in the Risk Index for Mexico it has less indicators than the WRI; therefore the weights given to each indicator had to change (Further information will be given in the results chapter).

Data was obtained from public official sources. Eleven sources was used, they are enlisted below (to know the official source of each indicator see annex 3):

- National Institute of Statistics and Geography (INEGI)
- National Center of Disasters Prevention (CENAPRED)
- Inventary System of Disasters (DesInventar)
- National Council for the Assessment of the Social Development Policy (CONEVAL)
- Mexican Transparency
- National System of Health Information (SINAIS)
- National Population Council (CONAPO)
- National Commission of Insurances and Guaranties (CNSF)
- Secretary of Public Education (SEP)
- National Institute of the Women (InMujeres)

As the adaptation process is also a result of this research; in the results chapter, the indicators and the weights are presented and explained.

3.3.2. Methodological procedure

The methodological procedure to obtain the Natural Risk Index for Mexico is explained in Figure 9. Knowing which the WRI indicators are and what data is required for its development, a search for that information was conducted in order to find which information was available or unavailable for all the Mexican states.

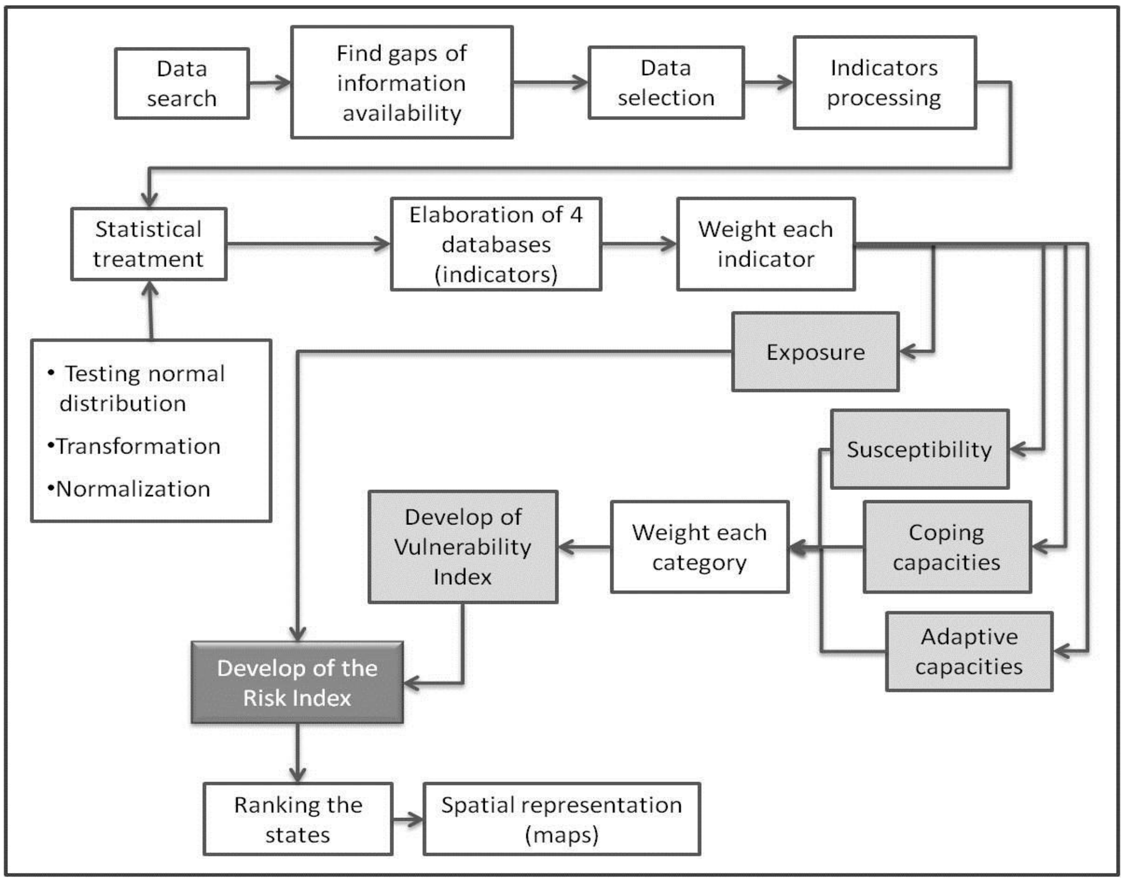


Figure 9. Methodological procedure of the study
Source: Own creation

Then, the data selection was made and a database for each indicator was elaborated with the available data. The next step was processing the indicators; in this phase all the databases was exported to the Statistical Software for Social Sciences (SPSS) for its analysis. When all the indicators were processed, a statistical treatment in SPSS was given to the indicators to integrate the categories of susceptibility, coping capacities and adaptive capacities.

The statistical treatment consisted of four steps:

1. First, to know if the indicators had a normal distribution, two distribution measures were analyzed; the asymmetry coefficient (skewness) and kurtosis. Since the values of these two measures were between-$[-0.5, 0.5]$, it was assumed that the indicator had a normal distribution due to the fact that one of the characteristics of a normal distribution is that it is symmetric (Jackson 2008).

   Also, the Shapiro-Wilk test, a non-parametric test, was applied to determine if indicators had a normal distribution. This test "is based on the observed distance between symmetrically positioned data value"(Marques de Sá 2007, p.187)

$$W = \left[\sum_{i=1}^{\kappa} \alpha_i (x_{n-i+1} - x_i)\right]^2 / \sum_{i=1}^{n} (x_1 - \bar{x})^2$$

   The decision of using this test instead of another one, was that, it was appropriate for small samples ($n < 50$) and that the statistical software used could carry out the test.
   That the significance of the test was equal or higher than 0.05, means that the indicators fit in a normal distribution. The results of these tests can be found in Annex 1.

2. If the tests were not significant (not normally distributed), the indicator had to be transformed in order to achieve data normality. The transformation

methods used, varied from indicator to indicator. The methods applied are enlisted below:

- Logarithm base 10 (Lg 10)
- Natural logarithm (LN)
- Reciprocal $(1/x)$
- Square root $(\sqrt[2]{x})$
- Arcsine-square root $\left(arcsin(\sqrt[2]{x})\right)$
- Logit $\left(Logit \ = Lg10\left(\frac{x}{1} - x\right)\right)$

To know which transformation method was used to each specific indicator see Annex 1.

3. After applying a transformation method to the indicators that required it, the normal distribution test was made again to check that the transformed indicators had a normal distribution. Since, the indicators still did not have a normal distribution; another transformation method was applied until data normality was obtained (See Annex 1).

4. Once the indicators had a normal distribution, these had to be normalized. Normalization is a very important and obligatory phase of development of combined indicators. Its function is to facilitate the comparability among indicators. It must be taken in consideration that, the indicators are expressed in different units of measure (economic units, percentages, rates, etc.) therefore a normalization method must be used to "avoid the congregation of different measure units and the appearance of different phenomena scale" (Schuschny & Soto 2009, p.55).

The normalization method used was Min-Max. This method "transforms the data in values between the interval [0,1] using the distance among the minimum and maximum values" of the indicator (Schuschny & Soto 2009, p.58).

$$y_t^i = \frac{x_t^i - min_{\forall p}(x_t^i)}{max_{\forall p}(x_t^i) - min_{\forall p}(x_t^i)} \in [0,1]$$

Is important to stress that, for the exposure category it was decided not to transform and normalize the data because of two main reasons:

1. All the indicators of this category use the same unit measure (proportion of population exposed),

2. And due to the modifications made to the algorithm to obtain the exposure indicators (see annex 2), not all the States were exposed to the same hazards (nor in the same magnitude/intensity); therefore, normalizing the data would have caused a duplicity of values among those states with a normalized value of zero and those without population exposed when obtaining the exposure index. Therefore, causing a minimization of the real exposure of those states (with a normalized value of cero) when in reality these were greater than zero.

After their pertinent statistical treatment, the indicators were added into four new databases according to each study component (exposure, susceptibility, coping and adaptation). In this step, for the indicators of the components of coping capacities and adaptive capacities, it was necessary to invert the values of each indicator in order to show the lack of these capacities and to analyze them in the same way susceptibility was analyzed.

With these four databases ready, it was possible to start developing the risk index for Mexico. A specific maximum weight was assigned separately for each indicator in each and every one of the databases (in the results chapter, the weight of each indicator regarding its subcategory and component is shown), and the sum of all the indicator's weights of the components of susceptibility, coping capacities and adaptive capacities gave a total of 100. In others words each indicator has a proportional value considering the component as a whole (see Figure 10).

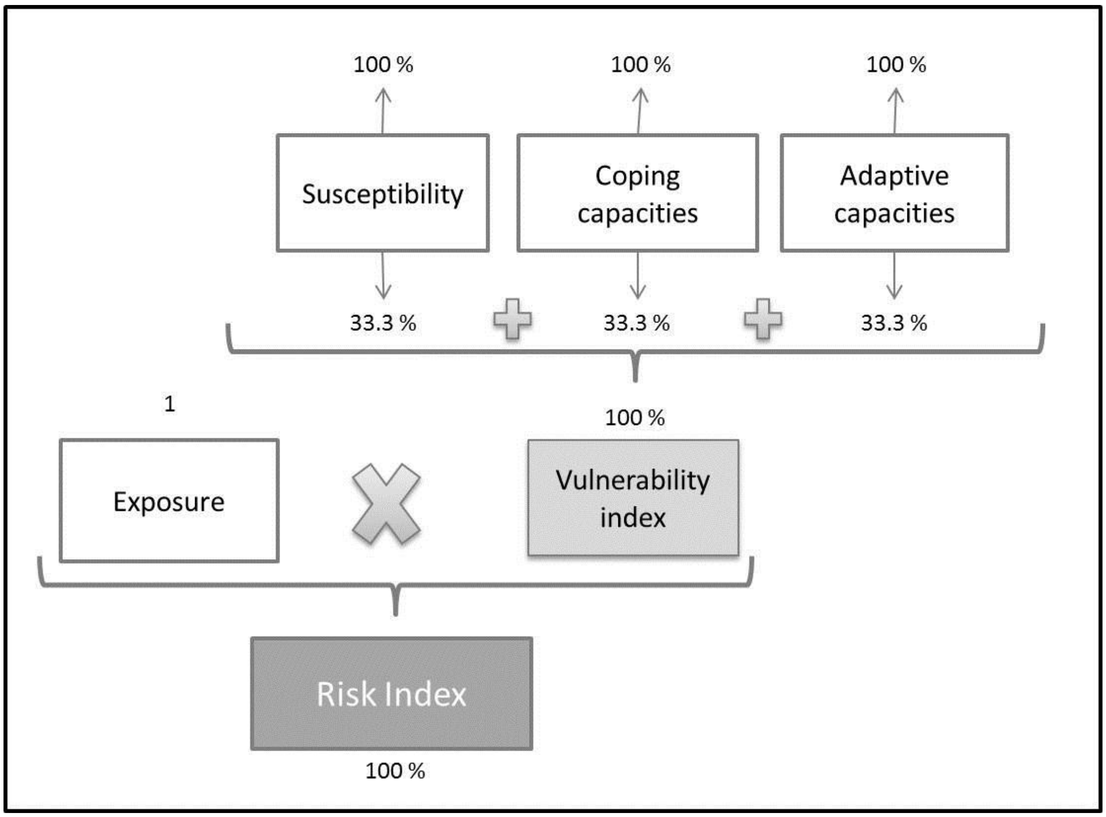


Figure 10. Structure and calculation of the national risk index
Source: Own creation based on Alliance Development Works, United Nations University, and The Nature Conservancy 2012

At the same time, in order to get the vulnerability index, these three components took another weight. Assuming vulnerability as a whole, the maximum weight that each of these three components showed was of 33.3 and for assessing the exposure, each of the four indicators had an equal weight and the whole component had a value of 1.

To know the specific value according to the weights, the equation of direct rule of three was used:

$$Y = \frac{B\ * A}{X}$$

Then, with the vulnerability index and the component of exposure, it was possible to determine the risk index for each state of Mexico. Exposure was multiplied by vulnerability and the result was a value between the interval of [0,100], where 0 means no risk and 100 the highest risk (Figure 10).

The next step was ranking the states in five categories:

1. Very low, 2. Low, 3. Medium, 4. High, 5. Very high

The ranking was made for all the components as well as vulnerability and risk.

For ranking the states in these five categories the quantile method was used. It had to be done separately for each component and the vulnerability and risk indices.

The value of the percentiles 20, 40, 60 and 80 was obtained. All the values until the percentile 20 integrate the first category; the second category comprises the values between the percentiles 21 and 40; the third category encompasses the values between the percentiles 41 and 60; the values between the percentiles 61 to 80 comprise the fourth category and the values from the percentile 81 to the highest value integrate the fifth category (See annex 2 to know the results of this procedure for each component)

Finally a spatial representation of each component and the vulnerability and risk indices using ArcMap was made. At the end, the obtained results were:

- 21 indicators databases (see digital annex 1)
- 6 components databases (see digital annex 2)
- 6 maps.

CHAPTER 4. RESULTS

This chapter is divided into two main sections. The results of the development of a methodological approach for a national risk index for Mexico are presented in the first section and the results of applying this methodological approach are shown next.

4.1. Methodological approach of the Risk Index for Mexico

The methodological approach encompassed the analysis of 21 indicators which were distributed into four components of risk. The indicators and theirs weights by component were presented next.

Exposure

The exposures of the four natural hazards that strike the Mexican territory the most were assessed:

- Earthquakes
- Storms (rainfalls and storms)
- Floods
- Droughts

Exposure was assessed separately to each hazard, therefore the population exposed to each of them in relation to the total population was considered as an indicator of this component (Figure 11).
The method used for obtaining exposure was different to the method used by the WRI; this due to the limitations of the available information for Mexico, therefore to measure the total exposure to natural hazards, each indicator had an equal value of 0.25; thus, in total exposure had a value of 1.

To know more detail information about each indicator the metadata in annex 3 should be reviewed.

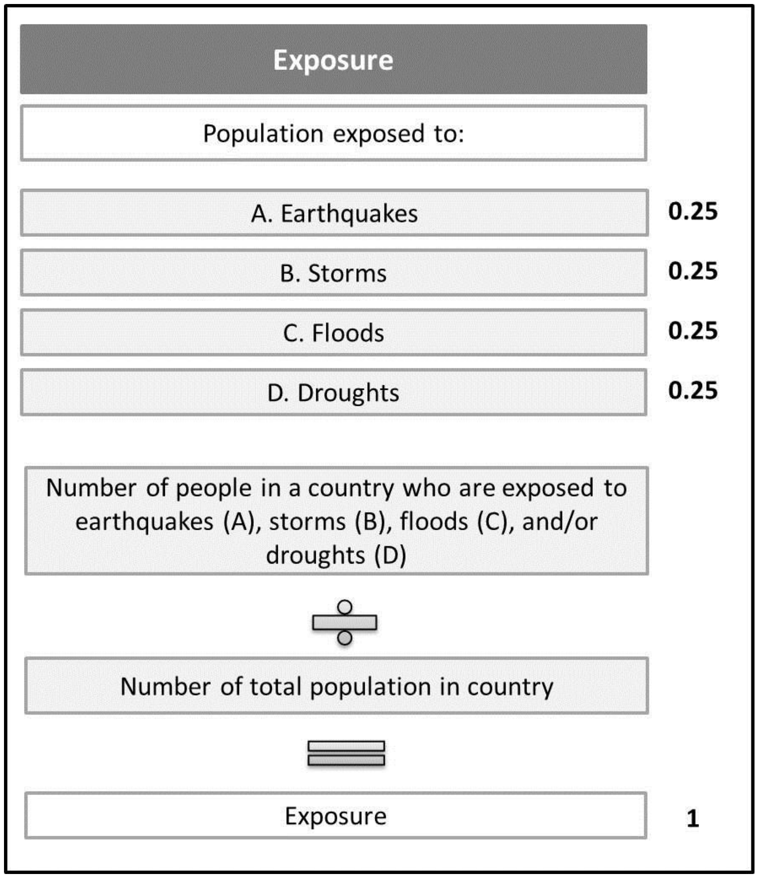


Figure 11: Indicators and weights of exposure
Source: Own creation

<u>Susceptibility</u>

It is divided into four subcategories:

- Public infrastructure
- Nutrition
- Poverty and dependencies
- Economic capacity and income distribution

In total, susceptibility is integrated by seven indicators and the weigh given to each indicator was the same given by the WRI (Figure 12). A detail description of the indicators is presented in annex 3.

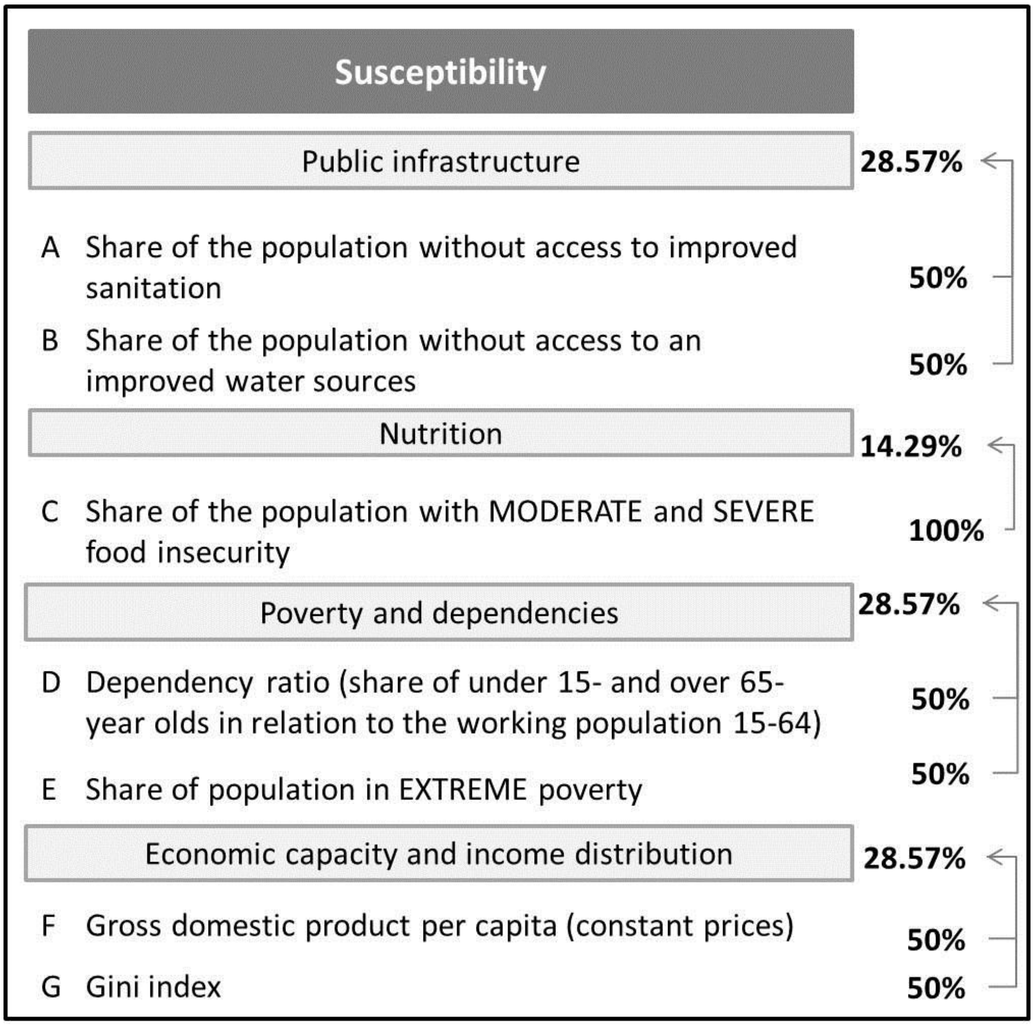


Figure 12: Indicators and weights of susceptibility
Source: Own creation

Coping

To measure the lack of coping capacities in Mexico four indicators distributed in the following three subcategories were used (Figure 13):

- Government and authorities
- Medical services
- Material coverage

In this component the indicators weights were modified because the methodological approach for Mexico has less indicators than the WRI, because of the lack of information to develop the missing indicator used in the WRI.

Regarding the weights, it was tried to give the same weight to each indicator inside their subcategory. More specific information regarding the indicators is shown in annex 3.

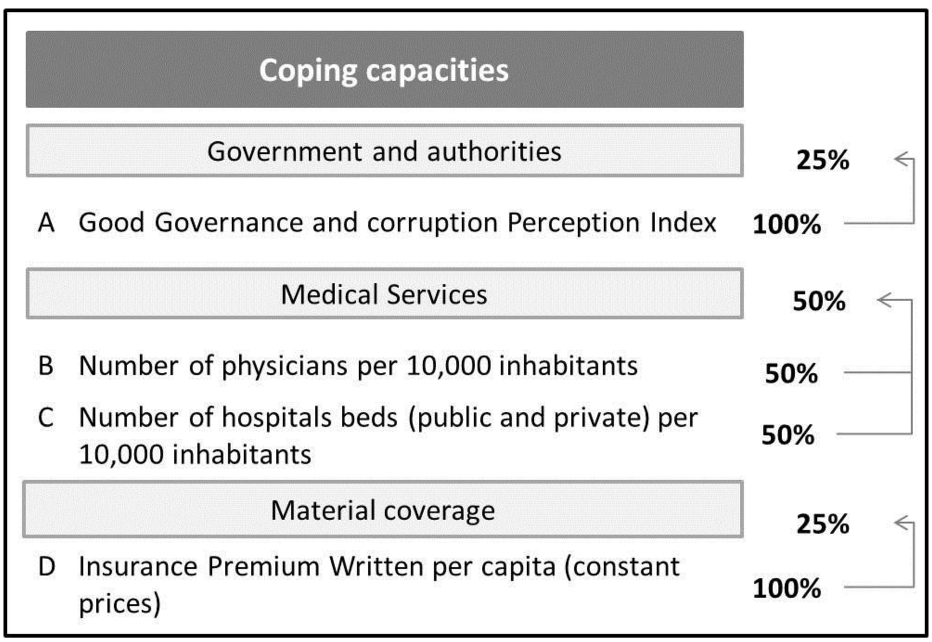


Figure 13: Indicators and weights of coping
Source: Own creation

Adaptation

This component has three subcategories with a total of six indicators (Figure 13). The subcategories are:

- Education and research
- Gender equity
- Investment

Comparing this component with the WRI component, the approach for Mexico has suffered some modifications; the more important one is the absence of the subcategory of environmental status/ ecosystem protection, due to the lack of appropriate data for generating the indicators (the reasons are presented in the next subsection). Due to this the weights of each subcategory and indicators have been modified (Figure 13). A detail description of each indicator is presented in annex 3.

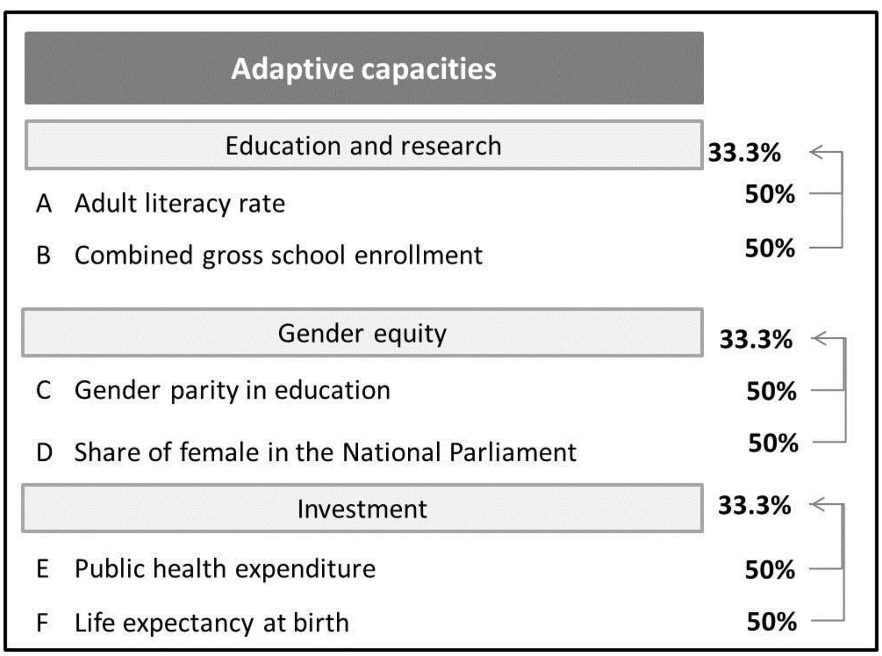


Figure 14: Indicators and weights of adaptive capacities
Source: Own creation

4.1.1. Comparability with the World Risk Index Indicators and Information Gaps

As this study takes as methodological base the indicators of the World Risk Index, in this subsection, a distinction between the comparability of the indicators used to develop the methodological approach for the Mexican risk index and those used in the WRI was made (to know more detailed reasons regarding the comparability of this indicators see annex 3 where the metadata of each indictor according to: data used for its elaboration, temporal scale, method / algorithms used, units of measure, data sources, comparability with the WRI indicator and validity and/or limitations, can be found).

Figure 15 shows that eleven of the twenty-one indicators can be considered or used just like the ones presented in WRI. This means that the data and the algorithm (method) used for its development were the same. In general, this is basic information that can be found in the official data sources, which are being constantly updated. For some of the indicators it wasn't even necessary to make any data processing.

Meanwhile, some modifications had to been done to four of the remaining indicators in order to adapt them to the specific circumstances presented in Mexico. These modifications were done due to data availability. For example in Mexico, undernourishment is measured with a different methodology so, even though these differences did not change the main aims of the indicator, it was important to take them into account when developing the index.

The rest of the indicators (six indicators) were not comparable with the WRI indicators because of the differences regarding the data and/or the algorithms to develop these indicators. This is the case of all the indicators of the exposure component, that due to lack of information and the limitations presented to apply the exact same method used by the WRI, finding another method to assess exposure with the available information was necessary (see annex 3 for more information).

Another important aspect which was taken into account while developing the indicators was the temporal scale. Getting the most current data for each indicator was one of the biggest concerns; however the temporality fluctuations depended on the information sources and the type of data. In most of the cases, the oldest information was from 2010 and the newest from 2013-2014.

Indicator	Temporal scale	Comparability with the WRI indicators
1. Population exposed to earthquakes	2010	Not comparable
2. Population exposed to storms	2010	Not comparable
3. Population exposed to floods	2010	Not comparable
4. Population exposed to droughts	2010	Not comparable
5. Share of population without access to improved sanitation	2010	Same indicator
6. Share of population without access to an improved water sources	2010	Same indicator
7. Share or population with MODERATE and SEVERE food insecurity	2012	Adapted to Mexico
8. Dependency ratio (share of under 15 and over 65 years old in relation to the working population 15-64)	2010	Same indicator
9. Share of population in EXTREME poverty	2012	Not comparable
10. Gross domestic product per capita	2012	Same indicator
11. Gini Index	2012	Same indicator
12. Good Governance and Corruption Perception Index	2010	Adapted to Mexico
13. Number of physicians per 10,000 inhabitants	2012	Same indicator
14. Number of hospital beds per 10,000 inhabitants	2012	Same indicators
15. Insurance Premium written per capita	2012	Not comparable
16. Adult literacy rate (15 years and over)	2010	Same indicator
17. Combined Gross Enrolment Ratio (GER)	2010/2011	Adapted to Mexico
18. Gender parity in education	2012/2013	Adapted to Mexico
19. Share of female in the State Congress	(Current Congress) 2014	Same indicator
20. Per capita public expenditure on health	2012	Same indicator
21. Life expectancy at birth	2012	Same indicator

Figure 15: Date of source and comparability with the WRI indicators
Source: Own creation

Besides the differences among indicators, there were also, some indicators of the WRI that were impossible to develop for the Mexican risk index. As it was mentioned before, the WRI is integrated by 28 indicators; seven of which are missing in the methodological approach for a national Risk Index for Mexico. Those seven indicators are:

- Population exposed to see level rise (Exposure)
- Good governance (Failed States Index) (Coping capacities)
- Private health expenditure (Adaptive capacities)
- Water resources (Adaptive capacities)
- Biodiversity and habitat protection (Adaptive capacities)
- Forest management (Adaptive capacities)
- Agricultural management (Adaptive capacities)

The main reason to exclude these indicators was the lack of information in a lower disaggregation level. It is important to mention that regarding availability, it was observed an information bias when the data was analyzed by components.

In the component of susceptibility all the information needed to elaborate the indicators was easily found, with historical and current information even in a lower disaggregation level than state. The reason for this is that this type of information is generally, socio economic data, relatively easy to obtain and that is usually relevant to assess the performance of a country and its states. This data is also commonly used by those in charge of making decisions for developing public policies.

On the other hand the availability of information required to develop the exposure indicators was very limited and some assumptions had to be done in order to get the population exposed by hazard (see annex 3 for detailed information). Moreover, it was not possible to assess the subcategory of environmental status/ ecosystem protection (the last four indicators mentioned above) of the adaptive capacities, because it was considered that with the available data it was not feasible to develop the indicators due to the level of disaggregation (most of the water statistics are disaggregate in hydro-administrative regions, a bigger area than state), the lack of some data, the difficulties of processing the information into indicators and the insufficient time to develop a new approach to assess the environmental status/ ecosystem protection for Mexico.

4.2. National Risk Index for Mexico

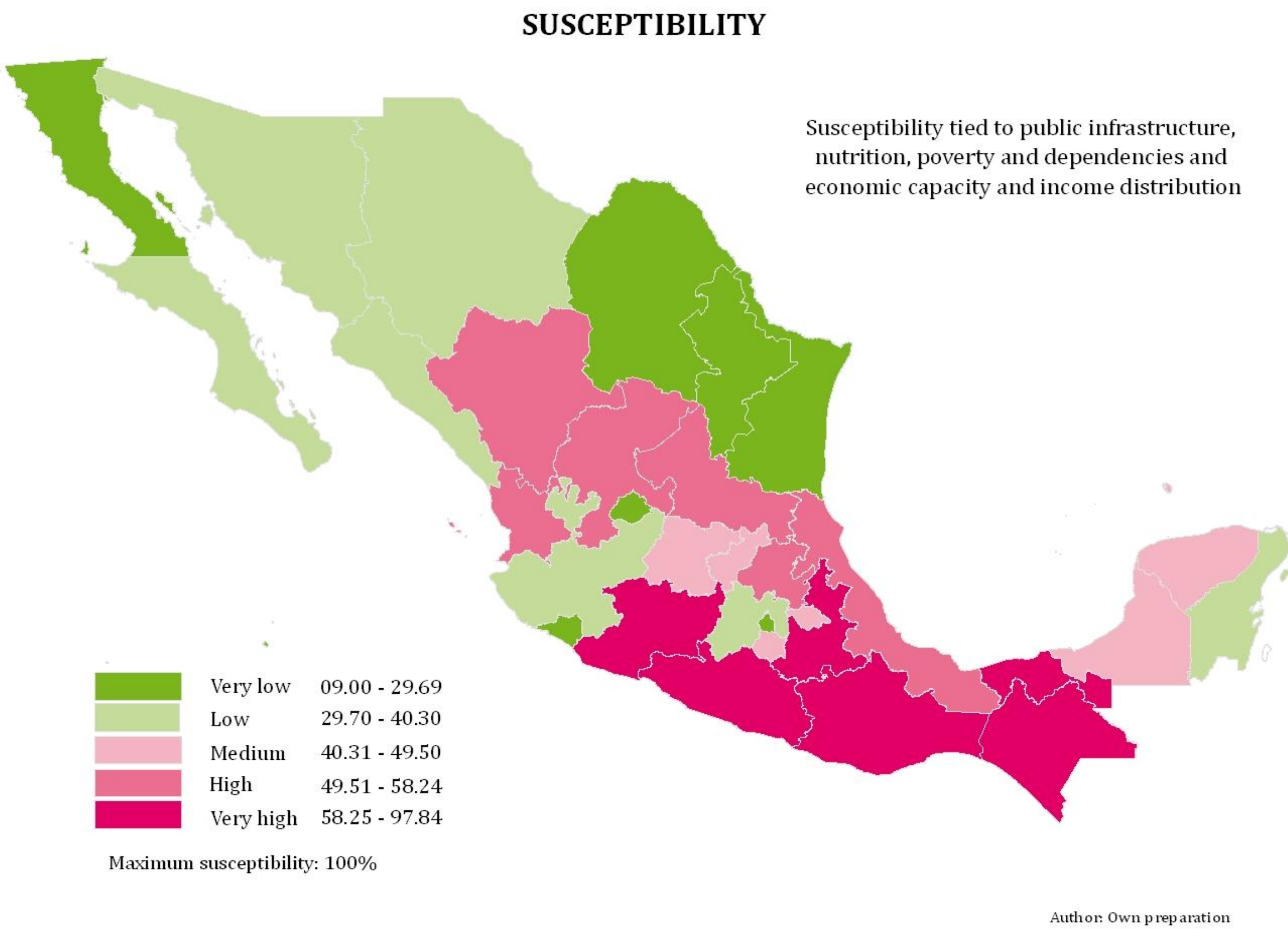
In this subsection the results of applying the methodological approach for a national Risk Index for Mexico are presented. The results are given by component: susceptibility, lack of coping capacities, lack of adaptive capacities, vulnerability, exposure and risk.

In general, the aim of this subsection is to show:

- the current situation of the states regarding each component of risk
- the differences among states by component
- the ranking of the three states with the highest and the lowest values by component

For better orientation on the political division of Mexico, a map of its regions and states can be found in annex 4. Also the values by rank and component of all the states can be found in annex 5.

4.2.1. Susceptibility



The map shows the degree of susceptibility of the states; understanding susceptibility as the structural characteristics (public infrastructure) and the framework conditions (nutrition, poverty, income distribution and economy) in which the states face potential natural hazards (see definition given by Alliance Development Works et al. 2011 in chapter 2).

At first glance, the map shows a high disparity because the values of the categories are very dispersed; being the lowest value 9 percent and the highest value 97.84 percent which indicate big differences among the states regarding their public infrastructure, the condition of nutrition and poverty of their inhabitants and the unequal income distribution and economic growth.

Also, it can be seen that the states of the north[2] (northeast and northwest) have lower susceptibility than those in the south (southeast and south), which present the three states with the highest susceptibility in Mexico. These disparities are not new and it is well known that the states with the highest social and economic needs are in the south part of Mexico. The top three states with the highest susceptibility are Guerrero, Chiapas and Oaxaca respectively (Figure 16) and the results of the component of susceptibility agree with the marginalization index, which asses the social disparity in the country, placing these states also at the top of the list (but in different order). In addition to this, Oaxaca and Chiapas are the states with the highest rural population, slightly more than half of its population lives in localities with less than 2,500 inhabitants.

On the opposite side are Distrito Federal, Nuevo Leon and Baja California, which are the states that present the lowest susceptibility (Figure 16); moreover they also occupied the last places regarding marginalization and even more, Mexico City and Nuevo León are the two states with the highest urban population in Mexico;

[2] It was taken the following regional classification. 1. Northeast integrated by: Chihuahua, Coahuila, Durango, Nuevo Leon and Tamaulipas. 2. Northwest: Sonora, Sinaloa, Baja California and Baja California Sur. 3. West: Jalisco, Nayarit, San Luis Potosí, Zacatecas, Aguascalientes, Michoacan, Guanajuato and Colima. 4. Center: Distrito Federal, Hidalgo, Puebla, Mexico, Tlaxcala, Queretaro and Morelos. 5. South: Guerrero, Oaxaca, Chiapas and Veracruz and 6. Southeast: Tabasco, Campeche, Yucatan and Quintana Roo. See annex 4.

practically 95 percent or more of their population lives in localities with more than 2,500 inhabitants.

States with the highest and the lowest susceptibility

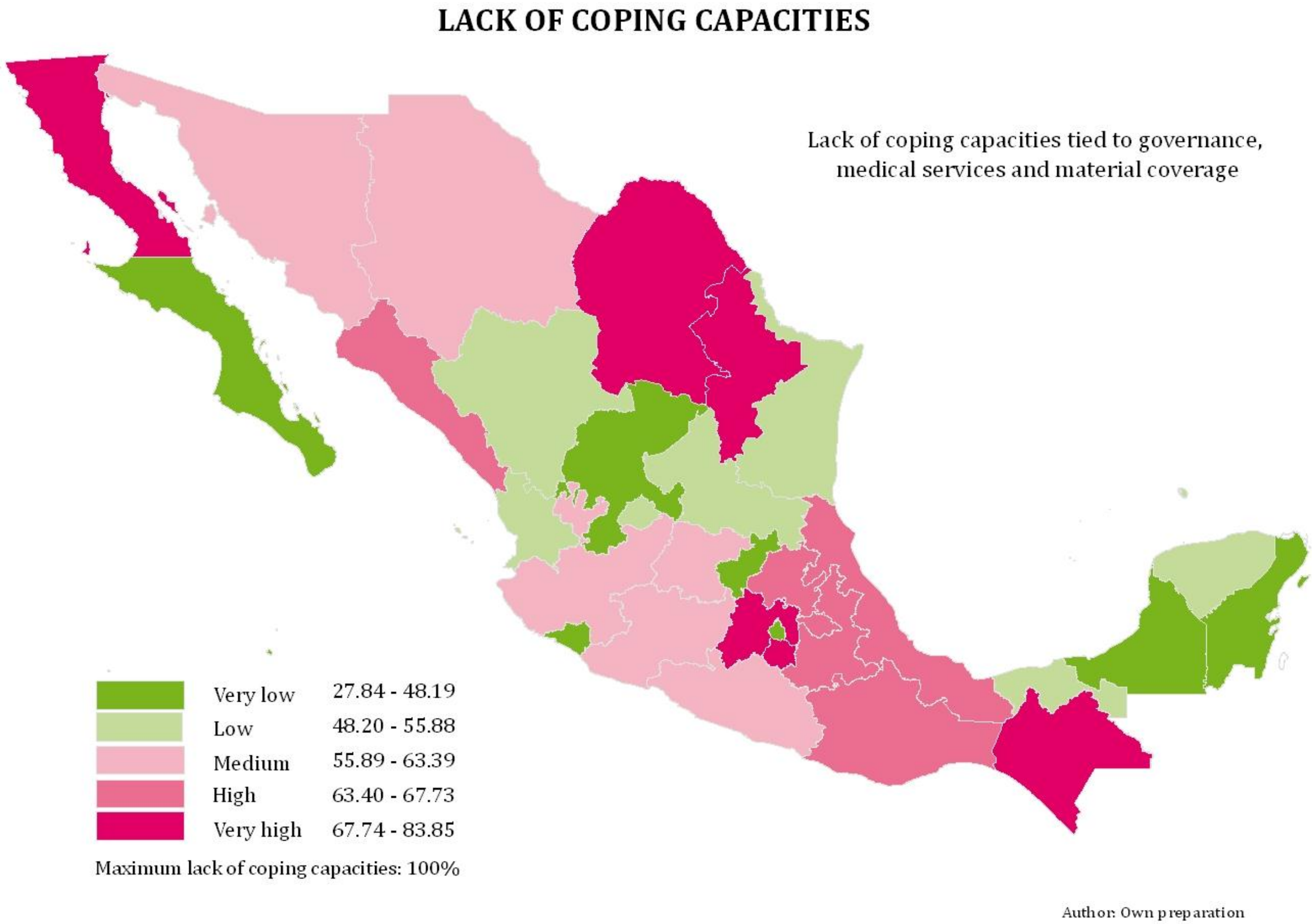
Guerrero	97.84%	Distrito Federal	09.00%
Chiapas	81.79%	Nuevo León	28.86%
Oaxaca	77.44%	Baja California	22.51%

Figure 16: States with the highest and the lowest susceptibility
Source: Own elaboration

The only state of the southeast with low susceptibility is Quintana Roo, which is one of the states with lower inhabitants in Mexico, but around 80 percent of its population lives in localities with more than 2500 inhabitants; being the metropolitan area of Cancun, the one which concentrates slightly more than a half of its entire population. This makes the metropolitan area of Cancun a nodal center for the provision of goods and services in the region. Besides, one of the main economic activities of Quintana Roo is the provision of tourism services at international level; therefore the provision of public infrastructure is very important to the state.

Perhaps, between susceptibility and the concentration of inhabitants in urban areas it could be a link or connection, because six of the seven states with the lowest susceptibility (except Aguascalientes), are also the states with the lowest rural population in Mexico. In this regard, the concentration of population in urban areas enables the provision of public infrastructure in an easier and cheaper way; also, the urban localities have better and larger availability of public services than the rural areas. Furthermore; the urban areas concentrate most of the secondary and tertiary economic activities and these economic activities present a larger participation in the economic growth of the states than primary activities.

4.2.2. Lack of coping capacities



The map reflects the lack of capacities or abilities (bind to governance, availability of medical services and insurance coverage) of the states to minimize the impacts of natural hazards. (see definition given by Alliance Development Works et al. 2011 in chapter 2).

It can be seen that the pattern, regarding the classification of lack of coping capacities is not widely focused by region as susceptibility. The states with the highest lack of coping capacities (Figure 17) are the state of Mexico, Chiapas and Nuevo Leon, states of the center, the south and the north of Mexico respectively.

These states are on the top of the list because they got the highest scores; however when analyzing the results of these states by indicators it is possible to know which aspects have the major deficiencies. In the case of the state of Mexico the high corruption[3] in public services of the state reduces its ability to act in an efficient way when a disaster strikes.

Meanwhile in Chiapas and Nuevo Leon the coverage of medical services per 100,000 inhabitants is low. In Chiapas case, one of the reasons that perhaps affect the low coverage is that this state is the second one with the largest number of localities in the country and with slightly more than a half of its population living in rural areas; this population's dispersion complicates the provision of medical services and medical infrastructure due to the high cost to get to each locality.

Nuevo Leon presents a deficit of physicians basically derived from two main reasons; the increase of the beneficiary population of social security and the insecurity that struck the state in the last years that caused many physicians to move out to other states or to the United States due to the fact that they were direct target of criminal organizations (Cortes 2012; Sexenio 2012)

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[3] According the indicator Coping A. Mexico is one on the states with higher corruption in the Country, just right after Distrito Federal, which is on the top of the list.

States with the highest and the lowest lack of coping capacities

Mexico	83.85%	Distrito Federal	27.84%
Chiapas	77.07%	Baja California Sur	33.27%
Nuevo Leon	76.59%	Queretaro	37.07%

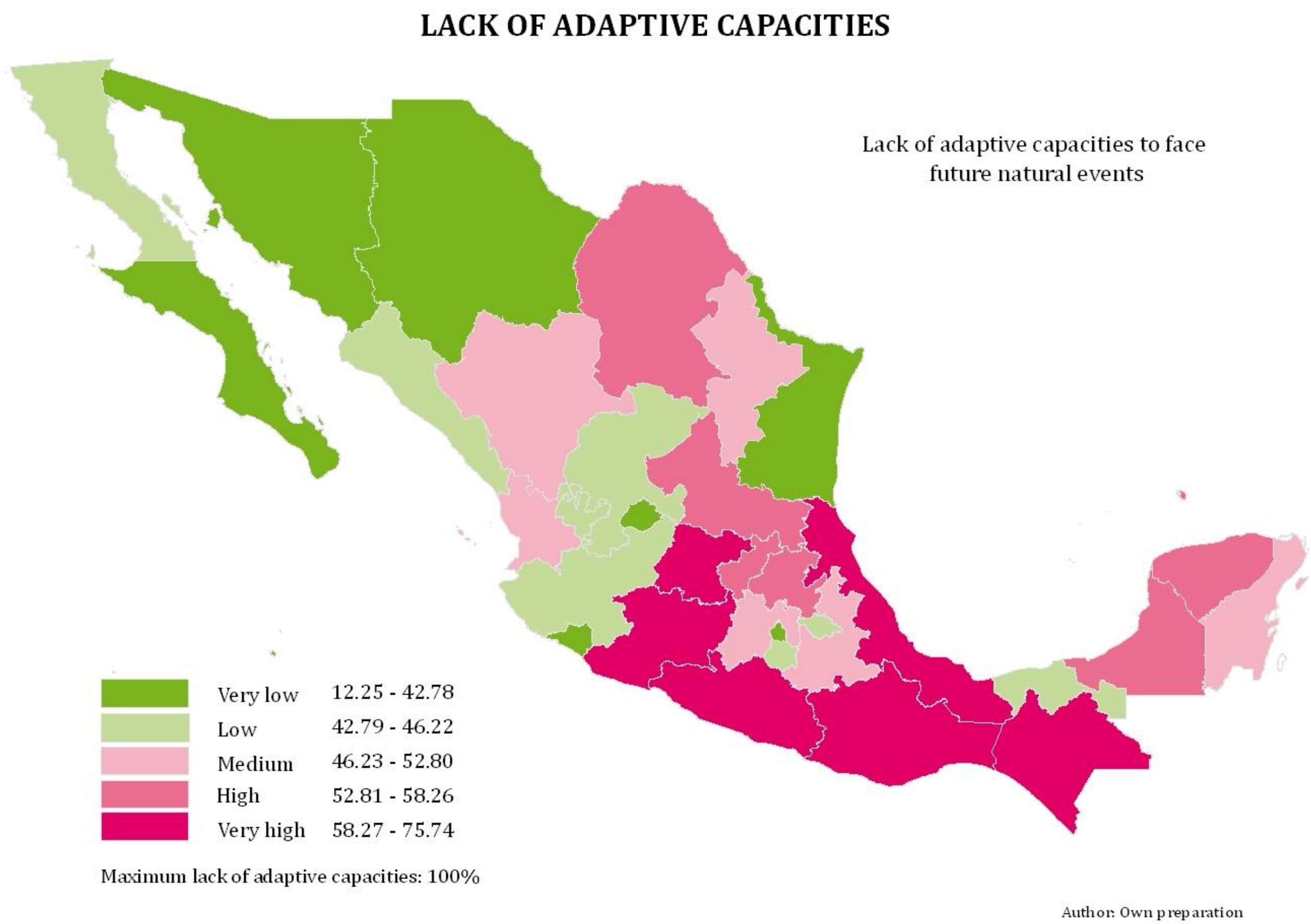
Figure 17: States with the highest and the lowest lack of coping capacities
Source: Own elaboration

It is important to mention that the states of Coahuila and Baja California that have very low susceptibility present a very high lack of coping capacities mostly due to the low coverage of medical services per 100,000 inhabitants.

On the other side, the states with the lowest lack of coping capacities are Distrito Federal, Baja California Sur and Queretaro (see Figure 17). Despite Distrito Federal got the highest score on the subcategory of Government, it got low scores on the other two subcategories (medical services and material coverage); however it is important that the district pays attention to this issue in order to improve its coping capacities.

Baja California Sur shows a more homogeneous performance in all the subcategories of the component; which locates the state in the last place of the corruption ranking and leaves it with a low value regarding the lack of material coverage (this makes sense because it is a state with many touristic infrastructure which is necessary to insure due to the fact that the state is prone to many natural hazards). While Queretaro got the lowest score regarding the per capita premium written for insurance against natural hazards

4.2.3. Lack of adaptive capacities



The map shows the classification of the states according to their lack of adaptive capacities, understood as all the capacities and strategies that allow the states to transform the currents structures, regarding education, gender equity and investment, to face future natural events. (see definition given by Alliance Development Works et al. 2011 in chapter 2).

It can be seen at first glance that the south and the west regions of the country concentrate the states with very high lack of adaptive capacities and that not one of the states is ranked with very low; while four of the seven states with very low lack adaptive capacities and none with a very high lack of them are located in the north part of Mexico.

The top three states with the highest lack of adaptive capacities are Chiapas, Guerrero and Michoacan (see Figure 18), which show the highest values in the subcategories of Education, Research and Investment of the adaptive capacities component. This means that there is a need to improve the access to education in all their levels (primary, secondary and tertiary education) because Chiapas and Guerrero are the two states with the highest illiteracy rates of Mexico, and Michoacan has one of the lower education enrollment rates. Besides, these states have a government expenditure on health per capita far beneath the national average.

The above information indicates that the current structures of these states is very weak and is not well prepared to face future natural events. Also, these elements are closely related to the social and economic aspects analyzed in the component of susceptibility and it is not possible to improve or modify the current structures to face future events without reducing their social needs (as poverty and undernourishment), as well as improving their economic capacity and income distribution.

On the other hand we find Mexico City, Baja California Sur and Aguascalientes, which got the lowest lack of adaptive capacities (see Figure 18); this means that in a general overview these states are the best prepared to face future natural events in comparison with the rest of the states. Distrito Federal and Baja California Sur also got the lowest scores regarding lack of capacities of investment, being these states the ones with the highest government expenditure on health per person at a national level. Distrito Federal has also the highest literacy rate and the highest school enrollment of the country.

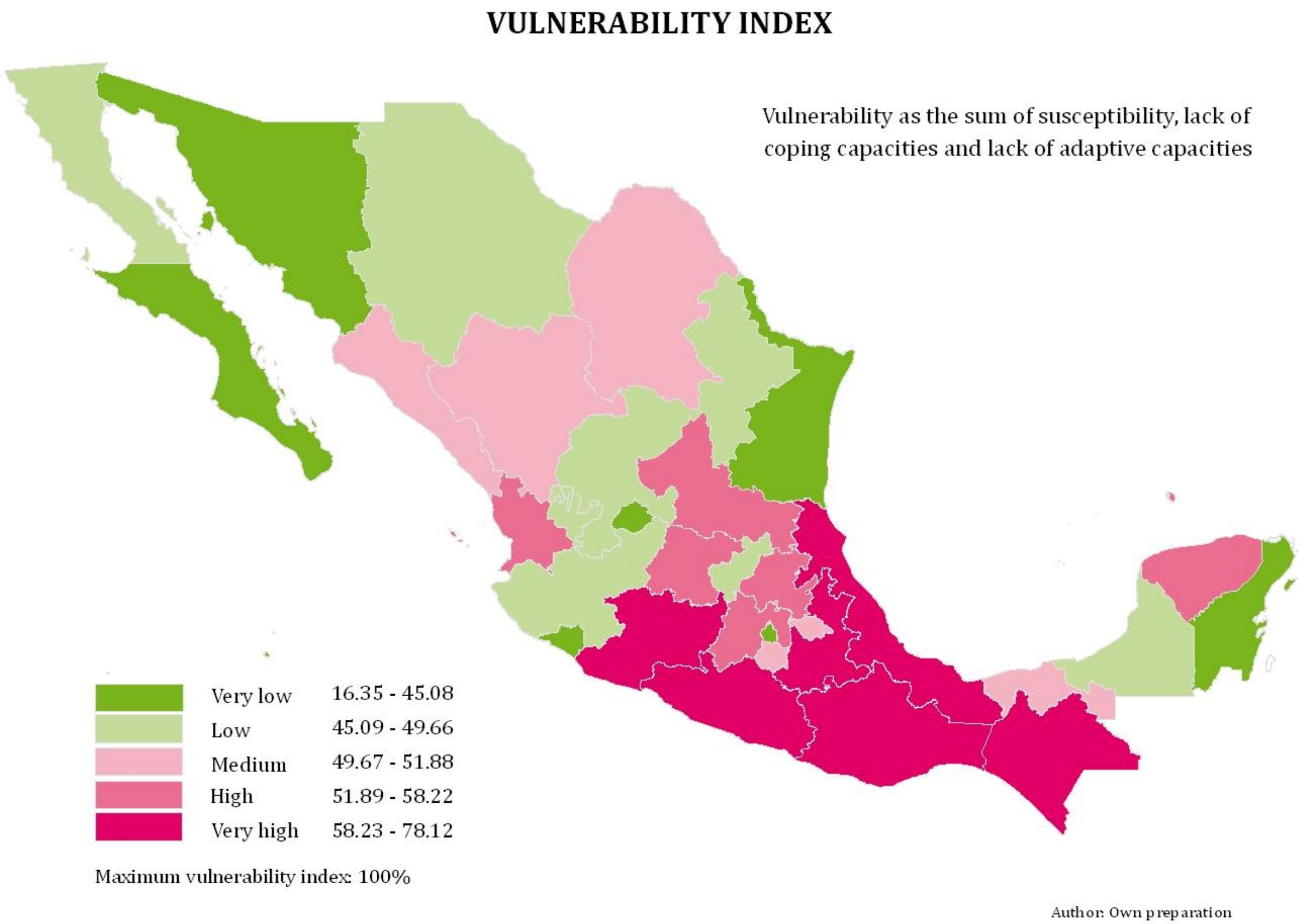
States with the highest and the lowest lack of adaptive capacities

Chiapas	75.74%	Distrito Federal	12.25%
Guerrero	71.67%	Baja California Sur	28.71%
Michoacan	67.69%	Aguascalientes	33.25%

Figure 18: States with the highest and the lowest lack of adaptive capacities
Source: Own creation

However, they also have some hot spots that are important to highlight. For example; regarding gender equity there are other states (Morelos, Zacatecas, Puebla, and Chihuahua, just to mention a few) with a better ranking than the states previously mentioned. This proves that gender disparities in education as well as in high hierarchy positions exist. Therefore it is necessary to reinforce women's empowerment and participation in those states.

4.2.4. Vulnerability



The map shows the vulnerability of the states of suffering negative impacts because of natural hazards, understood as the totality of susceptibility, lack of coping capacities and lack of adaptive capacities, presented individually above.

It can be observed that vulnerability has a regional distribution, were according to its ranking, the southern part of the country presents the highest vulnerability (all the states that integrate it are in this rank), and the west and the center region of Mexico, show a very high or high vulnerability. Meanwhile, the north (west and east) states of Mexico have the lowest vulnerability values and do not present high or very high vulnerability. This means that the socio economic situation of the states of Mexico is very contrasting and reflects large disparities among regions, showing that the south has a severe economic backwardness and a slow and very lacking social development.

The states with the highest vulnerability are Chiapas, Guerrero and Oaxaca respectively (Figure 19). Chiapas, with the worst performance in the component of susceptibility, was always on top of the list in the three components that encompass vulnerability; therefore it can be said that it is the state with the biggest economic problems and the largest social needs in Mexico, which may complicate disaster risk management in the state and even in the whole south region due to the fact that Guerrero and Oaxaca also belong to this region and got high scores in all the components, especially in susceptibility.

On the other side we can find Distrito Federal, Baja California Sur and Colima, three Mexican states with the lowest vulnerability rates. The performance of Distrito Federal could be pointed as the best since it got the lowest scores in every single component. Of course, this may be because Distrito Federal is the capital of the country, it concentrates many public and private services and because it receives each year, from the federal government, the second largest national budget for salaries and economic provisions (section 23 of the federal budget) (The largest budget of section 23 corresponds to the State of Mexico that with Distrito Federal integrate the metropolitan area of Mexico's City).

States with the highest and the lowest vulnerability

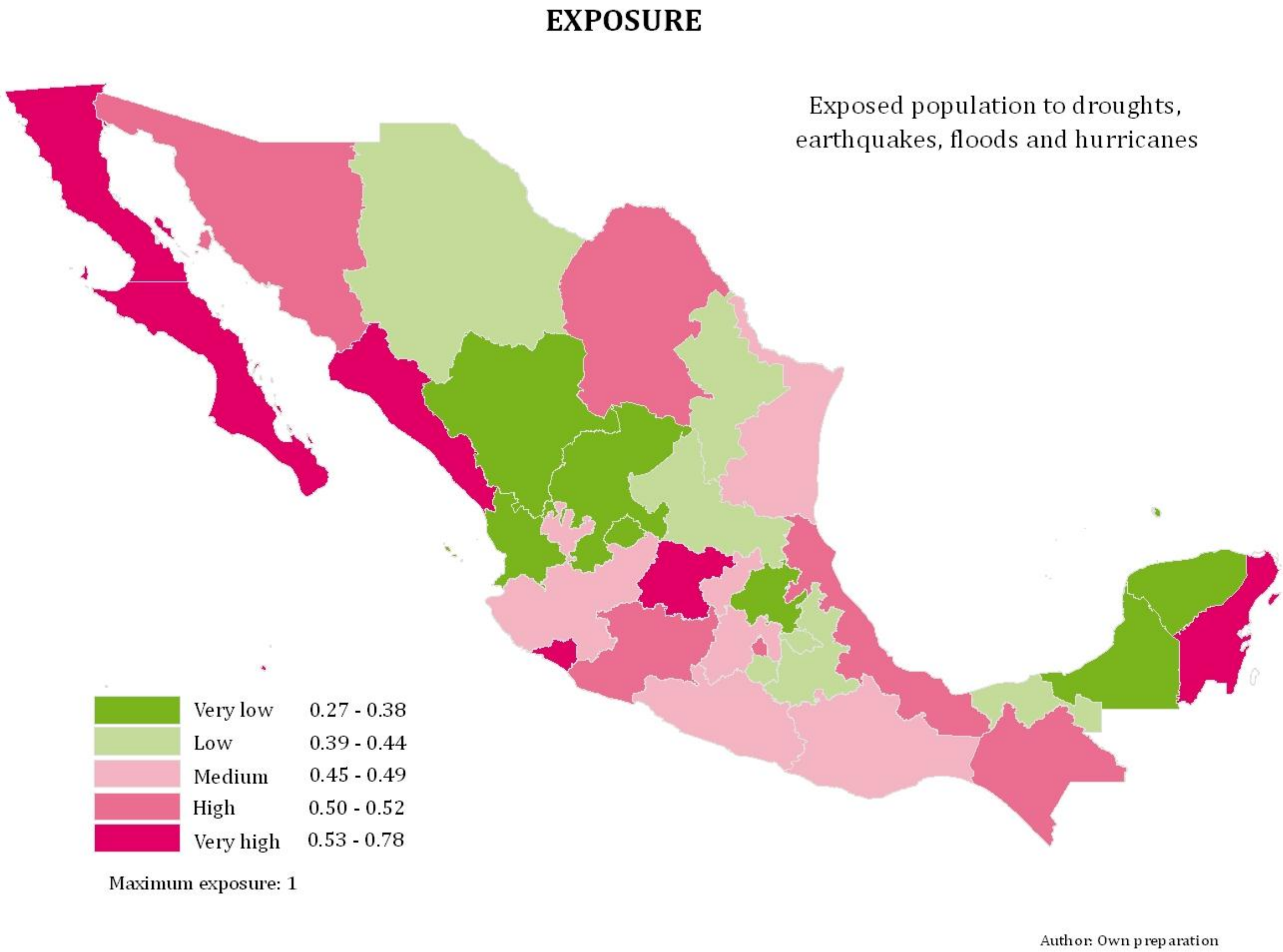
Chiapas	78.12%	Distrito Federal	16.35%
Guerrero	75.41%	Baja California Sur	31.69%
Oaxaca	70.00%	Colima	34.10%

Figure 19: States with the highest and the lowest vulnerability
Source: Own creation

As it was seen before, Baja California Sur has the second lowest score in the components of coping and adaptive capacities; being this last component where the state has its best performance. Meanwhile Colima (which was not listed in the bottom three of any of the components and was in a very low category in each one of them) got the third lower score regarding vulnerability. However it is important to take into consideration that this state had its lowest performance in coping capacities; so, its improvement of its coping capacities should be a point taken into consideration.

The only states of the south part of Mexico with very low and low susceptibility are Quintana Roo and Campeche respectively. Where Quintana Roo has a very good performance in the susceptibility's component and Campeche has one of its best score in the coping capacities component.

4.2.5. Exposure



The map shows the classification of the states of Mexico according to its level of exposure to earthquakes, droughts, hurricanes and floods as a whole.

At a first glance it can be seen that the map of exposure is very different to the other maps presented above because the states with very high and high levels are distributed around all the country. Also, the northwest region of the country, which encompasses some of the states with lower vulnerability, is the region with the highest exposure with a very high or high exposure. Most of states of the northeast part of Mexico have very low and low exposure, with Coahuila as an exception which has high exposure levels due to drought hazards.

Guerrero and Oaxaca, which have very high vulnerability ranks, show medium values of exposure, which gives them their best performance in this component. And the southeast region has the best performance with three of its four states with very low or low exposure.

The top three states with the highest exposure are Baja California, Baja California Sur and Quintana Roo (Figure 20), which in the rest of the components had a better performance. This means that the populations of these states are very exposed to the natural hazard analyzed as a whole. On the other hand we can find Nayarit, Aguascalientes and Yucatan with the lowest exposure.

States with the highest and the lowest exposure

Baja California	0.78	Nayarit	0.27
Baja California Sur	0.75	Aguascalientes	0.30
Quintana Roo	0.61	Yucatan	0.33

Figure 20: States with the highest and the lowest exposure
Source: Own creation

It has to be considered that, the result of this component is the addition of the exposure to each natural hazard. So, if the exposure is analyzed separately, it is possible to know which are the states more exposed by each hazard.

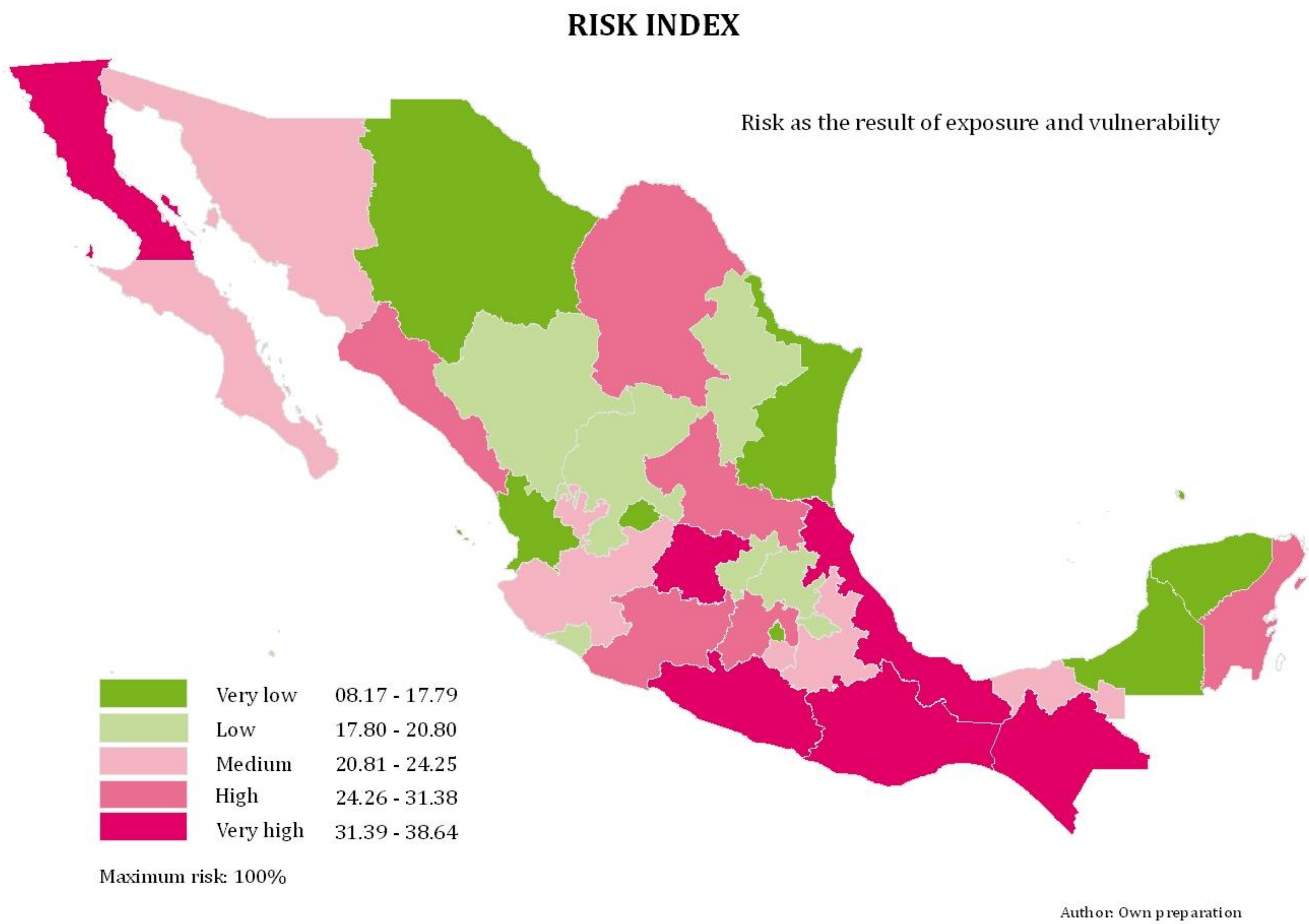
For example, Baja California, which in total has the highest score, is more exposed to earthquakes, droughts and floods. Meanwhile Baja California Sur is more prone to floods, hurricanes and droughts and Quintana Roo to hurricanes and floods. On the other hand, Nayarit, Aguascalientes and Yucatan are practically more exposed to floods than other hazards.

Making and analysis by hazard it can be observed that according to the data, Baja California Sur, Sinaloa, Mexico City, Tabasco and Campeche are the states with the highest exposure to floods in the country and that Tlaxcala, Puebla and Oaxaca[4] are the least expose to this hazard.

Regarding telluric hazards, the states with the highest exposure are Distrito Federal, Baja California, Guerrero, Colima, Mexico, Michoacan and Tlaxcala, which have a long list of earthquakes in their history. Meanwhile Baja California Sur, Quintana Roo, Sinaloa and Yucatan are the states with the highest exposure to hurricanes of the country. And finally the states of Coahuila, Baja California, Baja California Sur, Sonora and Guanajuato have the highest exposure to droughts.

[4] This result should be taken with discretion because the database of floods used in this study showed some uncertainties.

4.2.6. Risk index



The last map presented, shows the risk of the states of suffering disasters and is the result of the integration of the previous five maps; the result of multiply exposure by vulnerability.

At a first glance it can be seen that the states with very high risk are mainly concentrated in the south region with its four states in this level of risk. The northwest region on the other hand has very high to medium levels of risk and none of the states that comprises it got low or very low levels of risk. The rest of the regions (northeast, center, west, and southeast) are not well defined because their states have different levels of risk. Likewise, the states with the lowest risk are distributed in these regions.

The top three states with the highest risk of disasters (Figure 21) are Chiapas and Guerrero, which belong to the southern region, and Baja California which is located in the northwest region.

Chiapas and Guerrero got a high risk of disaster, mostly due to their high susceptibility and high lack of coping and adaptive capacities, this means than even when their exposure to the analyzed natural hazards is not so high, and their high vulnerability makes them very prone to suffer disasters. Moreover, it may happen that not so intense natural events in these states can trigger disaster, when the same natural events in other states with lower vulnerability could have a lower impact.

Meanwhile, Baja California's case is very different because even though it has a low vulnerability, it is the state with the highest exposure in the country; therefore its high risk is due to the high exposure to earthquakes, droughts and floods.

On the other hand, the states of Mexico with the lowest risk of disasters are Distrito Federal, Aguascalientes and Nayarit (Figure 21). These states have their differences as well; while Distrito Federal has a very low vulnerability that reduces its risk even when it has a high exposure, Aguascalientes and Nayarit on the opposite have a higher vulnerability but a very low exposure, making their disaster risk very low.

States with the highest and the lowest risk index

Chiapas	38.64%	Distrito Federal	08.17%
Guerrero	36.89%	Aguascalientes	11.40%
Baja California	35.72%	Nayarit	14.09%

Figure 21: States with the highest and the lowest risk
Source: Own creation

Comparing the situation of each state regarding its vulnerability and exposure, it was found that, nine of the thirty two states of Mexico got a higher score in exposure than in vulnerability while 23 states got a higher score in vulnerability than in exposure.

Knowing these differences is very important for decision making, because having this knowledge makes it possible to reduce the disaster risk in 23 states while improving the socio economic aspects analyzed in each component, in other words reducing their vulnerability to decrease their disasters risk.

Besides, these results can lead to foster differentiated strategies and policies for each state, which will allow them to focus on the hotspots they present, in order to face and reduce their vulnerability and consequently their disaster risk.

CHAPTER 5. DISCUSSION

This chapter is composed of two main sections. First, the adaptations of the WRI methodology is discussed and in the second section it is analyzed the methodology and results of the National Risk Atlas elaborated by the National Center of Disasters Prevention (CENAPRED); also it is analyzed the historical record of disasters developed by DesInventar, in order to know if there is a visible link between the number of disasters and the results of this study; and a comparison of the outcomes of this study regarding some aspects of risk management in Mexico, specifically those concerning the post disaster financial instrument of the federal government to face damages caused by disaster: FONDEN.

5.1. Adaptations of the WRI methodology

In 2011, the methodology of the World Risk Index was adapted to assess risk at a local level and it was tested in Indonesia "in order to separately illustrate and examine the local and regional differences in terms of exposure, susceptibility, coping capacities and adaptive capacities" (Alliance Development Works et al. 2011, p.36).

The study was carried on at the level of kabupaten, which can be compared with a state in Mexico or a district in Germany. In total twenty-six indicators were developed, of which five indicators assessed exposure to earthquakes, floods, storms, droughts, and the sea level rise and the remaining twenty-one indicators assessed vulnerability (Alliance Development Works et al. 2011).

As in this research, even when the structure of the WRI at global level remains the same, to assess local risk in Indonesia it was necessary to adapt or discard some indicators due to the availability of data. However, in the case of Indonesia assessing risk at local level offered the opportunity to integrate indicators that measured some relevant aspects that at the global level was not possible to get, because of the lack of comparable data (Alliance Development Works et al. 2011).

Regarding similarities and differences in the process of adapting the WRI methodology to Mexico and Indonesia it can be mentioned the following by component:

Exposure

As it was mentioned, Indonesia's risk index evaluated the exposure to five natural hazards and to do this it was used the same method as in the WRI, while for Mexico's risk index it was assessed the exposure to four natural hazards leaving aside the sea level rise. Also, the method to do it was different because of the data availability and the time to process the results.

However, the aim of the two methods was the same: to assess the population exposed to natural hazards.

Susceptibility

In both cases, susceptibility was the component with more indicators than the others. For Indonesia's risk index, the component was integrated by nine indicators (Alliance Development Works et al. 2011).while for Mexico's risk index by seven.

Four of the nine indicators used for Indonesia's risk index were new indicators to assess local aspects and the subcategory of nutrition was not include but it was the housing conditions subcategory that in the WRI was not included due to the lack of data (Alliance Development Works et al. 2011).

In the case of Mexico's risk index two indicators were adapted because of the data availability but in general the aim of these two indicators remains the same as the

WRI. Moreover, the nutrition subcategory was included but was not the housing subcategory due to it was tried to use the same indicators as the WRI.

Coping capacities

This is the component with the largest differences among the indices. In the WRI, coping capacities is integrated by five indicators, but in the Indonesia's risk index is integrated by seven indicators while in the Mexico's risk index by four.

Besides, all the indicators used in the Indonesia's risk index were new indicators to assess local aspects and none of them was included in the WRI. Also the subcategory of medical services was not included but it was the subcategory of social networks (Alliance Development Works et al. 2011). Meanwhile in the Mexico's risk index the subcategory of social networks was not included and it was impossible to find an indicator of the subcategory of Government and authorities whose aim was the same as in the WRI.

Adaptive capacities

It encompasses eleven indicators in the WRI, being the component with the largest number of indicators. In the Indonesia's risk index it is integrated by five indicators; three of these indicators were new indicators to assess local aspects. Also the subcategory of investment was discarded and the subcategory of adaptation strategies was included (Alliance Development Works et al. 2011).

In the case of the Mexico's risk index this component consists of six indicators, all of them are included in the WRI as well. But due to lack of information the subcategory of environmental status/ecosystem protection was not included in this study.

Another general difference is that for Indonesia, the risk index only was obtained for three kabupaten (districts or states) while for Mexico the thirty-two states were included in the study; therefore in the case of Mexico were selected indicators that had data for all the states.

Also, regarding the indicators, those used in the case of Mexico are more similar with respect of the WRI than those indicators used for the case of Indonesia. However, a plus that has the Indonesia's risk index is that it has more indicators that try to capture the local aspects. Maybe, in a future, to improve the Risk index for Mexico it would be necessary to add some indicators to capture the local situation; for example to develop an indicator regarding the use of the Mexico's Natural Disaster Fund among the states.

In general, even when the structure of these two adaptations is similar because both use the same risk components and they apply a similar method to obtain risk; the indicators to assess the components are quite different; therefore the results of the Indonesia's risk index and the results of the Mexico's risk index are not comparable due to their differences between indicators.

5.2. Comparison of the National Risk Index for Mexico

5.2.1. Mexico's Risk Atlas

The National Center of Disasters Prevention (CENAPRED) (2007, p.18) defines the national risk atlas as "an integral information system that encompass databases and geo-referenced information systems that allow to develop hazard analysis, vulnerability analysis and risk analysis in dealing with disasters at national, regional or local scale." "It proposes general guidelines and criteria to identify and quantify hazards, establish vulnerability functions and estimate the degree of exposure" so the states can develop their own risk assessments. (Guevara et al. 2006, p.11)

For the development of the Risk Atlas, CENAPRED states that risk has three components: hazard, exposure and vulnerability.

Hazard is defined as "the probability of occurrence in a given period a potentially damaging phenomenon. The potential danger is measured by its intensity and its return period"(Quaas 2005, p.6)

Exposure means "the number of persons, goods, assets, infrastructure and systems that are susceptible to damage "(Quaas 2005, p.6) and

Vulnerability: "Propensity of the exposed systems to be affected" (Quaas 2005, p.6)

Therefore risk is expressed as R: f(Hazard*Exposure*Vulnerability) (Quaas 2005, p.6)

In general, the methodology to develop the risk atlas consists of five steps (Guevara et al. 2006, p.18):

1. Identification of natural and anthropic phenomena
2. Determination of the hazard associated to the identified phenomenon
3. Identification of the exposed systems and their vulnerabilities
4. Evaluation of the different levels of risk associated with each type of phenomenon.
5. Systematic integration of information on natural and anthropogenic phenomena, hazard, vulnerability and risk

Until now, CENAPRED has focused, mainly on the two first steps, and had developed few risk maps. On the online map viewer in the webpage of CENAPRED (2014d) can be observed that regarding geological phenomena, the Risk Atlas has four maps and the four of them are about identification of geological phenomena and determination of hazards. In the case of hydro-meteorological phenomena it has thirty-one maps, of which twenty-five are about the identification of hydro-meteorological phenomena and determination of hazards; and the remaining six are about degree of risk to: hurricanes, snows, hailstorms, electric storms, low temperatures and droughts.

For the development of these six maps it was used the next equation (Jiménez et al. 2012, p.46):

$$IR = \{Ln[D] + 3\} * IVS * IP$$

Where:

IR= Risk Index

D= Population density

IVS= Social Vulnerability Index

IP= Hazard Index

Here, the exposure is assessed with the population density, the hazard with the hazard index and vulnerability with the social vulnerability index. The last one was developed by CENAPRED for all the municipalities of the country and it is integrated by three components: 1. socio-economic indicators regarding health, educations, housing conditions, employment, income and population. 2. Response capacities of the Government and 3. Public perception (García et al. 2006).

After all the above it can be concluded that there are many differences between the National Risk Atlas and the adaptation of the WRI methodology made in this study. First, the methodology to assess risk is different, this study states that risk is integrated by vulnerability and exposure; placing hazard inside exposure.

Then, in the National Risk Atlas, exposure is assessed with the population density while in this study is assessed with the proportion of the population exposed. Vulnerability has some similarities regarding the socio-economic indicators but the indicators to measure the government capacities are different.

Also, the National Risk Atlas do not assesses risk on a global way (adding together the exposure of all hazards); instead of this it assesses the risk to each hazard. Meanwhile the Risk Index for Mexico assessed risk on a global way and this single risk map can help to have a general overview of risk among the states; however it is also interesting to develop individual risk maps for each hazard.

Because the used methodologies are very different it is impossible to compare the results of the Risk Index for Mexico and the Maps of the National Risk Atlas.

In the future, it would be very interesting merge both methodologies, taking the strengths of each one of them to develop a new and improved risk index for Mexico.

5.2.2. Historical inventory of disasters

DesInventar is an historical inventory of disasters created by the Network for Social Studies on Disaster Prevention in Latin America (LA RED), used for most of the countries in this continent (DesInventar 2013). Mexico had its inventory of disaster from 1970 to 2011, an inventory that records not just the events of large magnitudes/intensities but also small events that can be considered as disasters because they affect the local population.

All disasters caused by earthquakes, hurricanes and droughts[5], registered from 1990 to 2011 have been selected in order to know which states have been more struck by disaster in the past and if this behavior has a relation or link with the states with higher risk according to this study.

According to DesInventar (2013) from 1990 to 2011 there were 5,036 disasters of any intensity/magnitude caused by earthquakes, hurricanes and droughts in all the country. The states with the highest number of disasters were Veracruz, Distrito Federal, Chiapas, Puebla, Oaxaca and Guerrero. In total, these states suffered 2,034 disasters, which imply that 40.39 percent of the disasters registered in Mexico in

[5] Floods are excluded of this analysis to avoid duplicity of information because the database of DesInventar regarding floods was used to develop the indicator of exposure to floods.

twenty one years, occurred just in six states. This is a high percentage taking into consideration that Mexico has thirty two states. This means that 59.61 percent of the registered disasters were distributed in 26 states.

Some coincides about the states with the highest risk and the states with the highest number of disasters were found. It can be seen, in figure 22, that Chiapas, the state with the highest disaster risk, occupies the third position in the ranking concerning the states with highest number of disasters, while Veracruz is at the top of that ranking.

States with the highest and the lowest risk, their number of disasters and position in the national ranking

State	Risk	Disasters 1990-2011	Ranking (disasters)
Chiapas	38.64%	317	3
Guerrero	36.89%	243	6
Baja California	35.72%	66	27
Guanajuato	34.78%	88	23
Oaxaca	32.20%	263	5
Veracruz	31.49%	601	1
Distrito Federal	08.17%	330	2
Aguascalientes	11.40%	45	31
Nayarit	14.09%	65	28
Campeche	17.08%	82	24
Yucatan	17.27%	224	7
Tamaulipas	17.28%	194	9
Chihuahua	17.79%	135	17

Figure 22: States with the highest number of disasters from 1990 to 2011
Source: Own. The number of disaster was got from DesInventar 2013

It is worth mentioning that Baja California and Guanajuato are between the states with the lowest disasters registered in the inventory, even though they have a very high risk of disasters according to this study. But, it is necessary to take into account that natural hazards do not provoke disasters by themselves, and that disasters will depend of the interaction among the society with their environment, factors that reflect their vulnerability (UNISDR 2001). So, in Baja California's case, its high risk might be largely due to exposure and its low vulnerability may counteract the effects and impacts of the natural hazards reducing its number of disasters.

Leaving aside these two states, it is also very interesting that the four states of the southern region (Chiapas, Guerrero, Oaxaca and Veracruz) belong to the top six states with the highest number of disasters and even more interesting that nearly 30 percent of the disasters occurred from 1990 to 2011 took place in this region.

As it was mentioned in the results chapter, the states of the south region are in the range of medium to high exposure, but all of them have a very high vulnerability, thus, there is a link between high vulnerability and number of disasters because "there is a high disaster risk if one or more natural hazards occur in vulnerable situations" (Romero & Maskrey 1993, p.7). So, it can be argued that high vulnerability makes the states of the southern region more prone to disaster.

It is also possible that many of the registered disasters in these four states were not provoked by hazards of large intensity/magnitude that in other states, with lower vulnerability, would not trigger a disaster. However because of their high vulnerability the events become disastrous. This information supports Mansilla's idea (2006, p.14) that argues that "disasters are indicators of deficit on the levels of development or the inadequate manifestation of development styles that can be expressed in environmental, social, economic and even political terms".

On the other hand, Aguascalientes, Nayarit, Campeche, and Chihuahua; four of the seven states with very low risk, occupied the bottom places regarding the number of disasters, with just 6.49 percent of the total of disasters occurred in these states.

The three remaining states show differences among their position on the ranking of disasters and their levels of risk. Especially Distrito Federal that according to the data available at DesInventar is the second state with the highest number of disasters and that according to the present study is the state with the lowest risk in Mexico. Perhaps this is due to the higher concentration of population and the problems regarding urbanization, however a deeper analysis is necessary to find the real reasons.

5.2.3. Mexico's Natural Disaster Fund (FONDEN)

FONDEN is a budgetary mechanism established by the federal government at the end of the ninety's with the purpose of supporting post disaster activities of emergency, recovery and reconstruction (Hofliger et al. 2012). Years later, seeing the necessity and importance of the proactive management of risk, a budget for preventing disaster activities was also included in the found (Hofliger et al. 2012).

Thus, FONDEN has two main objectives: recovery, reconstruction and acquisition of risk transfer instruments; and risk identification and reduction. To accomplish the first objective FONDEN has three financial instruments: 1. Program FONDEN for reconstruction, 2. Trust FONDEN and 3. Found for emergency attention FONDEN. While for the second objective, the institution has two instruments: 1. Program Found for Prevention of Natural Disaster (FOPREDEN) and 2. Trust for Prevention of Natural Disasters (FIPREDEN) (Hofliger et al. 2012).

However, the instruments for recovery and reconstructions continue being the most important and with higher monetary resources than the financial instruments for risk identification and risk reduction. For that reasons the following analysis is focused just in the Program FONDEN.

The Program FONDEN finances reconstruction's activities that help reduce vulnerability and increase resilience; also this fund is used to finance relocation of public buildings and communities that are in high risk zones (Hofliger et al. 2012). States can apply to the Program FONDEN, for reconstruction of public infrastructure and dwelling damages due to disasters. For this it is necessary that the Mexican Secretary of Government, who is in charge of FONDEN, issues a declaration of disaster (Hofliger et al. 2012). A declaration of disaster is a public manifestation about the occurrence of a disaster that caused serious damages and has exceeded the local capacity of response (operative and financial) (Hofliger et al. 2012). After, the damages and the application for the monetary resources are assessed, and in case of a satisfactory resolution, the resources are authorized by the federal government (Hofliger et al. 2012).

According to the historical data of the Federation’s Official Journal (DOF) (2014) from 1999 to 2013 625 disaster declarations were issued in Mexico. Being Veracruz, Chiapas, Nuevo León, Oaxaca, Guerrero, Puebla, San Luis Potosi and Jalisco the states at the top of the list, which means that eight states concentrate slightly more than the 50 percent of the disasters declarations from 1999 to 2013.

Relating the states with the highest and the lowest risks and their number of disasters declaration, we can observe in figure 23 of the present research, that the four states of the southern region are on the top of both rankings, which also coincides with the number of historical disasters ranking.

Veracruz is by far, the state with the highest number of disasters declaration, gathering 15.20 percent of the total declarations. And the four states of the southern region together gather 33.28 percent of the declarations. It implies that the capacity of response, operative and financial, in all the states of this region is very low and deficient and it agrees with a diagnostic of UNPD (2009, p.1) that mention that 65 percent of the surveyed municipalities in the south region "do not have: risk atlas, regulations to invest with low vulnerability, emergency response plans, trained personnel to protect population, among others".

Moreover, Baja California and Guanajuato have few declarations of disaster, which coincides with their situation regarding number of disasters.

States with the highest and the lowest risk, their number of declaration of disaster (DoDis) and position in the national ranking

State	Risk	Declaration of disaster 1999-2013	Ranking (DoDis)
Chiapas	38.64%	42	2
Guerrero	36.89%	30	5
Baja California	35.72%	5	29
Guanajuato	34.78%	11	23
Oaxaca	32.20%	41	4
Veracruz	31.49%	95	1
Distrito Federal	08.17%	4	32
Aguascalientes	11.40%	6	26
Nayarit	14.09%	12	21
Campeche	17.08%	6	27
Yucatan	17.27%	6	28
Tamaulipas	17.28%	23	9
Chihuahua	17.79%	19	13

Figure 23: States with the highest number of declaration of disaster from 1999 to 2013
Source: Own creation. The number of DoDis was got from DOF 2014

Regarding the states with the lowest risk, it can be observed in figure 23, that five of the seven states have also few declarations of disasters. Distrito Federal has the lowest declarations of disasters in the country and this corresponds with the level of risk, however it does not correspond with their number of disasters. So; perhaps it means that Distrito Federal has a high and efficient capacity of response.

According to Hofliger et al. (2012) disasters have imposed a significant charge on the public budget in Mexico and mention that from 1999 to 2011 the reconstruction post disaster cost authorized by FONDEN were around 1,460 million dollars per year of which 77 percent was designated to reconstruction of local (states and municipalities) assets; mostly highways (57 percent), hydraulic infrastructure (27 percent) and low income dwellings (9 percent).

Concerning the distributions of the resources of FONDEN, from 2000 to 2011 five states were the most benefited: Veracruz, Nuevo León, Tabasco, Chiapas and Oaxaca. Together they received 66.6 percent of the total resources of FONDEN (Hofliger et al. 2012). Besides, in 2013 of the total amount of authorized resources by FONDEN, slightly more than 50 percent were just for reconstruction of assets in Guerrero and Veracruz, and together all the states of the southern region used 67.40 percent of all the authorized resources (National Sistem of Civil Protection 2014).

FONDEN has focused on reconstruction of infrastructure, however the results suggest that it is necessary to concentrate efforts to reduce social and economic vulnerability as well as increasing coping and adaptive capacities because the states with the higher risk (and higher vulnerability) are those that are using most of the resources of FONDEN, and their risk and vulnerability have not been reduced.

World Bank (2013) mentions that since its creation FONDEN has exceeded its annual budget to face all the damages due to disasters, however major disasters are not the ones that caused FONDEN to exceed its annual budget but rather, all the small but regular events.

In the same study carried out by the World Bank (2013), it was found that the poorest municipalities, with the most insufficient public infrastructure (highways, hospitals, schools, etc.) had a higher risk of disasters and are the ones that have had major losses, regarding public and private assets. The study also found out that the states with the highest susceptibility and vulnerability ranks were those which presented higher risks. The same states that have also required the highest amount of resources of FONDEN for reconstruction.

Besides FONDEN, the federal Government has other programs, that although are not mainly focused on providing relief to the population after a disaster, support and in somehow help to accomplish this goal. Such is the case of Oportunidades and the Program of Temporary Employment (World Bank 2013). However these programs offer a temporary relief and do not reduce vulnerability. While according to the results obtained in this research, where 23 states got a higher score in vulnerability than in exposure, in order to reduce the risk of suffering a disaster, it is necessary to reduce their vulnerability.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

The main objective of this research was to develop a national risk index for Mexico, largely based on the world risk index methodology developed by UNU-EHS. To accomplish the objective, first were analyzed the gaps regarding information availability for developing the index. Then the WRI methodology was adapted for its implementation in Mexico and the fours components of risk (susceptibility, coping capacities, adaptive capacities and exposure) were assessed. Finally a risk typology for the Mexican states was developed.

Regarding the adaptation of the World Risk Index to the national scale it can be concluded that in general, it was achieved the adaptation of the methodology to assess risk in Mexico having a general overview about risk and vulnerability and their spatial distribution inside the country. But, there were some difficulties or aspects to take into consideration when adapting the methodology of the WRI to Mexico.
The main difficulties were the existing information gaps and the time consuming searching and analyzing the available information to develop the indicators. In this phase, it was found that there is information bias. Socio- economic data are relatively easy to obtain, even in lower disaggregation level than state (municipalities for example); however information about some coping capacities and adaptive capacities are not so easy to obtain. Also, the information about environmental status and ecosystem protection is limited or non-existent for each state. Therefore, there is a lack of relevant environmental information in Mexico to assess the environmental status of the states. Only some information was found but in a higher disaggregation level (regions for example).

As all indices, the methodology of the National Risk Index for Mexico has some weaknesses. The principal ones are those related to the component of exposure. The information to assess exposure to floods has some uncertainties therefore there is not 100 percent reliable. Also, as the method to assess exposure had to be modified due to the information availability it should be strengthened trying to develop a better way to assess the exposure of the population to hazards. Also, the component of coping capacities is integrated by four indicators, so it is necessary to add new indicators (as in the case of Indonesia) to strengthen the component.

In a future, to improve the Risk index for Mexico it would be necessary to add some indicators to capture the local situation of Mexico; for example developing an indicator regarding the use of the Mexico's Natural Disaster Fund. Or take into consideration the indicators used in the social vulnerability index (developed by CENAPRED) regarding the Government response capacity. Besides it would be very important that the National Risk Index for Mexico include indicators to assess the environmental aspects as well as the ecosystem management; taking in mind that the environment is also damage when disasters strike.

Also, as a recommendation it would be interesting to develop risk maps to each natural hazard, because it could be helpful to identify or suggest differentiated strategies to reduce vulnerability focusing in those specific hazards.

One of the strengths that have the WRI is has a relatively easy method to obtain each component, vulnerability and risk and in general it allows the use of new indicators to assess the local situations taking into consideration the subcategories of the components (as the case of Indonesia). So, there is a methodology to assess risk and get an overview of risk at national scale.

In general, the outcomes of the index are reliable. However the results have to be taken with discretion, having in mind that they are based on the use of specific indicators. Therefore they are just an approximation of the reality.

Regarding the results of applying the methodology it can be concluded that; there is a high disparity among states regarding public infrastructure, condition of nutrition, poverty and income distribution. The states of the north of Mexico have lower susceptibility than the states of the south (southeast and south regions). Also, the current structures of the states of the south region, regarding education, gender equity and investment are very week and are not well prepared to face future natural events. They need to strengthen their adaptive capacities

The northwest is the region with the highest exposure of Mexico All its states present a very high and high exposure to droughts, earthquakes, floods and hurricanes; but also most of its states have a very low vulnerability. Besides all its states have very high to medium levels of risk but mostly due to exposure; meanwhile, all the states of the south region have a very high risk of disasters, mostly due to their high vulnerability.

Moreover; nine of the thirty two states of Mexico got a higher score in exposure than in vulnerability while 23 states got a higher score in vulnerability than in exposure. Knowing these differences is very important for decision making because it is possible to reduce the disaster risk of this 23 states while improving the socio economic aspects and the governments' capacities of response, this mean reducing their vulnerability to reduce their risk to disasters.

It was also found that there is a link between high vulnerability and number of disasters. Nearly 30 percent of disasters from1990 to 2011 have occurred in the states of the south region, which are the ones with very high vulnerability. And the states of the south region are those that also have required the highest amount of resources of FONDEN for reconstruction

In terms of risk management the outcomes of this research can help the states and the federal government in the designing and implementation of proactive pre-disaster actions, taking into consideration their structural characteristics and current abilities.

Besides it is important that the federal government realizes that it is necessary to tie the risk management strategies with the social and economic strategies (education, reduction of poverty, employment, etc.) to join efforts for the reduction of vulnerability.

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ANNEXES

- **Annex 1.** Indicators Statistical Treatment
- **Annex 2.** Classification by quantile.
- **Annex 3.** Indicators Metadata
- **Annex 4.** Map of the regions and states of Mexico
- **Annex 5.** Results by component and state

ANNEX 1. INDICATORS STATISTICAL TREATMENT

In this annex can be found the asymmetry coefficient (skewness) and kurtosis and the Shapiro-Wilk test to probe normal distribution.

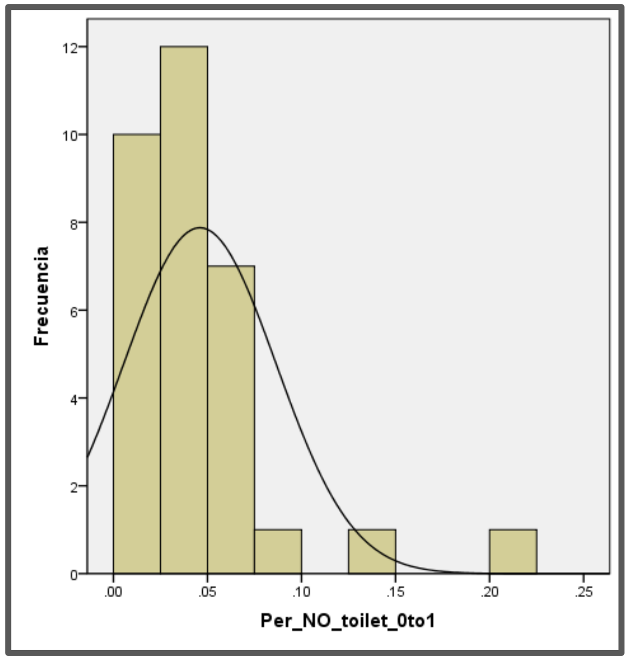
The tests were applied for each indicator and in case the indicator had not had a normal distribution the indicator was transformed and the normal distribution of its transformation also was tested. For more information see Chapter 3.

The statistical treatment only was applied to the Indicators of Susceptibility, Coping Capacities and Adaptive Capacities.

Susceptibility: Indicator A

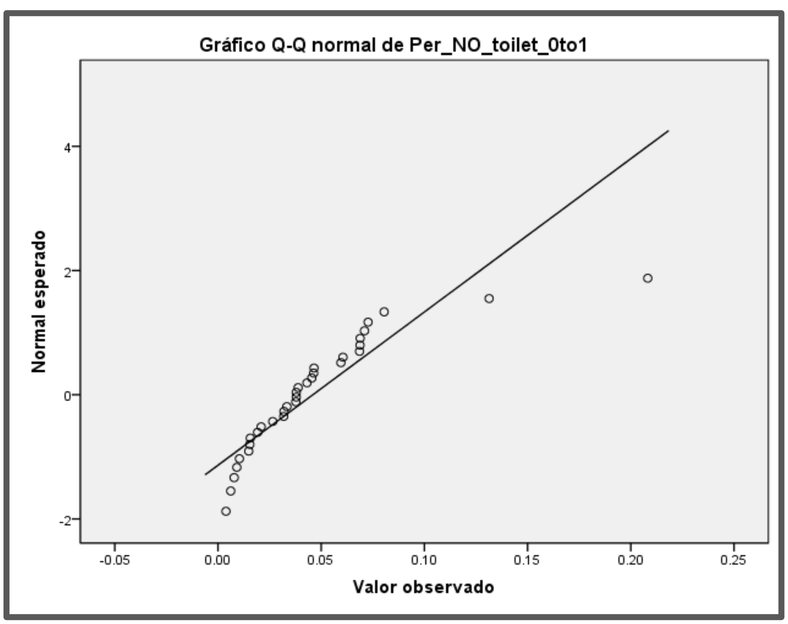
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		.0460	.00716
Intervalo de confianza para la media al 95%	Límite inferior	.0314	
	Límite superior	.0606	
Media recortada al 5%		.0409	
Mediana		.0379	
Varianza		.002	
Desv. típ.		.04052	
Mínimo		.00	
Máximo		.21	
Rango		.20	
Amplitud intercuartil		.05	
Asimetría		2.371	.414
Curtosis		7.788	.809



Normality test

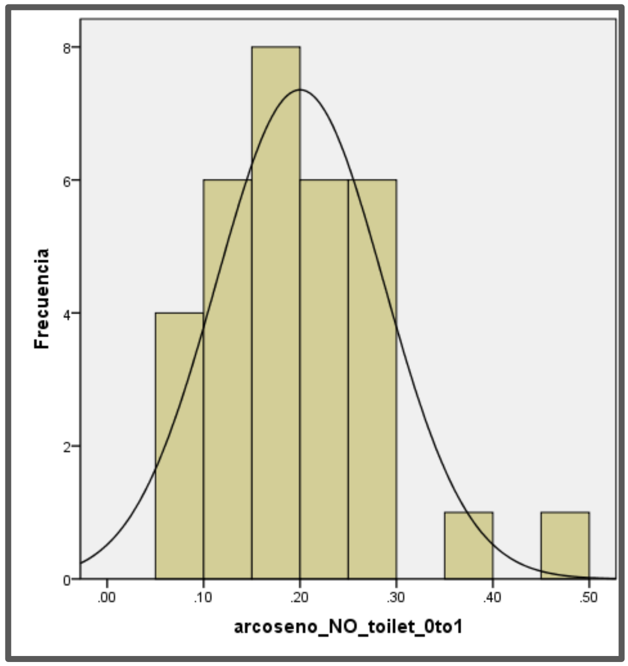
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Estadístico	gl	Sig.	Estadístico	gl	Sig.
Per_NO_toilet_0to1	.182	32	.008	.779	32	.000



<u>Test to verify normal distribution of the transformation</u>

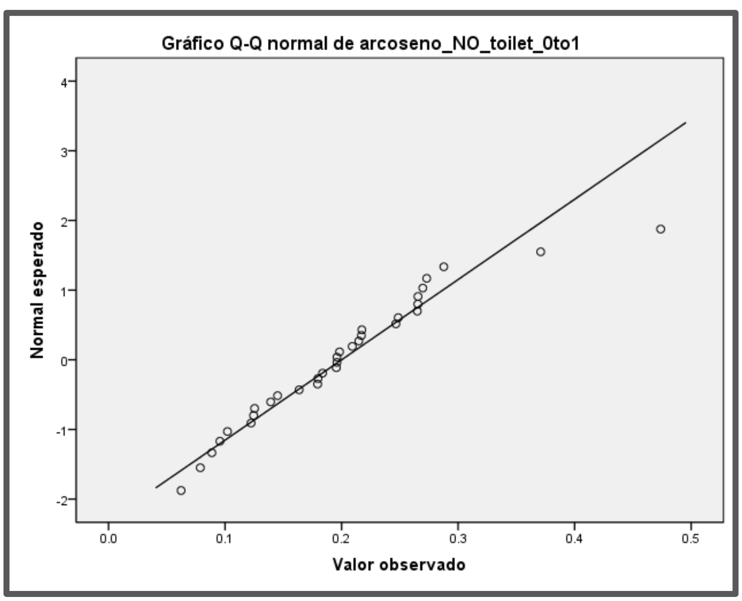
ARCOSEN

		Estadístico	Error típ.
Media		.2000	.01534
Intervalo de confianza para la media al 95%	Límite inferior	.1687	
	Límite superior	.2313	
Media recortada al 5%		.1943	
Mediana		.1960	
Varianza		.008	
Desv. típ.		.08677	
Mínimo		.06	
Máximo		.47	
Rango		.41	
Amplitud intercuartil		.13	
Asimetría		.966	.414
Curtosis		2.017	.809



Normality test

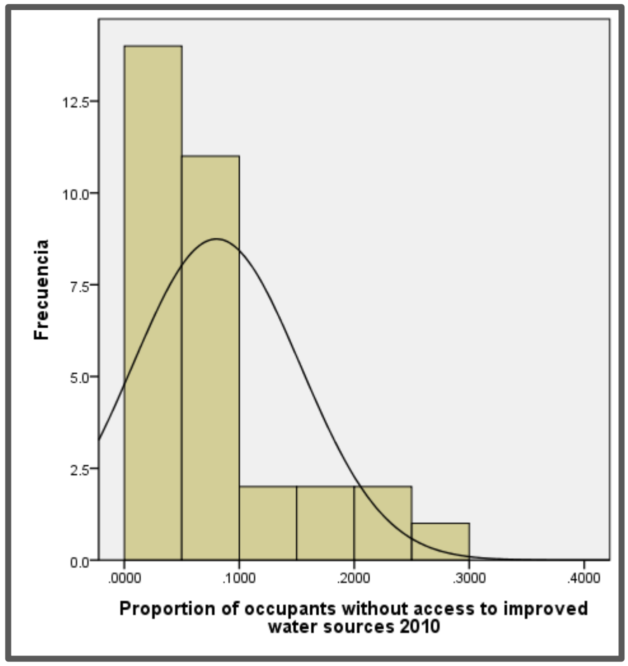
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Estadístico	gl	Sig.	Estadístico	gl	Sig.
Arcoseno	.108	32	.200	.937	32	0.60



Susceptibility: Indicator B

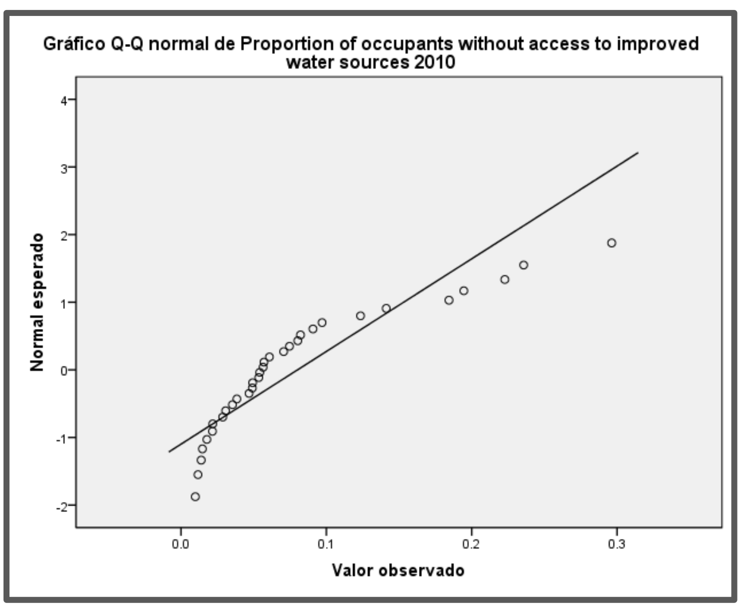
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		.080180	.01290
Intervalo de confianza para la media al 95%	Límite inferior	.053867	
	Límite superior	.106492	
Media recortada al 5%		.073303	
Mediana		.055306	
Varianza		.005	
Desv. típ.		.0729821	
Mínimo		.0098	
Máximo		.2963	
Rango		.2865	
Amplitud intercuartil		.0663	
Asimetría		1.525	.414
Curtosis		1.704	.809



Normality test

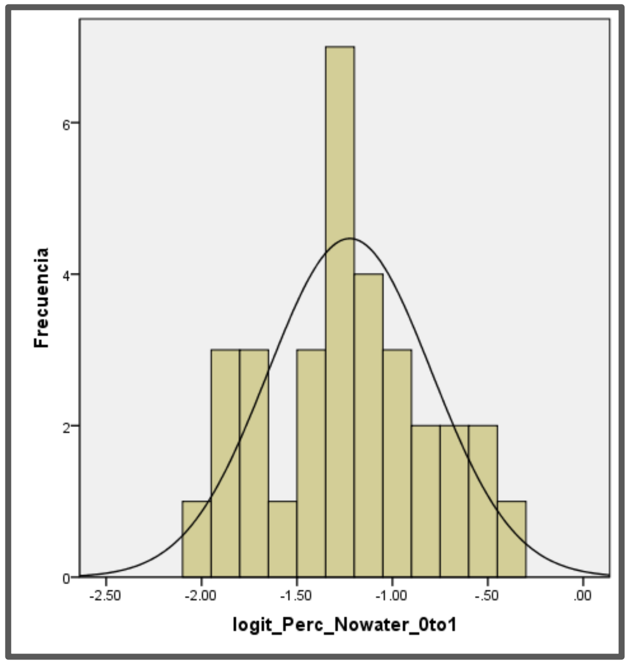
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.208	32	.001	.816	32	.000



Test to verify normal distribution of the transformation

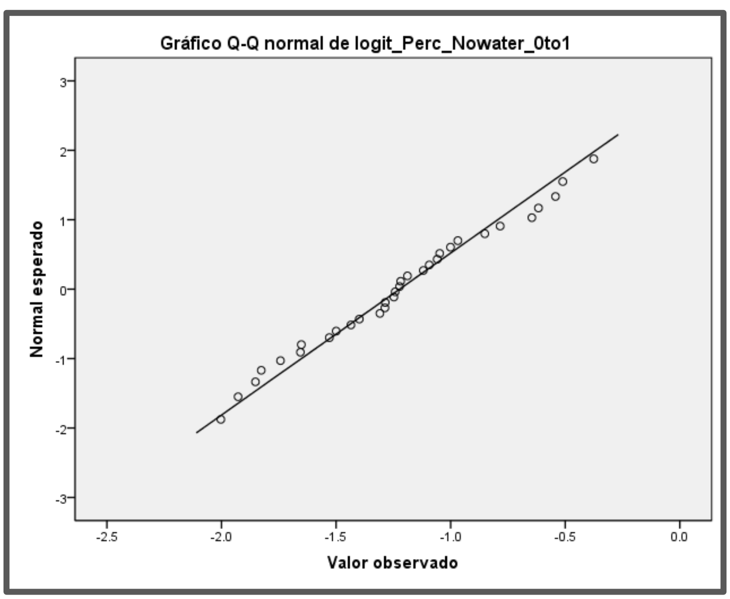
LOGIT

		Estadístico	Error típ.
Media		-1.2231	.07572
Intervalo de confianza para la media al 95%	Límite inferior	-1.3775	
	Límite superior	-1.0686	
Media recortada al 5%		-1.2256	
Mediana		-1.2326	
Varianza		.183	
Desv. típ.		.42835	
Mínimo		-2.00	
Máximo		-.38	
Rango		1.63	
Amplitud intercuartil		.55	
Asimetría		.096	.414
Curtosis		-.566	.809



Normality test

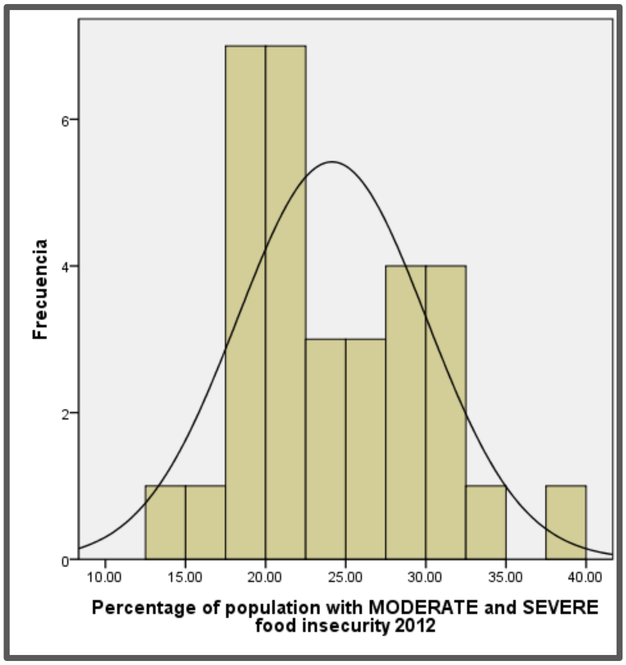
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Estadístico	gl	Sig.	Estadístico	gl	Sig.
Arcoseno	.077	32	.200	.977	32	0.724



Susceptibility: Indicator C

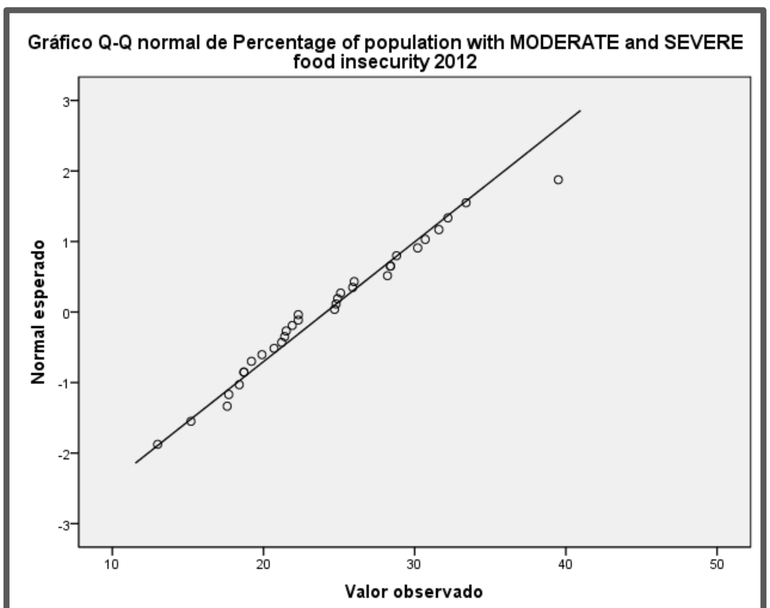
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		24.1406	1.0409
Intervalo de confianza para la media al 95%	Límite inferior	22.018	
	Límite superior	26.264	
Media recortada al 5%		23.988	
Mediana		23.500	
Varianza		34.673	
Desv. típ.		5.888	
Mínimo		13.000	
Máximo		39.500	
Rango		26.500	
Amplitud intercuartil		9.025	
Asimetría		.458	.414
Curtosis		.087	.809



Normality test

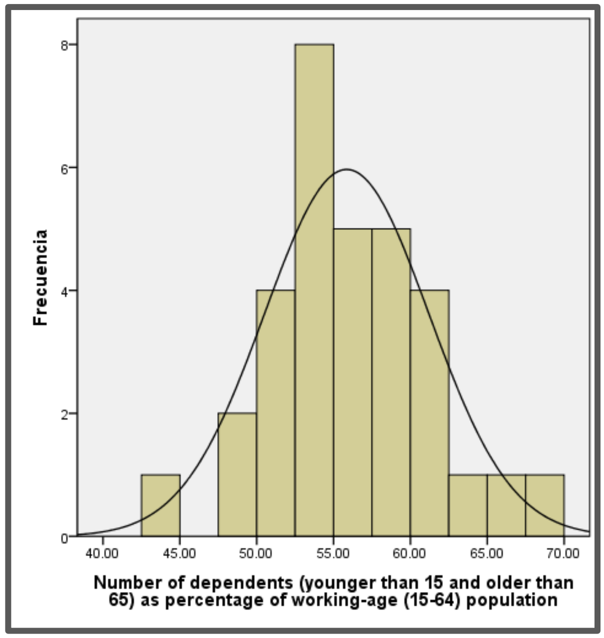
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.123	32	.200	.977	32	.719



Susceptibility: Indicator D

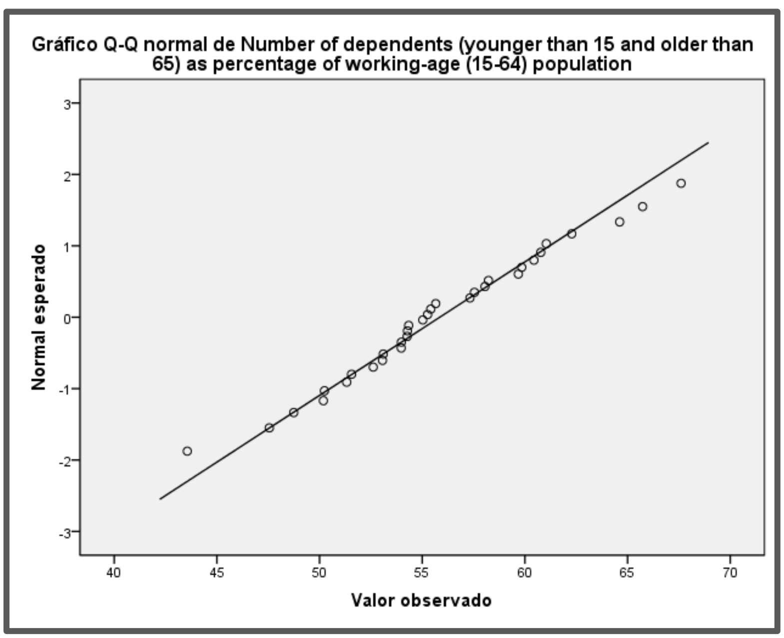
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		55.853	.945
Intervalo de confianza para la media al 95%	Límite inferior	53.9246	
	Límite superior	57.7812	
Media recortada al 5%		55.8389	
Mediana		55.1439	
Varianza		28.605	
Desv. típ.		5.34840	
Mínimo		43.5558	
Máximo		67.6075	
Rango		24.05	
Amplitud intercuartil		7.08	
Asimetría		.137	.414
Curtosis		.119	.809



Normality test

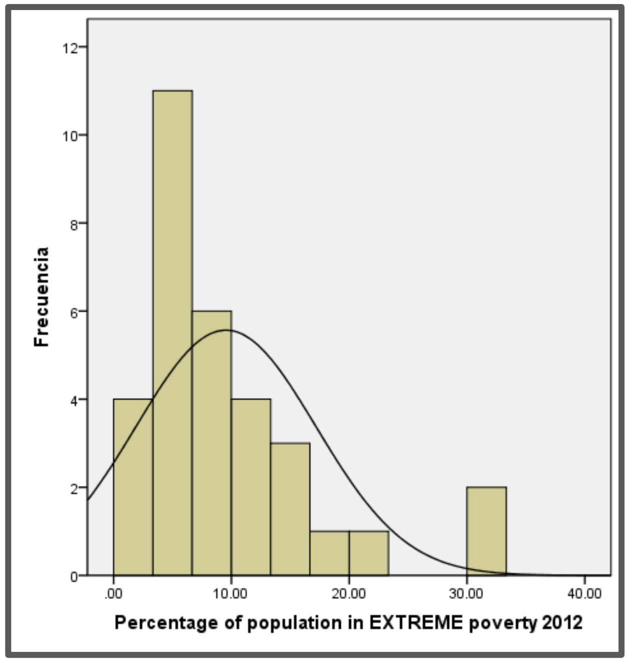
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.109	32	.200	.988	32	.971



Susceptibility: Indicator E

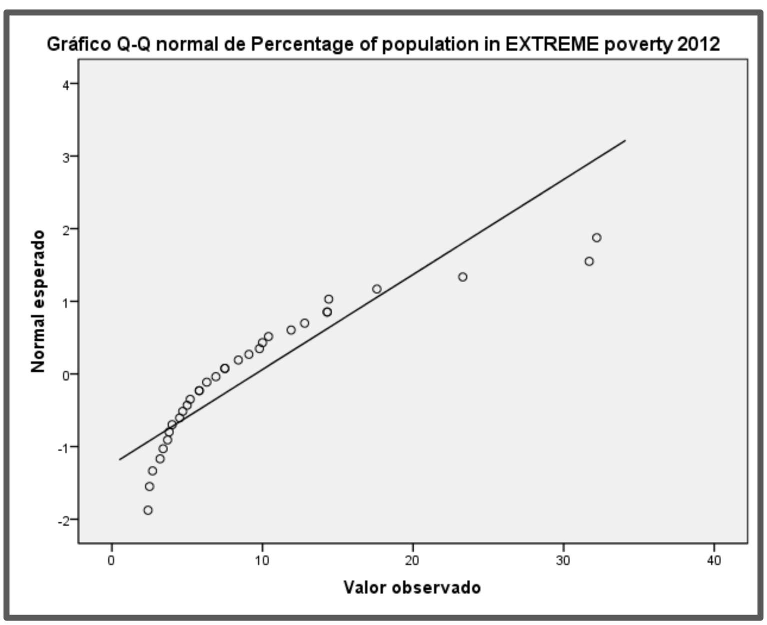
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		9.534	1.351
Intervalo de confianza para la media al 95%	Límite inferior	6.7783	
	Límite superior	12.2904	
Media recortada al 5%		8.6799	
Mediana		7.2000	
Varianza		58.435	
Desv. típ.		7.64429	
Mínimo		2.40	
Máximo		32.20	
Rango		29.80	
Amplitud intercuartil		8.45	
Asimetría		1.801	.414
Curtosis		3.144	.809



Normality test

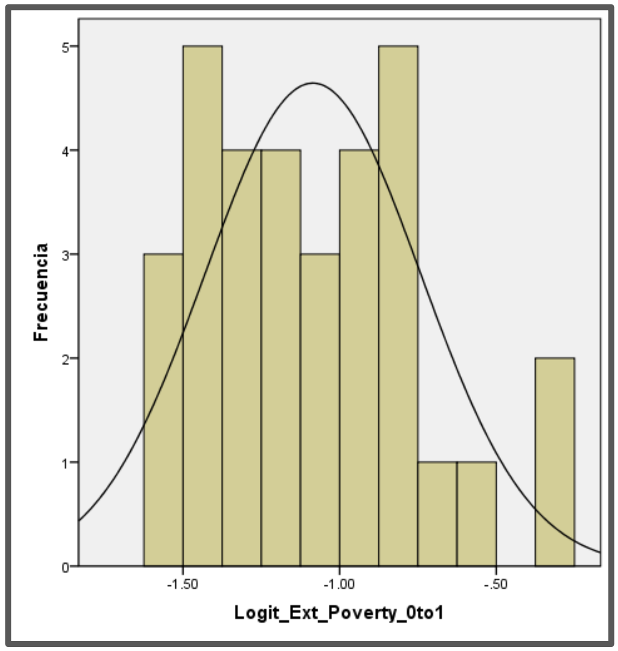
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.175	32	.014	.793	32	.000



Test to verify normal distribution of the transformation

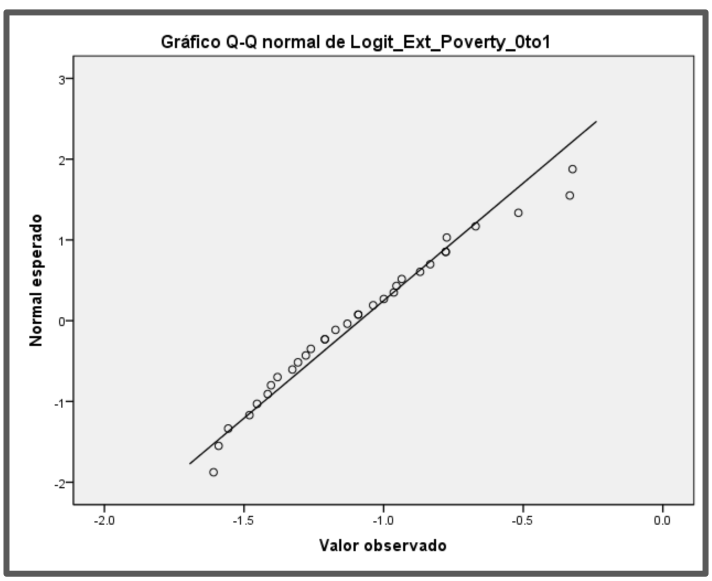
LOGIT

		Estadístico	Error típ.
Media		-1.0855	.0607
Intervalo de confianza para la media al 95%	Límite inferior	-1.2094	
	Límite superior	-.9617	
Media recortada al 5%		-1.0989	
Mediana		-1.1106	
Varianza		.118	
Desv. típ.		.34357	
Mínimo		-1.61	
Máximo		-.32	
Rango		1.29	
Amplitud intercuartil		.52	
Asimetría		.527	.414
Curtosis		-.231	.809



Normality test

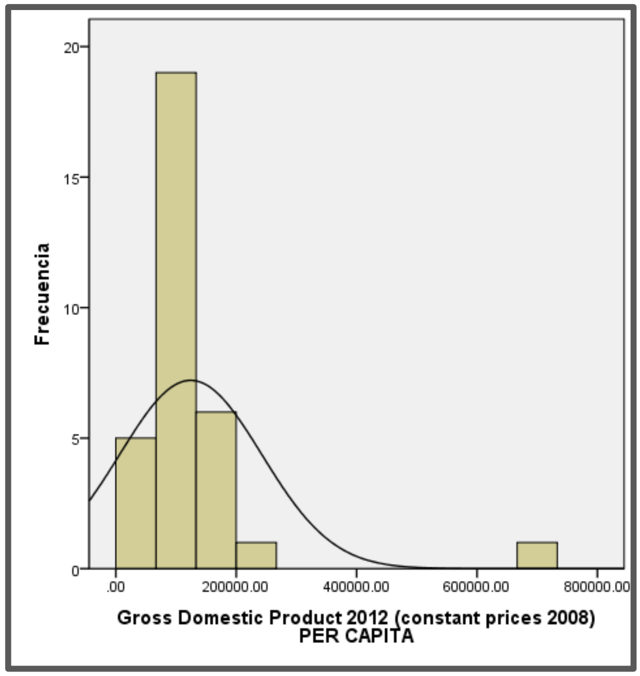
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Estadístico	gl	Sig.	Estadístico	gl	Sig.
Arcoseno	.080	32	.200	.962	32	0.314



Susceptibility: Indicator F

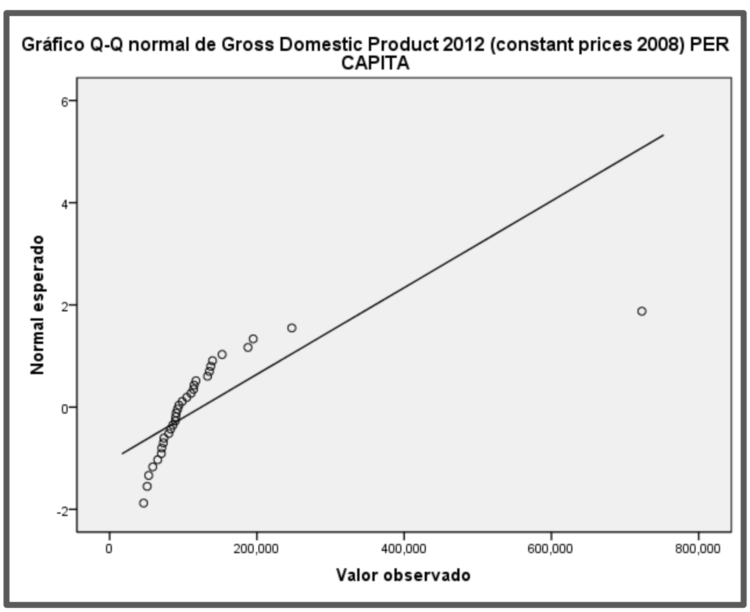
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		124290.2	20851.7
Intervalo de confianza para la media al 95%	Límite inferior	81762.87	
	Límite superior	166817.60	
Media recortada al 5%		105183.12	
Mediana		93157.10	
Varianza		13913415577	
Desv. típ.		117955.14	
Mínimo		46178.23	
Máximo		722826.95	
Rango		676648.72	
Amplitud intercuartil		61689.97	
Asimetría		4.49	.41
Curtosis		22.73	.81



Normality test

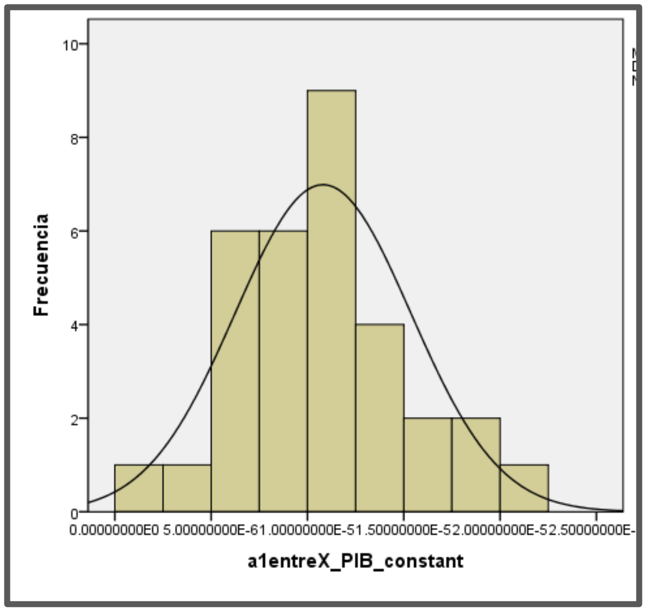
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.292	32	.000	.490	32	.000



Test to verify normal distribution of the transformation

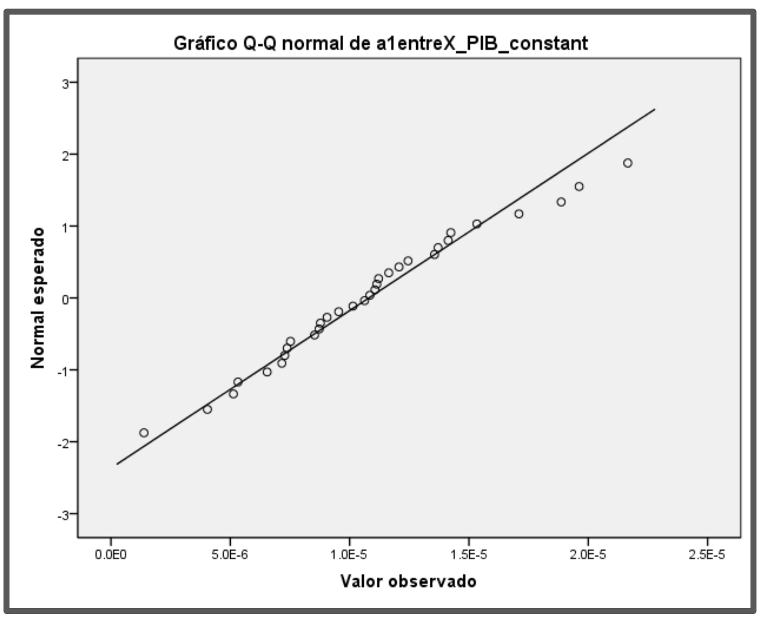
1/x

		Estadístico	Error típ.
Media		.0000108	.0000008
Intervalo de confianza para la media al 95%	Límite inferior	.0000092	
	Límite superior	.0000125	
Media recortada al 5%		.0000107	
Mediana		.0000107	
Varianza		.0000000	
Desv. típ.		.0000046	
Mínimo		.0000014	
Máximo		.0000217	
Rango		.0000203	
Amplitud intercuartil		.0000063	
Asimetría		.427	.414
Curtosis		.233	.809



Normality test

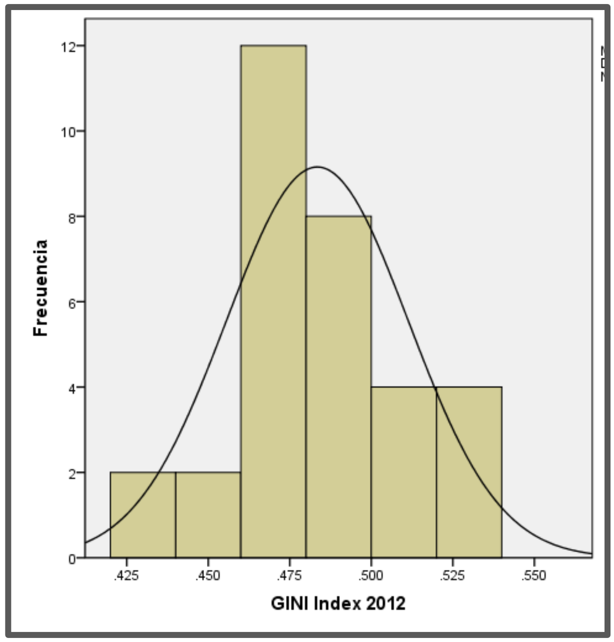
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Estadístico	gl	Sig.	Estadístico	gl	Sig.
Arcoseno	.089	32	.200	.980	32	0.806



Susceptibility: Indicator G

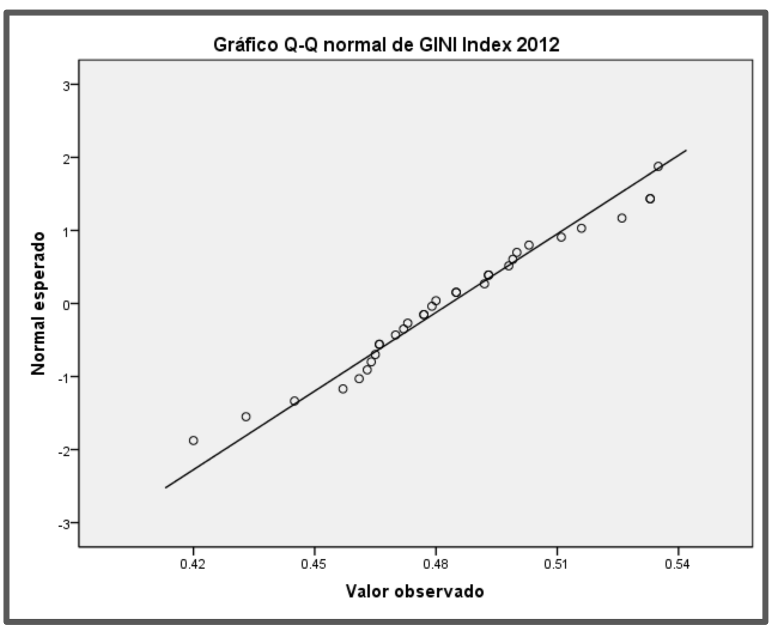
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		.48344	.004929
Intervalo de confianza para la media al 95%	Límite inferior	.47338	
	Límite superior	.49349	
Media recortada al 5%		.48387	
Mediana		.47950	
Varianza		.001	
Desv. típ.		.027883	
Mínimo		.420	
Máximo		.535	
Rango		.115	
Amplitud intercuartil		.035	
Asimetría		.041	.414
Curtosis		-.027	.809



Normality test

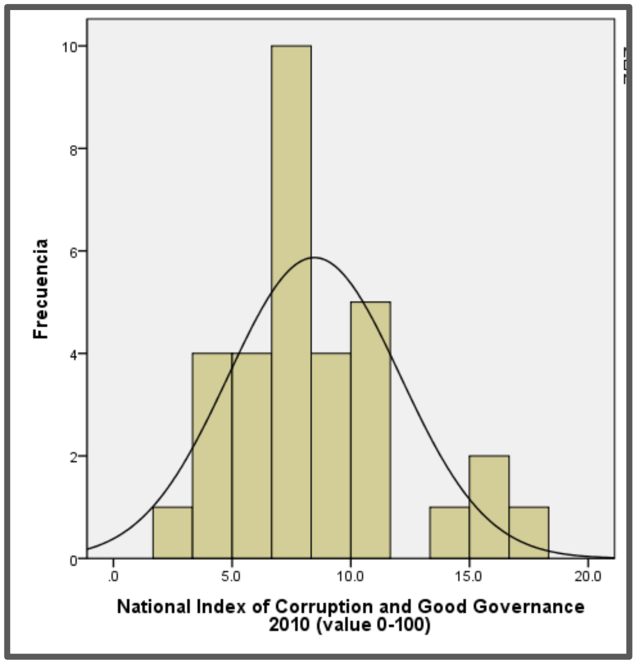
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.085	32	.200	. 974	32	.605



Coping capacities: Indicator A

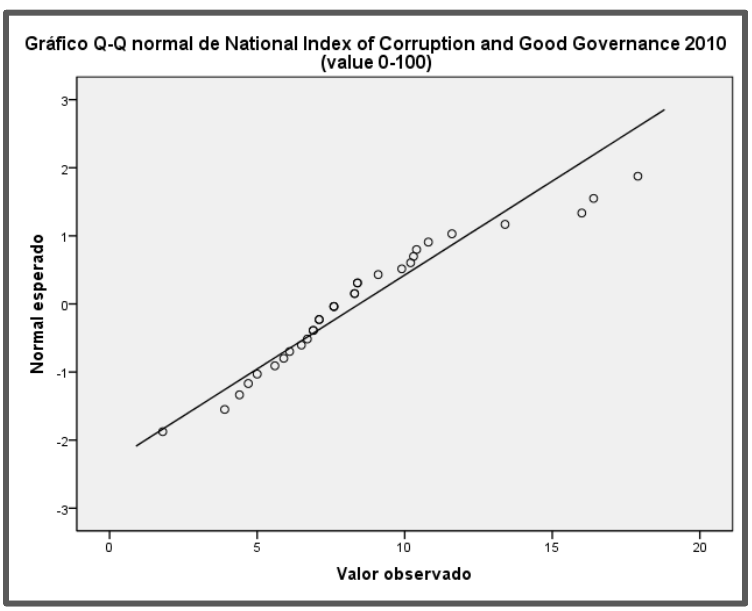
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		8.463	.6407
Intervalo de confianza para la media al 95%	Límite inferior	7.156	
	Límite superior	9.769	
Media recortada al 5%		8.296	
Mediana		7.600	
Varianza		13.137	
Desv. típ.		3.6244	
Mínimo		1.8	
Máximo		17.9	
Rango		16.1	
Amplitud intercuartil		4.1	
Asimetría		.955	.414
Curtosis		1.019	.809



Normality test

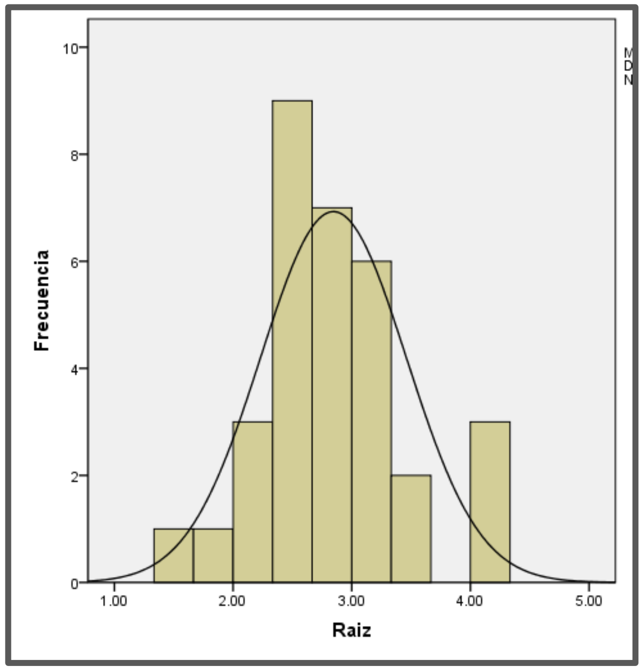
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.163	32	.030	.929	32	.038



Test to verify normal distribution of the transformation

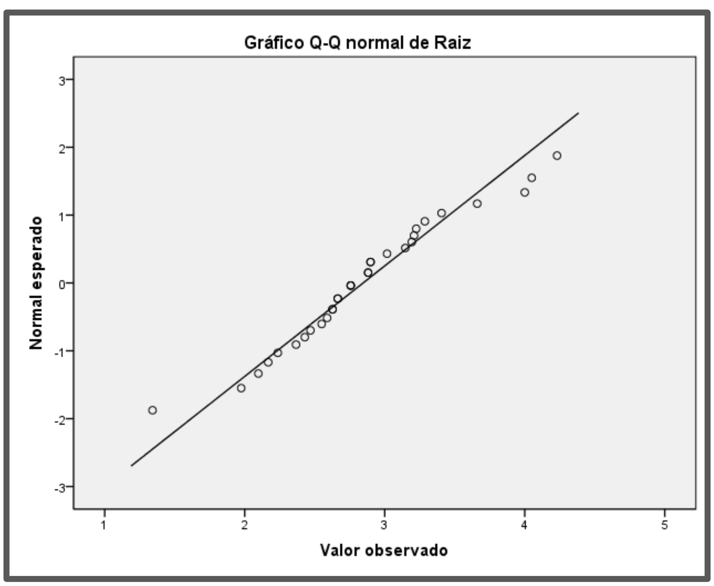
RAIZ

		Estadístico	Error típ.
Media		2.8455	.10857
Intervalo de confianza para la media al 95%	Límite inferior	2.6241	
	Límite superior	3.0670	
Media recortada al 5%		2.8427	
Mediana		2.7568	
Varianza		.377	
Desv. típ.		.61415	
Mínimo		1.34	
Máximo		4.23	
Rango		2.89	
Amplitud intercuartil		.72	
Asimetría		.237	.414
Curtosis		.725	.809



Normality test

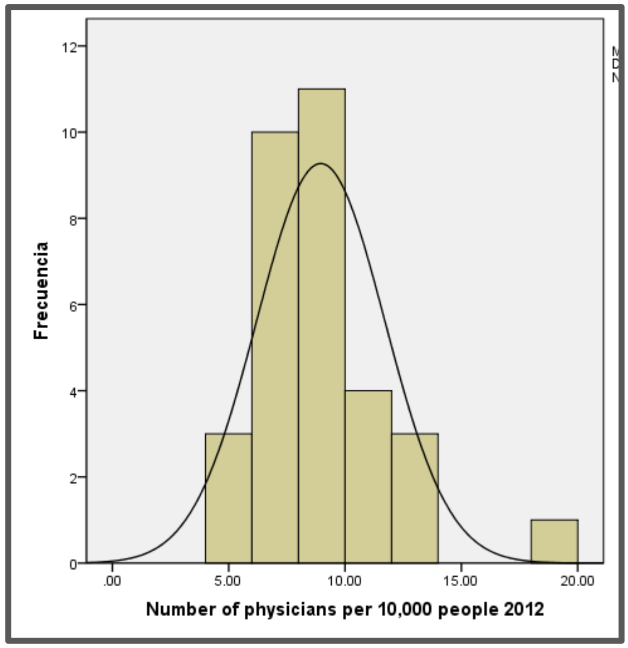
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.12	32	.200	.971	32	0.528



Coping capacities: Indicator B

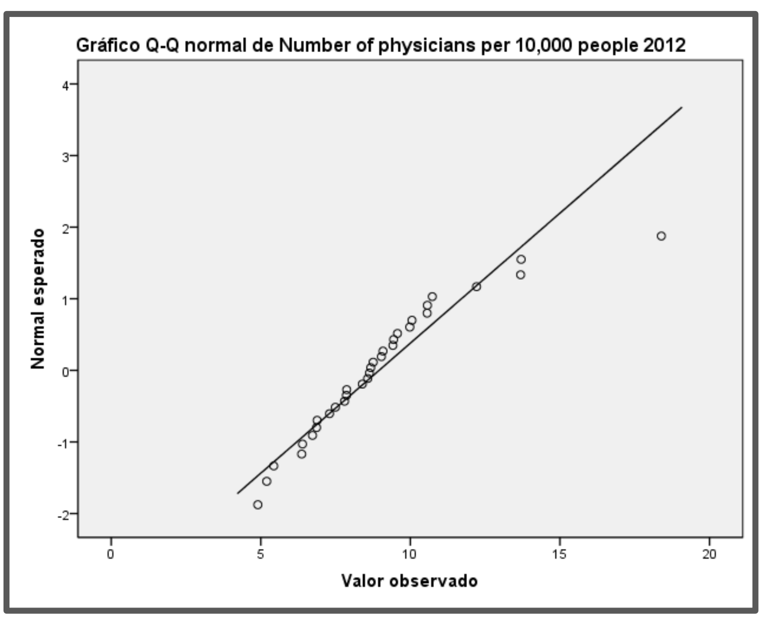
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		8.9547	.48678
Intervalo de confianza para la media al 95%	Límite inferior	7.9619	
	Límite superior	9.9475	
Media recortada al 5%		8.7472	
Mediana		8.6525	
Varianza		7.583	
Desv. típ.		2.75364	
Mínimo		4.90	
Máximo		18.39	
Rango		13.49	
Amplitud intercuartil		3.05	
Asimetría		1.426	.414
Curtosis		3.401	.809



Normality test

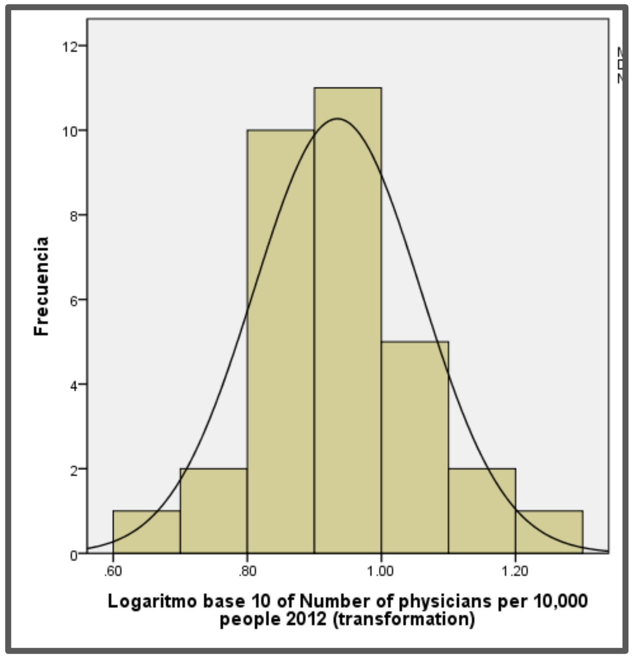
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.1 43	32	.152	.901	32	.007



Test to verify normal distribution of the transformation

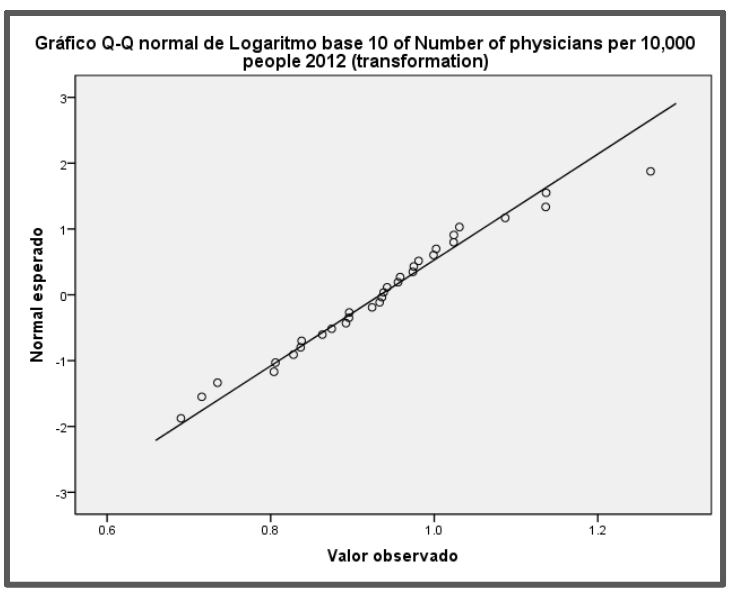
LOG 10

		Estadístico	Error típ.
Media		.9343	.02197
Intervalo de confianza para la media al 95%	Límite inferior	.8895	
	Límite superior	.9791	
Media recortada al 5%		.9316	
Mediana		.9371	
Varianza		.015	
Desv. típ.		.12429	
Mínimo		.69	
Máximo		1.26	
Rango		.57	
Amplitud intercuartil		.16	
Asimetría		.328	.414
Curtosis		.683	.809



Normality test

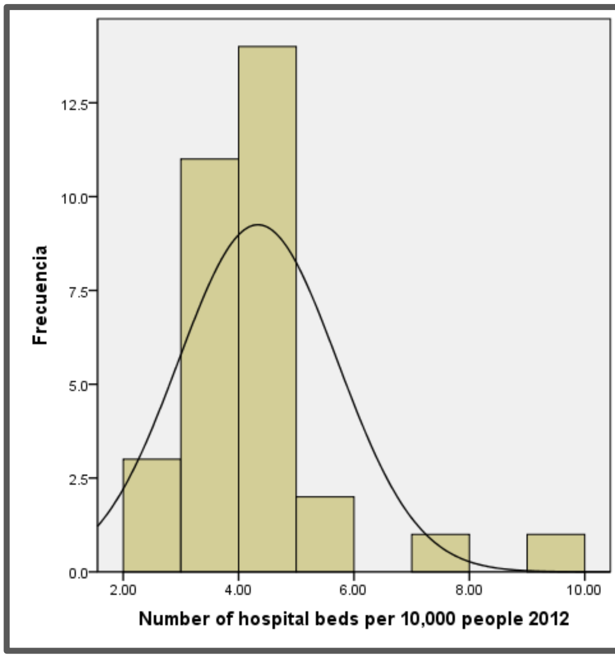
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.094	32	.200	.979	32	0.771



Coping capacities: Indicator C

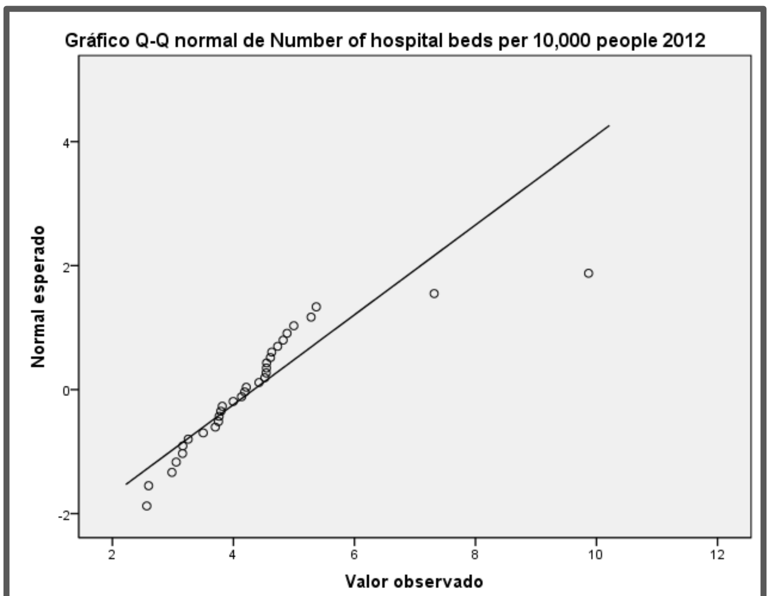
<u>Test to verify normal distribution of the indicator</u>

		Estadístico	Error típ.
Media		4.3353	.24392
Intervalo de confianza para la media al 95%	Límite inferior	3.8379	
	Límite superior	4.8328	
Media recortada al 5%		4.1786	
Mediana		4.1999	
Varianza		1.904	
Desv. típ.		1.37984	
Mínimo		2.57	
Máximo		9.87	
Rango		7.30	
Amplitud intercuartil		1.16	
Asimetría		2.321	.414
Curtosis		8.031	.809



Normality test

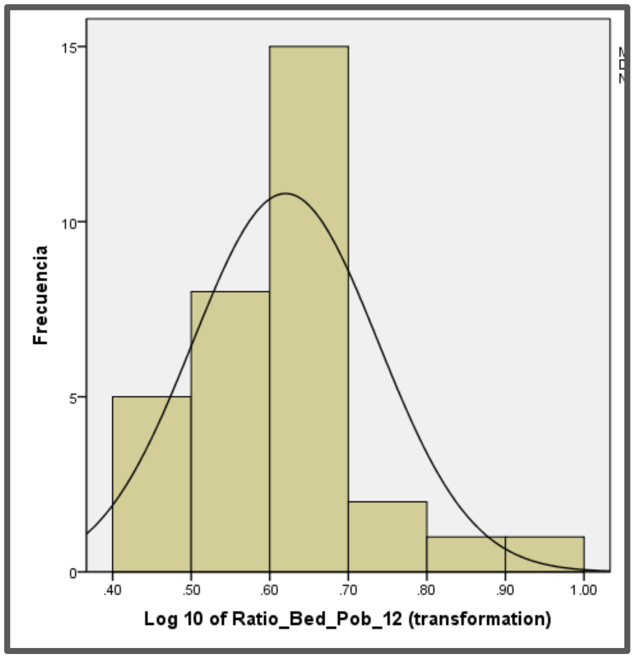
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.191	32	.005	.790	32	.000



Test to verify normal distribution of the transformation

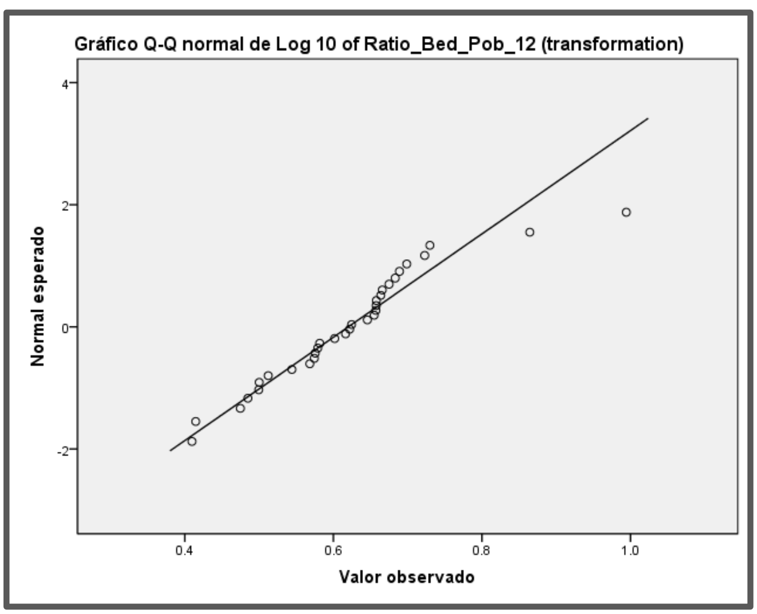
LOG 10

		Estadístico	Error típ.
Media		.6201	.02089
Intervalo de confianza para la media al 95%	Límite inferior	.5775	
	Límite superior	.6627	
Media recortada al 5%		.6136	
Mediana		.6232	
Varianza		.014	
Desv. típ.		.11817	
Mínimo		.41	
Máximo		.99	
Rango		.58	
Amplitud intercuartil		.12	
Asimetría		.872	.414
Curtosis		2.439	.809



Normality test

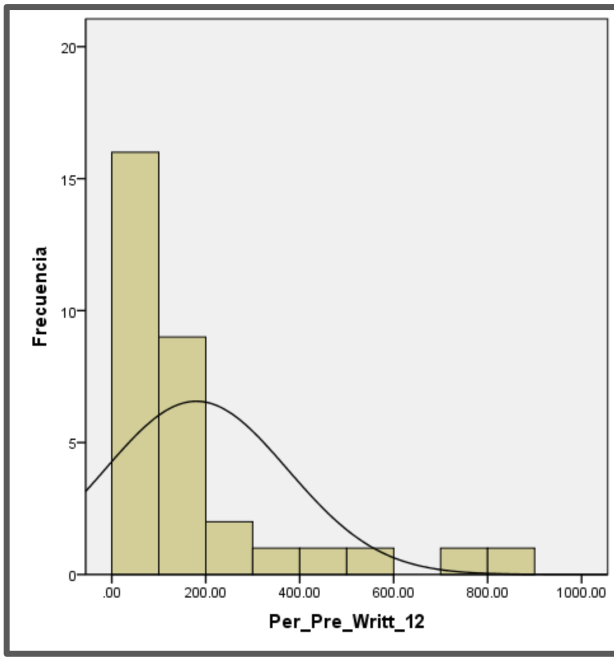
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.128	32	.200	.931	32	0.041



Coping capacities: Indicator D

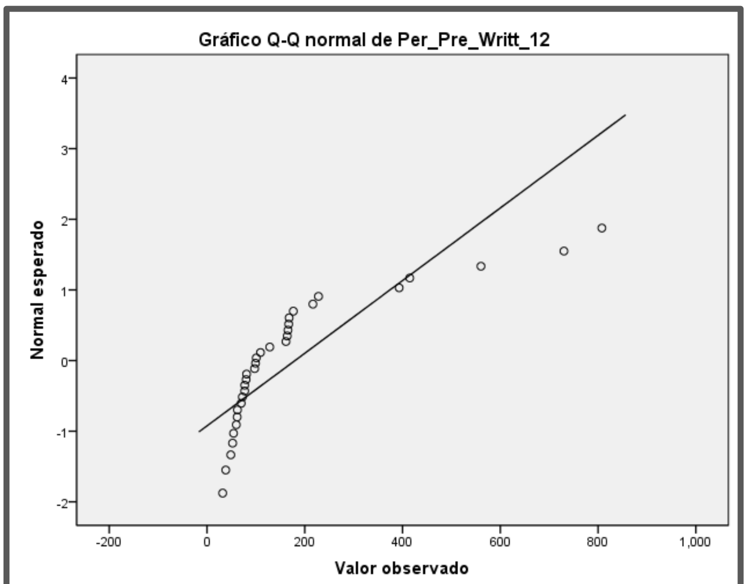
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		179.862	34.374
Intervalo de confianza para la media al 95%	Límite inferior	109.755	
	Límite superior	249.969	
Media recortada al 5%		154.682	
Mediana		100.070	
Varianza		37811.295	
Desv. típ.		194.451	
Mínimo		32.04	
Máximo		807.69	
Rango		775.65	
Amplitud intercuartil		110.13	
Asimetría		2.180	.414
Curtosis		4.253	.809



Normality test

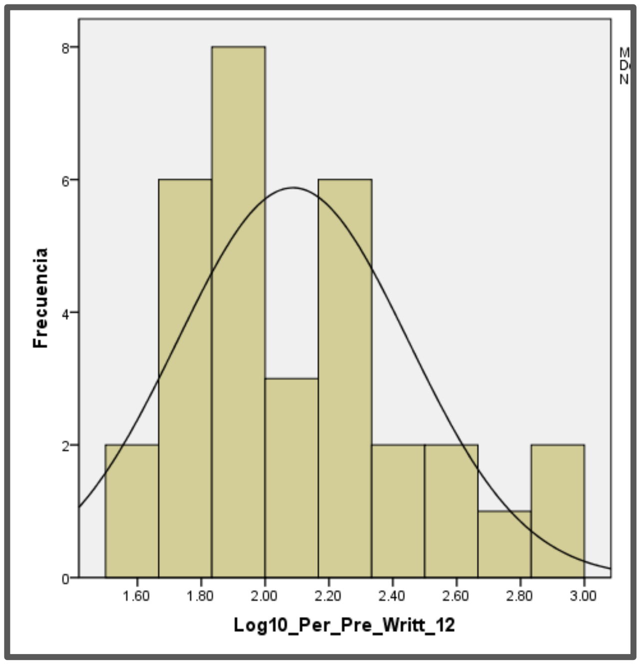
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.288	32	.000	.683	32	.000



Test to verify normal distribution of the transformation

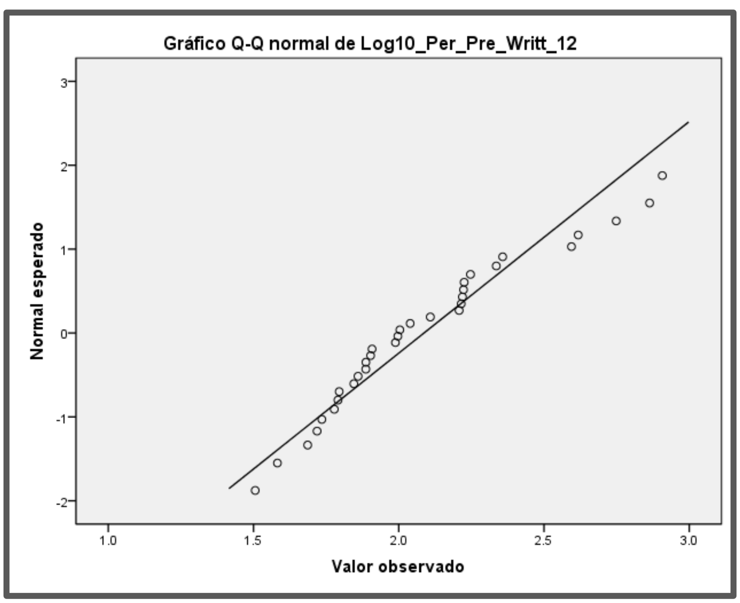
LOG 10

		Estadístico	Error típ.
Media		2.0869	.0640
Intervalo de confianza para la media al 95%	Límite inferior	1.9563	
	Límite superior	2.2174	
Media recortada al 5%		2.0729	
Mediana		2.0003	
Varianza		.131	
Desv. típ.		.36208	
Mínimo		1.51	
Máximo		2.91	
Rango		1.40	
Amplitud intercuartil		.43	
Asimetría		.741	.414
Curtosis		-.035	.809



Normality test

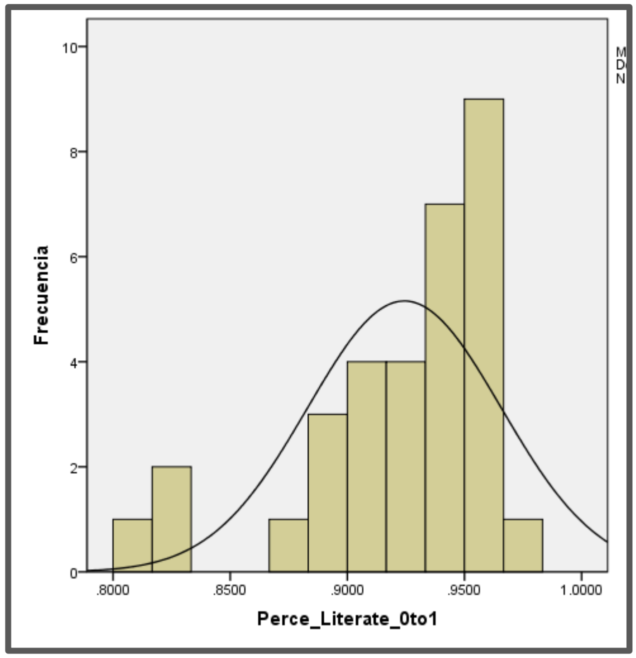
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.127	32	.200	.939	32	0.071



Adaptive capacities: Indicator A

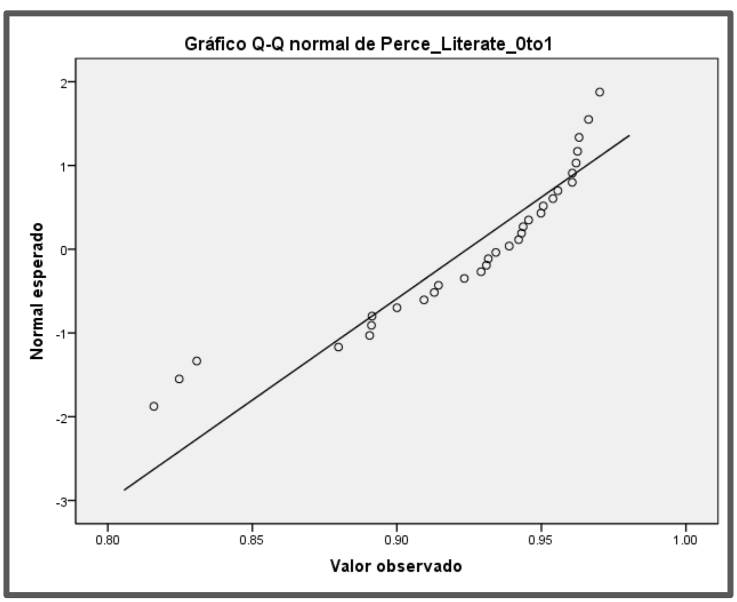
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		.924348	.00729
Intervalo de confianza para la media al 95%	Límite inferior	.909472	
	Límite superior	.939225	
Media recortada al 5%		.927724	
Mediana		.936544	
Varianza		.002	
Desv. típ.		.0412610	
Mínimo		.8159	
Máximo		.9702	
Rango		.1542	
Amplitud intercuartil		.0529	
Asimetría		-1.344	.414
Curtosis		1.307	.809



Normality test

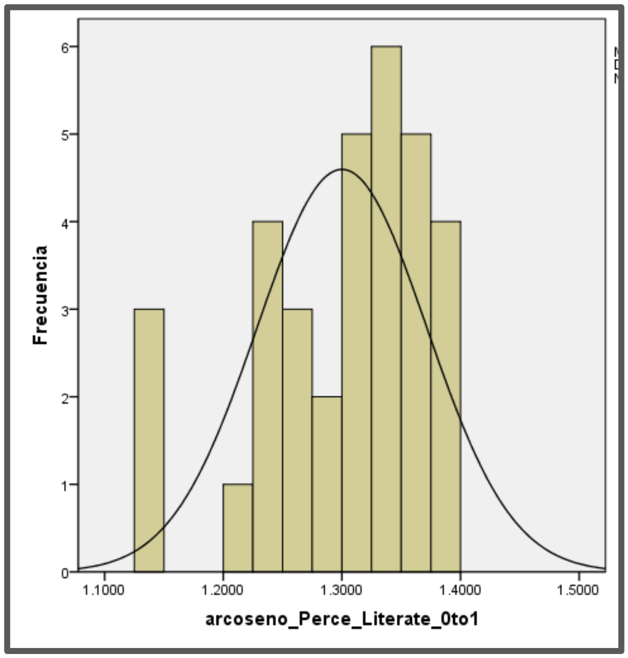
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.171	32	.018	. 853	32	.000



<u>Test to verify normal distribution of the transformation</u>

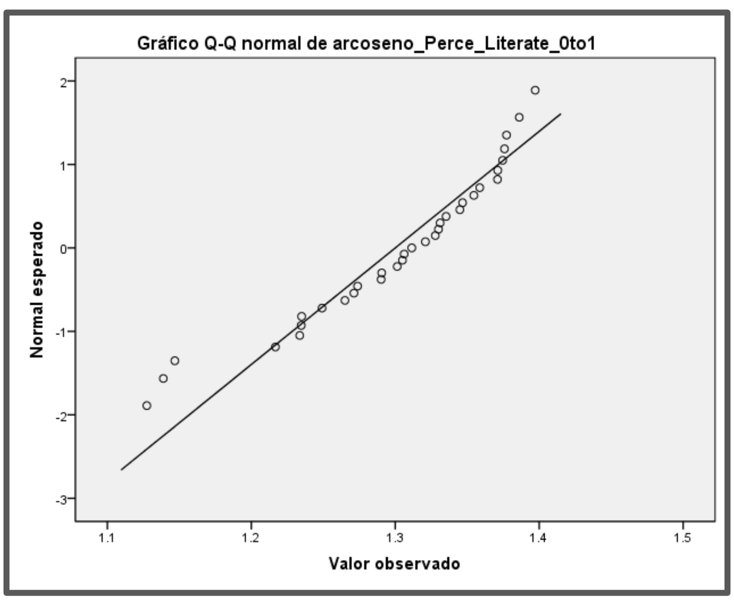
<u>ARCSEN</u>

		Estadístico	Error típ.
Media		1.3003	.0129
Intervalo de confianza para la media al 95%	Límite inferior	1.274095	
	Límite superior	1.326531	
Media recortada al 5%		1.304529	
Mediana		1.316189	
Varianza		.005	
Desv. típ.		.0727181	
Mínimo		1.1274	
Máximo		1.3972	
Rango		.2698	
Amplitud intercuartil		.1046	
Asimetría		-.934	.414
Curtosis		.282	.809



Normality test

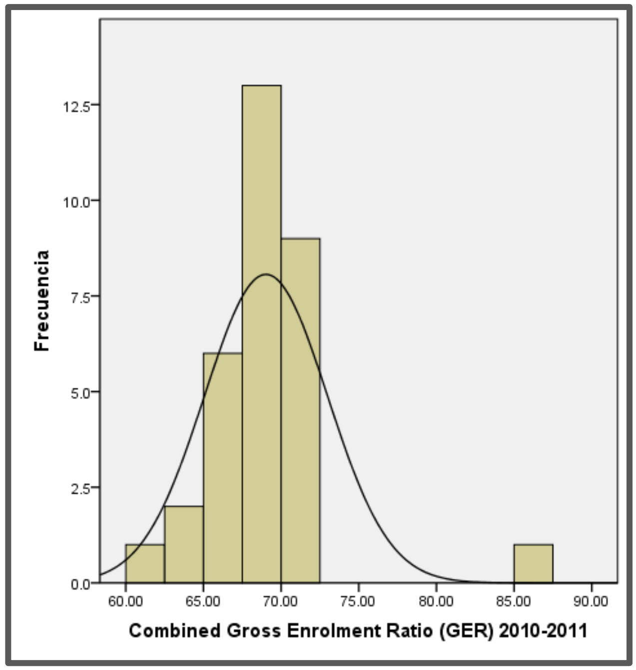
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.131	32	.179	.913	32	0.014



Adaptive capacities: Indicator B

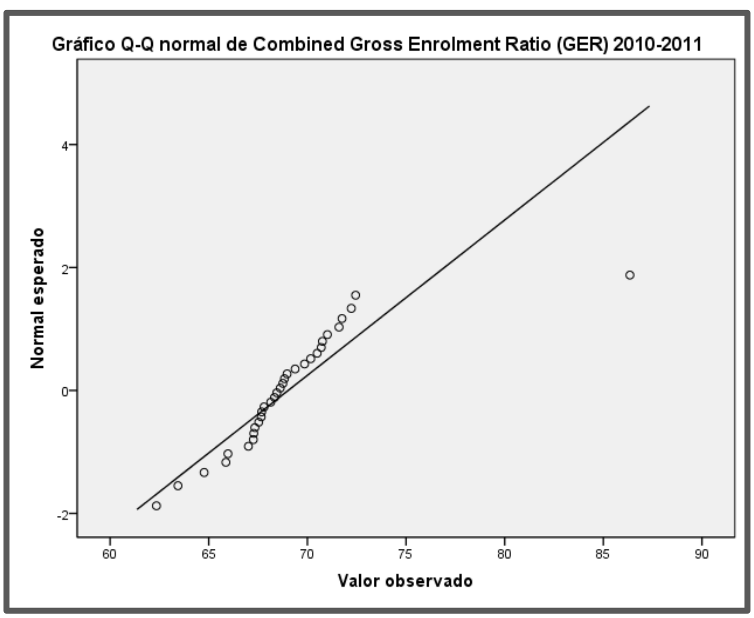
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		69.0251	.69970
Intervalo de confianza para la media al 95%	Límite inferior	67.5981	
	Límite superior	70.4522	
Media recortada al 5%		68.7006	
Mediana		68.5355	
Varianza		15.667	
Desv. típ.		3.95811	
Mínimo		62.35	
Máximo		86.35	
Rango		24.00	
Amplitud intercuartil		3.35	
Asimetría		2.600	.414
Curtosis		11.671	.809



Normality test

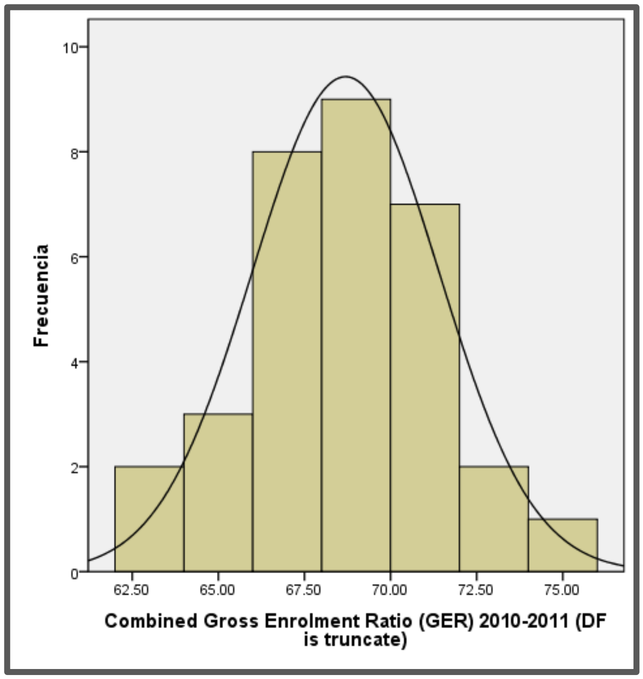
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.163	32	.031	.763	32	.000



Test to verify normal distribution of the transformation

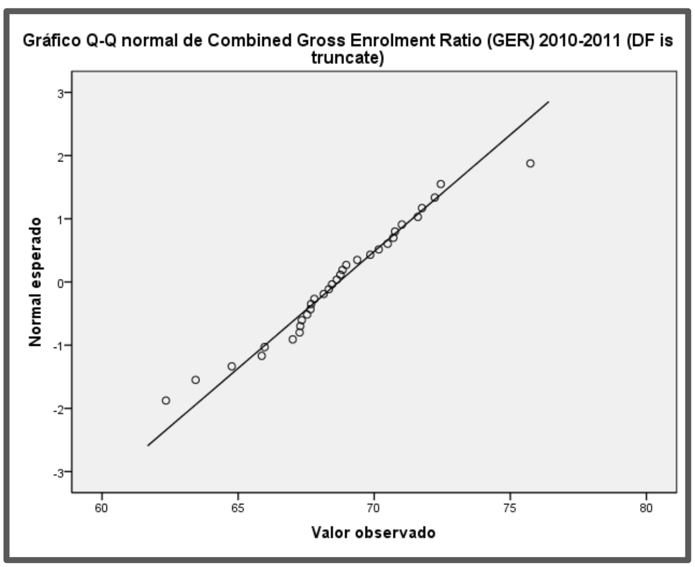
TRUNCATE

		Estadístico	Error típ.
Media		68.6937	.47859
Intervalo de confianza para la media al 95%	Límite inferior	67.7176	
	Límite superior	69.6697	
Media recortada al 5%		68.7006	
Mediana		68.5355	
Varianza		7.329	
Desv. típ.		2.70729	
Mínimo		62.35	
Máximo		75.74	
Rango		13.39	
Amplitud intercuartil		3.35	
Asimetría		.033	.414
Curtosis		.931	.809



Normality test

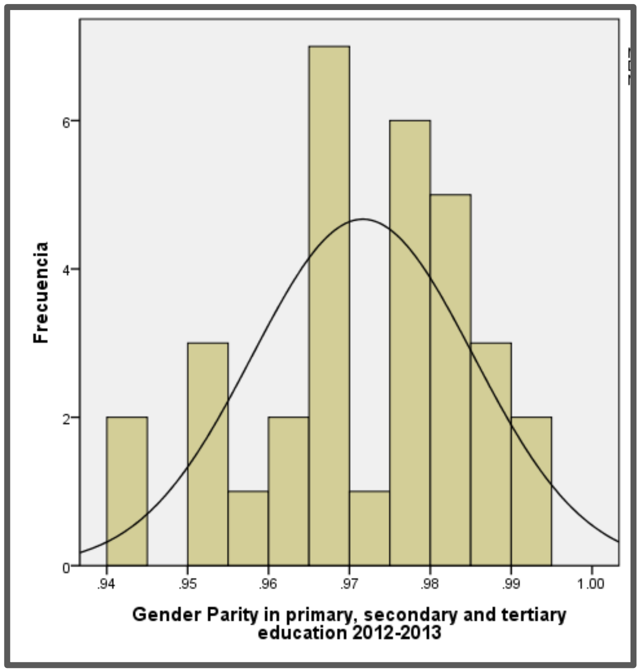
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.111	32	.200	.970	32	0.781



Adaptive capacities: Indicator C

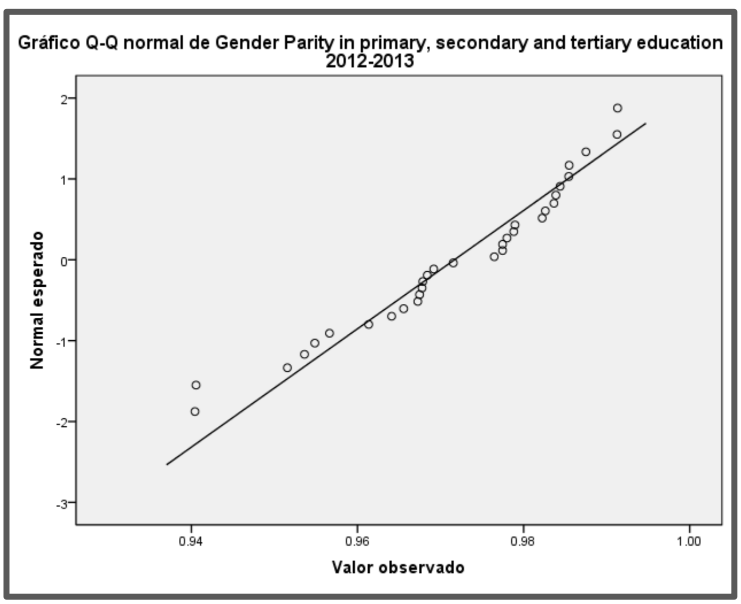
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		.9717	.00242
Intervalo de confianza para la media al 95%	Límite inferior	.9667	
	Límite superior	.9766	
Media recortada al 5%		.9723	
Mediana		.9740	
Varianza		.000	
Desv. típ.		.01367	
Mínimo		.94	
Máximo		.99	
Rango		.05	
Amplitud intercuartil		.02	
Asimetría		-.685	.414
Curtosis		-.122	.809



Normality test

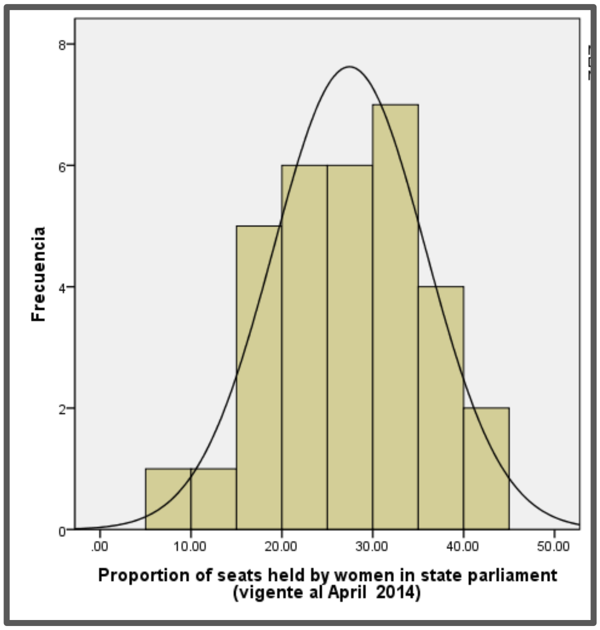
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.138	32	.129	.940	32	.076



Adaptive capacities: Indicator D

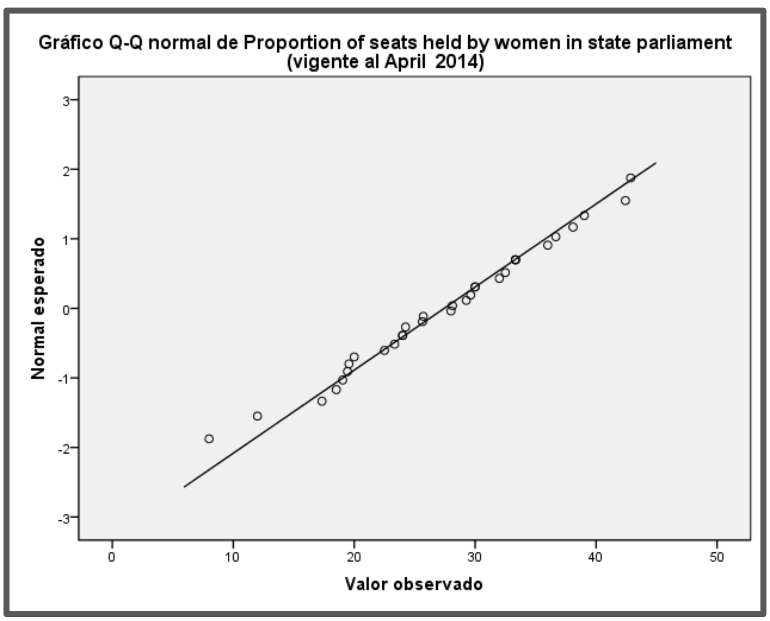
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		27.4353	1.47974
Intervalo de confianza para la media al 95%	Límite inferior	24.4174	
	Límite superior	30.4533	
Media recortada al 5%		27.5840	
Mediana		28.0625	
Varianza		70.068	
Desv. típ.		8.37068	
Mínimo		8.0000	
Máximo		42.86	
Rango		34.86	
Amplitud intercuartil		12.71	
Asimetría		-.174	.414
Curtosis		-.213	.809



Normality test

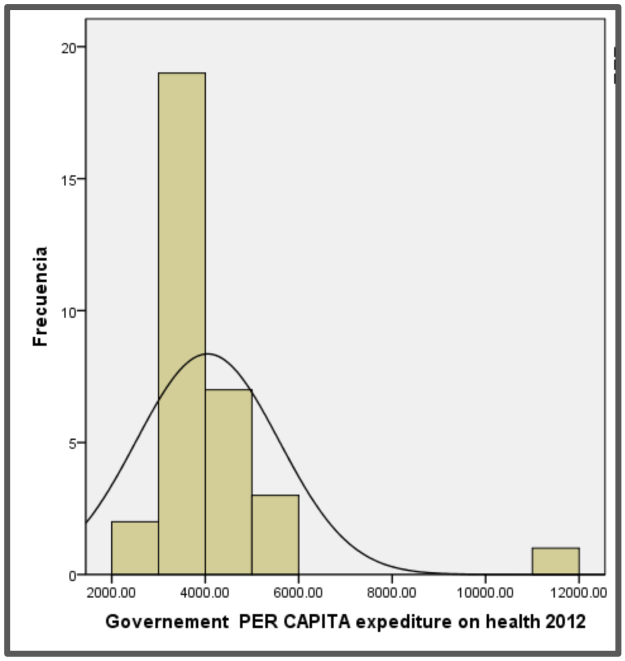
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.063	32	.200	.985	32	.931



Adaptive capacities: Indicator E

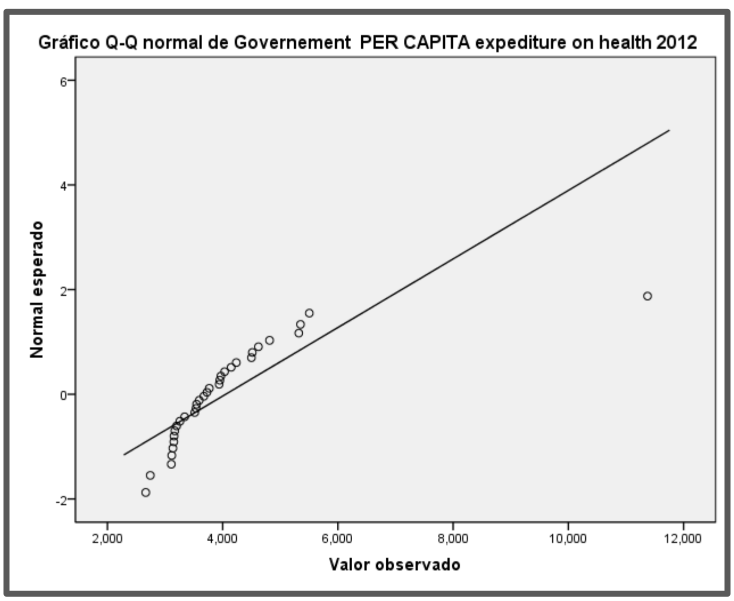
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		4051.908	269.925
Intervalo de confianza para la media al 95%	Límite inferior	3501.3910	
	Límite superior	4602.4242	
Media recortada al 5%		3842.8667	
Mediana		3699.1096	
Varianza		2331512.3	
Desv. típ.		1526.92903	
Mínimo		2663.96	
Máximo		11374.19	
Rango		8710.22	
Amplitud intercuartil		1256.64	
Asimetría		3.761	.414
Curtosis		17.556	.809



Normality test

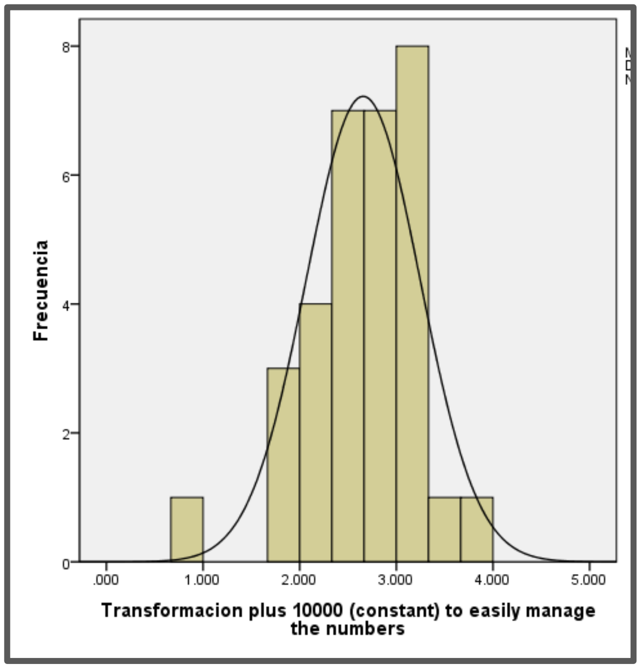
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.206	32	.001	. 614	32	.000



Test to verify normal distribution of the transformation

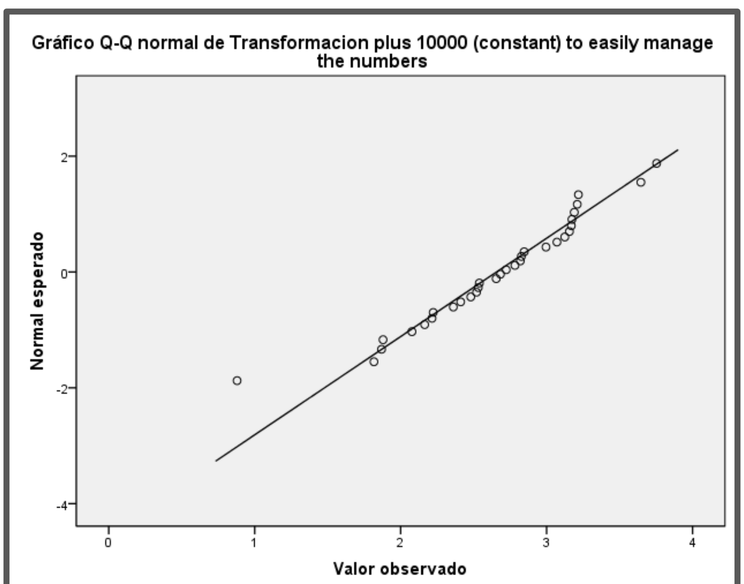
1/x

		Estadístico	Error típ.
Media		2.6566	.1042
Intervalo de confianza para la media al 95%	Límite inferior	2.44415	
	Límite superior	2.86900	
Media recortada al 5%		2.67708	
Mediana		2.70350	
Varianza		.347	
Desv. típ.		.589194	
Mínimo		.879	
Máximo		3.754	
Rango		2.875	
Amplitud intercuartil		.891	
Asimetría		-.721	.414
Curtosis		1.385	.809



Normality test

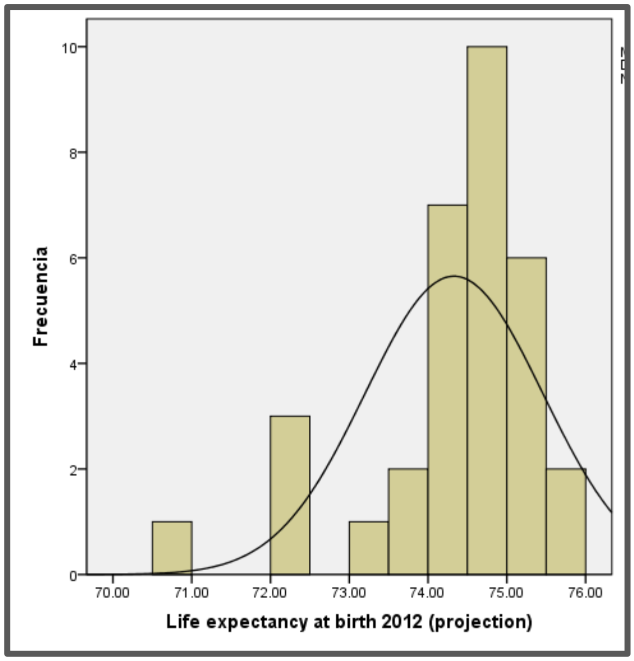
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.108	32	.200	.958	32	0.249



Adaptive capacities: Indicator F

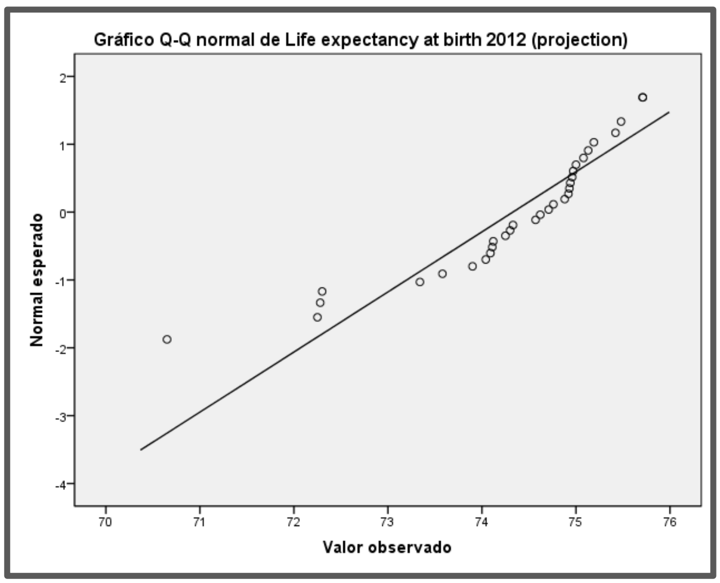
Test to verify normal distribution of the indicator

		Estadístico	Error típ.
Media		74.3288	.19963
Intervalo de confianza para la media al 95%	Límite inferior	73.9216	
	Límite superior	74.7359	
Media recortada al 5%		74.4231	
Mediana		74.6650	
Varianza		1.275	
Desv. típ.		1.12926	
Mínimo		70.65	
Máximo		75.71	
Rango		5.06	
Amplitud intercuartil		.94	
Asimetría		-1.571	.414
Curtosis		2.718	.809



Normality test

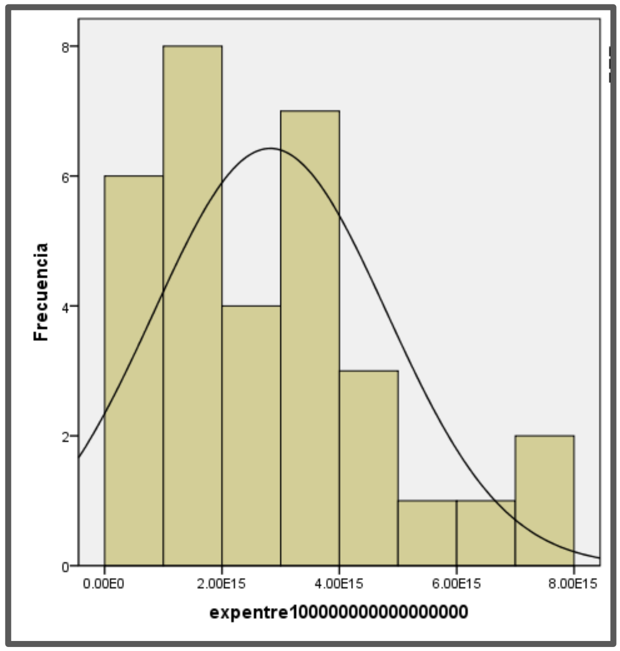
Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.180	32	.010	. 852	32	.000



Test to verify normal distribution of the transformation

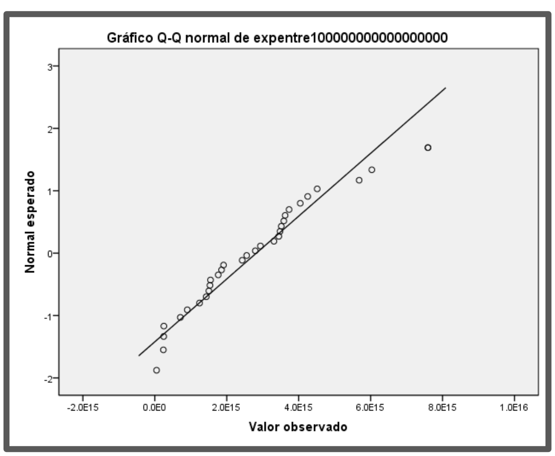
EXPONENT

		Estadístico	Error típ.
Media		2821891219877420	351226597282404
Intervalo de confianza para la media al 95%	Límite inferior	2105559851987980	
	Límite superior	3538222587766860	
Media recortada al 5%		2706935046351750	
Mediana		2673234554010330	
Varianza		39475239244344200000000000000000	
Desv. típ.		1986837669371710	
Mínimo		48184254770261.40	
Máximo		7593381587902060	
Rango		7545197333131800	
Amplitud intercuartil		2257904566840350	
Asimetría		.793	.414
Curtosis		.387	.809



Normality test

Kolmogorov-Smirnova			Shapiro-Wilk		
Estadístico	gl	Sig.	Estadístico	gl	Sig.
.114	32	.200	.934	32	0.049



Annex 2: Classification by quantile.

For ranking the states in 5 categories it was necessary to use the quantile method.

The results of this procedure for each component are presented below. For more information regarding the method see Chapter 3.

- **Susceptibility**

N	Válidos	32
	Perdidos	0
Percentiles	20	29.2076
	40	39.0413
	60	48.8948
	80	58.2951

PERCENTILES		RANK		Classification
0-	20	0.000	29.208	Very Low
21-	40	29.208	39.041	Low
41-	60	39.041	48.895	Medium
61-	80	48.895	58.295	High
81 y	más	58.295	más	Very high

- **Coping Capacities**

N	Válidos	32
	Perdidos	0
Percentiles	20	47.1293
	40	55.8067
	60	63.3628
	80	68.1694

PERCENTILES	**RANK**		**Classification**
0- 20	0.000	47.1293	Very Low
21- 40	47.1294	55.8067	Low
41- 60	55.8068	63.3628	Medium
61- 80	63.3629	68.1694	High
81 y más	68.1695	más	Very high

- **Adaptive Capacities**

N	Válidos	32
	Perdidos	0
Percentiles	20	40.9639
	40	45.4851
	60	52.6004
	80	58.7978

PERCENTILES	RANK		Classification
0- 20	0.000	40. 964	Very Low
21- 40	40. 965	45.485	Low
41- 60	45.486	52.600	Medium
61- 80	52.601	58.798	High
81 y más	58.799	más	Very high

- **Exposure**

N	Válidos	32
	Perdidos	0
Percentiles	20	.3788
	40	.4358
	60	.4890
	80	.5290

PERCENTILES	**RANK**		**Classification**
0- 20	0.000	.3788	Very Low
21- 40	.3789	.4358	Low
41- 60	.4359	.4890	Medium
61- 80	.4891	.5290	High
81 y más	.5291	más	Very high

- **Vulnerability**

N	Válidos	32
	Perdidos	0
Percentiles	20	43.9206
	40	49.5460
	60	51.8065
	80	58.7857

PERCENTILES	**RANK**		**Classification**
0- 20	0.000	43.921	Very Low
21- 40	43.922	49.546	Low
41- 60	49.547	51.807	Medium
61- 80	51.808	58.786	High
81 y más	58.787	más	Very high

- **Risk**

N	Válidos	32
	Perdidos	0
Percentiles	20	17.5878
	40	20.6468
	60	24.1555
	80	31.4256

PERCENTILES	RANK		Classification
0- 20	0.000	17.588	Very Low
21- 40	17.589	20.647	Low
41- 60	20.648	24.156	Medium
61- 80	24.157	31.426	High
81 y más	31.427	más	Very high

Annex 3. Indicators Metadata

To facilitate the understanding of the indicators, below is presented a description of each of them according to:

- Data used for its elaboration
- Temporal scale
- Method / Algorithm
- Unit of measure
- Data sources
- Comparability with the WRI indicator
- Validity and/or limitations

Exposure	
Indicator A (name)	
Population exposed to earthquakes (PEE_t)	
Data used	**Temporal scale**
- Total population of the state (n_t)	2010
- Total population of municipalities with an intensity scale of earthquakes between VI and XII (q_t)	2010
-Mercalli intensity scale by municipality	2014
Method / algorithm	**Unit of measure**
$$PEE_t = \frac{q_t}{n_t}$$	Proportion of population exposed to earthquakes
Data sources	
Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010 (INEGI 2010) http://www.inegi.org.mx/sistemas/olap/proyectos/bd/consulta.asp?p=17118&c=27769&s=est	
Centro Nacional de Prevención de Desastres (2014a) (CENAPRED) / Global de intensidades escala de Mercalli http://www.atlasnacionalderiesgos.gob.mx/index.php/biblioteca/category/15-geo	
Comparability with the WRI indicator	
These indicators are not comparable with the exposure indicators of the WRI because the data sources and the procedure to obtain it were not the same.	
Validity/limitations of indicator	
Information availability is the biggest limitation for these indicators. The database of intensity of earthquakes (Mercalli) by municipality elaborated by CENAPRED was used for developing this indicator. The scale of Mercalli goes from I to XII, therefore for developing this indicator it was assumed that the total population of the municipalities with a scale of Mercalli between VII (very strong) and XII (catastrophic) was the population exposed. Besides it was assumed that the total population of the states and the municipalities has not changed during the time therefore the population of the year 2010 was taken as base year to make the calculations.	

Exposure	
Indicator B (name)	
Population exposed to hurricanes (PEH_t)	
Data used	**Temporal scale**
- Total population of the state (n_t)	2010
- Total population of municipalities with very high and high hurricane hazard (q_t)	2010
-Hazard level for presence of hurricanes by municipality	2014
Method / algorithm	**Unit of measure**
$$\boldsymbol{PEH_t = \frac{q_t}{n_t}}$$	Proportion of population exposed to hurricanes
Data sources	
Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010 http://www.inegi.org.mx/sistemas/olap/proyectos/bd/consulta.asp?p=17118&c=27769&s=est	
Centro Nacional de Prevención de Desastres (CENAPRED) (2014b) / Grado de peligro por presencia de ciclones tropicales http://www.atlasnacionalderiesgos.gob.mx/index.php/biblioteca/category/17-hidrometeorologicos	
Comparability with the WRI indicator	
These indicators are not comparable with the exposure indicators of the WRI because the data sources and the procedure to obtain it were not the same.	
Validity/limitations of indicator	
Information availability is the biggest limitation for these indicators. The hazard level for presence of hurricanes by municipality elaborated by CENAPRED was used for developing this indicator. The hazard level goes from Very low to Very high; therefore for developing this indicator it was assumed that the total population of the municipalities with a level of high and very high was the population exposed. Besides it was assumed that the total population of the states and the municipalities has not changed during the time therefore the population of the year 2010 was taken as base year to make the calculations.	

Exposure	
Indicator C (name)	
Population exposed to floods (PEF_t)	
Data used	**Temporal scale**
- Total population of the state (n_t)	2010
- Total population of municipalities with very high and high hurricane hazard (q_t)	2010
- Flood events by municipality	1970-2011
Method / algorithm	**Unit of measure**
$$PEF_t = \frac{q_t}{n_t}$$	Proportion of population exposed to floods
Data sources	
Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010 http://www.inegi.org.mx/sistemas/olap/proyectos/bd/consulta.asp?p=17118&c=27769&s=est	
Sistema de Inventario de efectos de desastres (DesInventar) http://online.desinventar.org/desinventar/#MEX-1250695136-mexico_inventario_historico_de_desastres	
Comparability with the WRI indicator	
These indicators are not comparable with the exposure indicators of the WRI because the data sources and the procedure to obtain it were not the same.	
Validity/limitations of indicator	
Information availability is the biggest limitation for these indicators. The database does not have information regarding affected population (or it is incomplete). However in order to get some estimates; it was assumed that the total population of the municipalities that registered a natural event during 1970 to 2011, was the population affected. Besides it was assumed that the total population of the states and the municipalities has not changed during the time therefore the population of the year 2010 was taken as base year to make the calculations.	

Exposure

Indicator D (name)

Population exposed to droughts (PED_t)

Data used	Temporal scale
- Total population of the state (n_t)	2010
- Total population of municipalities with very high and high hurricane hazard (q_t)	2010
-Hazard level of droughts by municipality	2014

Method / algorithm	Unit of measure
$PED_t = \frac{q_t}{n_t}$	Proportion of population exposed to droughts

Data sources

Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010 http://www.inegi.org.mx/sistemas/olap/proyectos/bd/consulta.asp?p=17118&c=27769&s=est

Centro Nacional de Prevención de Desastres (CENAPRED) (2014c)/ Grado de peligro por sequías http://www.atlasnacionalderiesgos.gob.mx/index.php/biblioteca/category/17-hidrometeorologicos

Comparability with the WRI indicator

These indicators are not comparable with the exposure indicators of the WRI because the data sources and the procedure to obtain it were not the same.

Validity/limitations of indicator

Information availability is the biggest limitation for these indicators. The hazard level of droughts by municipality, elaborated by CENAPRED, was used for developing this indicator. The hazard level goes from Very low to Very high; therefore for developing this indicator it was assumed that the total population of the municipalities with a level of high and very high was the population exposed.

Besides it was assumed that the total population of the states and the municipalities has not changed during the time therefore the population of the year 2010 was taken as base year to make the calculations.

Susceptibility

Indicator A

Share of the population without access to improved sanitation (PsIS)

Data used	Temporal scale
- Total occupants of private inhabited dwellings (n_t)	2010
- Occupants of private inhabited dwellings without toilet (q_t)	2010

Method / algorithm	Unit of measure
$PsIS_t = \left(\frac{q_t}{n_t}\right) * 100$	Percentage of population without access to improved sanitation

Data sources

Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010
http://www.inegi.org.mx/sistemas/olap/Proyectos/bd/censos/cpv2010/Viviendas.asp?s=est&c=27875&proy=cpv10_viviendas

Comparability with the WRI indicator

This indicator measures the same as the WRI indicator, therefore it can be comparable.

Validity/limitations of indicator

Improved sanitation is considered here as the availability of sanitary installations (toilet) for human waste disposal.

Susceptibility

Indicator B	
Share of the population without access to an improved water sources (PsIW)	
Data used	**Temporal scale**
- Total occupants of private inhabited dwellings (n_t)	2010
- Occupants of private inhabited dwellings without access to improved water sources (q_t)	2010

Method / algorithm	**Unit of measure**
$$PsIW_t = \left(\frac{q_t}{n_t}\right) * 100$$	Percentage of population without access to improved water sources

Data sources

Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010
http://www.inegi.org.mx/lib/olap/consulta/general_ver4/MDXQueryDatos.asp?proy=cpv10_viviendas

Comparability with the WRI indicator

This indicator measures the same as the WRI indicator, therefore it can be comparable.

Validity/limitations of indicator

Improved water sources are considered here as the availability of piped water inside, or outside the dwelling or water from a hydrant.

Therefore not improved water sources are tanker truck, water wells, rivers and/or lakes.

Susceptibility

Indicator C

Share of the population with MODERATE and SEVERE food insecurity (PmsFI)

Data used	Temporal scale
- Total population according their nourishment (n_t)	2012
- Population with moderate food insecurity (q_t)	2012
- Population with severe food insecurity (x_t)	2012

Method / algorithm	Unit of measure
$$\mathbf{PmsFI}_t = \left(\frac{q_t + x_t}{n_t}\right) * 100$$	Percentage of population with moderate and severe food insecurity

Data sources

Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL)(2012)

http://www.coneval.gob.mx/Medicion/Paginas/Medici%C3%B3n/Pobreza%202012/Anexo-estad%C3%ADstico-pobreza-2012.aspx

Comparability with the WRI indicator

This indicator was adapted to the circumstances and data availability of the states of Mexico. It aims is to assess the same that the WRI indicator so it both can be comparable.

Validity/limitations of indicator

For the determination of the nourishment, Mexico developed a National Scale of Food Security with four levels: Food security, Mild food insecurity, Moderate food insecurity and Extreme food insecurity.

The indicator takes the moderate and extreme food insecurity because according with the CONEVAL these to levels shown the lack of access to food.

Susceptibility

Indicator D

Dependency ratio (share of under 15 and over 65 year olds in relation to the working population 15-64) (DeR)

Data used	Temporal scale
- Total population 15 to 64 years (n_t)	2010
- Population between 0 and 14 years (q_t)	2010
- Population aged 65 or older (x_t)	2010

Method / algorithm	Unit of measure
$\mathbf{DeR}_t = \left(\frac{q_t + x_t}{n_t}\right) * \mathbf{100}$	Percentage of dependents in relation to the working population

Data sources

Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010
http://www.inegi.org.mx/lib/olap/consulta/general_ver4/MDXQueryDatos.asp?proy=cpv10_viviendas

Comparability with the WRI indicator

It is the same indicator used in the WRI

Validity/limitations of indicator

The data required for develop this indicator are easy to obtain and they are available even in lower levels of disaggregation (municipalities and agebs)

Susceptibility

Indicator E

Share of population in Extreme poverty (ExP)

Data used	Temporal scale
- Share of population in extreme poverty (ExP)	2012

Method / algorithm	Unit of measure
It was not necessary to carry out no method because the indicator was elaborated by the Government	Percentage of population in extreme poverty in relation with the total population

Data sources

Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL)
http://www.coneval.gob.mx/Medicion/Paginas/Medici%C3%B3n/Pobreza%202012/Anexo-estad%C3%ADstico-pobreza-2012.aspx

Comparability with the WRI indicator

Both indicators measure extreme poverty but they do it in a different way. The WRI indicator assumes that the population living on less than 1.25 USD/day is in extreme poverty and the methodology of CONEVAL for measuring poverty is based on the value of the Social Deprivation Index and the poverty line.

Validity/limitations of indicator

The social deprivation index measures the number of deprivations that a person has according to educational gap, access to health services, social security, quality and spaces of the dwelling, access to basic household services and access to food. And the poverty line is based on the value of the basic food basket and defines a monetary value for other non-food resources. Hence, a person is in extreme poverty when he has three or more number of deprivations and its acquisition potential is under the minimum wellbeing line (CONEVAL 2014).

Susceptibility

Indicator F

Gross domestic product per capita (constant prices 2003, Mexican pesos) (GDPp)

Data used	Temporal scale
- Gross domestic product by state in constant prices (q_t)	2012
- Total population by state (projection) (n_t)	2012

Method / algorithm	Unit of measure
$$\mathbf{GDPp}_{t} = \left(\frac{q_t}{n_t}\right)$$	Monetary value of the wealth of a state that corresponds to each person

Data sources

Instituto Nacional de Estadística y Geografía / Sistema de Cuentas Nacionales de Mexico(2012b):

http://www.inegi.org.mx/sistemas/olap/Proyectos/bd/derivada/pib/pib_est_AB2003.asp?s=est&c=17384&proy=pib_est2003

Consejo Nacional de Población (2012):

http://www.conapo.gob.mx/es/CONAPO/Consultas_Interactivas

Comparability with the WRI indicator

This indicator is comparable with the WRI indicator

Validity/limitations of indicator

A common indicator used to evaluate the economic growth of a country.

Susceptibility	
Indicator G	
Gini Index (Gini)	
Data used	**Temporal scale**
- Gini coefficient	2012
Method / algorithm	**Unit of measure**
It was not necessary to carry out no method because the indicator was elaborated by the Government	Degree of inequality
Data sources	
Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL) http://www.coneval.gob.mx/Medicion/Paginas/Medici%C3%B3n/Pobreza%202012/Anexo-estad%C3%ADstico-pobreza-2012.aspx	
Comparability with the WRI indicator	
It is the same indicator used for the WRI	
Validity/limitations of indicator	
This index was obtained already elaborated for the CONEVAL The gini index goes from 0 to 1 where 0 is perfect equality and 1 is inequality.	

Coping capacities

Indicator A

Good Governance and Corruption Perception Index

Data used	**Temporal scale**
- Good Governance and Corruption Perception Index	2010

Method / algorithm	**Unit of measure**
It was not necessary to carry out no method because the indicator was elaborated by the Government	Degree of corruption

Data sources

Transparencia mexicana (2011)
http://www.tm.org.mx/wp-content/uploads/2013/05/01-INCBG-2010-Informe-Ejecutivo1.pdf

Comparability with the WRI indicator

To measure the capacities of Government and authorities the WRI has two indicators; the corruption perception index and the Good governance. Instead, in this study just one indicator is considered because it integrates, in a certain way, both indicators.

Validity/limitations of indicator

Mexican transparency elaborated an index to measure corruption in administrative processes. This index is based on the Corruption Perception Index elaborated by Transparency International.

It measures corruption in 35 public services provided by the three levels of government and private enterprises. Using a scale from 0 to 100, where 0 means no corruption and 100 is the highest level of corruption (Tranparencia Mexicana 2011).

Coping capacities

Indicator B

Number of physicians per 10,000 inhabitants (PhyPe)

Data used	Temporal scale
- Number of physicians (doctors) in contact with patients in public institutions (q_t)	2012
- Number of physicians (doctors) in contact with patients in private institutions (x_t)	2012
- Total population (projection) (n_t)	2012

Method / algorithm	Unit of measure
$\mathbf{PhyPe}_t = \left(\frac{(q_t + x_t) * 10,000}{n_t}\right)$	Number of physicians

Data sources

Secretaría de Salud y los Servicios Estatales de Salud/Sistema Nacional de Información en Salud (SINAIS)(2012)
http://www.sinais.salud.gob.mx

Instituto Nacional de Estadística y Geografía / Estadísticas de salud en establecimientos particulares(2012a)
http://www.inegi.org.mx/Sistemas/Olap/Proyectos/bd/continuas/salud/RecHumanos.asp?s=est&c=33420&proy=esep_rechum

Consejo Nacional de Población:
http://www.conapo.gob.mx/es/CONAPO/Consultas_Interactivas

Comparability with the WRI indicator

This indicator is comparable with the WRI indicator. Both use the same type of information.

Validity/limitations of indicator

To elaborate the indicator only were considered the physicians in direct contact with patients and it was excluded nurses and midwifes. Also physicians in administrative positions were excluded.

Coping capacities

Indicator C

Number of hospital beds per 10,000 inhabitants (HBPe)

Data used	Temporal scale
- Number of hospital beds in public institutions (q_t)	2012
- Number of hospital beds in private institutions (x_t)	2012
- Total population (projection) (n_t)	2012

Method / algorithm	Unit of measure
$$\mathbf{HBPe}_t = \left(\frac{(q_t + x_t) * 10,000}{n_t}\right)$$	Number of hospital beds

Data sources

Secretaría de Salud y los Servicios Estatales de Salud/Sistema Nacional de Información en Salud (SINAIS)

http://www.sinais.salud.gob.mx

Instituto Nacional de Estadística y Geografía / Estadísticas de salud en establecimientos particulares

http://www.inegi.org.mx/Sistemas/Olap/Proyectos/bd/continuas/salud/RecHumanos.asp?s=est&c=33420&proy=esep_rechum

Consejo Nacional de Población:

http://www.conapo.gob.mx/es/CONAPO/Consultas_Interactivas

Comparability with the WRI indicator

This indicator is comparable with the WRI indicator. Both use the same type of information.

Validity/limitations of indicator

To elaborate the indicator only were considered the hospitals beds for the patients. Surgical beds were excluded.

Coping capacities	
Indicator D	
Insurance Premium written per capita (constant prices) (IPWPe)	
Data used	**Temporal scale**
- Premium written by operation type (q_t)	2012
- Total population (projection) (n_t)	2012
Method / algorithm	**Unit of measure**
$$\mathbf{IPWPe}_t = \left(\frac{(q_t)}{n_t}\right)$$	The value of the premium written that corresponds to each person
Data sources	
Comisión Nacional de Seguros y Fianzas (CNSF)(2014) http://www.cnsf.gob.mx/InformacionEstadistica/Paginas/InformacionConsolidada.aspx	
Consejo Nacional de Población: http://www.conapo.gob.mx/es/CONAPO/Consultas_Interactivas	
Comparability with the WRI indicator	
This indicator is not comparable with the WRI indicator. The data used for its elaboration is different.	
Validity/limitations of indicator	
The indicator takes into consideration the insurance premium written of agricultural insurances and earthquakes, hydro meteorological phenomena and other hazards. It is not available the number of insurances by state..	

Adaptive capacities

Indicator A	
Adult literacy rate (15 years and over) (ALr)	
Data used	**Temporal scale**
- Total population 15 years and over (n_t)	2010
- Literate population 15 years and over (q_t)	2010
Method / algorithm	**Unit of measure**
$$\mathbf{ALr}_t = \left(\frac{(q_t)}{n_t}\right)$$	Rate of literacy
Data sources	
Instituto Nacional de Estadística y Geografía / Censo de Población y Vivienda 2010 http://www.inegi.org.mx/lib/olap/consulta/general_ver4/MDXQueryDatos.asp?#Regreso&c=27823	
Comparability with the WRI indicator	
This indicator is the same used in to develop the WRI. The same data are used therefore they are comparable.	
Validity/limitations of indicator	
The data required to develop this indicator was obtained from an official source and this type of data are very easy to find for its comparability among states	

Adaptive capacities

Indicator B

Combined Gross Enrolment Ratio (GER)

Data used	Temporal scale
- Total population aged 6 to 24, enrollment in primary education (q_t)	2010/ 2011
- Total population aged 6 to 24, enrollment in secondary education (x_t)	2010/ 2011
- Total population aged 6 to 24, enrollment in tertiary education (y_t)	2010/ 2011
- Total population aged 6 to 24 (n_t)	2010/ 2011

Method / algorithm	Unit of measure
$\mathbf{GER}_t = \left(\frac{(q_t + x_t + y_t)}{n_t}\right) * \mathbf{100}$	Percentage of students enrollment in any level of education..

Data sources

Secretaria de Educación Pública (SEP) / Dirección General de Planeación y Estadística Educativa(2014)

http://www.objetivosdedesarrollodelmilenio.org.mx/cgi-win/odm.exe/SHIODM003000100010,16,E

Comparability with the WRI indicator

This indicator has some modification regarding the WRI indicator; however it tries to measure the same that the WRI indicator therefore they are comparable.

Validity/limitations of indicator

The education system in Mexico divided in basic, upper secondary education and higher education. Basic education integrates primary school and middle school (secundaria) and upper secondary is high school.

To develop this indicator, in primary school was consider the basic education, high school was taken as secondary school and tertiary education as a higher education. The information was obtained by school year.

Adaptive capacities

Indicator C	
Gender parity in education	
Data used	**Temporal scale**
- Men aged 6 to 24, enrollment in primary education (q_m)	2012/ 2013
- Women aged 6 to 24, enrollment in primary education (q_w)	2012/ 2013
- Men aged 6 to 24, enrollment in secondary education (x_m)	2012/ 2013
- Women aged 6 to 24, enrollment in secondary education (x_w)	2012/ 2013
- Men aged 6 to 24, enrollment in tertiary education (y_m)	2012/ 2013
- Women aged 6 to 24, enrollment in tertiary education (y_w)	2012/ 2013
Method / algorithm	**Unit of measure**
$\mathbf{GER}_t = \left(\frac{(q_w + x_w + y_w)}{q_m + x_m + y_m}\right)$	Ratio of women to men enrollment in any education level.

Data sources

Secretaria de Educación Pública (SEP) / Dirección General de Planeación y Estadística Educativa
http://www.objetivosdedesarrollodelmilenio.org.mx/cgi-win/odm.exe/SHIODM003000100010,16,E

Comparability with the WRI indicator

This indicator has some modification regarding the WRI indicator; however it tries to measure the same that the WRI indicator therefore they are comparable.

Validity/limitations of indicator

As well as the last indicator described, this indicator takes into consideration the differences in the education system in Mexico: basic, upper secondary and higher education.
The indicator adds all the men and women in the three education levels to know the gender parity in the whole education system. The information was obtained by school year, starting around September.

Adaptive capacities

Indicator D	
Share of female in the State Congress (FSC)	
Data used	**Temporal scale**
- Total seat in the state Congress (n_t)	Current Congress to march 2014
- Total seats occupied by men in the state Congress (q_t)	Current Congress to march 2014
- Total seats occupied by women in the state Congress (x_t)	Current Congress to march 2014
Method / algorithm	**Unit of measure**
$\mathbf{FSC}_t = \left(\frac{x_t}{n_t}\right) * \mathbf{100}$	Percentage of female in the State Congress
Data sources	
Instituto Nacional de las Mujeres (InMujeres)(2014) http://enlamira.inmujeres.gob.mx/index.php?option=com_docman&task=doc_view&gid=222&tmpl=component&format=raw&Itemid=212	
Comparability with the WRI indicator	
It is the same indicator used in the WRI.	
Validity/limitations of indicator	
Every three years there are elections in the states to elect the new Congress, however not all the states have election at the same time. That is why it is impossible to give an exact temporal scale to this indicator.	

Adaptive capacities	
Indicator E	
Per capita public expenditure on health (PePH)	
Data used	**Temporal scale**
- Government expenditure on health (population WITH Social security) (q_t)	2012
- Government expenditure on health (population WITHOUT Social security) (x_t)	2012
- Total population (n_t)	2012
Method / algorithm	**Unit of measure**
$$\mathbf{PePH}_t = \left(\frac{q_t + x_t}{n_t}\right)$$	Monetary value of the public expenditure on health that corresponds to each person
Data sources	
Secretaría de Salud y los Servicios Estatales de Salud/Sistema Nacional de Información en Salud (SINAIS) http://www.sinais.salud.gob.mx	
Consejo Nacional de Población: http://www.conapo.gob.mx/es/CONAPO/Consultas_Interactivas	
Comparability with the WRI indicator	
It is the same indicator used in the WRI.	
Validity/limitations of indicator	
The measure unit of this indicator is Mexican pesos.	

Adaptive capacities	
Indicator E	
Life expectancy at birth (LEB)	
Data used	**Temporal scale**
- Life expectancy at birth (LEB)	2012
Method / algorithm	**Unit of measure**
It was not necessary to carry out no method because the indicator was elaborated by the Government	Years on life expectancy
Data sources	
Consejo Nacional de Población / Proyecciones de la población http://www.conapo.gob.mx/es/CONAPO/De_las_Entidades_Federativas_2010-2050	
Comparability with the WRI indicator	
It is the same indicator used in the WRI.	
Validity/limitations of indicator	
This indicator was development by the National Population Council. However this is only a projection because the last census was in 2010.	

Annex 4. Map of the Regions and states of Mexico

Source: Own creation

Annex 5. Results by component and state

Susceptibility

State	Susceptibility index	Classification	Ranking states
Guerrero	97.84	Very high	1
Chiapas	81.79		2
Oaxaca	77.44		3
Puebla	61.93		4
Michoacán de Ocampo	59.63		5
Tabasco	58.38		6
Nayarit	58.24	High	7
Zacatecas	57.50		8
Veracruz de Ignacio de la Llave	57.12		9
San Luis Potosí	56.95		10
Hidalgo	53.97		11
Durango	50.70		12
Guanajuato	49.50	Medium	13
Campeche	46.49		14
Yucatán	44.67		15
Querétaro	42.07		16
Morelos	41.70		17
Tlaxcala	41.02		18
Sinaloa	40.30	Low	19
Chihuahua	38.73		20
México	38.20		21
Jalisco	36.15		22
Sonora	35.64		23
Quintana Roo	34.47		24
Baja California Sur	33.17		25
Aguascalientes	29.69	Very low	26
Tamaulipas	28.48		27
Coahuila de Zaragoza	24.89		28
Colima	22.78		29
Baja California	22.51		30
Nuevo León	20.86		31
Distrito Federal	9.00		32

Lack of coping capacities

State	Lack of Coping Capacities	Classification	Ranking states
México	83.85	Very high	1
Chiapas	77.07		2
Nuevo León	76.59		3
Coahuila de Zaragoza	74.49		4
Morelos	70.84		5
Baja California	68.82		6
Hidalgo	67.73	High	7
Oaxaca	67.43		8
Sinaloa	66.07		9
Veracruz de Ignacio de la Llave	66.04		10
Puebla	65.34		11
Tlaxcala	64.58		12
Michoacán de Ocampo	63.39	Medium	13
Jalisco	63.24		14
Guanajuato	63.03		15
Sonora	61.50		16
Guerrero	56.93		17
Chihuahua	56.28		18
Yucatán	55.88	Low	19
San Luis Potosí	55.79		20
Aguascalientes	52.69		21
Durango	51.93		22
Tabasco	51.85		23
Nayarit	50.66		24
Tamaulipas	49.51		25
Zacatecas	48.19	Very low	26
Colima	45.54		27
Quintana Roo	43.60		28
Campeche	40.10		29
Querétaro	37.07		30
Baja California Sur	33.27		31
Distrito Federal	27.84		32

Lack of adaptive capacities

State	Lack of Adaptive Capacities	Classification	Ranking states
Chiapas	75.74	Very high	1
Guerrero	71.67		2
Michoacán de Ocampo	67.69		3
Veracruz de Ignacio de la Llave	66.12		4
Oaxaca	65.35		5
Guanajuato	59.61		6
San Luis Potosí	58.26	High	7
Querétaro	58.10		8
Yucatán	56.14		9
Campeche	54.06		10
Hidalgo	53.04		11
Coahuila de Zaragoza	52.89		12
México	52.80	Medium	13
Puebla	51.79		14
Nuevo León	51.26		15
Durango	49.84		16
Quintana Roo	48.59		17
Nayarit	48.34		18
Baja California	46.22	Low	19
Sinaloa	45.30		20
Tabasco	44.45		21
Tlaxcala	44.39		22
Jalisco	43.91		23
Zacatecas	43.44		24
Morelos	43.27		25
Chihuahua	42.78	Very low	26
Sonora	38.24		27
Tamaulipas	37.96		28
Colima	34.09		29
Aguascalientes	33.25		30
Baja California Sur	28.71		31
Distrito Federal	12.25		32

Vulnerability

State	Vulnerability	Classification	Ranking states
Chiapas	78.12	Very high	1
Guerrero	75.41		2
Oaxaca	70.00		3
Michoacán de Ocampo	63.51		4
Veracruz de Ignacio de la Llave	63.03		5
Puebla	59.63		6
México	58.22	High	7
Hidalgo	58.19		8
Guanajuato	57.32		9
San Luis Potosí	56.94		10
Nayarit	52.36		11
Yucatán	52.18		12
Morelos	51.88	Medium	13
Tabasco	51.51		14
Durango	50.77		15
Coahuila de Zaragoza	50.71		16
Sinaloa	50.51		17
Tlaxcala	49.95		18
Zacatecas	49.66	Low	19
Nuevo León	49.52		20
Jalisco	47.72		21
Campeche	46.84		22
Chihuahua	45.88		23
Baja California	45.81		24
Querétaro	45.70		25
Sonora	45.08	Very low	26
Quintana Roo	42.18		27
Tamaulipas	38.61		28
Aguascalientes	38.51		29
Colima	34.10		30
Baja California Sur	31.69		31
Distrito Federal	16.35		32

Exposure

State	Exposure	Classification	Ranking states
Baja California	0.78	Very high	1
Baja California Sur	0.75		2
Quintana Roo	0.61		3
Guanajuato	0.61		4
Sinaloa	0.57		5
Colima	0.54		6
Sonora	0.52	High	7
Distrito Federal	0.50		8
Veracruz de Ignacio de la Llave	0.50		9
Coahuila de Zaragoza	0.50		10
Chiapas	0.49		11
Michoacán de Ocampo	0.49		12
Guerrero	0.49	Medium	13
México	0.49		14
Oaxaca	0.46		15
Jalisco	0.46		16
Querétaro	0.46		17
Tamaulipas	0.45		18
Tabasco	0.44	Low	19
San Luis Potosí	0.43		20
Morelos	0.43		21
Puebla	0.41		22
Tlaxcala	0.40		23
Chihuahua	0.39		24
Nuevo León	0.39		25
Durango	0.38	Very low	26
Zacatecas	0.37		27
Campeche	0.36		28
Hidalgo	0.35		29
Yucatán	0.33		30
Aguascalientes	0.30		31
Nayarit	0.27		32

Risk Index

State	Exposure	Vulnerability	Risk Index	Classification	Ranking states
Chiapas	0.49	78.12	38.64	Very high	1
Guerrero	0.49	75.41	36.89		2
Baja California	0.78	45.81	35.72		3
Guanajuato	0.61	57.32	34.78		4
Oaxaca	0.46	70.00	32.20		5
Veracruz de Ignacio de la Llave	0.50	63.03	31.49		6
Michoacán de Ocampo	0.49	63.51	31.38	High	7
Sinaloa	0.57	50.51	28.62		8
México	0.49	58.22	28.42		9
Quintana Roo	0.61	42.18	25.75		10
Coahuila de Zaragoza	0.50	50.71	25.26		11
San Luis Potosí	0.43	56.94	24.74		12
Puebla	0.41	59.63	24.25	Medium	13
Baja California Sur	0.75	31.69	23.76		14
Sonora	0.52	45.08	23.48		15
Tabasco	0.44	51.51	22.72		16
Morelos	0.43	51.88	22.46		17
Jalisco	0.46	47.72	21.93		18
Querétaro	0.46	45.70	20.80	Low	19
Hidalgo	0.35	58.19	20.61		20
Tlaxcala	0.40	49.95	19.79		21
Durango	0.38	50.77	19.53		22
Nuevo León	0.39	49.52	19.16		23
Colima	0.54	34.10	18.47		24
Zacatecas	0.37	49.66	18.37		25
Chihuahua	0.39	45.88	17.79	Very low	26
Tamaulipas	0.45	38.61	17.28		27
Yucatán	0.33	52.18	17.27		28
Campeche	0.36	46.84	17.08		29
Nayarit	0.27	52.36	14.09		30
Aguascalientes	0.30	38.51	11.40		31
Distrito Federal	0.50	16.35	8.17		32

State	Susceptibility	Lack of Coping Capacities	Lack of Adaptive Capacities	Exposure	Vulnerability	Risk Index	Classification	Ranking states
Chiapas	81.79	77.07	75.74	0.49	78.12	38.64	Very high risk	1
Guerrero	97.84	56.93	71.67	0.49	75.41	36.89		2
Baja California	22.51	68.82	46.22	0.78	45.81	35.72		3
Guanajuato	49.50	63.03	59.61	0.61	57.32	34.78		4
Oaxaca	77.44	67.43	65.35	0.46	70.00	32.20		5
Veracruz de Ignacio de la Llave	57.12	66.04	66.12	0.50	63.03	31.49		6
Michoacán de Ocampo	59.63	63.39	67.69	0.49	63.51	31.38	High risk	7
Sinaloa	40.30	66.07	45.30	0.57	50.51	28.62		8
México	38.20	83.85	52.80	0.49	58.22	28.42		9
Quintana Roo	34.47	43.60	48.59	0.61	42.18	25.75		10
Coahuila de Zaragoza	24.89	74.49	52.89	0.50	50.71	25.26		11
San Luis Potosí	56.95	55.79	58.26	0.43	56.94	24.74		12
Puebla	61.93	65.34	51.79	0.41	59.63	24.25	Medium risk	13
Baja California Sur	33.17	33.27	28.71	0.75	31.69	23.76		14
Sonora	35.64	61.50	38.24	0.52	45.08	23.48		15
Tabasco	58.38	51.85	44.45	0.44	51.51	22.72		16
Morelos	41.70	70.84	43.27	0.43	51.88	22.46		17
Jalisco	36.15	63.24	43.91	0.46	47.72	21.93		18
Querétaro	42.07	37.07	58.10	0.46	45.70	20.80	Low risk	19
Hidalgo	53.97	67.73	53.04	0.35	58.19	20.61		20
Tlaxcala	41.02	64.58	44.39	0.40	49.95	19.79		21
Durango	50.70	51.93	49.84	0.38	50.77	19.53		22
Nuevo León	20.86	76.59	51.26	0.39	49.52	19.16		23
Colima	22.78	45.54	34.09	0.54	34.10	18.47		24
Zacatecas	57.50	48.19	43.44	0.37	49.66	18.37		25
Chihuahua	38.73	56.28	42.78	0.39	45.88	17.79	Very low risk	26
Tamaulipas	28.48	49.51	37.96	0.45	38.61	17.28		27
Yucatán	44.67	55.88	56.14	0.33	52.18	17.27		28
Campeche	46.49	40.10	54.06	0.36	46.84	17.08		29
Nayarit	58.24	50.66	48.34	0.27	52.36	14.09		30
Aguascalientes	29.69	52.69	33.25	0.30	38.51	11.40		31
Distrito Federal	9.00	27.84	12.25	0.50	16.35	8.17		32