Indicators of Disaster Risk and Risk Management

Program for Latin America and the Caribbean
Summary Report

Inter-American Development Bank

Environment, Rural Development and Disaster Risk Management Division (INE/RND)

TECHNICAL NOTES

No. IDB-TN-169

September 2010

Indicators of Disaster Risk and Risk Management

Program for Latin America and the Caribbean
Summary Report

Inter-American Development Bank
2010

FOREWORD

Disaster risk is not only associated with the occurrence of intense physical phenomenon but also with the vulnerability conditions that favour disasters when such phenomena occur. Vulnerability is intimately related to social processes in disaster prone areas and is usually related to the fragility, susceptibility or lack of resilience of the population when faced with different hazards. In other words, disasters are socio-environmental by nature and their materialization is the result of the social construction of risk. Therefore, their reduction must be part of decision making processes. This is the case not only with post disaster reconstruction but also with public policy formulation and development planning. In this regard, it is necessary to strengthen institutional development and stimulate investment in vulnerability reduction, in order to contribute to the sustainable development of countries. In so doing, it is essential to promote knowledge about the levels of vulnerability and the society's capacity to manage risk, in order to facilitate the efficient allocation of resources for improving risk management.

The purpose of the Bank's Disaster Risk Management Policy (GN-2354) is to guide the Bank's efforts to assist its borrowers in reducing risks emanating from natural hazards and in managing disasters, in order to support the attainment of their social and economic development goals. In this regard and in order to enhance its sector dialogue with countries, in 2003 the Bank initiated the preparation of a System of Indicators of Disaster Risk and Risk Management, that is representative, robust, easily understood by public policymakers, relatively simple to update periodically; and that allow comparative analysis among countries. Through the technical cooperation ATN/JF-7906/07-RG, financed with resources of the Japan Special Fund of the Inter-American Development Bank (IDB), the Bank contracted the Institute of Environmental Studies (IDEA in Spanish) of the National University of Colombia, Manizales, which, under the leadership of Dr. Omar Dario Cardona, developed the methodology and applied the Indicators to 12 countries using data for the period 1985 to 2000. In 2008, a methodological review and updating of the indicators were conducted through the technical cooperation: Application and Update of the Indicators of Disaster Risk and Risk Management (RG-T1579/ATN/MD-11238-RG), financed with resources from the Multidonor Disaster Prevention Trust Fund of the Bank.

This Technical Note presents the Indicator of Disaster Risk and Risk Management updated for the following borrowing member countries; Argentina, Barbados, Bolivia, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Dominican Republic, and Trinidad and Tobago. The Risk Indicators represent a contribution to knowledge and awareness within the Bank and among its borrowing member countries of the importance of disaster risk management for development. We anticipate that these indicators will assist in integrating disaster risk management into the Bank's country programming, as well as project preparation, monitoring and evaluation exercises. We also expect that this tool will be of use to relevant officials in central and local governments as well as international development agencies, for policy and investment decision-making.

Hector Malarin
Chief, INE/RND

Contents

Introduction

A System of Indicators for Disaster Risk Management

Risk is not only associated with the occurrence of intense physical phenomena, but also with the vulnerability conditions that favor or facilitate disasters when these phenomena occur. Vulnerability is intimately related to social processes in disaster prone areas and is also usually related to the fragility, susceptibility or lack of resilience of the population when faced with various hazards. In other words, disasters are socio-environmental by nature and their occurrence is the result of socially created risk. This means that in order to reduce disaster risk, society must embark in a decision-making processes. This process is not only required during the reconstruction phase immediately following a disaster, but should also be a part of overall national public policy formulation and development planning. This, in turn, requires institutional strengthening and investments in reducing vulnerability.

All types of risk management capabilities need to be strengthened in order to reduce vulnerability. In addition, existing risks and likely future risks must also be identified. This cannot be accomplished without an adequate measure of risk and monitoring to determine the effectiveness and efficiency of corrective or prospective intervention measures to mitigate or prevent disasters. The evaluation and follow-up of risk is needed to make sure that all those who might be affected by it, as well as those responsible for risk management are made aware of it and can identify its causes. To this end, evaluation and follow up must be undertaken using methods that facilitate an understanding of the problem and that can help guide the decision-making process.

The methodology proposed in this report measures risk and vulnerability using relative indicators at the national level. The aim is to provide national decisionmakers with access to the information that they need to identify risk and propose adequate disaster risk management policies and actions. The proposed system of indicators allows for the identification of economic and social factors that affect risk and risk management, as well as the international comparison of these factors.

To make sure that this methodology is easy to use, it must include a limited number of aggregate indicators that will be of use to policymakers. While this methodology is national in nature, the research also evaluated subnational and urban data using a similar conceptual and methodological approach in order to illustrate the application of this model at the regional and local levels. The goal of this research program was to adjust the methodology and apply it to a wide range of countries in order to identify analytical factors (economic, social, resilience, etc.) to carry out an analysis of the risk and risk management conditions in those countries. The integrated system detailed in this report allows a holistic, relative and comparative analysis of risk and risk management (Cardona 2001, 2004, 2010). In accordance with program requirements, this methodology is expected to have three major impacts at the national level.

First, it should lead to an improvement in the use and presentation of information on risk. This will assist policymakers in identifying investment priorities to reduce risk (such as prevention and mitigation measures), and direct the post disaster recovery process.

Second, the methodology provides a way to measure key elements of vulnerability for countries facing natural phenomena. It also provides a way to identify national risk management capacities, as well as comparative

data for evaluating the effects of policies and investments on risk management.

Third, application of this methodology should promote the exchange of technical information for public policy formulation and risk management programs throughout the region.

In addition, the research program is expected to help fill an important information gap for national decisionmakers in the financial, economic, environmental, public health, territorial organization, and housing and infrastructure sectors. The methodology provides a tool for monitoring and promoting the development of risk management capacities. Because the data is comparable across countries, it will make it possible for policymakers to gauge their country's relative position and compare their evolution over time. Finally, the results of the Disaster Risk Indicators Program yield a tool that the IDB can use to guide its policy dialogue and assistance to member countries. It also contributes to the Bank's Action Plan and, in particular, to promoting the "evaluation of methods available for estimating risk, establishing indicators of vulnerability and vulnerability reduction and stimulating the production and diffusion of wide-ranging information on risks." It is also related to an IDB strategic area; namely, it provides information on risks in order to facilitate decision-making (Clarke and Keipi, 2000).

A Measurement Approach Based on Composite Indicators

Creating a measurement system based on composite indicators is a major conceptual and technical challenge, which is made even more so when the aim is to produce indicators that are transparent, robust, representative, replicable, comparable, and easy to understand. All methodologies have their limitations that reflect the complexity of what is to be measured and what can be achieved. As a result, for example, the lack of data may make it necessary to accept approaches and criteria that are less exact or comprehensive than what would have been desired. These trade-offs are unavoidable when dealing with risk and may even be considered desirable. Based on the conceptual framework developed for this program (Cardona *et al*., 2003a), a system of risk indicators is proposed that represents the current vulnerability and risk management situation in each country. The indicators proposed are transparent, relatively easy to update periodically, and easily understood by public policymakers. Four components or composite indicators have been designed to represent the main elements of vulnerability and show each country's progress in managing risk. The four indicators are the Disaster Deficit Index (DDI), the Local Disaster Index (LDI), the Prevalent Vulnerability Index (PVI), and the Risk Management Index (RMI).

The *Disaster Deficit Index* measures country risk from a macroeconomic and financial perspective according to possible catastrophic events. It requires the estimation of critical impacts during a given period of exposure, as well as the country's financial ability to cope with the situation.

The *Local Disaster Index* identifies the social and environmental risks resulting from more recurrent lower level events (which are often chronic at the local and subnational levels). These events have a disproportionate impact on more socially and economically vulnerable populations, and have highly damaging impacts on national development.

The *Prevalent Vulnerability Index* is made up of a series of indicators that characterize prevalent vulnerability conditions reflected in exposure in prone areas, socioeconomic weaknesses and lack of social resilience in general.

The *Risk Management Index* brings together a group of indicators that measure a country's risk management performance. These indica-

tors reflect the organizational, development, capacity and institutional actions taken to reduce vulnerability and losses, to prepare for crisis and to recover efficiently from disasters.

The system of indicators covers different areas of the risk problem, taking into account issues such as: potential damages and losses resulting from extreme events; recurrent disasters or losses; social and environmental conditions that make particular countries or regions more disaster prone; the capacity of the economy to recover; the operation of key services; institutional capacity and the effectiveness of basic risk management instruments (such as risk identification, prevention and mitigation measures, financial mechanisms and risk transfer); emergency response levels; and preparedness and recovery capacity.

The Disaster Deficit Index relates assumed (deductive) indicators and depends on the simple modeling of physical risk as a function of the occurrence of a potentially extreme hazard (scientific prediction). The Local Disaster Index relies on indicators of past events with different impact levels (history). The Prevalent Vulnerability and the Risk Management indices are composites derived by aggregating quantitative and qualitative indicators. The indices were constructed using a multi-attribute technique and the indicators were carefully related and weighted. The indicators and the variables used in their construction were chosen through an extensive review of the risk management literature, assessment of available data, and broad-based consultation and analysis. The program reports listed in the bibliography detail the conceptual framework, the methodology, and the treatment of the data and statistical techniques used in the modeling (Cardona *et al*., 2003a, 2003b, 2004a, 2004b and 2005).[1]

This system of indicators has been designed to permit measurement and monitoring over time, and to identify risks and their causes. Its aim is also to facilitate comparisons across countries by using criteria related to hazard levels and the socioeconomic conditions that affect vulnerability. This system of indicators provides a holistic approach to evaluation that is also flexible and compatible with other evaluation methods. As a result, it is likely to be increasingly used to measure risk and risk management conditions. The systems main advantage lies in its ability to disaggregate results and identify factors that should take priority in risk management actions, while measuring the effectiveness of those actions. The main objective is to facilitate the decision-making process. In other words, the concept underlying this methodology is one of controlling risk rather than obtaining a precise evaluation of it (physical truth), (Cardona 2001; Carreño 2006).

[1] See also http://idea.unalmzl.edu.co

The Disaster Deficit Index (DDI)

This index measures the economic loss that a particular country could suffer when a catastrophic event takes place, and the implications in terms of resources needed to address the situation. Construction of the DDI requires undertaking a forecast based on historical and scientific evidence, as well as measuring the value of infrastructure and other goods and services that are likely to be affected. In order to do this, we must define an arbitrary reference point in terms of the severity or periodicity of dangerous phenomena. Objective modeling must take into account existing information and knowledge gaps and restrictions. The DDI captures the relationship between the demand for contingent resources to cover the losses caused by the Maximum Considered Event (MCE),[2] and the public sector's economic resilience (ER) - that is, the availability of internal and external funds for restoring affected inventories.

$$DDI = \frac{MCE\ Loss}{Economic\ Resilience}$$

Estimating Probable Losses

Potential losses were calculated using a model that takes into account different hazards (which are calculated in probabilistic form according to historical data on the intensity of past phenomena) and the actual physical vulnerability of the elements exposed to such phenomena. This analytical and predictive model is not based on historical measures of losses (deaths and number of people affected), but rather on the intensity of the phenomena. Actuarial requirements imply that we must avoid making estimates of risk based on previous damage statistics over short time periods. Modeling must be done by inference, by evaluating the likelihood of high-impact, low-probability events, as well as the vulnerability of infrastructure and other elements that are exposed to hazard (see Cardona *et al*., 2004a, 2004b and 2005, for additional details of the technical bases of the models used).

MCE has been defined with an arbitrary return period (we used three scenarios) as the worst situation, which requires feasible corrective or prospective planning actions to mitigate it in order to reduce potential negative effects for each country or subnational unit under study. The economic loss or demand for contingent resources (the numerator of the index) is obtained from modeling the potential impact of the MCE for three return periods: 50, 100 and 500[3] years, whose probability during any 10 years exposure period is 18 percent, 10 percent and 2 percent, respectively.

A particularly useful indicator for risk assessment is the expected annual loss, L_y^P, which is defined as the expected loss value in any one year. It is also known as the pure or technical premium. This value is equivalent to the annual average investment or saving that a country would have to make in order to approximately cover losses associated with future major events (Cardona et al 2008).

Resources Potentially Available to the Government

ER (the denominator of the index) represents internal and external resources that were avail-

[2] This model follows the insurance industry in establishing a reference point (the Probable Maximum Loss, PML) for calculating potential losses (ASTM, 1999; Ordaz, 2002).

[3] Most existing construction codes are based on the maximum possible intensity of events in approximately a 500 year time period. Particularly important infrastructure are designed for maximum intensity events of several thousand years. However, the majority of buildings and public works constructed in the twentieth century have not been designed to withstand such events.

able to the government when the evaluation was undertaken. However, access to these resources has limitations and costs that must be taken into account. Seven constraints are explicitly taken into consideration in this study:

- *Insurance and reinsurance payments* for insured government-owned goods and infrastructure;
- *Disaster reserve funds*;
- Public, private, national or international *aid and donations*;
- *New taxes*;
- *Budgetary reallocations*, which usually corresponds to the margin of discretional expenses available to the government;
- *External credit* that the country could obtain from multilateral organizations and in the external capital market; and
- *Internal credit* the country may obtain from commercial banks as well as the central bank.

The DDI captures the relationship between the demand for contingent economic resources to cover the economic losses that the public sector must assume, and the nation's economic resilience, that is, its ability of generate internal and external funds to replace the affected infrastructure and goods. A DDI greater than 1.0 reflects the country's inability to cope with extreme disasters even by going into as much debt as possible. The greater the DDI, the greater the gap between losses and the country's ability to face them. Government responsibility was restricted to the sum of losses associated with public sector buildings and housing for the lowest income population.

The current report presents the comparison of results for seventeen countries[4]: Argentina, Barbados, Bolivia, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru and Trinidad and Tobago.

DDI for 2008 was calculated with the most recent available information. Regarding to the exposed values, references of built areas and their value are established according to the existent statistical information and the proxies made by the consultant group respectively. Likewise, the economic resilience (denominator of the index) was estimated in terms of GDP percentage for each fund, taking as reference the economic information available for 2006 and 2007 due to gaps in the information that has not been incorporated in the database.

Results of the countries in this summary version present some differences in comparison with the previous results (Cardona 2005, 2008) due to improvements have been made in the *proxy* of exposed goods of the countries, and, on the other hand, because some indicators related with the funds of the ER were adjusted in the original databases. Likewise, in some cases new data and information sources of the Economic Commission for Latin America and the Caribbean (ECLAC) and the IDB (*Latin Macro Watch Country Tables)* have been used. The previous version took into account values of national governments and, within public corporations, non-financial public sector, nevertheless in some cases this information was incomplete. The report of each country contains a detailed description of these considerations.

The left side of figure 1 shows the DDI in 2008 calculated for an MCE with 500 years of return period (2 percent probability of occurrence in ten years). The right side of the figure shows the maximum loss, *L*, for the government during the same period. Figure 2 shows the Disaster Deficit Index and potential losses when faced with an event with 100 years of return period (10 percent probability of occurrence in ten years).

[4] Some countries have been evaluated in the framework of CAPRA (Central America Probabilistic Risk Assessment, available at www.ecapra.org) and the country-specific catastrophe risk reports of Guatemala, El Salvador, Belize, and Honduras developed by the IDB.

Figure 1. DDI and Probable Maximum Loss in 500 Years

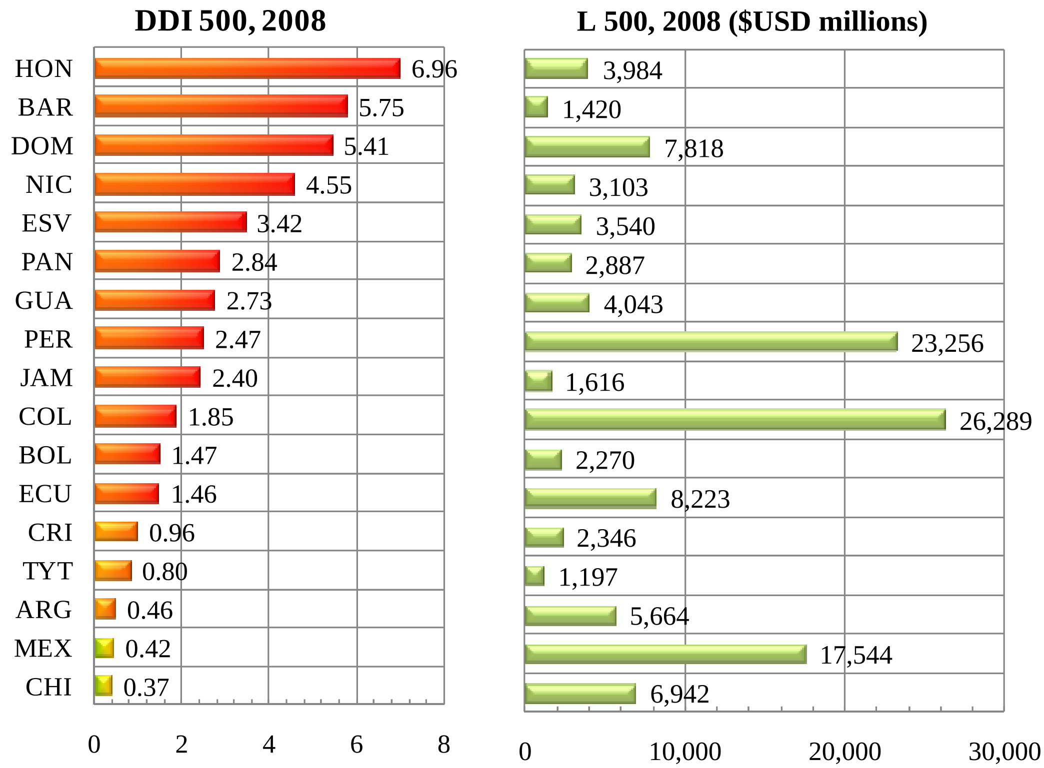


Figure 2. DDI and Probable Maximum Loss in 100 Years

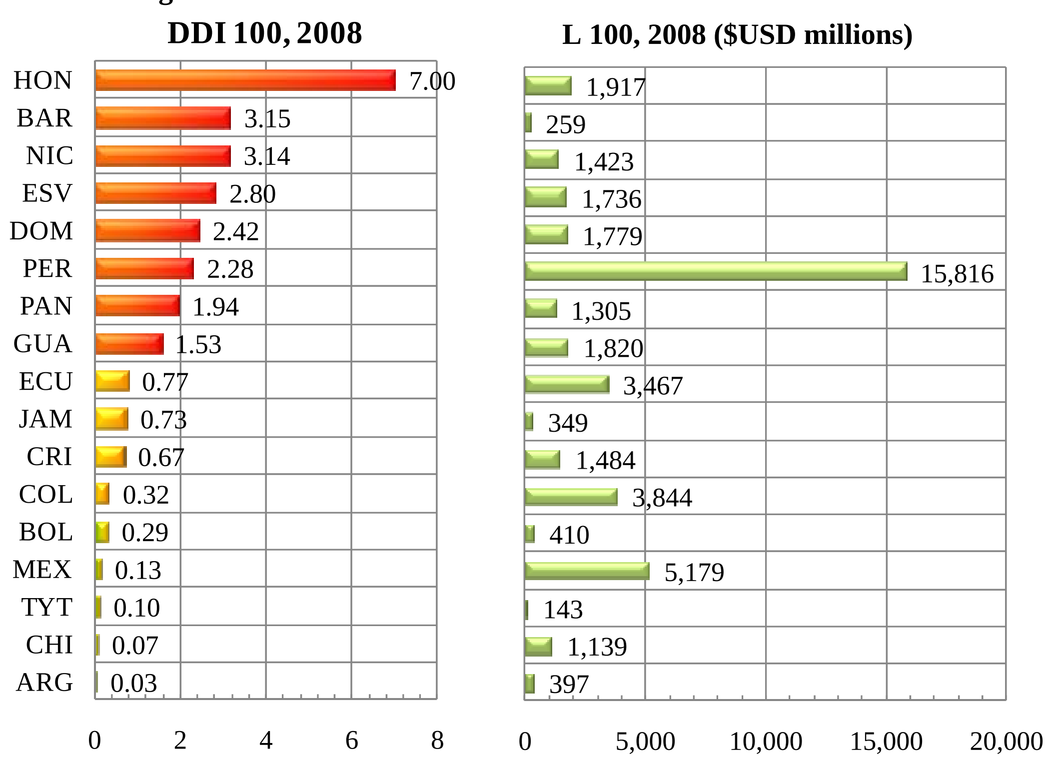


Figure 3. DDI and Probable Maximum Loss in 50 Years

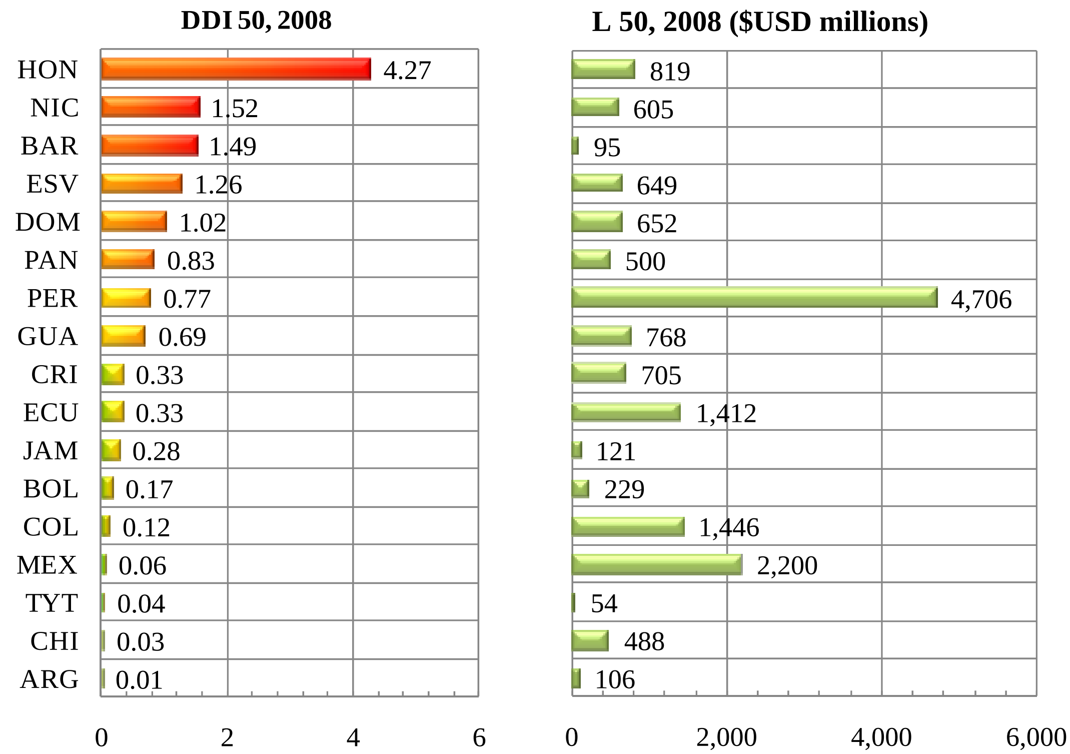
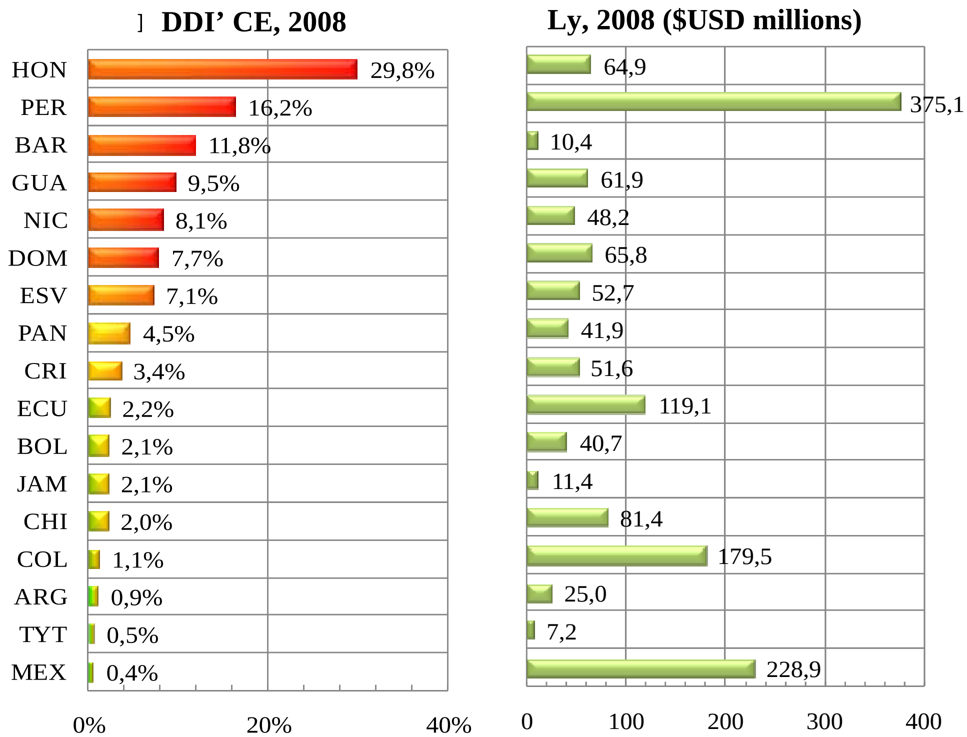


Figure 3 shows the DDI and potential losses when faced with an event with 50 years of return period (18 percent probability of occurrence in ten years). The results, calculated for 2008, indicate that although maximum probable losses of Honduras (HON), Barbados (BAR), Nicaragua (NIC) and El Salvador (ESV) are relatively lower than the losses of Colombia (COL), Peru (PER) and Mexico (MEX), DDI of those countries is excessively high for the three return periods. On the other hand, Chile (CHI), MEX, Argentina (ARG), Trinidad and Tobago (TTO) and Costa Rica (CRI) have the capacity to cover the losses due to a low probability/high consequences extreme event. In the case of lower impact events, for a 100 years return period, ARG, CHI, TTO,MEX, Bolivia (BOL) , COL, CRI, Jamaica (JAM) and Ecuador (ECU) could access to resources that allow covering losses of the public sector and the low-income population, although it can be observed considerable losses in MEX, COL and ECU. Peru stands out from the other countries due to the great magnitude of losses that can present in the three return years evaluated.

To help place the Disaster Deficit Index in context, we've developed a complementary indicator, DDI**'**, to illustrate the portion of a country's annual Capital Expenditure (CE) that corresponds to the expected annual loss or the pure risk premium. That is, DDI' shows the percentage of the annual investment budget that would be needed to pay for future disasters. The left side of figure 4 shows the DDI'_{CE} for 2008. The right side shows the annual expected loss, *Ly*. These indices were calculated evaluating losses in US dollars at constant value for 2000.

Results obtained for 2008 indicate that although annual average loss in HON, BAR and NIC are relatively lower than annual average loss in PER, MEX and COL, DDI' due to capital expenditures are very high; that is, the annual cost of future disasters represents 29.8%, 11.8% and 8.1% of capital investment respectively.

Figure 4. DDI’ and Annual Average Loss



In the case of PER, the annual average loss is the highest compared with the other countries evaluated and this represents the 16.2% of the capital investment in the country. Seven countries have values greater than 7 percent of investment budget.

These indicators provide a simple way of measuring a country’s fiscal exposure and potential deficit (or contingency liabilities) in case of an extreme disaster. They allow national decisionmakers to measure the budgetary implications of such an event and highlight the importance of including this type of information in financial and budgetary processes (Freeman *et al*., 2002b). These results substantiate the need to identify and propose effective policies and actions such as, for example, using insurance and reinsurance (transfer mechanisms) to protect government resources or establishing reserves based on adequate loss estimation criteria. Other such actions include contracting contingency credits and, in particular, the need to invest in structural (retrofitting) and nonstructural prevention and mitigation to reduce potential damage and losses as well as the potential economic impact of disasters.

Figure 5 to 8 present the comparison of the results of the DDI and the DDI’$_{CE}$, estimated for all evaluated countries for which the required information was possible to obtain.[5] Results for the three return periods (50, 100 and 500) for 1995, 2000, 2005 and 2008 are included. The situation has been improving in most countries over time on exception of BAR, Dominican Republic (DOM), Guatemala (GUA), HON and PER. This has been due to changes not only in exposition and vulnerability but mainly due to lower accessibility to feasible resources. Details on each specific situation are described in the report of each country.

[5] Barbados and Honduras do not have available data on the required variables in the international databases for 1995 and it was not possible to obtain them directly from the governments.

Figure 5. DDI (Tr 50 years)

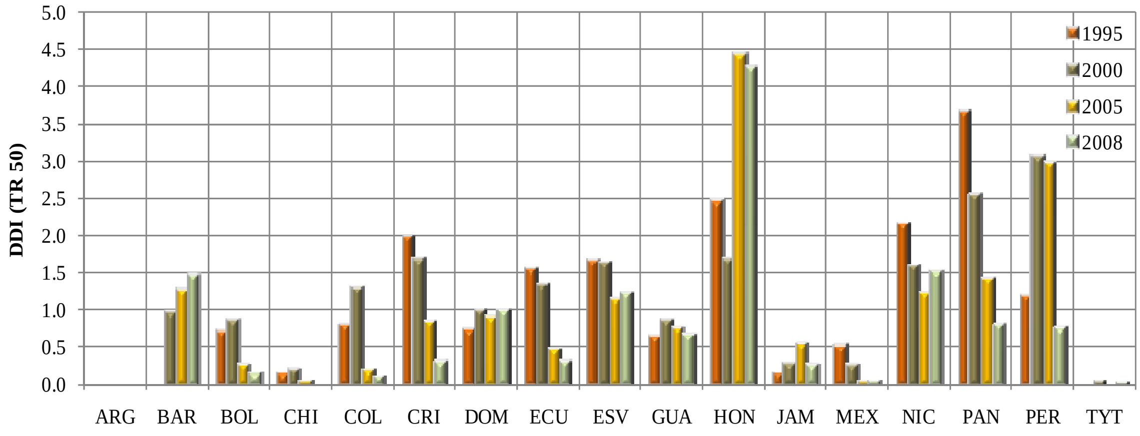


Figure 6. DDI (Tr 100 years)

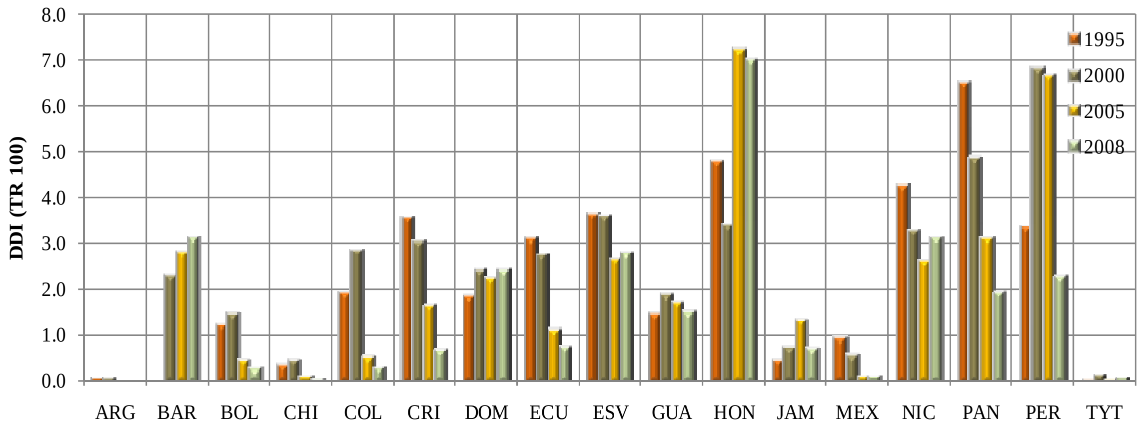


Figure 7. DDI (Tr 500 years)

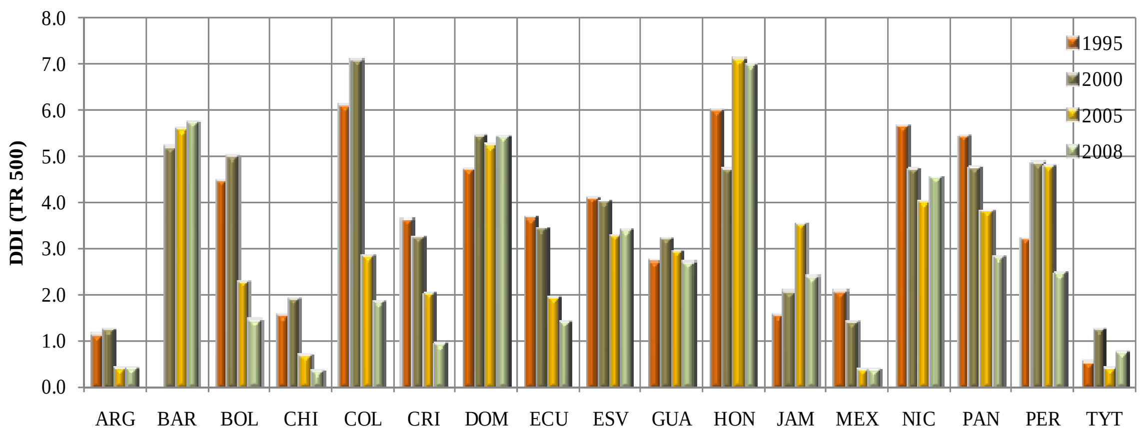
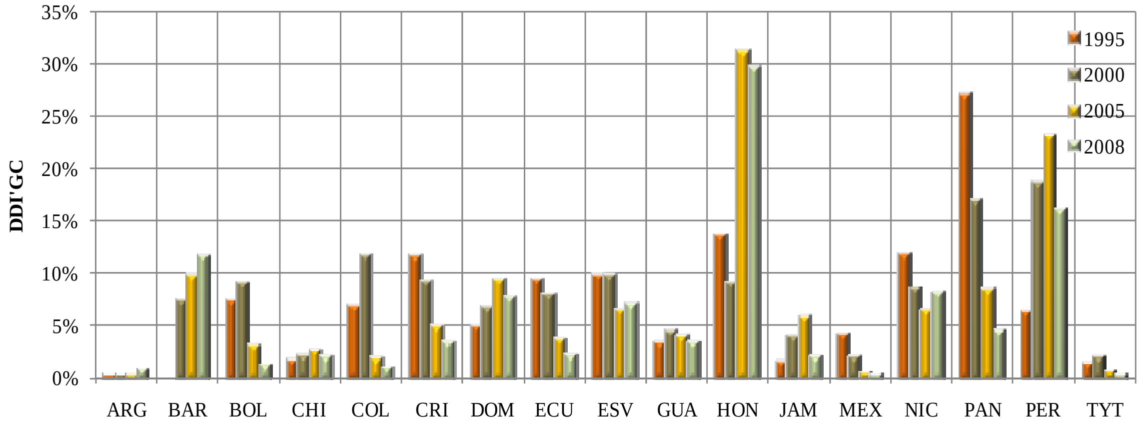


Figure 8. DDI'CE



The Local Disaster Index (LDI)

This index represents the propensity of a country to experience small-scale disasters and their cumulative impact on local development. The index attempts to represent the spatial variability and dispersion of risk in a country resulting from small and recurrent events. This approach is concerned with the national significance of recurrent small scale events that rarely enter international, or even national, disaster databases, but which pose a serious and cumulative development problem for local areas and, more than likely, also for the country as a whole. These events may be the result of socio-natural processes associated with environmental deterioration (Lavell, 2003a; Lavell, 2003b) and are persistent or chronic in nature. They include landslides, avalanches, flooding, forest fires, and droughts as well as small earthquakes, hurricanes and volcanic eruptions.

For the purposes of this study, we classified the various types of events registered in the DesInventar database[6] into six phenomena: geodynamic (internal and external), hydrological, atmospheric, technological, and biological (Cardona *et al.*, 2004a, 2004b, 2005). To further simplify, external geodynamic phenomena are referred to as *landslides and debris flows*, whereas internal geodynamic phenomena are referred to as *seismo-tectonic*. Hydrological and atmospheric phenomena were grouped and are referred to as *floods and storms*. Finally, technological and biological phenomena are simply referred to as *other* events. In addition, the database was standardized to take into account three variables: i) the number of deaths, ii) the number of people affected by the events, and iii) direct losses (that is, the economic value of housing and crops lost or damaged) for the four types of event. The database also combines disaggregated data for the number of people affected by disasters with that for people left homeless. The reason for doing this is that in some countries both designation depict the same thing. Destroyed and affected housing are also aggregated; an "affected" house is equivalent to one-quarter of a destroyed house. The cost of rebuilding destroyed houses is taken to be the average cost of a social housing unit during the period of analysis. The value of one hectare of crops was calculated on the basis of the weighted average price of crop areas that are usually affected by disasters, taking into account expert opinion in the country at the time of analysis.

The LDI is equal to the sum of three local disaster subindicators that are calculated based on data from the DesInventar database for number of deaths (K), number of people affected (A) and economic losses (L) in each municipality.

$$LDI = LDI_{Deaths} + LDI_{Affected} + LDI_{Losses}$$

The Local Disaster Index captures simultaneously the incidence and uniformity of the distribution of local effects. That is, it accounts for the relative weight and persistence of the effects attributable to phenomena that give rise to municipal scale disasters. The higher the relative value of the index, the more uniform the magnitude and distribution of the effects of various hazards among municipalities. A low LDI value means low spatial distribution of the effects among the municipalities where events have occurred. The range of each LDI is from 0 to 100 and the total LDI is the sum of the three components. A low LDI value (0-20) means high concentration of small disasters in few municipalities and a low spatial distribution of their effects between the municipalities where

[6] The database was put together by La Red de Estudios Sociales en Prevención de Desastres de América Latina (La RED).

they had taken place. Medium LDI values (20-50) means small disasters concentration and distribution of their effects are intermediate; high LDI values (from 50 onward) indicate that the majority of municipalities suffer small disasters and their effects are similar in all affected municipalities. High values reflect vulnerability and hazards are generalized in the territory.

Original methodological formulation of the LDI (IDEA, 2005) enclosed the effects of all the events (both small and big) occurred in the country; that is, both effects of small and frequent events and extreme and sporadic events. From the moment that evaluation was made, it was considered that reflecting the influence of extreme events was not the objective of this indicator. A recommendation for a further evaluation, as current, was to take into account only the small events. Thus, this updating excludes extreme events from the database through statistical identification of outliers. Likewise, a standardization process was made for obtaining a minimum and a maximum value for the Persistence Indices (IP) that makes part of LDI calculations. Consequently, this formulation allows clearly identify what type of events has the greater incidence and regularity in municipalities of the country (Marulanda and Cardona, 2006; Marulanda *et al* 2008, 2009a).

In a complementary way, it has been formulated the LDI' that measures the concentration of aggregate losses at municipal level. Its value is between 0.0 and 1.0. A high LDI' value means high economic losses concentration due to small disasters in few municipalities. For example, an LDI' equal to 0.80 and 0.90 means that approximately 10% of municipalities of the country concentrates approximately 70% and 80% respectively of the losses that have taken place due to small disasters in the country. Calculation of LDI and LDI' was made again for all the previous periods given that the extreme events were extracted from the database. Likewise minor adjustments were made to the analytical formulation of the LDI. An event is considered as big when the number of deaths is greater than 50, the affected are greater than 2500 and the destroyed houses are more than 500[7]. Table 1 summarizes the state of updating of the DesInventar database for the countries studied; this will be reflected in the results presented.

Table 1. DesInventar database

Country	DesInventar database?	Latest year Available
Argentina	YES	2004
Barbados	NO	-
Belice	NO	-
Bolivia	SI	2007
Chile	YES	2000
Colombia	YES	2007
Costa Rica	YES	2007
Ecuador	YES	2007
El Salvador	YES	1996-2005
Guatemala	YES	2000
Honduras	NO	-
Jamaica	YES	2000
Mexico	YES	2007
Nicaragua	NO	-
Panama	YES	2007
Peru	YES	2007
Dominican Republic	YES	2000
Trinidad and Tobago	YES	2000

Figures 9, 10 and 11 present results for the three LDI taking into account the number of deaths, affected and economic losses.

The data for most countries studied show that, during this period, there was a greater incidence and persistence in the distribution of deaths among municipalities. However, BOL obtained a low value of LDI_K what means higher concentration of deaths among municipalities.

7 Thresholds and technique of outliers identification was proposed by Marulanda and Cardona (2006) where derived the concepts of intensive and extensive risk used in the Global Assessment Report on Disaster Risk Reduction (UN, 2009). This report proposed the thresholds for deaths and destroyed houses here used.

Figure 9. LDI_K for 2001-2005 and 2006-2008

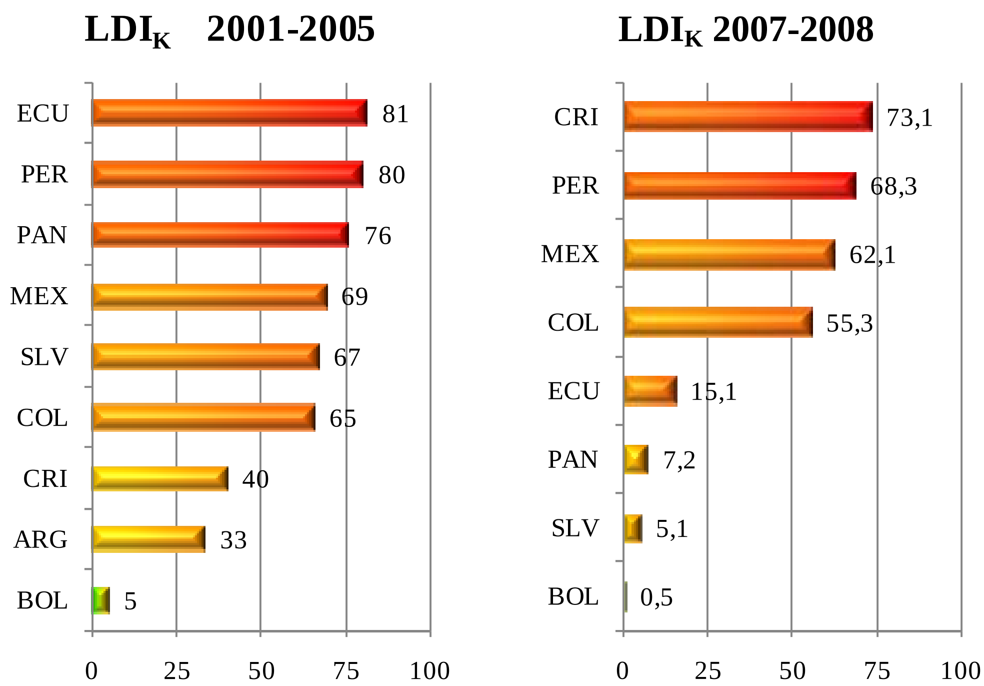


Figure 10. LDI_A for 2001-2005 and 2006-2008

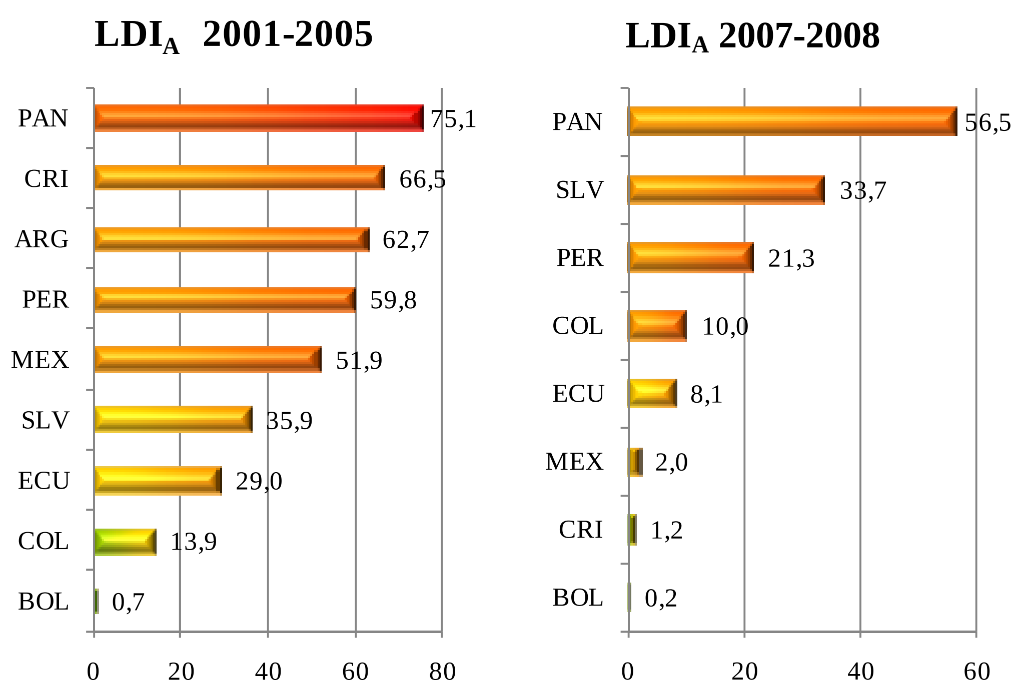


Figure 11. LDI_L for 2001-2005 and 2006-2008

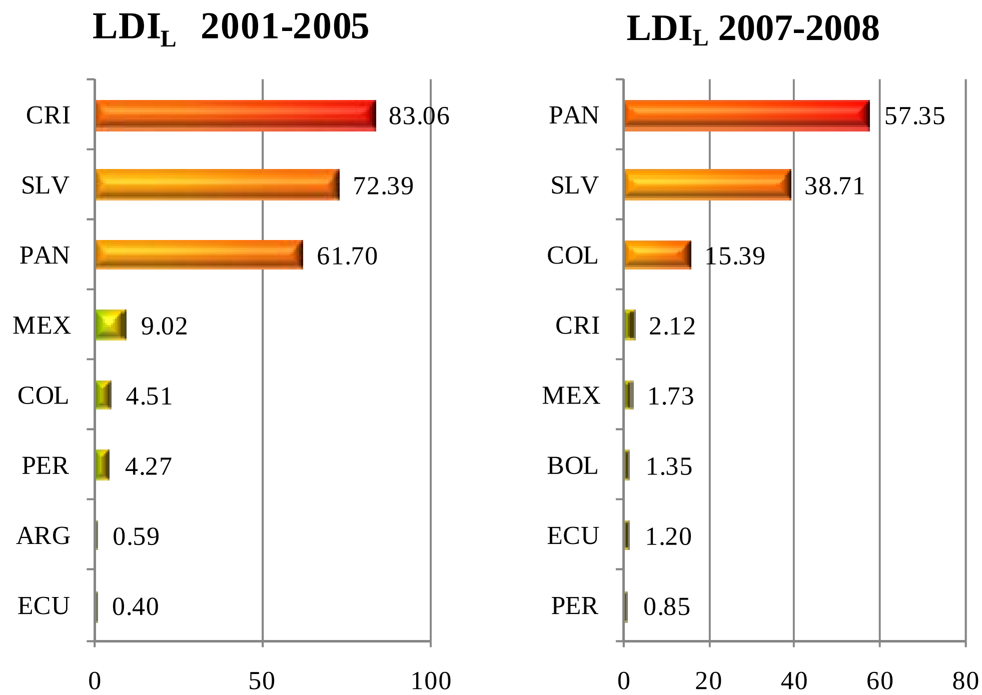
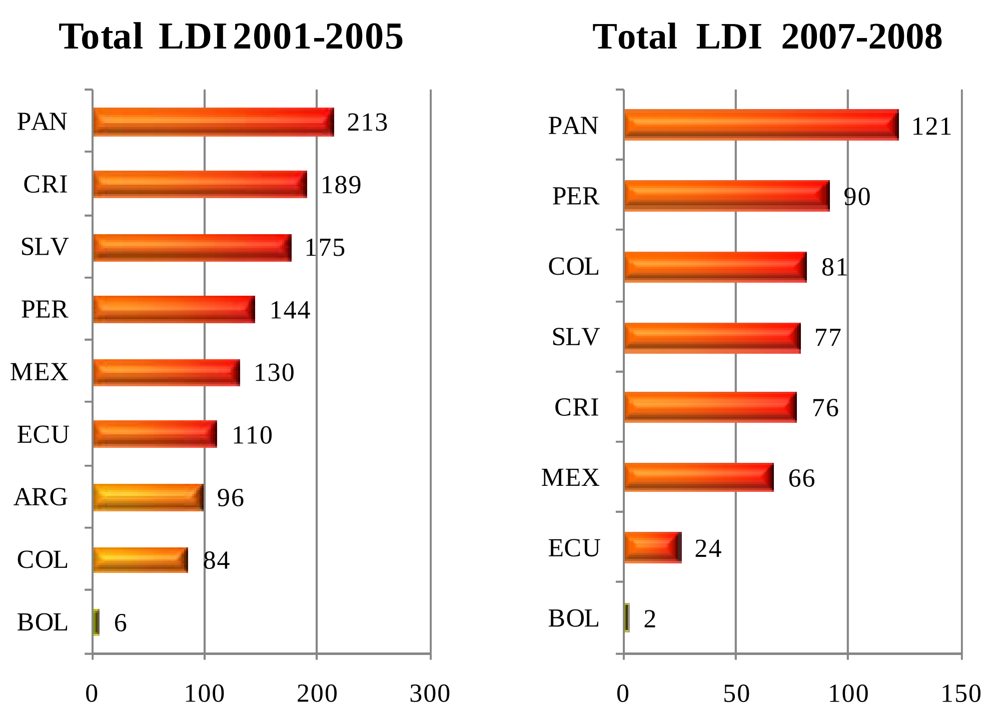


Figure 12. Total LDI (aggregated) for 2001-2005 and 2006-2008



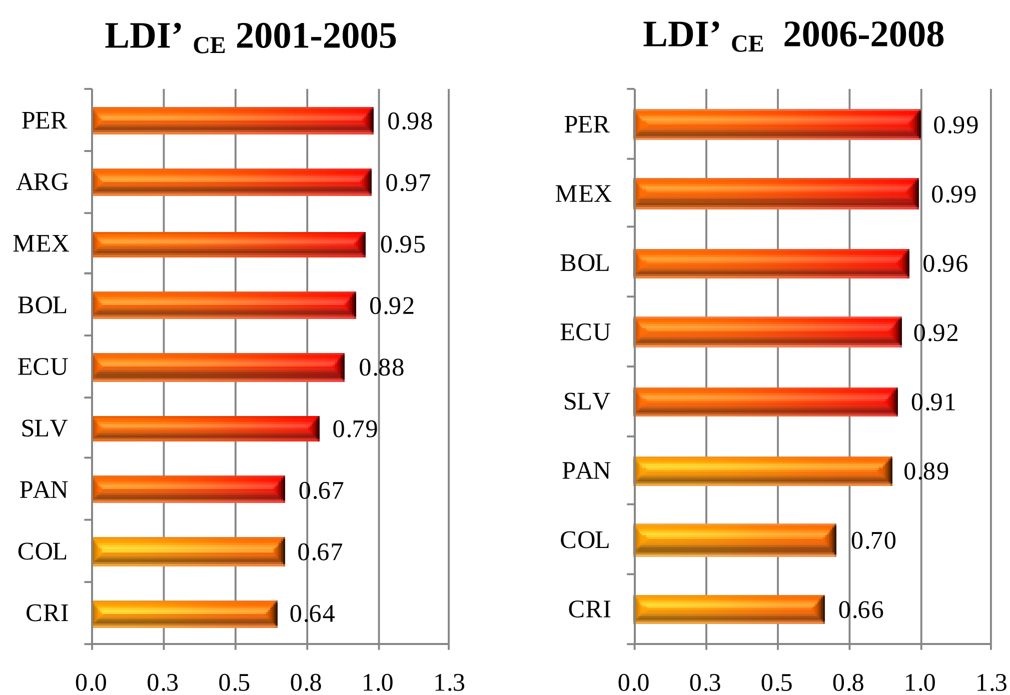
Regarding LDI_A, BOL and COL show lower incidence and persistence in the distribution of the number of people affected. Disasters between 2001 and 2005 were due to several landslides and floods in many municipalities in the countries. LDI_L shows relative losses in CRI and SLV were more similar and more evenly distributed among all municipalities than in other countries. This means that there is a lower variability of risk in the country. It is important to point out that although the period 2006-2008, of three years is not comparable with previous periods of five years, the value for this period is illustrative of what has been the evolution of the indicator at the moment of the evaluation.

Figure 12 presents the results of the total LDI, that is, the aggregated value for the three effects considered. In this figure can be observed that Panama (PAN), CRI and SLV present the greatest incidence and regularity of the effects of small disasters of the countries evaluated in the period 2001-2005, while for the partial period 2006-2007 the highest values correspond to PAN, PER and COL.

In general it is conclude that most of countries evaluated present a considerable LDI, what reflects an important incidence and regularity of the effects. This can be the result of processes of environmental degradation, vulnerability increasing at municipal level and rising of the recurrence of events characteristics of climate variability and change.

Although the LDI takes into account the total deaths, affected, and economic losses, it is important to emphasize that it is a measure of uniformity of dispersion of these figures. Therefore, in order to evaluate the LDI, the figures were normalized according to the total area of the municipalities to which they correspond, and were related to the number of municipalities where effects were registered. Similarly, we calculated a LDI**’** that takes into account the concentration of losses (direct physical damage) at the municipal level and is aggregated for all events in all countries. This indicator shows the disparity of risk within a single country. Figure 13 presents the results obtained for LDI’.

Figure 13. LDI’ for the periods 2001-2005 and 2006-2007



LDI’ shows that in countries such as PER, ARG, MEX and BOL, losses during the period studied were concentrated in a few municipalities. An LDI’ of 0.98, 0.97, 0.95, 0.92, signifies that 10 percent of the municipallities concentrate 88, 87, 85 and 82 percent of losses, respectively.

The usefulness of these indices for economic analysts and sector officials in charge of establishing rural and urban policies lies in the fact that they allow them to measure the persistence and cumulative impact of local disasters. As such, they can prompt the consideration of risk in territorial planning at the local level, as well as the protection of hydrographic basins. They can also be used to justify resource transfers to the local level that are earmarked for risk management and the creation of social safety nets

Figures 14 to 16 present the results obtained for the three subindicators LDI_K, LDI_A, LDI_L for all the countries evaluated in the periods 1991-1995, 1996-2000 and 2001-2005. Figure 17 presents the results for the same periods of the total LDI, and the results for LDI’ are illustrated in figure 18.

Figure 14. IDL_K for periods 1991-1995, 1996-2000 and 2001-2005

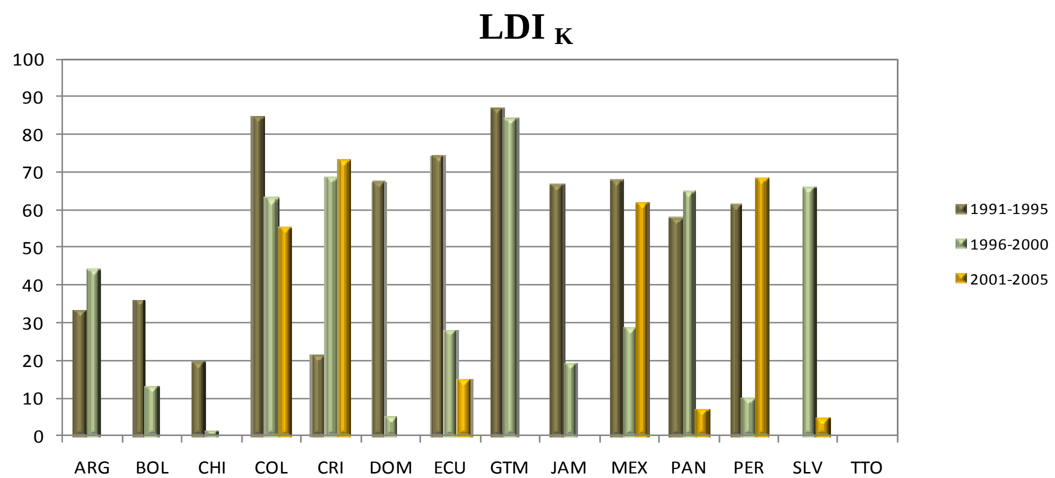


Figure 15. IDL_A for periods 1991-1995, 1996-2000 and 2001-2005

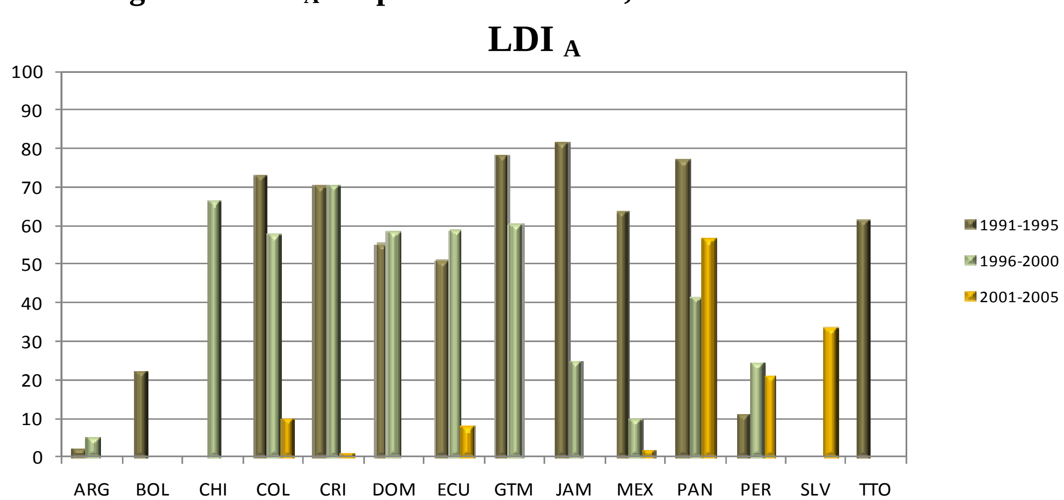


Figure 16. IDL_L for periods 1991-1995, 1996-2000 and 2001-2005

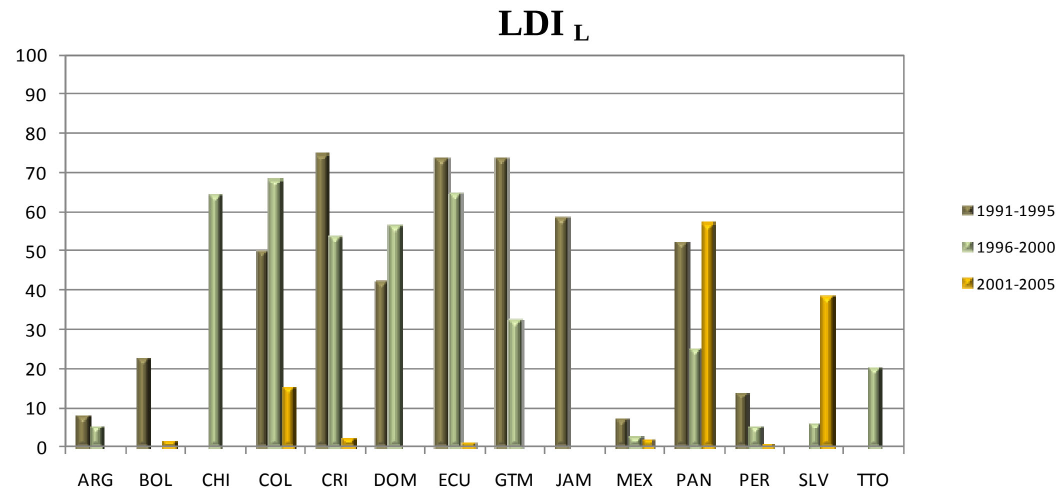


Figure 17. IDL for periods 1991-1995, 1996-2000 and 2001-2005

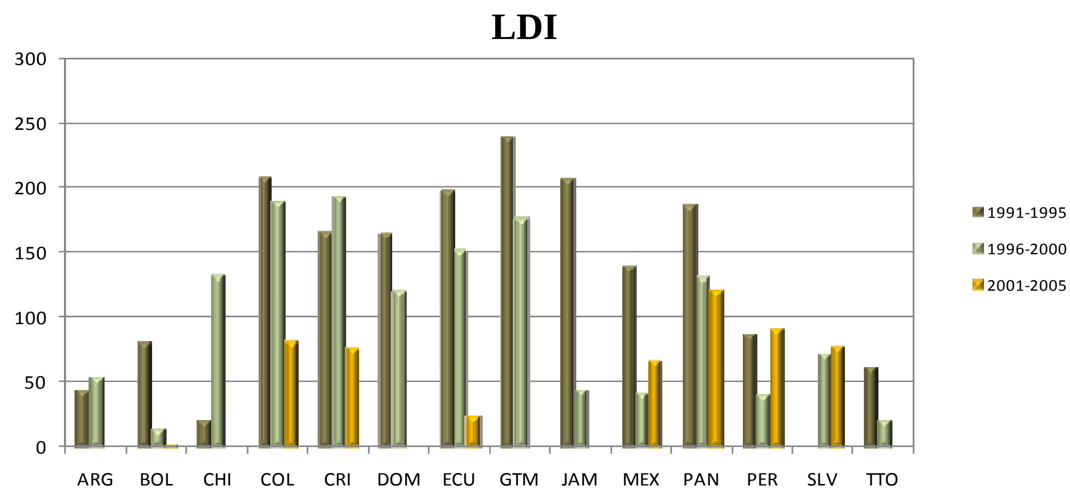
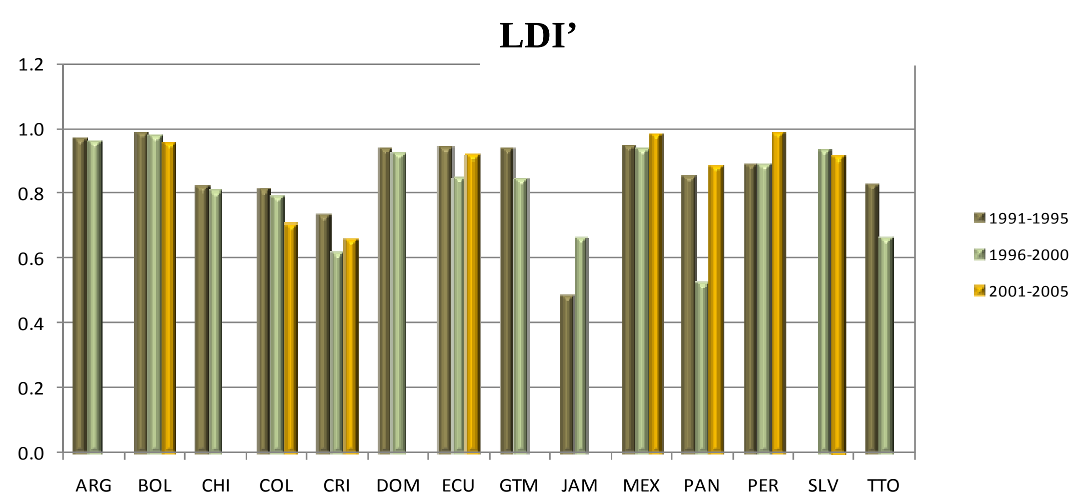


Figure 18. IDL' for periods 1991-1995, 1996-2000 and 2001-2005



These indices are useful for economic analysts and sectoral officials, related to the promotion of rural and urban policy development, because they can detect the persistency and accumulation of effects of local disasters. They can stimulate the consideration of risk problems in territorial planning at the local level and the intervention and protection of hydrologic basins, and they can justify resource transfers to the local level with specific goals of risk management and the creation of social security nets.

The Prevalent Vulnerability Index (PVI)

This index depicts predominant vulnerability conditions by measuring exposure in prone areas, socioeconomic fragility and lack of social resilience. These items provide a measure of direct as well as indirect and intangible impacts of hazard events. The index is a composite indicator that provides a comparative measure of a country's pattern or situation. Inherent[8] vulnerability conditions underscore the relationship between risk and development (UNDP, 2004). Vulnerability, and therefore risk, are the result of inadequate economic growth, on the one hand, and deficiencies that may be corrected by means of adequate development processes. Although the indicators proposed are recognized as useful for measuring development (Holzmann and Jorgensen, 2000; Holzmann, 2001) their use here is intended to capture favorable conditions for direct physical impacts (exposure and susceptibility), as well as indirect and, at times, intangible impacts (socioeconomic fragility and lack of resilience) of potential physical events (Masure, 2003; Davis, 2003). The PVI is an average of these three types of composite indicators:

$$PVI = (PVI_{Exposure} + PVI_{Fragility} + PVI_{\neg Resilience})/3$$

The indicators used for describing exposure, prevalent socioeconomic conditions and lack of resilience have been estimated in a consistent fashion (directly or in inverse fashion, accordingly), recognizing that their influence explains why adverse economic, social and environmental impacts take place following a dangerous event. Each one is made up of a set of indicators that express situations, causes, susceptibilities, weaknesses or relative absences affecting the country, region or locality under study, and which would benefit from risk reduction actions. The indicators were identified based on figures, indices, existing rates or proportions derived from reliable databases available worldwide or in each country (see methodology: Cardona *et al*., 2004a, 2004b, and 2005).

[8] That is to say, the predominant socioeconomic conditions that favor or facilitate negative effects as a result of adverse physical phenomena (Briguglio, 2003b).

Indicators of Exposure and Susceptibility

The best indicators of exposure and/or physical susceptibility (PVI_{ES}) are the susceptible population, assets, investment, production, livelihoods, historic monuments, and human activities (Masure, 2003; Lavell, 2003b). Other indicators include population growth and density rates, as well as agricultural and urban growth rates. The indicators used are listed below.

- ES1. Population growth, average annual rate.
- ES2. Urban growth, avg. annual rate (%).
- ES3. Population density (people/5 Km^2).
- ES4. Poverty, population living on less than US$1 per day PPP.
- ES5. Capital stock in millions US dollar per thousand square kilometers.
- ES6. Imports and exports of goods and services as a percent of GDP
- ES7. Gross domestic fixed investment as a percent of GDP.
- ES8. Arable land and permanent crops as a percent of land area.

These variables reflect the nation's susceptibility to dangerous events, whatever their nature or severity. Exposure and susceptibility are necessary conditions for the existence of risk. Although, in any strict sense it would be necessary to establish if exposure is relevant for each potential type of event, we may nevertheless assert that certain variables reflect comparatively adverse situations where natural hazards can be deemed to be permanent external factors without needing to establish their exact nature. Figure 19 shows the PVI_{ES} by country and period, weighted using the Analytic Hierarchy Process (AHP).

Indicators of Socioeconomic Fragility

Socioeconomic fragility (PVI_{SF}), may be represented by indicators such as poverty, lack of personal safety, dependency, illiteracy, income inequality, unemployment, inflation, debt and environmental deterioration. These indicators reflect relative weaknesses that increase the direct effects of dangerous phenomena (Cannon, 2003; Davis, 2003; Wisner, 2003). Even though these effects are not necessarily cumulative (and in some cases may be superfluous or correlated), their influence is especially important at the social and economic levels (Benson, 2003b). The indicators are listed below.

- SF1. Human Poverty Index, HPI-1.
- SF2. Dependents as a proportion of the working age population.
- SF3. Inequality as measured by the Gini coefficient.
- SF4. Unemployment as percent of the total labor force.
- SF5. Annual increase in food prices (%).
- SF6. Share of agriculture in total GDP growth (annual %).
- SF7. Debt service burden as a percent of GDP.
- SF8. Soil degradation resulting from human activities (GLASOD).[9]

These indicators show that there exists an intrinsic predisposition for adverse social impacts in the face of dangerous phenomena regardless of their nature or intensity (Lavell, 2003b; Wisner, 2003). The propensity to suffer negative impacts establishes a vulnerability condition of the population, although it would be necessary to establish the relevance of this propensity in the face of all types of hazard. Nevertheless, as with exposure, it is possible to suggest that certain values of specific variables reflect a relatively unfavorable situation in the eventuality of natural hazard, regardless of the exact characteristics of those hazards. Figure 20 shows the PVI_{SF} weighted using the AHP.

Indicators of (Lack of) Resilience

Lack of resilience (PVI_{LR}), seen as a vulnerability factor, may be represented by means of the inverse[10] relationship of a number of variables that measure human development, human capital, economic redistribution, governance, financial protection, community awareness, the degree of preparedness to face crisis situations, and environmental protection. These indicators are useful to identify and guide actions to improve personal safety (Cannon, 2003; Davis, 2003; Lavell, 2003a; Lavell, 2003b; Wisner, 2003).

- LR1. Human Development Index, HDI [Inv]
- LR2. Gender-related Development Index, GDI [Inv]
- LR3. Social expenditures on pensions, health and education as a percent of GDP [Inv]
- LR4. Governance Index (Kaufmann) [Inv]
- LR5. Infrastructure and housing insurance as a percent of GDP [Inv]
- LR6. Television sets per 1000 people [Inv]
- LR7. Hospital beds per 1000 people [Inv]
- LR8. Environmental Sustainability Index, ESI [Inv]

These indicators capture the capacity to recover from or absorb the impact of dangerous phenomena, whatever their nature and severity (Briguglio, 2003b). Not being able to adequately face disasters is a vulnerability condition, although in a strict sense it is necessary to establish this with reference to all potential types of hazard. Nevertheless, as with exposure and socioeconomic fragility, we can posit that some economic and social variables (Benson, 2003b) reflect a comparatively unfavorable position if natural hazards exist. Figure 21 shows the PVI_{LR} weighted using the AHP.

[9] Global Assessment of Human-induced Soil Degradation

[10] The symbol [Inv] is used here to indicate an inverse variable ($\neg R$ = 1- R).

Figure 19. PVI for Exposure and Susceptibility

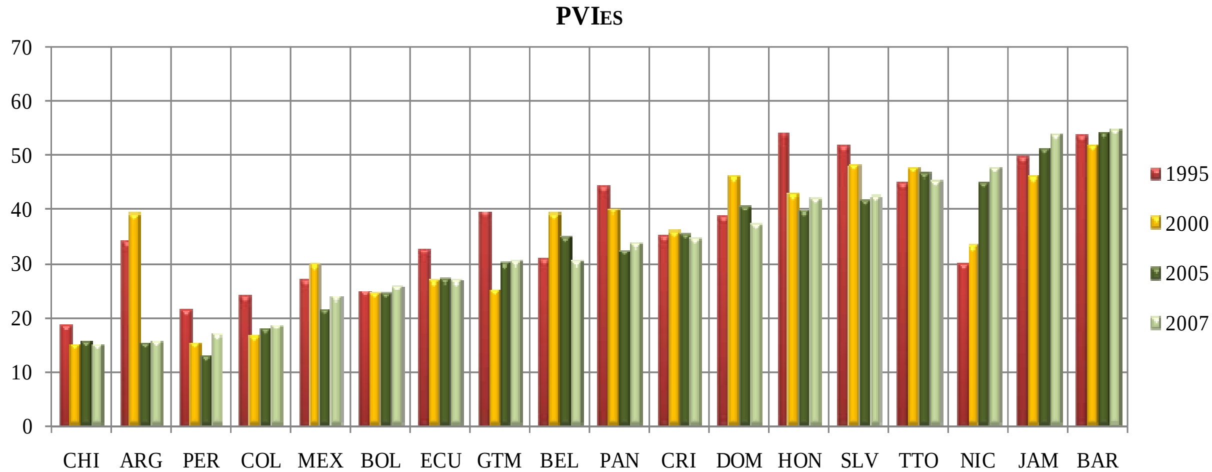


Figure 20. PVI for Socioeconomic Fragility

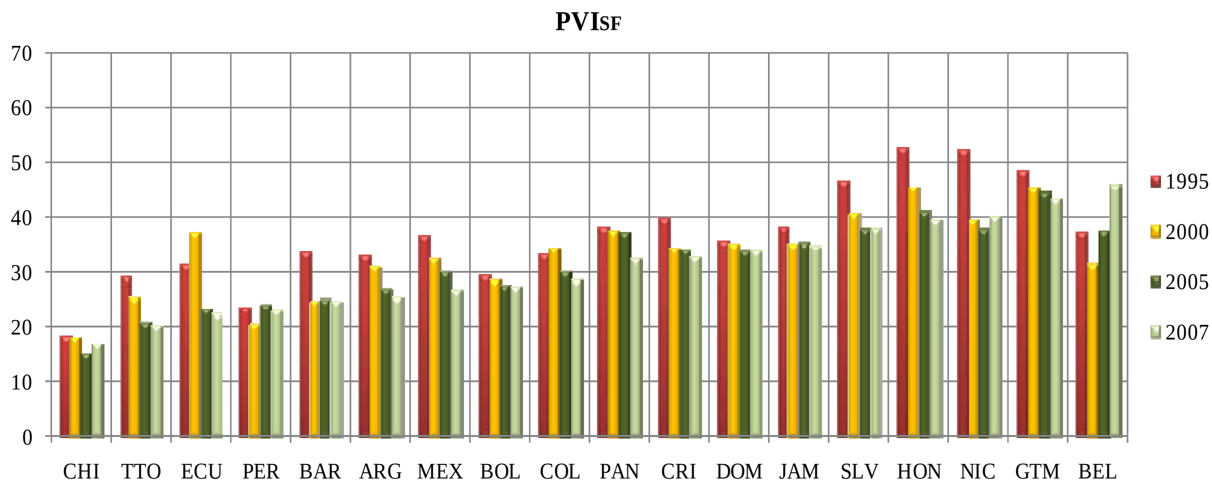
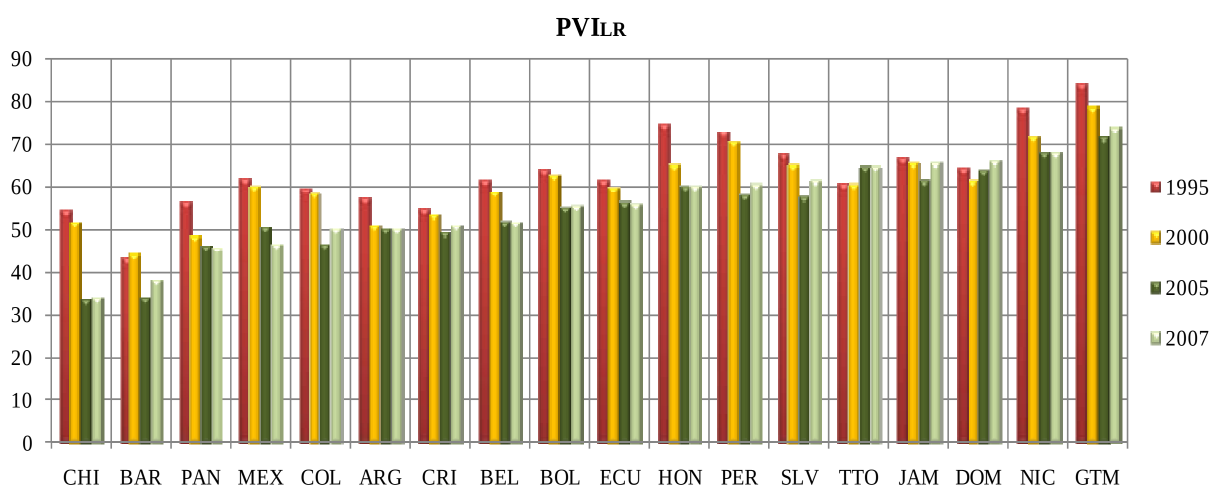


Figure 21. PVI Due to Lack of Resilience



Figures 19, 20 and 21 present the results for the three PVI that were calculated from different databases of the World Bank, ECLAC, UNDP, IDB and from the own countries. From figure 19 to 21 it is concluded that the prevalent vulnerability index in relation with exposition and physical vulnerability, PVI_{ES} in the smallest countries such as BAR, JAM, TTO and SLV is systematically greater. NIC presents a relative increase of exposition and susceptibility in the last years. CRI, TTO, Belize (BEL), PAN and DOM have had a slight diminish from 2000, and in ARG reduction for 2005 is very notable. The prevalent vulnerability index in terms of socio-economic fragility, PVI_{SF} for BEL, GTM, NIC, HON and SLV is relatively high, although in the majority of the countries the socio-economic fragility has registered a diminish through the time, with exception of BEL, NIC and CHI, especially in the last period. Values of the prevalent vulnerability index in terms of lack of resilience, PVI_{LR}, in general, are very high, and the value is very notable in GUA and NIC although it is being reducing. The index has also remarkably decreased in CHI, PAN, MEX, BEL, BOL, HON and PER. CHI and BAR present greater resilience. Figures 22 and 23 illustrate average and aggregated PVI of the countries evaluated. Although in 2007 NIC presents the highest value that has been more or less constant through the years. HON, GTM, JAM and SLV also present very high PVI values since 1995. Most countries show a declining trend in vulnerability along the years of evaluation with exception of NIC where a sustained increasing is presented and in HON, JAM, SLV, BEL, BAR, BOL, PER, COL and CHI have been a slight increase in 2007. Other notable PVI values are in DOM and TTO. CHI, ARG, MEX, COL and PER present the lower PVI values in the regional context.

PVI varies between 0 and 100, a value of 80 means very high vulnerability, from 40 to 80 means high, from 20 to 40 is a medium value and less than 20 means low. PVI was calculated again for all the periods due to various values of the databases that were not known, currently are available or have been modified as result of revisions that were made after the previous evaluation of the index. Modifications in maximum and minimum reference values were also made for this new evaluation due to standardization of values of subindicators can be made in a uniform form for all the evaluated countries.

Figure 22. PVI for Countries Studied

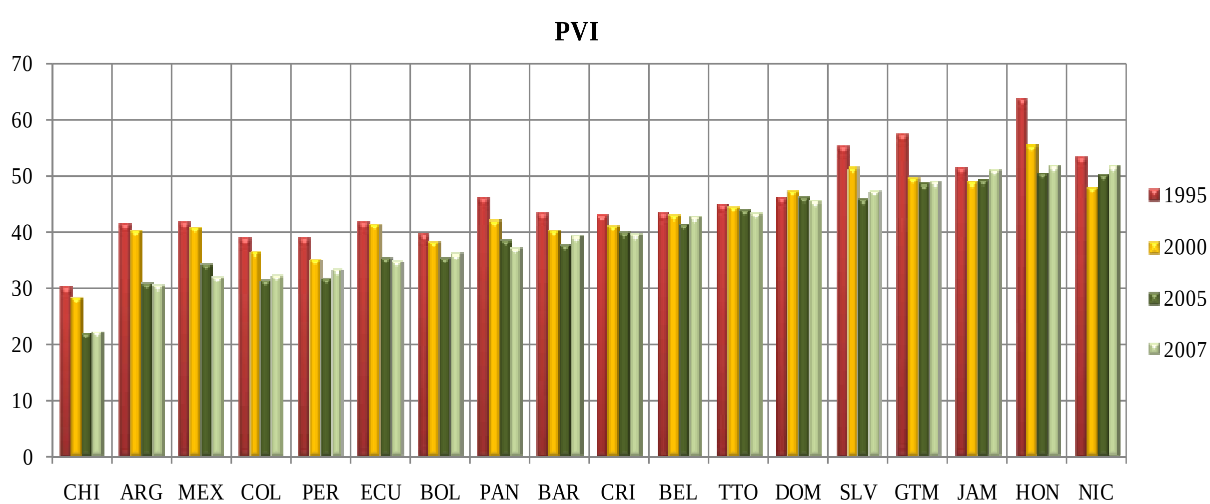
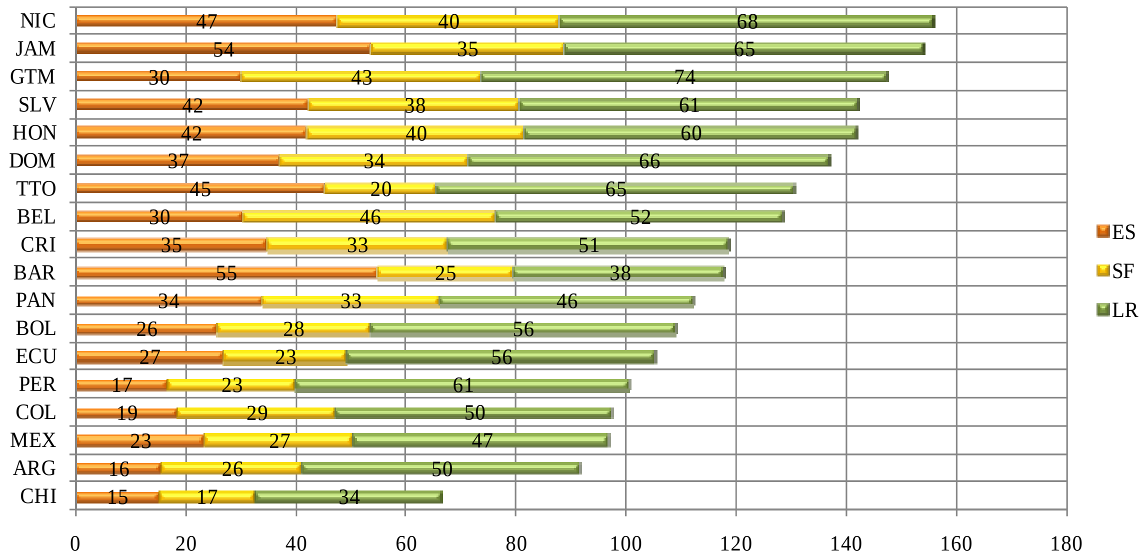


Figure 23. Aggregate PVI for 2007



In general, total PVI has been decreasing in the most of countries. A slight increase has been presented only in some countries in the last period that cannot be considered definitive due to the normal adjustments of the most recent subindicators. An important group of countries present an average PVI high in 2007: NIC, HON, JAM, GTM, SLV, DOM, TTO and BEL. The other countries present an intermediate PVI and there are no countries that present a low value of PVI. In general, the lack of resilience is the subindicator that most contribute to the results of the prevalent vulnerability and exposition in the case of small countries or islands as it is illustrated in the case of BAR and JAM.

PVI reflects susceptibility due to the level of physical exposition of goods and people, which favor the direct impact. Likewise, reflects conditions of social and economic fragilities, which favors the indirect and intangible impact.

The index also reflects the lack of capacity to absorb the consequences, efficiently respond and recover. Reduction of these kinds of factors, object of a process of sustainable human development and explicit policies of risk reduction, is one of the aspects where special emphasis must exist.

The Prevalent Vulnerability Index should form part of a system of indicators that allows the implementation of effective prevention, mitigation, preparedness and risk transfer measures to reduce risk. The information provided by an index such as the PVI should prove useful to ministries of housing and urban development, environment, agriculture, health and social welfare, economy and planning. Although the relationship between risk and development should be emphasized, it must be noted that activities to promote development do not, in and of themselves, automatically reduce vulnerability.

The Risk Management Index (RMI)

This index was designed to assess risk management performance. It provides a qualitative measure of management based on predefined targets or benchmarks that risk management efforts should aim to achieve. The design of the Risk Management Index involved establishing a scale of achievement levels (Davis 2003; Masure 2003) or determining the "distance" between current conditions and an objective threshold or conditions in a reference country (Munda 2003; Carreño et al 2007a).

The RMI was constructed by quantifying four public policies, each of which has six indicators. The policies include the identification of risk, risk reduction, disaster management, and governance and financial protection. Risk identification (RI) is a measure of individual perceptions, how those perceptions are understood by society as a whole, and the objective assessment of risk. Risk reduction (RR) involves prevention and mitigation measures. Disaster management (DM) involves measures of response and recovery. And, finally, governance and financial protection (FP) measures the degree of institutionalization and risk transfer. The RMI is defined as the average of the four composite indicators:

$$RMI = (RMI_{RI} + RMI_{RR} + RMI_{DM} + RMI_{FP}) / 4$$

Each indicator was estimated based on five performance levels (*low, incipient, significant, outstanding,* and *optimal*) that correspond to a range from 1 (low) to 5 (optimal).[11] This methodological approach permits the use of each reference level simultaneously as a "performance target" and allows for comparison and identification of results or achievements. Government efforts at formulating, implementing, and evaluating policies should bear these performance targets in mind.

[11] It is also possible to estimate the RMI by means of weighted sums of fixed values (such as 1 through 5, for example), instead of using fuzzy sets and linguistic descriptions. However, that simplification eliminates the nonlinearity of risk management and yields less accurate results.

Risk Identification Indicators

It is important to recognize and understand the collective risk to design prevention and mitigation measures. It depends on the individual and social risk awareness and the methodological approaches to assess it. It then becomes necessary to measure risk and portray it by means of models, maps, and indices capable of providing accurate information for society as a whole and, in particular, for decisionmakers. Methodologically, RMI_{RI} includes the evaluation of hazards, the characteristics of vulnerability in the face of these hazards, and estimates of the potential impacts during a particular period of exposure. The following six indicators measure risk identification RMI_{RI}:

- RI1. Systematic inventory of disasters and losses.
- RI2. Hazard monitoring and forecasting.
- RI3. Hazard evaluation and mapping.
- RI4. Vulnerability and risk assessment.
- RI5. Public information and community participation.
- RI6. Risk management training and education.

Figure 24 shows the RMI_{RI} for each country and period studied, weighted using the AHP.

Indicators of Risk Reduction

The major aim of risk management is to reduce risk. Reducing risk generally requires the implementation of structural and nonstructural prevention and mitigation measures. It implies a process of anticipating potential sources of risk, putting into practice procedures and other

measures to either avoid hazard, when it is possible, or reduce the economic, social and environmental impacts through corrective and prospective interventions of existing and future vulnerability conditions. The following six indicators are used to measure RMI_{RR}:

- RR1. The extent to which risk is taken into account in land use and urban planning.
- RR2. Management of river basins and environmental protection.
- RR3. Implementation of control and protection techniques prior to hazard events.
- RR4. Relocation of persons living in disaster prone areas and improvements to housing in those areas.
- RR5. Updating and enforcement of safety standards and construction codes.
- RR6. Reinforcement and retrofitting of public and private assets.

Figure 25 shows the RMI_{RR} for each country and period studied, weighted using the AHP.

Indicators of Disaster Management

The goal of disaster management (RMI_{DM}) is to provide appropriate response and recovery efforts following a disaster. It is a function of the degree of preparation of the responsible institutions as well as the community as a whole. The goal is to respond efficiently and appropriately when risk has become disaster. Effectiveness implies that the institutions (and other actors) involved have adequate organizational abilities, as well as the capacity and plans in place to address the consequences of disasters. The following six indicators measure the capacity for disaster management RMI_{DM}:

- DM1. Organization and coordination of emergency operations.
- DM2. Emergency response planning and implementation of warning systems.
- DM3. Supply of equipment, tools and infrastructure.
- DM4. Simulation, updating and testing of inter-institutional response capability.
- DM5. Community preparedness and training.
- DM6. Rehabilitation and reconstruction planning.

Figure 26 shows the RMI_{DM} for each country and period studied, weighted using the AHP.

Governance and Financial Protection Indicators

Adequate governance and financial protection are fundamental for sustainability, economic growth and development. They are also basic to risk management, which requires coordination among social actors as well as effective institutional actions and social participation. Governance also depends on an adequate allocation and use of financial resources to manage and implement appropriate retention and transfer strategies for dealing with disaster losses. The following six indicators measure governance and financial protection RMI_{FP}:

- FP1. Decentralized organizational units, inter-institutional and multisector coordination.
- FP2. Availability of resources for institutional strengthening.
- FP3. Budget allocation and mobilization.
- FP4. Existence of social safety nets and funds.
- FP5. Insurance coverage and loss transfer strategies for public assets.
- FP6. Housing and private sector insurance and reinsurance coverage.

The value of each composed element is between 0 and 100, where 0 is the minimum performance level and 100 is the maximum level. Total RMI is the average of the four composed indicators that admit each public policy. When value of RMI is high, performance of risk management in the country is better.

Figure 24. RMI Related to Risk Identification

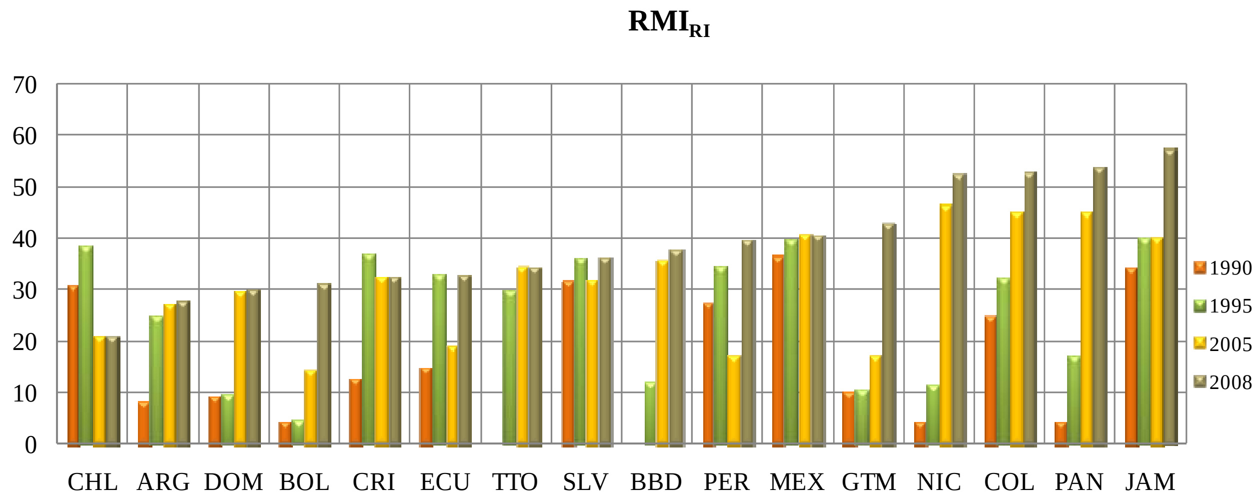


Figure 25. RMI Related to Risk Reduction

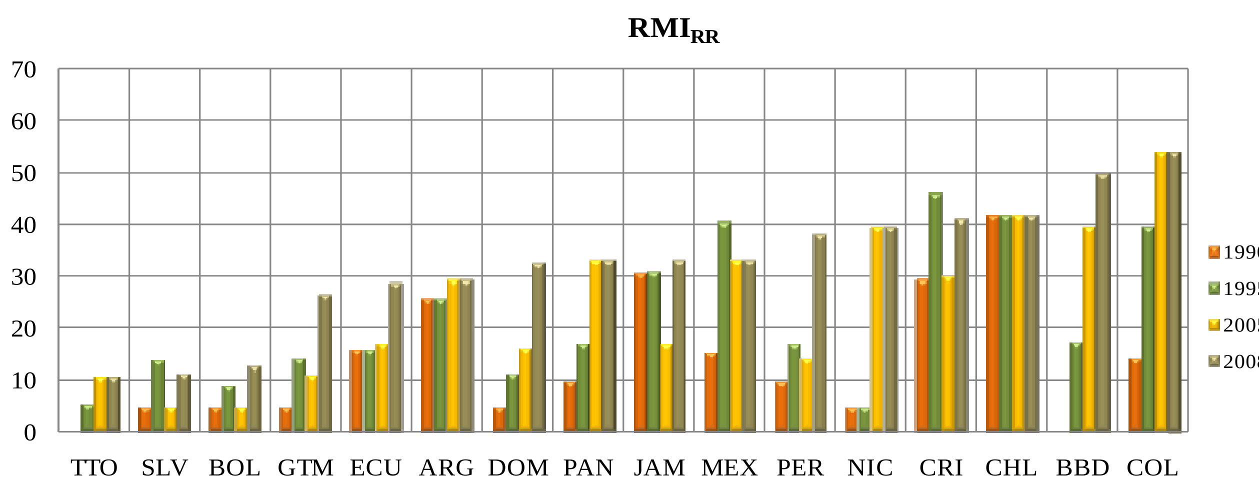


Figure 26. RMI Related to Disaster Management

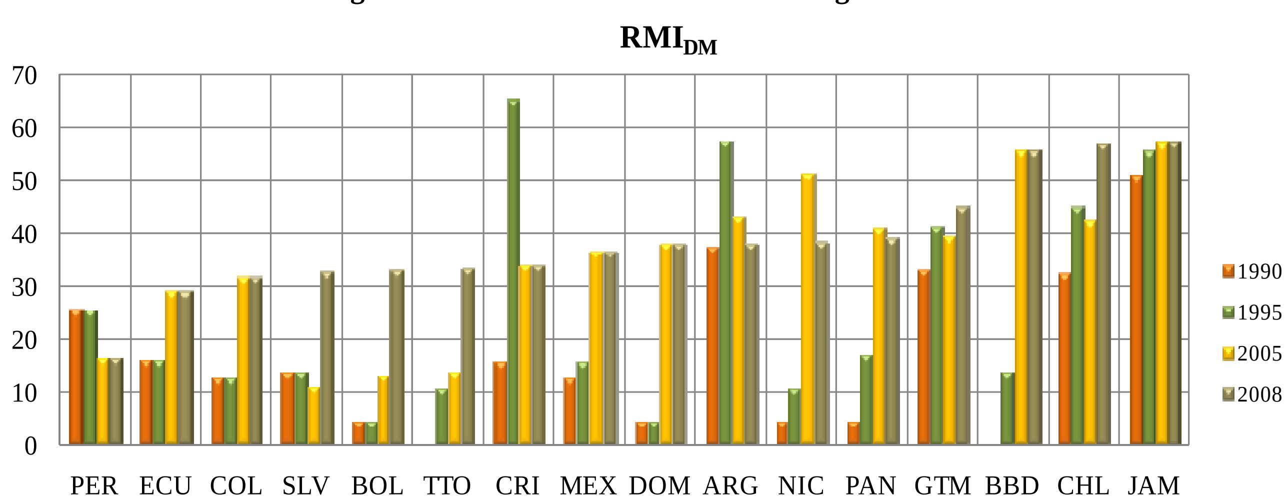


Figure 27. RMI Related to Financial Protection and Governance

RMI_{FP}

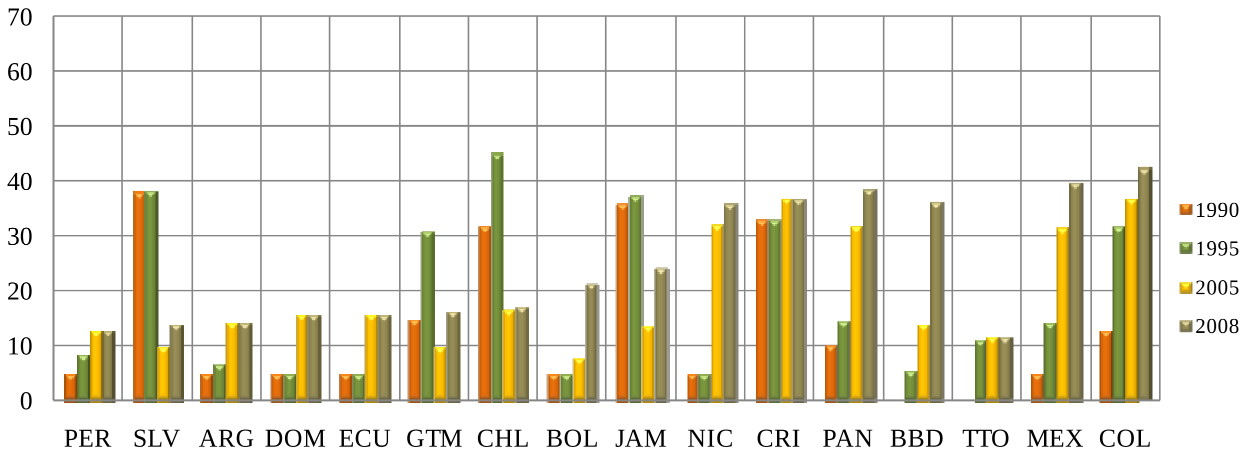


Figure 28 shows the total RMI value, result of the risk management performance estimation of the countries having into account the four public policies. Figure 29 shows RMI values for 2008 obtained by adding the four components related to risk identification, risk reduction, disaster management and financial protection. The highest values correspond to COL and BBD and the lowest values correspond to TTO, SLV, BOL and ECU. It can be observed notable difference between the countries that present a greater risk management performance than those that have not reached relative advances. Nevertheless, even in the case of countries with greater qualifications, risk management is incipient or significant in the best of the cases; therefore, there is still much further to reach an effective disaster risk management in the countries and in the region.

Figure 30 shows the risk management behavior and the form of the membership functions for each performance level and probability of risk management effectiveness according to the method used (Carreño *et al.*, 2004, Cardona *et al.*, 2005). According to the theory that supports the method used here, the probable effectiveness of risk management in the majority of cases does not rise above 60 percent. Most countries generally reach a level of effectiveness of between 20 and 30 percent. This is very low when compared to required effectiveness.[12]

The low level of effectiveness of risk management that may be inferred from the RMI values for this group of countries is confirmed by the high risk levels represented in the DDI, the LDI and the PVI over the years. In part, the high risk levels are due to the lack of effective risk management in the past.

The risk management experts of this new evaluation in most countries (with exception of COL, DOM, ECU) considered that the evaluation made for 2000 was not correct (it was excessive or not very objective), reason why this year has not been included in the figures.

---

[12] For each possible value of the subindicators we defined functions or fuzzy sets, which are shown in the upper graph of figure 30. Risk management performance is defined by this group of functions, which yield the curve shown in the lower graph. This curve represents the degree of effectiveness of risk management according to the level of performance obtained with the different subindicators. The lower graph shows that increasing risk management effectiveness is nonlinear. Progress is slow in the beginning, but once risk management improves and becomes sustainable, performance and effectiveness also improve. Once performance reaches a high level, additional (smaller) efforts increase effectiveness significantly, but small improvements in risk management are negligible and unsustainable and, as a result, they have little or no effectiveness (Carreño 2006).

Figure 28. RMI for Each Country

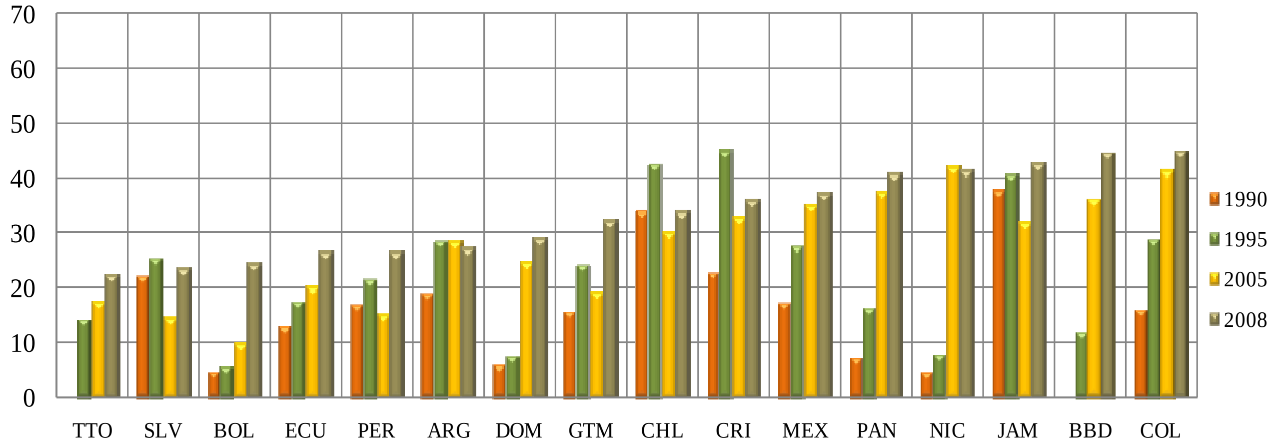


Figure 29. Aggregate RMI for 2008

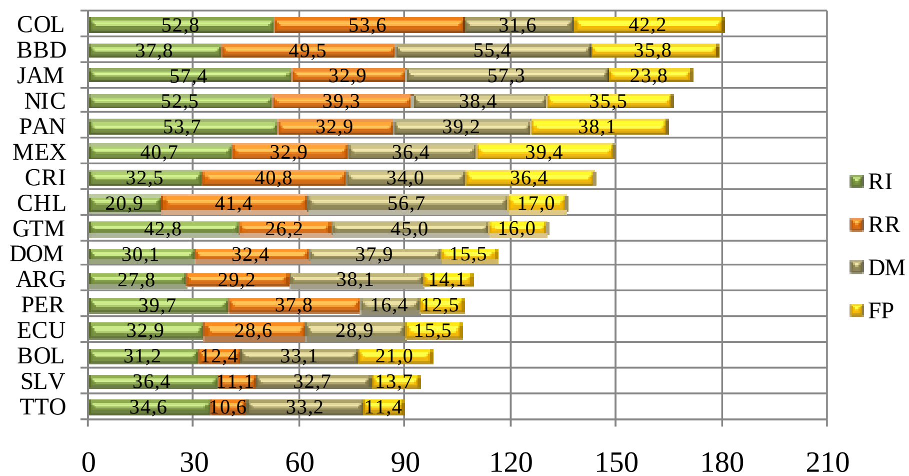
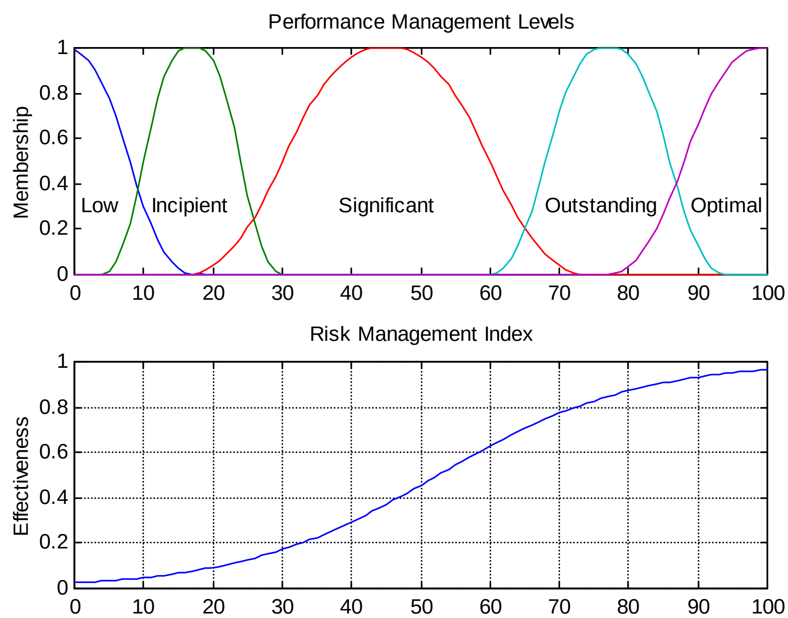


Figure 30. Risk Management Behavior and Probability of Effectiveness



In the previous assessment, only risk management officials established the weights applied and carried out the benchmark for most countries. These RMI evaluations would appear to be overly generous when compared to those undertaken by independent and external experts. Taking into account the evaluation made on the advances of the Hyogo framework and the reviewing of experts and academic institutions, it was considered that the least objective qualifications were those made for 2000 in the previous assessment. The present results of RMI have been obtained from queries made not only to employees of different institutions involved in the risk management but also to independent experts in each country. In this way, this index reflects the performance of the risk management based on evaluations of officials, professionals and academics.

Conclusions

The indicators of risk and risk management presented in this report have permitted an evaluation of a wide group of Latin American and Caribbean countries based on integrated criteria. The results show that it is possible to describe risk and risk management using coarse grain measures and classify countries according to a relative scale.

The Disaster Deficit, Local Disaster and Prevalent Vulnerability indices (DDI, LDI and PVI) are risk proxies that measure different factors that affect overall risk at the national level. By depicting existing risk conditions, the indicators highlight the need for intervention. This study indicates that the countries of the region face significant risks that have yet to be fully recognized or taken into account by individuals, decisionmakers and society as a whole. These indicators are a first step in correctly measuring risk so that it can be given the priority that it deserves in the development process. Once risk has been identified and measured, activities can then be implemented to reduce and control it. The first step in addressing risk is to recognize it as a significant socioeconomic and environmental problem.

The results obtained for the period 1990 to 2008, using an ordinal ranking scale, are as follows: Honduras, Barbados, Dominican Republic, Nicaragua and El Salvador are most prone to future extreme disaster risk based on evaluations for the year 2008. These countries are likely to suffer significant losses and lack the economic resilience to address them adequately. Panama, Guatemala Peru and Jamaica also face relatively high risk, particularly in the case of low probability, high consequence events (100 and 500 years of return period). Colombia, Bolivia, Ecuador are in the mid-range of countries. They may suffer high losses but its economic resilience is relatively high. Chile, Mexico, Argentina, Trinidad and Tobago and Costa Rica have minor relative risk profiles for extreme events, but this does not mean that risk is low. Large-scale losses are expected in some of these countries.

Local data for the period 2001-2005 indicate that Costa Rica, Panama, El Salvador and Peru face relatively high risk in the event of recurrent and highly spatially dispersed, small-scale events. Mexico and Ecuador are in the mid-range of countries, with a greater variability. And Bolivia presents a lower relative incidence of smaller scale dispersed events.

There is no clear regional tendency of the risk associated with smaller scale events. The effects in terms of deaths, affected population, and destruction of housing and crops do not follow an easily identified pattern. However, the low level of awareness of events that have cumulative national and local impacts is worrisome.

In 2007, Nicaragua, Jamaica, Guatemala, El Salvador, Honduras, Dominican Republic, Trinidad and Tobago and Belize had the highest prevalent vulnerability indices. The other countries had an intermediate PVI. Prevalent vulnerability has dropped over the last years. However, vulnerability is still very high in the vast majority of countries.

The Risk Management Index was the first systematic and consistent international technique developed to measure risk management performance. The conceptual and technical bases of this index are robust, despite the fact that it is inherently subjective. Although the method may be refined or simplified in the future, its approach is quite innovative because it allows the measurement of risk management and its probable effectiveness. The analysis shows that Trinidad and Tobago, El Salvador, Bolivia, Ecuador, Peru, Argentina and Dominican

Republic have made the least progress over the last few years. Guatemala posted a slightly better performance. Chile, Costa Rica and Mexico showed even more improvement, while Panama, Nicaragua, Barbados and Colombia posted the most significant advances in risk management practice. The overall tendency since the 1990s has been one of increased concern for risk management. As a result, the evaluation of advances made has improved from “low” to “significant” in the majority of cases. On average, risk management performance is something better than “incipient,” and (probable) effectiveness is still very low (0.2 - 0.3). This suggests that considerable efforts are required to promote effective and sustainable risk management, even in the more advanced countries. In general the greatest advances have been made in risk identification and disaster management. Risk reduction, financial protection and institutional organization have as yet been approached very timidly.

Taking into account relative positions in the ranking of indicators, Nicaragua, Dominican Republic, El Salvador and Honduras face the greatest risk and some of them, El Salvador and Dominican Republic have achieved the lowest levels of development in risk management. Guatemala and Jamaica are high vulnerable countries and Panama, Peru, Colombia, Bolivia and Ecuador are countries in an intermediate position. In Nicaragua and Jamaica, risk is high but risk management performance is good. In Argentina and Trinidad and Tobago, while risk is low, so is risk management performance. Costa Rica, Chile and Mexico exhibit relatively low risk levels and acceptable risk management performance.

The product of the effort of this project has been the construction of a comprehensive profile of disaster risk indicators for the Latin America and the Caribbean countries. This profile is the first step for the creation of a “common operative image” of disaster risk reduction in the region. That is, a common knowledge base to which can be accessed, that can be viewed, understandable by the different decision-makers responsible of risk reduction in the region. Any group that is not included or that fail in the understanding the level and frequency of risk, probably, would lose its active compromise in the risk reduction process. Thus, construction of an effective common knowledge base for the decision-makers system responsible of disaster risk reduction is fundamental for achieving changes in the practice.

Results of the exercise of indicators evaluation give a particular idea of the situation and the level of efficacy and efficiency of the countries analyzed, with all the advertencies that can be made about the accuracy of the data. In these reports, when it comes to convince decisionmakers of the virtues of the system of indicators, not only of the method and the veracity of the results in a comparative or individual base but also the pertinence of the results in terms of opening or “inviting” to political and actions changes that drive to risk reduction, understanding risk us a development problem.

Bibliography

Albala-Bertrand, J.M. 1993. Natural Disaster Situations and Growth: A Macroeconomic Model for Sudden Disasters Impacts. *World Development* 21(9): 1417-1434. London

_______. 2002. Urban Disasters and Globalization. *The Future of Disaster Risk: Building Safer Cities.* Conference organized by the ProVention Consortium, DMF, and the World Bank. Available at http://www.proventionconsortium.org/conferences/washington_agenda.htm

Arundel A. and C. Bordoy. 2002. Methodological evaluation of DG Research's composite indicators for the knowledge based economy. Paper presented by DG RTD at the consultation meeting of Interservice on structural indicators, July 11, 2002. London.

ASTM. 1999. Standard Guide for the Estimation of Building Damageability in Earthquakes, E 2026-99. West Conshohocken, Pennsylvania.

Barbat, A. 2003a. *Vulnerability and Disaster Risk Indices from Engineering Perspective and Holistic Approach to Consider Hard and Soft Variables at Urban Level*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

_______. 2003b. *Detailed Application of the Holistic Approach for Seismic Risk Evaluation on an Urban Center Using Relative Indices.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Barbat, A.H, and M.L. Carreño. 2004a. *Indicadores de Riesgo y Gestión a Nivel Subnacional: Aplicación Demostrativa en los Departamentos de Colombia*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

_______. 2004b. *Análisis de Riesgo Urbano Utilizando Indicadores: Aplicación Demostrativa para la Ciudad de Bogotá, Colombia*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

Benson, C. 2003a. *The Economy-wide Impact of Natural Disasters in Developing Countries*. London: University of London.

_________ 2003b. *Potential Approaches to the Development of Indicators for Measuring Risk from a Macroeconomic Perspective*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

_______ __ 2004. Macroeconomic Concepts of Vulnerability: Dynamics, Complexity and Public Policy. In *Mapping Vulnerability: Disasters, Development and People*, eds. G. Bankoff, G. Frerks and D. Hilhorst. London: Earthscan Publishers.

Birkmann, J. (ed.) (2006) *Measuring vulnerability to hazards of natural origin. Towards disaster resilient societies*. United Nations University Press, Tokyo, New York (480 p.)

Briguglio, L. 2003a. *Some Considerations with Regard to the Construction of an Index of Disaster Risk with Special Reference to Islands and Small States*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

__________. 2003b. *Methodological and Practical Considerations for Constructing Socioeconomic Indicators to Evaluate Disaster Risk*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

Briguglio, L., G. Cordina, S. Bugeja and N. Farrugia. 2005. *The Development of an Index on Economic Resilience*. International Workshop on Building the Economic Resilience of Small Status, organised by the Commonwealth Secretariat and Department of Economics of University of Malta, Valleta.

Cannon, T. 2003. *Vulnerability Analysis, Livelihoods and Disasters Components and variables of vulnerability: modelling and analysis for disaster risk management*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

Cardona, O.D. 2001. *Estimación Holística del Riesgo Sísmico Utilizando Sistemas Dinámicos Complejos.* Polytechnical University of Catalonia, Barcelona.
Available at http://www.desenredando.org/public/varios/2001/ehrisusd/index.html

___________. 2004. The Need for Rethinking the Concepts of Vulnerability and Risk from a Holistic Perspective: A Necessary Review and Criticism for Effective Risk Management. In *Mapping Vulnerability: Disasters, Development and People*, eds. G. Bankoff, G. Frerks and D. Hilhorst. London: Earthscan Publishers.

___________. 2006. A System of Indicators for Disaster Risk Management in the Americas en *Measuring Vulnerability to Hazards of Natural Origin: Towards Disaster Resilient Societies*, J. Birkmann (Ed.), United Nations University Press, Tokyo.

___________. 2007. Disaster Risk and Vulnerability: Notions and Metrics of Environmental Insecurity for a Decision Science" in *Coping with Global Environmental Change, Disasters and Security Threats, Challenges, Vulnerabilities and Risks*, Editors: H.G. Brauch, U. Oswald Spring, P. Kameri-Mbote, C. Mesjasz, J. Grin, B. Chourou, J. Birkmann: Springer- Verlag (en impresión), Holanda.

____________. 2008. *Indicators of Disaster Risk and Risk Management- Program fro Latin America and the Caribbean: Summary Report – Second Edition. Updated 2007,* Inter-American Development Bank, Infrastructure and Environment Sector, Washington. Available at http://idea.unalmzl.edu.co

___________. (2010). "Disaster Risk and Vulnerability: Notions and Measurement of Human and Environmental Insecurity" in *Coping with Global Environmental Change, Disasters and Security - Threats, Challenges, Vulnerabilities and Risks*, Editors: H.G. Brauch, U. Oswald Spring, C. Mesjasz, J. Grin, P. Kameri-Mbote, B. Chourou, P. Dunay, J. Birkmann: Hexagon Series on Human and Environmental Security and Peace, vol. 5 (Berlin – Heidelberg – New York: Springer-Verlag).

Cardona, O. D. and A.H. Barbat. 2000. *El Riesgo Sísmico y su Prevención*. Cuaderno Técnico 5, Calidad Siderúrgica. Madrid.

Cardona, O.D., Hurtado, J.H., Duque, G., Moreno, A., Chardon, A. C., Velásquez L.S. and Prieto, S.D. 2003a. *La Noción de Riesgo desde la Perspectiva de los Desastres: Marco Conceptual para su Gestión Integral.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

____________. 2003b. *Indicadores para la Medición del Riesgo: Fundamentos para un Enfoque Metodológico.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

____________. 2004a. *Dimensionamiento Relativo del Riesgo y de la Gestión: Metodología Utilizando Indicadores a Nivel Nacional.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

____________. 2004b. *Resultados de la Aplicación del Sistema de Indicadores en Doce Países de las Américas.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

____________. 2005. *Sistema de indicadores para la gestión del riesgo de desastre: Informe técnico principal.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Cardona, O.D., Ordaz, M.G., Marulanda, M.C., & Barbat, A.H. (2008). Estimation of Probabilistic Seismic Losses and the Public Economic Resilience—An Approach for a Macroeconomic Impact Evaluation, *Journal of Earthquake Engineering*, 12 (S2) 60-70, ISSN: 1363-2469 print / 1559-808X online, DOI: 10.1080/13632460802013511, Taylor & Francis, Philadelphia, PA.

Cardona, O.D. Ordaz, M.G., Moreno, A.M., & Santa-Cruz, S. 2006. A method to evaluate the macroeconomic disaster deficit, *Proceedings of First European Conference on Earthquake Engineering and Seismology*, European Association of Earthquake Engineering EAEE, Geneva.

Carreño-Tibaduiza, M.L 2001. *Sistema Experto para la Evaluación del Daño Postsísmico en Edificios*. Magister Thesis, Civil and Environmental Engineering Department, University of Los Andes, Bogotá.

____________. 2006. *Técnicas innovadoras para la evaluación del riesgo sísmico y su gestión en centros urbanos: Acciones ex ante y ex post.* Doctoral Thesis, Technical University of Catalonia, Barcelona.

Carreño, M.L, Cardona, O.D., Barbat, A.H. (2004). *Metodología para la evaluación del desempeño de la gestión del riesgo*, Monografía CIMNE IS-51, Universidad Politécnica de Cataluña, Barcelona.

____________. (2005). *Sistema de indicadores para la evaluación de riesgos*, Monografía CIMNE IS-52, Universidad Politécnica de Cataluña, Barcelona.

____________. (2007a). A disaster risk management performance index, *Journal of Natural Hazards*, February 2007, DOI 10.1007/s11069-006-9008-y, 0921-030X (Print) 1573-0840 (Online), Vol. 41 N. 1, April, 1-20, Springer Netherlands.

____________. (2007b). Urban seismic risk evaluation: A holistic approach, *Journal of Natural Hazards*, 40, 137-172. DOI 10.1007/s11069-006-0008-8. ISSN 0921-030X (Print) 1573-0840 (Online), Springer Netherlands

____________. (2008). Application and robustness of the holistic approach for the seismic risk evaluation of megacities, *Innovation Practice Safety: Proceedings 14th World Conference on Earthquake Engineering, Beijing*, China.

Carreño, M.L., Cardona, O.D., Marulanda M.C., & Barbat, A.H. (2009). "Holistic urban seismic risk evaluation of megacities: Application and robustness" en *The 1755 Lisbon Earthquake: Revisited*. Series: Geotechnical, geological and Earthquake Engineering, Vol 7, Mendes-Victor, L.A.; Sousa Oliveira, C.S.; Azevedo, J.; Ribeiro, A. (Eds.), Springer.

Cherchye L. and T. Kuosmanen. 2002. *Benchmarking Sustainable Development: A Synthetic Meta-Index Approach.* Catholic University of Leuven, Campus Kortrijk and Center for Economics Studies, Belgium. The Netherlands: Wageningen University, Department of Social Sciences.

Cherchye L., W. Moesen and T.V. Puyenbroeck. 2003. *Legitimately Diverse, yet Comparable: On Synthesising Social Inclusion Performance in the EU.* Catholic University of Leuven, Campus Kortrijk and Center for Economics Studies, Belgium.

Clarke, C. and K. Keipi. 2000. *Indicators Program for Disaster Risk Management*. Technical Cooperation Profile. Washington, D.C.: Inter-American Development Bank.

Comfort, L. 2003. *Measuring Vulnerability to Hazards: Concepts, Methods, and Practice,* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Davidson, R. 1997. *An Urban Earthquake Disaster Risk Index*. The John A. Blume Earthquake Engineering Center, Department of Civil Engineering, Stanford University, Report No. 121, Stanford.

Davis, I. 2003. *The Effectiveness of Current Tools for the Identification, Measurement, Analysis and Synthesis of Vulnerability and Disaster Resilience*. Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

ECLAC 2003. *Handbook for estimating the socio-economic and environmental effects of disasters.* Economic Commission for Latin America and the Caribbean and World Bank. Four volumes.

Ermoliev, Y. M., T. Ermolieva, G. MacDonald and V. Norkin. 2000. Catastrophic Risk Management and Economic Growth. IIASA. Schlossplatz, Laxenburg, Austria. Interim Report IR-00-058.

Freeman, P.K., L.A. Martin, R. Mechler, and K. Warner. 2002a. Catastrophes and Development: Integrating Natural Catastrophes into Development Planning. *Disaster Risk Management Working Paper Series No.* 4. Washington: World Bank.

Freeman, P.K., L.A. Martin, J. Linneroot-Bayer, R. Mechler, G. Pflug and K. Warner. 2002b. *Disaster Risk Management: National Systems for the Comprehensive Management of Disaster Financial Strategies for Natural Disaster Reconstruction.* SDD/IRPD. Regional Policy Dialogue. Washington, D.C.: Inter-American Development Bank.

Funtowicz, S., and J. Ravetz. 1992. The Role of Science in Risk Assessment. In *Social Theories of Risk*, ed. S. Krimsky and D. Golding. Westport: Praeger.

Hofman, A. 2000. Standardised capital stock estimates in Latin America: a 1950-94 update. *Cambridge Journal of Economics*, 24. Boston.

Holzmann, R. 2001. *Risk and Vulnerability: The Forward Looking Role of Social Protection in a Globalizing World.* Social Protection, Working Paper No. 0109. Washington, D.C.: World Bank.

IDEA – Instituto de Estudios Ambientales (2005). *Indicadores de Riesgo de Desastre y de Gestión de Riesgos: Informe Técnico Principal,* edición en español e inglés, ISBN: 978-958-44-0220-2, Universidad Nacional de Colombia, Manizales. Disponible en: http://idea.unalmzl.edu.co

JRC-EC 2002. *State-of-the-art Report on Current Methodologies and Practices for Composite Indicator Development.* Applied Statistics Group, Joint Research Centre, European Commission, Institute for Protection and Security of the Citizen Technological and Economic Risk Management, Ispra, Italy.

_______. 2003. *First Workshop on Composite Indicators of Country Performance.* Applied Statistics Group, Joint Research Centre, European Commission, Institute for Protection and Security of the Citizen Technological and Economic Risk Management, Ispra, Italy.

Karlsson, J. 1998. *A systematic approach for prioritizing software requirements*. Disertación de Ph.D. No. 526. Sweden: Linkoping.

Kosko, B. 1992. *Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence*. New Jersey: Prentice Hall.

La RED. 2002. *Análisis comparativo de bases de datos de desastres.* Working Group 3 of Inter-Agency Tasks Force of ISDR on Risk, Vulnerability and Impact Assessment. Geneva.

Lavell, A. 2003a. *I. International Agency Concepts and Guidelines for Disaster Risk Management; II. The Transition from Risk Concepts to Risk Indicators*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

________. 2003b. *Approaches to the construction of risk indicators at different spatial or territorial scales and the major components of indicator systems- conceptual bases, risk construction processes and practical implications.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
Available at http://idea.unalmzl.edu.co

Marulanda, M.C. and O.D. Cardona 2006. *Análisis del impacto de desastres menores y moderados a nivel local en Colombia.* ProVention Consortium, La RED.
Available at: http://www.desinventar.org/sp/proyectos/articulos/

Marulanda, M.C., Cardona, O.D. & A. H. Barbat, (2008). "The Economic and Social Effects of Small Disasters: Revision of the Local Disaster Index and the Case Study of Colombia", in Megacities: Resilience and Social Vulnerability, Bohle, H.G., Warner, K. (Eds.) , SOURCE No. 10, United Nations University (EHS), Munich Re Foundation, Bonn.

____________. (2009a). "Revealing the Impact of Small Disasters to the Economic and Social Development", in *Coping with Global Environmental Change, Disasters and Security - Threats, Challenges, Vulnerabilities and Risks*, Editors: H.G. Brauch, U. Oswald Spring, C. Mesjasz, J. Grin, P. Kameri-Mbote, B. Chourou, P. Dunay, J. Birkmann: Springer-Verlag (in press), Berlin - New York.

____________. (2009b). Robustness of the holistic seismic risk evaluation in urban centers using the USRi, *Journal of Natural Hazards*, DOI 10.1007/s 11069-008-9301-z, Vol 49 (3) (Junio):501-516, Springer Science+ Business.

Masure, P. 2003. *Variables and indicators of vulnerability and disaster risk for land-use and urban or territorial planning*. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Munda, G. 2000. Multicriteria Methods and Process for Integrated Environmental Assessment. En *Métodos Numéricos en Ciencias Sociales (MENCIS 2000)*, eds. E. Oñate *et al*. Barcelona: CIMNE-UPC.

__________. 2003. *Methodological Exploration for the Formulation of a Socio-Economic Indicators Model to Evaluate Disaster Risk Management at the National and Sub-National Levels. A Social Multi-Criterion Model.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Munda, G., and M. Nardo. 2003. *On the Methodological Foundations of Composite Indicators Used for Ranking Countries.* Universitat Autonoma de Barcelona, Dept. of Economics and Economic History. Barcelona, Spain.

OCDE. 2003. *Composite Indicators of Country Performance: A Critical Assessment*, DST/IND (2003)5. Paris.

Ordaz, M. 2002. Estado actual y futuro de la normatividad. *Memorias,* VII Seminario Nacional de Ingeniería Sísmica, Cuernavaca.

Ordaz, M., and S. Santa-Cruz. 2003. *Computation of physical damage to property due to natural hazard events* . IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Ordaz, M.G., and L.E. Yamín. 2004. *Eventos máximos considerados (EMC) y estimación de pérdidas probables para el cálculo del índice de déficit por desastre (IDD) en doce países de las Américas.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Saaty, T. L. 1987. The analytic hierarchy process: what it is and how it is used. *Mathematical Modelling*, 9, 161-176.

_________. 1980. *The Analytic Hierarchy Proces*s. New York: McGraw-Hill Book Co.

UN - United Nations. 2009. Global Assessment Report on Disaster Risk Reduction (GAR). International Strategy for Disaster Reduction, Geneva.

Velásquez, C.A. 2009. *Reformulación del modelo del Índice de Déficit por Desastre*. Programa de Indicadores de Riesgo de Desastre y Gestión de Riesgos BID-IDEA-ERN. Universidad Nacional de Colombia, sede Manizales. Disponible en: http://idea.unalmzl.edu.co

Wisner, B. 2003. *Turning knowledge into timely and appropriate action: Reflections on IDB/IDEA program of disaster risk indicators.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. Available at http://idea.unalmzl.edu.co

Wisner, B., P. Blaikie, T. Cannon and I. Davis. 2003. *At Risk: Natural Hazards, People´s Vulnerability and Disasters*. London: Routledge.

World Bank, 2007. World Development Indicators 2007. Washington, D.C.: World Bank.