INTER-AMERICAN DEVELOPMENT BANK

Universidad Nacional de Colombia - Sede Manizales
Instituto de Estudios Ambientales
- IDEA -

INFORMATION AND INDICATORS PROGRAM FOR DISASTER RISK MANAGEMENT
IADB - ECLAC - IDEA

EXECUTION OF COMPONENT II

Indicators for Disaster Risk Management

OPERATION ATN/JF-7907-RG

INDICATORS FOR RISK MEASUREMENT
Methodological Fundamentals

Study coordinated by
Instituto de Estudios Ambientales

Manizales - Colombia
August 2003

INTER-AMERICAN DEVELOPMENT BANK
Universidad Nacional de Colombia - Sede Manizales
Instituto de Estudios Ambientales - IDEA

INFORMATION AND INDICATORS PROGRAM FOR DISASTER RISK MANAGEMENT

IADB - ECLAC - IDEA

EJECUTION OF COMPONENT II

Indicators for Disaster Risk Management

OPERATION ATN/JF-7907-RG

INDICATORS FOR RISK MEASUREMENT

Methodological Fundamentals

Prepared by
Omar D. Cardona
Technical Director

With

Jorge Eduardo Hurtado — **Ann Catherine Chardon**
Gonzalo Duque — **Luz Stella Velásquez**
Alvaro Moreno — **Samuel D. Prieto**

Taking into account
The expert meeting on disaster risk conceptualization and indicators modeling, Barcelona, July 9, 10 and 11 of 2003

Ian Davis — **Allan Lavell**
Alex Barbat — **Philippe Masure**
Lino Briguglio — **Louise Comfort**
Terry Cannon — **Andrew Maskrey**
Neil Doherty — **Tova Solo**
Caroline Clarke — **Kari Keipi**

Manizales - Colombia
August 2003

INDICATORS FOR RISK MEASUREMENT
Methodological Fundamentals[1]

1. Introduction

In general, countries have tended to be risk takers; under-investing in the reduction of vulnerability and relying on external support for reconstruction after the event takes place. In the aftermath of recent disasters, many countries have decided to allocate resources, before the occurrence of a possible disaster to better protect people and safeguard economic activities. This proactive approach calls for a fundamental shift in governments' role in disaster management, from the current policy of attempting to better prepare, respond and recover in the case of emergencies (the current policy, which has not halted rising disaster losses), toward a risk reduction and management approach that facilitates and supports the activities of a broad set of government, local authorities and private actors in reducing vulnerability within an integrated development framework (Clarke and Keipi 2000).

Necessarily, this framework requires governments and other stakeholders to take a broader view of disaster risk, and to develop a better understanding of the performance mechanisms of risk management, in the context of economic and social development. This requires improved data on the severity and frequency of natural phenomena in a particular place, and on the existing levels of vulnerability and resilience, in their physical, economic, social and environmental dimensions. This calls also for a far more convincing policy-oriented analysis of such data. This implies that government attention must focus on reducing disaster risk as a contribution to sustainable development, and not so much on emergencies *per se.* In turn, this approach requires operational tools for measuring vulnerability and risk management performance. By focusing attention on the different levels of vulnerability and disaster risk and on the range of causal factors which give rise to vulnerability and risk across countries, and on the fact that viable policies, approaches and strategies exist to intervene many of these causal factors, it may be possible to encourage the different stakeholders to take a more proactive role in reducing risk. Attention must be focused on the social, economic and territorial processes that are the primary causal factors explaining risk accumulation and recognition must be given to the fact that these are susceptible to modification through the adoption of appropriate policies, legislation, instruments and governance structures (Cardona and Maskrey 2000).

Deficiencies in data and poor quantitative analysis hamper governments in making informed choices concerning desirable risk management policies and other policies that may have major impacts on a country's vulnerability levels. In general, there are hard and fast rules as to what

[1] This document is the result of inputs and discussions of the local group of experts of the Instituto de Estudios Ambientales, IDEA, Universidad Nacional de Colombia, Manizales, and the contributions made during the expert meeting on disaster risk conceptualization and indicators modeling, held in Barcelona in July 9,10 and 11, 2003, for the execution of the Component II, Indicators of Risk Management, IADB Operation ATN/JF-7907-RG. This report has been developed by Omar D. Cardona, technical director of the project and the opinions expressed herein are only those of the authors and do not necessarily reflect the position of the Inter American Development Bank. The document is located in: http://idea.unalmzl.edu.co

constitutes a norm in a well-functioning risk management system, or how best to move towards its achievement. At present, the vulnerability and risk management performance of most countries cannot be effectively monitored to enable decision-makers to determine whether and to what extent vulnerability is diminishing or growing, or whether broad risk management policy goals are being attained. Put in a global or regional context, it is not possible, with the measurement tools available to determine how a particular country is faring in relation to others, or whether a country's performance is above or below the expected benchmark, taking into account its own particular circumstances.

A central feature or objective of the present "IADB/IDEA Indictors Program" is to construct a indicators model or index that describes comparative levels of disaster risk in different countries and allows the identification of the principal factors that contribute to the configuration of risk in each country (Clarke and Keipi 2000). The model will be constructed on the basis of a number of readily available and reasonably robust variables, which allow a *coarse grain* or low-resolution analysis of risk at a scale appropriate for national decision-making. Ideally, the risk model (index) will not only highlight the comparative levels of risk between countries, but also the factors that should be considered in order to reduce that risk. By focusing on vulnerability and risk, the indicators would be multi-sectorial in scope and social in focus, looking at the relative probabilities of a society being unable to absorb the impact and recover from a given range of dangerous events. The indicators (index) model would then be used as a tool to focus attention on risk, to stimulate actions to reduce risks in disaster-prone countries and to set priorities for the allocation of development assistance (Cardona and Maskrey 2000). It would be 'indicative' and not attempt or pretend to be comprehensive or precise. It would be useful to inform decision-takers on priority areas for action and resource allocation, but it would *not* replace the need for detailed risk assessments and profiles as a basis for planning at the national and sub-national levels.

2. Concept and use of indicators

In order to undertake risk analysis it is necessary to estimate the hazard or threat and to evaluate vulnerability. Risk could be evaluated taking these two factors into account (Taylor *et al* 1998). Changes in one or the other of these factors change the risk levels. Once risk has been evaluated, it may be possible to define a level of what is known as "acceptable risk" i.e. the possible social, economic, and environmental consequences that a society or a component of it implicitly or explicitly can tolerate. From a technical perspective it corresponds to a probability value that certain impacts will occur in a given time period, and that these are considered acceptable with reference to the determination of minimum demands and security requirements. Calculation of "acceptable risk" can be useful for decisions on protection and planning, when society is faced with the possible occurrence of a dangerous phenomenon.

It has been common to measure risk solely in physical terms given that social vulnerability is difficult to evaluate quantitatively. This does not imply, however, that it is not feasible to analyze vulnerability in relative terms or by means of indicators and indices, thus allowing a vision of "relative risk" which permits decisions to be taken and priorities established as regards prevention and mitigation. Risk indices should take into account both the physical aspects of risk as well as the social and cultural aspects. Such indices may be formulated, in principle, in terms of loads and resistances, which would broadly represent pressure and capacity to withstand pressure (demand and capacity) as is done in physical engineering applications. Load refers to the impact of an extreme phenomenon on a social system. This has two dimensions, firstly the magnitude and severity of the phenomenon, and, secondly, the duration of exposure. These factors are relevant to both rapid and slow onset events and are determined by the expected recovery time. Resistance describes the ability of a population to face up to an extreme event. Such resistance or capacity to withstand pressure is a function of diverse technical and non-technical factors. The technical factors relate to the level of protection afforded by technical measures, such as, for example, by dykes and dams for protection against floods or satisfactory construction of buildings against earthquakes, storms and floods. The non-technical aspects include the economic capacity of the community, the ability of the population to self protect, the social structure and its organizational levels, amongst others. These options may also be termed hard and soft resistance, basing on the terminology used in climate change adaptation literature.

When an intense event occurs, the load and the resistance work against each other. If the resistance is greater than the load then the effects are dissipated and no damage occurs. If the resistance is lower than the load, damage or disaster occurs. Analyses of this type may be *a posteriori* but it is also possible to undertake such analysis *a priori*, in the case of future events, thereby constituting a planning tool. This requires a prediction of the likely load of the impact and the likely resistance to such an impact. The loads and resistances must, therefore, be based on credible probabilities of occurrence. That is to say, maximum values for loads and resistances should not be used, but, rather, combinations of feasible resistances and credible loads.

From the risk management angle, the term resistance is equivalent to a determined capacity level, or, inversely, a critical level of vulnerability. The term load refers to the action of the phenomenon. Critical vulnerability is equivalent to the load a community can bear prior to recurring to external aid. Disaster occurs when the hazard (load) exceeds critical vulnerability levels (Plate 2002). This is a powerful engineering heuristic and illustrates that risk can be expressed in uni-dimensional numerical values. Amongst other things, this approach permits the design of indexes or indicators, as has previously been mentioned. In development and territorial planning contexts it is necessary to compare the load and critical vulnerability as a function of time, given that these two factors are not constant. As stated above, vulnerability is made up of many different components and depends on numerous factors such as physical and social frailty and social resilience. The lack of resilience is a vulnerability factor and critical in determining the time of recovery of the affected unit.

Finally, the validity of a risk model will depend on the existence of reliable and good quality data that satisfy the demands of the conceptual model. At present, data availability is still a major constraint. Most existing risk information is limited to hazard patterns. There is little comparative and accurate quantitative data on social and economic vulnerability, or on risk reduction factors. Data is produced in widely different formats and scales and in an *ad hoc* manner that renders its compilation and aggregation problematic. Due to institutional and human resource constraints, data is rarely collected systematically over long time periods. Most existing impact data such as that from insurance sources is limited to large-scale disasters, and that pertaining to small-scale events is often uneven and incomplete (UNDP 2000).

There are a wide range of approaches for integrating data and modeling risk and vulnerability. Inductive approaches model risk through weighting and combining different hazard, vulnerability and risk reduction variables. Deductive approaches are based on the modeling of historical patterns of materialized risk (i.e. disasters, or damage and loss that have already occurred). Other approaches combine the results of inductive and deductive modeling. An obstacle to inductive modeling is the lack of accepted procedures for assigning values and weights to the different vulnerability and hazard factors that contribute to risk. Deductive modeling will not accurately reflect risk in contexts where disasters occur infrequently or where historical data is not available. In spite of this weakness, deductive modeling offers a short cut to risk indexing in many contexts and can be used to validate the results from inductive models. There are no standard procedures for measuring or weighting the effectiveness of risk reduction, given the large number of stakeholders and the wide variety of activities involved. Approaches based on fuzzy logic and expert systems, however, can enable quantitative values to be assigned.

2.1 The usefulness of an indicators model

In order to conceive an indicators model for risk and risk management, we need, in general, to first reflect on the concept and utility of indicators as such. This requires an epistemological critique and an analysis of their appropriateness in terms of the dimensioning of risk and management options. This comprises the relationship between knowledge and policy definition and this relationship must be as solid as possible.

The usefulness of indicators depends on how they are employed. The way in which indicators are used to produce a diagnosis has various implications. The first relates to the structuring of the theoretical model. The second refers to the way risk management objectives and goals are decided on. This aspect is important given that it is preferable to promote an understanding of reality not in strict terms of the ends to be pursued, but, rather, in terms of the identification of a range of possibilities, information on which is critical to organize and orientate the praxis of effective intervention. History is seen as a movement in the structure of reality and in the genesis of social profiles, rather than as a description of its morphology. This means that we need a risk diagnosis that, as far as possible, permits decision-making, recognizing the double dimension that risk represents: a given situation and a possible future. Recognition of this double dimension using indicators allows us to reflect on the potentialities present in a given situation. Knowledge of this offers a basis for organizing effective intervention through risk management (Cardona 2003a/b).

The measurement of risk provides a diagnosis of the possibility and impact of a dangerous event, taking into account political, cultural and psychosocial factors. The utility of this exercise will depend on the reliability of the figures produced. Often, as opposed to providing a range of alternative development possibilities, a diagnosis evaluates the conditions required in order to achieve a previously fixed goal or offers a somewhat arbitrary reference point for evaluators. With risk, particular caution is required due to the importance of the notion of “acceptability” and decisions as to the cut off point that allows us to ascertain whether the situation is acceptable or not. An important consideration in this regard relates to summing and weighting procedures. Inappropriate weighting may lead to distortion of reality.

Another consideration relates to the aggregative level at which the index is pitched. Moreover, we also need to know if the diagnosis permits us to distinguish between conjuncture and structural processes and micro and macro spatial scales. The latter distinction is of great importance in risk analysis given the local character and dimensions of risk. Analysis at a macro scale (at the national level, for example) may hide information about local and regional levels. Conversely, if the aggregation level is to narrow, the information may not be useful enough for national purposes.

Thus, in the same way as we may make reference to the significant articulation of concrete and abstract categories, we may also conceive the articulation of concepts and indicators thus providing an indicative structure. Faced with the difficulty of finding adequate indicators for representing risk and risk management it is important to emphasize the possibility of using "tracer" or joint indicators. Here, we are dealing with indicators that not only indicate orders of magnitude, but that may also help contribute to an understanding of a total or holistic situation (Cardona and Barbat 2000). This requires qualitative indicators that help provide an understanding of the significance of reality for particular actors. These indicators attempt to improve the limits of our understanding of reality. From this perspective the question is not how to arrive at an explanation that is increasingly exhaustive, using aggregation procedures, but rather how to enrich our understanding of reality in the most inclusive form possible. Thus, the problem basically refers to how we may establish a relationship between diverse concept-indicators and the empirical reality they are used to depict, in order that the structuring or linking of these not only reflects the specific characteristics of a given situation, but also indicates the different ways of advancing in the solution of problems.

The most serious weakness of indicators or indices is principally associated with subjectivity in their estimation, the selection of variables, the measurement technique used, and the aggregating procedures employed, when they are composite indicators. The question of the subjective selection of variables is difficult to resolve mainly because the weighting or value they are given is essentially qualitative. Particularly, if weighting is applied, an important subjective component is introduced (Briguglio and Pratt 1999). The measurement technique may have limitations due to the absence of data or the reliability of this. In the case of composite indicators these are the result of summing and averaging other sub indices. This may hide useful information of an individual nature. These aspects signify that in general, a model of indicators is susceptible to academic questioning. Due to this, and taking into account such limitations and weaknesses, the indicators should, as far as possible, be easy to measure, tangible and adequate for the level of aggregation of the system under analysis. They should be focused on clear and practical aspects, sensitive to changes in the system and the collection of information should neither be difficult or costly. Measurements should be susceptible to being repeated in the future. A problem often encountered when compiling composite indices relates to the summing and weighting of its components. There are no standard procedures for measuring or weighting the effectiveness of risk reduction, given the large number of stakeholders and the wide variety of activities involved.

Approaches based on fuzzy logic and expert systems, however, can enable quantitative values to be assigned

2.2 Risk indicators development

Different indicators can be designed for risk analysis and risk management purposes. These may include context indicators which can be descriptive or predictive, or management indicators that may relate to efficiency and results. They may be numeric, relational, or composed indicators, amongst others. In their design, we need to define what they express or singularize, design their attributes (quantity and quality) and specify the unit of measurement or operational unit (numerical, linguistic, or formula). The cases may vary in quantity and quality and can, therefore, be classified as qualitative and quantitative. The quality of an indicator depends on the quality of the components used in its design and the quality of the systems used in collecting and registering data. Specifically, the quality and utility of the indicator mainly relate to its validity (if it effectively measures what it attempts to measure) and reliability (if repeated measurement under similar conditions always give the same result). Other quality attributes of indicators are: specificity (that it only measures the phenomenon it intends to measure), sensitivity (that it can measure the changes that need to be measured), measurability (that it is based on available and easily obtained data), relevance (that it is able to give clear replies to the most important questions), comparability (that the variable can be used for comparisons across countries or over time) and cost-effectiveness (that the results justify the investment in time and other resources) (PAHO 2001). In addition care must be taken to avoid redundant variables (i.e. taking two variables which measure the same things are would therefore be very closely correlated).

The usefulness of a risk indicator will depend on the underlying conceptual framework. An indicator cannot be decontextualized given that it expresses the magnitude of a force in a given moment. This force results from the articulation of a series of processes that are integrated in a conditional manner and articulated to the constitutive actions of the subjects. Here we are dealing with the possible configuration of potential in progress: knowledge in order to transform (Zemelman, 1989). As argued above, there are many different definitions and conceptual models of hazard, vulnerability and risk currently in use. These can create confusion and impede communication of information. Establishing a set of clearly defined working definitions is therefore a basic precondition for modelling. In the case of risk indicators, conceptual models need to consider not only hazard and vulnerability factors but also the effectiveness of risk management and reduction measures. Different models would be required to measure different aspects of risk, for example, potential loss of life, possibility of loss of livelihood, probability of infrastructure disruption etc. Similarly, vulnerability does not exist as an abstract category and can only be defined with respect to a given hazard or hazards. There are important differences between absolute and relative risk, which also need to be confronted. Small countries may have a high relative risk levels, but very low absolute risk, in comparison with large countries (UNDP 2000).

With the analysis or depiction of collective risk using indicators it is important to recognize three methodological levels: articulation between levels or areas of reality (economic, political, cultural etc.), articulation of temporal and spatial dimensions (macro-micro, conjuncture, sequence) and the articulation that ensues from the dialectic between praxis and structure (actors and social forces). The importance of the first level resides in the achievement of a contextualization of the data and in the heuristic richness this isolated data then achieves in permitting the characterization of a given situation. The spatial-temporal articulation responds to the need to delimit the spatial scale used and take into account the temporal rhythms and horizons of this representation. Finally, the third level of articulation relates to a context where not only the government but also other social forces exist which, under certain circumstances, can impress certain directions on the types of intervention to be pursued.

Result indicators must be used with care where reality is conceived as a process with transitory properties that are not necessarily reflected by the indicator. This does not signify that result indicators should be thrown out. Rather, we need to anticipate their uncritical and ingenuous use. This is apparently the case today with diverse methods proposed for the estimation of risk and vulnerability at different spatial scales. The *indicatum* or reality comprises a series of processes that need to be reconstructed (Zemelman 1989). In our case we are dealing with risk or risk factors (hazard and vulnerability), which in themselves may be complex and composed realities. There are different types of hazard and many dimensions of vulnerability. Moreover, vulnerability is conditioned by the type of hazard. This makes the reconstruction of reality and possibility, referred to here as risk and risk management, more complex.

In the case of collective risk it is important to recognize that complex systems are involved involving multiple facets of society (physical, social, economic, cultural) that are not likely to be measured in the same manner. Physical or material reality have a “harder” topology that allows the use of quantitative measure, whilst collective and historical reality have a “softer” topology in which the majority of the qualities are described in qualitative terms (Munda 2000). These aspects indicate that a weighting or measurement of risk and risk management involves the integration of diverse disciplinary perspectives and this may usher in problems of comparability.

In other words, in order to measure risk and its management we need a holistic focus (Cardona 2001). This type of integral and multidisciplinary focus can more consistently take into account the non- linear relations of the parameters, the context, complexity and dynamics of social and environmental systems, and contribute to more effective risk management by government and other critical actors in order to achieve a preventive attitude when faced with risk and disaster. These types of models may elicit controversies when seen from a reductionist perspective. Nevertheless, when faced with the complexity of the socio-technical system to be represented when modeling risk, an approximate response to the correct formulation of the problem seen from a holistic perspective (that will necessarily be more or less vague) may be preferable to an exact response to an incorrect formulation of the problem when this is achieved with certain precision, but in a fragmented and reductionist fashion.

A number of questions may be useful in guiding the design of a model or system of risk and risk management indicators. In the design of risk indicators a series of aspects must be taken into account, such as the character or type of evaluation, the objectives, approach, and methodology, the availability of information, quality control, and the extent to which the indicator represents reality. The Appendix I presents a group of oriented questions to facilitate the formulation of a model of indicators for the relative measurement of risk.

3. Politics and the decision-making process

Political decisions on risk are many times taken under conditions of uncertainty and are based on data of variable, and at times, undetermined quality. This may be complicated by the political manipulation of uncertainty in order to speed up or slow down a decision and action. Quality, understood as the ability of a product to satisfy determined requisites, is the concept that underlies the determination of its attributes, and a criteria that allows an analysis of the decision making process (Funtowicz and Ravetz 1990, 1992). So, the key question is: what is the role of the information in decision-making? Once the problem of designing criteria has been resolved, the following question arises: who will determine the criteria to be used? (Corral 2000) Uncertainty with regard to collective risk and the fact that the scientific community can not possibly resolve and characterize these problems totally ("given that no expert can provide certainty for political decisions") has led to a request for the inclusion of more actors, including the community, in the decision making process. This permits a plurality of perspectives which, whilst not denying the competence of experts, permits the inclusion of a wide range of stakeholders in decision-making. It provides a combination of skills that permit all those involved in the problem to enrich the collective vision. Thus, the determination of criteria must be arrived at by dialogue and cooperation between experts, decision makers and other relevant actors, using the notion of "quality" as a baseline.

The perceptions of different actors must be taken into account in the design of criteria, thus providing the analysis with a capacity to change or adapt and accompany the dynamic nature of the process. The legitimacy of the obtained results is another point to be considered. When social analysis is undertaken, the results very often relate to the position taken by the analyst or the institution that requires the study (Corral 2000). Where criteria are decided by a process of plural representation of stakeholders, the results could be legitimized on the grounds that they were obtained in an open and transparent manner, even when they are not acceptable to all parties.

Therefore, the models that are applied in the design of public policies such as risk management may influence the quality of the decision process. Opting for one type of modeling over another (for instance, mono as opposed to multi criteria models) may lead to different results which then push public policy objectives in a determined direction. Therefore, despite what many believe, the design of a public policy like risk management is very much related to the evaluation technique used to orient that policy. The quality of the evaluation technique, called by some its scientific pedigree, has unsuspected influence on policy formulation. If the diagnosis invites action it is much more effective than where the results are limited to identifying the simple existence of weaknesses or failures.

The quality attributes of a model are represented by its "applicability", "transparency", "presentation" and "legitimacy". Respect for these attributes determines the scientific pedigree of a particular technique. Applicability refers to the way a model is adjusted to the evaluation problem at hand, to its reach and comprehensiveness and the accessibility, aptitude and level of confidence of the information required. Transparency is related to the way the problem is structured, facility of use, flexibility and adaptability and to the level of intelligibility and comprehensiveness of the algorithm or model. Presentation relates to the transformation of the information, visualization and understanding of the results. Finally, legitimacy is linked to the role of the analyst, control, comparison, the possibility of verification and acceptance and consensus on the part of the evaluators and decision makers.

4. The search for indicators for risk evaluation

National level aggregated variables may facilitate the identification of macro level actions and policies by national level decision makers (Briguglio 2003). But, an indicator designed for this particular scale of analysis would provide only a limited amount of the information required by sub national and local risk managers and decision makers. Due to this fact, it is also convenient and desirable to explore indicator systems that allow for the measuring of relative risk at the sub national level- departments, provinces, states or economic regions- and at the urban-metropolitan levels including the districts, municipalities or localities that comprise such areas (Cardona 2003; Barbat 2003) providing non national level decision makers with relevant policy and action information and national decision makers with additional elements for the design of national level policies related, for example, to the need for decentralization and overall regional or urban level strategies and actions. The indicators required at these different levels may have elements in common but will also require the use of different variables according to the scale of resolution required.

Taking into consideration the need for different scale approaches, in this document we present ideas on three different categories of indicators which adhere to similar conceptual and methodological premises but allow an analysis at the national, sub national and urban-metropolitan scales. These indicators or indices, should allow us to capture different analytical elements (economic, social, resilience etc.) which would then allow a situational analysis and, possibly, some understanding of causal aspects. That is to say, these could comprise part of an integral system which reflects holistically and comparatively the different aspects of risk and risk management. (Cardona 2001)

4.1 Hazards and their time frameworks

Whether we are dealing with the national, sub-national, urban-metropolitan or local levels, analysis must commence from the perspective of physical phenomenon that may negatively affect exposed elements. This implies the definition of some arbitrary reference point in terms of the severity or period of return of dangerous phenomenon. This risk factor must be modeled in the most objective fashion taking into account existing restrictions as regards information and knowledge. However, given that the potential influence of events is progressive ranging from lower to higher severity levels (more frequent events will have lower intensities and less frequent events, higher levels) it is necessary to consider some reference point, considered adequate for analytical purposes. This means that it is necessary to define a feasible maximum hazard level as a basis for the elaboration of a risk scenario. In doing this one introduces a temporal framework for the analysis. In other words, we would attempt the same procedure as is used in the insurance industry where a reference point is established for calculating feasible losses, known as the Probable Maximum Loss (Ordaz, 2002), whose period of return is fixed arbitrarily at 100, 200 or 500 years. In this case it is also necessary to define a Probable Maximum Event for which it is relevant to plan corrective or prospective actions that allow a reduction of the possible negative consequences for the country or sub- national unit considered for analysis.

One may conclude that even where different hazards exist with potentially different impacts on the country, their impact in similar time periods will not be the same. An indicator could be constructed that represents the maximum probable demand in socio economic terms associated with the most critical loss scenario taking into account the maximum probable event for the unit under analysis. This situation would generally be associated with a major or extreme catastrophic event such as a very severe earthquake, hurricane, tsunami, volcanic eruption or flood. Such a selection does not necessarily require detailed analysis of all possible dangerous phenomenon only for one or two types of event given that the type of event that is likely to be associated with catastrophic damage may be easily identifiable.

One of the major concerns associated with the impact of dangerous events comprises the relationship of probable losses to the capacity of the affected country or sub national unit to confront the ensuing economic and social consequences. It is thus convenient to be able to provide some dimensioning of this relationship, which may perhaps be termed an *index of deficit due to disaster*, in the form of indicators or sub indicators. As regards the economic demands that the impacts of catastrophic events signify, the indicator must take into account available resources and resource deficits from national and international sources, the fiscal and debt situations, insurance coverage etc.

Below, we will only develop notions with regard to three different but complimentary approaches that may be taken. The first relates to the probable maximum intensity event and economic loss that the analyzed spatial unit could suffer when faced with the occurrence of a catastrophic event and the implications in terms of needed resources to confront the situation. This implies a predictive analysis based on historical and scientific evidence and the dimensioning of the value of probably affected elements. The second relates to the dimensioning of historical losses suffered due to all large and medium scale events during a manageable historical period, let us say 30 years, and their relationship to the capacity of the affected unit to absorb and adjust to the shocks. This signifies a deductive analysis based on historical experience. The third approach considers the significance for a country or sub national unit of the recurrent occurrence of small scale events that rarely enter international or even national disaster data bases but which pose a serious and accumulative development problem for local areas and, given their overall probable impacts, for the country as a whole.

4.1.1 Catastrophic maximum impact events

Possibly, the greatest difficulties faced would be associated with the process for modeling an index of deficit due to disaster given the complexity of evaluating the hazard and the Probable Maximum Event, and due to the type of suppositions that need to be made and which would undoubtedly generate controversy.

At the sub national level it is usual for countries to be divided in departments, provinces or states. These will have differential levels of autonomy depending on the levels of political, administrative and fiscal decentralization implemented.

In the case of national level calculations of Maximum Probable Events and losses one would take 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 sub national analysis even more important. On the other hand, such sub national events would not occur simultaneously.

Analysis at the sub national level would allow national decision makers to evaluate and compare the risk levels in different areas of the country. Most surely other critical contexts will be identified which though not reaching the levels implied in the Maximum Probable Event at the national level, could approach these and demand resources that the national level would have to assume to a great degree. On the other hand, this type of sub national analysis would be of great use to sub national decision makers helping them to identify key risk problems and identify actions that they must take on their own or in coordination with the national levels. Such sub national level analysis requires greater effort and levels of information and scale resolution. However, it is convenient to undertake such analysis as it offers national and sub national decision makers a tool that is useful in defining public policies and planning needs in order to reduce risk in the different regions of the country.

The variables and indicators for these sub national levels will be similar to those at the national level, but may require modifications considered appropriate in accord with the spatial scale of the sub national units.

What might be different between national and sub-national levels is that resources may exist at the sub national level in order to cover response and reconstruction needs. To the extent greater fiscal decentralization exists and the Maximum Probable Event is smaller than at the national level the responsibility assumed by the sub national level will possibly be greater. This type of evaluation is thus of great importance to decision makers in order for them to predict or plan for the social and economic implications faced by sub national decision makers and those that need to be coordinated and agreed with national levels.

Dropping down the spatial and administrative scale the need for evaluations within urban-metropolitan and large cities is also desirable. Taking into account the spatial scale at which urban risk analysis is undertaken, it would be necessary to estimate the damage and loss scenarios that could exist for the different exposed elements that characterize the city (buildings, infrastructure, installations etc.). The Maximum Probable Event for the city would allow us to evaluate in greater detail the potential direct damage and effects and, then, prioritize the interventions and actions that are required in each area of the city in order to reduce risk

It is important to indicate here that the most critical situation for the urban area as a whole could be related to a phenomenon that is different to that which could cause the most serious impacts in a particular area of the city. This makes analysis difficult because we would have to make estimations for various hazards given that risk and hazard could vary notoriously spatially (as is demonstrated by micro-seismic and flooding studies). However, using historical information one can identify the hazard that in general would cause the most critical impact in the whole city and make comparisons of risk based on this point of reference.

The type of evaluation proposed for the urban level should be applied in various cities in the region with the idea of illustrating the type of results that could be obtained and, consequently, the type of risk management activities that are most appropriate. For this type of examples it is necessary to identify cases where the information required is easy to obtain and where hazard and physical risk studies exist at an adequate level of refinement and resolution.

4.1.2 Direct and indirect economic losses over delimited periods

The maximum probable event method outlined above allows a dimensioning of the worst possible impact scenario taking into account a period of return ranging between 500 and 1500 years. Such a long term scenario, which could in fact occur at any time in the future, could be complimented with analysis that takes shorter time frameworks into account, based on the analysis of medium and large scale disaster occurrence over, lets say, the last 30 years. A thirty year time period although not capturing all possible large scale or catastrophic events may be seen to be sufficient to depict losses of great relevance for national and sub-national decision makers or international development and financing agencies. In fact, if we take the period from 1970 to date in the Latin American and Caribbean region most disaster prone countries have suffered numerous medium and large scale events and disasters covering a wide range of possible detonating phenomenon. Moreover, this period covers the end of the import substitution and commercial agriculture export development model dominant until the late 70s and the period of evolution of more recent neo-liberal and globalization models and frameworks. This is important when considering modern impacts and losses associated with disasters.

An indicator constructed on the basis of calculable direct and indirect disaster losses in different countries, sub-national and urban units over the last 30 years is feasible given existing data bases and studies on disaster impact. Although not exhaustive, existing data is sufficiently representative to be used in an indicator model. Moreover, existing data and the number of disasters it covers could be pondered in order to arrive at a reasonable approximation to minimum total economic and human losses during this period. Once this has been calculated using all available sources (data from ECLAC studies, from national governments, insurance companies, OFDA-AID etc.) the losses may be compared on an annual average basis or for the whole period using data on national income, national GDP, national external and internal debt, financial resources made available for disaster reconstruction and other financial variables in order to come to conclusions in terms of the impact on the countries and in terms of their capacity to absorb and respond to disasters. This type of analysis has been used previously and could be widened to take into account a wider range of variables than has been the case to date, where calculations are normally made in terms of loss compared to the size of the countries GNP, external debt and financial reserves.

4.1.3 Indices for recurrent, small scaled disasters at the local level

Although the previous maximum event and historical incidence approaches are convenient in order to determine the most critical feasible situations and the medium term impact of medium and large scale disasters that should be the objective of specific social and economic policies, it is also necessary to construct a complimentary index or indicator which can account for recurrent lower scale events that systematically affect local development and which may in many cases be the result of socio-natural processes associated with environmental deterioration (Lavell, 2003). Such events are associated with persistent or chronic events such as land slides, avalanches, forest fires, drought and also lower scale earthquakes, hurricanes, volcanic eruptions, and flooding.

Thus, we can also suggest the construction of a complimentary index of recurrent local disasters where the objective is to demonstrate and measure the susceptibility of a country to s small scale and recurrent disasters, the accumulative impact of which may be highly significant at the local level, and, consequently, at the national level. This index could attempt to represent the spatial variability and dispersion of risk within a country as expressed in the occurrence of smaller and more recurrent events. Here it should also be remembered that small and medium scale events today maybe the precursors of larger disasters in the future given the future possible rapid increase in population, production and infrastructure in the affected areas.

Information for this indicator could be taken from the data base DESINVENTAR constructed by The Social Network for Disaster Prevention in Latin America-LA RED. This base has data for over 16 countries in the region discriminated according to type of event and type of effects at the local level for a period which in many cases extends from 1970 to date. The DESINVENTAR base has over 80,000 registries for the 16 countries, 70% of which are post 1970. Procedures could be undertaken in order to fine tune the base and guarantee its statistical consistency and guidelines established for the characterization of the events in terms of disaster size or magnitude.

The formulation of this index would be of particular importance in order to elaborate a scaling factor allowing the adequate comparison of large and small countries which when compared only in terms of the Maximum Probable Event and the disaster deficit indicator could generate inconsistencies and false perceptions.

Such an index is of equal use at the sub national level because it allows us to identify how susceptible the area is to lower level disasters and the impacts this signifies for local and municipal development. This index would allow us to obtain a notion of the spatial variability and dispersion of risk within a sub national unit resulting from smaller and recurrent events. From the risk management angle this type of information could contribute to orienting advisory capacities and support resources to municipalities, in accord with the history of past events and impacts. Many municipalities have not recovered from previous events when they are affected by another event which may not be considered relevant at the national or even sub national levels, but which signifies a constant erosion of local development gains and opportunities. This type of context must be identified given that recurrent small scale disasters notably increase the difficulties of local development. Such events usually affect the livelihoods and means of subsistence of poor populations thus perpetuating their levels of poverty and human insecurity.

Using the three methods outlined above it may be possible to construct an index for probable extreme hazards (scientific prevision), for events occurring in defined time periods (deductive approach) and one for historical events with differing levels of impacts (memory) at the national, regional or local levels. However, some phenomenon associated with slow onset processes such as drought and environmental deterioration may be difficult to dimension deductively or inductively such that they require a special treatment. In any of the three cases diverse suppositions must be made and the best possible criteria used in the process of estimating indicators given that certain information will be unavailable at an adequate scale of resolution or with acceptable levels of accuracy and quality. Nevertheless, the sum of the results could facilitate the identification and justification of relevant risk management actions.

4.2 Spatial scale and its Implications

Given that the notion of the *national level* has no relationship to spatial scale, it is important to be particularly careful when considering the physical and economic size of countries (Briguglio 2003). Although in general one considers small countries to be more vulnerable, when risk is expressed not only in terms of possible adverse effects but also in terms of resilience and the capacity of countries to face up to critical situations, paradoxical situations may appear (Benson 2003). In the same way, the impact of small and recurring events that are paid little attention at the national level in a large country may signify accumulative negative effects of great importance at the local level (Lavell 2003). For this reason it is necessary to identify and model this type of situation given that it may disorient or affect the pertinence or effectiveness of risk management. In other words, apart from the consideration given to the conceptual framework that helps structure the problem, it is also necessary to consider the deviations or influence that the particular methodological framework used may have on the results (Benson 2003). This aspect may have an unsuspected influence as regards the identification of management policies,

5. Representing vulnerability

Vulnerability is a key issue in understanding disaster risk and impacts and must be adequately dimensioned in any indicator model according to the spatial or social scale considered. In the present section of our document we will attempt to identify certain needs and options as regards this dimension recognizing from the outset that a clear specification needs to be made prior to analysis as regards the particular social structures or contexts to which we are referring with the application of vulnerability analysis, taking into consideration the insecurity, fragility, resilience, etc. of the different components that come into play-poor population, critical infrastructure, subsistence economies, modern agricultural sectors, at the national, sub national or local levels, etc.

Here, we offer an analysis based on the identification of three categories or components of vulnerability—exposure and physical susceptibility, socio-economic fragility, and social resilience (see the projects conceptual document for details as to these components or levels). This is one alternative amongst many. Thus, for example, we could also adhere to the classification of vulnerability factors or contributing causes developed by Wisner, Blaikie *et al* in their book *At Risk* and presented at the first international consultant meeting of the present project celebrated in

Barcelona in July by Terry Cannon and Ian Davis, co authors of the mentioned study. Wisner *et al* identify five vulnerability factors or components that help explain the vulnerability of people and their livelihoods—initial well being, resilience of livelihoods, mechanisms for self protection, mechanisms of social protection, and aspects related to the structure of government, civil society, participation, development of social capital etc. These factors represent in many ways a more detailed development of the three factors we consider below.

Indicators used for describing exposure, prevalent socio-economic conditions and lack of resilience must be formulated in a consistent fashion (directly or in inverse fashion, accordingly), recognizing that their influence explains why adverse economic, social and environmental effects are consummated when a dangerous event occurs. Each aspect may be a series of indicators that express situations, causes, susceptibilities, weaknesses or relative absences affecting the country, region or locality under analysis and in favor of which risk reduction actions may be oriented. These indicators must be chosen such that they best represent the situation under analysis using reliable, quality information (Comfort, 2003). The use of variables that represent similar aspects, or the repeated use of the same indicator means that they are being assigned a greater weight as regards other variables used in the indicator system or model (Davidson, 1997, Cardona, 2001, Briguglio, 2003).

In the case of exposure and /or physical susceptibility, the indicators that best represent this are population, fixed capital, livelihoods, investment, production, essential patrimony, and human activities (Masure 2003). It is desirable to have available data on the more susceptible segments such as poor population, insecure settlements and infrastructure, fragile crops, unstable sources of work. Other indicators of this type may be found in population, agricultural and urban growth and densification rates.

Socio-economic fragility may be represented by indicators such as poverty, illiteracy, unemployment, inflation, debt, dependency, social disparities, human insecurity, and environmental deterioration. These are indicators that reflect relative weaknesses and conditions of deterioration that would increase the direct effects associated with dangerous phenomenon (Cannon 2003; Davis 2003). Even though such effects are not necessarily accumulative and in some cases may signify a type of double accountancy, their influence is especially important at the social and economic levels. A reduction of these types of factors as a result of a sustainable process of human development and explicit policies of risk reduction are one of the aspects that must be given special attention.

The lack of resilience or capacity to confront or absorb the impact of dangerous phenomenon is related to development levels and the explicit existence of risk management policies and actions. The lack of resilience, seen as a vulnerability factor, may be represented at all levels by means of the inverse treatment of a number of variables related to governance, financial protection, economic redistribution, human development levels, collective perceptions, human capital, the level of technological development and preparedness to face crisis situations. This collection of indicators on their own and particularly where they are disaggregated at the local level could help in the identification and orientation of actions that should be promoted, strengthened or prioritized in order to increase human security (Cannon 2003; Davis 2003). Their participation in an indicator system is justified to the extent that the execution of effective prevention, mitigation, preparedness and risk transfer actions help reduce risk whilst their absence or insufficiency leads to increases in risk.

6. Methodology for evaluating and relating indicators

Using indicators to estimate or measure risk permits the combination of quantitative and qualitative techniques relating to hazards and vulnerability. Indicators permit the identification of features that are not possible to estimate or turn out to be imprecise using mathematical models or algorithms. However, any indicator model must be consistent in the way it relates the selected variables. This implies, for example, that with proposed estimations we must define if the relations are accumulative or multiplicative. We must also be able to discern if variables are to be given different weights that allow us to judge their contribution to what we wish to measure or represent, or if their contribution is merely indicative and for comparative purposes.

Indicators proposed for different spatial or social levels must be based on figures, indices, existing rates or proportions that derive from reliable data bases available in the countries, regions or cities. Some values will have to be standardized for the study area or population. Nevertheless, the option also exists of making qualitative valuations using pertinent variables for which no specific indicator exists and that reflect what we want to measure. In these cases it is necessary to qualify the variables using linguistic scales that may run from 1 to 7 or 1 to 5, for example (Briguglio 2003; Davis 2003; Masure 2003). For example, in relationship to some desirable characteristic we may evaluate whether it is non existent, below average, average, above average or optimum. Thus, variables may be proposed that more clearly reflect what we want to represent as it is presented in the Appendix II and III. Fuzzy logic permits the use of linguistic variables that define functions of pertinence to fuzzy groups and fuzzy base rules that permit the aggregation and intersection of facets and variables (Pedrycz 1995; Jang et al 1997; Leondes 1998). This type of technique even allows us to obtain numeric indices (defuzzification) resulting from the relationship between variables and these are an alternative for qualitative evaluation and for their combination with numeric values (Cardona 2001). These considerations will be the object of future study with the objective of defining in detail the definitive indicators and the means to relate them.

In conclusion, this type of holistic approach to evaluation will probably be increasingly accepted and used as one of the best options for representing risk and risk management situations. This is due to its flexibility, possible compatibility with other specific evaluation techniques, its complexity and imprecision. Its strength rests in the ability to disaggregate results and identify factors that should be the objective of risk management actions, allowing the measurement of their effectiveness. The objective is to stimulate decision making. The concept underlying the method is one of control and not the precise evaluation of risk, a procedure and objective that is normally based on the concept of physical truth.

APPENDIX I: ORIENTING QUESTIONS

.
Character and purpose:

- What is the purpose of evaluation?
- What is the level of resolution?
- Should it be a multidimensional evaluation?
- Are the objectives unrealistic or unachievable?
- Which could be the final and intermediate objectives?
- In what language will we express the results?
- With reference to what objectives and in what environments will results apply?
- How can the results be used?
- How can one evaluate the use of the results?
- What for and for whom could the evaluation be useful?
- Who can use the information?
- Who cares about and is willing to share responsibility for the evaluation and its utilization?
- How do we get administrative decisions relating to the indicators?

Focus and methodology:

- Will the method be quantitative or qualitative?
- How do we define sub-indexes and weights?
- Will the approach be based on objective or subjective criteria?
- Will the design be static or dynamic?
- How will reliability or validity be tested?
- Will the approach be holistic or sectoral?
- Will the procedures be inductive or deductive?
- What mapping scales should be used to change qualitative data into a quantitative scale (e.g. 1 to 5, with 1 being the smallest occurrence, 5 the largest, and 3 representing an average).
- Should we allow for non linear occurrences (e.g. exponential: 2.0, 2.8, 4.8, 10.4, 33.4 or U shaped: 10, 8, 4, 8, 10 or S shaped: 2, 8, 12, 13, 12)

Data:

- What are the sources of the data?
- Which methods are available to procure data when this is not officially published?
- What methods are to be employed to ensure that data is comparable?
- What measures should be taken when data is missing?
- What are the potential difficulties in quantifying information?
- Why should we aim for simplicity?
- How do we generate confidence in the estimates produced?

Quality control:

- Which should the role of evaluators be?
- Who is best qualified to perform evaluation?
- What is the role of experts and consultants?
- How do we involve nationals from each country to participate in the evaluation?

The extent to which the indicator represents reality (indicatum):

- What aspects must be specified in order to evaluate vulnerability?
- What indicators are easy to comprehend and intuitively meaningful?
- Which are the hazards to be considered?
- Are all hazards exogenously determined?
- Which are the exposed elements?
- What type of qualities must be taken into account?
- How should we consider different hazards, different degrees of exposure, and different country conditions?
- What could be the effect of country size and variations in this?
- What thresholds are to be set?
- Is vulnerability influenced by economic and ecological susceptibility?
- Are structural handicaps the same thing as vulnerability?
- What variables may be considered exposure indicators?
- How should we measure impacts?
- How do we take into account the performance of critical facilities and lifelines?
- How do we factor in consider macro-economic resilience?
- How do we measure institutional capacities?
- How do we take the local level into account?
- What should we test the robustness of the indicators

APPENDIX II: COMPILATION OF RISK FACTORS

In all sources consulted by IDEA, numerous factors are associated with risk and vulnerability. These have been brought together and classified here in order to take account of the complexity of the concepts. Diverse methodologies exist. The most recent of these developed by UNDP and GTZ have been proposed for the national and local levels and include risk indicators that attempt to reflect some or the majority of the factors that are included in our list below. (UNDP 2003; GTZ 2003). A classification of the principle physical, natural, ecological, technological, social, economic, cultural, territorial, educational, functional, politico-institutional, administrative and temporal factors was achieved. Some of these factors are intimately linked, given they are mutually conditioned and reinforced.

- Physical factors
    - Location

- Natural factors
    - Nature of the phenomenon and magnitude
    - Fragile ecosystems
    - Soil type
    - Erosion
    - Global climatic phenomenon. Warming leads to increase in sea levels that render certain coastlines and islands uninhabitable due to flooding

- Ecological factors
    - Environmental degradation

- Technological factors
    - Housing type
    - Technical deficiencies in construction. Height, materials, construction system, hammer effect, maintenance.
    - Quality of infrastructure
    - Water treatment and supply

- Social factors
    - Population
    - IHD
    - Mortality rate at birth
    - Child mortality rates
    - Life expectation
    - Malnutrition
    - Marginality
    - Segregation
    - Population density
    - Population growth
    - Urban population

  - Urban population density
  - Growth in urban population during last three year
  - Gender
  - Age
  - Physical incapacities
  - Community organization. Cooperatives, associations, NGOs, churches
  - Recovery capacity

- Economic factors
  - Resources.
  - Poverty
  - GNP and its growth
  - Production structure
  - Low levels of economic diversity
  - Marginalization from markets
  - Dependency on external economic conditions
  - Need for imports in the electricity and manufacturing sectors
  - National external and internal debt
  - Commercial openness
  - Concentration on few export products
  - Peripheral status
  - Investment in health, education and infrastructure
  - Increase in external debt obliges the export of natural resources at any price. The pressure on the environment is high.
  - Tourism development in coastal areas and lumbering has generated intense pressures on land, thus increasing erosion.
  - Presence of particular branches on the economy. Tourism, Agriculture, Transport- road networks and transport systems
  - High freight costs
  - Lack of access to land and property
  - Access profiles of households
  - Income opportunities
  - Household budgets
  - Market access
  - Access to banks
  - Access to credit
  - Access to emergency aid permitting a household to purchase food, reconstruct homes
  - Economic crisis does not allow maintenance of structures
  - Recovery capacity

- Territorial factors
  - Ability to attain certain level of planning competence
  - Land property land
  - Land use

- Past disasters occurred in a place
- Rapid urbanization
- Overcrowding of houses in marginal areas. Interruption in water filtering and drainage.
- Wars
- Isolation of health and educational centers
- Lack of access to property

- Cultural factors
  - History
  - Caste
  - Religion
  - Ethnicity
  - Class and class relations
  - Domination structures
  - Ideology
  - Flexibility
  - Lack of ethics
  - High levels of fatalism
  - Traditional pernicious habits
  - Lack of a multi hazard perspective
  - Waste management

- Educational factors
  - Illiteracy rate
  - Lack of development of a prevention culture
  - Access to information

- Functional factors
  - Response capacity during emergencies
  - Evacuation capacity

- Political, institutional and administrative factors
  - Development pattern
  - Governance
  - Weak democratic structures. Lack of participation of the population in democratic processes
  - Iniquity
  - Lack of political will
  - Malversation as an indicator of corruption and clientelism
  - Risk reduction plans are not included in development plans
  - Norms and types of norm
  - Wars
  - State allocation of resources
  - Agrarian reform

- Food policy
- Continuity in policies
- Prevention and mitigation policies
- Lack of national organization for prevention and attention
- Institutional location of responsible organizations- Ministry of the Presidency, Army etc.
- Existence of impact studies when a new project is designed. Norms exist and are applied.
- Lack and failings in construction codes
- Personnel training
- Distribution of the budget
- Lack of coordination
- Lack of or insufficiency in the mechanisms or instruments for financial risk spreading-disaster funds, insurance policies.
- Lack of research institutes in natural and physical sciences, hydrometeorology, development, engineering and technical sciences, political science, seismology, volcanology, cartography and geodesics, geography, geology, geophysics
- Lack of a multi hazard perspective
- Periodicity of meetings of operational organizations
- Lack of technical organizations
- Local and regional committees with real legal faculties
- Low density of educational and health facilities

- Temporal factors
    - Time of occurrence
    - Duration of the event

A consideration of one or another vulnerability factor depends on the type of hazard, the spatial scale (national, regional, local) and, finally, the temporal scale that is contemplated (before, and /or during and /or after impact).

APPENDIX III: FRAGMENT OF THE DRAFT ISDR/UNDP PROPOSAL
Conceptual Framework to Guide and Monitor Disaster Risk Reduction

The following proposal aims to develop a common framework for understanding, guiding and monitoring disaster risk reduction at all levels. The ultimate goal of this collective and interactive endeavor is to encourage and increase appropriate and effective disaster reduction practices (ISDR 2003).

Attached, please find a very preliminary first draft proposal for a conceptual framework to guide and monitor disaster risk reduction, in matrix form, organized around the following categories and components:

Political	Commitment Policy and planning Legislation Resources
Institutional organization	Normative framework Monitoring
Risk identification	Risk assessment (hazard analysis and vulnerability and capacity assessment)
Knowledge	Information management and communication Education and training Public awareness Research
Risk management applications	Environmental management Social protection and safety nets Financial instruments Land use planning, urban and regional planning Physical/structural measures Forecasting and early warning systems Preparedness and emergency management

REFERENCES

Briguglio, L.and Pratt, C. (1999). *Report of the Meeting of Experts on the Environmental Vulnerability Index,* UNEP/SOPAC, Valleta, Malta.

Cardona, O.D. (2001).“*Estimación Holística del Riesgo Sísmico utilizando Sistemas Dinámicos Complejos”* http://www.desenredando.org/public/varios/2001/ehrisusd/index.html, Universidad Politécnica de Cataluña, Barcelona.

Cardona, O.D. (2003). "*La Necesidad de Repensar de Manera Holistica los Conceptos de Vulnerabilidad y Riesgo: Una crítica y una revión necesaria para la gestión*", Artículos 2003 en la página de LA RED. http://www.desenredando.org/public/articulos/2003/rmhcvr/index.html

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

Cardona, O.D. and Maskrey, A., (2000). *Expert Meeting on Risk and Vulnerability Analysis and Indexing*, Workshop Goals and Methodology, UNDP/DRRP, September 11and 12,Geneva.

Clark, C. and Keipi, K. (2000*). Indicators Program for Disaster Risk Management*, Technical Cooperation Profile, Inter-American Development Bank, IADB, August 2000, Washington.

Corral, S. (2000): “Explorando la Calidad de los Procesos de Elaboración de Políticas Ambientales” *Métodos Numéricos en Ciencias Sociales (MENCIS 2000)*, Oñate, E. *et al.* (Eds.) CIMNE-UPC, Barcelona.

Funtowicz, S., and Ravetz, J. (1990):*Uncertaintv and Qualitv in Science for Policv*. Dordrecht, Kluwer Academic Publishers.

Funtowicz, S., and Ravetz, J. (1992): The Role of Science in Risk Assessment. *Social Theories of Risk*. S. Krimsky and D. Golding. Westport, Praeger: 59-88.

GTZ (2003). *Indicators and other Disaster Risk Management Instruments for Communities and Local Governments*, Comprehensive Risk Management by Communities and Local Governments, Component III. by Hahn, H., Initial Draft. Background study for Inter-American Development Bank, IADB, Regional Policy Dialogue, Washington.

ISDR (2003). A Framework for Understanding, Guiding and Monitoring Disaster Risk Reduction, Draft Proposal, International Strategy on Disaster Reduction ISDR/UNDP, Geneva.

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

PAHO (2001). *Indicadores de Salud: Elementos Básicos para el Análisis de la Situación de Salud*. Tomado del Boletín Epidemiológico, Organización Panamericana de la Salud OPS/PAHO, Vol.22 No. 4, http://www.paho.org/Spanish/SHA/be_v22n4-indicadores.htm, Diciembre 2001.

Plate, E. (2002). *Implications of Global Environmental Change on Risk Management and Human Security*, Working Group 3, International Symposium on Disaster Reduction and Global Change, DKKV/NKGCF, Federal Foreign Office, Berlin, Germany.

Taylor C., Vanmarcke E., and Davis J. (1998): “Evaluating Models of Risk from Natural Hazards” *Paying the Price*, Kunreuther H., and Roth R.J., (Eds.) Joseph Henry Press, Washington.

UNDP (2000) *Expert Meeting on Risk and Vulnerability Analysis and Indexing*, Bases for the World Vulnerability Report WVR and Disaster Risk Index, DRI. (Aysan, Y., Maskrey, A. and Cardona, O.D.) UNDP/DRRP, September 11 and 12,Geneva.

UNDP (2003) *Development and Disaster Risk: A Global Report*, Chapter 2th: Geographies of Risk, Multi-Hazard Disaster Risk Index, DRI, Draft version, Geneva.

Zemelman, H. (1989). *Crítica Epistemológica de los Indicadores*, El Colegio de México, Centro de Estudios Sociológicos, Jornadas 114.