





Figure 1. New version of the model (Carreño et al. 2004; 2005)

– equilibrium on the verge of chaos – of the system exposed to the agent that triggers the crisis.

The possibility of this occurring should always be considered within a period or “window” of time, which would mean expressing each factor in terms of probability.

But how can vulnerability or instability conditions be measured if the concept encompasses a causal reality of adverse effects that is more wide-reaching than denoted by the physical fragility of the exposed elements?

The vulnerability of human settlements to natural phenomena, for example, is closely tied to the social processes that take place there. In other words, it does not solely depend on the physical susceptibility of the material context, but also on social fragility and the lack of resilience or recovery capacity of the elements exposed to threats of different kinds.

This points to the need for a comprehensive description of vulnerability, recognising that there are aspects of vulnerability that are dependent on hazard and others that are not but which aggravate the situation, and that assessment can be made on the basis of indicators or proxies for the purposes of follow-up, from the perspective of control and not that of physical truth.

Here it is necessary to move beyond the

antagonism between “objectivism” and “constructivism” and rely more on qualitative as well as quantitative risk analysis methods. The action or decision that is implicitly associated with the concept of risk makes it necessary to establish the relation between the subjective perception of risk and the scientific demand for its objective measurement.

Based on these considerations, a model for disaster risk assessment from a holistic perspective was proposed in the late 1990s (Cardona 2001), and subsequently applied with Hurtado and Barbat in 2000. In these studies, disaster risk was assessed on the basis of various dimensions or aspects of vulnerability that can be subdivided into three categories or factors:

- a) Exposure and physical susceptibility, which represent a “hard” risk factor related to potential damage to physical infrastructure and the environment,
- b) Socioeconomic fragilities, which contribute to a “soft” risk factor related to potential impact on the social context, and
- c) Lack of resilience to cope with and recover from disasters, which also contributes to a “soft” risk factor or second order impact on communities and organisations.

From a holistic perspective, risk signifies economic, social and environmental consequences caused by potential physical phenomena.

The holistic approach referred to here signifies a process of integration and disaggregation, preserving the synergies or relations among components. It is a notion of complex thought, which separates and reunites, which distinguishes – without dividing – and reconnects.

Carreño et al. (2004; 2005) developed an alternative version of the model, in which risk assessment is carried out with physical risk affected by an impact factor deriving from the surrounding conditions, such as socioeconomic fragilities and lack of resilience, both of which are conditions that aggravate the scenario of physical losses.

Figure 1 illustrates the new version of the holistic perspective model, in which risk,  $R$ , is a function of the potential physical damage,  $D$ , and an impact factor,  $I$ . The first is obtained from the susceptibility of the exposed elements,  $D_i$ , to the hazards,  $H_i$ , taking into account the potential intensity,  $I$ , of the events in a period of time,  $t$ . The second is dependent on social fragilities,  $F_i$ , and aspects related to the lack of resilience,  $R_i$ , of the social-technical system or context prone to disasters.

Using the meta-concepts of control theory and complex dynamical systems, risk reduction calls for corrective and prospective interventions aimed at vulnerability factors and, when possible, the hazards themselves.

In other words, risk reduction requires a control system (institutional structure) and actuation system (public policies and actions) to implement the necessary changes in the exposed elements or the complex system where risk is a socio-environmental process.

This model was applied in the development of the system of risk indicators and risk management developed and implemented in 12 countries in the Americas under the coordination of IDEA, with financial support from the Inter-American Development Bank (IDEA 2005).

Another model proposed and presented in Bonn at the 2nd Meeting of the Expert Working Group on Vulnerability, on behalf of the UNU-ESH, is the so-called BBC concept (Bogardi, Birkmann, Cardona)<sup>1</sup> which views vulnerability as a link in the hazard-vulnerability-risk chain. This conceptual framework argues that vulnerability should be viewed as a process and advocates proactive actions before risk manifests itself (Birkmann 2006).

In conclusion, while it is possible to propose different ways of measuring or analysing vulnerability and risk, it is essential to overcome the antagonism between “objectivism” and “constructivism” and rely more on qualitative as well as quantitative measures.

It is conceptually and pragmatically unsatisfactory to leave the issue as a simple matter of

relativity and say that individuals subjectively perceive and confront risk in their own way. This position is totally ineffectual given the inescapable need for risk interventions from the viewpoint of public policy.

The attributes that determine the quality of a model are its applicability, transparency, presentation and legitimacy.

The scientific pedigree of an evaluation technique will depend on its fulfilment of these attributes or properties. Applicability is linked to the adaptation of the model to the problem, to its scope and completeness, and to the accessibility, suitability and reliability of the information required. Transparency is related to the structuring of the problem, facility of use, flexibility and adaptability, and the extent to which the model or algorithm is intelligible or understandable. Presentation refers to the transformation of the information, the visualisation and comprehension of results. Finally, legitimacy is tied to the role of the analyst, checks and controls, the possibility of verification and the acceptance and consensus of evaluators and decision makers.

<sup>1</sup> Given this name by the first two authors, and in which the third author did not participate in its conception, but was included because the proposal is based on his previous works.

**Birkmann, J. (Ed.) (2006):** Measuring Vulnerability to Hazards of Natural Origin: Towards Disaster Resilient Societies. United Nations University Press, UNU-EHS.

**Cardona, O.D. (1985):** Hazard, Vulnerability and Risk Assessment, unedited working paper, Institute of Earthquake Engineering and Engineering Seismology IZS, Skopje, Yugoslavia.

**Cardona, O.D. (1986):** “Estudios de Vulnerabilidad y Evaluación del Riesgo Sísmico: Planificación Física y Urbana en Áreas Propensas”, Asociación Colombiana de Ingeniería Sísmica, Boletín Técnico AIS No. 33, Bogotá.

**Cardona, O.D. (1995):** Prevención de Desastres y Preparativos para Emergencias: Aspectos Técnico-científicos, Sociales, Culturales e Institucionales, Centro de Estudios sobre Desastres y Riesgos Naturales CEDERI, Universidad de los Andes, Bogotá.



**Cardona, O.D. (1999):** “Environmental Management and Disaster Prevention: Two Related Topics - A Holistic Risk Assessment and Management Approach”, Natural Disaster Management, Ingleton J. (Ed.) IDNDR, Tudor Rose, IDNDR, London, UK.

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

**Cardona, O.D. (2003):** “The Need for Rethinking the Concepts of Vulnerability and Risk from a Holistic Perspective: A Necessary Review and Criticism for Effective Risk Management”, in Mapping Vulnerability: Disasters, Development and People, G. Bankoff, G. Frerks, D. Hilhorst (Ed), Earthscan Publishers, Londres.

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

**Cardona, O.D., Hurtado J.E. (2000):** “Modelación Numérica para la Estimación

Holística del Riesgo Sísmico Urbano, Considerando Variables Técnicas, Sociales y Económicas” Métodos Numéricos en Ciencias Sociales (MENCIS 2000), Oñate, E. et al. (Eds.) CIMNE-UPC, Barcelona.

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

**Carreño, M.L., Cardona, O.D. & Barbat, A.H. (2005):** Sistema de indicadores para la evaluación de riesgos, Monografía CIMNE IS-52, Universidad Politécnica de Cataluña, Barcelona.

**IDEA (2005):** Sistema de indicadores para la gestión del riesgo de desastre: Informe técnico principal. Programa BID/IDEA de Indicadores para la Gestión de Riesgos, Universidad Nacional de Colombia, Manizales. <http://idea.unalmz.edu.co>

**UNDRP (1980):** Natural Disasters and Vulnerability Analysis, Report of Experts Group Meeting of July 9-12, 1979, Geneva.