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Updating the Indicators of Disaster Risk and Risk Management for the Americas

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Abstract In order to improve disaster risk understanding and disaster risk management performance in Latin America and the Caribbean a transparent, representative and robust system of indicators was developed by the Institute of Environmental Studies (IDEA in Spanish) of the National University of Colombia, Manizales. This system of indicators which is easily understood by public policymakers and relatively easy to update periodically, has been designed between 2003 and 2005 to communicate risk in the decision makers' own language and to allow cluster and comparison between countries. The indicators were developed with the support of the Inter-American Development Bank (IDB).

Four composite indicators have been designed to represent the main elements of vulnerability and show each country's progress in managing risk. They are the 'Disaster Deficit Index', the 'Local Disaster Index', the 'Prevalent Vulnerability Index', and the 'Risk Management Index'. 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.

In this way, 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.

In 2008 a methodological review and the updating of the indicators was made. Indicators were updated to 2005 and for the most recent date according to information availability (2007 or 2008). In addition, new countries were included in the program. This has allowed a systematic and quantitative benchmarking of the Americas countries during different periods between 1980 and 2008. This paper describes the current methodologies for each index and illustrates some results in each case.

Key words Indicators; Risk Assessment; Risk Management; Disasters; Vulnerability; Natural

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Hazards; Risk Modelling

INTRODUCTION

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.

Disaster risk management requires measuring of risk, and this risk measuring signifies 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 that could facilitate a multidisciplinary evaluation and intervention (Cardona 2004).

The Disaster Risk Management Indicators Program in the Americas meets these needs. The System of Indicators proposed by IDEA for the Inter-American Development Bank (IDB) permits a systematic and quantitative benchmarking of each country during different periods between 1980 and 2008, 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 (but also at the subnational and urban level to illustrate its application in those scales), allowing the identification of key issues by economic and social category. It also makes the creation of national risk management performance benchmarks possible in order to establish performance targets for improving management effectiveness.

The system of indicators, an outcome of the IDB-IDEA program, provides a holistic approach to evaluation that is also flexible and compatible with other evaluation methods (Cardona 2001; 2004). As a result, it is likely to be increasingly used to measure risk and risk management conditions. The system's 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). Figure 1 shows a scheme of the conceptual framework and model used by the system of indicators, adapted from Cardona (1999: 65), Cardona and Barbat (2000), IDEA (2005), Carreño et al. (2007, 2009) and ICSU-LAC (2010).

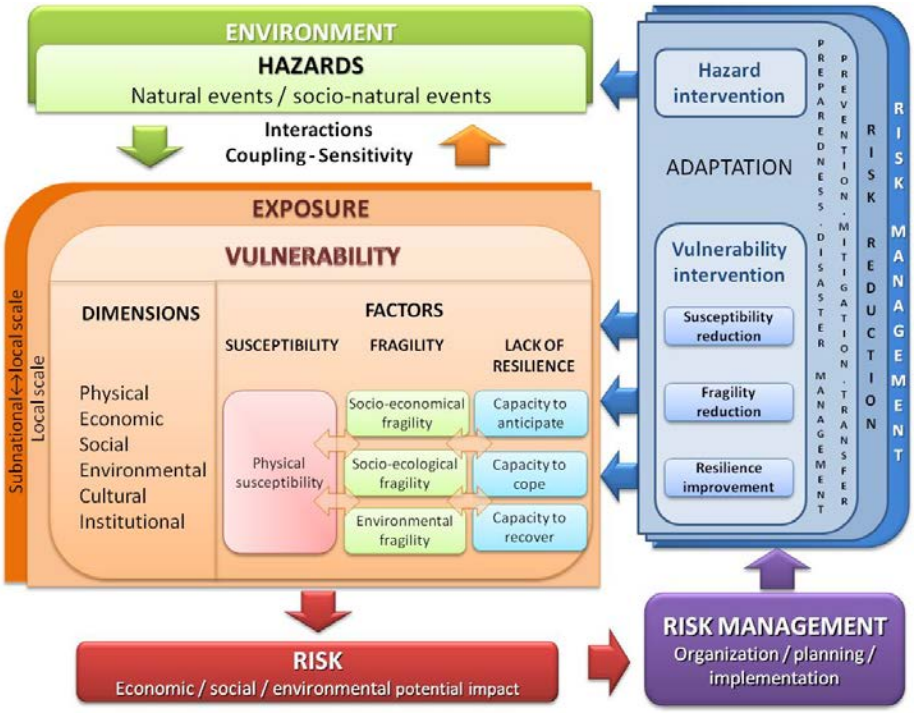

Figure 1: Theoretical framework for a holistic approach to disaster risk assessment and management.

This System of Indicators had three specific objectives: *i)* improvement in the use and presentation of information on risk. This assists policymakers in identifying investment priorities to reduce risk (such as prevention and mitigation measures), and directs the post disaster recovery process; *ii)* to provide 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; and *iii)* application of this methodology should promote the exchange of technical information for public policy formulation and risk management programs throughout the region. The System of Indicators was developed to be useful not only for the countries but also for the Bank, facilitating the individual monitoring of each country and the comparison between the countries of the region.

Four composite indicators have been designed to represent the main elements of vulnerability and show each country’s progress in managing risk. They are described in the following sections. Program reports, technical details and the application results for the countries in the Americas can be consulted at the following web page: http://idea.unalmzl.edu.co (Cardona et al. 2003a/b, 2004a/b; Carreño et al. 2005; IDEA 2005, Cardona 2005, 2008, 2010).

THE DISASTER DEFICIT INDEX (DDI)

The DDI measures country risk from a macro-economic and financial perspective when faced with possible catastrophic events. This requires an estimation of critical impacts during a given exposure time, as well as the capacity of the country to face up to this

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situation financially. 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. See Cardona (2005, 2008, 2010), Cardona et al. (2008, 2008a, 2010) for more details about this methodology.

The DDI captures the relationship between the demand for contingent resources to cover the losses, L_R^P, caused by the Maximum Considered Event (*MCE*), and the public sector's economic resilience, R_E^P, (that is, the availability of internal and external funds for restoring affected inventories). Thus, DDI is calculated using the equation 1, as follows:

$$DDI = \frac{MCE\ loss}{Economic\ Resilience}, \quad DDI = \frac{L_R^{\ P}}{R_E^{\ P}} \tag{1}$$

where $$L_R^{\ P} = \varphi\, L_R \tag{2}$$

L_R^P represents the maximum direct economic impact in probabilistic terms on public and private stocks that are governments' responsibility. The value of public sector capital inventory losses is a fraction φ of the loss of all affected goods, L_{R}, which is associated with an MCE of intensity I_R, and whose annual exceedance rate (or return period, R) is defined in the same way for all countries. This total loss L_R, can be estimated as follows:

$$L_R = E\, V(I_R F_S)\, K \tag{3}$$

where, E is the economic value of all the property exposed; $V(\ )$ is the vulnerability function, which relates the intensity of the event with the fraction of the value that is lost if an event of such intensity takes place; I_R is the intensity of the event associated to the selected return period; F_S is a factor that corrects intensities to account for local site effects; and K is a factor that corrects for uncertainty in the vulnerability function. Detailed information about the loss estimation can be found in Ordaz and Santa-Cruz (2003).

The economic resilience, R_E^P (the denominator of the index), is defined in equation 4:

$$R_E^{\ P} = \sum_{i=1}^{n} F_i^{\ P} \tag{4}$$

where F_i^P represents the possible internal and external resources, that were available to the government, in its role as a promoter of recovery and as owner of affected goods, when the evaluation was undertaken. The resources taken into account includes: the insurance and reassurance payments that the country would approximately receive for goods and infrastructure insured by government; the reserve funds for disasters that the country has available during the evaluation year; the funds that may be received as aid and donations, public or private, national or international; the possible value of new taxes that the country could collect in case of disasters; the margin for budgetary reallocations of the country, which usually corresponds to the margin of discretional expenses available to government; the feasible value of external credit that the country could obtain from multilateral organisms and in the external capital market; and the internal credit the country may obtain

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from commercial and, at times, the Central Bank, when this is legal, signifying immediate liquidity.

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. For greater DDI, greater gap between losses and the country's ability to face them. If constrictions for additional debt exist, this situation implies the impossibility to recover.

A complementary indicator, DDI', has been developed to illustrate the portion of a country's annual Capital Expenditure, $E_C^{\,P}$, which corresponds to the expected annual loss, $L_y^{\,P}$, 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.

$$DDI' = \frac{\text{Expected annual loss}}{\text{Capital expenditures}}\ ,\ DDI' = \frac{L_y^{\,P}}{E_C^{\,P}} \qquad (5)$$

The pure premium 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 major future disasters. The DDI' was also estimated with respect to the amount of sustainable resources due to inter-temporal surplus.

Figures 2 and 3 show the results for the DDI_{500} (with a MCE with 500 years of return period) and DDI' for countries of Latin America and the Caribbean (LAC) for 2008.

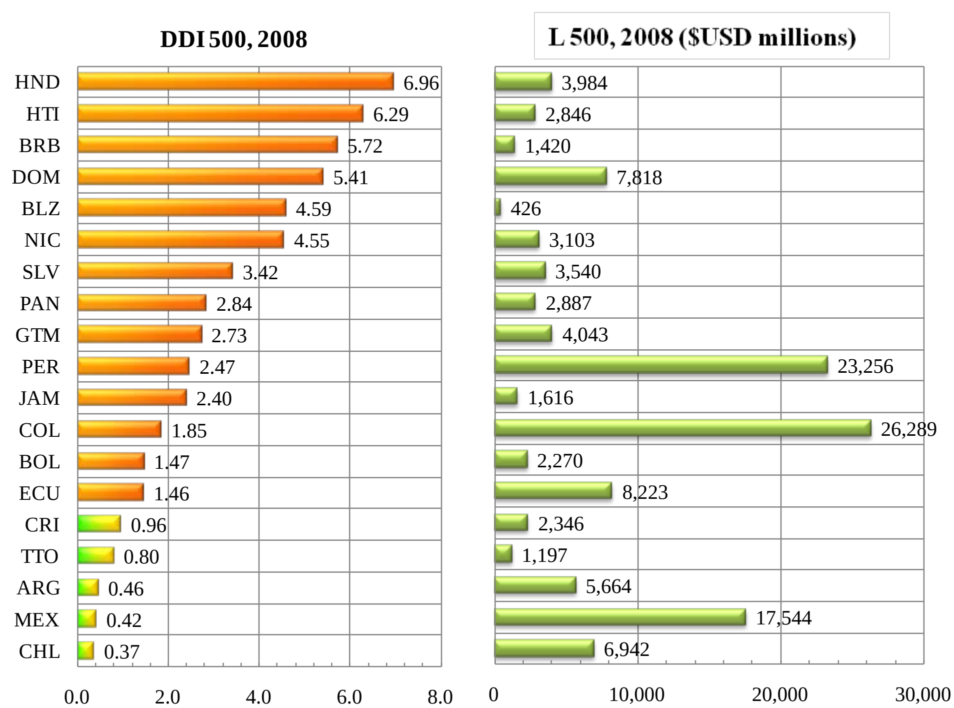

Figure 2. DDI (500 year period of return) and probable maximum loss for 500 years return period for 19 countries if the Latin American and Caribbean Region in 2008

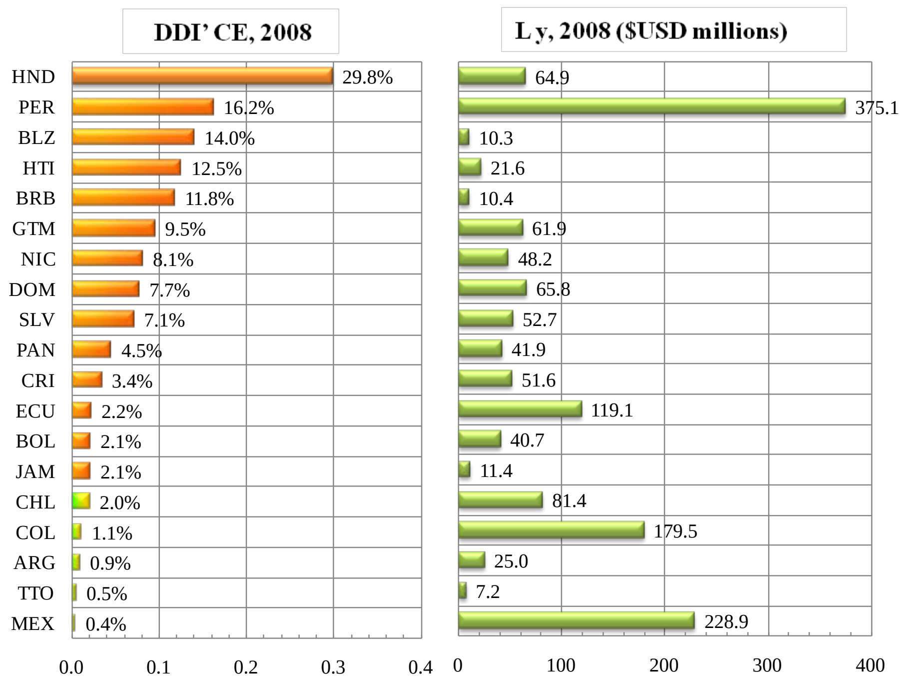

Figure 3. DDI' based on capital expenditure and the average annual loss for 19 countries of the Latin America de Caribbean region in 2008

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 decision makers 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. 2002). 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.

THE LOCAL DISASTER INDEX (LDI)

The LDI identifies the social and environmental risks resulting from more recurrent lower level events (which are often chronic at the local and subnational levels). These particularly affect the more socially and economically fragile population and generate a highly damaging impact on the countries development. 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

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the result of socio-natural processes associated with environmental deterioration (Lavell 2003a/b) 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.

The LDI is equal to the sum of three local disaster sub-indices that are calculated based on data from the DesInventar database (made by the Network of Social Studies in Disaster Prevention of Latin America, La RED in Spanish) for number of deaths *K*, number of people affected *A*, and losses *L* in each municipality, taking into account four wide groups of events: landslides and debris flows, seismo-tectonic, floods and storms, and other events. LDI is obtained from equation 6:

$$LDI = LDI_K + LDI_A + LDI_L \tag{6}$$

The DesInventar database contains a historical inventory of disasters and a methodology for analysis. It consists of a software application that allows for gathering, systematising, organising and consulting information recorded in the system both from a spatial and temporal point of view, as well as for the development of an information capturing and analysis methodology. The database analyses small disasters as a set of adverse impacts on goods, infrastructure, lives and social relations caused by the interaction of socio-environmental and anthropogenic phenomena in given vulnerability conditions. More information about this database can be found at http://www.desinventar.org/.

Figure 4 illustrates schematically how LDI is obtained for a country based on the information of events in each municipality.

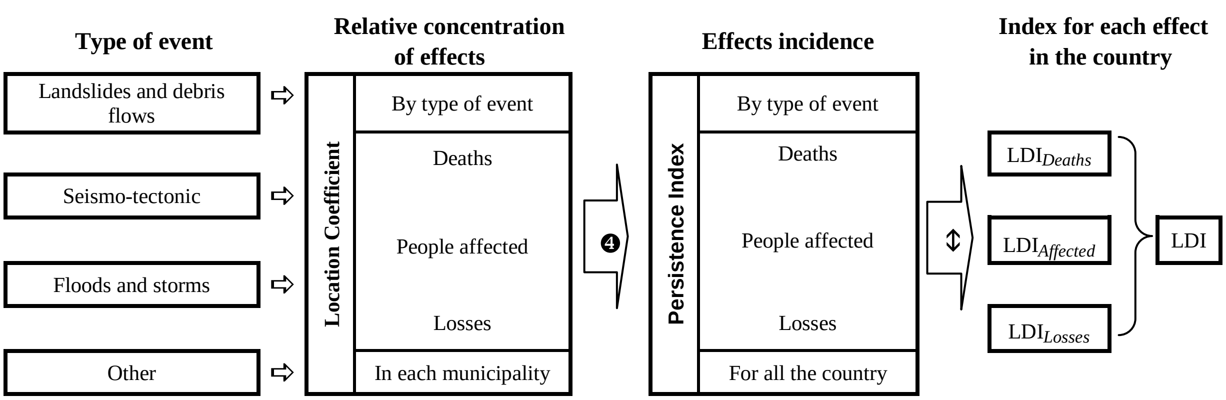

Figure 4. Diagram for the calculation of the LDI (IDEA 2005)

The local disaster subindicators for each type of variable (*K*,*A*,*L*) are obtained from equation 7 according to the new modified formulation (Marulanda and Cardona 2006; Marulanda et al. 2008, 2008a),

$$LDI_{(K,A,L)} = \left(1 - \sum_{e=1}^{E} \left(\frac{PI_e}{100}\right)^2\right) \lambda \Big|_{(K,A,L)} \tag{7}$$

λ is a scaling coefficient and *PIe*, as expressed in equation 8, corresponds to the Persistence Index of effects (*K*,*A*,*L*) caused by each type of event e,

$$PI_{e(K,A,L)} = 100 \sum_{m=1}^{M} \frac{LC_{em}}{LC_m} \Big|_{(K,A,L)} \tag{8}$$

where

$$LC_{m\,(K,A,L)} = \sum_{e=1}^{E} LC_{em\,(K,A,L)} \tag{9}$$

LC_{em} corresponds to a Location Coefficient of effects *x* (*K*,*A*,*L*) caused by each type of event *e* in each municipality *m*, as is established in equation 10,

$$LC_{em\,(K,A,L)} = \frac{x_{em}\, x_{eC}}{x_m\, x_C}\, \eta \,\Big|_{(K,A,L)} \tag{10}$$

where the values of variable *x* corresponding to *K*, *A* or *L*, are:
x_{em} the value *x* caused by event *e* in municipality *m*;
x_m sum totals for *x* caused by all types of event considered in municipality *m*;
x_{eC} the value of *x* for event *e* throughout the country;
x_C the total sum of *x* throughout the country, and
η is the relation between all types of events *E* and the number of municipalities in country *M*, where some effects have been registered.

These coefficients account for the relative weight of the effects caused by different types of events in the municipalities with respect to the country as a whole. Therefore, the Persistence Indices capture simultaneously for a given period (year, five years etc.) the incidence –or relative concentration– and the homogeneity of local level effects for each type of event with respect to other municipalities and types of events in the country.

The LDI captures simultaneously the incidence and uniformity of the distribution of local disaster effects; i.e. it accounts for the relative weight and persistence of the disaster effects at county scale. The total LDI is obtained by the sum of three LDI's that are calculated based on the information available in the DesInventar database, regarding deaths, affected people and economic losses in each county of the country. If the relative value of the index is high, the uniformity of the magnitude and distribution of the effects of various hazards among counties is greater. A low LDI value means low spatial distribution of the effects among the counties 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 counties and a low spatial distribution of their effects between the counties where they had taken place. Medium LDI values (20-50) means small disasters concentration and distribution of their effects are intermediate; high LDI values (greater than 50) indicate that the majority of counties suffer small disasters and their effects are similar in all affected counties. High values reflect that vulnerability and hazards are generalized in the territory.

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The LDI takes into account only the small and moderate events, the extreme events are excluded from the database through statistical identification of outliers (Marulanda and Cardona 2006; Marulanda et al. 2008a/b).

In a complementary way, an LDI' that measures the concentration of aggregate losses at county level has been formulated. Its value is between 0.0 and 1.0. A high LDI' value means that high economic losses concentration due to small disasters has occurred in few counties. For example, an LDI' equal to 0.66 and 0.83 means that approximately 10% of counties of the country concentrates approximately 35% and 97% of the losses respectively. More details about the calculation method can be found in Cardona (2005), Marulanda et al. (2008, 2008a, 2010)

Figure 5 shows an example of results of the LDI for countries of Latin America and the Caribbean region in the period 1996 to 2000.

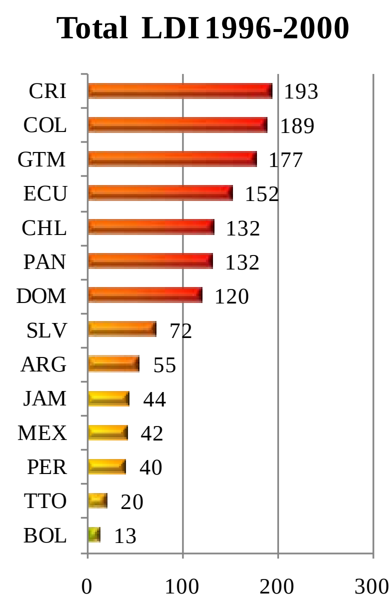

Figure 5. Total LDI 1996-2000

PREVALENT VULNERABILITY INDEX (PVI)

The PVI is made up of a series of indicators that characterize prevailing vulnerability conditions reflected in exposure in prone areas, socioeconomic fragility and lack of resilience in general. 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 (IDEA 2005). Inherent vulnerability conditions underscore the relationship between risk and development (UNDP 2004). Vulnerability, and therefore risk, is 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

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capture favorable conditions for direct physical impacts (exposure and susceptibility, ES), as well as indirect and, at times, intangible impacts (socio-economic fragility, SF, and lack of resilience, LR) of potential physical events (Masure 2003; Davis, 2003). The PVI, as shown in equation 11 is an average of these three types of composite indicators:

$$PVI = PVI_{ES} + PVI_{SF} + PVI_{LR} \tag{11}$$

The sub-indices for prevalent vulnerability conditions for each type of situation (*ES*, *SF*, *LR*) are obtained from equation 12

$$PVI^{t}_{c(ES,SF,LR)} = \frac{\sum_{i=1}^{N} w_i I^{t}_{ic}}{\sum_{i=1}^{N} w_i} \bigg|_{(ES,SF,LR)} \tag{12}$$

where, w_i is the weight assigned to each indicator, corresponds to each normalized indicator as expressed in equations 13 and 14. These represent the conditions of vulnerability for each situation (*ES*, *SF*, *LR*) respectively,

$$I^{t}_{ic} = \frac{x^{t}_{ic} - \min(x^{t}_{i})}{rank\,(x^{t}_{i})} \quad \text{, for (ES, SF)} \tag{13}$$

and

$$I^{t}_{ic} = \frac{\max(x^{t}_{i}) - x^{t}_{ic}}{rank\,(x^{t}_{i})} \quad \text{, for (LR)} \tag{14}$$

x^{t}_{ic} is the original data for the variable for country *c* during time period *t*, and

x^{t}_{i} is the variable considered jointly for all countries.

x^{t}_{M} it is the maximum value defined for the variable at *t* period

x^{t}_{m} it is the minimum value defined for the variable at *t* period

(x^{t}_{i}) rank it is the difference between the maximum and minimum value (x^{t}_{M} - x^{t}_{m}) at *t* period.

The weighting technique used to obtain the PVI was the Analytic Hierarchy Process (AHP); a widely used technique for multi-attribute decision making proposed by Saaty (1980, 1987).

The indicators used for describing exposure, prevalent socioeconomic conditions and lack of resilience have been estimated in a consistent way (directly or in inverse way, accordingly), recognizing that their influence explains why adverse economic, social and environmental impacts take place following a dangerous event (Cardona and Barbat 2000; Cardona 2004). 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. Figure 6 presents the structure of the PVI

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as a composite index, the component indicators used for exposure and susceptibility; social fragility and lack of resilience are listed. These indicators are obtained from national and international data bases and mainly from the World Development Indicators (WDI) of the World Bank.

In general, PVI reflects susceptibility due to the degree of physical exposure of goods and people, PVI_{ES}, which favour the direct impact in case of hazard events. In the same way, it reflects conditions of socioeconomic fragility that favour the indirect and intangible impact, $PVI_{SF.}$ Also, it reflects lack of capacity to absorb consequences, for efficient response and recovering, PVI_{LR}. Reduction of these kinds of factors, as the purpose of the human sustainable development process and explicit policies for risk reduction, is one of the aspects that should be emphasized. More information about the used indicators can be find in (Masure 2003; Lavell 2003a/b; Cannon 2003; Davis 2003; Wisner 2003, Benson 2003; Briguglio 2003). Details about the calculation method are in Cardona (2005).

Description	Indicator	Weight
Population growth, average annual rate (%)	**ES1**	*w1*
Urban growth, avg. annual rate (%)	**ES2**	*w2*
Population density, people/5 Km^2	**ES3**	*w3*
Poverty-population below US$ 1 per day PPP	**ES4**	*w4*
Capital stock, million US$ dollar/1000 km^2	**ES5**	*w5*
Imports and exports of goods and services, % GDP	**ES6**	*w6*
Gross domestic fixed investment, % of GDP	**ES7**	*w7*
Arable land and permanent crops, % land area	**ES8**	*w8*

→ PVI_{ES}

Description	Indicator	Weight
Human Poverty Index, HPI-1	**SF1**	*w1*
Dependents as proportion of working age population	**SF2**	*w2*
Social disparity, concentration of income measured using Gini index	**SF3**	*w3*
Unemployment, as % of total labor force	**SF4**	*w4*
Inflation, food prices, annual %	**SF5**	*w5*
Dependency of GDP growth of agriculture, annual %	**SF6**	*w6*
Debt servicing, % of GDP	**SF7**	*w7*
Human-induced Soil Degradation*	**SF8**	*w8*

→ PVI_{SF} → **PVI**

Description	Indicator	Weight
Human Development Index, HDI [Inv]	**LR1**	*w1*
Gender-related Development Index, GDI [Inv]	**LR2**	*w2*
Social expenditure; on pensions, health, and education, % of GDP [Inv]	**LR3**	*w3*
Governance Index [¥] [Inv]	**LR4**	*w4*
Insurance of infrastructure and housing, % of GD [Inv]	**LR5**	*w5*
Television sets per 1000 people [Inv]	**LR6**	*w6*
Hospital beds per 1000 people [Inv]	**LR7**	*w7*
Environmental Sustainability Index, ESI [Inv]	**LR8**	*w8*

→ PVI_{LR}

Figure 6. Diagram for the estimation of PVI_{ES}, PVI_{SF}, PVI_{LR} and the total PVI (IDEA 2005)
* For example the Global Assessment of Human-induced Soil Degradation (GLASOD) (Oldeman et al. 1990)

¥ Scaling of six indicators that consider some dimensions of governance: The Voice and Accountability; Political Stability; Absence of Violence; Government Effectiveness; Regulatory Quality; Rule of Law; and Control of Corruption (Kaufmann et al. 2003).

Figure 7 shows the obtained results of the total PVI for 1995, 2000, 2005 and 2007. Figure 8 shows the results for 2007 as a ranking of the evaluated countries.

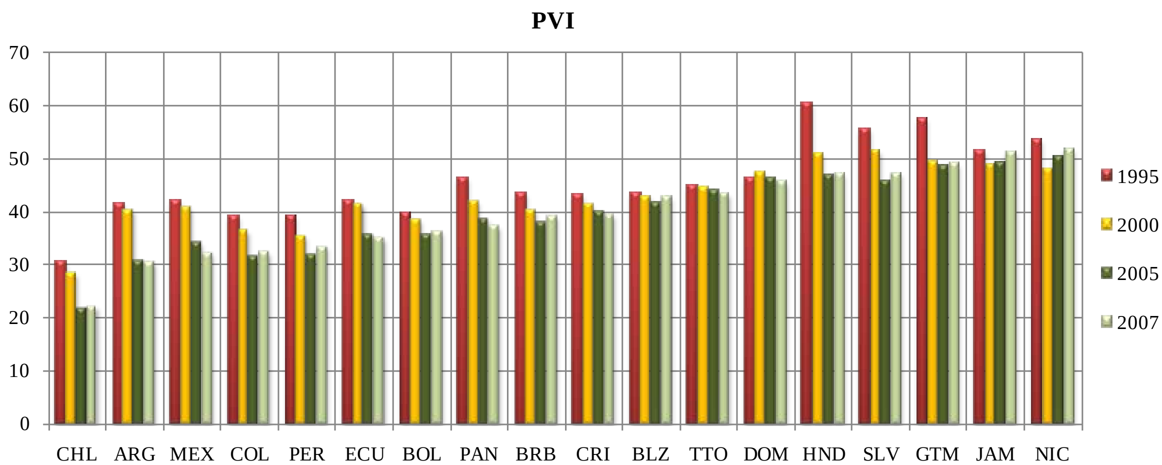

Figure 7. PVI for the 18 countries of the Latin America and Caribbean region

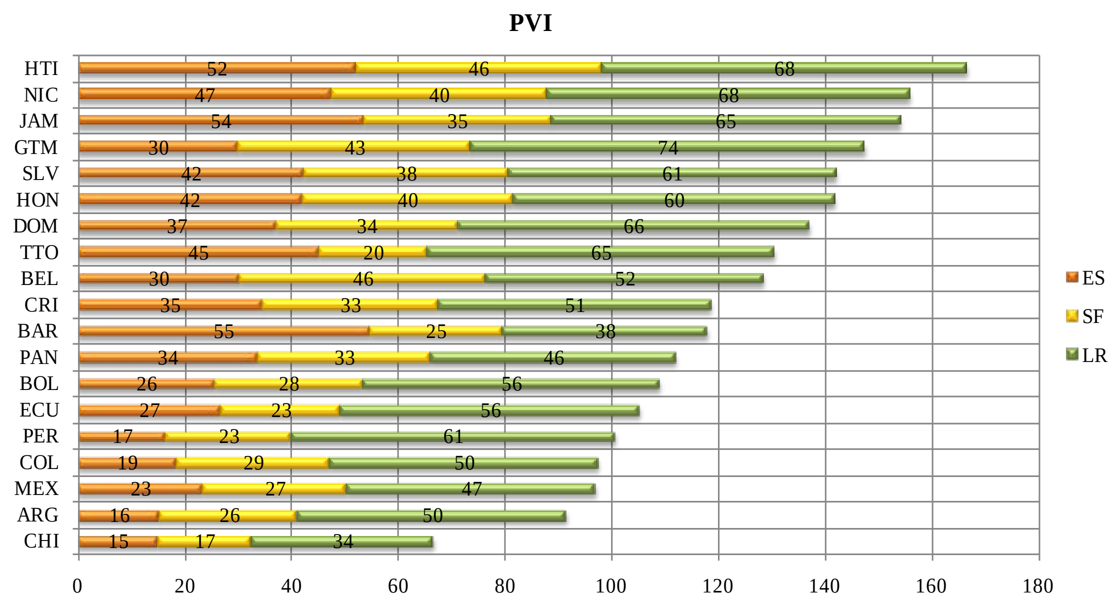

Figure 8. PVI of 2007 for the evaluated countries

THE RISK MANAGEMENT INDEX (RMI)

The RMI 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 crises and to recover efficiently from disasters (Carreño et al. 2004, 2007). 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 RMI 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; Munda and Nardo 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, as indicated in equation 15, is defined as the average of the four composite indices:

$$RMI = (RMI_{RI} + RMI_{RR} + RMI_{DM} + RMI_{FP})/4 \tag{15}$$

The indicators for each type of public policy (*RI, RR, DM, FP*) are obtained through equation 16,

$$RMI^{t}_{c(RI,RR,DM,FP)} = \left.\frac{\sum_{i=1}^{N} w_i \, I^{t}_{ic}}{\sum_{i=1}^{N} w_i}\right|_{(RI,RR,DM,FP)} \tag{16}$$

where, w_i is the weight assigned to each indicator, RMI^{t}_{ic}

corresponding to each indicator for the territorial unity in consideration *c* and the time period *t* –normalized or obtained by the defuzzification of the linguistic values. 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). These represent the risk management performance levels defined by each public policy respectively. Such linguistic values, according to the proposal of Cardona (2001) are the same as a fuzzy set that have a membership function of the bell or sigmoidal (at the extremes) type, given parametrically by the equations 17 and 18.

$$bell(x;a,b,c) = \frac{1}{1 + \left|\frac{x-c}{a}\right|^{2b}} \tag{17}$$

where the parameter *b* is usually positive.

$$sigmoidal(x;a,c) = \frac{1}{1 + \exp\left[-a(x-c)\right]} \tag{18}$$

where *a* controls the slope at the crossing point, 0.5 of membership, *x* = *c*.

These weights have been assigned using Analytic Hierarchy Process (AHP); see Saaty and Vargas (1991). Figure 9 shows the structure of the RMI as a composite index.

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 (Carreño et al. 2004; 2005,).

Indicator	Description	Weight
RI1	Systematic disaster and loss inventory	w_{RI1}
RI2	Hazard monitoring and forecasting	w_{RI2}
RI3	Hazard evaluation and mapping	w_{RI3}
RI4	Vulnerability and risk assessment	w_{RI4}
RI5	Public information and community participation	w_{RI5}
RI6	Training and education on risk management	w_{RI6}
RR1	Risk consideration in land use and urban planning	w_{RR1}
RR2	Hydrographical basin intervention and environmental protection	w_{RR2}
RR3	Implementation of hazard-event control and protection techniques	w_{RR3}
RR4	Housing improvement and human settlement relocation from prone-areas	w_{RR4}
RR5	Updating and enforcement of safety standards and construction codes	w_{RR5}
RR6	Reinforcement and retrofitting of public and private assets	w_{RR6}
DM1	Organization and coordination of emergency operations	w_{DM1}
DM2	Emergency response planning and implementation of warning systems	w_{DM2}
DM3	Endowment of equipments, tools and infrastructure	w_{DM3}
DM4	Simulation, updating and test of inter institutional response	w_{DM4}
DM5	Community preparedness and training	w_{DM5}
DM6	Rehabilitation and reconstruction planning	w_{DM6}
FP1	Interinstitutional, multisectoral and decentralizing organization	w_{FP1}
FP2	Reserve funds for institutional strengthening	w_{FP2}
FP3	Budget allocation and mobilization	w_{FP3}
FP4	Implementation of social safety nets and funds response	w_{FP4}
FP5	Insurance coverage and loss transfer strategies of public assets	w_{FP5}
FP6	Housing and private sector insurance and reinsurance coverage	w_{FP6}

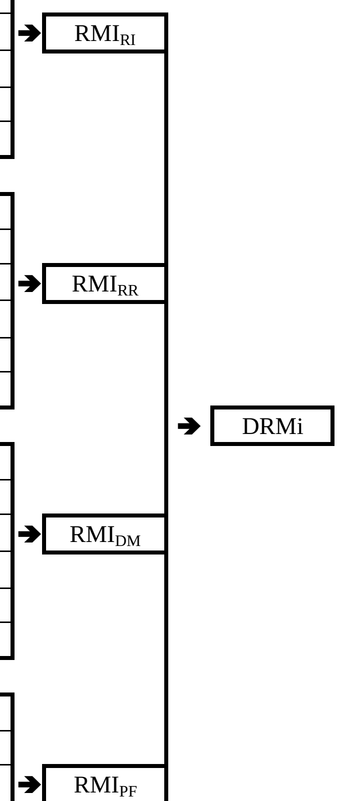

Figure 9. Component indicators of the DRMi (IDEA 2005, Carreño et al. 2007)

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 decision makers. 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 metric of risk seen as a basis for intervention is relevant when the population recognizes and understands that risk.

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The major aim of risk management is to reduce risk (RMI_{RR}). 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 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 preparedness 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.

Adequate governance and financial protection (RMI_{FP}) 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.

Figure 10 displays the results of the application of the RMI in countries of LAC region from 1990 to 2008, each five years and Figure 11 displays the ranking of the countries for 2008. More details about this methodology and its application can be find in Cardona (2005, 2008, 2010), Carreño (2006), Carreño et al. (2004, 2007)

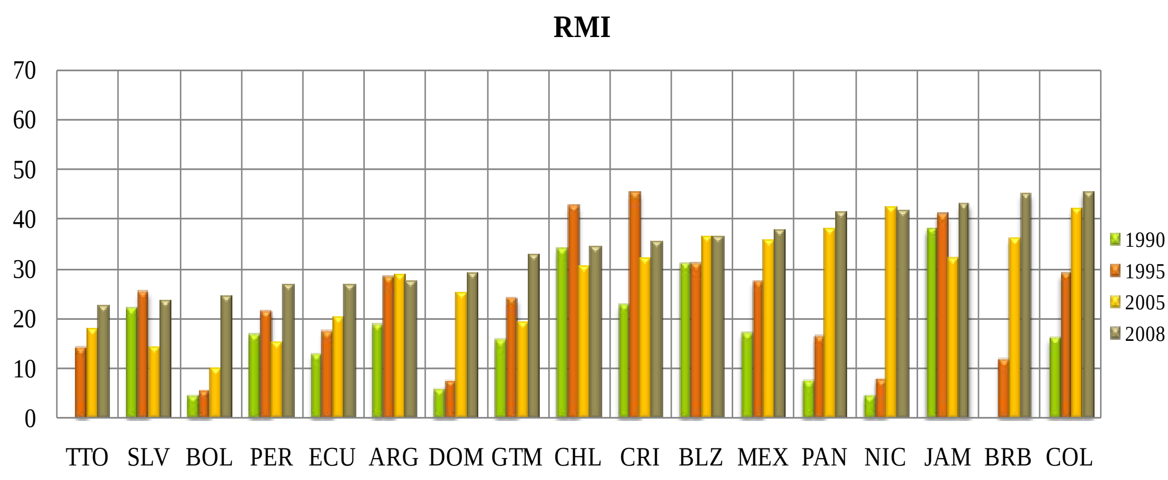

Figure 10. DRMi for 17 countries of the LAC region

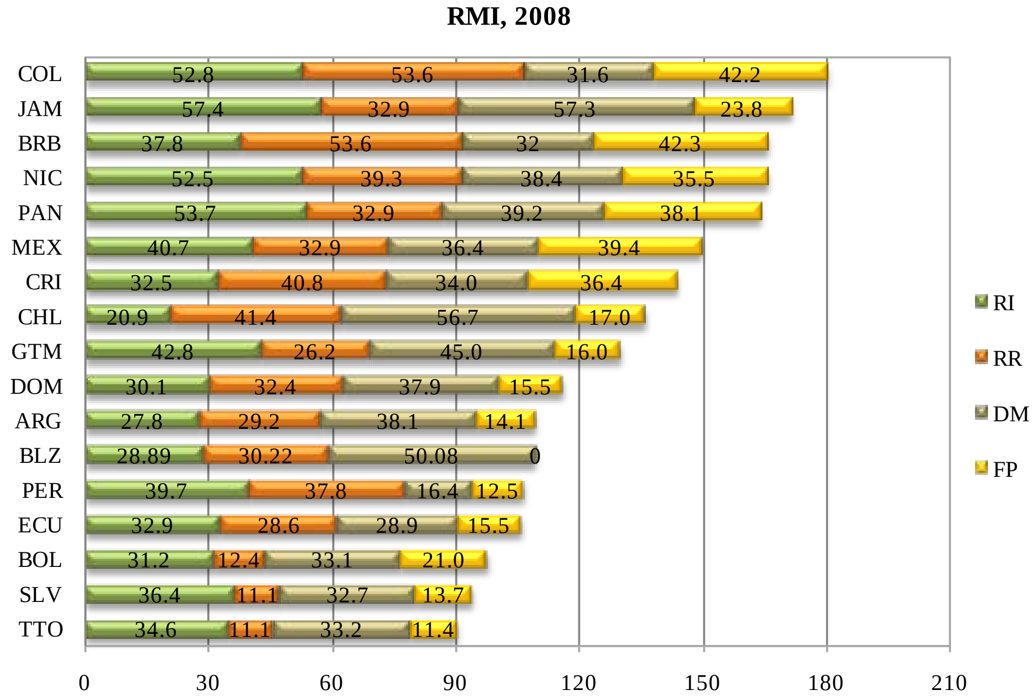

Figure 11. DRMi for 2008

CONCLUSIONS AND FUTURE ANALYSIS

The program of indicators laid heavy emphasis on developing a language of risk that various kinds of decision makers understand. 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 RMI is also novel and far more wide-reaching in its scope than other similar attempts in the past. In some ways this is the most sensitive and interesting indicator of all. It is certainly the one that can show the fastest rate of change given improvements in political will or deterioration of governance. This index has the advantage of being composed of measures that more or less directly map sets of specific decisions/actions onto sets of desirable outcomes. The indicators of risk and risk management described here have permitted an evaluation of eighteen 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 1980–2008. The reports of the program also estimated the indicators at the subnational and urban level. This profile is a first step for creating a “common operating picture” of disaster risk reduction for the region. That is, it represents a common knowledge base that can be accessed, viewed, and understood by all of the different policy makers responsible for disaster risk reduction in the region. Any group that is not included or that fails to comprehend the level and frequency of risk will likely fail to engage actively in the risk reduction process. Consequently, the construction of an effective common knowledge base for the system of decision makers responsible for disaster risk reduction is fundamental to achieving change in practice.

Undoubtedly, the construction of the indicators is methodologically complex for run-of-the-mill professionals whilst the demands for information are relatively onerous in some cases, given access and identification problems. Certain variables or types of information are not readily available and require research as opposed to rote collection where such information exists as a normal part of data systematization at the national or international levels. Doubts exist as to the veracity and accuracy of some items of information, although overall the procedures used to “test” the information assure a very reasonable level of accuracy and veracity. In the same way, weighting procedures and decisions could be questioned at times but again, overall, the decisions taken seem to be well justified and lead to adequate levels of accuracy. The use of official employees of risk management institutions at the national level in order to undertake the qualitative analyses is open to revision given the clear bias, in some cases, in favor of positive qualifications. The alternative, using scientists, informed independent persons and academics would resolve certain problems but may create others. Thus, maybe a cross check double entry approach is best where both types of sectors are taken into consideration.

To date the system of indicators has been opened up to scrutiny and discussion by international advisors, academics, risk professionals and a limited number of national technical and professional staff, but too few policy makers as such. In the short term it would thus be very wise to organize a series of national dialogues where the derived indicator results and implications are presented to a selected number of national level policy and decision makers. This would allow a testing of relevance and pertinence and offer conclusions as regards future work on the program. It is very important to take into account the set of “next steps” that might be taken to improve the reliability and validity of the data collected and the analyses undertaken. In the future, sustainability for the program and promoting its applicability at the decision maker level requires, amongst other things: a) Dissemination of the guidelines to easy analysis and indicator calculation; b) Transformation of indices into political indicators; c) The diffusion and acceptance of the indicators and the method by national decision makers in analyzed countries and in others, and d) An agreement as to procedures for future collection of information and analysis.

Lastly, perhaps the most important contribution of the program was to initiate a systematic procedure of measuring and documenting disaster risk across the twelve nations engaged in this project. Once initiated, however, the program itself becomes a process in which the participants learn by engaging in data collection, analysis, and interpretation of findings. Some of the methods, adopted because no other measures existed, may now be reexamined and redesigned as cumulative data show new possibilities for refining the measures, or as data collection methods yield new possibilities for more complete and comprehensive documentation of risk and risk reduction practices.

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