# INDICATORS OF DISASTER RISK AND RISK MANAGEMENT

Summary Report


Inter-American Development Bank
Sustainable Development Department
Environment Division

Photo Credits: The Earth (EERI). Galeras volcano; illegal construction in urban area; slope stabilization in Manizales, Colombia; seismic resistant retrofitting; classroom education; (O. D. Cardona).

# INDICATORS OF DISASTER RISK AND RISK MANAGEMENT

PROGRAM FOR LATIN AMERICA AND THE CARIBBEAN

SUMMARY REPORT

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This report presents an updated summary of the results of a project on disaster risk management indicators financed by the IDB and coordinated by Omar D. Cardona of the Instituto de Estudios Ambientales (IDEA), Universidad Nacional de Colombia (Manizales). Participating in the study were: Jorge E. Hurtado, Ann Catherine Chardon, Alvaro M. Moreno, Samuel D. Prieto, Luz Stella Velásquez, and Gonzalo Duque. Also involved in the study were the disaster risk management centers from the Universidad Nacional Autónoma de Mexico (UNAM) and Universidad de Los Andes (CEDERI), Colombia, under the direction of Mario G. Ordaz and Luis E. Yamín, respectively. The author is grateful for the technical research assistance provided by Mabel C. Marulanda, Dora C. Suarez, Lina M. López, Juan P. Londoño, Gabriel J. Cardona, Martha L. Carreño, César A. Velásquez, Jairo A. Valcarcel, Manuel B. Puerto, Antonio Zeballos, Sandra Santa-Cruz, Sina del Rosario Cabral, and Fernando Ramírez.

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# Foreword

Hurricanes, earthquakes, landslides and floods have caused US$ 3.2 billion in physical losses annually in Latin America and the Caribbean during the past thirty years. On a yearly basis, disasters in the region claim more than 5,000 lives and affect 4 million people. Over this period, these losses have been trending upward as a result of development processes that lead the environmental destruction in vulnerable sites and rapid growth in hazard-prone areas. Disasters (including the small-scale disasters that go unnoticed by the outside world) damage rural and urban livelihoods, as well as social and productive capital, having a proportionately greater impact on small farmers and micro-entrepreneurs. Increased poverty has often resulted. In many cases, disasters have a longer term impact on the development prospects of countries and reduce the effectiveness of the Bank's development assistance to the region.

A growing body of evidence and experience shows that there are considerable economic and social gains to be made by adopting a proactive approach to risk reduction. Measures to reduce vulnerability to natural hazards can be integrated into development programs and post-disaster reconstruction. However, in order to integrate disaster risk reduction into development policies and practices, risk must be documented with quantifiable and timely information in a manner that is easily understood by decision-makers who are not disaster experts.

The original 2005 paper on Indicators of Disaster Risk and Risk Management described the application of a system of four indicators in 12 countries. They measure the potential impact of natural hazards, the key element of those countries' vulnerability, and their capacity to manage risks. The development of the system relied on data from Argentina, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Peru, and Trinidad and Tobago. This report updated adds to the existing database of countries by including Bolivia and Nicaragua. The indicators for these 14 countries can help steer financial, economic, environmental and social policies and programs at the national level, and can also be adapted to regions and municipalities.

The indicators are designed to generate knowledge and awareness within the IDB and among borrowing governments 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 and portfolio management exercises. We also expect that this tool will be of use to government officials in sector ministries as well as local governments, and international development agencies.

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# Contents

# Overview

Disaster risk management requires measuring risk to take into account not only the expected physical damage, victims and economic equivalent loss, but also social, organizational and institutional factors. The difficulty in achieving effective disaster risk management has been, in part, the result of the lack of a comprehensive conceptual framework of disaster risk to facilitate a multidisciplinary evaluation and intervention. Most existing indices and evaluation techniques do not adequately express risk and are not based on a holistic approach that invites intervention.

The various planning agencies dealing with the economy, the environment, housing, infrastructure, agriculture, or health, to mention but a few relevant areas, must be made aware of the risks that each sector faces. In addition, the concerns of different levels of government should be addressed in a meaningful way. For example, risk is very different at the local level (a community or small town) than it is at the national level. If risk is not presented and explained in a way that attracts stakeholders' attention, it will not be possible to make progress in reducing the impact of disasters.

Risk is most detailed at a micro-social or territorial scale. As we aggregate and work at more macro scales, details are lost. However, decision-making and information needs at each level are quite different, as are the social actors and stakeholders. This means that appropriate evaluation tools are necessary to make it easy to understand the problem and guide the decision-making process. It is fundamentally important to understand how vulnerability is generated, how it increases and how it builds up. Performance benchmarks are also needed to facilitate decisionmakers' access to relevant information as well as the identification and proposal of effective policies and actions. The Disaster Risk Management Indicators Program meets this need. The system of indicators proposed in this paper permits a systematic and quantitative benchmarking of each country during different periods between 1980 and 2000, as well as comparisons across countries. It also provides a more analytically rigorous and data driven approach to risk management decision-making. This system of indicators enables the depiction of disaster risk at the national level,[1] allowing the identification of key issues by economic and social category. It also makes possible the creation of national risk management performance benchmarks in order to establish performance targets for improving management effectiveness.

The system describes a series of risk factors that should be reduced through public policies and actions to reduce vulnerability and maximize the resilience and coping capacity of the population. The risk factors are generally represented by indicators available in international databases. Lack of data in some cases makes it necessary to also propose more subjective qualitative indicators. In the case of risk management indicators, some indices are weighted using national experts to provide opinions and information. Each index was derived on the basis of current theory and statistical techniques, and has a number of empirical variables associated with it. The choice of variables was driven by a number of factors, including: country coverage, the soundness of the data, direct relevance to the phenomenon that the indicators are intended to measure, and quality. Direct measures were used wherever possible, although proxies had to be used in some cases. In general, the variables used are those that have extensive country coverage; however, in some cases more narrow variables are used if they measure critical aspects of risk that would otherwise be overlooked.

[1] To illustrate the concept, this report also details the use of the methodology at the subnational and urban level.

# 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). 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 indicators 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).[2]

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).

[2] 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),[3] and the public sector's economic resilience (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[4] 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.

**Resources Potentially Available to the Government**

Economic resilience (the denominator of the index) represents internal and external re-

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

[4] 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.

sources that were available 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 left side of figure 1 shows the DDI in 2000 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.

With the exception of Costa Rica (CRI) all countries have a DDI greater than 1.0. Bolivia (BOL), with a DDI of 5.7, is in the most critical situation and could face a loss of US$2.84 billion.

**Figure 1. DDI and Probable Maximum Loss in 500 Years**

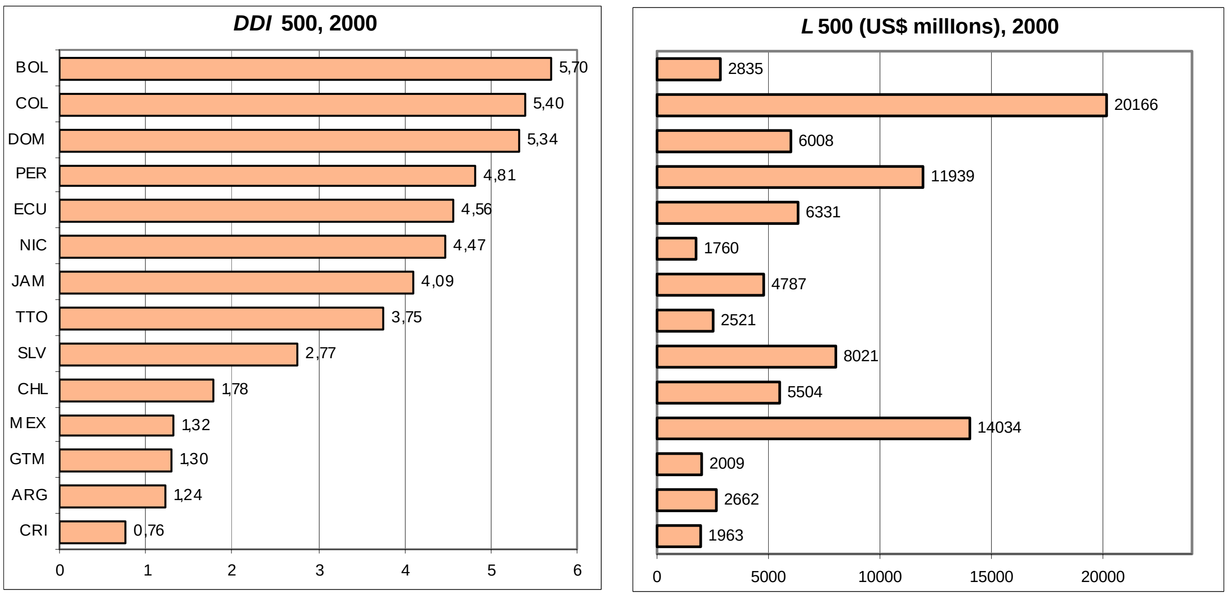
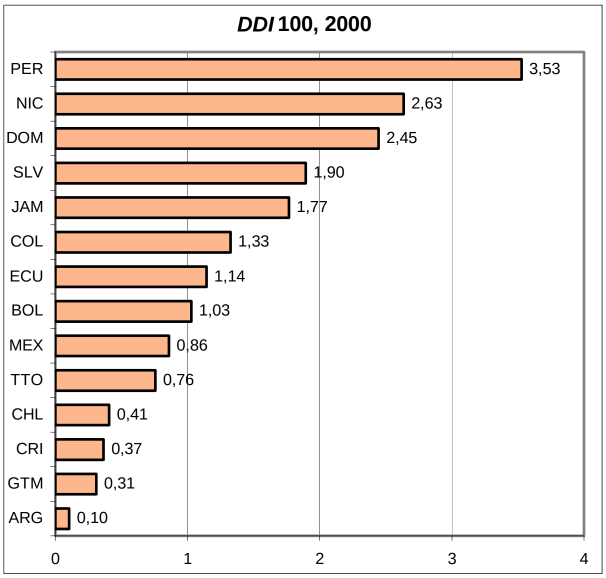


Figure 2 shows the Disaster Deficit Index and potential losses when faced with an event with 100 years of return period (5 percent probability of occurrence in ten years). In this case, access to reconstruction resources is critical for eight of the fourteen countries studied. The DDI for the other six countries is below 1.0. However, the impact for Mexico (MEX) could be very high even though its index is less than one.

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). In four of the countries studied, the macroeconomic impact would be considerable if this high probability event should occur. The potential losses are particularly high even though some countries have a greater economic resilience.

**Figure 2. DDI and Probable Maximum Loss in 100 Years**



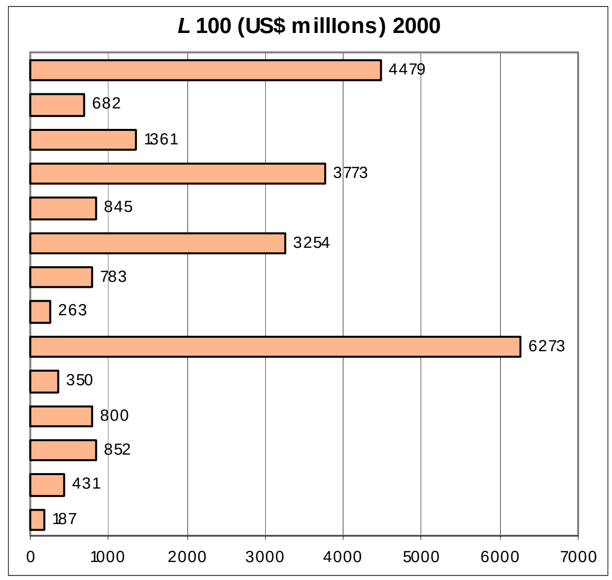
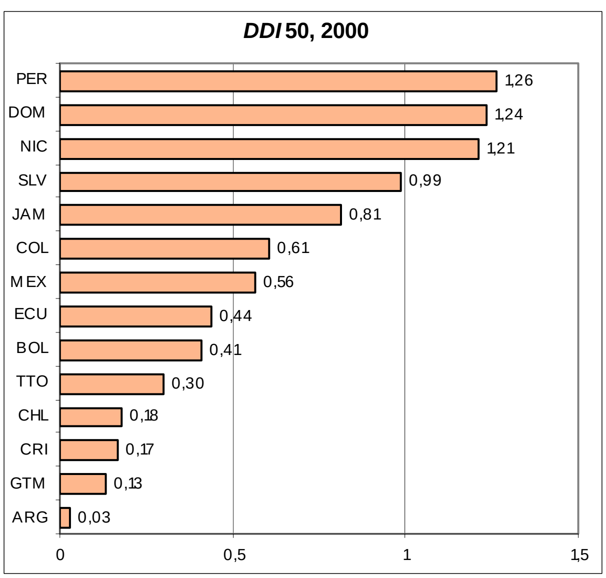
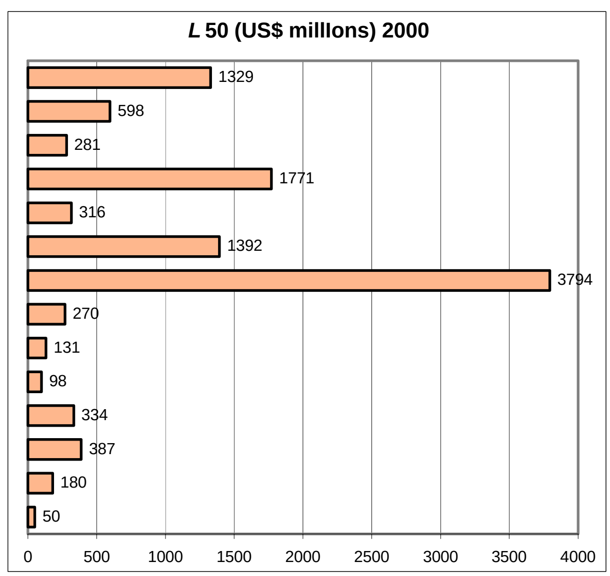




**Figure 3. DDI and Probable Maximum Loss in 50 Years**

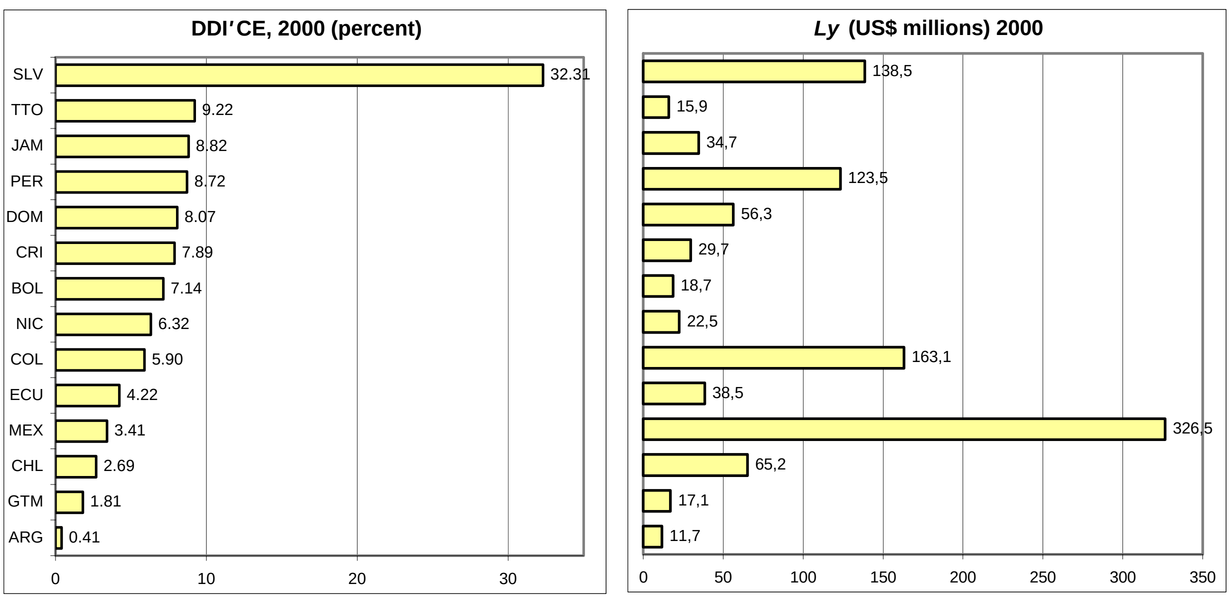


To help place the Disaster Deficit Index in context, we've developed a complementary indicator, DDI**'**, to illustrate the portion of a country's annual Capital Expenditure (CE) that corresponds to the expected annual loss or the pure risk premium. That is, DDI' shows the percentage of the annual investment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

El Salvador (SLV) shows the highest DDI' relative to capital expenditures. The annual cost of future disasters represents 32 percent of capital investment. Trinidad and Tobago (TTO) follows in importance with 9.2 percent. Only four countries have values below 5 percent of the 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 4. DDI' and Annual Probable Loss**



# 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[5] 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, number of people affected and losses 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.

Figure 5 shows the total LDI in 2000, which was obtained by adding its three components: the LDI related to the number of deaths (K), the number of people affected (A), and total losses (L).

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

**Figure 5. Total LDI**

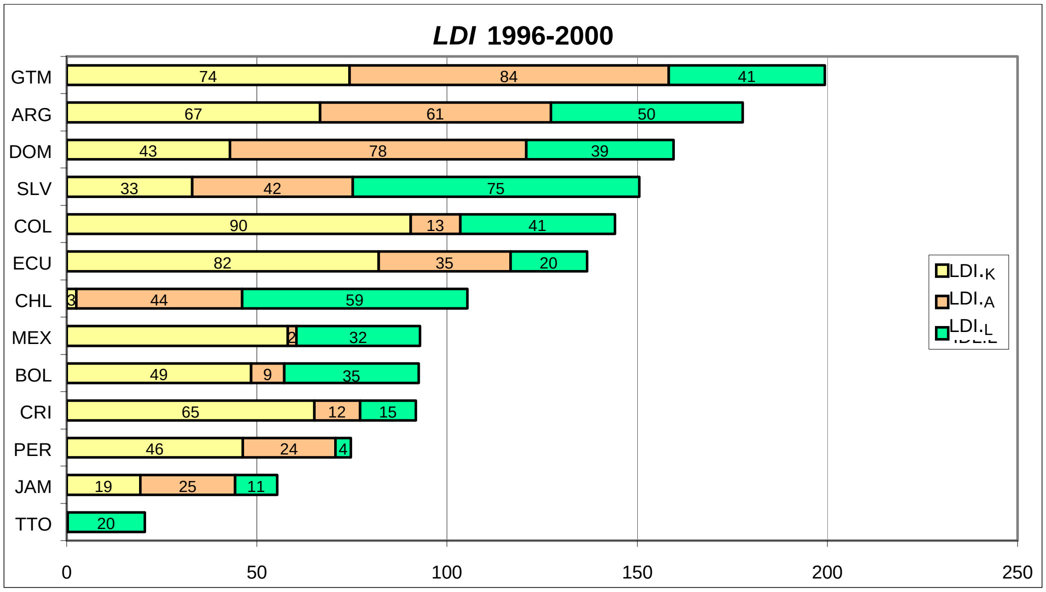
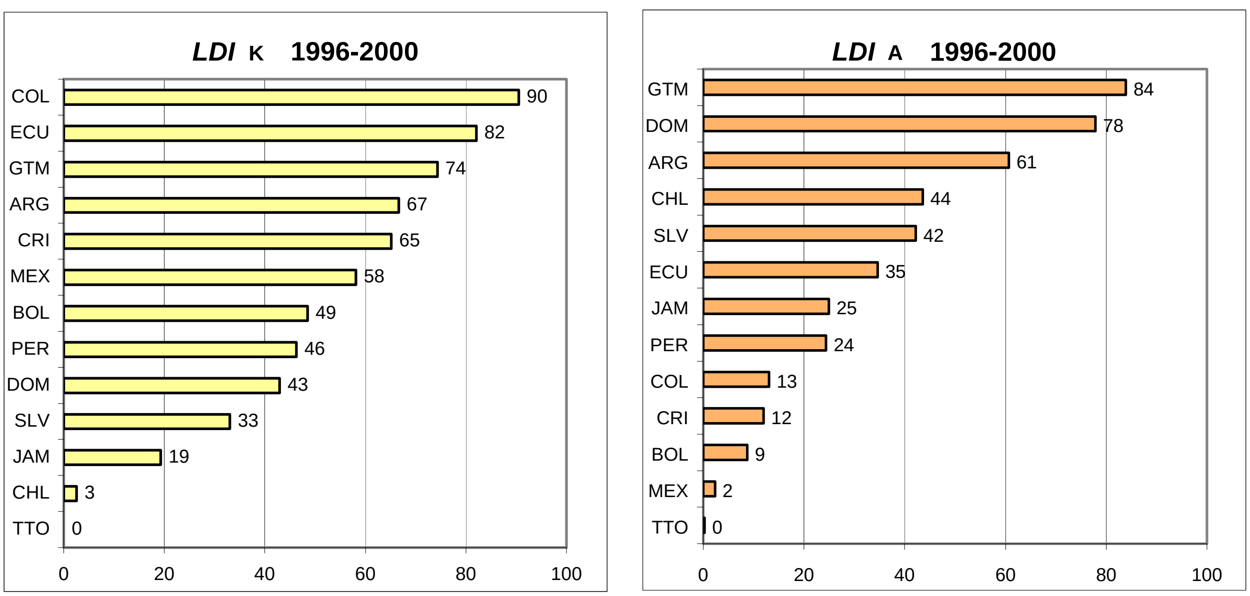



**Figure 6. $LDI_K$ and $LDI_A$**




The left side of figure 6 shows the LDI for 1996 - 2000 based on number of deaths, $LDI_K$. The right side of the figure shows the indicator for the number of persons affected, $LDI_A$. The data for Colombia and Ecuador (ECU) show that, during this period, there was a greater incidence and persistence in the distribution of deaths among municipalities. However, data for Guatemala (GTM) and the Dominican Republic (DOM) show a greater incidence and persistence in the distribution of the number of people affected. Disasters between 1996 and 2000 generated numerous landslides and floods in many municipalities in these four countries. Colombia was affected by an earthquake in coffee growing areas in 1999, and by extensive flooding in the north in 1995 and 2000. Guatemala suffered the consequences of hurricane

Mitch, while the Dominican Republic was buffeted by hurricane Georges in 1998.

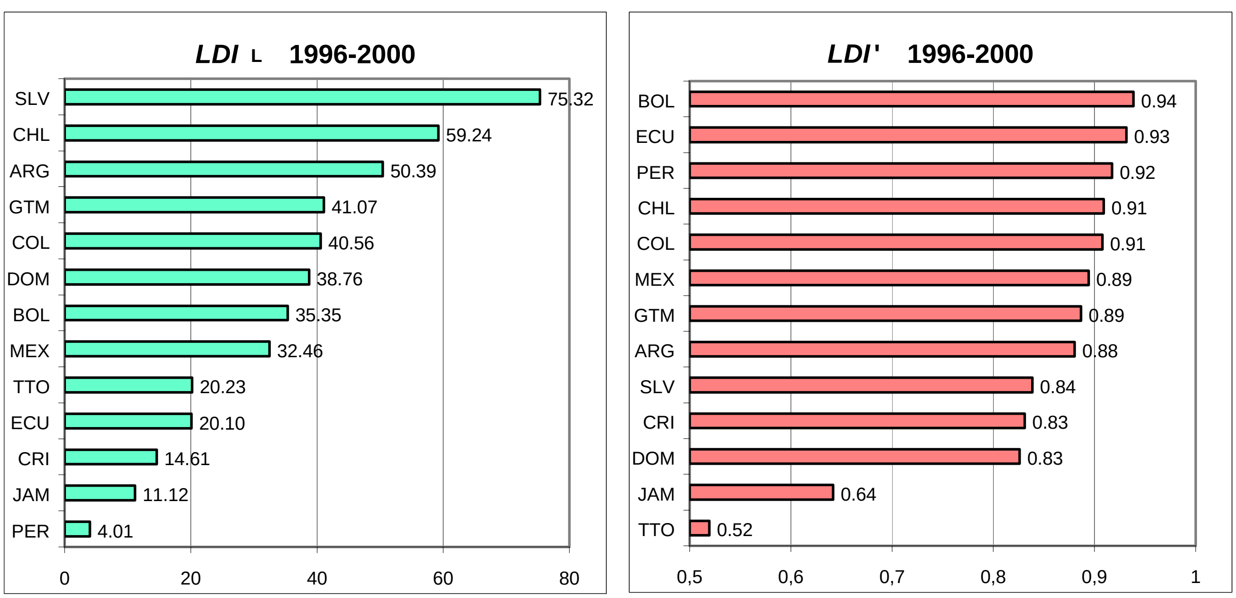
Although the Local Disaster Index takes into account the total number of deaths, persons affected, and economic losses, it is important to emphasize that it is a measure of uniformity of dispersion of these figures. Therefore, in order to evaluate the LDI, the figures were normalized according to the 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. The left side of figure 7 shows the LDI for 1996-2000. The right side of the figure shows LDI**'** for the same period.

$LDI_L$ shows relative losses in El Salvador 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. LDI**'** shows that in countries such as Bolivia, Ecuador and Peru (PER), losses during the period studied were concentrated in a few municipalities. An LDI**'** of 0.93, 0.92 and 0.91 signifies that 10 percent of the municipalities concentrate 82, 78 and 75 percent of losses, respectively (see methodology: Cardona *et al*., 2004a, 2004b, and 2005).

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.

**Figure 7. $LDI_L$ and LDI'**



# 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[6] 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).

[6] 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 8 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).[7]

These indicators show that there exists an intrinsic predisposition for adverse social impacts in the face of a 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 9 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[8] 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 10 shows the $PVI_{LR}$ weighted using the AHP.

[7] Global Assessment of Human-induced Soil Degradation

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

**Figure 8. PVI for Exposure and Susceptibility**

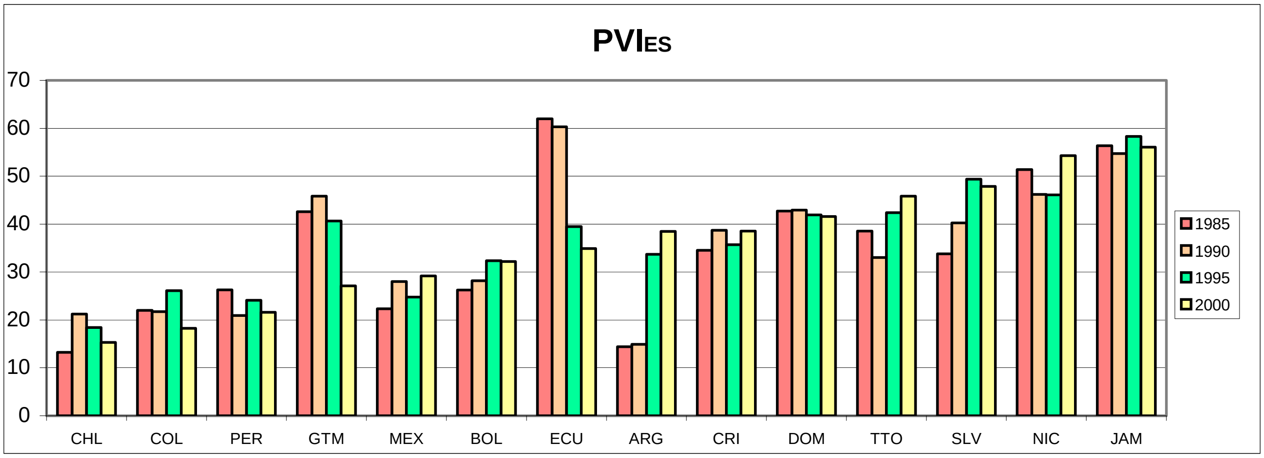



**Figure 9. PVI for Socioeconomic Fragility**

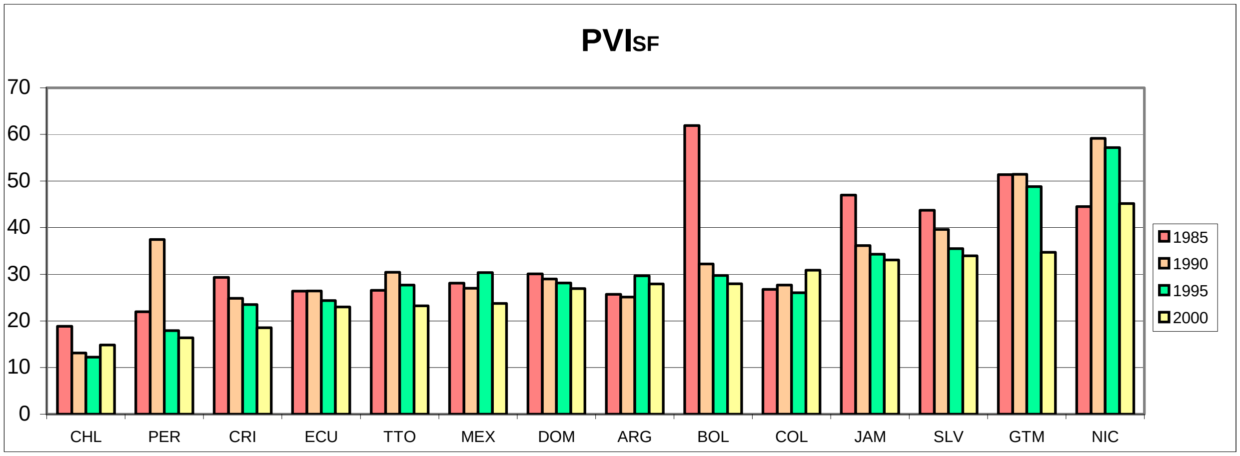
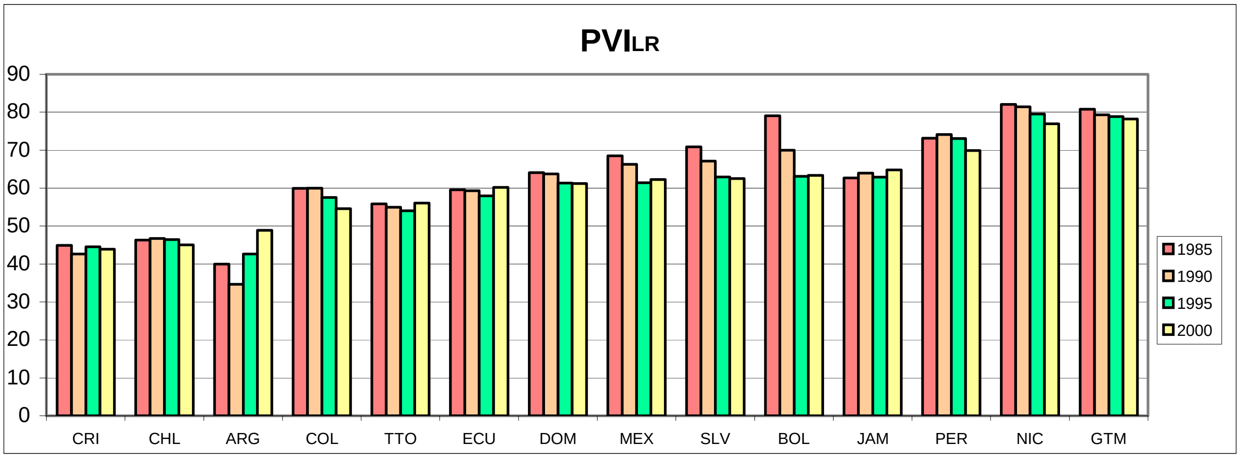



**Figure 10. PVI Due to Lack of Resilience**



Figures 8 through 10 show that small countries, such as Jamaica (JAM), Nicaragua (NIC), El Salvador, Trinidad and Tobago, the Dominican Republic and Costa Rica, consistently have greater $PVI_{ES}$. In addition, there has been a relative increase in exposure and susceptibility in Argentina (ARG), Bolivia, Costa Rica, El Salvador, Mexico and Trinidad and Tobago, during the last few years. Ecuador and Guatemala posted significant declines in the index, while Chile and Colombia show only a slight decrease in exposure and susceptibility. The Prevalent Vulnerability Index measuring socioeconomic fragility ($PVI_{SF}$) for Colombia, El Salvador, Guatemala, Jamaica and Nicaragua is relatively high. However, in most other countries socioeconomic fragility has decreased over time (with exception of Colombia and Chile in the most recent period studied). The values of $PVI_{SF}$ are generally very high; however, a declining trend is apparent during the past few years. The exceptions are Guatemala, Nicaragua and Peru where the index remains high, and Jamaica, Ecuador and Argentina where no recent declines are evident. The countries with the greatest apparent resilience are Costa Rica and Chile.

Figure 11 shows the Prevalent Vulnerability Index for each country studied for the period 1985 through 2000. The Prevalent Vulnerability Index increased between 1985 and 2000 for every country except Peru and Guatemala (where it declined), and Jamaica (where it remained unchanged). The countries with the highest PVI are Jamaica, El Salvador and Guatemala; however, each paints a different picture of vulnerability. The PVI for Nicaragua is not only one of the highest, it also increased steadily during the period studied. The index for Guatemala, Bolivia, Ecuador and Jamaica have been higher than that of any of the other countries, however they posted a significant decline since 1985. Finally, while Jamaica has the highest Prevalent Vulnerability Index, it has remained relatively unchanged since 1985.

The situation between 1995 and 2000 changed significantly. Most countries show a declining trend in vulnerability from 1995 to 2000. The exceptions are Costa Rica, the Dominican Republic, El Salvador, and Ecuador where vulnerability increased slightly, and Argentina, which posted a significant increase in vulnerability. The case of Argentina is particularly noteworthy because, in 1985 and 1990, it had the lowest PVI of any of the countries studied. However, vulnerability had increased markedly by 1995 and posted another increase in 2000. The countries with the lowest relative PVI are Chile, Costa Rica and Colombia.

Figure 12 shows the aggregated Prevalent Vulnerability Index for all the countries in 2000. The values in this graph are obtained by adding the three components: exposure and susceptibility, social fragility and lack of resilience. This aggregate value takes into account the physical exposure of infrastructure and persons (direct impact), as well as social and economic fragility (indirect and intangible impact). In addition, it reflects a country's inability to deal with the consequences of a disaster, responding efficiently to it, and recovering from it. In order to reduce these factors of vulnerability, countries need to embark in a sustainable development process and enact explicit policies to reduce risk.

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.

**Figure 11. PVI for Countries Studied**

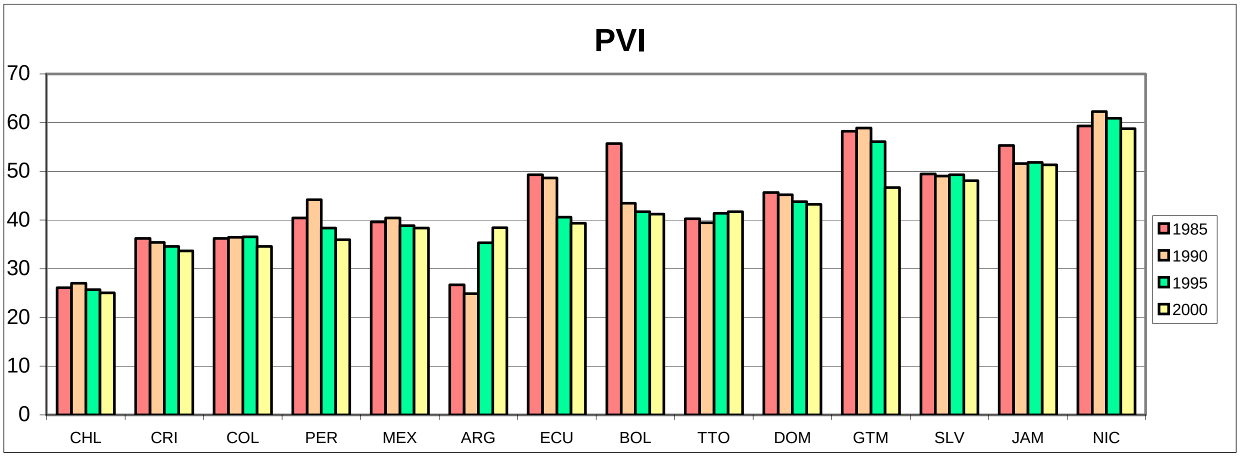
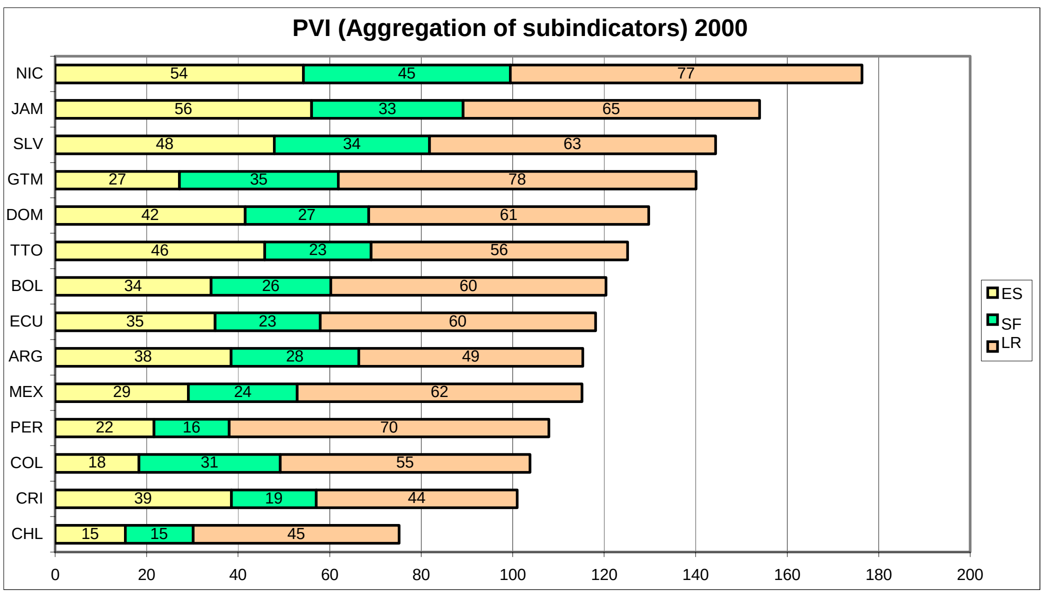



**Figure 12. Aggregate PVI**



# 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).

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).[9] 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.

**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 13 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

[9] 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.

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 14 shows the $RMI_{RR}$ fore 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 15 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.

Figure 16 shows the $RMI_{FP}$ for each country and period studied, weighted using the AHP.

**Figure 13. RMI Related to Risk Identification**

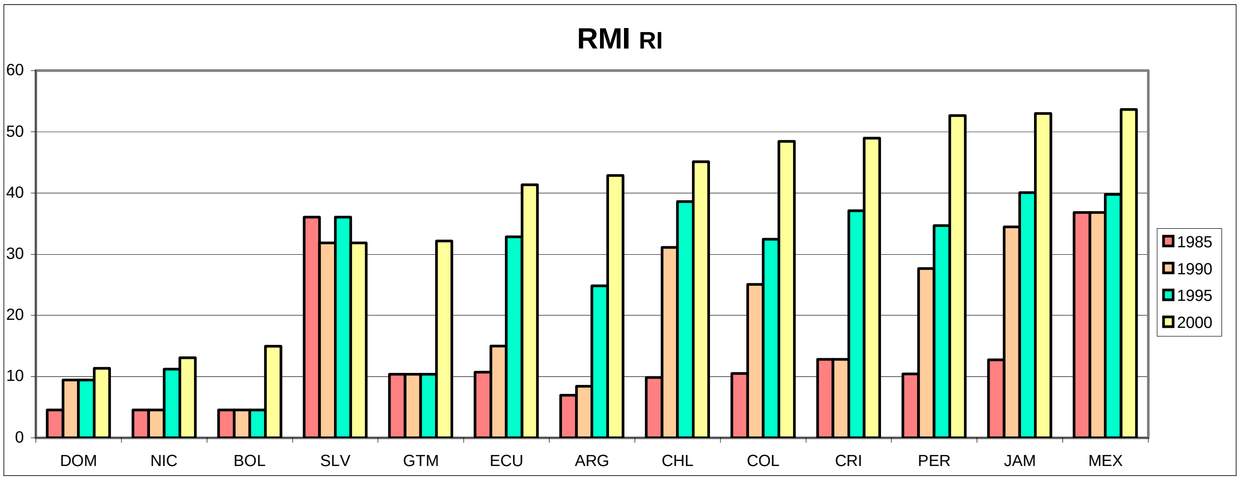



**Figure 14. RMI Related to Risk Reduction**

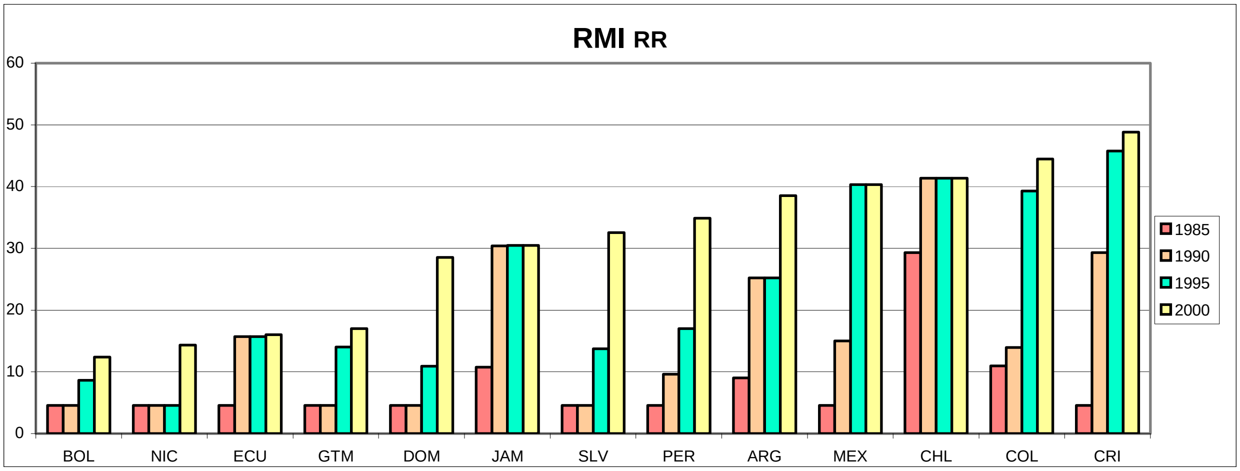



**Figure 15. RMI Related to Disaster Management**

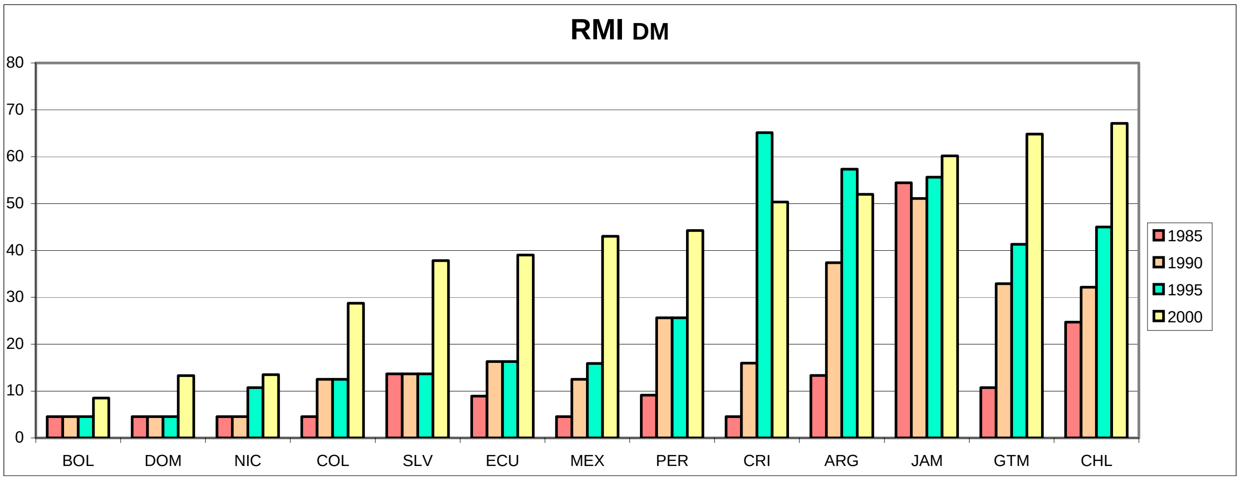
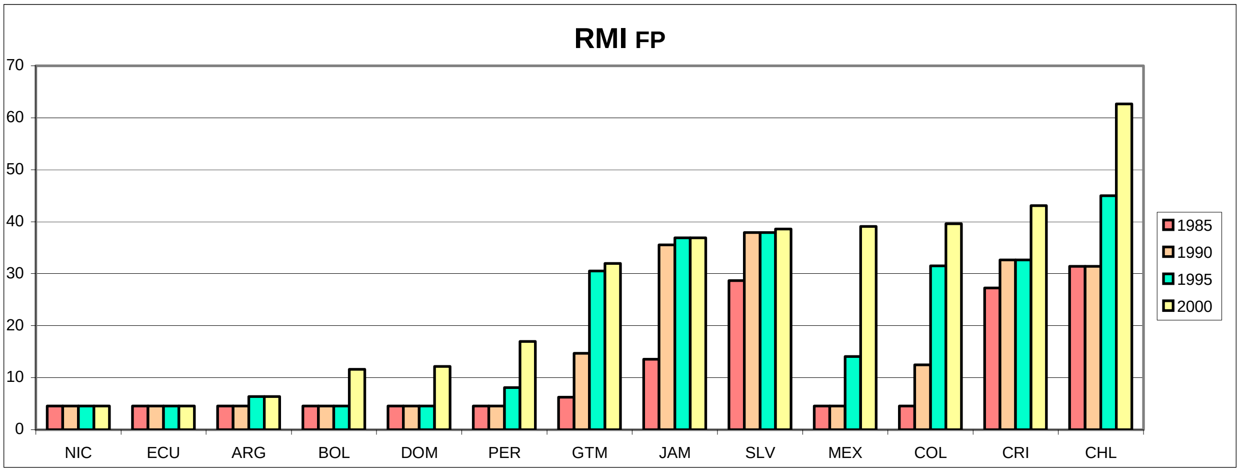


**Figure 16. RMI Related to Financial Protection and Governance**




Figures 13 and 16 show that most countries have made adequate progress in identifying risks, particularly Mexico, Jamaica and Peru. Costa Rica, Colombia, Chile and Mexico show the greatest advances in risk reduction. The largest improvements in the region were made in the indicator for disaster management. Chile, Guatemala and Jamaica posted the strongest showing in 2000; however, in the mid-1990s, Argentina, Costa Rica, and Jamaica posted relatively strong indicators. The least relative improvement in the region was in financial protection and governance. The best postings for this indicator were in Chile, Costa Rica, Colombia and Mexico.

Figure 17 shows that the Risk Management Index for most countries studied has improved. However, because all the countries started at a very low threshold, the average RMI remains relatively low. The countries with the largest improvement in the index, Costa Rica and Chile, only reach the "significant" level. Bolivia, Nicaragua and the Dominican Republic posted the lowest index. Figure 18 shows risk management by type of method used (Carreño *et al.*, 2004, Cardona *et al.*, 2005).

**Figure 17. RMI for Each Country**

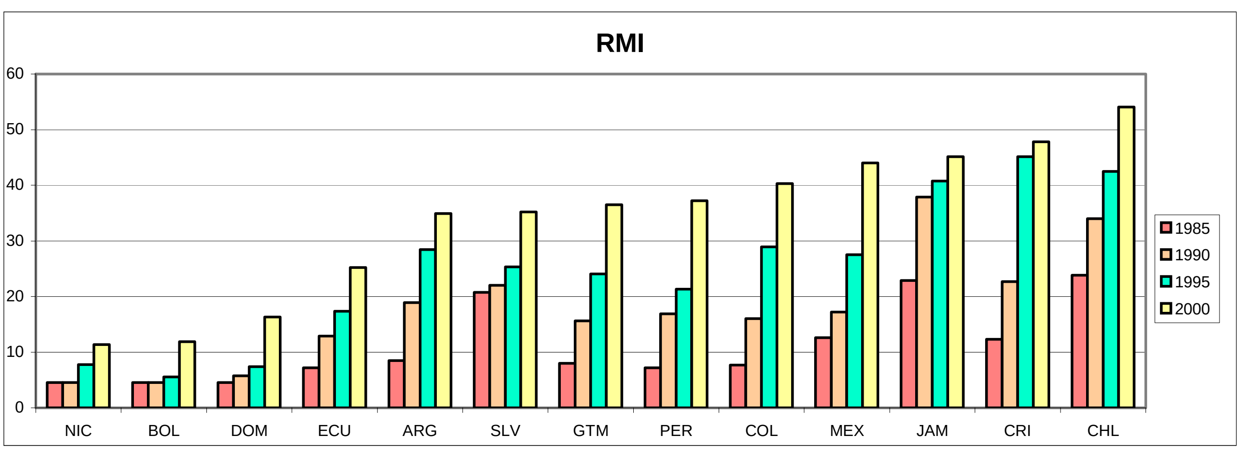
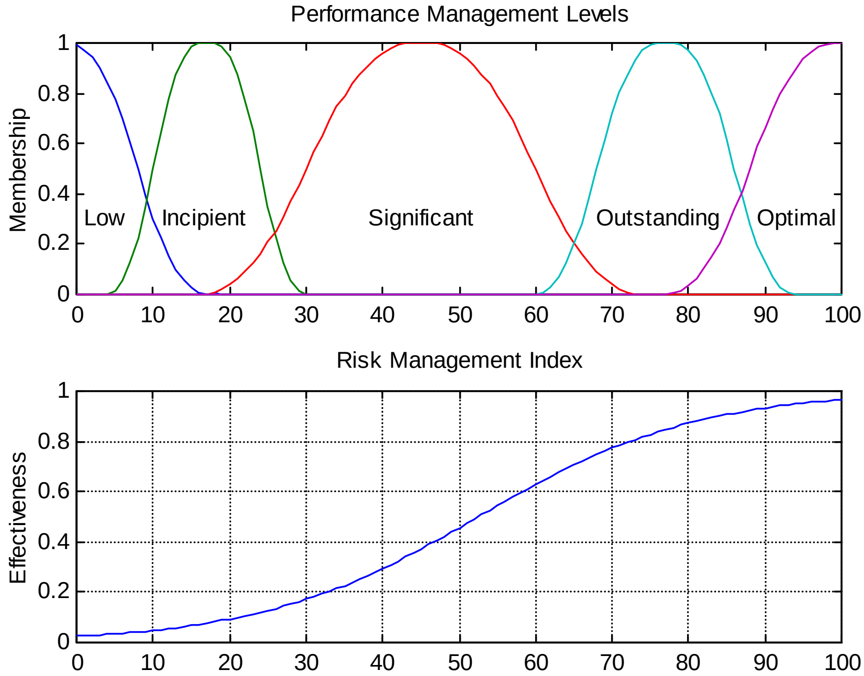


**Figure 18. Risk Management Behavior and the Form of the Functions for Each Performance Level and Probability of Effectiveness**

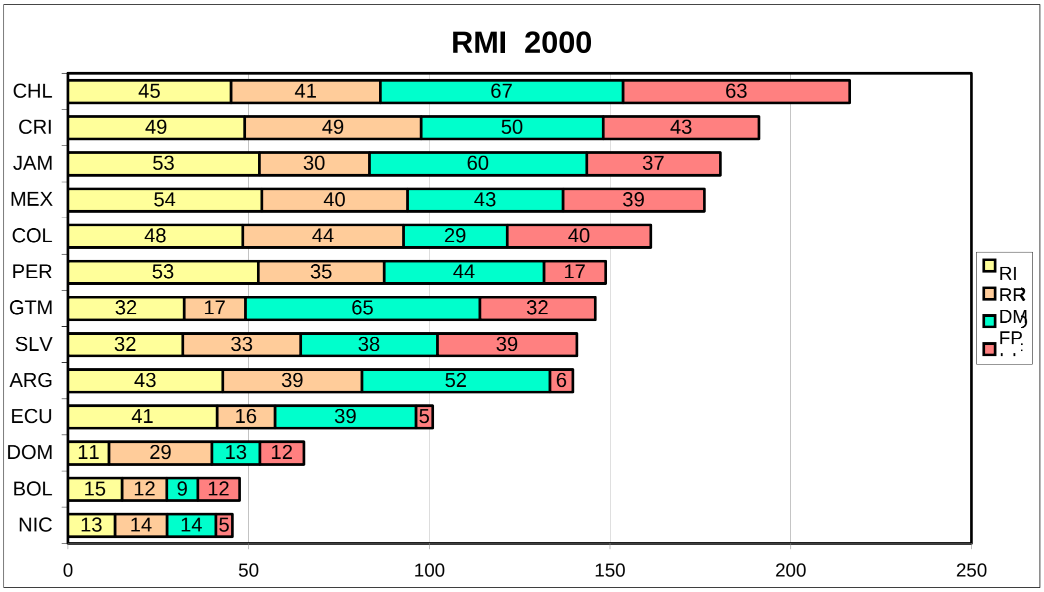



According to the theory that supports the method used here, the probable effectiveness of risk management in the majority of cases does not rise above 60 percent. Most countries[10] generally reach a level of effectiveness of between 20 and 30 percent. This is very low when compared to required effectiveness. Effectiveness was even lower in the past. 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. Figure 19 shows RMI values for 2000 obtained by adding the four components related to risk identification, risk reduction, disaster management and financial protection. Here it is possible to conclude that Nicaragua, Bolivia and the Dominical Republic are the countries with the lowest advance in the region.

Risk management officials established the weights applied and carried out the evaluations for most countries. These evaluations would appear to be overly generous when compared to those undertaken by local external experts. The latter evaluations appear to be more objective. While we have used the evaluations of national officials in this study, external evaluations are considered to be very pertinent. Perhaps, with time, they will become more desirable, particularly if undertaken in coordinated and concerted fashion, thus eliminating *status quo* factors in the evaluations.

[10] For each possible value of the subindicators we defined functions or fuzzy sets, which are shown in the upper graph of figure 18. 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.

**Figure 19. Aggregated RMI**



# Subnational Indicators

Although the development of subnational indicators was not originally part of this study, it does serve a useful demonstration purpose. Depending on the country, subnational divisions (department, states or provinces) have different degrees of political, financial and administrative autonomy. Nevertheless, the system of indicators that was developed allows for the individual or collective evaluation of subnational areas and was developed using the same concepts and approaches outlined for the nation as a whole. The pilot project was carried out in Colombia.[11]

While the variables and indicators for the subnational analysis are similar to those used at the national level, some modifications may be necessary to take into account scale differences. For example, in calculating the Maximum Considered Event, the national analysis takes the single most catastrophic event conceivable. However, this event is only the most critical of a series of events that could affect different areas of the country. Maximum probable impacts in these areas will not necessarily be associated with the same type of hazard event identified for the national level. This makes the subnational analysis even more difficult. On the other hand, these events would not occur simultaneously at the subnational level.

Subnational analysis allows national decisionmakers to evaluate and compare risks in different areas of the country. It is likely that other critical events will be identified that, while not reaching the levels implied by the MCE at the national level, could approach it and demand resources that have to be provided by the national government. Subnational analysis is also useful for local decisionmakers because it helps them to identify key risks as well as the actions that they must take to mitigate or avoid them, whether on their own or in coordination with national authorities. Subnational analysis requires greater effort and more detailed information. Nevertheless, it offers national and subnational decisionmakers a useful tool for defining public policies and planning needs in order to reduce risk.

An analysis of the Disaster Deficit Index (DDI) at the subnational level is likely to show that state, municipal or local governments have the resources required to finance response and reconstruction needs. However, if fiscal decentralization is broad enough and the MCE is smaller than at the national level, the responsibility assumed by subnational governments could be much greater. This likelihood makes this sort of evaluation of great importance to decisionmakers because it allows them to predict and plan for the social and economic implications of disasters (including reaching agreements with national authorities to address these problems in a coordinated manner).

An index such as the Local Disaster Index (LDI) can be of use at the subnational level because it measures how susceptible an area is to lower level disasters, as well as their likely impacts on local and municipal development. The LDI provides a measure of the spatial variability and dispersion of risk in a subnational unit resulting from smaller and recurrent events. From a risk management perspective, this type of information could target advisory and support services to municipalities in line with past events and impacts. In many cases, a municipality has not recovered from a disaster when another one strikes. Although this may not be considered relevant at the national or even subnational levels, it implies a constant erosion of local development gains and opportunities. It is important to identify recurrent small-scale dis-

[11] See Barbat and Carreño (2004a) for a comprehensive report on the results for all the indicators and different time periods.

asters not only because of their significant impact on local development, but also because they usually affect the livelihoods of poor populations.

Figure 20 shows the DDI for the year 2000 and for an MCE of 500 year of return period in Colombia's 32 departments. This example only takes into account the economic resilience of each department, and does not take into consideration resources available from the national government.

Figure 21 shows the aggregate Local Disaster Index for 1986-1990. Figure 22 shows the Prevalent Vulnerability Index (PVI) for each department in 2000.

**Figure 20. $DDI_{500}$ for Colombia, by Department (2000)**

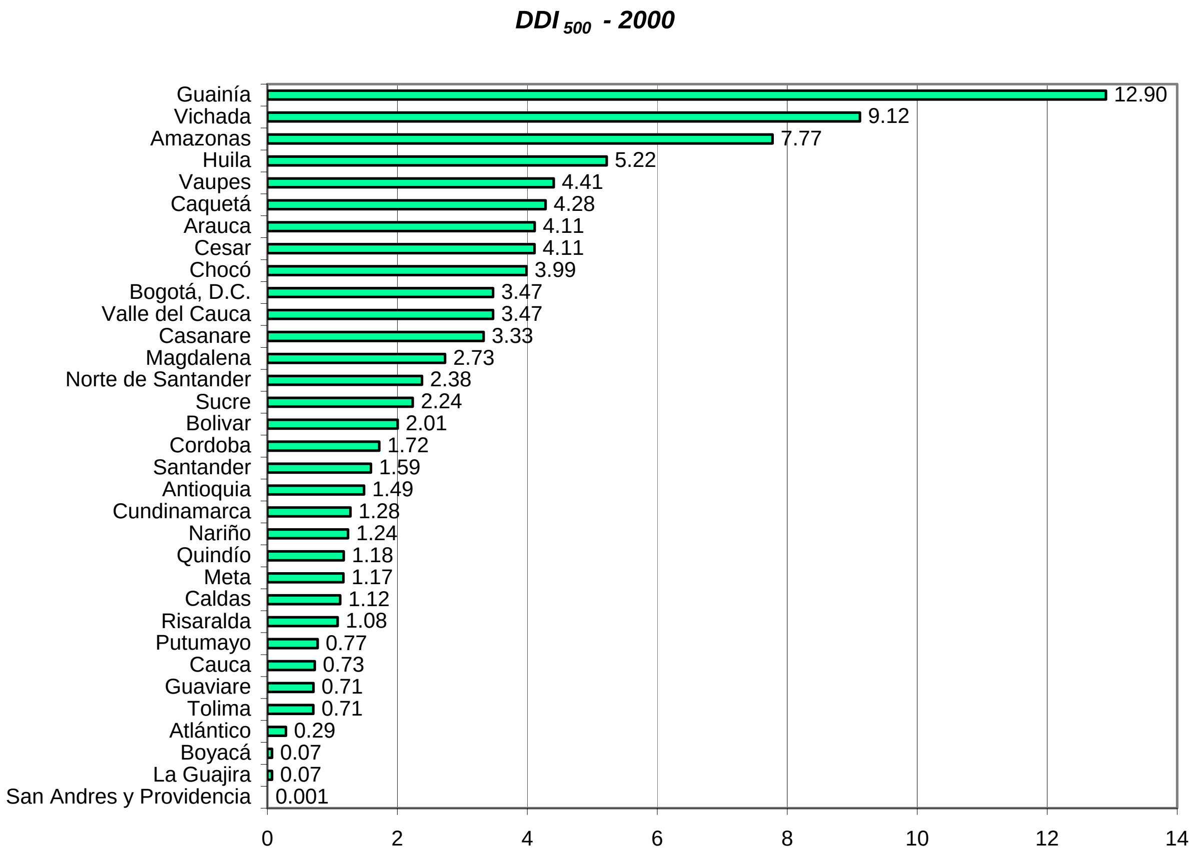
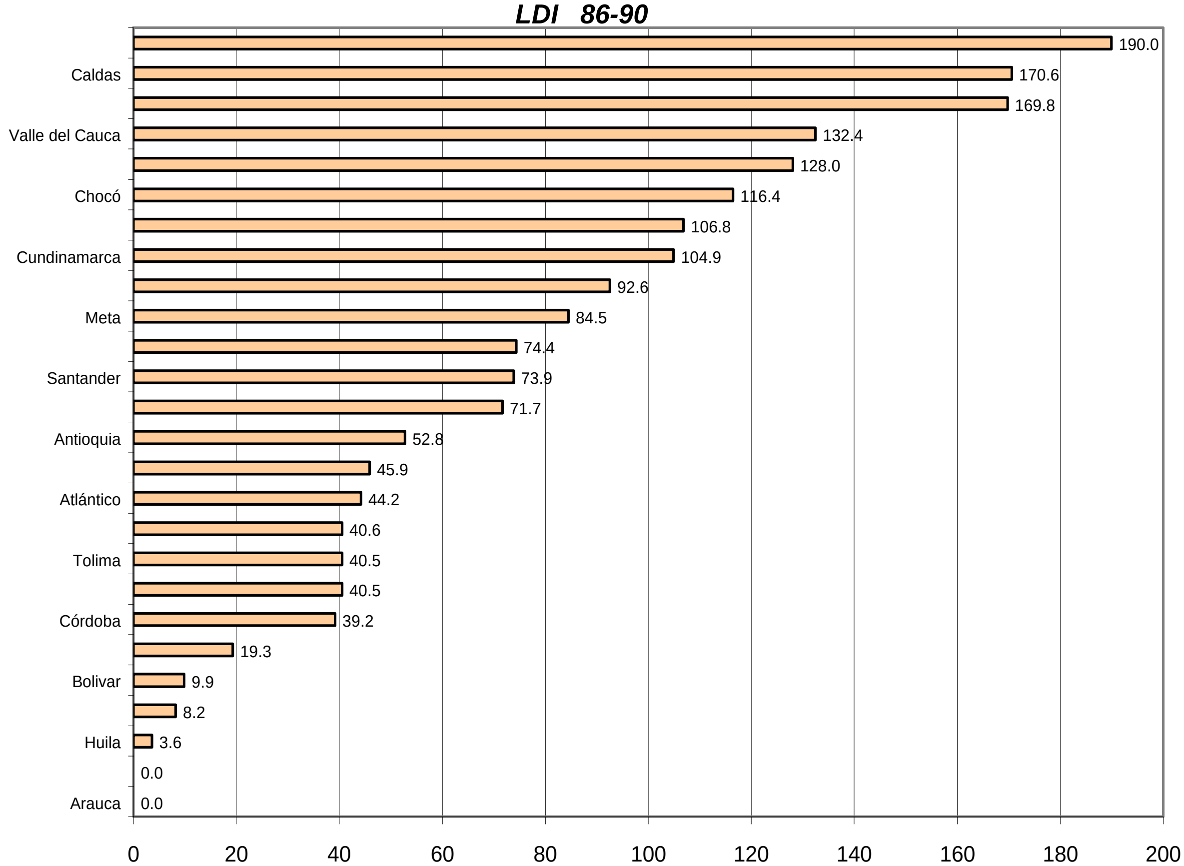


**Figure 21. Aggregate LDI for Colombia, by Department (1986-1990)**



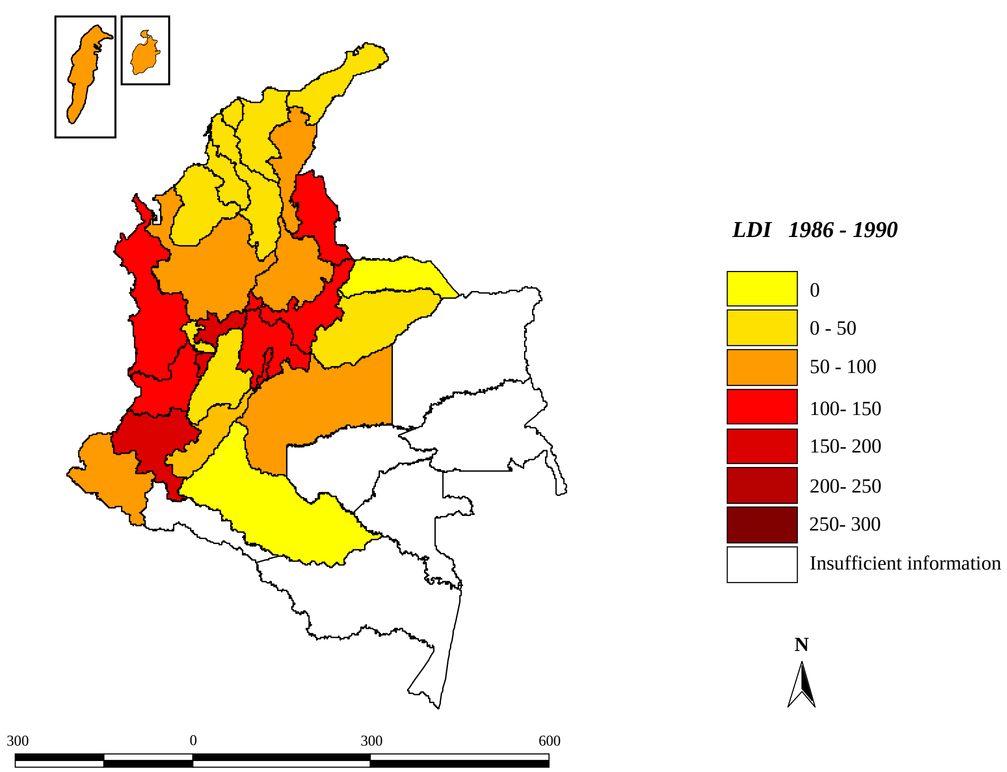
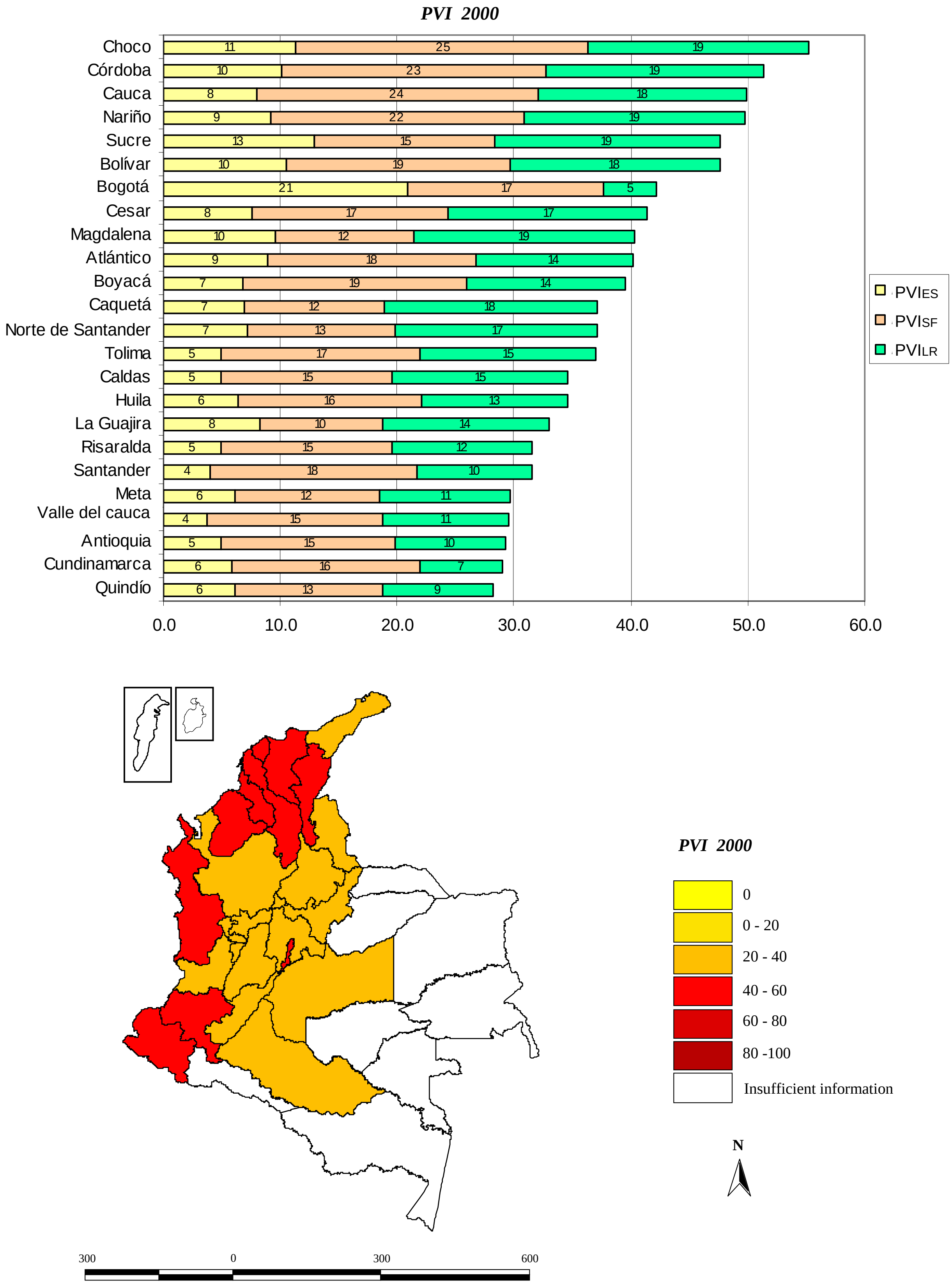



**Figure 22. Aggregate PVI for Colombia, by Department (2000)**



# Urban Indicators

Risk analysis can further be disaggregated to metropolitan areas, which are usually made up of administrative units such as districts, municipalities, communes or localities. All of these have different risk levels and requirements to estimate potential damage and/or losses for the different types of infrastructure (i.e., buildings, public works, roads, etc.) that are exposed to hazard events. The estimation of a MCE for the city would allow us to evaluate in greater detail the potential direct damage and impacts to prioritize interventions and actions required to reduce risk in each area of the city.

The urban risk indicators are similar to those used at other levels but with the addition of two new indicators: the Index of Physical Risk and the Impact Factor. The former is based on hard data, while the latter is based on soft variables that depict social fragility and lack of resilience. In turn, these two indicators allow us to create a Total Risk Index, $R_T$, for each unit of analysis. These indicators require greater detail than that used at the national or regional level and they focus on urban variables (Cardona and Barbat, 2000; Barbat, 2003a; Barbat, 2003b). In other words, we have developed a methodology that combines the Disaster Deficit and the Prevalent Vulnerability indices used for the national and subnational analyses.

It is important to point out that different urban areas may be most affected by different phenomena (as shown by studies of seismic microzonation and flooding). In other words, risk and hazards vary greatly spatially (i.e. an urban center). This complicates the analysis because, strictly speaking, we would need to carry out different impact analyses for each section of an urban area. Yet, historical data can be used to identify the type of event that would cause the most critical impact on the city as a whole and use this estimate as a reference point.

In order to demonstrate the types of results that may be obtained with this methodology, we evaluated risk faced by the city of Bogota, Colombia. The choice was made based on the availability of risk studies as well as the ease with which the data could be obtained.[12] Earthquakes were chosen as the worst type of threat for the Bogota metropolitan area. A holistic evaluation of seismic risk was carried out, beginning with various scenarios of potential losses. The next step was the creation of indicators of damage and direct effects for each unit of analysis, which, in this case, is the locality or district. An indicator of physical risk ($R_P$) was obtained for each locality by taking into account potential deaths, number of persons injured, the extent of the area destroyed and the impact on vital infrastructure and services, including water, electricity, roads, and housing. An indirect impact factor (1 + F), based on an aggravating coefficient *F*, was determined for each unit of analysis on the basis of indicators of social fragility and lack of resilience. The aggravating coefficient ranges between 0 and 1.

This coefficient is estimated for each locality by means of a series of nonlinear functions whereby the net values of the indicators are related to an impact factor. Each factor is also assigned a weight consistent with the Analytic Hierarchy Process (AHP).

Figure 23 presents the indicators and their weights, while figures 24 and 25 show the impact factor as a function of population density and public space, respectively. Figures 26 through 29 present the results of the holistic estimation of seismic risk for Bogota using these indicators.

[12] Barbat and Carreño (2004b) present a detailed summary of the results.

**Figure 23. Indicators of Physical Risk, Social Fragility and Lack of Resilience, with Related Weights**

| *Ind* | *Description* | *w* |
|---|---|---|
| $F_{RF1}$ | Damaged area | 31 |
| $F_{RF2}$ | Number of deceased | 10 |
| $F_{RF3}$ | Number of injured | 10 |
| $F_{RF4}$ | Ruptures in water mains | 19 |
| $F_{RF5}$ | Rupture in gas network | 11 |
| $F_{RF6}$ | Fallen lengths on HT power lines | 11 |
| $F_{RF7}$ | Telephone exchanges affected | 4 |
| $F_{RF8}$ | Electricity substations affected | 4 |

>> **$R_P$ Physical risk**

| *Ind* | *Description* | *w* |
|---|---|---|
| $F_{FS1}$ | Slums-squatter neighborhoods | 18 |
| $F_{FS2}$ | Mortality rate | 4 |
| $F_{FS3}$ | Delinquency rate | 4 |
| $F_{FS4}$ | Social disparity index | 18 |
| $F_{FS5}$ | Population density | 18 |
| $F_{FR1}$ | Hospital beds | 6 |
| $F_{FR2}$ | Health human resources | 6 |
| $F_{FR3}$ | Public space/shelter facilities | 4 |
| $F_{FR4}$ | Rescue and firemen manpower | 3 |
| $F_{FR5}$ | Development level | 9 |
| $F_{FR6}$ | Preparedness/emergency planning | 9 |

>> **$F$ Aggravating Coeff.**

>> $$R_T = R_P(1+F)$$

**Figure 24. Factor of physical risk as a Function of Population Density**

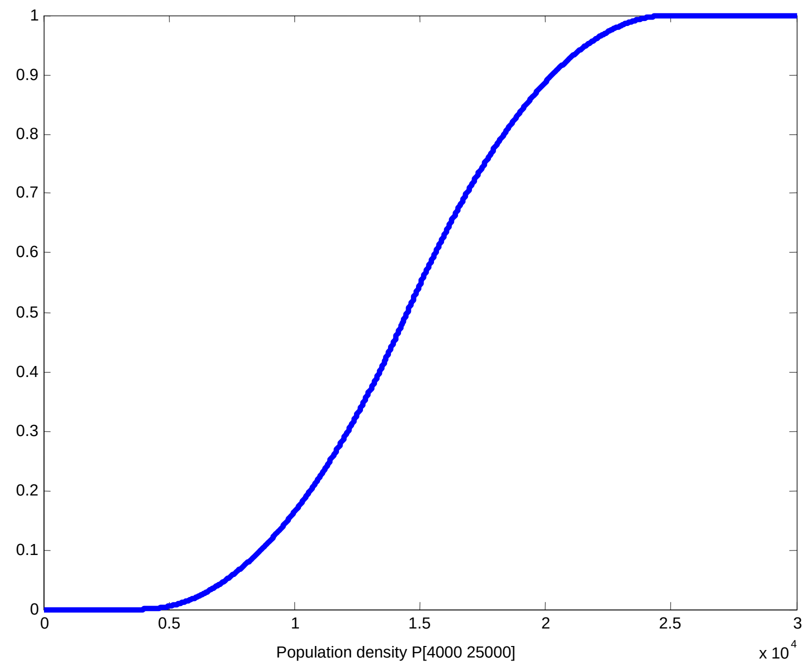



**Figure 25. Factor of social fragility as a Function of Public Space Available**

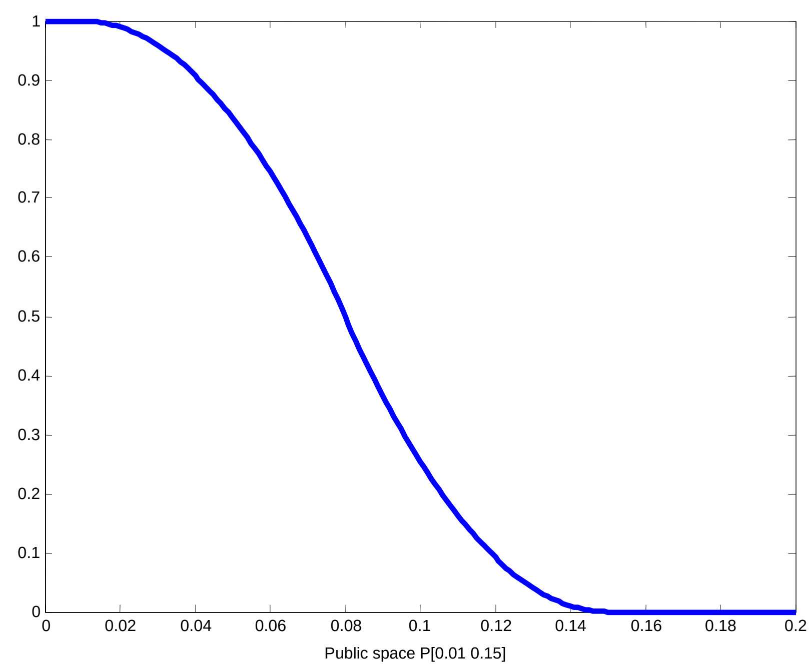


**Figure 26. Physical Risk Index for the Localities of Bogota**

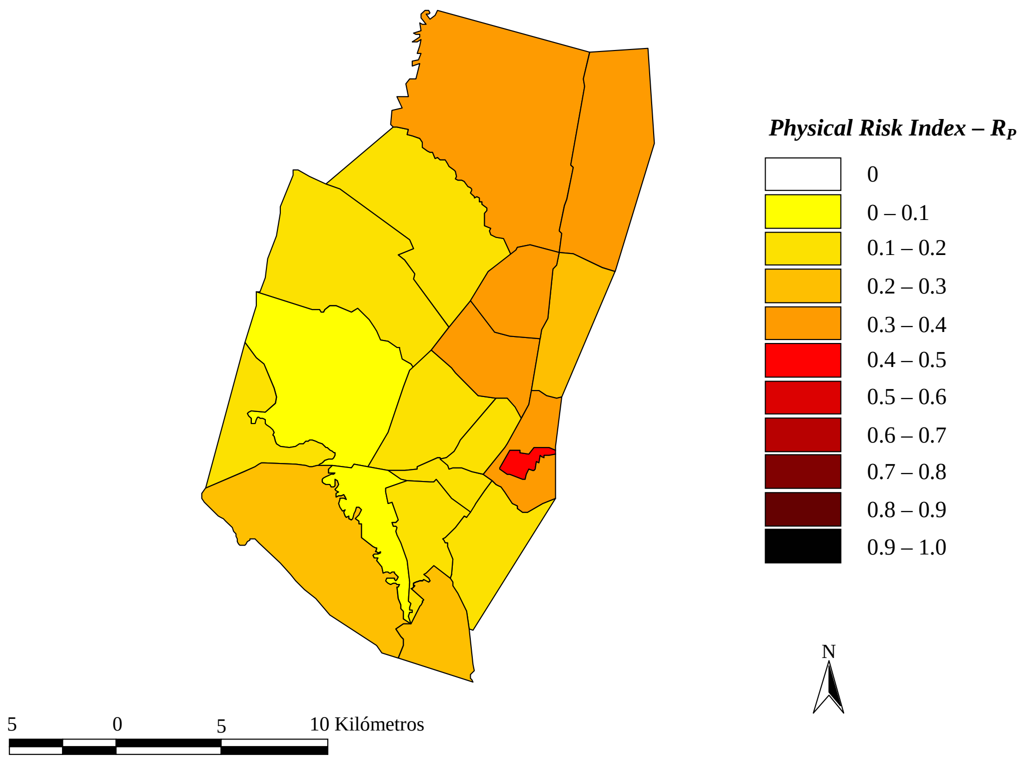



**Figure 27. Values and Ranking of the Localities According to the Physical Risk Index**

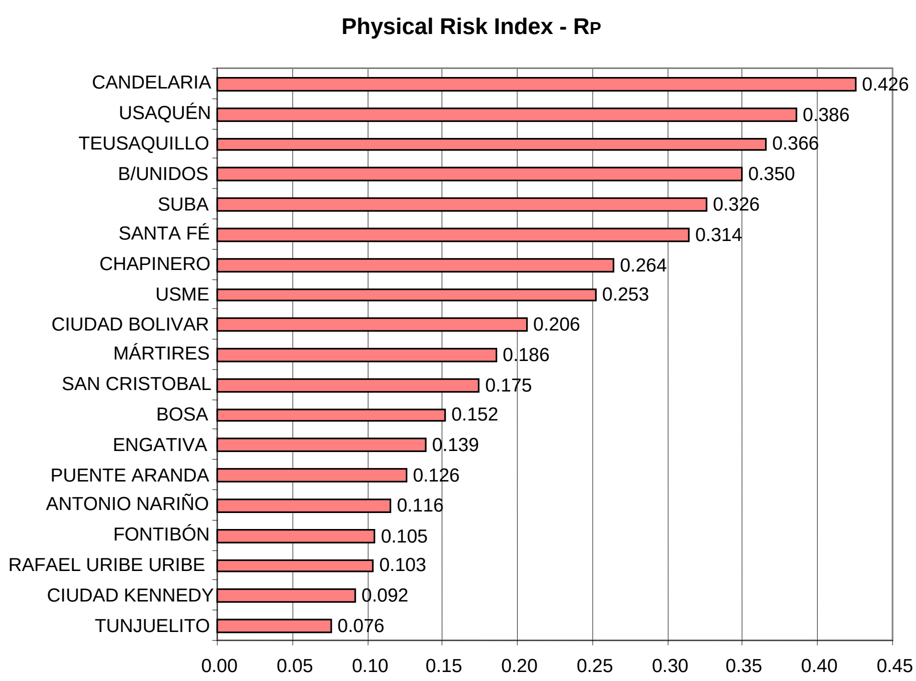


**Figure 28. Total Risk Index for the Localities of Bogota**

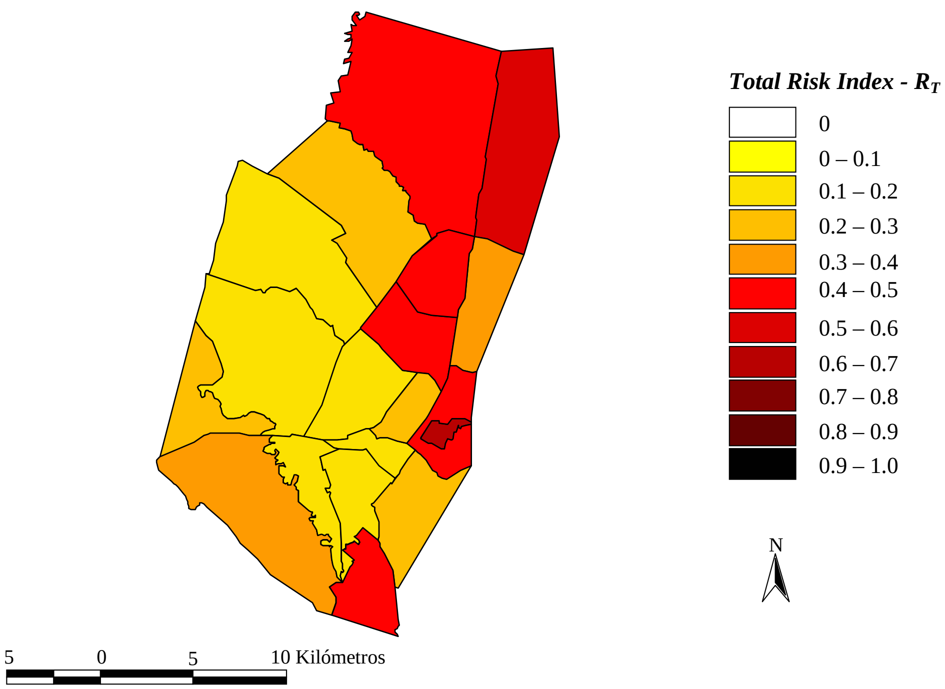
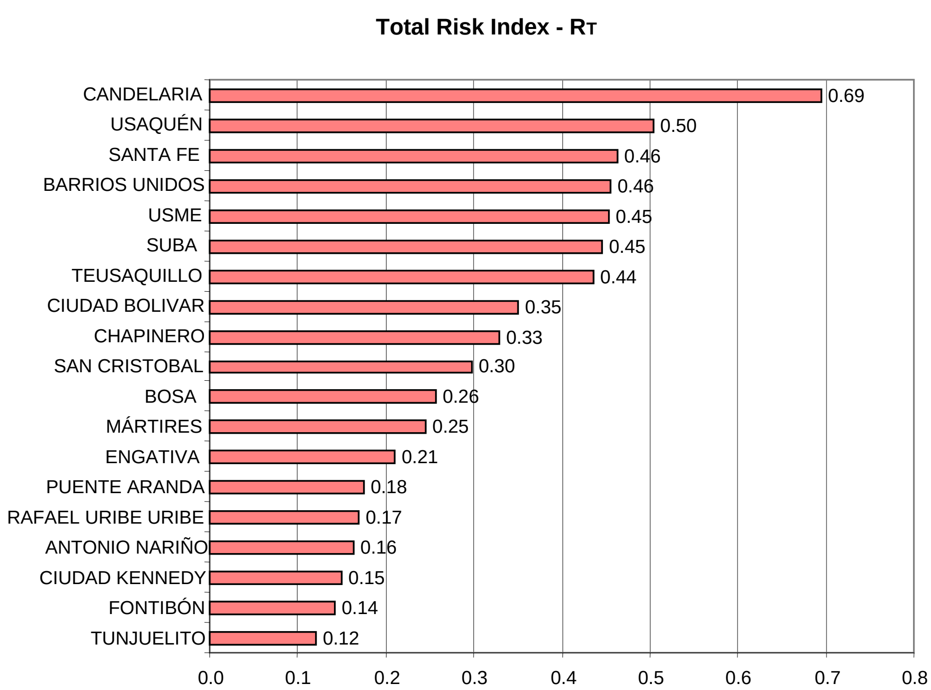



**Figure 29. Values and Ranking of the Localities According to the Total Risk Index**



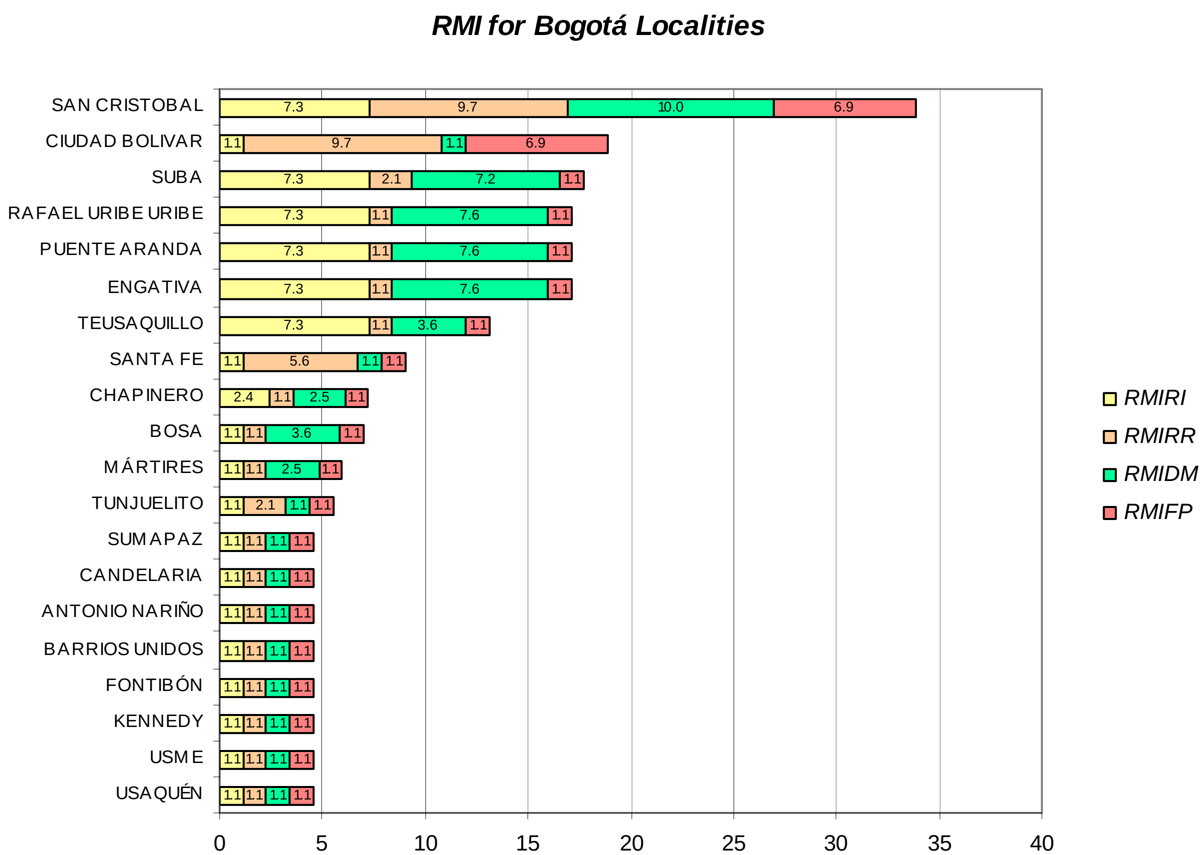
The Risk Management Index, including its component indicators (identification of risk, risk reduction, disaster management, and financial protection and governance) was estimated with the assistance of experts from the *Dirección de Prevención y Atención de Emergencias* [Directorate of Emergency Prevention and Response] of Bogota as well as outside experts. As is the case with other indicators, the weights used are consistent with the AHP.

Table 24 shows the RMI for Bogota. Figure 30 shows the results of the analysis for each one of Bogota's localities for 2003, which was obtained following the same procedures as for the city as a whole.

**Table 24. The Risk Management Index for Bogota**

| Indicator | 1985 | 1990 | 1995 | 2000 | 2003 |
|---|---|---|---|---|---|
| **$RMI_{RI}$** | 4.6 | 13.9 | 35.6 | 56.2 | 67.1 |
| **$RMI_{RR}$** | 11.0 | 13.9 | 13.9 | 46.1 | 56.7 |
| **$RMI_{DM}$** | 4.6 | 8.3 | 8.3 | 24.0 | 32.3 |
| **$RMI_{FP}$** | 4.6 | 57.5 | 54.8 | 57.6 | 61.4 |
| **$RMI_{average}$** | **6.2** | **23.4** | **28.1** | **46.0** | **54.4** |

**Figure 30. Ranking of Localities According to the RMI**



# Conclusions

The indicators of risk and risk management presented in this report have permitted an evaluation of twelve 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. An evaluation of individual countries allowed us to compare individual performance indicators for the period 1980–2000.[13] The report also estimated the indicators at the subnational and urban level.

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 and subnational levels. 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, decision-makers 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 1995 to 2000, using an ordinal ranking scale, are as follows: El Salvador, Jamaica, Peru and the Dominican Republic are most prone to future extreme disaster risk based on evaluations for the year 2000. These countries are likely to suffer significant losses and lack the economic resilience to address them adequately. Colombia and Bolivia also face relatively high risk, particularly in the case of low probability, high consequence events. Trinidad and Tobago, Ecuador and Mexico are in the mid-range of countries. The first two countries have a relatively poor ability to obtain reconstruction assistance, while Mexico may suffer high losses but its economic resilience is relatively high. Argentina, Chile, Costa Rica and Guatemala have minor relative risk profiles for extreme events, but this does not mean that risk is low. Large-scale losses are not expected in these countries, and their capacity to deal with losses is relatively good. In general, the risk associated with extreme events has increased over time in all the countries.

Local data for the last two decades indicate that Argentina, El Salvador and Guatemala face relatively high risk in the event of recurrent and highly spatially dispersed, low scale events. They are followed by Colombia and the Dominican Republic where events that could pose a hazard occur with less regularity and dispersion at the municipal level. Bolivia, Chile, and Mexico rank between these countries and Costa Rica, Peru, Trinidad and Tobago, and Jamaica where there is a lower relative incidence of smaller scale dispersed events.

Bolivia, Ecuador, Peru, and Chile have the highest relative concentration of economic losses associated with recurrent events, with losses concentrated in a limited number of municipalities. 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.

[13] For obvious space limitations the results for each country cannot be included in this report.

Toward the end of the 1990s, Nicaragua, El Salvador, Jamaica and Guatemala the Dominican Republic had the highest prevalent vulnerability indices. Social and economic conditions in Trinidad y Tobago and Ecuador also presage that a hazard event could easily become a disaster. The Prevalent Vulnerability Index for Bolivia, Argentina and México is much better than that of the previous countries, but not quite as robust as that of Peru, Colombia, Costa Rica and Chile, which have the lowest levels of vulnerability and lack of resilience. With the exception of Argentina and Trinidad and Tobago, prevalent vulnerability has dropped over the last 20 years. However, vulnerability is still very high in the vast majority of countries.

The Risk Management Index is 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 Nicaragua, Bolivia, the Dominican Republic and Ecuador have made the least progress over the last few years. Argentina, El Salvador and Guatemala posted a slightly better performance. Peru and Colombia showed even more improvement, while Chile, Costa Rica, Jamaica and Mexico posted the most significant advances in risk management practice. The overall tendency since the 1980s 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, the Dominican Republic, Bolivia, El Salvador and Guatemala face the greatest risk and have achieved the lowest levels of development in risk management. Ecuador, Argentina, Peru, Colombia and Jamaica are in an intermediate position. However, the latter two countries are special cases. In Jamaica, risk is high but risk management performance is good. In Argentina, 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 Next Steps: A Regional Assessment Program Based on Indicators

The system of indicators for disaster risk and risk management performance assessment is a powerful tool to guide actions and the allocation of resources to reduce disaster risk as well as to improve the effectiveness of national and regional efforts and the development assistance provided by the international community. The development of this set of robust indicators makes possible the creation of a permanent program to ensure that this information is consistently available.

We propose setting up a ***Disaster Risk Management Assessment Program (RiskMAP)***, which would provide a comprehensive framework to profile risk, identify the performance of national disaster risk management systems, and develop appropriate risk management solutions at the national and regional levels.[14] The program would include a monitoring and evaluation process for tracking progress in the countries' risk profiles, as well as for tracking the effectiveness of efforts to promote sound national and regional risk management systems.

The aim of the program is to make possible a consistent and independent use of the indicators, and a replicable and manageable application process (in terms of time and cost). In addition, it would make it possible for assessment teams and countries to receive feedback on the robustness of the methodologies and on the updating process. RiskMAP would have three primary components or areas of work: country assessments; indicators, methodologies and data improvement; and risk management solutions.

**Component 1: Country Assessments**

The core of the RiskMAP program would be the country assessments, which would use a set of indicators to profile disaster risk and the soundness of national risk management systems. It would also establish best practices for risk management and identify development and technical assistance requirements for strengthening risk management at the national level. The Disaster Risk Management Assessment Program would be voluntary and countries would request participation. In other words, the assessments would be triggered by the requesting country.[15] This will ensure that the assessment and ensuing discussion of risk management options will have the cooperation of key policymakers and institutions. Countries would receive a national report detailing the results of the assessment and recommendations for strengthening risk management. While the report itself may remain proprietary, the indicator that it yields would be registered in the RiskMAP program and included in annual publications of regional disaster risk management conditions and efforts. *Certified teams, drawn from regional centers of excellence and others would undertake the country assessments using the set of indicators. Manuals and supervisory details would be developed during the program's design and start-up phase.*

**Component 2. Indicators, Methodologies, and Data Improvement**

This component establishes a process through which the indicators and methodologies used

[14] It is understood that this would accomplished with the cooperation of participating countries.

[15] The program will assist the countries in making the request.

in the country assessments are validated and updated as needed, and new indicators are added to the core set. This process would include periodic reviews by experts, as well as annual meetings of national stakeholders dealing with policy and technical issues. Special activities related to data improvement and the evaluation of additional indicators (such as subnational indicators) for inclusion in the core set of indicators would be developed and validated under this component.

*The advantages of a formal and transparent peer-reviewed process for the adoption of methodological refinements and additions to the core set of indicators are: (i) a direct and clear link of new developments in datasets into methodology refinements; and (ii) a visible platform for vigorous technical and stakeholder reviews of the indicators as well as related methodological issues that include the publication of technical papers.*

**Component 3. Risk Management Solutions**

This component would promote dialogue between countries and the development of national and regional risk management solutions. The forums would center on a discussion of the annual report on the state-of-the region in disaster risk management based on the assessment program and conference of stakeholders and participants. These meetings would promote the exchange of technical information to facilitate the formulation of public policy, benchmarking of disaster risk and risk management and, through financial support to selected subregional working groups, promote the work on risk management solutions. It is expected that regional partners such as CEPREDENAC, CDERA, and CAPRADE will facilitate this dialogue and action.

**Setting Up a RiskMAP Program**

It may take two to three years to establish a sustainable RiskMAP. The first step would be to evaluate options and develop the proposed institutional arrangements for the program, including its governance structure. Ideally, this proposal would be developed jointly with selected international financial institutions, and bilateral and UN agencies, in consultation with the countries of the region. During the first year, the proposed institutional arrangement for the program would be developed and initial agreements and partnerships required for the pilot phase would be entered into. The pilot phase of the program would be implemented during the second and third years.

The aim of this phase would be to establish a permanent structure to provide consistent guidance and resources to reduce disaster risk and improve the effectiveness of national and regional efforts and international development assistance. An explicit objective for the program is to establish organizational and governance structure that avoid the worst of bureaucratic rigidities and is able to effectively promote the dynamic interaction of the program's stakeholders.

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